Social Network Analysis (SNA) and adaptive co-management to forest fires in Portugal:

A case study of the Serra de Monchique, Algarve

Guilherme Saad Ximenes

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Spatial Planning and Urbanism

Supervisor: Professora Doutora Maria do Rosário Sintra de Almeida Partidário

Examination Committee

Chairperson: Professor Doutor João Rafael Marques Santos

Supervisor: Professora Doutora Maria do Rosário Sintra de Almeida Partidário

Member of the Committee: Professor Doutor Mário Adriano Ferreira do Vale

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DECLARATION

I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Lisbon University.

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ABSTRACT

Collaborative forest management for forest fire reduction (i.e. adaptive co-management for forest fires) involves diverse actors (entities and landowners) acting in integrated networks in the management of forest territory to promote social learning and collaboration, central aspects of adaptive co-management for forest fires. The research applied a Social Network Analysis (SNA) approach to the network of actors involved in forest territory management in Monchique (case study) to analyse the network structure, its interactions dynamics, collaboration and knowledge flows on forest territories, analysing which aspects of the current actor network contribute to, or constrain, adaptive co-management to forest fires in Monchique. The result showed aspects that contribute to adaptive co-management, such as a high density of interactions between entities of the SGIFR and the potential role of central actors, namely governmental entities, to promote social learning and articulation among other actors that are less integrated in the network. On the other hand, aspects that limit adaptive co-management were identified, such as the prevalence of interactions of low intensity and/or frequency (weak ties) that limit collaboration and the peripheral role (i.e, less integrated into the network) of local entities and landowners that undermine the integration of local knowledge and practices into the network and so highlighted the importance of a more local and decentralized network structure to better integrate these relevant local actors by strengthening the role of the Municipal Commissions for Integrated Rural Fire Management (CMGIFR).

Key words: Social Network Analysis; Adaptive co-management; Collaborative networks; Forest fires

RESUMO

A gestão colaborativa das florestas para a redução de incêndios (i.e., co-gestão adaptativa aos incêndios florestais) envolve diversos atores (entidades e proprietários rurais) atuando em redes integradas na gestão do território florestal para promover a aprendizagem social e a colaboração, aspetos centrais da co-gestão adaptativa aos incêndios florestais. A investigação aplicou uma abordagem da Social Network Analysis (SNA) na rede de atores envolvidos na gestão dos territórios florestais em Monchique (estudo de caso) para analisar a estrutura da rede, sua dinâmica de interações, de colaboração e os fluxos de conhecimentos sobre os territórios florestais, analisando quais aspetos da atual rede de atores contribuem, ou limitam, a co-gestão adaptativa aos incêndios florestais em Monchique. O resultado mostrou aspetos que contribuem para a co-gestão adaptativa, como uma alta densidade de interações entre atores da rede e o potencial papel de atores centrais, nomeadamente entidades governamentais, para promover a aprendizagem social e a articulação entre os demais atores pouco integrados à rede. Por outro lado, foram identificados aspetos que limitam a co-gestão adaptativa, como o predomínio de interações de baixa intensidade e/ou frequência (laços fracos) que limitam a colaboração e o papel periférico (i.e., menos integrado à rede) de entidades locais e dos proprietários rurais que comprometem a integração de conhecimentos e práticas locais na rede e, assim destacou-se a importância de uma estrutura de rede mais local e descentralizada e local para melhor integração destes atores locais através do fortalecimento do papel das Comissões Municipais de Gestão Integrada de Incêndios Rurais (CMGIFR).

Palavras chave: Análise de redes sociais; Co-gestão adaptativa; Redes colaborativas; Incêndios florestais

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

CMGIFR	*MUNICIPAL COMMISSION FOR THE INTEGRATED MANAGEMENT OF RURAL FIRES*
CTI	*INDEPENDENT TECHNICAL COMMISSION*
ENF	*NATIONAL STRATEGY FOR FOREST*
IFN	*NATIONAL FOREST INVENTORY*
INSNA	*INTERNATIONAL NETWORK FOR SOCIAL NETWORK ANALYSIS*
LULC	*LAND USE AND LAND COVER*
NRM	*NATURAL RESOURCE MANAGEMENT*
PNDFCI	*NATIONAL PLAN FOR FOREST DEFENCE AND FIRE FIGHTING*

PNGIFR	*NATIONAL PLAN FOR INTEGRATED MANAGEMENT OF RURAL FIRES*
SES	*SOCIO-ECOLOGICAL SYSTEMS*
SGIFR	*INTEGRATED MANAGEMENT SYSTEM FOR RURAL FIRES*
SNA	*SOCIAL NETWORK ANALYSIS*
UCINET	*SOFTWARE USED TO DEVELOP THE SOCIAL NETWORK ANALYSIS*

1. INTRODUCTION

The severity and impacts caused by forest fires registered in recent decades in Portugal, particularly the fires that occurred in 2017, led the government to a critical evaluation of the forest fire prevention policies that were currently in effect. In this perspective, it was identified the existence of systemic failures in the effective reduction of fire risks that are directly related to the lack of an integrated management of forest territories located in fire prone areas. As a result, the National Plan for Integrated Management of Rural Fires (PNGIFR), approved in 2020, guided the restructuring of the Integrated Management System for Rural Fires (SGIFR), in order to facilitate the operationalisation of an integrated management of forest territories for the prevention of forest fire risks. The SGIFR has thus established an integrated management model focused on increasing and strengthening the articulated and collaborative networks of actors (entities and forest owners) to share information and promote joint strategies and actions between multiple actors with powers to intervene in forest management and fire risk reduction.

Based on the scientific literature review, forest territories are characterized as social-ecological systems (SES) that involve a complexity of interactions between ecological (resources, ecosystems) and social systems (users, governance) that affect each other, influencing and being influenced by the social, economic and political context. Therefore, forest fires represent "SES pathologies" as they result from a complex dynamic of problematic interactions between social and ecological systems occurring (and being reinforced) over time. To deal with this complexity, non-linearity and uncertainties inherent to the management of forest systems, collaborative management focused on fire risk prevention (i.e. adaptive co-management to forest fire risks) points to the need to involve multiple actors (institutional and community) with different visions, competences and knowledge to act in articulated networks in the management of forest territories. Articulated and collaborative networks of actors in adaptive co-management contribute to facilitate social learning and dialogue, dynamic interaction between actors (learning by doing), sharing of different visions, interests and intervention priorities in the territory (problem solving), as well as the establishment of respective responsibilities and task sharing in the management of SES. The scientific literature on adaptive co-management also highlights the importance of articulating and integrating diverse knowledge systems and experiences (local and scientific) to broaden the understanding of the complexity, and uncertainties, inherent to the dynamics of SES interactions, in order to direct strategies and adaptive practices oriented towards sustainability.

Over the last twenty years, several studies in the field of natural resource management (NRM) have adopted a Social Network Analysis (SNA) approach to identify patterns of interactions between actors (structure) of the network and the role that actors play in the dynamics of collaboration and information and knowledge flows within the network. As a result, these studies have analysed existing weaknesses and gaps in the current structure and dynamics of the actors' network and intended to guide strategies to promote knowledge sharing and collaboration among network actors from the perspective of adaptive co-management of natural resources and ecosystems. However, there is a lack of studies with an SNA approach to identify and analyse in depth the patterns of interactions and the role of the actors in the network of forest territories management in Portugal to enable the assessment of if and how this current

network structure and dynamics/flows have contributed to, or constrained, an adaptive co-management to forest fire risks. Thus, the motivation of this research is to contribute to this gap with the adoption of a SNA approach to identify the patterns of interactions (structure) of the network of actors that are part of the SGIFR, as well as the dynamics/flows and role of actors within the network, to analyse how this network of actors have contributed, or restricted, adaptive co-management to forest fire risks. The study aims to answer the following Research Question (RQ): “How can a social network approach (SNA) contribute to promoting adaptive co-management to forest fire risk management in the Serra de Monchique?”. To this end, the Serra de Monchique, located in the district of Faro (southern Portugal), was selected as a case study, a region that suffered a severe forest fire in 2018 and, still today, has extensive areas of its territory classified as highly susceptible to the occurrence of new forest fire events.

This master Thesis is being developed in the context of the Project BRIDGE (Bridging science and local communities for wildfire risk reduction) developed at the Instituto Superior Técnico (IST) in partnership with the Laboratório Nacional de Engenharia Civil (LNEC) and the Universidade do Algarve (UAlg), with funding from the Fundação para a Ciência e Tecnologia (FCT). BRIDGE is an action research project that aims to promote and integrate scientific and community knowledge through innovative living laboratories (InnoLab) to promote social learning about forest territories and expand local capacities to adapt to forest fire risks in the municipality of Monchique. As expected contribution of the Thesis to the BRIDGE project is the result of the analysis of the patterns of interactions and collaboration between actors, institutional and community, in the management of forest territories, and the flows of information and knowledge (local and scientific) existing within this network of actors focused on the reduction of forest fire risks in Monchique.

1.1 OBJECTIVES

The objective of the Thesis is to answer the RQ: "How can a social network approach (SNA) contribute to promoting adaptive forest fire risk management in the Serra de Monchique?". To this end, it aims to investigate the role of an SNA approach applied to the SGIFRs´ network in the forest territories management in Serra de Monchique, the adopted case study. The purpose is to identify the structure and the dynamics of the actors ‘network and to analyse how the network has contributed to, or limited, collaborative and adaptive management (i.e. adaptive co-management) for the reduction of forest fire risk.

The specific objectives of the research are:

- ✓ To identify the characteristics of the network of actors of the SGIFR in the management of forest territories in the Serra de Monchique, and to analyse the information and knowledge flows on forest fires within the network, and the current dynamics of collaboration in the integrated management of forest territories focused on fire risk reduction;
- ✓ To analyse, from their position in the network structure, the role that the entities of the SGIFR play (influence, support and/or brokerage) in the dynamics of collaboration and in the flows of

information and knowledge within the network of integrated management of forest territories in the Serra de Monchique.

- ✓ To identify the patterns of interactions of forest owners in the Serra de Monchique with the SGIFR entities in order to analyse the potential integration and contributions of local knowledge and experiences in the integrated management of forest territories from the perspective of adaptive co-management to fire risks;
- ✓ Based on the results of the SNA of the actors' network in the management of the forest territories of Serra de Monchique, reflect on characteristics of the current structure and dynamics of the network and the role played by actors that contribute to promote, or limit, adaptive co-management to forest fire risk for other forest territories in Portugal.

1.2 STRUCTURE OF THE THESIS

The Thesis is structured in five chapters. Chapter one is the Introduction. Chapters two and three focus on the analysis of the literature review relevant to the research. In Chapter two on adaptive co-management to forest fires, the evolution of forest systems in Portugal is analysed, as well as contextual issues leading to a scenario of susceptibility to forest fire events in the country, and the current strategies being adopted regarding policies and regulations directed to forest fire risk prevention (sub-item 2.1). Subsequently, an analysis of the concepts of social-ecological systems and adaptive co-management is developed focused on two central aspects, social learning and collaboration, highlighting the important role of the actors' network in the adaptive co-management of complex SES oriented towards sustainability (2.2). In Chapter three on social network analysis (SNA), the evolution of the SNA approach and its current definition in the scientific literature is presented (3.1), with further analysis of Graph Theory in SNA by presenting the central components of network graphs (sociogram) and the main network analysis metrics (sociometrics) commonly adopted and considered in this research (3.2). Finally, an in-depth analysis of the case studies which adopted the SNA approach to actors' network (governance) in natural resource management (NRM) is presented as an important methodological benchmark to support the analysis of the effects (positive and negative) of the main aspects of the actors' network on the adaptive co-management of natural resources and ecosystems, as well as reflecting on previous experiences and respective lessons of the SNA approach in NRM.

Chapters four and five focus on the application of SNA in the Serra de Monchique (case study) and the analysis of the results obtained from the perspective of adaptive co-management of forest fires. In Chapter four with contributions of SNA in adaptive co-management to forest fires, presents a characterization of the Municipality of Monchique and its current context of high susceptibility to forest fire events (4.1), the description of the SNA approach and the methodology applied to the case study (4.2), subsequent analysis of the results obtained in the case study and in-depth discussion of these results, incorporating key aspects of the literature review (4.3). Finally Chapter five present the conclusions of the Thesis in light of the objectives (general and specific) defined in the research plan with directions for future research in the area.

2. ADAPTIVE CO-MANAGEMENT TO FOREST FIRES

2.1 FORESTS AT RISK OF FIRE IN PORTUGAL

The reforestation of extensive deforested areas has occurred in many European countries in the last 200 years and Portugal, which in the early 19th century had less than 10% of its territory occupied by forests, is an example of an intense reforestation process occurring mainly after 1880 (Mather et al. 2006), as shown in the evolution of forest areas in **Figure 1**. During the 20th century, reforestation was the priority of the national forest policy in order to reverse the decreasing trend of forest areas in the country with the enactment of laws under the Forestry Regime to promote the reforestation of large areas, namely wasteland areas. In this perspective, the most expressive policy of the Forestry Regime was the Forest Stand Plan (1938), also known as "Plano dos Baldios", the main instrument adopted by the Portuguese State to encourage and support private owners to promote the reforestation of wasteland areas, namely with pine species (Mourato et al, 2020).

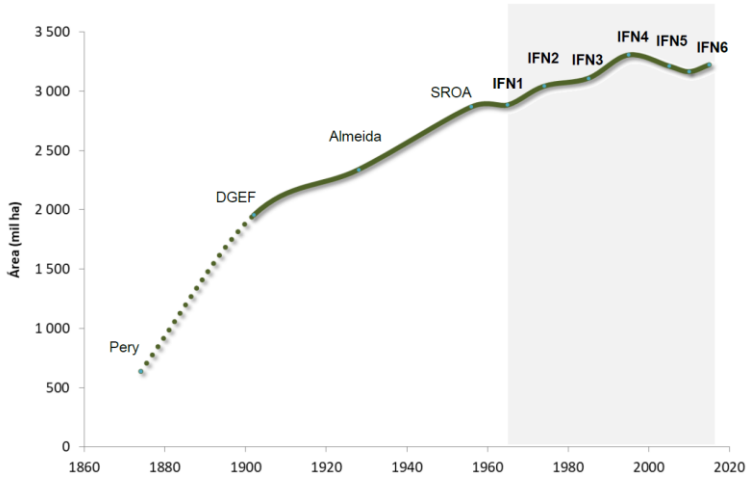


Figure 1. Evolution of the forested area in Portugal (ICNF, 2020)

After the 1950s, there was a new phase of expansion of forestry areas, strongly based on intensive monoculture eucalyptus plantations, promoted by private groups and supported by the state through financial instruments to encourage private forestation on wasteland with clearly economic objectives linked to the paper and cellulose industry. Later, in the context of the post-revolution of 1974, an intensification of eucalyptus monoculture took place, particularly during the 1980s with the Portuguese Forestry Project (which lasted until 1989) that recommended the forestation of around 150,000 hectares in private areas to supply wood for the industrial sector. As a result, eucalyptus plantations were expanded on a large scale, over extensive areas and at an intense rate for clearly productive purposes (Bento-Gonçalves, 2021). This intensification of eucalyptus monoculture continued over the following two decades, increasing more than half a million hectares of forested areas (Mather et al., 2006).

At the beginning of the 21st century, the Legal Regime for Arborisation and Reforestation Actions (Decree-Law No. 96/2013) was enacted in 2013, which became known as the "law liberalising the planting of eucalyptus", lifting the authorisation for afforestation of areas of less than two hectares. This

regulation was coupled with the new National Strategy for Forests (ENF), adopted in 2015, which envisaged an increase in the area of pine trees and the maintenance of eucalyptus areas, contrasting with the ENF of 2006 which, on the other hand, encouraged a decrease in both. Thus, from the 1950s onwards, the forestry policies promoted by the State were mainly aimed at encouraging reforestation by private initiative linked to the paper and cellulose industry, resulting in the intense expansion of eucalyptus forest areas in the country, as illustrated in **Figure 2**.

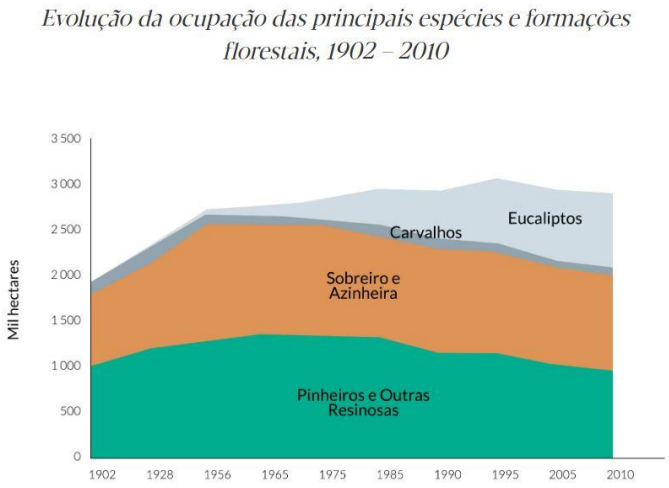


Figure 2. Evolution of occupation of the main forest species (Portugal.pt Platform)

As a consequence of the reforestation-oriented policies promoted by the State in land occupation in Portugal, data from the 6th National Forest Inventory (IFN6, 2019), developed by the Institute for Nature Conservation and Forests (ICNF), show that in 2015, forest areas represented the main land use in the country, occupying 36.2% of mainland Portugal. The decreasing trend in forest areas, which had been occurring since 1995, was reversed from 2015, with an increase of 59 thousand hectares of forests (1.9%) compared to 2010. The Land Use and Land Cover Chart (COS2018) of the General Directorate of Territory (DGT) pointed out that in 2018, forest areas in Portugal occupied 38.8% (3,460 thousand hectares). Also as the result of the intense process of expansion of eucalyptus monoculture to provide raw material for the paper and cellulose industry, data from the IFN6 (2019) also highlighted that in 2015, eucalyptus was one of the most expressive species in the country, occupying 26% of Portuguese forests, followed by cork oak and pine (22% each).

This analysis shows that the intense (re)forestation that occurred in Portugal was strongly focused on encouraging and supporting the intervention of private forest owners in extensive forest areas directly linked to the paper and cellulose industry, reinforcing and consolidating the central role of private initiative in the management of forest territories. As a result, information provided in the Forestry Report (RCM No. 13/2019) shows that, in relation to the distribution of the profile of forest owners, 84% are private owners, 14% community and only 2% public, placing Portugal as one of the countries in Europe with the highest percentage of private forests. In terms of private forest management, industrial owners manage only 8% of private forests and therefore most of them belong to non-industrial (i.e., singular) private owners. These data show a particular pattern in Portugal with a predominance of fragmented

private forests on small forest properties, hindering efficient forest management in economic terms and scale, and by the fact that many owners do not reside on site (Mather et al., 2006).

Another fundamental issue for understanding the (problematic) dynamics of the management of forest areas in Portugal refers to the gradual destructuring of forest territories. From the 1960s, with the Colonial War and, subsequently, with the industrialisation of the coast and intensification of rural emigration, there has been an intense depopulation of the country's interior and gradual abandonment of forestry properties, with a consequent reduction in human and economic resources that compromise the management of private forest areas (Mourato et al., 2020). Added to this trend of depopulation of rural areas, competitiveness in the international market with the stabilisation of wood prices for grinding that occurred from the 1980s generated severe impacts on the devaluation of forests with consequent reduction in the profitability of forest exploitation and limiting the capacity to attract and capture investments in forest assets.

Thus, the start of the 21st century is marked by a forest mass concentrated in small and fragmented forest properties with intensive monoculture of eucalyptus and pine, in a context of depopulation of rural areas and low profitability of forest exploitation, enhancing abandonment of forest assets, undermine proper forest management and increase the accumulation of fuels in rural properties (Bento-Gonçalves, 2021). This context, therefore, reinforces the existence of extensive areas classified as susceptible to wildfires (**Figure 3**), amplifying the risks and creating the conditions for the occurrence of huge forest fires which become increasingly larger, more destructive and more recurrent (Bento-Gonçalves, 2021).

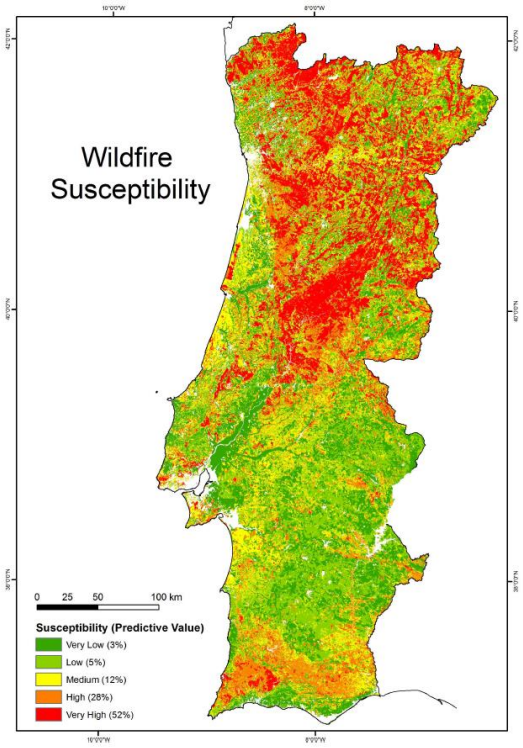


Figure 3. Wildfire susceptibility in Portugal (Verde e Zêzere, 2010)

The first forest fires of major expression in the continental territory were reported from the 1960s onwards, highlighting the event that occurred in 1975, which became known as the "hot summer", both for the revolutionary context and for the intensity of forest fires. Throughout the 1980s and, mainly, the 1990s, other forest fires of more expression occurred which resulted in a larger extension of burnt areas, as shown in **Figure 4** below. In 2003 occurs the first huge disaster with an unprecedented burned area, followed by a new phase of severe fires associated with extreme drought in 2005, placing the problem of forest fires on the political, social, economic and environmental agenda of the country. This severe fire event led to the promulgation of the National Forest Fire Defence Plan (PNDFCI - RCM No. 65/2006), coordinated by the extinct Agency for the Prevention of Forest Fires (AGIF), created in 2004. However, "*despite the new approaches and instruments adopted ... many objectives and targets to be achieved by the PNDFCI for 2006-2012 and 2012-2018 were not achieved, having privileged the strengthening of the combat device (land and air means), to the detriment of a strategy more focused on prevention*" (Mourato et al., 2020: 6).

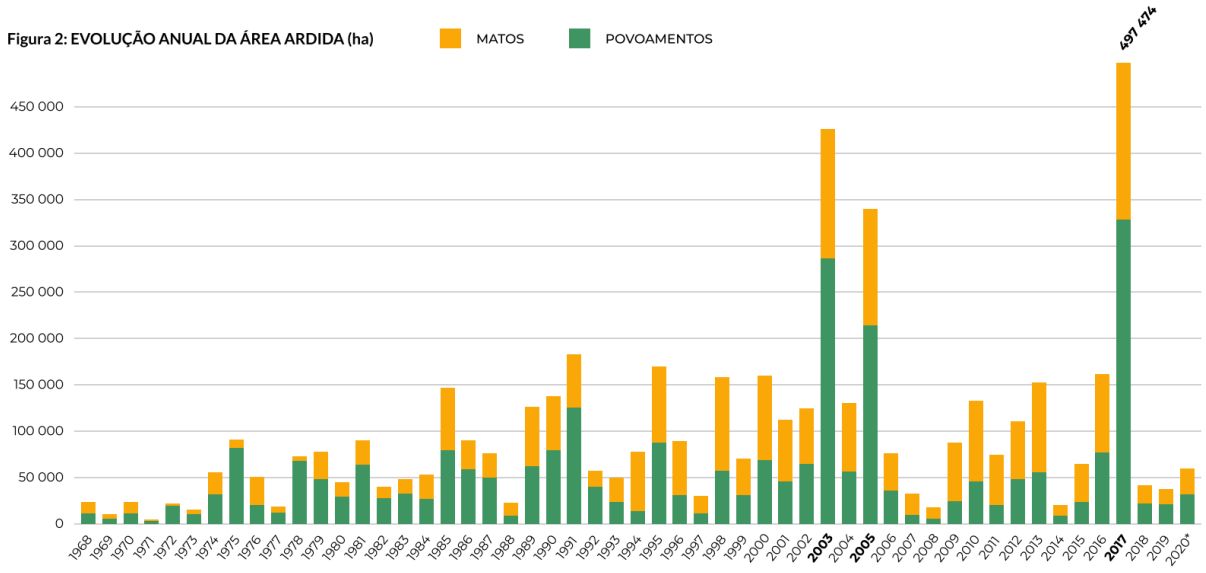


Figure 4. Annual evolution of burnt area in Portugal (ha) (Mourato et al., 2020)

In 2017, the worst forest fire reported in Portugal occurs and resulted in more than 100 fatalities, which represented a historical mark in the country and triggered a huge national commotion. This tragedy led the Government to create the Independent Technical Commission (CTI) to analyse the facts relating to the 2017 fires in order to carry out a critical analysis and review of the PDFCI from a logic focused on risk prevention. The CTI analysis pointed out that the main causes of the 2017 fires were related the accumulation of fuel in drought years, fragilities aggravated by heat waves and/or extreme weather events and, mainly, the existence of systemic failures in forest fire reduction related to the lack of integrated management of forest territories at risk of fires (CTI, 2017).

