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Concurso de Projetos Exploratórios em Todos os Domínios Científicos 2023

2023.12456.PEX

Estado

Submetida

Submetida em

01.03.2024 12h40 GMT

Dados gerais

Investigador responsável

Akli Benali

Título do projeto em português

Decifrando o comportamento do fogo para melhorar a tomada de decisão usando uma abordagem inovadora de hackathon

Título do projeto em inglês

Deciphering wildfire behavior to improve operational decision-making using an innovative hackathon approach

Acrónimo do projeto

FIRE-HACK

Palavras-chave em português

machine learning | modelação | impactos pós-fogo | incêndios

Palavras-chave em inglês

machine learning | modelling | post-fire impacts | wildfires

Área científica principal

Domínio científico

Ciências Agrárias

Área científica

Agricultura, Silvicultura e Pescas

Subárea científica

Silvicultura

Painel de avaliação

Agriculture, Forestry and Fisheries

Calendarização

Data de início

01.01.2025

Duração (meses)

15

Instituições

Instituição proponente

Instituição	Unidade de I&D
Universidade de Lisboa (UL) - Instituto Superior de Agronomia	→ Universidade de Lisboa (UL) - Instituto Superior de Agronomia - Centro de Estudos Florestais

Descrição da instituição e respetivas competências para o desenvolvimento do projeto

Instituto Superior de Agronomia (ISA) belongs to the University of Lisbon. ISA's mission is Higher Education, Research & Development, and Technology Transfer in the scientific fields of Agriculture, Forestry and Natural Resources Engineering, Food Science and Engineering, Animal Production Engineering, Environmental Engineering, Biology, and Landscape Architecture. ISA has about 1634 undergraduate, master and PhD students. The 124 Professors and 71 Researchers are PhD with scientific work published in international journals, books, conferences. ISA is involved in 130 R&D projects (53 international, leading partner of 4 international and 32 national), financed by EC and national funds. ISA is also involved in projects of Technology Transfer. ISA hosts 3 recognized scientific research centres. The Forest Research Centre (CEF) for the integrated research of forestry and related ecosystems, forestry products and forest related service. The Centre for Linking landscape, Environment, Agriculture and Food (LEAF) for the research of entire Agro-Food chain aiming the conservation of natural resources and the production and food quality. The Centre for Applied Ecology "Prof Baeta Neves" (CEABN), an integrated research unit with InBIO (Associate Lab, FCT), in partnership with CIBIO, for the research in applied ecology to forest and agricultural ecosystems, contributing to sustainable management and use of soil. Administrative staff and a project support team support activities.

Instituições de colaboração

-

Equipa de investigação

Investigador responsável

Akli Benali Nuclear IR

Ciência ID
9614-439A-49AE

Instituição à qual está associado no âmbito do projeto de investigação
Instituto Superior de Agronomia

CV
Obtido em 22-02-2024 at 15:36:21 GMT

CV narrativo do IR

Percurso Científico e Curricular

I hold a **MSc in Environmental Resources Management** and started my research career in 2008 at the Faculty of Science and Technology (New Univ. Lisbon). I worked on topics such as soil erosion, vegetation dynamics and vector-borne diseases. This period was very important to develop my generic research skills, including statistical modeling and remote sensing.

In 2011, I moved to the School of Agriculture (Univ. of Lisbon) to work on wildfires. I gained experience on national and international projects, and posteriorly completed the **PhD in Sustainable Forests and Products** (2015-2018). This period was important to deepen my knowledge on wildfires, specially on remote sensing and fire behavior modeling.

I participated in the **FIRE-MODSATII projec**t that designed an operational wildfire behavior prediction system (2019-2022). I integrated the **National Decision Support Unit for Wildfire Analysis** of the National Authority for Emergency and Civil Protection and provided support to incident command posts of several large wildfires (2019-2023). This experience improved my knowledge on fire behavior and suppression strategies, and helped me to better identify the information required to support decision-making.

Since 2021, I am a **Junior Researcher** funded by FCT with a work plan focused on: i) improving fire risk assessment; ii) supporting safer and more effective suppression strategies; iii) improving post-fire impact estimation; iv) disseminating fire research outcomes to society. I **coordinated a diverse team of experts** in the “Alvares - a case of resilience to fire” (2017/2018) and the “Pilot implementation of the National Plan for Integrated Wildland Fire Management” projects (2022/2023).

I am a licensed fire suppression technician (see Annexes) and currently I am completing the prescribed burning accreditation. Both are very important to have a better understanding on fire behavior and better target research efforts to meet operational needs.

Contribuições para a Ciência e a Sociedade

Contribuições da originalidade de ideias, ferramentas, metodologias ou conhecimento

Three major contributions are highlighted:

1. Eliminating wildfires is unrealistic. Thus, it is essential to manage the landscape to minimize the occurrence of intense and impactful wildfires. However, this concept is still not fully integrated in landscape and fire management. I have contributed with methodologies and knowledge, that set **“fire behavior” as a central element of fire management,** such as: understand how different prevention strategies can reduce burned area [1,2], assess fire risk in the human settlements [3,4] and estimate the impact of wildfires in forest economic revenues [5,6]. Focusing on potential fire behavior is necessary to change the current management paradigm.
2. Observations on wildfire behavior are crucial to move the body of knowledge forward. I conceptualized and designed a novel, o**pen-access, wildfire spread and behavior database for Portugal (PT-FireSprd),** that significantly expands extant information [7]. It has a large potential to improve current knowledge and contribute to significant progress on operational fire management and will be FIRE-HACK’s cornerstone.
3. The definition of effective suppression strategies require information useful to anticipate wildfire behavior. I led the **development of a fire spread prediction system** that has been used to **support operational decision-making** in large wildfires both in the National Decision Support Unit for Wildfire Analysis of the National Authority for Emergency and Civil Protection and on the field. The simulation system was calibrated using

extensive PT-FireSprd observations [7]. It provides probabilistic predictions of potential fire behavior by integrating uncertainty in the main input variables [8]. Meaningful model outputs were co-designed with firefighters.

These contributions have had a relevant impact and benefited a **large number of stakeholders,** such as: government agencies, fire fighters, forest associations, landowners, pulp-paper industry, municipalities and other researchers.

Contribuições para o desenvolvimento de competências ao nível individual e/ou em equipas

I have **participated in several national and international projects**, with different roles. In the FORESTER, FRISCO and FUEL-SAT research projects I have contributed with my expertise in wildfires, modeling and remote sensing. In the aftermath of the dramatic 2017 wildfire season, I **coordinated a multidisciplinary team** of experts in the "Alvares - a case of resilience to fire" project that developed science-based proposals for a resilient landscape (2017/2018). In 2022/2023, I **coordinated a multidisciplinary team** that helped the Agency for Integrated Rural Fire Management (AGIF) in the "Pilot implementation of the National Plan for Integrated Wildland Fire Management", funded by DG Reform (EC). The successful coordination of these two consulting projects was possible due to a set of **relevant skills**, such as: leadership, ability to see the bigger picture, and capacity of integrating multidisciplinary inputs from different team elements.

The FIRE-MODSATII project (2019-2022) had a rich and tight collaboration with fire operatives that has lasted up to today. Collaborating with the National Decision Support Unit for Wildfire Analysis showed that the integration of scientific knowledge and tools in operational contexts contributes to **improved decision-making**. Outside of the fire season, I provided **training to fire operatives**, mostly in fire spread simulation and remote sensing, that has been included in internal accreditation (Annexes). Overall,this interaction has contributed to improve myself as a researcher, but also, I strongly believe that I have contributed to improve many fire operatives. In this context, it is crucial to be able to harmonize the communication between practice and science, which is very different in many ways. These skills are essential to foster **effective knowledge transfer**, but most importantly, **effective co-creation processes**.

Besides fire operatives, I have provided **training to forest technicians** of over 30 municipalities (Annexes) in topics such as fire behavior, simulation and fuel management optimization. Overall, interactions with practitioners have been extremely important to guide my research objectives to answer practical and useful questions.

I am currently **supervising one Phd and two MSc students** (which are fire operatives). I believe my technical expertises, but also my full availability and experience, has helped these students to develop their work according to high standards.

Finally, I was deeply involved in the creation of the **COST action "**european Network on Extreme fiRe behaviOr (NERO)" (2023-ongoing). NERO is an excellent opportunity to bridge scientists and practitioners around the topic of extreme fire behavior at an european and pan-european level. As a **vice-chair**, I believe that my expertise in fire behavior, but most importantly, my capacity to bridge practitioners and researchers will be essential to the success of NERO.

Contribuições para a Comunidade Científica e para a Sociedade

The contributions to the **research community** include:

- **Papers**: I have published several papers in relevant peer-reviewed journals in the topics of landscape management [1,2], fire risk assessment [3,4,6], fire behavior [7,8] and fire impacts [9,10,11];
- **Key datasets**: acknowledging the existence of critical data gaps required to better understand the drivers of fire behavior and its impacts, I have made a significant effort to build relevant open-access datasets. These have covered the characterization of fuel models [12] and live moisture content [13], observed fire behavior [7] and burn severity [9]. These datasets will be essential for FIRE-HACK;
- **Open-access packages**: to implement faster and better calibration of fire spread modelling systems [14]
- **Science Communication**: I co-created in 2016 a highly attended monthly event entitled 'Coffee with Science' that aims to disseminate and discuss the work produced in my Research Center;
- **Paper review** and scientific **dissemination** in conferences.

The contributions to a **broader society** include:

- Development of science-based **proposals to improve the resilience of a fire-prone area** in the center of Portugal (Alvares) (2017-2018) [15]. It had the involvement of academia, government agencies, forest companies and associations and landowners. The work was considered a good reference in terms of good practices to reduce vulnerability to wildfires in similar areas of the country. We followed-up the work in subsequent years, providing the support to local stakeholders to set up an Integrated Landscape Management Area;
- Organized a **workshop** entitled "Disruptive Business Models for Forest Protection and Valuation" (2019) that joined a very diverse group of stakeholders to discuss the main problems of the rural areas in Portugal and identify potential solutions;
- **Practical hand-book** with good practices for managing water resources in fire-prone watersheds in Portugal [16];
- The creation of **web-platform to disseminate scientific datasets** to researchers, fire operatives, forest and land managers, and other relevant stakeholders (https://pccir.isa.ulisboa.pt/). The platform is under development;
- **Extensive training** of fire operatives and forest technicians on topics such as, remote sensing, fire behavior, fire spread modeling and fuel management optimization (Annexes);
- The integration in the **National Decision Support Unit for Wildfire Analysis** and operational support in the **field** during large wildfires (2019-2023). This is most likely my most important contribution to society because it is a tangible example of scientific knowledge and tools being

applied to improve real decision-making. In the next two years, I will integrate the simulation system developed in FIRE-MODSATII in the operational systems of the National Authority of Civil Protection.

Resultados ou/e atividades relevantes

The following activities best describe my research career and experience:

1. Following the “Alvares” project, I published several **papers** [1,2,3,5,6] that focused on **improving landscape management** by integrating information on fire behavior and fire regime. The papers developed a set of innovative methodologies based on simulation tools that enable probabilistic and scenario analysis. This work is helping to change how fire and landscape management is done in fire-prone areas of Portugal. I had a central role in the conceptualization, implementation and analysis of this approach.
2. Based on the collaboration with the National Authority of Emergency and Civil Protection and its fire operatives, I conceptualized and designed a **novel, open-access, wildfire spread and behavior database for Portugal** (PT-FireSprd) [7]. It characterizes key fire behavior descriptors (e.g. rate of spread) based on detailed fire progression that was mapped by combining multiple sources of data, including airborne, remote sensing and field data. PT-FireSprd has a large potential to improve scientific knowledge and operational fire management.
3. I have developed a **fire spread prediction system** that has been used to support operational decision-making in large wildfires both in the National Decision Support Unit for Wildfire Analysis as well as on the field [8]. The simulation system provides probabilistic predictions of potential fire behavior in the following hours, by integrating uncertainty in the main input variables. The associated papers are under preparation, but decisions have been shaped by the simulation outputs.
4. The 2017 fire season led to an unprecedented large number of fatalities and damages, stressing the importance of ensuring the safety of people and assets from high intensity wildfires. Based on a previous work [3], I led the development of a novel methodology that estimates **fire risk in settlements** based on potential fire behavior and vulnerability data [4]. The paper also showed that current risk mitigation actions cover a very small fraction of the high-risk settlements. In the future, this work can be used to guide the implementation of appropriate mitigation measures.
5. Finally, I have developed work to improve our understanding of **wildfire impacts** in several domains, such as forest revenues [5], water quality [16], soil erosion [10,11], and severity in soil and vegetation [9].

Que relevância atribui a este financiamento para a fase atual da sua carreira e/ou do seu percurso de investigação?

FIRE-HACK **follows two important steps** of my career:

- The **FIRE-MODSAT II project** (2019-2023) that personally enhanced my fire behavior and analysis skills, and socially integrated scientific information in fire suppression decision-making. It has contributed to increase my operational knowledge and have clearer understanding of what information is necessary in practice.
- The **Junior Researcher contract** (2021-ongoing) that aims at i) improving fire risk assessment; ii) supporting safer and effective suppression strategies; iii) improving post-fire impact estimation; iv) disseminating fire research outcomes to society.

FIRE-HACK will move forward the body of scientific knowledge on fire behavior drivers and impacts. Taking into account that fire behavior is a central and key element of prevention, suppression and post-fire management, improving knowledge on fire behavior drivers and impacts will surely foster a wide variety of additional **future research and attract new funding**.

Regarding the operational side, FIRE-HACK will focus on areas where better and more **practical knowledge** is required to improve decision-making. Considering the tight collaborations I have established with stakeholders, which have contributed to define FIRE-HACK’s main goals, the **potential of integrating the knowledge** attained in this project is exceptionally high. This will, for example, contribute to improve operational capacities (e.g. training) and guide the development of enhanced products, which together will certainly contribute to improve decision-making.

Although I have had the opportunity to lead consultancy projects and apply project management tools, FIRE-HACK will provide me the **unique experience of leading a research project**. This will surely improve my professional skills, particularly management capacity. This will also be an opportunity to train operatives and young researchers and contribute to development of their skills.

Finally, the **ongoing COST action** “european Network on Extreme fiRe behaviOr (NERO)”, that is focused on improving the understanding on extreme fire behavior is perfectly aligned with FIRE-HACK’s objectives. The knowledge and tools created in NERO and FIRE-HACK will be complementary. NERO opens the door to international collaboration, with highly valuable research and operative members, while FIRE-HACK will provide the necessary means to investigate the fundamentals of fire behavior and impacts. Both projects will significantly benefit with the foreseen interactions.

In the future, the knowledge attained in FIRE-HACK will contribute to improve my main work areas: **i)** risk assessment and land management; **ii)** fire behavior and spread prediction, and **iii)** quantification of fire impacts. These are fundamental to improve decision-making in major phases of fire management (prevention, suppression and post-fire restoration and recovery).

Membros

José Miguel Oliveira Cardoso Pereira	Nuclear	Membro

Associação
Confirmada

Ciência ID
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Obtido em 23-02-2024 at 21:05:55 GMT

Manuel Lameiras de Figueiredo Campagnolo Nuclear Membro

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CV
Obtido em 17-01-2024 at 13:42:26 GMT

Rui Figueira Nuclear Membro

Associação
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CV
Obtido em 22-01-2024 at 13:27:04 GMT

Novas contratações

(BI-a - 01) Bolsa de Investigação - Estud. dout. ou lic. e mestres em CNCG

Instituição
Instituto Superior de Agronomia

Tarefas
Assembling the fire behavior and environmental surrogates database · 1 pessoa * mês
Determining the key fire behavior drivers · 3.75 pessoa * mês
Dissemination and Outreach · 2.75 pessoa * mês
Identifying the links between fire behavior and its impacts · 3.75 pessoa * mês

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Consultores

Paulo Fernandes

Associação
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CV
Obtido em 19-01-2024 at 12:06:36 GMT

Enquadramento da sua participação no projeto

Paulo Fernandes is a wildfire researcher with an exceptional publication record in fire behavior, fire management and burn severity (among other fire-related topics). In addition, Paulo Fernandes has created dissemination material to improve operational-decision making focused on wildfire behavior and its main drivers (weather and fuels).

Fábio Silva

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CV
Obtido em 23-01-2024 at 21:02:08 GMT

Enquadramento da sua participação no projeto

Fábio Silva has more than 20 years of operacional experience in wildfires. He was the National Operations Responsible for the Special Force of Civil Protection and head of a specialized fire analysis and suppression unit. He has extensive operational experience and knowledge on fire behavior and fire supression strategies\tactics. He has co-authored research papers, participated in task forces in Chile, Spain and Canada. He was an expert consultant of the European Civil Protection Mechanism in 2023's Chile fire season. Fábio Silva has important skills to help better understand the fire behavior drivers, the main factors that affect fire suppression effectiveness, as well as, help translate FIRE-HACKs outcomes in the most effective way to integrate operational decision-making.

Sinopse do cv da equipa

FIRE-HACK will improve knowledge regarding i) the key **drivers of wildfire behavior** and ii) **wildfire behavior effects** on suppression effectiveness and soil-vegetation burn severity (i.e impacts). These questions rise from literature review, as well as inputs provided by fire operatives following previous and on-going collaborations. FIRE-HACK will move both the body of knowledge and practice forward by using an **innovative Hackathon approach**. The team will be composed by Akli Benali (AB), José M.C. Pereira (JMCP), Manuel Campagnolo and Rui Figueira (RF), supported by the experienced consultants Paulo Fernandes (PF) and Fábio Silva (FS).