Based on the report developed by CTI, namely the need to promote an integrated management of forest systems focusing on the prevention of forest fires, the Agency for the Integrated Management of Rural Fires - AGIF is created in 2018 (Decree-Law no. 12/2018), attached to the presidency of the Council of Ministers. AGIF has the function of coordinating the three main entities competent for the management

of forest fires: the National Authority for Emergency and Civil Protection (ANEPC), the National Republican Guard (GNR) and the Institute for Nature Conservation and Forests (ICNF). Following this, based on the recommendations of the CTI and the Diagnosis Report and the measures for action to enhance forest territory and encourage active forest management (Order No. 5.838/2018), the National Plan for the Integrated Management of Rural Fires - PNGIFR (RCM 45-A/2020) is approved in 2020, aligned with the UN Sendai Framework for Disaster Risk Reduction 2015-2030, of which Portugal is a signatory.

This new legal and regulatory framework, which guides forest fire management strategies for 2020-2030, highlights the systemic risk of fire and, therefore, "cannot be resolved by adopting a single general, linear and sequential solution, but rather through a set of solutions that are intended to be articulated" (PNGIFR, 2020: 23). In this perspective, four strategic guidelines were defined: Enhance, Care, Modify and Manage, which due to their interdependence can generate positive reinforcement cycles among them (**Figure 5**). The PNGIFR also guides the restructuring of the Integrated Rural Fire Management System (SGIFR) aiming to facilitate the operationalisation of an integrated management of forest territories through networks of actors (entities) acting in an articulated and collaborative manner, under the coordination of AGIF, for the prevention and reduction of forest fire risks in Portugal.

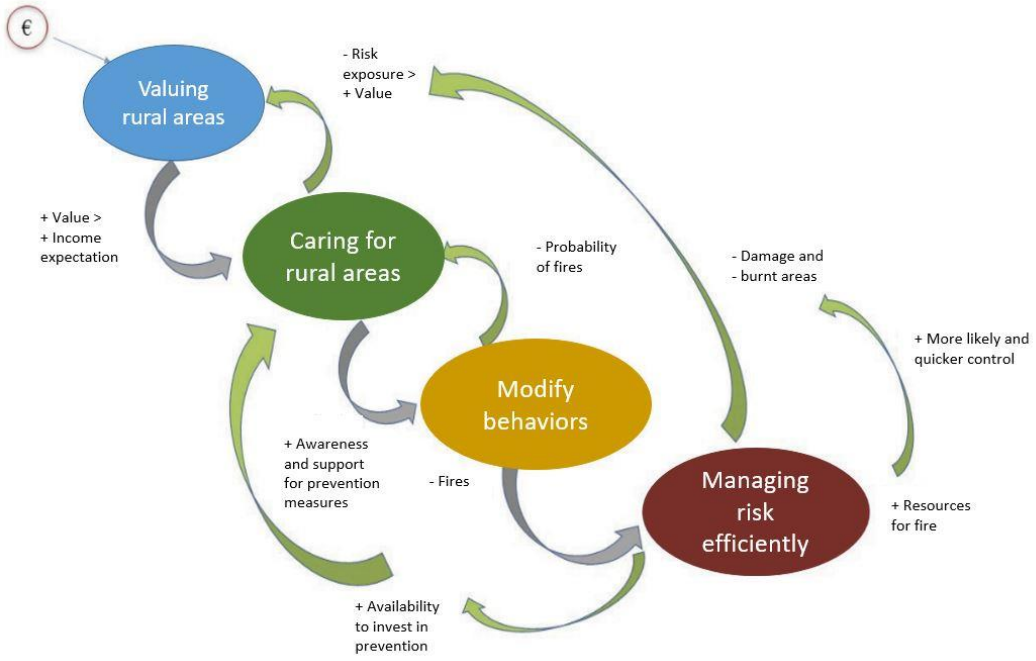


Figure 5. Strategic guidelines and reinforcement cycles for fire risk management (adapted from PNGIFR, 2020: 23)

As established in the regulation (Decree-Law No. 82/2021), the SGIFR aims to ensure the coordination and articulation of joint actions involving multiple entities, both at central and local level, with the assignment of the respective responsibilities along the process chain related to fire management (**Figure 6**). Thus, an integrated management model for forest territories is established to enhance and strengthen the articulation between all entities that are part of the System, territorially organised through

institutional articulation between multiple committees acting at municipal, regional, inter-municipal and national level. Through this integrated management based on networks of entities, SGIFR aims to: (i) promote better articulation, information exchange and collaboration between multiple entities involved, directly or indirectly, in forest management, (ii) (re)orientate the current forest planning and management instruments at all levels of public policies and programmes and, (iii) stablish instruments for monitoring and assessment to contribute to the continuous improvement of the PNGIFR and SGIFR processes.

Figure 6. Phases of the SGIFR Process Chain (translated from PNGIFR, 2021)

The SGIFR also highlights that the multiple entities that integrate the System have different visions and perceptions of the current risks, the main vulnerabilities and the most appropriate strategies to be adopted and, mainly, different competences and scopes of action, being necessary to involve a wide range of entities focused on forest fire prevention. Therefore, *Table 1. Summary of responsibilities of the SGIFR entities* provided in the PNGIFR (RCM nº 45-A/2020) and reproduced in **Annex 1**, various entities that need to be involved in the forest integrated management are listed, such as the Institute for Nature Conservation and Forests (ICNF), National Republican Guard (GNR), National Authority for Emergency and Civil Protection (ANEPC), Armed Forces, Local Governments, Fire Brigade, Forest Producers' Organisations (OPF), among others. These entities, based on their specific competences along the phases of the SGIFR process chain and under the coordination of AGIF, should act in networks in a coordinated, articulated and collaborative manner to facilitate and strengthen the integrated (and resilience) management of forest territories in fire risk areas.

2.2 ADAPTIVE CO-MANAGEMENT: LITERATURE REVIEW

Social-ecological systems (SES) involve a complex set of interactions between ecological (resources and ecosystems) and social (users and governance) systems that affect each other, influencing or being influenced by the related social, economic and political contexts and ecosystems (Ostrom, 2009; Binder et al., 2013). According to the framework proposed by Ostrom (2009), SES comprises 4 dimensions of interactions, in a multi-level analysis of specific social, economic and political (S) contexts, with the 1st level being the interactions between the ecological system (resource, ecosystems), the social system (users, governance) and their effects (outcomes), moving on to the analysis of 2nd, 3rd... level variables for a deeper understanding of SES dynamics (Ostrom 2007, 2009; Binder et al. 2013) - **Figure 7**.

Due to their complexity, SES have attributes that differentiate them from simple systems, including non-linearity, uncertainty, emergence, scale and self-organization (Berkes et al., 2003). In this logic, forest systems can be understood and analyzed as complex SES and, consequently, the occurrence of forest fire events resulting from a set of problematic and negative interactions existing between social and ecological systems that are manifested in the current risks and vulnerability to fires of forest territories in Portugal. Corroborating with this analysis, Fischer et al. (2016), who analysed the dynamics of SES in fire-prone forest areas in Oregon, USA, identified forest fires as "SES pathologies" because they result from complex and problematic interactions between social and ecological systems over time and difficult to resolve due to this complexity, non-linearity and uncertainties of forest systems management.

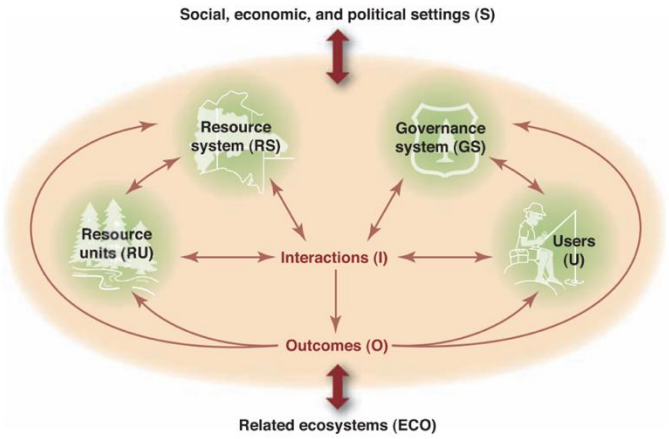


Figure 7. Framework for analysing social-ecological systems (Ostrom, 2009)

The concept of adaptive management appears initially in the book Adaptive Environmental Assessment and Management, by C.S. Holling (1978), known as the "father" of adaptive management, in a context of the 1970's in which the perception of the limits of natural resources gained notoriety. Thus, integrating environmental, social and economic issues into environmental management policies and strategies was pointed out as critical, highlighting the need to address prudent management in light of the excessive consumption of these resources. Adaptive management is thus an approach to natural resources management that emphasizes the importance of better understanding the dynamics of SES, strengthening the bridge between science and practice to promote social learning, and structuring management interventions and policies as experiments (e.g., "learning by doing"), guiding the necessary adjustments towards the resilience of complex systems (Holling, 1978).

Folke et al. (2005) analyse that, to enhance the capacity to deal with the uncertainty and unpredictability inherent to complex systems, it is essential to combine diverse knowledge systems in continuous and dynamic learning environments focused on experimentation, making use of disturbances as opportunities to learn, transform and promote adaptive SES towards sustainable trajectories (Berkes et al, 2003) - **Figure 8**. The strength of adaptive management thus focuses on recognising (rather than ignoring), the non-linearity and uncertainty of SESs, to extend flexibility to deal with an uncertain future in natural resource management through social learning and improve management over time (Fabricius & Currie, 2015). Armitage et al. (2009) indicate that this iterative process of co-learning and co-production of knowledge in adaptive management should involve managers, stakeholders and scientists

throughout the planning, implementation, monitoring and evaluation of decision outcomes (effects) in natural resource management.

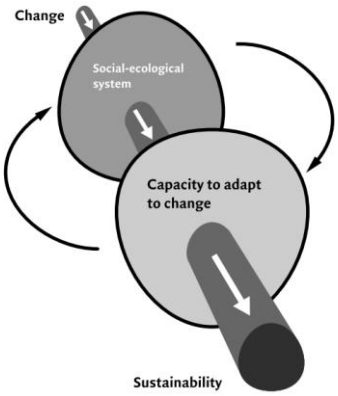


Figure 8. Sustainability as a dynamic process that requires adaptive capacity in SES (Berkes et al., 2003: 4)

In the late 1990s, the critical review of the adaptive management approach pointed to the representation and legitimacy of diverse interests, as well as the sharing of visions and negotiation among all stakeholders (Armitage et al. 2007) as the main challenge needed to be addressed in the adaptive management logic. This critical review lead to the rise of the collaborative management approach, i.e. co-management (Hasselman, 2017). Co-management approaches are based on promoting interaction spaces to facilitate dialogue and the sharing of visions, interests and tasks between the state and multiple public agencies, businesses and private actors, social organisations and communities of natural resource users (Carlsson & Berkes 2005), illustrated in **Figure 9**. A central aspect of co-management is to promote collaborative networks between local resource users, government and others stakeholders to enhance joint resolution and power and responsibility sharing in natural resource management (Berkes, 2009). It also emphasises interventions at the local scale, being context-specific and problem solving oriented, highlighting the importance of involving multiple resource managers with some power over the territory (institutional and community), leading to joint and decentralised decision-making processes (Hasselman, 2017) and oriented towards the transformation of the SES into more desired states (Folke et al., 2005).

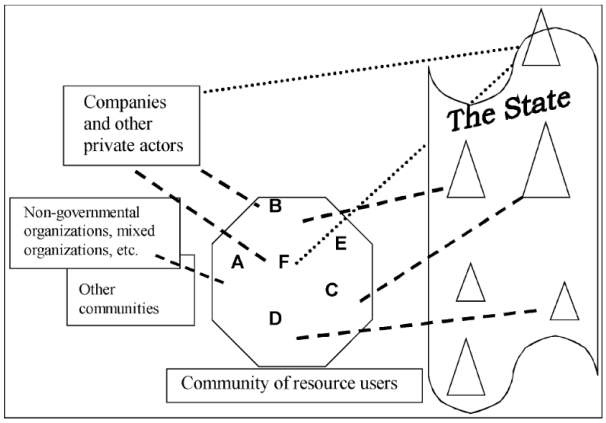


Figure 9. Example of the co-management approach (Carlsson & Berkes, 2005: 69)

As systematized by Armitage et al. (2007), the 21st century resource management approach has as a trend: (i) the understanding of change and uncertainty as inherent to social-ecological systems, (ii) the need to emphasize knowledge and social learning for adaptability, renewal and transformation and, (iii) broad participation in the design of strategies and actions to respond to change and guide more adaptive complex systems. Aligned with this perspective, adaptive co-management emerges as an approach to complex SES governance aiming to integrate social learning and experimentation (learning-by-doing) features of adaptive management and the linking (vertical and horizontal) and collaboration functions between actors of collaborative management (Plummer et al, 2012) and, thus, learning and collaboration represent key aspects of adaptive co-management (Armitage et al. 2009).

Fabricius & Currie (2015) point out that adaptive co-management refers to a process that allows stakeholders to share responsibilities, find common goals and trajectories, as also the interaction of diverse knowledge systems, social learning and learning from experimentation, making natural resource management more flexible to respond to complex systems. Adaptive co-management is thus a dynamic and continuous process of learning-by-doing (Folk et al., 2002) involving shared vision, dialogue and interactions between actors in territory management (Carlsson & Berkes, 2005), social learning and problem solving, leading to co-management-as-governance (Berkes, 2009). The main characteristics of adaptive co-management include (Armitage et al., 2007):

- Shared vision, purpose, and/or problem definition to provide a common focus among actors and interests
- Dialogue, interaction, and collaboration among actors
- Distributed control among multiple actors at multiple levels
- Commitment to knowledge generation and sharing
- Flexible, negotiated learning with an inherent recognition of uncertainty

In the adaptive co-management approach, the role of social networks has been highlighted as a key aspect that contributes to expand connections (structural and functional) between actors (Plummer et al., 2012), create dynamics and information flows, identify knowledge gaps and create skills that improve adaptive capacity in ecosystem management (Olsson et al., 2004). And further, actor networks make it possible to share different visions in the decision-making process (Baiard et al., 2016) and connect diverse knowledge and experience systems, broadening understanding about complex SES and helping guide adaptive strategies and practices (Armitage et al., 2007). Thus, the potential contributions related to strengthening networks of actors acting within a perspective of adaptive co-management include: promoting social learning about complex SES, expanding dynamic interactions between multiple actors (learning-by-doing) focused on problem solving, and fostering agreements towards co-responsibility and shared tasks in the management of natural resources and ecosystems.

3. SOCIAL NETWORK ANALYSIS (SNA)

3.1 SNA: CONCEPT

Society is structured in systems composed of a set of actors (individuals, groups and/or entities) and the existing ties between them (i.e., relationships, interactions), the social networks. The study of social networks focuses on analysing social systems based on the patterns of relationships between the actors that compose the system and their position within the network (Wasserman & Faust, 1994; Borgatti et al., 2018). Thus, the central analytical unit of the study of social networks is neither the whole 'system', nor individual 'parts', but rather the 'relationship between parts' (Stein et al., 2011), which define the network data to be analysed with the SNA method. SNA has been adopted as a method to identify the network structure of actors in social systems, their dynamics of interactions, connectivity, and the flows within the network (e.g., flows of information, knowledge, beliefs, and values), as well as the position that actors occupy in the network structure to identify their influencing and/or intermediation role among other actors (Borgatti et al., 2018).

> "*Social network analysis provides a precise way to define important social concepts, a theoretical alternative to the assumption of independent social actors, and a framework for testing theories about structured social relationships. The methods of network analysis provide explicit formal statements and measures of social structural properties that might otherwise be defined only in metaphorical terms.*" (Wasserman & Faust, 1994: 17)

For decades, SNA has been adopted in identifying and analysing the network structure and dynamics of social systems. Freeman (2004), in *The Development of Social Network Analysis*, highlighted two important lines of research that emerged in the early decades of the 20th century and led to the "birth" of modern SNA: (i) sociometrics, an approach developed by Jacob Moreno with support from Helen Hall Jennings between the 1930s/40s to analyse interpersonal relationships in groups of individuals, and (ii) the structural perspective developed by William Lloyd Warner and his students at Harvard University, beginning in the 1920s, based on ethnographic investigations to analyse the social structure and interactions between individuals in American industrial communities.

In 1934, Jacob Moreno published the study *Who Shall Survive? A New Approach to the Problem of Human Interrelations*, an empirically based structural investigation with the adoption of a quantitative method to analyse the organisation of social groups and the position of individuals within them, adopting for the first time the term Network to refer to the effects of the social network on individuals, beyond the relationship between two people and/or the immediate group. In that work, the Sociogram model is introduced, a graphic representation of social networks in which people (or any other social units) are represented as points in two-dimensional space, and the relationships between pairs of people are represented by lines connecting the corresponding points (i.e., a visual representation of social network with dots and lines) - **Figure 10**. Another important contribution of J. Moreno (1934) and H. Jennings to the study of social networks refers to Sociometrics, a structural analysis tool composed of a set of measures of social variables (metrics) to analyse interpersonal relationships in small social groups

based on the results and analysis of the sociogram. Two fundamental pillars of modern social network analysis then emerged (Wasserman & Faust, 1994): a visual expression of social group structure (sociogram, graph) and a probabilistic model of structural outcomes based on network indicators (sociometrics, metrics), which created the foundations of Graph Theory.

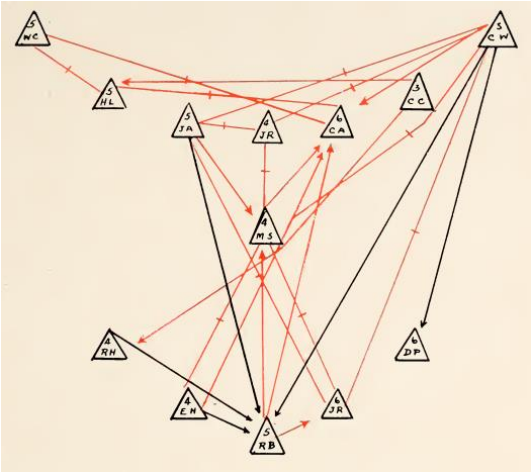


Figure 10. Sociogram of a football team (Moreno, 1934)

In parallel to the work of J. Moreno and H. Jennings, William Lloyd Warner and students at Harvard University contributed to the development of the structural perspective in social network studies through ethnographic-based investigations of the social structure and patterns of interactions between individuals in American industrial communities (interpersonal networks). Among the studies were *The Yankee City* (1929), which investigated the patterns of interactions between individuals in the industrial community in Newburyport, Massachusetts, and the *Deep South Project* (1933), which studied the impact of racial differences on social stratification and interactions between individuals in the community of Natchez, Mississippi. The ethnographic and structural-based research conducted at Harvard University, led by L. Warner, contributed significantly to grounding the characteristics of modern SNA through the development and application of a formal methodology for social network analysis. However, it did not advance the development of a conceptual model of the structural perspective in network studies and, thus, is little recognized in the historical review of SNA.

Between the 1940s and the 1970s, there was a period of little activity and advancement of social network centres, known as the Dark Ages of social network research (Freeman, 2004). However, although not significantly, there were a number of small efforts that kept the structural perspective alive, especially in the 1960s when the social scientist community began to recognize the wide range of empirical applications of the structural SNA approach and its potential use in social studies. Only in the 1970s did social network analysis gain prominence and notoriety in the scientific community again with the research carried out by Harrison Colyer White at Harvard University's Centre for Social Network Research. H. White and his students made a significant contribution by applying a formal methodology for social network research from the structural perspective, serving as a reference for the establishment of modern theory and research on social networks, helping to promote the recognition of SNA as a research field. As highlighted by Scott & Carrington (2011):

> *"Certainly the majority of the published work in the field has been produced by White and his former students. Once this generation started to produce, they published so much important theory and research focused on social networks that social scientists everywhere, regardless of their field, could no longer ignore the idea. By the end of the 1970s, then, social network analysis came to be universally recognized among social scientists"* (Scott & Carrington, 2011: 27).

The 1970s therefore represented a key turning point for the advancement and recognition of the social network approach as a promising field of research by social scientists and the scientific community in general. In this context, a more tightly integrated and interchangeable approach among several SNA schools began to occur, which culminated in several conferences and meetings in the area of social networks, most notably the 1st Conference of Social Network Researchers held at Dartmouth University in 1975. In parallel, another fact that contributed to boost research in social networks in the scientific community was the development of mathematical models and computer programs that represented fundamental technical contributions in the methodology and application of social network research, namely in the development of graphs and analysis of network metrics (Freeman, 2004; Scott & Carrington, 2011), pillars of Graph Theory. Finally, and still as a fundamental aspect for the establishment of SNA as a scientific field, it is important to highlight the founding of the International Network for Social Network Analysis (INSNA)[1] in 1977 and the creation of the newsletters Connections (1977) and Social Networks (1978). Such events broadened the intellectual and personal exchange and connectivity among various network analysts, contributing to boosting research in the field of SNA.

As a result of these events that boosted social network research, namely the development of theoretical and methodological bases of SNA, the advancement of mathematical and computational models (software), the interaction and exchange among social network researchers, and the wide recognition of the SNA method by the scientific community, there was an expressive increase in the number of studies with a social network approach between 1981 and 1999 (**Figure 11**). Since then, the SNA approach has spread across several fields of study, such as community studies, business, health, psychology, economics, sociology among others (Omondiagbe et al., 2017).

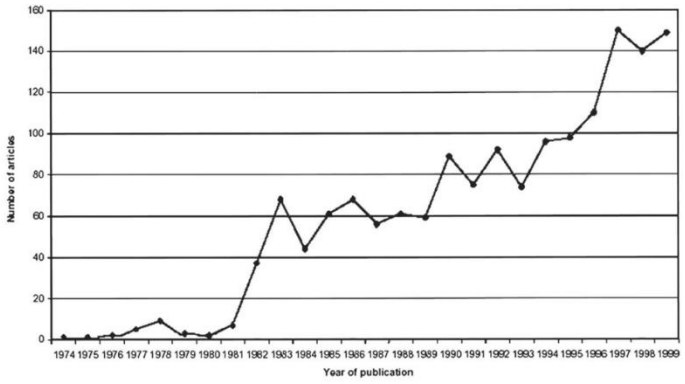


Figure 11. Number of social networks articles by year (Otte & Rousseau, 2002 in Freeman, 2004)

[1] International Network for Social Network Analysis - https://www.insna.org/

The evolution of the theoretical and methodological basis of social network research briefly presented above, therefore, has led to the establishment of four (4) fundamental aspects that represent the modern paradigm of SNA (Freeman, 2004): (1) a structural approach focused on the analysis of ties between actors (individuals, groups or entities), (2) strongly anchored in Graph Theory with the use of graphs (sociogram) and network analysis metrics (sociometrics), (3) grounded in empirical and probabilistic (quantitative) data, and (4) extensive use of mathematical and/or computational models (software).

3.2 GRAPH THEORY

Graph Theory in SNA focuses on the graphic representation of the patterns of interactions (structure) of the social network (sociogram) and a set of measures of social variables (metrics, sociometrics) to identify the dynamics and flows of the network, as well as the position and role of actors within the network. The analysis is fundamentally based on relational network data (i.e., ties between actors), of a quantitative and probabilistic nature, and analysed using mathematical and computational models, such as the UCINET software (Borgatti et al., 2002).

There are several types of ties possible to be investigated in the structural perspective of SNA, as systematized by Borgatti et al. (2018) in the taxonomy of types of relations (**Table 1**). Among the relational data of the network, it is possible to analyse the relationships between the actors (similarities, relational roles or relational cognition), commonly adopted in community, ethnographic or health and psychology studies, or the patterns of interactions between the actors (e.g., talked to, collaborates with etc.) and respective flows within the network (e.g., information, knowledge, values etc.). This analysis focus on interactions/flows between actors currently adopted in governance systems and/or natural resource and ecosystem management studies (Groce et al., 2018).

Table 1. Taxonomy of types of relations (Borgatti et al, 2018)

Relational states	Similarities	Location	Same spatial and temporal space
		Participation	Same clubs, same events
		Attribute	Same gender, same attribute
	Relational roles	Kinship	Mother of, sibling of
		Other role	Friends of, boss of, student of
	Relational cognition	Affective	Likes, hates
		Perceptual	Knows, knows of, sees as happy
Relational events		Interactions	Sold to, talked to, helped, collaborates with
		Flows	Information, knowledge, believes, attitudes

According to definitions of Graph Theory applied in SNA, in the graphic representation of social networks (sociogram) the nodes represent the network actors (individuals, groups or entities) and the lines represent the ties between them (relationships, interactions). If there is a line (tie) between two nodes, they are said to be reachable by a path, where the Geodesic Path is the shortest path length between two nodes and the Geodesic Distance is their length (Hanneman & Riddle, 2005; Robins, 2015). When a node does not establish any kind of interaction with other node(s) in the network (absence of ties), the node is identified as isolated and if a given node interacts with a single actor, it is called a pendant.

Graphs can represent two distinct types of actors´ networks: Indirected Networks or Directed Networks. Indirected Network is commonly adopted to analyse social networks focusing on reciprocal ties between

actors (symmetric, no directionality), e.g. kinship relationships (A is the mother of B, and therefore B is the son of A). The Directed Network focuses on the analysis of non-reciprocal ties between actors in the network (asymmetric) and thus interactions have directionality (arrows), e.g. information sharing (A shares with B, but B does not share with A). In the Directed Network, the flows of interactions can be of two types: unidirectional (e.g., E→F) or bidirectional (e.g., B←→J). **Figure 12** illustrates a model of a graph of Directed Network (with directionality of interaction and flows) and Valued Network (with weights of interactions, such as intensity or frequency), also highlighting the main elements that are part of the graph theory perspective of SNA.