The team has the required competencies to tackle FIRE-HACK's main challenges that result from extensive experience in wildfire research. Particularly, in the last effective five years the team has published **relevant work on essential topics for FIRE-HACK** such as:

- **Fire behavior:** with particular emphasis on the creation of the novel Portuguese fire spread database [7], fire behavior modeling [1,2,3,4,6,8,14,17], and significant operational experience in wildfire analysis (see Narrative CV);
- **Wildfire impacts**: on different components, such as forest economic revenues [5,6], safety of human settlements [3,4], soil-vegetation severity [9], soil erosion [10,11] and water quality [16].

The team has developed **core datasets** on fire spread and behavior [7], vegetation fuels [12, 13] and burn severity [9] that will be the basis of FIRE-HACK. The team has also worked in **other fire-related topics**, such as fire management and regime [18-24], at diverse spatial scales and contexts. The consultant PF will provide a very significant added value with his extensive knowledge in fire behavior [29,30] and fire impacts [31,32].

FIRE-HACK will benefit from the team's extensive modeling experience that comprise several research papers that used **statistical modeling** [19-28], **machine learning** [33-36] and the combination of both techniques [20,21,37-39]. The team also has experience in combining **statistical modeling with fire behavior simulatio**n [17, 40] and has applied modeling to a wide range of topics, such as remote sensing, wildfires, ecosystem services and biodiversity. The team's modeling skills will be essential in FIRE-HACK to determine the drivers of wildfire behavior and identify the relations between behavior and impacts.

RF (coordinator) and MC are steering committee members of the **Green Data Science (GDS) Master** launched in 2023 in ISA (https://www.isa.ulisboa.pt/ensino/mestrados/mcdaafa/lp/en). The GDS MSc focuses on the application of data science to food production systems, environmental quality management and natural resources. MC teaches “Applied Machine Learning” and “Introduction to Python” following his extensive experience in teaching graduate courses on Statistics, Pattern Recognition, Geographical Information Systems and Algorithms & Programming. RF teaches “Data Management and Storage” and “Data Science Hackathon Project” courses. FIRE-HACK will benefit greatly from being integrated in a suitable academic environment focused on key topics such as data science, advanced modeling and programming, that combines the creativity and innovation of students with the extensive experience of the professors.

FIRE-HACK will follow an innovative approach by using **data science Hackathons** to address its key research questions. Hackathons are known to promote creativity and innovation in a stimulating environment, benefiting from a variety of skills, interests and backgrounds of its participants. RF coordinates the “Data Science Hackathon Project” in the GDS MSc and has participated in other relevant Hackathons focused mainly on biodiversity (e.g. https://www.gbif.org/project/82221/european-training-hackathon-on-species-checklists-using-gbif-datam). Recently, RF, MC and AB organized a Hackathon focused on solving a practical problem associated with the success of wildfires in escaping initial attack. All together, the team has the necessary experience to implement data science Hackathons to tackle the main FIRE-HACK’s objectives.

FIRE-HACK’s team has significant **practical wildfire experience** that will help, not only to address the project’s main research questions, as well as to translate the main findings into operational knowledge. AB has experience in guiding scientific work to answer to ‘real world problems’ and working with practitioners regarding fire prevention, suppression and post-fire recovery (see Narrative CV). AB has integrated the National Decision Support Unit for Wildfire Analysis of the National Authority for Emergency and Civil Protection, as well as incident command posts of several large wildfires. During this period, AB has significantly improved his competences in fire behavior analysis and strategic suppression decision-support. JMCP and PF coordinated a group of experts that analyzed the fire season of 2022, following a request by the Portuguese government [41]. JMCP coordinated projects requested by national authorities regarding the design of fuel breaks, fuel management and vulnerability at the wildland-urban interface level. In addition, FIRE-HACK will benefit from the valuable operational experience of FS, which has more than 25 years of fire fighting, including 10 years as National Operations responsible for the Special Civil Protection Force. FS will contribute with his vast knowledge on fire suppression and practical fire behavior.

Finally, the interactions that the team has had with multiple and diverse stakeholders ensure that scientific work will be guided to **improve practical knowledge and decision-making processes**. Besides the above mentioned experience in fire suppression, the team has recently published a practical hand-book for water managers [16]. FIRE-HACK will benefit from the existing web-platform to disseminate scientific datasets to researchers and practitioners (https://pccir.isa.ulisboa.pt/).

Resumo

Resumo em português

Nos últimos anos, os incêndios têm resultado num número sem precedentes de vítimas mortais e feridos, na destruição de casas e infraestruturas. Apesar da sua relevância, o nosso conhecimento sobre este fenómeno tão complexo ainda é muito limitado. Uma melhor compreensão do comportamento do fogo, ou seja, da forma como um incêndio se inicia e propaga pela paisagem, é de extrema importância para aplicações de investigação e gestão, abrangendo todo o ciclo: mitigação, preparação, resposta e recuperação.

Para promover melhorias significativas na gestão de incêndios, são necessários os seguintes passos chave: i) um conjunto de dados abrangente e de alta qualidade sobre o comportamento do fogo, ii) uma caracterização robusta das relações entre os principais fatores e os impactos do comportamento do fogo e iii) uma disseminação eficaz do conhecimento para os decisores.

Apesar de vários estudos sobre os principais fatores do comportamento do fogo, o conhecimento científico evoluiu muito pouco e, por exemplo, muitos sistemas de modelação de propagação de fogo ainda usam a formulação de Rothermel publicada há mais de 50 anos. Recentemente, Duane et al. (2021) identificaram os principais mecanismos novos incêndios florestais muito intensos e rápidos. No entanto, há ainda uma capacidade limitada de prever a ocorrência e o comportamento de incêndios florestais governados por esses mecanismos, sendo necessários avanços significativos no conhecimento atual e nas ferramentas operacionais.

A forma como um incêndio se propaga e comporta na paisagem está intimamente ligada aos impactos que irá gerar. Compreender quais condições permitem uma supressão de incêndios segura e eficaz é uma prioridade de investigação. No entanto, a identificação dos fatores mais relevantes que determinam a eficácia da supressão e as janelas de supressão adequadas ainda é muito limitada. Sabe-se também que o comportamento dos incêndios afeta a consequente severidade. Apesar de vários estudos, os mecanismos entre o comportamento do fogo e a severidade ainda não são bem compreendidos, o que limita a qualidade das ações de mitigação e resposta.

Os principais objetivos do FIRE-HACK são melhorar a nossa compreensão atual sobre:

- Os principais fatores que determinam o comportamento dos incêndios florestais e como eles estão relacionados;
- As ligações entre o comportamento dos incêndios florestais e os impactos do fogo, em particular, a eficácia da supressão de incêndios e a severidade.

A equipa possui uma vasta experiência no estudo da gestão de incêndios, comportamento do fogo e impactos pós-incêndio, bem como em modelação com recurso a diferentes técnicas, organização de hackathons de ciência de dados e análise operacional do comportamento dos incêndios florestais. O projeto contará com a participação próxima de especialistas das organizações mais importantes na gestão de incêndios, que, juntamente com dois consultores experientes, contribuirão para a qualidade dos resultados do projeto.

A primeira inovação do FIRE-HACK será a análise de uma base de dados de comportamento de incêndios nova e única, criada pela equipa (PT-FireSprd). A segunda inovação será a implementação de hackathons de ciência de dados para abordar os dois principais objetivos.

A base de dados PT-FireSprd, que contém dados de progressão e comportamento para 80 grandes incêndios ocorridos em Portugal (2015-2021), será o ponto central do FIRE-HACK. Esta será atualizada com novos incêndios florestais (2022-2024), um novo descritor de comportamento do fogo (intensidade) e uma lista abrangente de variáveis ambientais relevantes (T2).

As relações entre os principais descritores do comportamento do fogo e as variáveis ambientais serão estudadas (T3). A relação entre os impactos do fogo e o comportamento será estudada com enfoque em dois sub-problemas: i) quais são os fatores que determinam a eficácia da supressão de incêndios e ii) quais são os fatores que determinam a severidade (T4). Ambas as tarefas serão realizadas usando hackathons, que são uma abordagem inovadora na investigação de incêndios. Os hackathons são excelentes formas de resolver problemas do mundo real, promovendo a criatividade e a inovação. As equipas competirão entre si utilizando técnicas de exploração de dados e modelação adequadas para problemas de ‘big data’.

A Tarefa 5 terá como objetivo disseminar eficazmente o conhecimento, os dados e as ferramentas produzidas no FIRE-HACK para investigadores e operacionais. Estes incluirão: i) a base de dados de comportamento de incêndios atualizada, ii) os modelos desenvolvidos, iii) um manual prático, usando linguagem simples e prática e iv) um vídeo curto. Um seminário final e uma sessão de formação avançada estão previstos para o final do projeto.

Além do grande impacto potencial que o FIRE-HACK pode ter na investigação, pretende-se direcionar o conhecimento adquirido para apoiar uma melhor tomada de decisões e contribuir para avançar tanto o conhecimento científico quanto o operacional.

Resumo em inglês

In recent years, wildfires have led to an unprecedented number of fatalities and injuries, the destruction of houses and infrastructures. Despite its relevance, our knowledge of such complex phenomena is still **very limited**. A better understanding of fire behavior, i.e. the way a burning fire ignites and spreads through the landscape, has paramount importance for research and management applications, covering the entire management cycle: mitigation, preparation, response, and recovery.

To foster significant improvements in fire management, the following key steps are necessary: **i)** a comprehensive **high-quality fire behavior data set**, ii) a robust **characterization of the relations between drivers and impacts** of fire behavior, and iii) an **effective knowledge dissemination** to decision-makers.

Despite several studies regarding the **main drivers of fire behavior**, scientific knowledge has evolved very little, and, for example, many fire spread modeling systems still use Rothermel's empirical formulation published more than 50 years ago. Recently, Duane et al. (2021) identified the mechanisms of emerging novel very intense and fast wildfires. However, science still has limited capacity to anticipate and predict the occurrence and behavior of wildfires governed by these mechanisms, and demands significant advances in current knowledge and operational tools are needed.

How a wildfire spreads and behaves in a landscape is tightly connected to the **impacts** it will generate. Understanding what conditions allow for safe and effective **fire suppression** is a key research priority. However, identifying the most relevant factors governing suppression effectiveness and suitable suppression windows is still very limited, hindering fire suppression response and analysis. Wildfire behavior is also known to affect **burn severity**. Despite several studies, the mechanisms between fire behavior and severity are still not well understood, which hinders better mitigation and response actions.

The main **objectives** of **FIRE-HACK** are to improve our current understanding regarding:

- The main **drivers of wildfire behavior** and how they are related.
- The **links between wildfire behavior and fire impacts**, in particular, the effectiveness of fire suppression and burn severity.

The **team** has extensive experience in the study of fire management, behavior and post-fire impacts topics, as well as, modeling using different techniques, organization of data science hackathons and practical wildfire behavior analysis. The project will count with the close involvement of experts from the most important organizations related with fire management, that along with two experienced consultants, will contribute to the quality of the project's outputs.

The **first innovation** of FIRE-HACK will be the analysis of a novel and unique fire behavior database created by the team (PT-FireSprd). The **second innovation** will be the implementation of data science hackathons to tackle the two main objectives of FIRE-HACK.

The **PT-FireSprd database**, that contains progression and behavior data for 80 large wildfires that occurred in Portugal (2015-2021) will be the centerpiece of FIRE-HACK. In **Task 2**, this database will be updated with new wildfires (2022-2024), a new fire behavior descriptor (fireline intensity) and a comprehensive list of relevant environmental surrogates.

In **Task 3**, the relations between the main fire behavior descriptors and surrogate variables, will be studied and modeled. Target response variables will be the rate-of-spread, fireline intensity and growth rate, due to their widely recognized relevance for fire research and management. In **Task 4**, the relation between fire impacts and behavior will be studied and modeled, focusing on two sub-problems: i) what are the factors that determine fire suppression effectiveness and ii) what are the factors that determine burn severity. Both Task 3 and Task 4 will be done using **data science hackathons**, which are an innovative approach to wildfire research. Hackathons are excellent ways to solve 'real-world' problems, promoting creativity and innovation, benefiting from a variety of skills, interests and backgrounds of its participants. Hackathon teams will compete, using different exploratory data analysis and modeling techniques suitable for big data problems.

Task 5 will aim at effectively disseminating the knowledge, data and tools produced in FIRE-HACK to researchers and practitioners. These will include: i) the updated fire behavior database, ii) the models developed, iii) a practical handbook, using easily understandable and practical language, and iv) a short video with the main findings of FIRE-HACK. A final seminar and an advance training session are foreseen at the end of the project.

Besides the large potential impact that FIRE-HACK may have on research, it will target its main findings to support better decision-making and contribute to move both the **body of scientific and operational knowledge forward**.

Resumo para publicação

Resumo para publicação em português

-

Resumo para publicação em inglês

-

Estado da arte e objetivos

In recent years, wildfires have led to an unprecedented number of fatalities and injuries, the destruction of houses and infrastructures. Despite its relevance, our knowledge of such complex phenomena is still **very limited** [42]. One of the most fundamental and intriguing aspects is associated with **understanding wildfire behavior**, i.e. the way a burning fire ignites and spreads through the landscape. This depends on complex interactions between fuels, topography and weather, over a wide range of scales, and can be characterized using metrics such as the rate of spread, growth rate, and flame length [43].

A better understanding of fire behavior is a key scientific challenge with paramount importance for research and management applications [44]. It has implications for the entire fire management cycle: mitigation, preparation, response, and recovery. Understanding and predicting how wildfires will potentially behave in the landscape is essential to plan **mitigation** actions, such as fuel management [1,2,15,17,40], protection of settlements [3,4], and reducing the risk of economic losses [5,6]. Planning **pre-suppression** activities and defining resource dispatch to wildfires requires knowledge of what potential fire behavior can be expected [45]. Fire behavior affects the delineation of safe and effective **response** strategies and tactics during a wildfire and the definition of early alerts and evacuations [45,46]. High-intensity wildfires are often uncontrollable, posing significant threats to firefighters and communities [47]. Wildfire behavior also affects the degree of disturbance caused in soil and vegetation, i.e. severity [48,49]. It influences a wide range of post-fire impacts, particularly soil erosion [10,11] and water quality [16], as well as the required post-fire **recovery** actions.

To foster significant improvements in fire management, the following key steps are necessary: **i)** a comprehensive **high-quality fire behavior data set**, ii) a robust **characterization of the relations between drivers and impacts** of fire behavior, and iii) an **effective knowledge dissemination** to decision-makers.

Fire behavior data can be compiled from laboratory or field experiments, prescribed fires, or wildfires. This requires, for example, systematic mapping of the fire front progression across space and time, and estimation of fire behavior descriptors [7]. Unfortunately, reliable high high-quality information, particularly on wildfires burning under extreme conditions, is difficult to collect [50]. Despite these limitations, some authors have made relevant efforts in compiling wildfire fire behavior observations (see [7] for a comprehensive list). In particular, the FIRE-HACK team has compiled the first open-access fire progression and behavior database in Mediterranean Europe. The Portuguese Large Wildfire Spread Database (PT-FireSprd) includes the reconstruction of 80 large wildfires that occurred in Portugal between 2015 and 2021 [7], dramatically expanding existing information on wildfire behavior.

Several authors have studied and modeled the **main drivers of fire behavior** [e.g. 30,51]. However, scientific knowledge has evolved very little, and, for example, many fire spread modeling systems still use Rothermel's empirical formulation published more than 50 years ago [42] that does not effectively explain how fire spreads [41]. Recently, Finney et al. have shed light on new physical mechanisms governing fire spread [52], but much work (and data) is still needed to develop improved knowledge and tools. Duane et al. (2021) identified the mechanisms of emerging novel very intense and fast wildfires [43], in particular: i) unstable atmospheric conditions and pyroconvection, ii) new interactions between drought, hot environments, and novel wind situations, iii) novel fuel availability and, iv) lengthening of the fire season. Currently, science has limited capacity to anticipate and predict the occurrence and behavior of wildfires governed by these mechanisms. The speed at which these events are occurring worldwide demands significant advances in current knowledge and operational tools.

How a wildfire spreads and behaves in a landscape is tightly connected to the **impacts** it will generate. Understanding when fire behavior will allow for safe and effective **fire suppression** is a key research priority [45]. However, identifying the most relevant factors governing suppression effectiveness and identifying suitable suppression windows is still fraught with uncertainties mainly due to limited fire behavior data, the response of firefighters, and other relevant factors (e.g. accessibility). Wildfire behavior is also known to affect **burn severity**. Several authors have shown that severity depends on fuels, topography and weather [e.g 30,31,47], although only a few have linked severity with fire behavior [48,53]. The mechanisms between fire behavior (e.g. intensity) and severity are still not well understood, which hinders better mitigation (e.g. preventive fuel treatments) and response actions (e.g. allowing unplanned ignitions to burn over the landscape).

The main **objectives** of **FIRE-HACK** are to improve our current understanding regarding:

- The main **drivers of wildfire behavior** and how they are related.
- The **links between wildfire behavior and fire impacts**, in particular, the effectiveness of fire suppression and soil-vegetation severity.

Improving our knowledge in this field is crucial to improving the entire fire management cycle, which is especially relevant considering the emergence of more frequent extreme wildfires. To address these aspects, FIRE-HACK will use an innovative approach of data science **Hackathons** that will thoroughly exploit the novel **PT-FireSprd** fire behavior database. Besides the large potential impact that FIRE-HACK may have on research, it will target its main findings to support better decision-making and contribute to move both the **body of scientific and operational knowledge forward**.

Plano de investigação e métodos

FIRE-HACK presents an **exploratory approach** focused on improving our understanding of 'real-world' problems using hackathons. FIRE-HACK will focus on improving current scientific and operational knowledge regarding the identification and characterization of i) the main drivers of wildfire behavior, and ii) the main factors behind fire suppression effectiveness and burn severity (impacts), with emphasis on the influence of wildfire behavior.