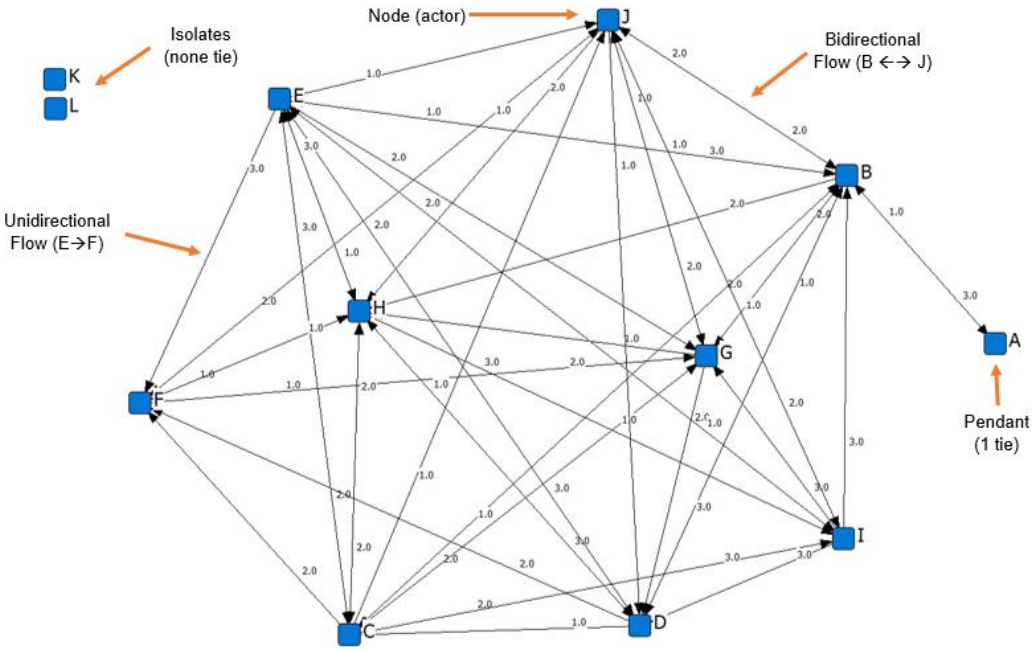


Figure 12. Basic elements of the Directed and Valued Network (author)

Currently there are several metrics for social network analysis (sociometry) to identify the structure and dynamics of the network, to analyse its density, connectivity, degree of centralisation and, the position and role of the actors in terms of their influence and/or importance in the connection between actors or subgroups (components) of the network. For the purposes of this study, which aims to analyse the structure and dynamics of the actors' network in the management of forest territories for fire prevention, five (5) SNA metrics commonly adopted in studies of actors' networks in natural resource management (Groce et al., 2018) were selected and applied: (1) Density, (2) Network Centralisation Degree, (3) Reachability, (4) Node Degree and, (5) Betweenness Centrality. **Table 2** presents the network metrics adopted in this research with a brief descriptive based on Wasserman & Faust (1994), Hanneman & Riddle (2005), Scott & Carrington (2011) and Borgatti et al. (2018).

Table 2. SNA metrics adopted in the study (author).

SNA Measures	Description
Density	Proportion of ties in a network that are actually present (vs all potential ties that could exist); the extent to which all individual actors are linked together

SNA Measures	Description
Network Centralisation Degree	Measures the extent to which one actor in a network is holding all the ties of that network; low values indicate a more even distribution of ties among all the nodes, suggesting a more cohesive (interconnected) network
Reachability	The total number of steps required to disseminate a specific information within the network by the shortest paths, i.e. the speed with which a specific node can reach all other nodes in the network.
Node Centrality Degree	Number of immediate contacts an actor has in a network, regardless of tie direction. Measures an actor's level of involvement or activity in the network. Use of directed ties can give measures of in-degree (number of ties received by an actor from others, suggesting prestige or importance) and out-degree (number of ties given by the actor to others, suggesting influence).
Betweenness Centrality	Calculates how many times an actor (A) sits on the shortest path between other pairs of actors; actor A is thus in a position of connecting the other actors.

Density (1) is the proportion of possible ties that actually exist in the network. This metric is calculated by the ratio between the number of existing interactions in the network and the total number of possible interactions multiplied by 100, ranging between 0 (0%), indicating a centralised network, and 1 (100%), representing a distributed network, also called cohesive network (Bodin, 2017). This indicator allows the analysis of the existing social activity in the network (Robins, 2015), the level of connectivity (Tabassum et al., 2018) and the potential dissemination of information within the network (Hanneman & Riddle, 2005). Density (D) is calculated as follows:

$$Density\ (D) = \frac{\text{Existing relationships (ER)}}{\text{Possible relationships (PR)}}\, x\ 100,$$

where the total number of possible interactions (PR) can be calculated as

$$Possible\ relationships\ (PR) = \text{Total number of nodes (TNN)}\ x\ (\text{TNN} - 1)$$

The Degree of Network Centralisation (2) is a metric adopted to assess to what extent the dynamics of interactions and flows existing in the network are dominated by a single node. In this way, it is possible to understand, for example, when an actor plays a central role in the network, while other actors must first interact with the central actor in order to connect with others (Velazquez & Norman, 2005). The Degree of Network Centralisation can be calculated in the UCINET software in the Network > Centrality > Degree function and the result can range from 0.000 (0%) in distributed networks to 1.000 (100%) in centralised networks.

There is an inverse proportional relationship between Network Density and Degree of Centralisation, i.e. the higher the centralisation of the network the lower its density, and vice-versa. As illustrated in **Figure 13**, the network on the left presents a centralized structure with a density of 0.2 (20%), resulting from the ratio between 4 existing ties of the total 20 possible ties, and a degree of centralization of 75,000 (75%), where node A clearly exerts the role of centrality in the network (i.e., interactions between nodes B, C, D and E must pass through node A). On the other hand, the network on the right presents

a distributed structure with a density of 1 (100%), as all 20 possible ties effectively occur in the network, and a degree of centralisation 0.000 (0%), where there is no node playing a centrality role in the network (i.e., all nodes interact with each other).

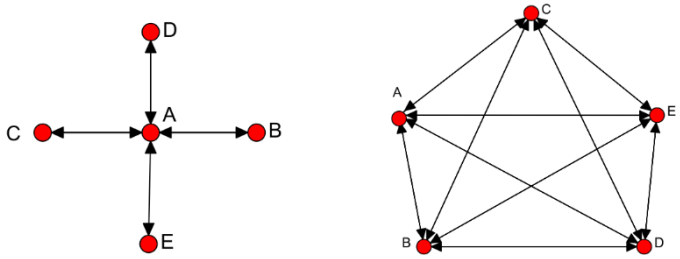


Figure 13. Centralized (left) and distributed (right) networks (Velázquez & Norman, 2005).

Reachability (3) of a network is a metric adopted to evaluate the average length of the shortest paths (geodesic paths) from a given node to reach all other nodes in the network, and can be calculated in UCINET in the function Network > Dyadic measures > Reachability. A node is said to be "reachable" by another node if there is a set of paths through which we can follow from the source to the target node, regardless of the number of nodes that lie between them (Hanneman & Riddle, 2005; Scott & Carrington, 2011). Accessibility allows us to identify how quickly a given actor can reach all the other actors in the network (Tabassum et al., 2018), indicating the total number of steps required to disseminate information within the network (Ramia et al., 2018).

Node Centrality allows the evaluation of the position and role of a given node within the network. Several metrics have been proposed in SNA studies to analyse the centrality of network actors. In this research two metrics developed by Freeman (1979) were selected, recognized by the scientific community and commonly adopted to evaluate node centrality in the network: Node Degree and Node Betweenness. Both metrics are available in the UCINET software and can be calculated through the functions Network > Centrality > Degree and Network > Centrality > Freeman Betweenness > Node Betweenness, respectively.

The Node Degree (4) is a metric that allows identifying the total number of ties of a given node with the other nodes of the network, that is, the number of actors to which a given actor is directly linked and thus establishes interactions within the network. It is an important metric that allows assessing the centrality of specific actors who occupy a strategic position within the network (Wasserman & Faust, 1994), exploring their role of influence, popularity and/or prestige (Scott & Carrington, 2011) or even, in a sociological perspective, it can indicate the actors with greater control, autonomy and/or power in the network (Borgatti et al., 2018). The Node Degree can be assessed both from the point of view of outgoing interactions (OutDegree) and incoming interactions (InDegree) of an actor in the network, as described below:

OutDegree - indicates the total number of outgoing interactions of the actor, i.e., the total number of interactions that a given actor has with the other actors in the network. Actors with high values of outbound interactions exercise a role of influence, power and/or expansiveness with the other actors within the network;

InDegree - indicates the total number of input interactions of the actor, that is, the total number of interactions that the other actors in the network have with a given actor. Actors with high values of entrance interactions exercise a role of support, prestige and/or popularity with the other actors in the network.

Node Betweenness (5) is a metric that allows identifying the intermediation role of a node between pairs of nodes in the network, indicating how often this intermediary node is positioned in the shortest paths (geodesic) in the interactions between the other nodes (Borgatti et al., 2018). Actors that are located among many others occupy a strategic position of intermediation between the interactions of the other actors in the network, connecting disconnected segments and playing a brokerage role in the network (Stein et al., 2011). Thus, actors identified with high Node Betweenness are "vital" elements in network connectivity and information diffusion, on the other hand, they possess power to control, filter and/or alter information and knowledge flows within the network (Agneessens et al., 2017).

The Node Betweenness metric also makes it possible to identify the paths with the highest concentration of flows between nodes within the network. This metric consists in identifying the lines with higher volume of flows within the network, thus indicating which interactions between actors are more central in the network dynamics (Hanneman & Riddle, 2005). The lines with "highest traffic" of flows within the network are called "Bridges" and represent connectors in the flows and the link between subgroups in the network (Tabassum et al., 2018). The actors located at the ends of the bridges are identified as Gatekeepers and have the power to control the bridge flows between various regions within the network (Hanneman & Riddle, 2005; Vélazquez & Norma, 2005). In **Figure 14**, the interaction between the actors G and F represents a bridge and concentrates greater volume of flows within the network, connecting the right subgroup (A, B, C, D, E and F) to the left subgroup (G, H, I and J) and thus, the actors G and F are the gatekeepers.

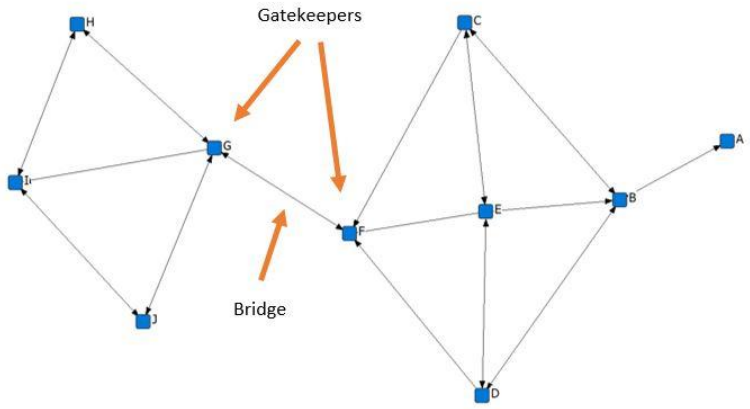


Figure 14. Betweenness centrality in a directed network – bridges and gatekeepers (author).

In addition to network metrics, it is possible to collect and analyse values (weights) of interactions between actors. Adding value scales for the existing interactions within the network is important, because an analysis of directed networks indicates only the existence or absence of interactions between pairs of actors, without considering the magnitude (weight) of each interaction (Wasserman & Faust, 1994). A directed valued network are composed of three sets of information: the nodes (actors)

and the lines (interactions), both existing in the directed network, adding also values attached to the lines (e.g., strengths or frequencies). As indicated in **Figure 15**, in the graph representation of directed valued networks, the value of interaction is indicated near the sending node (e.g., node E has an interaction of weight 3 with node F, and this value is indicated near to node E). Resulting from the analysis of values of interactions (weights), it is possible to categorize the existing interactions in the network as being strong interactions (high values) or weak interactions (low values) (Robins, 2015).

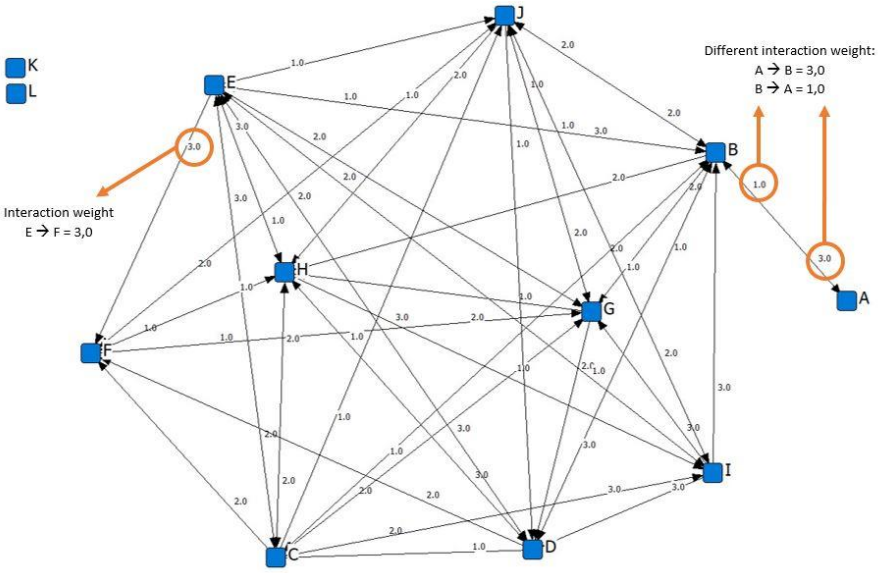


Figure 15. Model of a Valued Directed Network (author).

This section therefore presented the principal components for a graph analysis (sociogram) of a Directed Valued Network in the SNA Graph Theory approach. This five metrics (sociometrics) were adopted to identify patterns of interactions (the structure) of the Monchique actor network in the management of forest territories focusing on the reduction of forest fires (case study). In addition to the network structure, such metrics, including values (weights) of the interactions between actors, make it possible to identify and analyse the dynamics and flows existing within the network from the analysis of network density and connectivity (Density / Reachability), the degree of network centralization (Network centralization) the position of centrality of actors within the network and its potential role of influence, prestige and/or power within the network (Node Degree) or that occupy a position of mediation and articulation between the other actors (Node Betweenness) and, finally, the interactions between pairs of actors that concentrate the largest flows of the network, the "bridges" (Edge Betweenness).

3.3 SNA IN NATURAL RESOURCES MANAGEMENT (NRM): CASE STUDIES REVIEW

As presented above, since the 1970s, the SNA approach was established as a field of research in the social sciences and gained notoriety and supporters in the scientific community in general. As a reflection, it was found that the number of studies that incorporated a social network approach has grown exponentially from the 1980s/90s (Otte & Rousseau, 2002 in Freeman, 2004) in various areas of research, such as studies on community structures, social movements, crime and terrorism, cultural

networks, and scientific among other areas (Scott & Carrington, 2011). Groce et al. (2018) analysed a total of 85 studies that used SNA in the context of natural resource conservation and management published between 1992 and 2017, and found that 86% of them were published during or after 2010 (**Figure 16**), highlighting that the SNA approach represents a recent and promising field of research in the field of natural resource and ecosystem management (NRM) research.

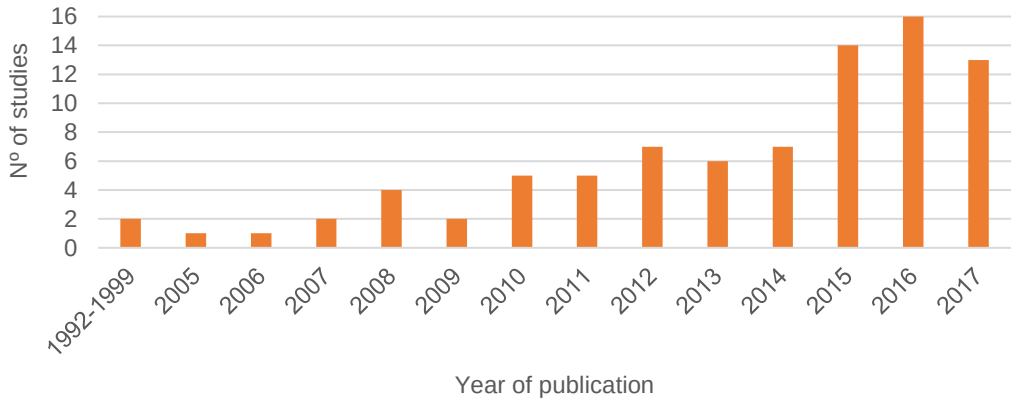


Figure 16. Evolution of NRM studies with a SNA approach (based on Groce et al. 2018)

Also, according to Groce et al. (2018), within a total of 85 studies in the field of natural resource and ecosystem management with an SNA approach published between 1992-2017, 54 studies (64% of the total) aimed to identify and analyse the social processes existing within the actor network, namely information and/or knowledge flows, social influence of actors, learning and collaboration in NRM. Among these, the majority (47 studies) focused on developing a descriptive analysis of the structure of the actor network in a given spatio-temporal context (i.e, a portrait of the social network) and its interrelation with the social processes within the network (highlighted in orange in **Figure 17**). Nowadays, few studies have advanced with an analysis of the social and environmental effects (outcomes) associated with the structure and dynamics of the actors' network, which is only possible from the temporal analysis of the network or comparative analyses between different networks. This is still a future perspective for investigations within the scope of SNA in NRM.

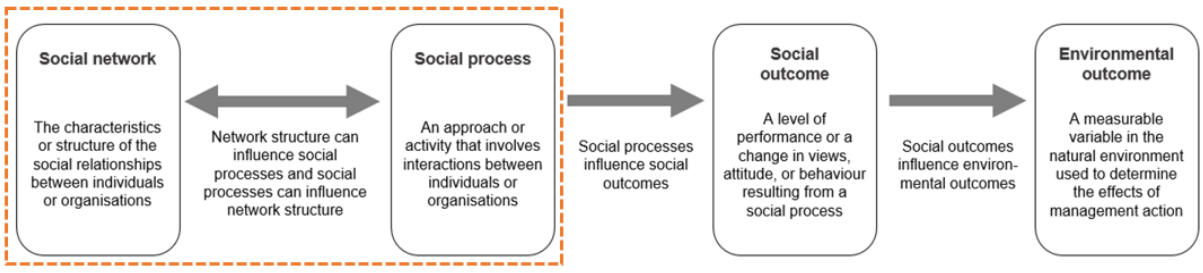


Figure 17. Conceptual diagram linking social networks, processes and outcomes (adapted from Groce et al. 2018)

Table 3. Selected case studies of SNA in NRM between 2009-2022 with focus on adaptive co-management (author)

Author(s)	Year	Network location	SNA application (brief description)
Ball et al.	2022	Hampshire, England	Analysis of the network characteristics, actors and their roles and, identify interventions to improve an integrated and adaptive governance of the River Test and River Itchen
Aubin et al.	2019	Thau lagoon, France	Analysis of the role and influence of local authorities to enhance adaptive capacity to climate change of the Local Water Management Plan
Tuda et al.	2019	Kenya and Tanzania, Africa	Analysis of the collaborative network of the marine governance systems in southern Kenya and northern Tanzania for adaptive marine transboundary conservation governance
Omondiagbe et al.	2017	Waiheke Island, New Zealand	Analysis of the structure of the actors´ network and how this structure could contribute to collaboration and collective action for the sustainable management of invasive species on Waiheke Island
Ogada et al.	2017	Lake Naivasha, Kenya	Analysis of the structure of the actors' network based on the multiple interests, influences and interactions in the management of Lake Naivasha
Fischer et al.	2016	Oregon, United States	Analysis of interactions between networks of forest restoration and protection organizations with a focus on the capacity to address wildfire risks in fire-prone areas in Oregon
Fliervoet et al.	2016	Waal River, Netherlands	Analysis of the collaborative networks among multiple actors at different levels in floodplain management and explores the consequences of removing the central actors from the network
Mannetti et al.	2015	Kalahari, South Africa	Analysis of the social structure of the ≠Khomani Bushmen community with a focus on traditional knowledge sharing and collective action for adaptive co-management of local natural resources
Cárcamo et al.	2014	Coastal Islands, Chile	Analysis of the governance network focusing on collaboration, knowledge exchange and, learning between actors for adaptive co-management of coastal ecosystem governance network in northern Chile
Cohen et al.	2012	Solomon Islands, Oceania	Analysis of the governance network focusing on collaboration, knowledge exchange and, learning between organisations for adaptive co-management of Solomon Islands coastal ecosystems
Stein et al.	2011	Mkindo Catchment, Tanzania	Analysis of the collaborative networks among actors that directly or indirectly influence water flows in the Mkindo Catchment to enhance problem-solving capacity and adaptive water resource management
Prell et al.	2009	Peak District, United Kingdom	Analysis of the role and influence of stakeholders in the management of the Peak District National Park to guide strategies to increase participation in decision-making processes and promote collective action

Table 3 presents a brief description of 12 case studies published between 2009 and 2022 which adopted an SNA approach to develop a descriptive analysis of the network structure of actors in a specific spatio-temporal context (i.e. single network) and its relation to social processes (flows, learning, social influence and collaboration) focused on collaborative management (co-management), adaptive management or adaptive co-management of natural resources/ecosystems. Stein et al. (2011) point out that descriptive analysis of network structure at a given point in time provides a 'static' view of the network, however, although it is recognised that networks change over time, the patterns of interaction between actors - the network structure - will not easily change. Thus, such studies have developed an analysis of actors' network structure to understand structural problems and identify opportunities to improve collaborative networks and increase problem-solving and adaptive capacity in NRM, stressing that it´s more promising and efficient to build strategies on existing social network structure than to impose new structural and institutional arrangements (Omondiagbe et al., 2017).

To identify the structure and flows within the network aiming to facilitate social learning and collaboration in the NRM actor network, both aspects of adaptive co-management, a key focus of the studies was on the analysis of network density (i.e., the number of existing interactions between actors relative to the total number of possible interactions). Studies have indicated that cohesive networks (with high density of interactions), particularly with a predominance of strong interactions between actors (e.g., high intensity and/or frequency of interactions), contribute to the sharing of common visions (Prell et al., 2009) and to broadening the flow of information and knowledge within the network (Stein et al., 2011; Ball et al., 2022), facilitating social learning and adaptive governance (Tuda et al., 2019).

Networks with a high density of interactions also facilitate communication between different actors (Fliervoet et al., 2016), mutual understanding and consensus (Cohen et al., 2012), the establishment of common agreements and norms between actors (Fischer et al., 2016) and the strengthening of mutual trust (Mannetti et al., 2015; Omondiagbe et al., 2017), thus, contributing to promote collaboration and capacity for collective actions (Cárcamo et al., 2014; Ogada et al., 2017). Fischer et al. (2016), who analysed the interactions between distinct networks of forest restoration and forest fire protection organisations, both in joint actions (a. works with) and information sharing (b. info from), highlighted that networks with a high density structure of interactions represent an opportunity to promote cooperation in solving complex and larger scale problems associated with landscape management in the context of forest fire risks (**Figure 18**).

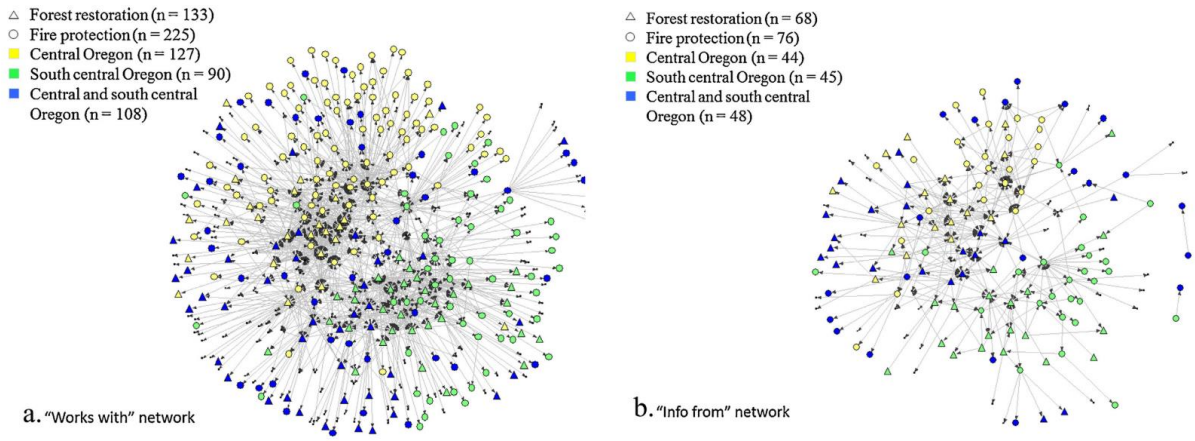


Figure 18. Organizations (nodes) and interactions between them (lines) (Fischer et al., 2016: 22)

On the other hand, studies have identified that cohesive actor network structures (i.e. high density of interactions between actors) tend to be less innovative in the long run given the potential homogenization of ideas and information within the network (Prell et al, 2009), limiting knowledge diversity by the absence of interactions with different views (Ogada et al., 2017) and, thus, reducing the potential for innovation in adaptive co-management (Mannetti et al., 2015; Fliervoet et al., 2016; Omondiagbe et al., 2017). In this perspective, Prell et al. (2009) and Ogada et al. (2017) identified that new ideas and information tend to flow through interactions with actors that are less connected (peripheral) or have weak ties within the network (i.e. low intensity and/or frequency of interactions), which can contribute to creating more adaptive and resilient networks, although such weak ties may represent low trust and be more easily "broken" within the network.

Another central aspect in the analysis of the actors' network in NRM approached in the studies refers to the position of centrality that specific actors occupy within the network and its implications for the role played by these central actors in the dynamics and flows existing within the governance network. Prell et al. (2009) identified that actors in a position of centrality in the network played a more active role in the dynamics and flows of information and communication, while other actors occupied peripheral positions (marginalized) with a less active role. Corroborating with this finding, Ogada et al. (2017) found that actors with influence in the network are (i) in a central position in the network (high InDegree), (ii) connect to the other central actors in the network and, (iii) are located in the intermediation of actors that have weak interactions with each other (high node betweenness), as also analysed by Aubin et al. (2019) and illustrated in **Figure 19**.

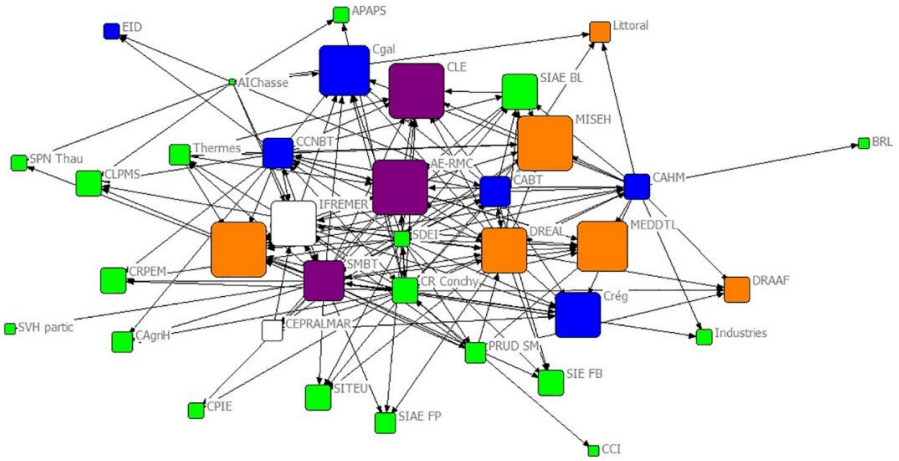


Figure 19. Representation of central actors in the Thau basin network (Aubin et al. 2019: 2019)

However, the studies identified negative aspects for adaptive co-management related to network structures centralised in specific actors. As a first point, it was identified that actors in strategic positions within the network (i.e., position of centrality and/or intermediation between other actors) can control, filter and/or change information and knowledge flows (Aubin et al., 2019), as well as control interactions and connectivity between actors (Cárcamo et al., 2014) and, thus, have more influence and control over the network (Ogada et al., 2017). Another negative aspect of centralized networks is related to the high number of interactions that central actors have within the network and, therefore, may feel divided and tend to centralize on specific groups of actors, positioning themselves in possible contexts of disputes of interests and conflicts between actors (Prell et al., 2009), negatively influencing decision-making processes in natural resource management (Omondiagbe et al., 2017).

Finally, the studies highlighted that, although in the initial phase of adaptive co-management the central actors play an important role in linking unconnected actors/groups, centralised networks can hinder the planning and solutions of complex long-term problems that require a more decentralised structure (Prell et al., 2009) to enable a greater flow of information and knowledge within the network and strengthen mutual trust, collaboration between actors and collective action, positive aspects of cohesive networks (high density). In this perspective, Fliervoet et al. (2016) and Ball et al. (2022) who analysed the centrality role of state actors in NRM and their influence in decision-making as a result of their regulatory functions, indicate the importance of guiding strategies to give more authority to local actors, strengthening a more collaborative governance model. Such model recognizes other partners (beyond government actors) to promote knowledge and responsibility sharing among actors, expand network flexibility and create learning environments for adaptive co-management of natural resources and ecosystems.

Table 4 presents a synthesis of the main aspects of actor networks and their potential effects (positive or negative) on NRM, and which resulted from the analysis of the set of case studies adopted as reference for this research.

Table 4. Network aspects - advantages and disadvantages for natural resource management (author).

Network aspects	Effects on NRM
Density (Cohesive networks)	(+) Facilitate the flow of information and knowledge, communication, and collaboration among actors (Stein et al., 2011; Mannetti et al., 2015: Ball et al., 2022) (+) Promote communication and collective action, knowledge transfer, creation of common norms, and develop trust and mutual understanding (Fischer et al., 2016) (+) Promote communication, mutual trust, and conflict management, facilitating collaboration and collective actions (Fliervoet et al., 2016) (+) Promote trust between the actors (Mannetti et al., 2015; Omondiagbe et al., 2017) (+) Contribute to increasing the capacity for collective actions (Cárcamo et al., 2014) (-) Tend to homogenize ideas and knowledge, reducing the innovation potential for adaptive co-management (Mannetti et al., 2015; Fliervoet et al., 2016; Omondiagbe et al., 2017) (-) May limit knowledge diversity by the lack of different views (Ogada et al., 2017)
Central actors (Centralized networks)	(+) May facilitate coordination, knowledge dissemination and strengthen collaborations to drive collective action in the early stage (Prell et al, 2009; Omondiagbe et al, 2017) (+) Can help boost trust among previously unconnected actors, promote knowledge sharing, and drive collective actions (Cárcamo et al., 2014) (+) Have a brokerage role in the network, bridging disconnected segments within the network (Stein et al., 2011; Omondiagbe et al., 2017) and different scales (Cohen et al., 2012) (+) May have access to diversity of ideas and valuable information (Ogada et al., 2017) and tend to have a more holistic view of the problem (Prell et al., 2009) (+) May access new information and provide the opportunity to generate new knowledge needed to solve complex problems (Fischer et al., 2016) (-) May control, filter or change flows of information / knowledge (Aubin et al., 2019) and/or control interactions and connectivity (Cárcamo et al., 2014; Ogada et al., 2017) (-) Hamper long-term planning and problem solving (Prell et al., 2009), limiting collective action (Ball et al., 2022) and flows within the network in the long term (Ogada et al., 2017) (-) May feel divided between groups within the network and tend to position themselves in the context of disputed interests and conflicts between actors/groups (Prell et al., 2009) (-) Hamper a common definition of the problem and can negatively influence the decision making process (Mannetti et al., 2015)
Strong ties	(+) Facilitate the sharing of common visions, mutual support and trust and an effective communication for complex information and tasks (Prell et al., 2009) (+) Facilitate knowledge sharing, consensus and collective action (Cohen et al., 2012) (+) Facilitate social learning and contribute to adaptive governance (Tuda et al., 2019) (-) Tend to be less innovative and less exposed to new ideas, with homogenization of knowledge and information (Prell et al., 2009)
Weak ties	(+) New ideas tend to flow through weak ties (diversity of views and informations), helping to create a more resilient and adaptive network (Prell et al., 2009) (-) May reflect little trust between actors and can be easily "broken" (Prell et al., 2009) (-) Restricts collaboration and joint actions on complex tasks (Ogada et al., 2017)

Bodin (2017), in his study on collaborative networks in natural resource management, identified and analysed three different actors' network structures, which is an important contribution to the scientific

literature of the SNA approach in NRM. As illustrated in **Figure 20**, three different network structures were analysed by Bodin (2017): (a) Cohesive collaborative networks, characterised by a higher density of collaborative ties between actors, contributing to strengthen trust, collective action and the diffusion of information and knowledge among actors, however it presents a tendency of network homogenisation in the long term; (b) Centralised collaborative networks that are characterised by the existence of coordination ties, facilitating task coordination activities, articulation of quick responses in periods of crisis and access to resources external to the network, however with potential control of the dynamics and flows within the network by specific actors (central, influential) and; (c) Segmented collaborative networks, which present a structure composed of various sub-groups within the network connected through specific actors (intermediaries), contributing to promote innovation due to the heterogeneity of visions, perspectives and knowledge of various sub-groups, but which may limit trust and the diffusion of information within the network.

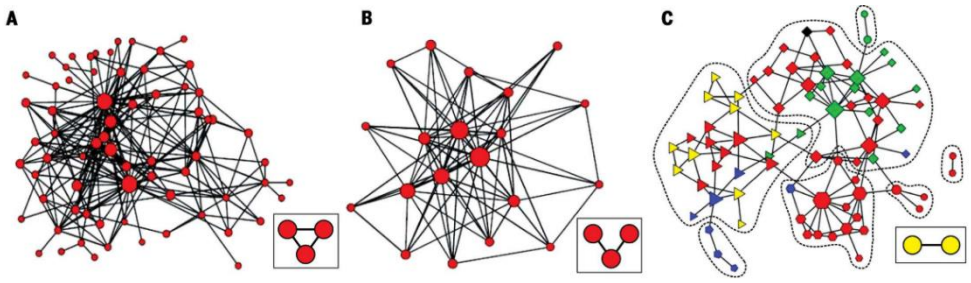


Figure 20. Different structural characteristics of collaborative networks – (a) cohesive networks, (b) centralized networks and, (c) segmented networks (Bodin, 2017: 2)

As a result of the literature review of the case studies with a SNA approach to identify and analyse the actors' network structure in NRM, together with the typology of collaborative networks identified by Bodin (2017), it is noted that each actor network structure (cohesive, centralised or segmented) has specific characteristics with positive or negative effects for an adaptive co-management of natural resources and ecosystems (including the forest territories). Newman & Dale (2005), in the study *Network Structure, Diversity, and Proactive Resilience Building*, analyse the importance of the dynamic balance between collaboration ties (cohesive networks) and coordination ties (centralized networks) to promote adaptive capacity and resilience. In this perspective, balancing different collaborative network structures can contribute to more efficient adaptive management of natural resources and ecosystems, however, "*how much of each type of tie is needed, and what an optimal ratio of bonding and bridging ties might be needed, also needs further investigation*" (Bodin & Crona, 2009).

4. SNA CONTRIBUTIONS TO ADAPTIVE CO-MANAGEMENT TO FOREST FIRES

4.1 SERRA DE MONCHIQUE: CASE STUDY

The municipality of Monchique is located in the southern region of Portugal, in the Algarve region, and is divided into three parishes: Parish of Monchique (centre), Parish of Marmelete (west) and Parish of

Alferce (east). According to data from the Land Use and Land Cover Map - COS2018 (DGT), Monchique has a territorial area of 39,530 ha and the main land uses refer to forests covering a total area of 25,983 ha (65.7%) and bush areas with 10,367 ha (26.2%) and therefore, when added together, forests and bushes occupy an area of 36,350.9 ha, representing around 92% of the territory of Monchique (**Figure 21**). Of the total area covered by forests, eucalyptus represents the main species with an area of 17,800 ha (68.5% of the forested area), followed by the cork oak with 6,833 ha (26.3%). Despite this significant area with eucalyptus occupation, data reveals a considerable reduction in the number of profitability forestry production units (75%), with profitable units decreasing from 98 in 2009 to 56 in 2019. These data reveal a decline in profitability associated with the market and external economic drivers with effects on the production costs and reduction of local productive capacity, increasing abandonment of forested areas.

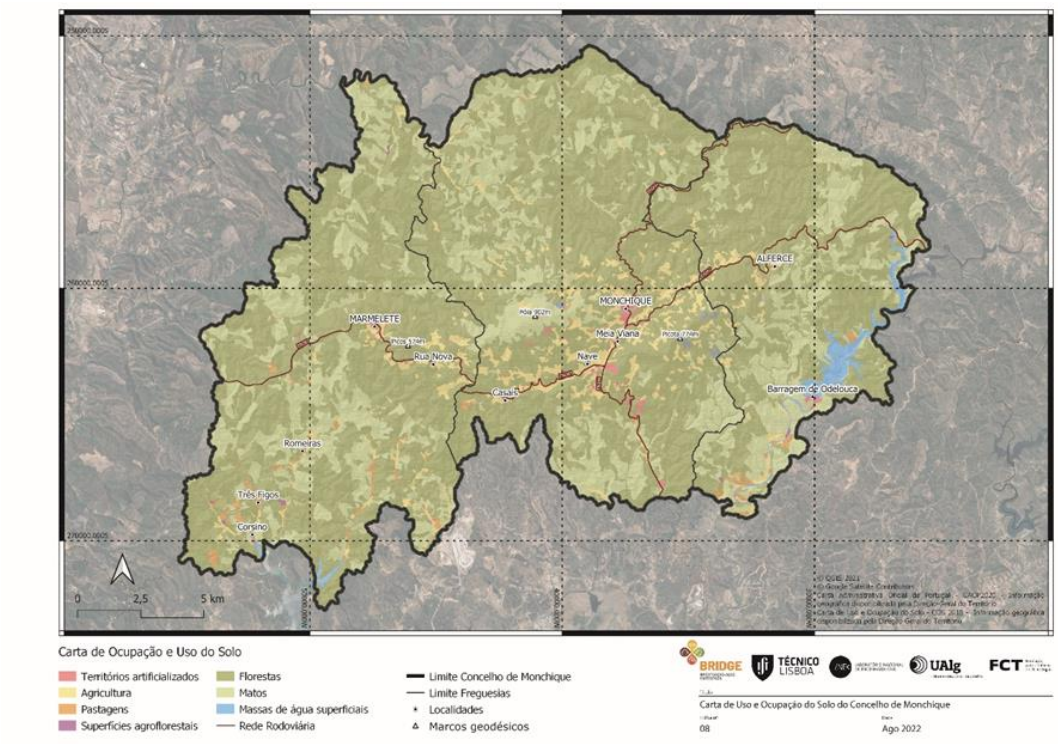


Figure 21. Land use and land cover (LULC) of Monchique Municipality, 2018 (BRIDGE Project)

Regarding the population dynamics in Monchique, the analysis of historical data from the Census (INE) reveals a depopulation trend occurring since the 1960s, with a significant decrease in total population from 14,779 in 1960 to 9,609 inhabitants in 1981 (-34.9%), maintaining this trend over the Census of 2001 (6,974) and 2011 (6,045), reaching a total population of 5,462 in 2021 (-63% compared to 1960). Consequently, the Demographic Density in the municipality also showed a significant drop from 37.3 hab./km2 in 1960 to 13.8 hab./km2 in 2021, a reduction of 63%. Another population aspect that results from the intense depopulation process in Monchique is the ageing trend of the population, where a gradual increase in the Ageing Index occurred from 266.1 in 2001, to 360.8 in 2011 and, finally, 336.2 in 2021, representing an increase of 26.3% from 2001-2021 in the ageing index.

These features highlight conditions amenable to forest fires in Monchique. The predominance of forest occupation in extensive areas of the municipality, mainly by intensive monoculture of eucalyptus, within a context of depopulation and gradual aging of the rural population and small, fragmented, forest properties with low profitability in forest exploitation, all reinforce the abandonment of forest assets and compromise the adequate management of forests (Bento-Gonçalves, 2021). This context is common to several territories in the Portugal, reflecting a historical (and problematic) process of evolution of forest systems with increasing risks and vulnerabilities to forest fires, as analysed in detail in sub-item 2.1.

Added to this context, Monchique has specific meteorology and vegetation characteristics, combining strong winds, low relative humidity and fine fuel in vegetation formations prone to rapid and intense fires (eucalyptus) that clearly favour severe fire (ITO, 2019). As events a result, data from the Municipal Forest Fire Defence Plan of Monchique (PMDFCI, 2012) highlights extensive rural areas classified as of "very high" risk of forest fires (areas in red in **Figure 22**) and therefore Monchique was classified by the Institute for Nature Conservation and Forests (ICNF), as a priority intervention area for Forest Fire Defence (DFCI, 2021).

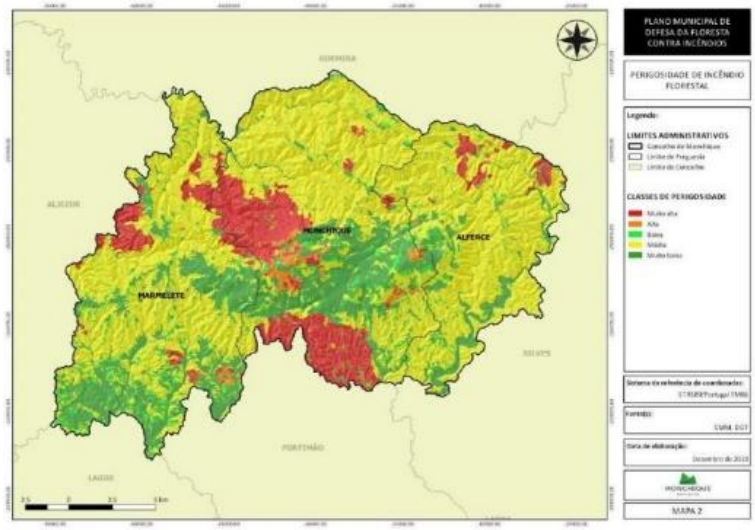


Figure 22. Forest fire risk map of Monchique (OTIS, 2019 in PMDFCI)

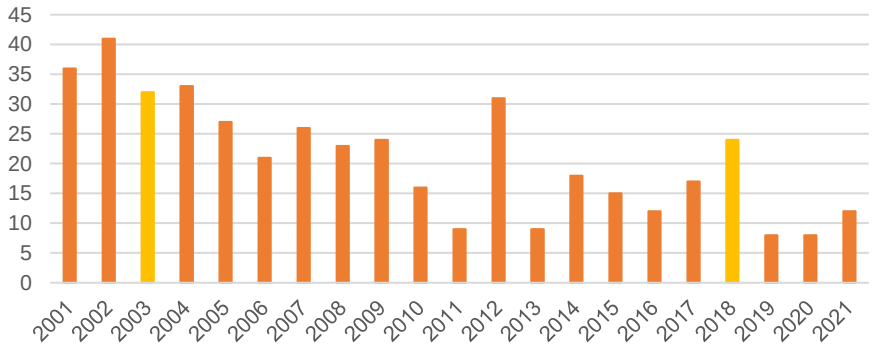


Figure 23. Registered fire events in Monchique between 2001-2021 (ICNF)

Figure 23 presents the forest fires in Monchique in the last two decades (2001-2021), noting that the events occur annually, although with periods of higher intensity and severity. From the cross-referencing

of the number of fire hotspots and the burnt area, the years 2003 and 2018 stand out, which, although registering a smaller number of fire hotspots compared to other years in the period, resulted in extensive burnt areas of 32,699 ha and 26,803 ha, respectively. In particular, the 2018 forest fire, the most recent and severe in the region, burned an extensive portion of the Monchique territory and, although it did not cause fatalities, caused incalculable damage to environmental heritage, local landowners and infrastructure in the region, according to the assessment of the Independent Technical Observatory in the Monchique Fire Assessment Report (OTI, 2019). Given the above, the Serra de Monchique was selected as a relevant case study for this research, but it is worth noting that the outcome of this SNA approach of the actors' network in forest management in Monchique will contribute, as well as can be replicated, in other forest territories susceptible to fire risks in Portugal.

4.2 SNA: METHOD APPLIED TO THE CASE STUDY

4.2.1. Boundaries of the actors' network

The SNA method to analyse the actors' network in the integrated management of forest territories in the Serra de Monchique adopted a whole-network approach that focuses on the collection of relational data, i.e. data from the 'relationship between parts' (Stein et al, 2011), which is quantitative in nature, to enable identifying and understanding the patterns of interactions (e.g., collaboration) between the actors that make up the system (network structure), as well as position (centrality) and the role of actors within the network (Wasserman & Faust, 1994; Borgatti et al., 2018). To analyse information and knowledge flows, the Direct Networks model was adopted as an SNA methodological option to analyse the non-reciprocal ties between network actors (asymmetric) and, thus, interactions present a directionality (arrows). Also as an option of the SNA method, values (weights) of the interactions between network actors were collected and analysed based on the Likert scale ranging from 1 (low), 2 (medium) or 3 (high) interaction, considering the lack of interaction as value "0". The direct valued network adopted in the research, therefore, is composed of three sets of information: the nodes (actors) and the lines (interactions), both existing in the direct network, adding values attached to the lines (i.e., strength and/or frequency), allowing to analyse the magnitude of the interactions (Wasserman & Faust, 1994), as well as to categorize the interactions within the network as being strong (high values) or weak (low values) (Robins, 2015).

For an SNA approach focusing on the analysis of the whole network, it is necessary to start by establishing the boundary of the network to be analysed based on the definition of the actors that compose the network and what should be considered as the interactions between the actors, i.e., which actors and which interactions should be included in the relational dataset, and which should be left out (Stein et al., 2011). Based on the objective of this research aiming to identify and analyse the actors' network for the adaptive co-management to fire risks in forest territories in the Serra de Monchique, the network boundary established is the set of actors with responsibilities and competences to intervene, directly or indirectly, in the management of forest territories. The interactions to be analysed focused on

two key aspects identified from the adaptive co-management literature review: the collaboration and the information sharing between actors within the network (Armitage et al. 2009).

Based on the legal and regulatory framework for forest management in place in Portugal, namely the National Plan for Integrated Management of Rural Fires (PNGIFR), all the actors (entities) that form part of the Integrated Management System for Rural Fires (SGIFR) were included given their specific competences to act in articulated and collaborative networks to strengthen the integrated management of forest territories in fire risk areas. Table 1. Summary of responsibilities of the SGIFR entities indicated in the PNGIFR (reproduced in **Annex A**) sets out the entities involved in this integrated forest management model and therefore considered for setting the network boundaries: AGIF, ICNF, GNR, ANEPC, Armed Forces, Fire Brigade, local governments, Forest Producers' Organisations (OPF), among others.

In addition to the entities defined by the PNGIFR to integrate the SGIFR, for this study it was decided to include in the actors network other four relevant entities in the context of the management of the forest territories of Monchique: (1) Associação Monchique Alerta, formed by local landowners affected by the severe forest fire of 2018, and (2) Nossa Terra Associação Ambiental, both entities representing local landowners in the municipality, as well as (3) the Centro de Estudos Florestais, linked to the ISA - Instituto Superior de Agronomia, of the University of Lisbon and (4) the non-governmental organisation GEOTA - Grupo de Estudos de Ordenamento do Território e Ambiente, both entities of local reference by promoting projects on the topic of forest fire risks in Monchique. As a result, 29 entities were identified (**Table 5**) as included in the network of actors (entities) analysed in this research. **Annex B** presents a detailed table of the entities incorporated into the social network analysis.

Table 5. Network of entities acting in the management of forest territories in Monchique (author)

	Entities	**SNA ID***
#1	Agência para a Gestão Integrada de Fogos Rurais	AGIF
#2	Instituto da Conservação da Natureza e das Florestas / Direção Regional do Algarve	ICNF
#3	Autoridade Nacional de Emergência e Proteção Civil / Comando Regional do Algarve	ANEPC
#4	Guarda Nacional Republicana / Posto Territorial de Monchique	GNR
#5	Estado-Maior-General das Forças Armadas	FFAA
#6	Instituto Português do Mar e da Atmosfera / Divisão de Previsão Meteorológica e Vigilância	IPMA
#7	Direção Geral do Território	DGT
#8	Comissão de Coordenação e Desenvolvimento Regional do Algarve	CCDR
#9	Comunidade Intermunicipal do Algarve	AMAL
#10	Direção Geral de Agricultura e Desenvolvimento Rural	DGADR
#11	Direção Regional de Agricultura e Pescas do Algarve	DRAPA
#12	Câmara Municipal de Monchique	CMMO
#13	Junta de Freguesia de Monchique	JFMO
#14	Junta de Freguesia de Alferce	JFAL
#15	Junta de Freguesia de Marmelete	JFME
#16	Associação dos Bombeiros Voluntários de Monchique	ABVM
#17	Associação dos Produtores Florestais do Barlavento Algarvio	ASPAF

	Entities	SNA ID*
#18	Cooperativa Agrícola do Concelho de Monchique	COOPM
#19	Agrupamento de Empresas Florestais	AFOC
#20	Associação da Indústria Papeleira	CELPA
#21	The Navigator Company	NAVCO
#22	Altri Florestal	ALTRIF
#23	Eglon-Timbers	EGLON
#24	E-Redes Distribuição	EREDES
#25	Rede Elétrica Nacional	REN
#26	Associação Monchique Alerta	ASSMA
#27	Nossa Terra Associação Ambiental	NTAA
#28	Instituto Superior de Agronomia / Centro de Estudos Florestais	ISA
#29	Grupo de Estudos de Ordenamento do Território e Ambiente	GEOTA

* Acronyms adopted in the SNA in this research, not necessarily representing the official ones.

The PNGIFR also highlights, in addition to the Forest Producers' Organisations (FPOs), the involvement of individual forest owners in the integrated management of forests focusing on fire risk reduction, considering that in Portugal forests are predominantly private and therefore landowners have the responsibility and competence to act directly over their own forest areas. In the perspective of adaptive co-management to forest fire risks, the involvement of forest owners is justified by the fact that it is essential to recognize and value local knowledge and experiences and to promote an active and collaborative role of these important actors who intervene directly in forest territories (Carlsson & Berkes, 2005; Armitage et al., 2007; Berkes, 2009; Hasselman, 2017). Thus, in addition to the analysis of interactions between SGIFR entities, the actor network analysis in this research aimed to map and engage Monchique's forest owners to identify the interactions of these relevant local actors with SGIFR entities and assess how they are (or not) connected in the management network of forest territories with potential contribution to fire risk reduction.

Official databases were consulted (e.g., INE, Pordata, DGT etc.) and contacts were made directly with representatives of the Monchique City Council to obtain information on the number of forest owners in the municipality in order to involve them in the research universe; however, there was no return given the unavailability of this information. Another approach was to identify the number of landowners in Monchique, considering that 65.7% of the municipality's territory is forest (COS2018) and thus assuming that the majority of landowners have private management of forest fragments on their properties. However, again, it was not possible to obtain this type of information, and only the number of rural properties was made available, which does not necessarily represent the number of landowners, as there are landowners with ownership of two or more rural properties.