The **first innovation** of FIRE-HACK will be the exploratory analysis of a novel and unique fire behavior database created by the team (PT-FireSprd, [7]). The **second innovation** will be the implementation of data science hackathons to tackle the two main objectives of FIRE-HACK. The project will count with the close involvement of experts from the main fire-related organizations in Portugal and two experienced consultants that will contribute to improve the quality of the project's outcomes, including a practical handbook for practitioners. Besides project management (Task 1), FIRE-HACK is divided in four major tasks:

(i) Assembling a database with fire behavior and environmental surrogates (**Task 2**);

(ii) Modeling the drivers of fire behavior (**Task 3**);

(iii) Modeling the relation between fire behavior and impacts (**Task 4**);

(iv) Effective dissemination of knowledge for researchers and practitioners (**Task 5**);

Task 2 will update the PT-FireSprd database, add a new fire behavior descriptor and associate relevant environmental data (i.e. surrogates). The **PT-FireSprd database** contains progression and behavior data for 80 wildfires that occurred between 2015 and 2021 in Portugal [7]. The fires range between 250 ha to about 45,000 ha and include several extreme cases. First, PT-FireSprd will be updated with wildfires that occurred in 2022, 2023, and possibly 2024. The objective is to have about 100 wildfires in the database, making PT-FireSprd an outstanding fire database worldwide. Note that each wildfire has multiple fire behavior observations and the current version has around 1200 observations. The National Authority of Emergency and Civil Protection will provide the airborne and field data for the 2022-2024 period. Second, a new fire behavior descriptor will be added to PT-FireSprd. Fireline intensity will be calculated using Byram's equation [54] taking into account rate-of-spread [7], fuel heat of combustion and fuel consumed in the active flaming front [12], all estimated based on datasets created previously by FIRE-HACK's team. Finally, relevant predictor variables will be extracted and associated with each fire behavior observation. The selection of the variables will be decided based on literature review and expert knowledge (including stakeholders and consultants), for example, regarding fuel characteristics [12] and moisture [13], topography and weather conditions [55]. Particular emphasis will be laid upon live fuel moisture content and the vertical structure of the atmosphere given the wide recognition that a better understanding of these mechanisms is required to tackle novel extreme wildfires [44]. Task 2 will produce the **FIRE-HACK database** that will be essential for the development of Tasks 3 and 4, and will be disseminated in Task 5.

In **Task 3**, the relations between the main fire behavior descriptors and surrogate variables, will be studied and modeled, using the FIRE-HACK database. The focus will be rate-of-spread, fireline intensity and growth rate, due to their widely recognized relevance for fire research and management. Additional environmental data will be defined by the FIRE-HACK team, experts, consultants and the hackathon teams. The most important part of the work will be done using **data science hackathons**, which have been used successfully in many other fields, but are an innovative approach to wildfire research. Hackathons are excellent ways to solve 'real-world' problems, promoting creativity and innovation, benefiting from a variety of skills, interests and backgrounds of its participants. Data management and feature engineering, assisted by expert knowledge, will be critical to capture the underlying structure of the phenomena. Modeling will be done using different approaches (e.g. statistical modeling, machine learning), suitable for big data problems, guided by both best performance and feature importance criteria. Two teams will compete to solve the same problem and will be evaluated by the criteria defined by the project team. The winning team will receive a higher prize to stimulate competition. FIRE-HACK's hackathons will benefit from being integrated in a suitable context created by the Green Data Science Master Programme. Task 3 will have the following outputs: final reports and code developed by each team, calibrated and validated models and the identification of the most important predictor variables (i.e. drivers). The FIRE-HACK team will integrate and harmonize the main findings and results from both teams into a single report and model.

In **Task 4**, the relation between fire impacts and behavior will be studied and modeled. The approach will be very similar to Task 3, with a few differences that need to be highlighted. Task 4 will divide the problem into **two sub-problems**: i) what are the factors that determine fire suppression effectiveness and ii) what are the factors that determine burn severity. These will require different dependent variables (details in Tasks). The innovation arises from the fact that the problems will be studied explicitly using fire behavior data from real wildfire observations (unprecedented thus far). The two hackathon teams will focus on each sub-problem individually. For each sub-problem, additional data (not compiled in Task 2) will be necessary. To study fire suppression effectiveness, data regarding the effective containment of each fire progression will be necessary. To study the impacts on soil and vegetation, we will use data from the burn severity Atlas for Portugal developed by the FIRE-HACK

team [9]. Additional data will be defined by the FIRE-HACK team, experts, consultants and the hackathon teams. The outputs of Task 4 will be similar to Task 3, and similarly, the FIRE-HACK team will compile the results from both teams into a single report and model.

The data, knowledge and results attained in Tasks 2, 3 and 4 will be disseminated in **Task 5**. The updated PT-FireSprd database, with additional wildfires, a new fire behavior descriptor and a comprehensive set of associated environmental variables will be disseminated in open-access for researchers and practitioners. Data will be disseminated through the **Zenodo** data repository (http://zenodo.org/) and the **PCCIR** web-platform (https://pccir.isa.ulisboa.pt/portal/home/), developed by the FIRE-HACK team. Project code and scripts will be open and shared through **repository GitHub**. The modeling and data analysis done in Tasks 3 and 4 will be compiled and published in the form of research papers. A special issue of the drivers of extreme fires will be proposed. Results will be compiled in a **practical handbook**, using easily understandable and practical language targeted to improve the knowledge of practitioners on fire behavior drivers and impacts, to more effectively contribute to better fire management in the future. A short video with the main findings of FIRE-HACK will be created and disseminated in social networks and Youtube.

Building upon the previous collaborations, representatives of the **most important organizations** related with **fire management** will be involved in FIRE-HACK. These will include the National Authority Emergency and Civil Protection (ANEPC), the Forest and Nature Conservation Institute (ICNF), the National Weather Institute (IPMA) and AFOCELCA, a private firefighting company. Practitioners will be engaged to participate in i) the kick-off meeting, ii) steering the hackathon teams through frequent meetings, iii) hackathon final meetings and iv) the final project meeting. These organizations will be invited to contribute and review the practical handbook.

The **FIRE-HACK team** covers all the expertise required for the success of the project, such as fire behavior, fire suppression experience, burn severity, modeling (statistical, machine learning) and organization of hackathons. Besides the use of high-quality fire behavior data, **FIRE-HACK's innovation** lies on the hackathon approach to tackle the two main research questions. It is expected that FIRE-HACK will provide the **proof-of-concept** for the use of hackathons to solve practical wildfire research and management problems.

Resources will be distributed mainly in three main areas:

i) A 12-month research grant that will guarantee the support to the main project activities, ensure all necessary data is available, summarize and harmonize the main results produced in the hackathons and work on their effective dissemination;

ii) Four hackathon teams (two per task) will receive differentiated prizes depending on their performance. These will stimulate competitiveness and the search for innovative solutions to FIRE-HACK's main questions;

iii) The effective dissemination of FIRE-HACK's results to researchers and practitioners, which is crucial to ensure that knowledge is integrated in research and fire management.

The proposed **timeline** is sufficient to address FIRE-HACK's objectives, based on the team's experience and the intensity associated with hackathons. Using a different approach, results would probably require more time to be produced. The **PI** will be extremely committed to the project (55% of time allocated), taking care of project management (Task 1), the assembly of the core database (Task 2), supervision of the modeling Tasks 3 and 4, and ensuring that the project outputs are correctly disseminated to researchers and practitioners (Task 5). The extensive experience and tight collaborations of the PI with practitioners will ensure their involvement and contribution to the success of FIRE-HACK.

Identifique se o plano de trabalhos requer recursos computacionais avançados a providenciar pela FCT

Sim

Identifique se o plano de trabalhos requer espaço num repositório de dados de investigação a providenciar pela FCT

Sim

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Tarefas

RESUMO DE CUSTOS POR INSTITUIÇÃO

Universidade de Lisboa (UL) - Instituto Superior de Agronomia	
1. Project Management	1 228,05 €
2. Assembling the fire behavior and environmental surrogates database	2 251,83 €
3. Determining the key fire behavior drivers	16 554,77 €
4. Identifying the links between fire behavior and its impacts	16 554,77 €
5. Dissemination and Outreach	13 165,29 €
Total	**49 754,71 €**

1 **Project Management** 15 meses De 01.01.2025 a 31.03.2026

Membros

Pessoas / Mês	Alocados
0.75	Akli Benali Instituto Superior de Agronomia
0.15	José Miguel Oliveira Cardoso Pereira Instituto Superior de Agronomia
0.15	Manuel Lameiras de Figueiredo Campagnolo Instituto Superior de Agronomia
0.15	Rui Figueira Instituto Superior de Agronomia

Descrição da tarefa e resultados esperados

Task 1 will ensure effective project management, including:

- Guaranteeing the administrative, financial and logistical aspects;
- Ensuring the delivery with the planned time frame of all project activities and outputs;
- Ensuring effective communication within the team and between the team and partners ;
- Write and submit progress and final reports.

The project will start with a kick-off meeting that will include team members and the operational partners.

Task 1 will use appropriate project management. The team will have monthly meetings to ensure all participants are aware of the project's development and to identify any management situations that need to be corrected. Management will include identifying risks and implementing mitigation actions if necessary. Monthly meeting steering meetings will be implemented.

Task 1 is linked with all remaining Tasks of the project. The project PI will assume the coordination of FIRE-HACK taking advantage of previous experience, assisted by the entire team.

Resources are required to organize the kick-off meeting, ensuring the participation of the. Expenses with the participation of the consultants in intermediate meetings and the final seminar are described in Tasks 3, 4 and 5.

Entregáveis e datas previstas de apresentação

Task 1 will be responsible for delivering the progress report (Month 12) and the final report (Month 16).

Justificação global dos custos da tarefa

Resources are required to organize the kick-off meeting, ensuring the participation of the. Expenses with the participation of the consultants in intermediate meetings and the final seminar are described in Tasks 3, 4 and 5.

Orçamentos

Instituição	Fin. solicitado
Instituto Superior de Agronomia	1 228,05 €

2 Assembling the fire behavior and environmental surrogates database

4 meses | De 01.01.2025 a 30.04.2025

Membros

Pessoas / Mês	Alocados
2	Akli Benali Instituto Superior de Agronomia
1	BI-a - 01 Bolsa de Investigação - Estud. dout. ou lic. e mestres em CNCG Instituto Superior de Agronomia
0.4	José Miguel Oliveira Cardoso Pereira Instituto Superior de Agronomia
0.4	Manuel Lameiras de Figueiredo Campagnolo Instituto Superior de Agronomia
1	Rui Figueira Instituto Superior de Agronomia

Descrição da tarefa e resultados esperados

Task 2 will construct the core database containing fire behavior and environmental surrogates for a wide set of large wildfires that occurred in Portugal in the last years. This database will be essential to tackle FIRE-HACK's research questions that will be addressed in Tasks 3 and 4.

The **PT-FireSprd database** contains progression and behavior data for 80 wildfires that occurred between 2015 and 2021 in Portugal [7], and results from a joint effort between researchers and practitioners. The fires range between 250 ha to about 45,000 ha and include several extreme events, such as Pedrogão Grande, the wildfires of October 2017, among others. It was created by combining satellite, airborne and field data. Each wildfire has multiple progression polygons and the current version has around 1200 fire behavior observations.

Task 2 will **update PT-FireSprd** by reconstructing **additional progressions** for wildfires that occurred in 2022, 2023 and 2024. The objective is to have about 100 wildfires in the database (~1500 observations), making PT-FireSprd a unique fire database at a global-level. This objective is perfectly feasible, considering the number of large wildfires that occurred in the last years. The tight collaboration with the National Authority of Emergency and Civil Protection (ANEPC) will guarantee the availability of airborne and field data for the 2022-2024 period. Reconstructing wildfire progressions is a laborious task, thus the team will test automated methods, based on machine-learning techniques [24,34], to assist the reconstruction of the progressions based on multi-source satellite data (Sentinel-2 and 3, Landsat 8 and 9, VIIRS, MODIS, Meteosat Second and Third Generation).

Fireline intensity is the rate of energy or heat release per unit time per unit length of fire front [54] and it is strongly connected with suppression capacity and fire effects. The current version of PT-FireSprd does not have fireline intensity estimations. The FIRE-HACK team will estimate fireline intensity for all wildfires applying Byram's equation [54]. It will use the estimated rate of spread, and both the fuel heat of combustion and fuel consumed in the active flaming front, associated with the main fire spread path. These three variables will be estimated based on datasets created previously by the FIRE-HACK team [7, 12].

Finally, relevant **environmental surrogates** will be extracted and associated with each fire behavior observation. The list of variables will be decided based on literature review and the knowledge of fire experts that will collaborate in FIRE-HACK (consultants and stakeholders). These will surely include variables associated with fuel characteristics [12] and moisture [13], topography and weather data (e.g. IPMA weather forecasts and ERA5 reanalysis data [55]). Particular emphasis will be laid upon live fuel moisture content and the vertical state of the atmosphere given the wide recognition that a better understanding of these mechanisms is required to tackle novel extreme wildfires [44]. Additional specific data will be added in Tasks 3 and 4.

The updated database will be hereafter referred to as the "**FIRE-HACK database**". It will be a geographical database with multiple fields, and will be an important output of the project that will be disseminated to the fire research and management community.

Given his large experience in wildfire reconstruction, and the extensive collaboration with ANEPC, the PI will reconstruct the progressions of the new wildfires. ANEPC will provide airborne and field data on fire progression. MC and JMCP will help implement automated fire progression mapping procedures, using their extensive experience with remote sensing classification and machine learning methods. The Research Grant will work on the extraction and processing of the environmental surrogate data. RF will help with data organization and associated metadata.

Entregáveis e datas previstas de apresentação

The deliverable will be a new version of PT-FireSprd (i.e. **FIRE-HACK database**), with additional wildfires, fire behavior descriptors and associated environmental variables. It will be produced in the form of a geographical data set with detailed metadata description identifying all the updates done. The dataset will be delivered at the end of Month 4, but will be only disseminated at the end of project (Month 15, see Task 5).

Justificação global dos custos da tarefa

Resources are necessary to hire a Research Grant that will work on the extraction and processing of the environmental surrogate data, and update of the FIRE-HACK database. He\she will guarantee, with the remaining team members, the robustness and quality of the database, a crucial issue for the correct development of tasks 3 and 4.

Orçamentos

Instituição	Fin. solicitado
Instituto Superior de Agronomia	2 251,83 €

3 **Determining the key fire behavior drivers** 4 meses De 01.05.2025 a 31.08.2025

Membros

Pessoas / Mês	Alocados
1.6	Akli Benali Instituto Superior de Agronomia
3.75	BI-a - 01 Bolsa de Investigação - Estud. dout. ou lic. e mestres em CNCG Instituto Superior de Agronomia
0.4	José Miguel Oliveira Cardoso Pereira Instituto Superior de Agronomia
0.8	Manuel Lameiras de Figueiredo Campagnolo Instituto Superior de Agronomia
1.2	Rui Figueira Instituto Superior de Agronomia

Descrição da tarefa e resultados esperados

Task 3 will study and model the relations between the main fire behavior descriptors and environmental surrogates, using the FIRE-HACK database compiled in Task 2.

In particular, Task 3 will focus on identifying and better understanding the main drivers of rate of spread, fire line intensity and growth rate. If necessary, additional environmental data will be added to the FIRE-HACK database, based on feedback of the FIRE-HACK team, practitioners and consultants.

To disentangle the key drivers of wildfire behavior, innovative **data science hackathons** will be implemented. Hackathons have been used successfully in many other fields, but are a novel approach to wildfire research. Hackathons are excellent ways to solve ‘real-world’ problems, promoting creativity and innovation, benefiting from a variety of skills, interests and backgrounds of its participants. Teams are set up by combining skills to roles, in order to develop a start to end data science methodology, based on the CRISP-DM (CRoss Industry Standard Process for Data Mining) framework. The sequential phases of the methodology — business understanding, data understanding, data preparation, modeling, evaluation, deployment — cover a deep analysis of the problem in question and the design and implementation of a solution. Considering the complexity of the problem (including space-time dependency), data management and feature engineering, assisted by expert knowledge, will be critical to capture the underlying structure of the phenomena to be expressed by the models. Different modeling approaches will be explored, including statistical and machine learning techniques (supervised, unsupervised), suitable for big data problems, guided by both best performance and feature importance criteria. Addressing spatial and temporal dimensions of the variables, their processing and feature engineering will require efficient computational approaches through parallel computing. This will benefit from grid computational resources provided by FCT, as well as, cloud-based data repositories.

In the hackathons, **two teams (4 to 6 people) will compete** to solve the same problem (i.e. identify the key drivers of wildfire behavior) and will be evaluated based on criteria defined by the project team. The winning team will receive a higher prize to stimulate competition. The hackathons will last three months and steering will be done once per week, integrating the FIRE-HACK team, consultants and practitioners. The hackathons will benefit from being integrated in a suitable context created by the Green Data Science Master Programme.

Task 3 will have the following **outputs**: final reports and code developed by each team, calibrated and validated models and the identification of the most important predictor variables. The FIRE-HACK team will integrate and harmonize the main findings and results from both teams into a single report and model.

Task 3 will tackle a key objective of FIRE-HACK. The knowledge and results will be disseminated in Task 5 and will likely be relevant for the accomplishment of Task 4.

RF will organize and supervise the hackathons. MC, AB and JMCP will steer the work and help summarize the main findings of the two hackathon teams. MC will provide assistance with exploratory data analysis, modeling tools and programming. AB and JMCP will ensure results are robust and suitable within the scope of fire research and management. The team will define the evaluation criteria and evaluate the works. Consultants and stakeholders will help steer the development of the work. All members will participate in the final hackathon meeting where results will be presented and discussed.