The only information obtained refers to the number of 226 rural producers in Monchique, available in the Agricultural Census 2019 (INE). Thus, the research considered this universe in the analysis of the actors' network, which, although it may not accurately represent the number of forest owners, provided a closest reference to the total number of landowners in Monchique. This universe of 226 rural producers was therefore adopted in the research as those who own, for the most part, forest fragments under their

private management, as well as to denominate these local actors as landowners of Monchique in this case study.

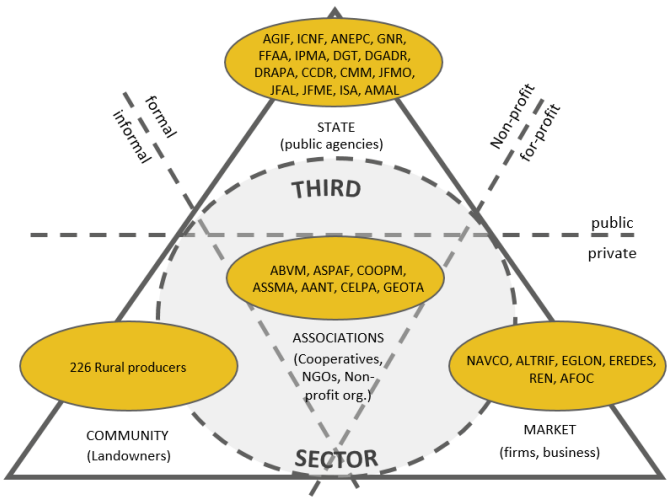


Figure 24. Category of the actors´network in Monchique (adapted from Avelino & Wittmayer, 2016: 634)

Finally, to facilitate the comprehension of the network of actors in the management of forest territories established for the case study (network boundaries), **Figure 24** above presents a systematization of the various actors (entities and landowners) based on the 4 categories of stakeholders proposed by Avelino & Wittmayer (2016): State (public agencies) with 14 entities, Associations (NGOs, (Cooperatives, non-profit organizations) with 10 entities, Market (companies, businesses) with 5 entities and Community composed of 226 landowners.

4.2.2. Data collection - survey

The survey with the actors of the integrated management network of forest territories in Monchique (entities and landowners) was developed with the application of online questionnaires between 01 May and 30 June 2022. The surveys were disseminated to the SGIFR entities through contacts (telephone and email) with representatives of the entities. The communication with landowners was carried out during local meetings and activities under the BRIDGE project and through contacts with local entities, namely Monchique Municipal Council and the social organisations representing this group (e.g. Aspaflobal, Coopachique, Monchique Alerta etc.), which contributed to the wide local publicising of the survey. Two survey questionnaire models were designed, one model being applied to the set of SGIFR entities and the other model directed at landowners (**Annex C**).

The survey applied to representatives of the 29 entities mapped and incorporated into the actors' network adopted as a "closed list" approach to the entities in the network (Ogada et al., 2017), i.e. a list of all the entities was presented in the questionnaire, asking the respondent to indicate which entities on the list it interacts with in forest management for fire risk reduction. Although a closed list of entities was presented, an "other entities" field was provided at the end of the questionnaire enabling the respondent to add other entities that might be relevant to the study from the perspective of snowball

sampling. If more than two respondents mention an entity that was not part of the original list, it is included in the network (Cárcamo et al., 2014; Fliervoet et al., 2016; Omondiagbe et al., 2017). The rationale behind this approach is that respondents should be able to define the boundaries of the network, but a threshold (the entity has to be mentioned more than twice) should be set to maintain a "manageable" network size and avoid the inclusion of irrelevant entities (Stein et al., 2011). Thus, as there were no indications of new entities in the network by at least two respondents, it was assumed that the original list included the most relevant entities in the network.

Since the focus of the research was to analyse the network of actors at the local level in the management of forest territories in Monchique, the survey attempted to involve representatives of entities at the regional and national levels of the SGIFR that operate as locally as possible in Monchique. For example, the response from GNR (national) was obtained from the Monchique Territorial Command (local) or, in the absence of local representation, a regional respondent was involved, such as ANEPC (national), which participated in the survey through the Algarve Regional Command for Emergency and Civil Protection (regional). This strategy aimed to collect data from the (more) local network of actors in forest management in the case study and thus attempt to analyse more closely the structure and dynamics of interactions of the network of SGIFR entities within the context of the Municipal Commissions for Integrated Management of Rural Fires which are not yet defined and effectively active.

The survey with entities aimed to collect information on the entity and, mainly, of the collaborative interactions and information sharing between the SGIFR entities for the management of forest territories focusing on fire risk reduction. To this end, the questionnaire was structured into two blocks of questions. The first block was designed to obtain information on the characterization of the entity: Name of the organization, Name and position of the respondent, Category (Public Sector, Third Sector, Private Sector or others), Scale of intervention (National, Regional, Sub-regional / Intermunicipal or Local) and in which phases the entity has competence to act in the forest fire management. Therefore, four options of phases were presented based on the chain of processes of the SGIFR:

- Planning guidelines and strategies for integrated forest fire management
- Forest fire prevention through the implementation of projects and actions
- Fire suppression and/or rescue during forest fire events
- Post-event and recovery of areas burned by forest fires

In the second part, focused on collecting data on the interactions between the entities of the SGIFR network, a closed list was presented with the name of the 29 entities followed by the question: "Which entities do you have interactions with, such as information sharing and/or joint actions on the issue of forest fires?". Based on the Likert Scale, four options of values were made available for response, being: 0 - no interaction, 1 - low interaction, 2 - medium interaction and 3 - high interaction. As previously mentioned, at the end of the closed list, a field with the option "Other entities" was made available, enabling the respondent to indicate eventual entities with which he/she has interactions and which were not considered in the list. The respondents did not indicate other entities to be included in the network

and, thus, it was assumed that the original list included the most relevant entities for the analysis of the SGIFR network.

The survey with landowners in Monchique was aimed at collecting data on their collaborative and/or sharing interactions with the entities that are part of the SGIFR in order to (i) identify how landowners are (or are not) connected to the network of entities and, (ii) assess the potential integration of the vision, local knowledge and practices of these important local actors into the flows within the network to contribute to an adaptive co-management of forest territories to fire risks. For this, the questionnaire with landowners was structured in two blocks of questions. In the first part of the questionnaire information was collected to enable a characterisation of the profile of the rural landowner respondent, such as: Name, Address (Municipality and Parish), Gender, Age, Nationality, Location and current uses of the property(ies) and whether he/she is a member of any local entity (associations and/or cooperatives).

In the second part of the questionnaire, questions were asked to collect data on the interactions of landowners with the entities of the SGIFR. Similarly, the list with the names of the 29 entities was presented with the question: "Which entities do you have interactions, such as sharing information and/or joint actions, on the issue of forest fires?". However, differently from the questionnaire with the entities, the landowners had two options to answer: 0 - does not interact or 1 - interacts. This strategy was adopted based on two aspects: (i) to make the questionnaire accessible, facilitating the interpretation and response by all landowners, considering that there are elderly landowners and/or landowners with low education and, (ii) in the expected result of the survey with landowners, the evaluation of values (weights) of the interactions with the entities did not justify incorporating a Likert Scale, but only if there are interactions or not (binary). At the end of the list of entities, a field with "Other entities" was made available, enabling the respondent to indicate possible entities with which he/she has interactions and that were not considered in the initial list, however the landowners also did not indicate other entities to be included in the network.

Also in the survey with landowners, a question was included asking to indicate up to five names of other landowners in Monchique with whom he/she usually interacts in the reduction of forest fire risks in order to deepen an analysis in the perspective of self-management of forest territories. However, it was not possible to advance with this analysis because the indications of names were not sufficient (i.e. incomplete names, abbreviations and/or indications of landowners from other municipalities) and the whole-network approach did not reveal to be adequate, being necessary an ego-network approach for this purpose. Thus, a self-management analysis of the forest territories stood as a future research perspective, as presented further on in Chapter 5. Concluding remarks and conclusions.

4.2.3. Analysis of the survey results

The survey results containing the respondents' profile information and the data of the existing interactions among the actors within the network (entities and landowners) were systematized in Excel spreadsheets and incorporated to the network interactions matrixes (**Annex D**) in the UCINET software

(Borgatti et al., 2002) for further elaboration of the network graphs (sociogram) and interpretation of the network structure. The graphs followed a Directed Valued Network model, as indicated in the methodology, and also incorporated specific data of actors' attributes (multi-attribute graphs), namely the Category (State, Third sector, Market or Community) and the scale of intervention (National, Regional, Local or Owners). The set of characterization data collected were used to contribute to the interpretation of the matrices and graphs and to support the analysis of the results of the actors' network.

Based on graphs prepared using the actors' interaction matrixes with the use of UCINET software, five network metrics defined for this investigation were applied, as previously presented in Chapter 3. (Social Network Analysis (SNA)), specifically in sub-item 3.2. (Graph Theory). The network metrics defined and applied were: (1) Density, (2) Network Centralization Degree, (3) Reachability, (4) Node Degree, and (5) Betweenness Centrality. For the interactions between the entities of the SGIFR it was incorporated in the metrics analysis the values (weights) of the interactions, ranging from 1 (low interaction) to 3 (high interaction).

From the interpretation of the multi-attribute graphs based on a Directed Valued Network model coupled with the results obtained with the application of the network metrics, the identification and analysis of the patterns of interactions, the structure and dynamics of the actors' network, as well as the flows and the position of the actors within the network, was developed. To facilitate a better reading and understanding of the SNA results, the next chapter (Results and discussion) was structured in three sections: initially the results of the analysis of the interactions between entities of the SGIFR network are presented, then the results of the landowners interactions with the network of entities and, finally, an analysis and discussion of the actors network (entities and landowners) focusing on the main aspects of the current structure and dynamics of the SGIFR network and its potential effects (positive and negative) for the adaptive co-management to fires in forest territories in Monchique.

4.3 RESULTS AND DISCUSSION

4..3.1. Network of SGIFR Entities

The survey applied with the 29 entities that are part of the SGIFR obtained 100% responses, i.e. all entities contacted responded to the questionnaire. The analysis of the information on the profile of the entities indicated that most of them belong to the public sector, representing 16 entities (55.2%), 7 entities are in the Third Sector (24.1%) and other 6 entities are from the private sector (20.7%), namely companies related to the paper and cellulose industry. Regarding the scale of operation, 17 entities (58.6%) have a national scale, while other entities are equally distributed on a regional scale (including inter-municipal) and local scale, with 6 entities for each scale (20.7% each). Thus, it is observed that the profile of the entities is mostly constituted by government entities at national level (**Figure 25**), including the Integrated Management Agency for Rural Fires - AGIF, the entity responsible for articulating and coordinating the SGIFR network in forest fire management.

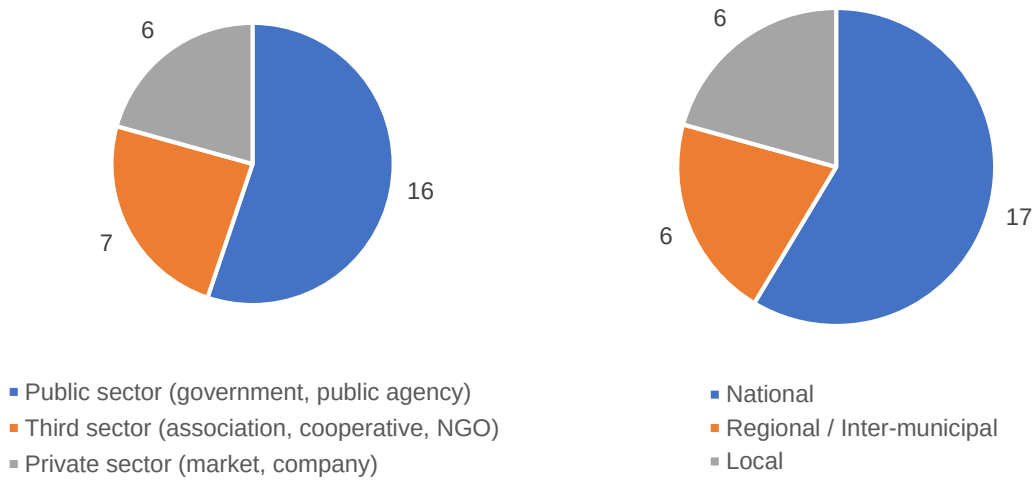


Figure 25. Category (left) and scale (right) of the entities in the network (author)

In terms of the competence to act along the SGIFR process chain for integrated forest fire management (**Figure 26**), 19 entities (65.5%) declared their involvement in planning actions for strategies for risk reduction, with 5 entities mentioning they are exclusively dedicated to this planning phase: AGIF, Regional Department of Agriculture and Fisheries of the Algarve (DRAPA), General Department of Agriculture and Rural Development (DGADR), Algarve Regional Coordination and Development Commission (CCDR-Algarve) and the Paper Industry Association (CELPA). Most entities indicated that they effectively participate in the implementation of actions and projects focused on reducing the risk of forest fires, representing 24 entities (82.8%). Among the entities that promote actions and projects for reducing forest fire risks, only the Portuguese Institute of the Sea and Atmosphere (IPMA) highlighted that it acts exclusively in this phase through fire monitoring, all other entities also act in other phases of forest fire management.

In fire suppression and rescue actions during events, 10 entities (34.5%) declared they have competencies to intervene in this phase, with 2 entities acting exclusively during forest fires, the National Authority for Emergency and Civil Protection (ANEPC), represented by the Algarve Regional Command for Emergency and Civil Protection, and the Grouping of Forestry Companies - Afocelca (AFOC). The Monchique Voluntary Fire Brigade Association (ABVM) indicated that, in addition to suppression and rescue actions in fire events, it also participates in actions and projects focused on risk reduction. Finally, 16 entities (55.2%) indicated competences for action in the post-event phase and in the recovery of burnt areas, with the Monchique Agricultural Cooperative – Coopachique (COOPM) highlighting that it acts exclusively in supporting rural landowners during the recovery of burnt areas. Thus, it can be seen that, in general, the entities indicated that they had responsibilities and competences for acting in different phases of integrated forest fire management in line with Table 1. Summary of the responsibilities of the entities of the NFISMS of the NFIP (**Annex A**).

Figure 26. Responsibilities of the entities throughout the stages of forest fire management (author)

Following this presentation of the main characteristics of the entities of the SGIFR, the results of the analysis reveal the patterns of interactions (structure) of the network, as well as the position and role of the actors (entities) in the dynamics and existing flows within the network. This analysis was supported by the data collected through the survey, where a list with the name of the 29 entities was presented and the following question was asked: "Which entities do you have interactions, such as information sharing and/or joint actions, on the forest fire issue?". Based on the survey responses, a multi-attribute graph was prepared with the representation of the existing interactions in the SGIFR network (**Figure 27**), incorporating the attributes of the entities, with different geometric shapes and colours, to facilitate the reading of the profile of the entities in the interpretation of the network graph: Category (State, Third sector or Private sector) and the scale (National, Regional or Local).

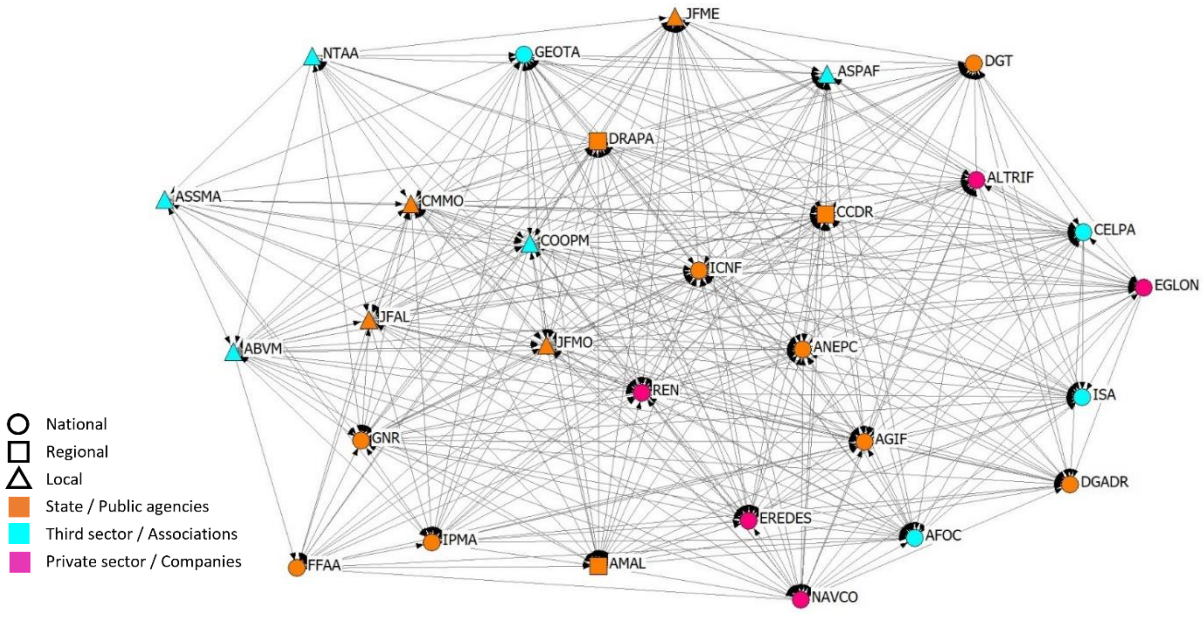


Figure 27. Network of SGIFR Entities (author)

As represented in the network graph above, there are currently 541 interactions occurring between the entities in the SGIFR from 812 possible interactions. The analysis of the Density metric (proportion of the possible ties that effectively occur in the network) showed an interaction density percentage of

66.62% that resulted from the application of the formula indicated below. Thus, the analysis of the Reachability metric, which evaluates the existence of connection paths between all actors, indicated that this more distributed structure of the SGIFR network enables a connection between all entities (i.e., all entities are "reachable" to each other).

$$Density\ (D) = \frac{541\ \text{existing interactions}}{812\ \text{possible interactions}}\ x\ 100,$$

Although the current network structure can be identified as a more distributed network, considering the high percentage of density of interactions between entities, the analysis of the Network Centralization Degree resulted in a percentage of 23.5%. This percentage points to the existence of specific entities that occupy a central position in the network structure, connecting entities that are not connected to each other (otherwise the density would be 100%) and therefore playing a role of influence, support and/or articulation in the dynamics and flows within the network. To identify which are the entities of the SGIFR that occupy a central position in the network structure, it was applied the two metrics of actors centrality analysis, the Node Degree and the Node Betweenness (Freeman, 1979).

The Node Degree assesses the position and role of a particular actor within the network structure based on the total number of interactions of the actor with the other network actors, or outgoing interactions (Out-Degree) as well as the total number of network interactions with a particular actor, or incoming interactions (In-Degree). In this analyzed network, the value of the Node Degree can vary between 0 for isolated actors (i.e., entities with no interactions) and 28 for actors who interact with all network actors, considering the number of network entities minus one (29 entities minus 1). Analysis of the result of the Node Degree (**Figure 28**) showed that the Institute for Nature Conservation and Forests (ICNF), Monchique Parish Council (JFMO), Coopachique (COOPM) and National Electric Network Company (REN) interact with all the entities in the SGIFR network, with a value of 28. CCDR-Algarve indicated that, with the exception of ABVM, it also interacts with all the other entities and therefore obtained a value of 27. On the other hand, the entities with the highest number of incoming interactions from the other entities in the network are ANEPC, Monchique Municipal Council (CMMO) and ICNF (value 25). The National Republican Guard (GNR), represented by the Monchique Territorial Post, also stood out in terms of the number of incoming interactions, with a value of 24.

The analysis of the metric Node Betweenness, which enables identifying the intermediation role of an actor between pairs of unconnected actors and its strategic position in the flows by the shortest paths (geodesic) within the network, pointed the ICNF as the entity with the highest value in comparison to all other entities. Thus, an integrated evaluation of the total number of outgoing (Out-Degree) and incoming (In-Degree) interactions, as well as the node betweenness value, highlighted the ICNF as the entity with the largest number of interactions and connections, occupying the most central position and intermediation of flows and interactions between entities of the SGIFR.

AGIF, the entity responsible for articulating and coordinating the SGIFR network, also stand out in the total number of interactions with other entities in the network, either in incoming interactions (score 24) or outgoing interactions (score 19). Finally, Monchique Alerta Association (ASSMA) and Nossa Terra environmental Association (NTAA), both local and representative entities of the landowners of

Monchique, had the lowest numbers of outgoing interactions, with scores of 8 and 11 respectively, as well as incoming interactions with a score of 10 each and therefore occupy the most peripheral positions within the network structure.

Figure 29 below presents a graphical representation of the network highlighting (in size) the entities that obtained high values of the Node Degree and therefore occupy positions of centrality within the structure of the SGIFR network.

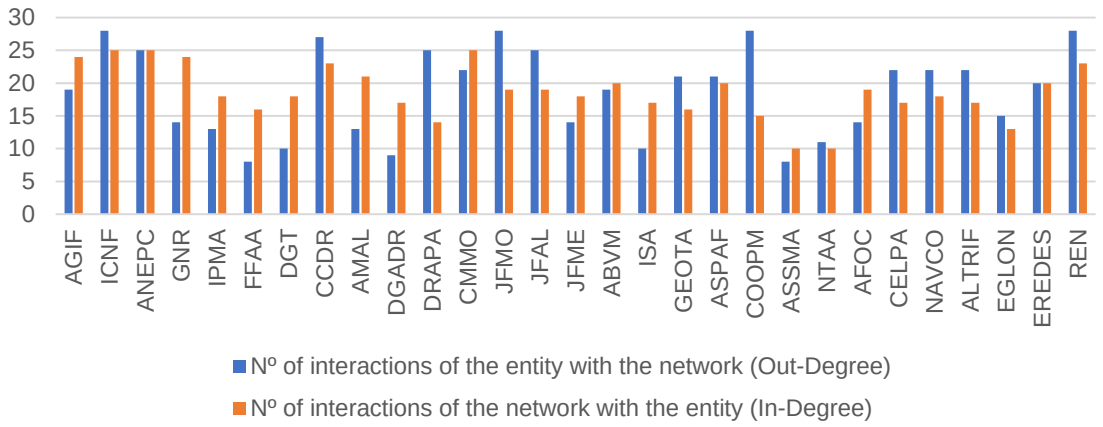


Figure 28. Node Degree Metric – Network of SGIFR Entities (author)

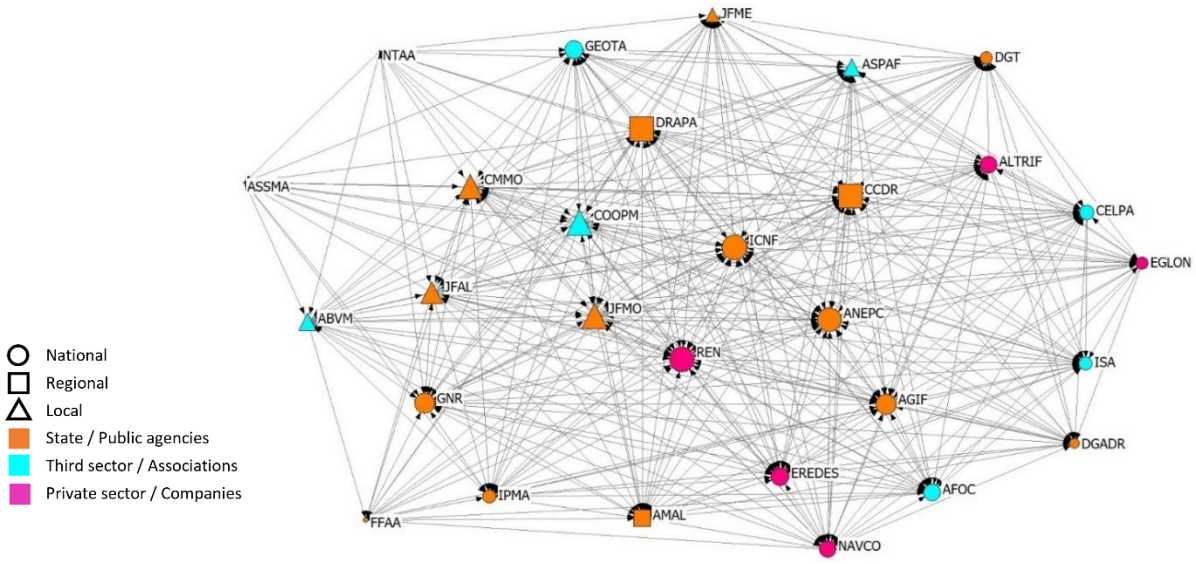


Figure 29. Node Degree Graph – Network of SGIFR Entities (author)

In addition to the number of existing interactions within the network, the survey also collected data on the values (weights) related to the intensity and/or frequency of these interactions based on a Likert Scale with three value options: 1 - low interaction, 2 - medium interaction or 3 - high interaction. From the 541 existing interactions between the entities of the SGIFR, 117 of them were indicated with weight 3, representing 21.63% of the total interactions, 167 with weight 2 (30.87%) and, finally, 257 interactions indicated as weight 1 (47.50%). Thus, although it has been verified a more distributed structure, given

the percentage of 66.62% of the network density, it is observed that most of the interactions are of low intensity and/or frequency, identified as weak ties. **Figure 30** presents a graphical representation of the network of entities with emphasis on the value of Node Degree (node size) and the interactions (lines) of weight 3 which, representing interactions of higher intensity and/or frequency, are called strong ties.