Entregáveis e datas previstas de apresentação

Task 3 will produce a **unique report** with the methods and main findings regarding the key fire behavior drivers identified. Project code and scripts will be open and shared through **repository GitHub**, including a final set of predictive models. These outputs are expected to be complete at the end of Month 8.

Justificação global dos custos da tarefa

Resources are necessary to hire a Research Grant that will support the development of the hackathons, process additional data, guarantee the proper link with FCT advanced computational resources and data repositories, organize hackathon weekly follow-up, harmonize the main findings and summarize them in a unique report.

Resources are required for consultants to attend the final hackathon meetings.

The largest fraction of the budget for this task will be assigned to the prizes to the hackathon teams, simulating human resources to work in a competitive environment and find ‘out-of-the-box’ solutions to 'real-world’ problems.

Orçamentos

Instituição	Fin. solicitado
Instituto Superior de Agronomia	16 554,77 €

4 **Identifying the links between fire behavior and its impacts** 4 meses De 01.09.2025 a 31.12.2025

Membros

Pessoas / Mês	Alocados
1.6	Akli Benali Instituto Superior de Agronomia
3.75	BI-a - 01 Bolsa de Investigação - Estud. dout. ou lic. e mestres em CNCG Instituto Superior de Agronomia
0.4	José Miguel Oliveira Cardoso Pereira Instituto Superior de Agronomia
0.8	Manuel Lameiras de Figueiredo Campagnolo Instituto Superior de Agronomia
1.2	Rui Figueira Instituto Superior de Agronomia

Descrição da tarefa e resultados esperados

Task 4 will study and model the relations between the fire behavior descriptors, environmental surrogates and two main impacts: i) fire suppression effectiveness and ii) burn severity in soil and vegetation. The FIRE-HACK database compiled in Task 2 will be used.

The approach will be very similar to Task 3, and only the **main differences will be highlighted** here:

1. The hackathon teams, as well as the FIRE-HACK team, will benefit from the experience and knowledge attained in Task 3, regarding the most important drivers of fire behavior.
2. The two hackathon teams will focus on each sub-problem individually. The evaluation criteria used to evaluate the work by the hackathons will be the same as Task 3.

The dependent variables will differ from Task 3 and will be different for the two sub-problems of Task 4:

1. To study fire suppression effectiveness, each fire progression polygon will need to be identified as “contained” or “not contained”. In addition, environmental data associated with the burned and the non-burned area will be necessary (e.g. accessibility, type of soil [46]). Comparison between both will provide useful insights regarding the main factors associated with the containment of a wildfire in a specific location. In addition, data regarding suppression resources will be necessary and provided by ANEPC.
2. To study the impacts on soil and vegetation, the dependent variable will be a set of satellite-derived severity indices (e.g. dNBR, RBR). We will use data from the burn severity Atlas for Portugal, developed by the FIRE-HACK team [9], a unique dataset that contains several satellite-derived severity indices estimated using Landsat data with a 30m resolution, covering 1984 to present.

Any additional data to address the sub-problems of Task 4 will be defined by the FIRE-HACK team, experts, consultants and the hackathon teams.

The outputs of Task 4 will be similar to Task 3, however, the FIRE-HACK team will compile the results from both teams into two final reports and models, for each studied fire impact.

Task 4 will tackle a key objective of FIRE-HACK. The knowledge and results will be disseminated in Task 5.

The roles of each team member and partner will be the same as in Task 3.

Entregáveis e datas previstas de apresentação

Task 4 will produce a unique report with the methods and main findings regarding the drivers of suppression effectiveness and burn severity. Project code and scripts will be open and shared through **repository GitHub**, including a final set of predictive models. These outputs are expected to be complete at the end of Month 12.

Justificação global dos custos da tarefa

Resources are necessary to hire a Research Grant that will support the development of the hackathons, process additional data, guarantee the proper link with FCT advanced computational resources and data repositories, organize hackathon weekly follow-up, harmonize the main findings and summarize them in a unique report. Resources are required for consultants to attend the final hackathon meetings. The largest fraction of the budget for this task will be assigned to the prizes to the hackathon teams, simulating human resources to work in a competitive environment and find ‘out-of-the-box’ solutions to 'real-world’ problems.

Orçamentos

Instituição	Fin. solicitado
Instituto Superior de Agronomia	16 554,77 €

5 **Dissemination and Outreach** 3 meses De 01.01.2026 a 31.03.2026

Membros

Pessoas / Mês	Alocados
1.5	Akli Benali Instituto Superior de Agronomia
2.75	BI-a - 01 Bolsa de Investigação - Estud. dout. ou lic. e mestres em CNCG Instituto Superior de Agronomia
0.15	José Miguel Oliveira Cardoso Pereira Instituto Superior de Agronomia

Pessoas / Mês	Alocados
0.15	Manuel Lameiras de Figueiredo Campagnolo Instituto Superior de Agronomia
0.15	Rui Figueira Instituto Superior de Agronomia

Descrição da tarefa e resultados esperados

Task 5 will disseminate the academic and practical knowledge and results attained in FIRE-HACK (Tasks 2,3,4) to researchers and practitioners.

FIRE-HACK has different target audiences. Considering that the objectives are to increase both academic and practical knowledge on fire behavior drivers and its impacts, different approaches are required. For **researchers**, the dissemination of FIRE-HACK's main findings will be done in the following ways:

1. The **FIRE-HACK database** (Task 2) will be disseminated in open-access through the **Zenodo** data repository (http://zenodo.org/) and the **PCCIR** web-platform (https://pccir.isa.ulisboa.pt/portal/home/). Both practitioners and researchers can use the data, but it is likely that the dataset will receive more attention by the latter;
2. The codes and scripts generated in Tasks 3 and 4 will be open and shared through the **GitHub repository**;
3. The main results of FIRE-HACK will be disseminated through **research papers**. In particular, a **special issue** on "Fire behavior drivers and impacts" will be proposed in a relevant journal (e.g. Fire, International Journal of Wildland Fire);

For **practitioners**, the main findings will be disseminated with the main objective effectively contributing to better fire management in the future, in the following ways:

4. A **practical handbook** (in Portuguese and English) with the results emerging from FIRE-HACK will be translated into simple and operational language. It will also contain a summary of fundamental knowledge on fire behavior, several descriptive infographics, and very practical connections of the projects main findings with fire management. The handbook will be inspired on [19] and on the "science you can use" concept from US Forest Service (https://www.fs.usda.gov/research/rmrs/products/sycu);

- A short **video** (in Portuguese and English) will be produced with a very summarized version of FIRE-HACK's main findings. The main purpose is to give visibility to the practical handbook, allowing the information to reach a broader audience, for example, through social networks and Youtube;
- A specific training session gathering the most relevant practitioners will be held at the end of the project. It will disseminate FIRE-HACK's findings, focusing on the novelty and potential use of the developed tools (i.e. models) and on specific case studies (i.e. wildfire events);

For both **researchers and practitioners**:

- Intermediate dissemination and outreach actions are foreseen to occur in social networks and in the NERO COST action. These should provide information to a broad audience regarding the development of intermediate stages of FIRE-HACK, for example, at the end of each task;
- A final conference will disseminate the main results of the project.

The entire FIRE-HACK team will participate in the final project meeting and will contribute to the creation of the practical handbook, video and research papers.

Entregáveis e datas previstas de apresentação

Task 5 will produce the following deliverables:

- The **FIRE-HACK database** (described in Task 2), will disseminated be at the end of the project (Month 15) through the Zenodo data repository (http://zenodo.org/), updating the previous version (https://zenodo.org/records/7495506) and the PCCIR web-platform (https://pccir.isa.ulisboa.pt/portal/home/);
- The FIRE-HACK handbook in PDF and printed version, as well as, a short dissemination video (Month 15);
- A final report (Month 16).

Justificação global dos custos da tarefa

Resources are necessary to hire a Research Grant that will support the creation of the practical handbook, video and research papers.

Resources are also required for to cover expenses with:

1. Consultants to attend the final project’s seminar;
2. Attend one international conference to disseminate project results;
3. Creation, publishing and printing costs with the practical handbook;
4. Production of the final dissemination short video;
5. One open-access paper.

Orçamentos

Instituição	Fin. solicitado
Instituto Superior de Agronomia	13 165,29 €

Calendarização e gestão do projeto

Lista de milestones

Data	Designação	Descrição	Tarefas
30.04.2025	M1 - Fire behavior and explanatory variables database assembled	The database with the fire behavior descriptors and associated key weather and landscape variables will be assembled with proper metadata description.	2. Assembling the fire behavior and environmental surrogates database
31.08.2025	M2 - Completion of "Fire Behavior Drivers" Hackathons	The hackathons focused on modelling the fire behavior and identifying its key drivers will be completed. The main conclusions attained by the two teams will be aggregated and summarized, providing useful information for the Task 4.	3. Determining the key fire behavior drivers
31.12.2025	M3 - Completion of "Fire Behavior Impacts" Hackathons	The hackathons focused on modelling the impact of fire behavior on fire suppression effectiveness and burn severity will be completed. The main conclusions attained by the two teams will be aggregated and summarized.	4. Identifying the links between fire behavior and its impacts

Cronograma

timeline.pdf

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Descrição da estrutura de gestão

The project PI will assume the coordination of FIRE-HACK taking advantage of previous experience with project management with multi-expert teams. The remaining elements of the team will assist the PI whenever necessary. The **PI will be responsible** for:

- Guarantee the administrative, financial and logistical aspects;
- Ensure the delivery with the planned time frame of all project activities and outputs;
- Ensure effective communication within the team and between the team and partners ;
- Write and submit progress and final reports (see timeline).