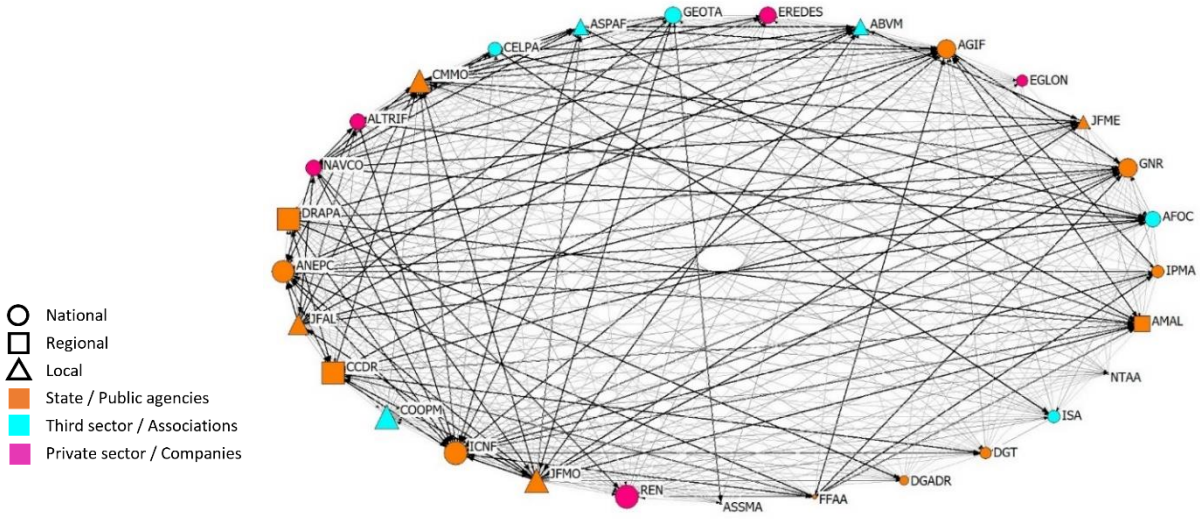


Figure 30. Node Degree with strong interactions highlighted – Network of SGIFR Entities (author)

The analysis of the Node Degree metric considering only the strong interactions (weight 3) of the network (**Figure 31**) revealed that The Navigator Company (NAVCO) and JFMO are the entities with the highest number of strong interactions with other network entities (outgoing interactions), with Out-Degree values of weight 3 in the range of 13 and 10 respectively. On the other hand, the entities that received the highest number of strong interactions from the other network entities (In-Degree) were CMMO, with a value of 13, followed by ICNF and ANEPC, both with a value of 11. In the interactions of weight 3, the AGIF obtained the values of 8 in the outgoing interactions (Out-Degree) and value 9 in the incoming interactions (In-Degree).

Figure 32 below presents the representation of the graph of interactions of weight 3 (strong), where the interactions with values of weight 1 and weight 2 were "removed" from the network. As mentioned, the entities with most centrality in the dynamics and flows between the strong interactions were CMMO, ICNF and ANEPC, however 3 entities were "excluded" from this weight 3 network by the lack of strong interactions, the company Eglon-Timbers (EGLON), Coopachique (COOPM) and the local association NTAA. The General Department of Territory (DGT), the Centre for Forestry Studies (ISA), DGADR, REN and ASSMA do not have interactions of higher intensity and/or frequency (weight 3) with the other network entities (Out-Degree), and the Group for Spatial Planning and Environment Studies (GEOTA) was not pointed out by the other network entities as being a strong interaction (In-Degree).

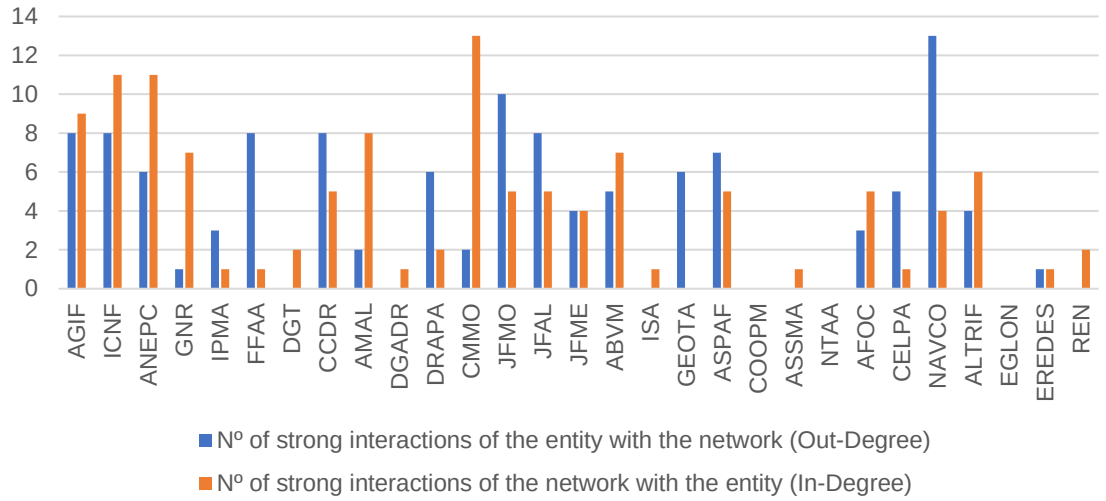


Figure 31. Node Degree of strong ties (weight 3) – Network of SGIFR Entities (author)

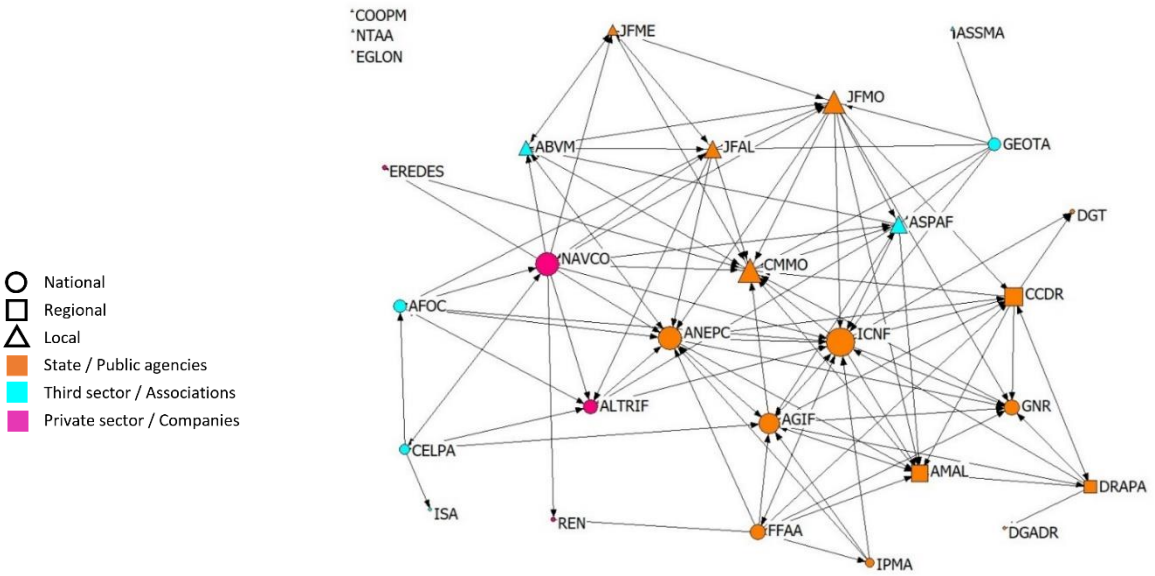
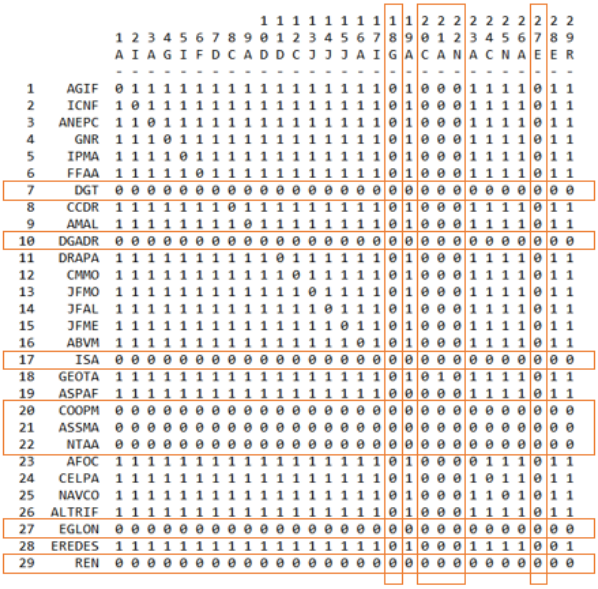


Figure 32. Graph of strong interactions (weight 3) – Network of SGIFR Entities (author)

When applied again the Reachability metric, considering now only the network of strong interactions of the SGIFR (**Figure 33**), it was verified that a more expressive total of 9 entities would not be "reachable" by the dynamics and respective flows (e.g., of information) between entities that have strong interactions between them (weight 3). Such entities include COOPM, NTAA and EGLON that do not maintain any type of strong interaction within the network, both incoming (In-Degree) and outgoing (Out-Degree) and therefore become isolated nodes of the "strong network". GEOTA and ASSMA mentioned that they have strong interactions with other network entities (Out-Degree), however they were not pointed out as being strong interactions by the network entities (In-Degree) and thus become unreachable by the interactions of weight 3 (vertical lines highlighted in orange in the figure).

Other 4 entities, namely DGT, DGADR, ISA and REN, although they were mentioned by the other network entities as being strong interactions, did not indicate interacting with higher intensity and/or frequency with the SGIFR network and, therefore, represent entities that would not maintain a flow of strong interactions within the network (horizontal lines highlighted in orange in the figure). As a result it was verified that, considering all the network interactions independent of the weight of interactions, all the entities are reachable, however when maintained only the strong interactions with weight 3, there is a set of entities that would be isolated or in marginal positions within the SGIFR network structure.



		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
		A	I	A	G	I	F	D	C	A	D	D	C	J	J	J	A	I	G	A	C	A	N	A	C	N	A	E	E	R
1	AGIF	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
2	ICNF	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
3	ANEPC	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
4	GNR	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
5	IPMA	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
6	FFAA	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
7	DGT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	CCDR	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
9	AMAL	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
10	DGADR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	DRAPA	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
12	CMMO	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
13	JFMO	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
14	JFAL	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
15	JFME	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
16	ABVM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	0	1	1
17	ISA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	GEOTA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	0	1	1
19	ASPAF	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	0	1	1
20	COOPM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	ASSMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	NTAA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	AFOC	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
24	CELPA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	0	1	1	0	1	1
25	NAVCO	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	0	1	0	1	1
26	ALTRIF	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1
27	EGLON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	EREDES	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	0	1
29	REN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 33. Reachability based on strong interactions (weight 3) – Network of SGIFR Entities (author)

Another important result refers to the analysis of existing interactions between the SGIFR entities mentioned in the survey as being of less intensity and/or frequency (weight 1), identified as weak ties. As shown in **Figure 34**, COOPM (18), DRAPA and REN (17 each) were the entities that pointed out the highest number of weak interactions with the other entities in the network (outgoing interactions) and, thus, with high Out-Degree values of weight 1 interactions. Regarding the entities with the highest number of weak interactions by the other network entities (incoming interactions), REN stands out again (15), as well as CCDR (13) and DGT (12).

Figure 35 below presents a representation of the network graph of the interactions of weight 1 (weak ties), where it is verified that REN, DRAPA and COOPM (highlighted in size), as well as GEOTA and CCDR-Algarve, are the entities with the highest centrality in the network structure where only the interactions of lower intensity and/or frequency were maintained. Other two entities, namely the companies E-Redes Distribution (EREDES) and EGLON, also obtained higher values, both of incoming and outgoing interactions, in the structure of the network of weak interactions of the SGIFR. Differently from the network of strong interactions (weight 3), in the network structure of weak interactions (weight 1), no entities were isolated (no ties), reinforcing that the interactions of lower intensity and/or frequency cover a larger number of entities. As a conclusion, it is possible to evaluate that the interactions of weight

1 (weak) are responsible for effectively maintaining the network structure cohesive and more connected, including all the entities being "reachable" only from the weak interactions within the SGIFR network.

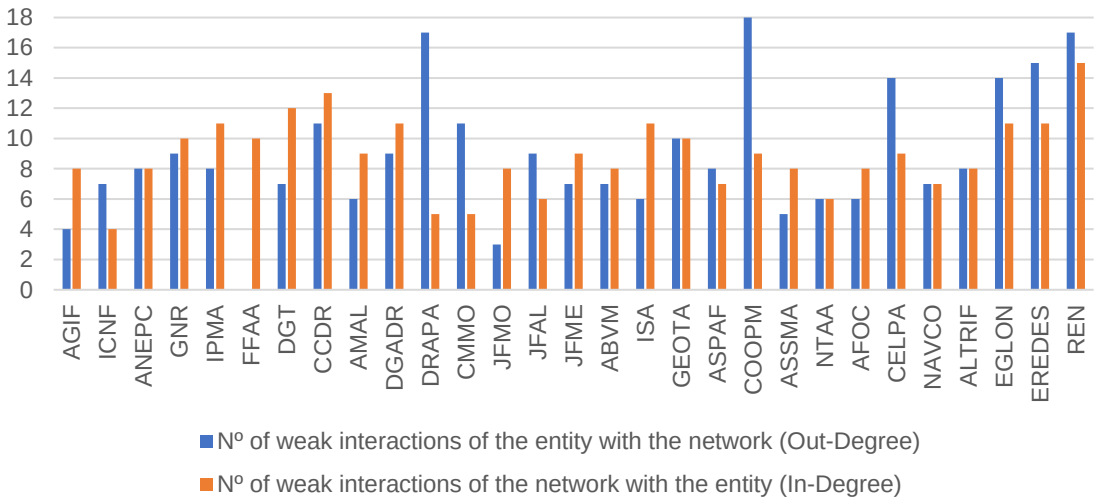


Figure 34. Node Degree of weak ties (weight 1) – Network of SGIFR Entities (author)

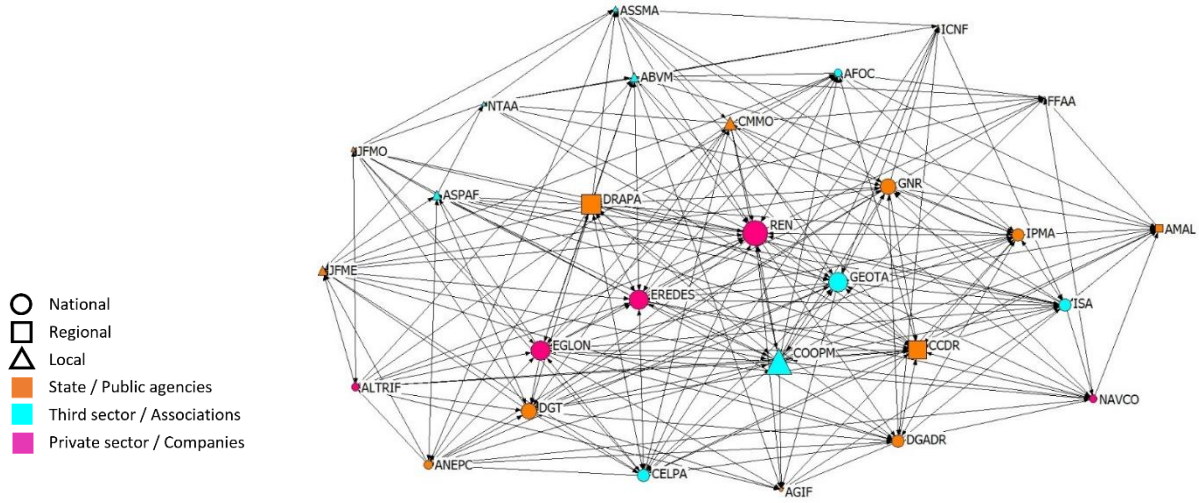


Figure 35. Graph of weak interactions (weight 1) – Network of SGIFR Entities (author)

As presented previously, there are 541 interactions between SGIFR entities out of 812 possible interactions, stating that 271 interactions are not happening, i.e., lacking interactions within the network. Therefore, the Node Degree metric was applied again to identify which entities have the highest number of lacking interactions. **Figure 36** demonstrates that the entities which have less outgoing interactions with the other entities in the network (i.e., lack of Out-Degree interactions) are the Armed Forces (FFAA) and ASSMA, with a score of 20 each, followed by DGADR (score 19) and DGT and ISA with score 18 each. On the other hand, ASSMA and NTAA represent the entities with which the network interacts less (i.e., lack of In-Degree interactions), both with a score of 18 each. Thus, it can be verified that of the local entities representing the rural landowners of Monchique and incorporated into the network analysis,

ASSMA and NTAA are the entities least connected to the SGIFR. The Association of Forest Producers of the Barlavento Algarvio - Aspaflobal (ASPAF), in turn, is the local entity with the lowest number of lacking interactions and therefore the most integrated to the current structure of the SGIFR network.

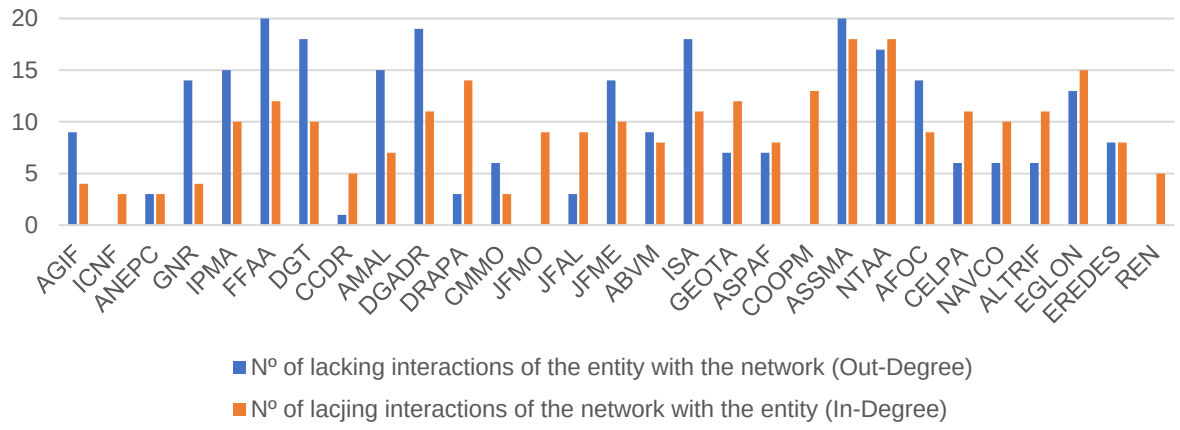


Figure 36. Node degree of lacking interactions – Network of SGIFR Entities (author)

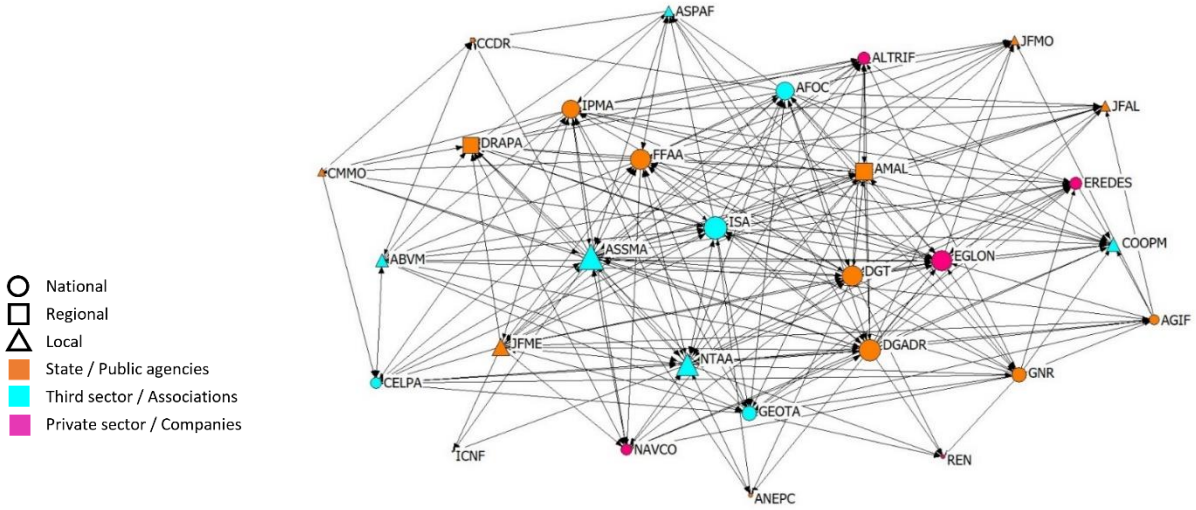


Figure 37. Graph of lacking – Non-Network of SGIFR Entities (author)

Figure 37 above presents, at last, a representation of the graph of the "non-network" of interactions, highlighting the size (Node Degree) for the entities that have more lacking interactions within the network, namely ASSMA and NTAA, as well as other entities that also have less interactions in the SGIFR network, namely FFAA, DGADR, DGT and ISA. This analysis of lacking interactions within the network is important to be developed since promoting such non-existent interactions would imply the increased integration of entities that are currently located on the periphery of the network structure, enhancing the interaction density percentage and therefore promoting a more distributed and cohesive network structure in comparison to the current SGIFR network.

4.4.2. Landowners

The survey with landowners in Monchique aimed to collect data on their information sharing and/or collaboration interactions with the entities that are part of the SGIFR in order to (i) identify how landowners are (or are not) connected to the network of entities and, (ii) assess the potential integration of the vision, local knowledge and practices of these important local actors into the flows within the network, contributing to an adaptive co-management of forest territories to fire risks. Thus, the questionnaire was structured in two blocks of questions: in the first part to collect information to characterize the respondent's profile and in the second part to collect data on the interactions of landowners with the network of entities of the SGIFR, with two options: 0 - does not interact or 1 - interacts. Of the total 226 landowners in Monchique, the survey obtained 24 responses, representing a sample of 10.6% of the universe in the research (see sub-item 4.2.1. Universe of the network of actors).

The analysis of the information on the profile of the 24 landowners who participated in the survey indicated that 16 of them (66.7%) are of Portuguese nationality and 8 (33.3%) of foreign nationality, in general from Northern Europe, also the majority of the respondents are male (62.5%) and aged between 50 and 79 years old (70.8%), according to the survey results presented in **Figure 38**. Regarding the landowners who are members of local entities in Monchique (**Figure 39**), 12 respondents (50%) declared not to be members of any local entity, and the other 12 landowners who mentioned participating in local entities are distributed among the associations Aspaflobal (ASPAF), Monchique Alerta (ASSMA) and Nossa Terra (NTAA), including the Coopachique (COOPM). It is important to note that there are some landowners who are members of more than one local entity, which justified the sum of 27 responses in this specific question.

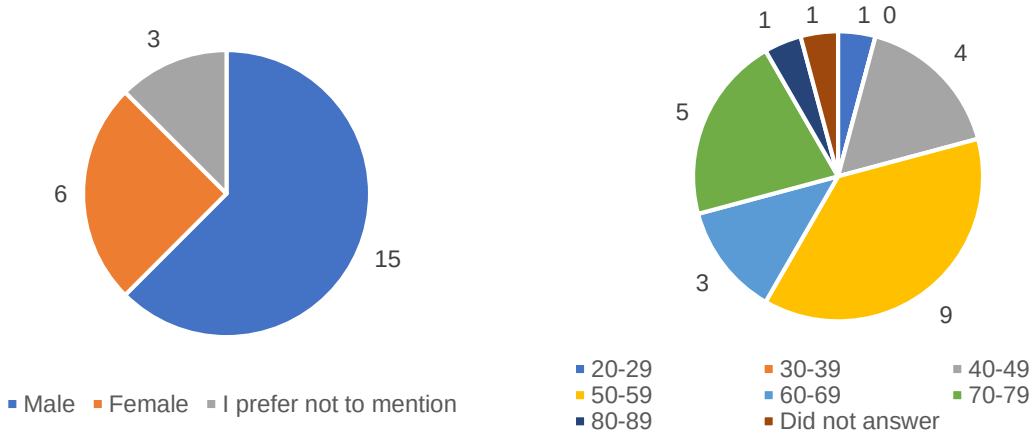


Figure 38. Gender and age of landowners (Author)

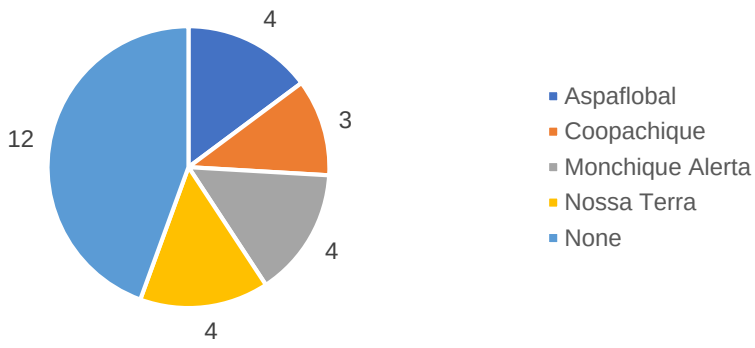


Figure 39. Rural landowners who are members of local entities in Monchique (Author)

Regarding the characteristics of the properties, the survey showed that 21 landowners have a single property in Monchique, representing the majority of respondents (87.5%), and only 3 of them declared to own two properties in the municipality (12.5%). Of the total 27 rural properties, therefore, a majority of them are located in the parish of Monchique (81.5%), 4 rural properties in the parish of Marmelete (14.8%) and only one in the parish of Alferce (3.7%). Regarding the uses of the rural properties (**Figure 40**), 16 rural owners indicated that they currently reside in the property (66.7%), the most common uses refer to agricultural and/or animal production (54.2%) and forestry production (29.2%), followed by leisure or recreation activities (25%) and tourism and hotel activities (20.8%). The other uses were less significant in the survey, with only 3 properties (11.1%) not currently in use.

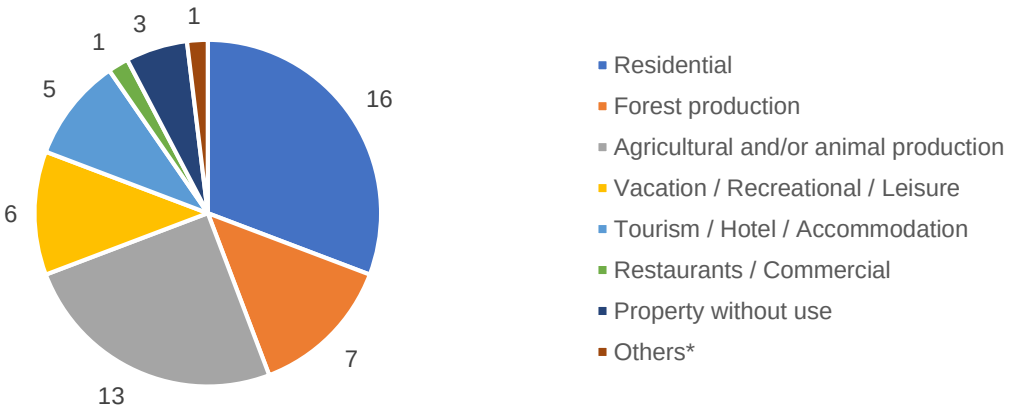


Figure 40. Current uses of rural properties in Monchique (Author)

The result of the analysis of the interactions of landowners with the entities of the SGIFR indicated that, of the 24 respondents, most of them mentioned interacting with at least one of the entities, representing 21 landowners (87.5%). Among the landowners that interact with the entities of the SGIFR, the landowner PN14 mentioned interacting with 27 entities and PN13 with 25 entities, both members of the Association of Forest Producers of Barlavento Algarvio - Aspaflobal (ASPAF) and of Portuguese nationality. PN08 mentioned to interact with 16 entities, followed by landowners PN11 and PE08, with 12 entities each, and PN12 who interacts with 10 entities. From the remaining 18 landowners, 15 interact

with 1 to 9 entities and only three landowners (12.5%) pointed not to have any kind of interaction with the SGIFR entities (PN02, PN05 and PN07).

Figure 41 shows the entities of the SGIFR network that have the highest number of interactions by the rural landowners of Monchique, noting that the most mentioned entities are the Monchique Municipal Council (CMMO) and Nossa Terra Environmental Association (NTAA), with 14 indications each, the Monchique Voluntary Firefighters Association (ABVM) with 13 indications and two national scale entities, the ICNF and GNR, with 10 indications each. Other entities with a higher degree of relevance from the indications of interactions by respondents were the Monchique Alerta Association (ASSMA), the Monchique Parish Council (JFMO), each with 9 indications, and the Coopachique (COOPM) with 8 indications, all on a local scale. The company E-Redes (EREDES), previously EDP, also received 8 nominations from landowners. The entities with the lowest number of indications by landowners were the Integrated Management Agency for Rural Fires (AGIF), the Armed Forces (FFAA), the Algarve Intermunicipal Community (AMAL), the Forestry Studies Centre (ISA), the Paper Industry Association (CELPA) and the company Eglon-Timbers (EGLON), being mentioned by 2 respondents each.

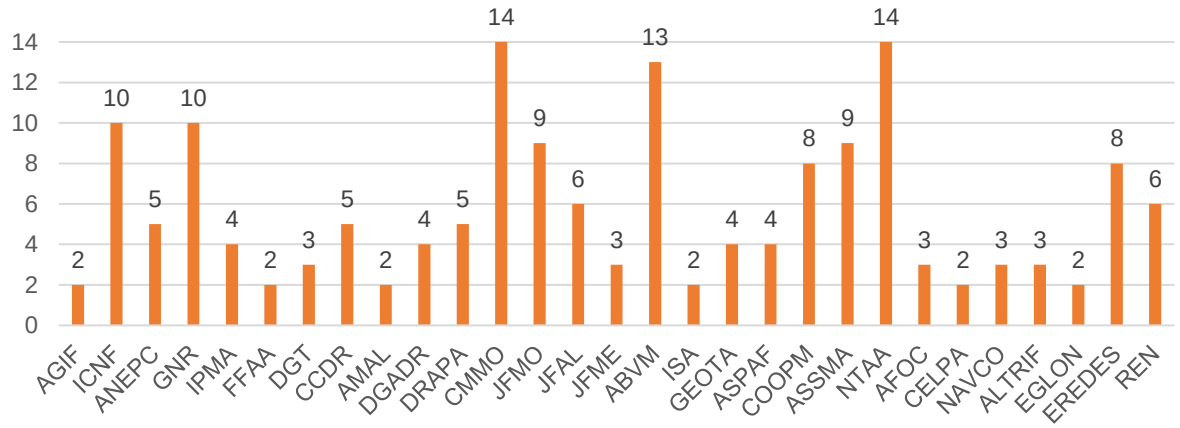


Figure 41. Interactions of landowners with the SGIFR Entities Network – Out-Degree (Author)

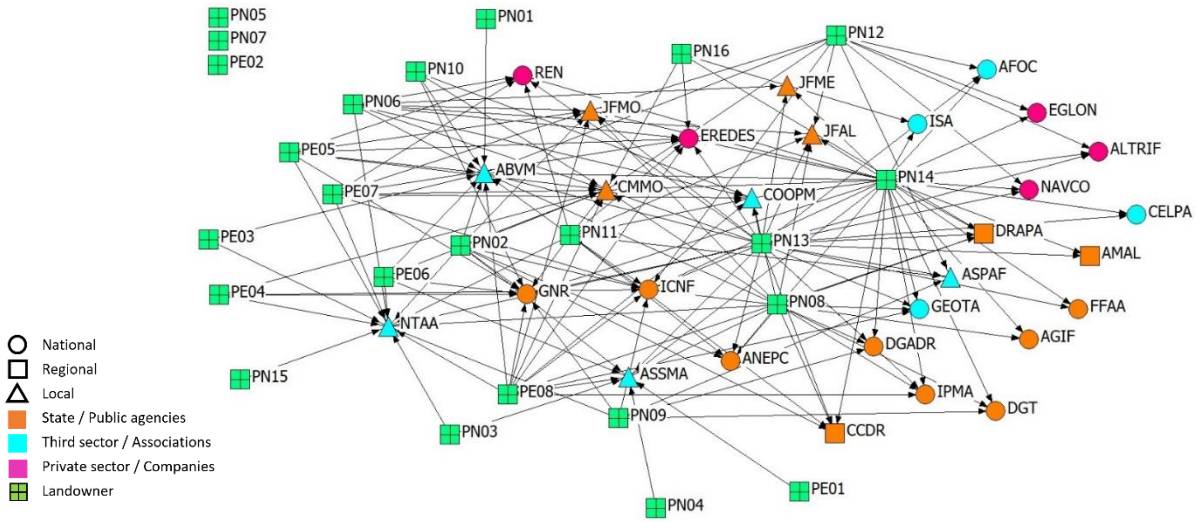


Figure 42. Graph of landowners' interactions with the SGIFR Network Entities (Author)

Figure 42 above presents the graphical representation of the landowners' interactions with the entities of the ISFM network. It is possible to visualize that the entities with the highest number of indications, and therefore in a more central position in the network, refer to the local entities, namely the CMMO, NTAA, ABVM, ASSMA and JFMO, as well as the two national scale entities, ICNF and GNR. The other entities, for having been less mentioned, came to occupy more peripheral positions in this network structure of the SGIFR that considered the interactions of the rural landowners of Monchique.

4.4.3. Discussion

The SGIFR network in the management of forest territories in Monchique is formed by 29 actors (entities). From the total of 812 possible interactions, 541 existing interactions between the network entities were identified, which represents a density of 66.62%, and can be evaluated as a cohesive network structure (Bodin, 2017). The analysis of the Reachability metric revealed that all entities are reachable within the network through multiple "paths" existing in this more distributed structure, facilitating connectivity and social activity between actors within the network (Robins, 2015; Tabassum et al., 2018). This distributed (cohesive) network structure enables the flow of an information (or knowledge) to travel throughout the network, facilitating communication between actors in natural resource management (NRM) and ecosystem management (Stein et al., 2011; Mannetti et al., 2015; Ball et al., 2022). In the SGIFR, therefore, this cohesive structure is positive given the different scales of intervention and competencies of the entities, where the flows of information and knowledge on fire risks can circulate among all the entities in the network, both at national, regional and local level and, consequently, reach local entities linked to landowners who act directly in forest management.

However, the analysis of the values (weights) of interactions between entities indicated that 257 interactions (47.50% of the total) represent interactions of low intensity and/or low frequency (weight 1), identified as weak ties. When weak ties were excluded from the SGIFR network, the density dropped to 34.97% and 9 entities (31% of the network entities) would no longer be "reachable" by the network flows, among them two relevant local entities representing rural landowners, Associação Monchique Alerta (ASSMA) and Nossa Terra Associação Ambiental (NTAA). This evaluation, therefore, indicated that weak ties (weight 1) represent the interactions that effectively maintain the current connectivity and cohesion of the SGIFR entities, which implies diverse effects (positive and negative) for adaptive co-management to forest fires. Prell et al. (2009) identified that cohesive networks with strong ties between actors (i.e., high intensity and/or frequency) tend to homogenize information and knowledge, being less exposed to new ideas and innovations. Thus, new ideas and visions tend to flow through weak ties, contributing to expand the diversity of knowledge and create a more adaptive and resilient network, this being a positive aspect of the SGIFR network. On the other hand, weak ties can reflect little trust between actors and be easily "broken" (Prell et al., 2009), limiting collaboration within the network and collective actions (Ogada et al., 2017), this being a negative aspect in this cohesive network structure anchored in the high number of weak interactions (weight 1) between the SGIFR entities.

The weak interactions proved to be expressive in the network of actors, however, interactions of higher intensity and/or frequency (weight 3) were also identified between specific entities, called strong ties.

Among the entities with strong interactions within the SGIFR network, stand out the Institute for Nature Conservation and Forests (ICNF), the National Authority for Emergency and Civil Protection (ANEPC) and the Monchique Municipality (CMM), which also represent the entities that occupy central positions in the network structure and have more influence on the network dynamics, given the high number of interactions they have with the SGIFR entities (high value of Node Degree). In addition to its centrality in the network, the ICNF also stood out as the main actor that plays an intermediation role between entities that are not connected to each other and, thus, plays an important role of articulation and connectivity within the network. The Agency for the Integrated Management of Rural Fires (AGIF), the entity responsible for the coordination of the SGIFR, although it is integrated into the network and connected to the other entities of the system, did not stand out as a central actor and/or with an important role of articulation and intermediation between the entities within the network.

Thus, although the network of entities in the management of forest territories shows a high density of interactions indicating a distributed and connected structure, the existence of specific entities occupying a position of centrality in the network and playing a role of influence and/or intermediation between unconnected entities was reflected in the 23.5% percentage obtained from the metric Network Centralisation Degree. A network structure with a certain degree of centralisation in key actors also has different effects for adaptive co-management of forest fires, both positive and negative. As a positive aspect, the potential brokerage role that central and/or intermediary actors can play by linking unconnected actors to each other (Stein et al., 2011; Cohen et al., 2012) stands out, accessing a greater diversity of views and information (Ogada et al., 2017) and thus creating opportunities for new knowledge needed to solve complex problems inherent to forest systems (Fischer et al., 2016). Actors occupying central and more influential positions in the network structure can further contribute to the dissemination of information/knowledge within the network, facilitate the coordination of complex tasks, and strengthen trust and collaboration among actors to promote collective actions in early stages of adaptive co-management (Prell et al., 2009; Omondiagbe et al., 2017).

From this perspective, the entities with the most strong interactions within the SGIFR and that occupy a central position in the management structure of forest territories, namely the ICNF, the ANEPC and the CMMO (including the AGIF which has an articulation and coordination function for the SGIFR entities), can contribute at an early stage of adaptive co-management to forest fires to: (i) expand interactions within the network, both between unconnected entities and entities in more peripheral positions (i.e, weakly integrated into the network), (ii) create opportunities for new knowledge and social learning about forest systems based on the articulation of different visions and information that " flow" through the weak ties and, (iii) strengthen the articulation and mutual trust between the entities of the SGIFR, facilitating partnerships and collaborations in collective actions focused on reducing forest fire risks. It is important to note that landowners have more interaction and are more connected with local scale entities of the SGIFR, however, with the exception of the CMMO that occupies a central position, the other local entities are less integrated and occupy peripheral positions in the network (i.e., have less interactions and/or weak interactions with other entities). Thus, it highlights the potential role of the central and influential entities of the SGIFR to increase and strengthen the integration of local entities in the network and thus promote and facilitate more involvement and engagement of landowners in the SGIFR.

On the other hand, studies of actor networks in natural resource management have pointed out that centralised network structures can have negative effects for adaptive co-management. Among such effects are the power of central actors (i.e., government entities that occupy a position of centrality in the current SGIFR network structure) to control, filter and/or change information and knowledge flows within the network (Aubin et al., 2019), control network interactions and connectivity (Cárcamo et al., 2014) or even take positions favourable to specific actor groups in the context of diverging interests or conflicts within the network, negatively influencing the common view of the problem and decision-making processes in adaptive co-management (Prell et al., 2009; Mannetti et al., 2015). Thus, it is important that in the long-term perspective this more traditional and hierarchical network structure becomes decentralized and local to "minimize" the control and influence (sometimes negative) of central entities over the network dynamics and flows in the management of forest territories.

As a result of the discussion presented, and responding to the Research Question (RQ): How can a social network approach (SNA) contribute to promoting adaptive forest fire risk management in the Serra de Monchique?", the SNA made it possible to identify aspects of the current structure and dynamics of the SGIFR network, as well as the role of the central entities in the network, and the relationship of the rural landowners of Monchique with this network of entities, contributing to better understand this network of actors in the perspective of an adaptive co-management of the forests of Monchique to fire risks. On the positive side, the research identified a distributed and cohesive network structure (high interaction density) that facilitates communication and information/knowledge flows between network entities about the forest territories of Monchique, promoting social learning about fire risks and about these forest systems in all their complexity, non-linearity and uncertainties (Berkes et al., 2003; Folke et al., 2005). From the perspective of adaptive co-management, social learning based on sharing information and knowledge about forest fires is a central aspect to better guide adaptive strategies and practices (Armitage et al., 2007) focused on reducing forest fire risks and promoting greater local resilience. The potential contribution of central and influential entities within the network (ICNF, ANEPC and CMMO) was also assessed as a positive aspect that can contribute to promote adaptive co-management of forests in Monchique through (i) their role in articulating entities that do not interact with each other and are not effectively integrated in the network, (ii) the creation of new knowledge through the role of brokering various views and information from different entities, and (iii) in strengthening articulation within the SGIFR network with a view to promoting collaboration and joint action to manage forest fire risks.

On the other hand, as an aspect of the SGIFR network that can undermine the adaptive co-management of forest fires in Monchique is the significant number of interactions of low intensity and/or frequency (weak ties) that may limit further interaction, mutual trust and joint actions between entities of the system, as such weak interactions can be easily broken and hinder collaboration in forest fire management. Another negative aspect of the current network structure analysed through the SNA refers to the centrality of the SGIFR network structure and dynamics in government entities, mostly acting at the national level, and the peripheral position (i.e. less integrated) of local entities, particularly local entities with which landowners have indicated maintaining more interaction in knowledge sharing and joint actions in forest fire risk reduction. In this perspective, since local entities (with the exception of CMMO)

are less integrated in the SGIFR network and, consequently, so are the landowners linked to these entities and who act directly in the management of forest territories in Monchique, the current structure restricts the effective incorporation of important local knowledge and current practices adopted by these local actors in forest fire management.

Furthermore, the lack of integration of local entities and the broad involvement and participation of Monchique's landowners in the SGIFR limits the structuring of tailor-made strategies that contribute to promoting adaptive forest systems from the perspective of sustainable trajectories (Berkes et al, 2003), due to: (i) the non-incorporation of local practices and experiences, essential for the resilience of complex systems, such as forests, in the perspective of "learning by doing" (Holling, 1978) and, (ii) hinders joint or decentralized decision making (Hasselman, 2017) and the effective sharing of responsibilities and tasks (Berkes, 2009) in the management of forest systems in Monchique for the reduction of fire risks. In this perspective, it is highlighted the need to promote a better articulation and integration of local entities in the SGIFR network and, by reflection, the rural landowners of Monchique, through the role of the Municipal Commissions for the Integrated Management of Rural Fires (CMGIFR), including the CMGIFR of Monchique, in a more local and decentralized SGIFR structure that will contribute to strengthen adaptive co-management to forest fires in Monchique.

5. FINAL REMARKS AND CONCLUSIONS

In the last decades there has been a increasing number of studies adopting a SNA approach to identify and analyse the structure and dynamics of actor networks focusing on the adaptive co-management of natural resources and ecosystems. However, there is a gap in this network approach focusing on the adaptive co-management of forest territories to fire risks. Based on the case study of Serra de Monchique, the main objective of this research focused on developing a SNA approach to identify the current structure and dynamics of the actor network of the Integrated Rural Fire Management System (SGIFR) and to analyse the main aspects of this SGIFR network that can contribute, or limit, the adaptive co-management of forest territories and, thus, contribute to the current gap of more in-depth studies on actor network approach in forest fire risk management.

The result of the research identified that the SGIFR network currently has positive aspects from the perspective of adaptive co-management of forest territories, in particular a distributed and cohesive network structure (high density of interactions) that facilitates communication and flows of information and knowledge between entities, contributing to social learning about complex forest systems and to guide adaptive strategies and practices to forest fire risks. The potential role of entities with more centrality in the dynamics and flows within the network to articulate and connect entities that are less integrated into the network was also identified as positive, to play a brokerage role for new knowledge from the articulation of different visions and information between entities, and to strengthen articulation and mutual trust within the SGIFR network to facilitate new collaborations and joint actions for forest fire risk management.

On the other hand, aspects that restrict adaptive co-management of forest territories were identified. Among the main negative aspects was the significant number of interactions of low intensity and/or frequency (weak ties) that may reflect a lack of mutual trust between the SGIFR entities and thus undermine collaboration and collective actions in forest fire management. Another negative aspect identified refers to the central role and influence of mostly national government entities and public agencies, with local entities occupying more peripheral positions (i.e. less integrated) in the SGIFR network, including entities that represent landowners. This hinders the incorporation of local knowledge and practices in forest fire risk reduction, the structuring of interventions in the logic of management by experimentation (e.g, "learning by doing") and joint decision-making among all actors (entities and landowners) to guide strategies and adaptive capacities focused on promoting resilient forests to fires. Thus, this research highlights the importance of rethinking the traditional and hierarchical structure of the current SGIFR network into a more decentralized and local structure that promotes a better integration of local entities in SGIFR. This will strengthen the role of the Municipal Commissions of Integrated Management of Rural Fires (CMGIFR) and may enable them to act in a more direct and articulated way with rural landowners in the management of forests to reduce fire risks.

A future perspective to follow-on from this research is the need for an analysis of the existing interactions between rural landowners and the role played by the local community in the perspective of self-management focused on the reduction of forest fire risks. To this end, the ego-network is another SNA approach that can be adopted, as a personal network research design that starts from the individual to a list of people to which they are connected, i.e., the boundaries of the network are not defined a priori, but rather are established based on the network of interactions of a specific individual (actor/ego) with other individuals with whom he or she interacts (others actors/alters). Another line of research that can be followed on is to develop an evolution analysis of the SGIFR network with the application of the SNA approach over time, enabling the identification of possible changes in the current structure and dynamics of this network of actors and analyse their reflexes (positive or negative) to promote an adaptive co-management of forests to forest fires.

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Annex A - Table of responsibilities of the SGIFR entities (PNGIFR, RCM 45-A/2020)

	Planeamento	Preparação	Prevenção	Pré-Supressão	Supressão e Socorro	Pós-Evento
AGIF, I. P.,	• Coordena a elaboração do Plano Nacional de Gestão Integrada de Fogos Rurais, a execução e as suas revisões, bem como a consolidação dos instrumentos de escala regional • Participa na integração de políticas públicas	• Coordena e assegura com as entidades do sistema a estratégia global de comunicação • Executa ações de sensibilização	• Promove a ação conjunta em ações de prevenção • Assegura informação atualizada no sistema de informação e comunicação	• Apoia a interpretação meteorológica e análise de risco, no âmbito do apoio à decisão de emissão de avisos e alertas. • Define as regras de identificação de perigosidade e risco de incêndio • Pré-posiciona peritos	• Disponibiliza peritos para o processo de decisão, comando e controlo • Recolhe e contribui com informação para avaliação de eficiência	• Coordena o processo de lições aprendidas • Compila e analisa informação sobre danos e custos de operação
ICNF, I. P.,	• Planeia um novo modelo de paisagem • Elabora as diretrizes operacionais e orçamento GFR de acordo com estratégia nacional	• Responsável pelo programa nacional de redução de ignições • Executa ações de sensibilização • Assegura gestão operacional 365 dias ano e logística das estruturas operacionais de GFR	• Assegura a execução de um programa de gestão de combustível à escala da paisagem • Assegura a execução da Rede Primária e promove outras ações de valorização e de gestão de combustível rural	• Apoia a análise de risco e decisão de emissão de avisos de perigo de incêndio • Apoia a definição das regras de identificação de perigosidade e risco de incêndio • Pré-posiciona meios • Participa na decisão da elevação de estado de alerta e pré-posicionamento	• Empenha, em apoio, meios especializados em GFR, incluindo maquinaria • Suporta o comando e controlo em articulação com a ANEPC •	• Recolhe, regista e reporta os danos apurados em GFR • Define as intervenções de estabilização e recuperação • Executa estabilização e recuperação nos territórios que gere
ANEPC	• Elabora as diretrizes operacionais e orçamento PCIR de acordo com estratégia nacional	• Responsável pelos programas - Aldeia Segura e Pessoas Seguras • Suporta as autarquias na identificação de refúgios e condições de evacuação • Executa ações de sensibilização	• Promove a execução da Rede Secundária e de outras ações de gestão de combustível em área edificada de interface	• Constitui célula de Análise de Risco para apoio à decisão operacional e de emissão de avisos e alertas. • Assegura o aviso às populações • Determina a elevação do estado de alerta e pré-posicionamentos	• Desenvolve e coordena o comando e controlo no âmbito do SIOPS de acordo com o SGO, em função da capacidade e independentemente da entidade Coordena taticamente os meios aéreos	• Recolhe, regista e reporta os danos apurados em PCIR, em plataforma interoperável.
GNR	• Elabora as diretrizes operacionais, dimensionamento do seu dispositivo e orçamento	• Coordena a fiscalização do cumprimento das disposições legais em matéria de gestão de combustível e uso do fogo • Executa ações de sensibilização • Executa ações de fogo controlado em articulação com o ICNF, I. P.,. • Mantém pronta uma força permanente da UEPS para ataque inicial e supressão do fogo no espaço rural e peri-urbano.	• Coordena a fiscalização do cumprimento das disposições legais em matéria de gestão de combustível e uso do fogo	• Coordena a fiscalização, vigilância e deteção, e assegura ataque inicial por meio terrestre e/ou aéreo • Coordena a Rede Nacional de Postos de Vigia (RNPV).	• Emprega meios de supressão • Assegura ataque inicial terrestre e com equipas ou brigadas helitransportadas, apoia ataque ampliado e executa ações de interdição de estradas, condicionamentos de circulação e abertura de corredores para forças de socorro. • Apoia evacuação de populações em perigo.	• Investiga a causa do incêndio em articulação com o ICNF, I. P.,

	Planeamento	Preparação	Prevenção	Pré-Supressão	Supressão e Socorro	Pós-Evento
FFAA	• Elabora as diretrizes operacionais, dimensionamento do seu dispositivo		Executa abertura de faixas de combustíveis, melhoria	• Assegura presença dissuasora em áreas protocoladas com o	• Apoia o rescaldo e a vigilância a reacendimentos • Apoia a logística das operações	Apoia a evacuação de populações
			de itinerários, manutenção de pontos de água.	ICNF, I. P., em articulação e coordenação com a GNR	• FFAA (Força Aérea): Efetua a observação e coordenação dos meios aéreos empenhados no Teatro de Operações • Apoia as operações com maquinaria e equipamentos de engenharia	
BOMBEIROS	• Participam na discussão do processo de planeamento e elaboração de diretivas operacionais	• Suporta as autarquias na identificação de refúgios e condições de evacuação • Suportam a capacitação das comunidades	• Suporta as autarquias na verificação de segurança de equipamentos de proteção e socorro • Verificam os seus próprios equipamentos • Apoiam queimas de agricultores	• Pré-posicionam meios de resposta	• Realizam supressão de acordo com a sua capacitação • Apoio ao socorro à população	• Colaboram na recuperação • Colaboram com a GNR preservando indícios para a investigação de causas
AUTARQUIAS	• Avalia as diretrizes operacionais nacionais ao seu nível com transposição para o planeamento municipal	• Mantém inventário das infraestruturas de defesa como locais de abrigo e de refúgio, rotas de evacuação e pontos de água • Prepara, através dos SMPC, a resposta operacional e logística • Sensibiliza os munícipes • Implementam à escala local os Programas Aldeia Segura e Pessoa Segura.	• Verificam a segurança de equipamentos de proteção e socorro • Promovem a execução da Rede de faixas e reduzem a carga combustível nos termos da Lei	• Pré-posicionam meios de resposta • Emitem avisos locais à população	• Apoiam logisticamente as operações • Apoio ao socorro à população	• Inventariam danos • Apoiam as populações na retoma das condições pré-evento • Atuam na reposição de serviços
IPMA	• Elabora estratégias de melhoria da informação de natureza meteorológica prestada e contribui para a qualificação profissional	• Executa procedimentos para melhoria dos produtos meteorológicos e de perigo de incêndio para disseminação às diferentes autoridades e programa ações de formação interna e externa • Disponibiliza informação meteorológica	• Assegura informação meteorológica e climatológica no sistema de comunicação de informação para avaliação de perigo meteorológico e risco potencial.	• Assegura em tempo real a informação meteorológica e de perigo de incêndio, e apoia a célula de análise de risco na tomada de decisão.	• Apoia a célula de análise de risco com a análise e evolução das condições meteorológicas no curto e muito curto prazo (próximas horas até 24 horas) e de perigo de incêndio.	• Avalia as condições meteorológicas e o desempenho dos índices de perigo de incêndio na deflagração, progressão e comportamento do fogo.

	Planeamento	Preparação	Prevenção	Pré-Supressão	Supressão e Socorro	Pós-Evento
Gestores de infraestruturas de interesse público	• Elabora estratégia, planeamento de acordo com as diretrizes operacionais nacionais	• Monitoriza e executa os trabalhos de gestão de combustível nas infraestruturas				• Avalia os danos nas infraestruturas • Atua na reposição de serviços • Intervenciona nas infraestruturas a recuperar
Proprietários florestais, agrícolas e organização de produtores florestais (incluindo AFOCELCA)	• Participam na discussão do processo de planeamento	• Participam na adoção de melhores práticas de medidas de autoproteção e redução de ignições	• Executam gestão de combustível, proteção do edificado, gestão de redes de defesa nas áreas sob sua gestão.	• Mobilizam preventivamente os seus meios de acordo com o risco.	• Através das equipas de sapadores florestais apoiam as ações de combate e rescaldo.	• Reportam danos e participam na recuperação do território
Direção-geral do território	• Elabora estratégias de melhoria da informação de natureza territorial bem como metodologias de articulação de planeamento territorial com os instrumentos de planeamento de defesa da floresta contra incêndio • Coordena a elaboração dos Planos de Paisagem	• Sistematiza informação e elabora produtos cartográficos de base e temáticos oficiais, designadamente Ortofotomapas, Modelo Digital do Terreno (MDT), Carta de Ocupação do Solo (COS), Carta do Regime de Uso do Solo (CRUS), Carta Cadastral (CC), Carta de Vulnerabilidades Territoriais;	• Assegura a disponibilização de informação geográfica, territorial e cadastral no sistema (SGIFR) e monitoriza a sua evolução			
CCDR	• Participam no planeamento e identificação de fontes de financiamento	• Apoia tecnicamente as autarquias				

	Planeamento	Preparação	Prevenção	Pré-Supressão	Supressão e Socorro	Pós-Evento
Direção-Geral de Agricultura e Desenvolvimento Rural e Direções Regionais de Agricultura e Pescas	• Desenha, em conjunto com o ICNF, I. P., mosaicos agrícolas e alinhamento da decisão de apoios em função de serviços de prevenção de incêndios, dada escala, morfologia da mancha e tipo de cultura	• Participa nos projetos de redimensionamento da propriedade rural e no melhor conhecimento sobre a mesma • Participa, em conjunto com o ICNF, I. P., na sensibilização de agricultores e pastores para as boas práticas na eliminação de sobrantes e uso do fogo de gestão	• Gestão de combustível, novas paisagens e práticas de valorização do território			• Participa no inventário e no apoio aos agricultores, proprietários fundiários e pastores, no apoio à emergência e à recuperação

Annex B – Map of actors in Serra de Monchique (Case study)

n#	SNA-ID	Entities	Category	Scale
1	AGIF	Agência para a Gestão Integrada de Fogos Rurais - AGIF	State / Public agencies	National
2	ICNF	Instituto da Conservação da Natureza e das Florestas - ICNF	State / Public agencies	National
3	ANEPC	Comando Regional de Emergência e Proteção Civil do Algarve - CREPC	State / Public agencies	National
4	GNR	Guarda Nacional Republicana - GNR / SEPNA / UEPS	State / Public agencies	National
5	FFAA	Estado-Maior-General das Forças Armadas	State / Public agencies	National
6	IPMA	Instituto Português do Mar e da Atmosfera - IPMA	State / Public agencies	National
7	DGT	Direção Geral do Território - DGT	State / Public agencies	National
8	DGADR	Direção Geral de Agricultura e Desenvolvimento Rural - DGADR	State / Public agencies	National
9	DRAPA	Direção Regional de Agricultura e Pescas do Algarve - DRAPA	State / Public agencies	Regional
10	CCDR	Comissão de Coordenação e Desenvolvimento Regional do Algarve	State / Public agencies	Regional
11	ABVM	Associação dos Bombeiros Voluntários de Monchique - ABVM	Third sector / Associations	Local
12	CMM	Câmara Municipal de Monchique	State / Public agencies	Local
13	JFMO	Junta de Freguesia de Monchique	State / Public agencies	Local
14	JFAL	Junta de Freguesia de Alferce	State / Public agencies	Local
15	JFME	Junta de Freguesia de Marmelete	State / Public agencies	Local
16	AFOC	Agrupamento de Empresas Florestais - AFOCELCA	Market / Business	National
17	ISA	Insituto Superior de Agronomia - ISA / Centro de Estudos Florestais - CEF	State / Public agencies	National
18	GEOTA	Grupo de Estudos de Ordenamento do Território e Ambiente - GEOTA	Third sector / Associations	National
19	AMAL	Comunidade Intermunicipal do Algarve - AMAL	State / Public agencies	Regional
20	ASPAF	Associação dos Produtores Florestais do Barlavento Algarvio - ASPAFLOBAL	Third sector / Associations	Regional
21	COOPM	Cooperativa Agrícola do Concelho de Monchique - COOPACHIQUE	Third sector / Associations	Regional
22	ASSMA	Associação Monchique Alerta	Third sector / Associations	Local
23	NTAA	Associação Ambiental - A Nossa Terra	Third sector / Associations	Local
24	CELPA	CELPA – Associação da Indústria Papeleira	Third sector / Associations	National
25	NAVCO	The Navigator Company	Market / Business	National
26	ALTRIF	Altriflorestal	Market / Business	National

27	EGLON	EGLON-TIMBERS	Market / Business	National
28	EREDES	E-Redes Distribuição SA	Market / Business	National
29	REN	Rede Elétrica Nacional - REN	Market / Business	National

Annex C – Models of the questionnaires applied in the case study

Análise de Rede de Atores – Incêndios florestais em Monchique

- Organizações -

Este é um questionário para a investigação "Análise da rede de atores e co-gestão adaptativa aos incêndios florestais: um estudo de caso da Serra de Monchique" destinado às organizações que integram o Sistema Nacional de Gestão Integrada de Fogos Rurais (SNGIFR), estabelecido pelo Decreto-Lei nº 82/2021, de 13 de outubro. A investigação é desenvolvida no âmbito da Dissertação do Mestrado em Ordenamento do Território e Urbanismo (MOTU) e do Projeto BRIDGE - unir a ciência e as comunidades locais para a redução do risco de incêndios florestais (PCIF/AGT/0072/2019), financiado pela Fundação para a Ciência e a Tecnologia (FCT).

A investigação visa identificar a estrutura da rede de atores de Monchique (entidades e proprietários rurais) e analisar a dinâmica de interações, de colaboração e de fluxos de informações e conhecimentos dentro da rede com foco no tema incêndios florestais. Com os resultados, procura-se analisar quais aspetos da estrutura e da dinâmica da rede de atores do SNGIFR contribuem, ou por outro lado restringem, a atuação de redes colaborativas para fortalecer a capacidade adaptativa aos incêndios florestais.

A sua participação é muito importante. Destaca-se que, embora seja solicitada a identificação do respondente para possibilitar uma análise da rede de atores, será atribuído um código a cada questionário que garante o anonimato e confidencialidade das informações fornecidas, sendo estes dados utilizados exclusivamente para os fins da presente investigação.

Para eventuais esclarecimentos ou informações adicionais, coloco-me à disposição através do e-mail: guilherme.saad@tecnico.ulisboa.pt ou do telefone: 916 062 217.

Tempo aproximado de duração: 10 minutos.

Por favor, antes de iniciar sua participação nesta investigação é necessário o seu consentimento.

Declaro ter lido e compreendido o intuito da investigação e aceito participar no estudo. Desta forma, permito a utilização dos meus dados para efeitos da presente investigação e com a garantia de confidencialidade e anonimato indicadas pelo investigador.

- ☐ Sim
- ☐ Não

---

1. Nome da organização:

_____

_____

2. Nome do respondente:

_____

_____

3. Cargo do respondente na organização:

_____

4. Em que categoria a seguir se enquadra a sua organização:

- ☐ Setor público (governo, agência pública, …)
- ☐ Terceiro setor (associação, cooperativa, ONG, …)
- ☐ Setor privado (empresa)
- ☐ Outro:

  _____

  _

5. Qual é a abrangência de atuação da sua Organização:

- ☐ Nacional
- ☐ Regional
- ☐ Sub-regional / Intermunicipal
- ☐ Local

6. Conforme o Sistema Nacional de Gestão Integrada de Fogos Rurais (SNGIFR), em quais fases a sua organização atua e/ou possui competência para intervir no tema incêndios florestais?
(selecione todas as opções válidas)

- ☐ Planeamento de diretrizes e estratégias para a gestão integrada de incêndios florestais
- ☐ Prevenção de incêndios florestais a partir da execução de projetos e ações
- ☐ Supressão do fogo e/ou socorro durante eventos de incêndios florestais
- ☐ Pós-evento e recuperação de áreas ardidas em incêndios florestais

7. Indique nos quadros a seguir com que outras organizações possui interações, tais como partilha de informação e conhecimentos e/ou ações conjuntas, com foco no tema incêndios florestais.
(considere 0 não interage, 1 baixa interação, 2 média interação, 3 alta interação)

7.1. Organizações do setor público (governo, agências públicas):

Lista de organizações do setor público	**Possui interação com …**			
	0 Não interage	**1** Baixa interação	**2** Média interação	**3** Alta interação
Agência para a Gestão Integrada de Fogos Rurais (AGIF)	( )	( )	( )	( )
Instituto da Conservação da Natureza e das Florestas (ICNF) / Direção Regional Algarve (ICNF Algarve)	( )	( )	( )	( )
Autoridade Nacional de Emergência e Proteção Civil (ANEPC) / Comando Regional de Emergência e Proteção Civil do Algarve (CREPC)	( )	( )	( )	( )
Guarda Nacional Republicana (GNR) / Serviço de Proteção da Natureza e do Ambiente (SEPNA)	( )	( )	( )	( )
Instituto Português do Mar e da Atmosfera (IPMA)	( )	( )	( )	( )
Forças Armadas (FFAA)	( )	( )	( )	( )
Direção Geral do Território (DGT)	( )	( )	( )	( )
Comissão de Coordenação e Desenvolvimento Regional do Algarve (CCDR Algarve)	( )	( )	( )	( )
Comunidade Intermunicipal do Algarve (AMAL)	( )	( )	( )	( )
Direção Geral de Agricultura e Desenvolvimento Rural (DGADR)	( )	( )	( )	( )
Direção Regional de Agricultura e Pescas do Algarve (DRAPA)	( )	( )	( )	( )
Câmara Municipal de Monchique (CMM)	( )	( )	( )	( )
Junta de Freguesia de Monchique (JF Monchique)	( )	( )	( )	( )

Lista de organizações do setor público	Possui interação com …			
	0 Não interage	**1** Baixa interação	**2** Média interação	**3** Alta interação
Junta de Freguesia de Alferce (JF Alferce)	( )	( )	( )	( )
Junta de Freguesia de Marmelete (JF Marmelete)	( )	( )	( )	( )

7.2. Organizações do terceiro setor (associações, cooperativas, ONGs …)

Lista de organizações do terceiro setor	Possui interação com …			
	0 Não interage	**1** Baixa interação	**2** Média interação	**3** Alta interação
Associação dos Bombeiros Voluntários de Monchique (ABVM)	( )	( )	( )	( )
Instituto Superior de Agronomia (ISA) / Centro de Estudos Florestais (CEF)	( )	( )	( )	( )
Grupo de Estudos de Ordenamento do Território e Ambiente (GEOTA)	( )	( )	( )	( )
Associação dos Produtores Florestais do Barlavento Algarvio (ASPAFLOBAL)	( )	( )	( )	( )
Cooperativa Agrícola do Concelho de Monchique (COOPACHIQUE)	( )	( )	( )	( )
Associação Monchique Alerta	( )	( )	( )	( )
A Nossa Terra Associação Ambiental	( )	( )	( )	( )
Agrupamento de Empresas Florestais (AFOCELCA)	( )	( )	( )	( )
Associação da Industria Papeleira (CELPA)	( )	( )	( )	( )

7.3. Organizações do setor privado (empresas)

Lista de organizações do setor privado	Possui interação com …			
	0 Não interage	**1** Baixa interação	**2** Média interação	**3** Alta interação
The Navigator Company	( )	( )	( )	( )
Iberflorestal - Comércio e Serviços Florestais SA	( )	( )	( )	( )
Altri Florestal SA	( )	( )	( )	( )
Eglon Timbers SA	( )	( )	( )	( )
EDP Distribuição SA	( )	( )	( )	( )
Redes Energéticas Nacionais (REN)	( )	( )	( )	( )

8. Possui interações com outras organizações do setor público, terceiro setor e/ou setor privado no tema incêndios florestais não listadas nos quadros acima? Se sim, indique abaixo:

Lista de Organizações	Possui interação com …			
	0 Não interage	**1** Baixa interação	**2** Média interação	**3** Alta interação
	( )	( )	( )	( )
	( )	( )	( )	( )
	( )	( )	( )	( )
	( )	( )	( )	( )

Agradecemos a sua participação.

Análise de Rede de Atores – Incêndios florestais em Monchique

- Proprietários Rurais -

Este é um questionário para a investigação "Análise da rede de atores e co-gestão adaptativa aos incêndios florestais: um estudo de caso da Serra de Monchique" destinado aos proprietários rurais do município de Monchique. A investigação é desenvolvida no âmbito da Dissertação do Mestrado em Ordenamento do Território e Urbanismo (MOTU) e do Projeto BRIDGE - unir a ciência e as comunidades locais para a redução do risco de incêndios florestais (PCIF/AGT/0072/2019), financiado pela Fundação para a Ciência e a Tecnologia (FCT).

A investigação visa identificar a estrutura da rede de atores de Monchique (entidades e proprietários rurais) e analisar a dinâmica de interações, de colaboração e de fluxos de informações e conhecimentos dentro da rede com foco no tema incêndios florestais. Com os resultados, procura-se analisar quais aspetos da estrutura e da dinâmica da rede de atores contribuem, ou por outro lado restringem, a atuação de redes colaborativas para fortalecer a capacidade adaptativa aos incêndios florestais.

A sua participação é muito importante. Destaca-se que, embora seja solicitada a identificação do respondente para possibilitar uma análise da rede de atores, será atribuído um código a cada questionário que garante o anonimato e confidencialidade das informações fornecidas, sendo estes dados utilizados exclusivamente para os fins da presente investigação.

Para eventuais esclarecimentos ou informações adicionais, coloco-me à disposição através do e-mail: guilherme.saad@tecnico.ulisboa.pt ou do telefone: 916 062 217.

Tempo aproximado de duração: 10 minutos.

Por favor, antes de iniciar sua participação nesta investigação é necessário o seu consentimento.

Declaro ter lido e compreendido o intuito da investigação e aceito participar no estudo. Desta forma, permito a utilização dos meus dados para efeitos da presente investigação e com a garantia de confidencialidade e anonimato indicadas pelo investigador.

- □ Sim
- □ Não

---

1. Nome do proprietário rural:

_____

2. Morada do proprietário rural (Concelho e Freguesia):

_____

3. Gênero do proprietário rural: □ Masculino □ Feminino □ Prefiro não dizer

4. Idade do proprietário rural: _____

5. Nacionalidade do proprietário rural: _____

6. É membro de alguma Entidade (selecione todas as opções válidas):

- ☐ Associação dos Produtores Florestais do Barlavento Algarvio (Aspaflobal)
- ☐ Cooperativa Agrícola do Concelho de Monchique (Coopachique)
- ☐ Associação Monchique Alerta
- ☐ Não sou membro de nenhuma entidade
- ☐ Outra:

  _____
  _

7. Onde localiza-se a(s) sua(s) propriedade(s) em Monchique? (selecione todas as opções válidas)

- ☐ Freguesia de Monchique
- ☐ Freguesia de Alferce
- ☐ Freguesia de Marmelete

8. Quais são os usos atuais da(s) sua(s) propriedade(s)? (selecione todas as opções válidas)

- ☐ Residencial
- ☐ Produção florestal
- ☐ Produção agrícola e/ou animal
- ☐ Lazer / Veraneio
- ☐ Alojamento / Hotelaria
- ☐ Restauração / Comércio
- ☐ Propriedade sem uso
- ☐ Outra:

  _____
  _

9. Indique até no máximo 5 (cinco) outros proprietários rurais de Monchique com os quais partilha informações e conhecimentos e/ou promove ações conjuntas no tema incêndios florestais: (por favor indicar nome e apelido)

#1. _____

#2. _____

#3. _____

#4. _____

#5. _____

10. Indique nos quadros a seguir com que outras organizações possui interações, tais como partilha de informação e conhecimentos e/ou ações conjuntas, com foco no tema incêndios florestais. (considere SIM – possui interação ou NÃO – não possui interação)

10.1. Organizações do setor público (governo, agências públicas):

Lista de organizações do setor público	Possui interação?	
	Sim	Não
Agência para a Gestão Integrada de Fogos Rurais (AGIF)	( )	( )
Instituto da Conservação da Natureza e das Florestas (ICNF) / Direção Regional Algarve (ICNF Algarve)	( )	( )
Autoridade Nacional de Emergência e Proteção Civil (ANEPC) / Comando Regional de Emergência e Proteção Civil do Algarve (CREPC)	( )	( )
Guarda Nacional Republicana (GNR) / Serviço de Proteção da Natureza e do Ambiente (SEPNA)	( )	( )
Instituto Português do Mar e da Atmosfera (IPMA)	( )	( )
Forças Armadas (FFAA)	( )	( )
Direção Geral do Território (DGT)	( )	( )
Comissão de Coordenação e Desenvolvimento Regional do Algarve (CCDR Algarve)	( )	( )
Comunidade Intermunicipal do Algarve (AMAL)	( )	( )
Direção Geral de Agricultura e Desenvolvimento Rural (DGADR)	( )	( )
Direção Regional de Agricultura e Pescas do Algarve (DRAPA)	( )	( )
Câmara Municipal de Monchique (CMM)	( )	( )
Junta de Freguesia de Monchique (JF Monchique)	( )	( )
Junta de Freguesia de Alferce (JF Alferce)	( )	( )
Junta de Freguesia de Marmelete (JF Marmelete)	( )	( )

10.2. Organizações do terceiro setor (associações, cooperativas, ONGs …)

Lista de organizações do terceiro setor	Possui interação?	
	Sim	Sim
Associação dos Bombeiros Voluntários de Monchique (ABVM)	( )	( )
Instituto Superior de Agronomia (ISA) / Centro de Estudos Florestais (CEF)	( )	( )
Grupo de Estudos de Ordenamento do Território e Ambiente (GEOTA)	( )	( )
Associação dos Produtores Florestais do Barlavento Algarvio (ASPAFLOBAL)	( )	( )
Cooperativa Agrícola do Concelho de Monchique (COOPACHIQUE)	( )	( )
Associação Monchique Alerta	( )	( )

Lista de organizações do terceiro setor	Possui interação?	
	Sim	Sim
A Nossa Terra Associação Ambiental	( )	( )
Agrupamento de Empresas Florestais (AFOCELCA)	( )	( )
Associação da Industria Papeleira (CELPA)	( )	( )

10.3. Organizações do setor privado (empresas)

Lista de organizações do setor privado	Possui interação?	
	Sim	Sim
The Navigator Company	( )	( )
Iberflorestal - Comércio e Serviços Florestais SA	( )	( )
Altri Florestal SA	( )	( )
Eglon Timbers SA	( )	( )
EDP Distribuição SA	( )	( )
Redes Energéticas Nacionais (REN)	( )	( )

11. Possui interações com outras organizações do setor público, terceiro setor e/ou setor privado no tema incêndios florestais não listadas nos quadros acima? Se sim, indique abaixo:

Lista de Organizações	Possui interação?	
	Sim	Sim
	( )	( )
	( )	( )
	( )	( )
	( )	( )

Agradecemos a sua participação.

Annex D – Network interactions Matrix

	AGIF	ICNF	ANEPC	GNR	IPMA	FFAA	DGT	CCDR	AMAL	DGADR	DRAPA	CMMO	JFMO	JFAL	JFME	ABVM	ISA	GEOTA	ASPAF	COOPM	ASSMA	NTAA	AFOC	CELPA	NAVCO	ALTRIF	EGLON	EREDES	REN
AGIF	0	3	3	3	1	2	1	3	3	0	3	3	0	0	0	2	1	0	3	0	0	0	2	2	2	2	0	2	1
ICNF	3	0	3	3	2	3	3	2	3	1	2	3	2	2	2	1	1	1	2	2	1	1	3	1	2	2	2	2	2
ANEPC	3	3	0	3	2	2	1	3	3	2	2	2	2	1	1	3	0	2	1	1	0	0	2	2	1	1	1	2	2
GNR	0	1	1	0	1	1	1	1	1	1	1	3	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
IPMA	3	3	3	2	0	2	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	1
FFAA	3	3	3	3	3	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
DGT	2	2	0	0	0	0	0	1	0	1	0	2	1	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
CCDR	3	3	3	3	2	2	3	0	3	2	3	3	2	2	2	0	1	1	1	1	1	1	1	1	1	1	1	2	2
AMAL	3	2	2	1	0	1	0	1	0	0	0	3	0	0	0	1	1	0	2	0	0	0	0	1	0	0	0	2	2
DGADR	1	1	1	1	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DRAPA	3	3	1	3	1	1	1	3	3	3	0	2	1	1	1	1	1	1	1	1	1	2	1	1	0	0	0	1	1
CMMO	2	2	2	2	1	1	1	0	2	0	0	0	2	2	2	3	0	1	3	1	0	1	2	0	1	1	1	1	1
JFMO	2	3	3	3	2	2	2	3	3	2	2	3	0	3	3	3	2	2	3	2	1	2	2	2	2	1	1	2	2
JFAL	1	2	3	2	1	1	0	2	1	1	2	3	3	0	3	3	0	2	2	2	1	1	3	2	3	3	0	1	1
JFME	0	0	2	1	0	0	0	2	2	1	0	3	3	3	0	3	0	0	1	1	0	0	1	0	0	0	0	1	1
ABVM	1	1	3	2	2	1	0	0	0	0	0	3	3	3	3	0	0	0	2	2	1	0	2	0	2	2	1	1	1
ISA	2	2	2	1	1	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
GEOTA	1	3	1	1	1	0	2	2	1	0	0	3	3	3	0	1	1	0	3	1	3	2	0	0	2	2	1	1	0
ASPAF	3	3	1	0	0	0	1	0	3	0	0	3	1	2	1	3	1	1	0	1	0	1	2	2	3	3	2	2	2
COOPM	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	2	0	2	2	1	1	1	1	1	1	1
ASSMA	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	2	0	2	0	2	0	0	0	0	0	0	0	0	1
NTAA	0	0	0	1	0	0	0	1	0	0	0	2	1	2	1	1	0	2	2	2	1	0	0	0	0	0	0	0	0
AFOC	2	2	3	2	1	1	0	0	1	0	0	1	0	0	0	1	2	0	0	0	0	0	0	2	3	3	0	0	1
CELPA	3	2	1	0	0	0	2	1	1	1	1	1	1	1	1	0	3	1	2	1	0	0	3	0	3	3	1	1	1
NAVCO	2	3	3	1	0	1	0	1	1	1	0	3	3	3	3	3	2	1	3	0	0	0	3	3	0	3	1	3	3
ALTRIF	1	3	3	2	0	0	1	2	0	2	2	2	1	2	1	1	2	2	2	0	0	0	3	2	2	0	1	1	1
EGLON	1	2	0	0	0	0	1	1	0	1	1	1	0	0	0	0	1	0	1	0	0	0	1	1	1	1	0	1	1
EREDES	2	2	2	1	0	0	0	1	2	1	1	3	1	1	1	1	1	0	1	0	0	0	1	1	1	1	0	0	1
REN	1	2	2	2	2	1	1	1	2	1	2	2	1	1	1	2	2	1	1	1	1	1	1	1	2	1	1	2	0
PN01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PN02	0	1	1	1	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0
PN03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
PN04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PN05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PN06	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1
PN07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PN08	1	1	1	0	1	0	1	1	0	1	1	1	1	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0	0
PN09	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
PN10	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
PN11	0	1	1	1	0	0	0	1	0	0	0	1	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0	1	1
PN12	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0	1	0	1	1	1	0	0
PN13	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1

PN14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1
PN15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PN16	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
PE01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
PE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
PE04	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
PE05	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1
PE06	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0
PE07	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1
PE08	0	1	0	1	1	0	0	0	0	0	1	1	1	0	0	1	0	1	0	1	1	1	0	0	0	0	0	1	0