The project will start with a **kick-off meeting** that will include team members and the representatives of the main fire management entities: the National Authority Emergency and Civil Protection (ANEPC), the Forest and Nature Conservation Institute (ICNF), the National Weather Institute (IPMA) and AFOCELCA, a private firefighting company. The PI will be responsible for engaging these stakeholders in FIRE-HACK.

One of the most important aspects of FIRE-HACK will be the innovative approach of using Hackathons to tackle the two main research questions. This will require an appropriate Hackathon management that will be done by RF, together with the project PI. **Hackathons** will have:

- Two hackathon teams for each task, composed of 4 to 6 people, each with a specific role;
- The hackathons will last 3 months;
- Once per week (on average), the hackathon teams will meet with the project team, operational partners and consultants once per week to steer the work and clarify relevant questions to the development of each task.

At the end of this period, the hackathon teams will:

- Present the work to the project team, partners and consultants;
- Provide a detailed report, codes and data used.

The project team will compile all relevant outputs from the hackathons and ensure these are used to produce the main outcomes of FIRE-HACK. The project team, along with a representative of each partner institution, will constitute the steering committee that will meet every three months (on average).

Monthly meeting steering meetings will be implemented.

A **final meeting** will be held where all the main results are presented to researchers and practitioners.

Questões éticas

Existem questões éticas identificadas neste projeto?

Não

Declarações de ética que considera apropriadas

-

Fundamentação

-

Agenda 2030

Enquadramento da candidatura nos OSD da Agenda 2030

ODS 15: Proteger a Vida Terrestre | ODS 13: Ação Climática

Fundamentação

Forests are fundamental to life on Earth, mitigating climate change through carbon sequestration, producing oxygen, and protecting watersheds that supply most of the freshwater in the globe. Forests provide essential habitats to more than 80% of terrestrial species. Besides the multiple ecosystem services, forests also provide important goods (e.g. wood). The sustainability of forests is therefore crucial for living beings, and for planet Earth, particularly to mitigate the impact of human activities in global warming.

Forests are threatened by unsustainable human activities and by natural disasters. In Mediterranean-climate areas, wildfires are the most important hazard and pose significant threats to the sustainability of forests. Wildfires destroy forests, their habitats and release large amounts of carbon to the atmosphere.

A better understanding of how wildfires behave will contribute to mitigate its negative impacts, contributing to protect life on land, promote sustainable ecosystems and decrease global climate warming. Wildfire behavior should be a central component of the fire management paradigm influencing actions associated with prevention, suppression and the mitigation of post-fire impacts. In addition, better understanding the links between wildfire behavior and burn severity is crucial to mitigate impacts, as well as, to help define the technical requirements of the use of unplanned low-intensity fires as a management tool. The latter can be a very useful tool to manage fuels, protecting forests from undesired high-intensity fires.

By promoting a much better academic and practical knowledge on fire behavior drivers and impacts, FIRE-HACK contributes directly to protect fire-prone forests (ODS15) and mitigate climate change (ODS13). In addition, according to the UN Agenda it is very important to “improve human, technical and professional skills, as well as expertise and capabilities to effectively formulate and implement policies, plans, programmes, research and projects on management, conservation and sustainable development of all types of forests (...)”. FIRE-HACK will contribute to this concern, by involving the most important stakeholders related with forests and wildfires in Portugal throughout its development, and by creating a practical handbook with a summary of knowledge that can be used to support better decision-making.

Outros projetos

-

Ficheiros anexos

Certificate_TrainingCourse_FEPC.pdf

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Certificate_FireSuppression_Technician.pdf

Obtido em 22-02-2024 pelas 15:40:01

Certificate_TrainingCourse_CIM-Aveiro.pdf

Obtido em 22-02-2024 pelas 15:40:01

Support_Letter_FIRE-HACK_AFOCELCA.pdf

Obtido em 22-02-2024 pelas 15:40:01

Certificate_TrainingCourse_AMAL.pdf

Obtido em 22-02-2024 pelas 15:40:01

Support_Letter_FIRE-HACK_ICNF.pdf

Obtido em 22-02-2024 pelas 15:40:01

Support_Letter_FIRE-HACK_IPMA.pdf

Obtido em 23-02-2024 pelas 08:40:36

Support_Letter_FIRE-HACK_ANEPC.pdf

Obtido em 29-02-2024 pelas 13:20:32

Indicadores

Indicadores de realização previstos

Descrição	2025	2026	Total
A · Publicações	0	0	
Livros	0	1	**1**
Capítulos de livros	0	0	**0**
Artigos em revistas internacionais	0	3	**3**
Artigos em revistas nacionais	0	0	**0**
B · Comunicações	0	0	
Comunicações em encontros nacionais	0	0	**0**
Comunicações em encontros científicos internacionais	0	2	**2**
C · Relatórios	0	0	**0**
D · Organização de seminários e conferências	0	1	**1**
E · Formação avançada	0	0	
Teses de Doutoramento	0	0	**0**
Teses de mestrado	0	2	**2**
Outras	0	1	**1**
F · Modelos	1	2	**3**
G · Aplicações computacionais	0	0	**0**
H · Instalações piloto	0	0	**0**
I · Protótipos laboratoriais	0	0	**0**
J · Patentes	0	0	**0**
K · Outros	0	0	
	0	0	**0**
	0	0	**0**
	0	0	**0**

Divulgação

Ações de divulgação da atividade científica previstas no projeto

The main results of FIRE-HACK will be disseminated through **research papers**. Two (2) to (3) papers are expected, depending on the quality of the results of Tasks 3 and 4. One (1) will be published in open-access. A **special issue** on “Fire behavior drivers and impacts” will be proposed to a relevant journal, that would include FIRE-HACK’s papers, as well as work from other researchers throughout the globe.

Two (2) communications are expected in an international conference regarding key fire behavior drivers and impacts. Besides the internal reports expected at the end of Tasks 3 and 4, a progress report is expected at Month 12 and final report one month after the end of the project (Month 16).

Besides the dissemination of an update and expanded fire behavior database in data repositories (see Task 5), the developed models for Tasks 3 and 4 will be disseminated in the Github repository.

A seminar will be organized at the end of the project to disseminate its results. An advanced training session target to the most relevant fire practitioners will be held at the end of the project. It will disseminate FIRE-HACK's findings, focusing on the novelty and potential use of the developed tools (i.e. models) and on specific case studies (i.e. wildfire events). In addition, considering the Green Data Science (GDS) Master environment where FIRE-HACK will be evolve, two (2) master thesis are expected.

One of the most important outputs of FIRE-HACK will be a **practical handbook** containing the most important and practical results for fire management. Language and design of the handbook are essential to engage stakeholders and guarantee that is effectively understood and integrated in their day-to-day practice. The handbook will be inspired by [19] and on the "science you can use" concept from US Forest Service (https://www.fs.usda.gov/research/rmrs/products/sycu). A short **video** will be produced with a very summarized version of FIRE-HACK's main findings. The main purpose is to give visibility to the practical handbook, allowing the information to reach a broader audience, for example, through social networks and Youtube;

Finally, besides social networks and Youtube, the project's results will be disseminated (and integrated) in the COST action "european Network on Extreme fiRe behaviOr (NERO)" (2023-ongoing).

Orçamento

Instituição proponente

Universidade de Lisboa (UL) - Instituto Superior de Agronomia

Rubrica	2025	2026	Total
Recursos Humanos	5 709,90 €	7 993,86 €	**13 703,76 €**
Justificação do financiamento solicitado One Research Grant (RG) for R&D activities to be carried out by doctoral students or by graduates and masters enrolled in non-degree-awarding courses academic (BI), for a period of 12 months.			
Missões	800,00 €	800,00 €	**1 600,00 €**
Justificação do financiamento solicitado Expenses with the consultants to ensure their participation in the kick-off meeting (Task 1), the hackathon final meetings (Tasks 3, 4) and the final seminar (Task 5).			
Instrumentos e equipamento científico e técnico	0,00 €	0,00 €	**0,00 €**
Subcontratos	0,00 €	0,00 €	**0,00 €**
Registo de patentes	0,00 €	0,00 €	**0,00 €**
Demonstração, Promoção e Divulgação	500,00 €	8 000,00 €	**8 500,00 €**
Justificação do financiamento solicitado Expenses related with: 1. The kick-off meeting, final seminar and the advanced training session; 2. One international scientific conference; 3. One open-access publication; 4. Design, publication and printing of the FIRE-HACK's practical handbook on fire behavior; 5. Creation of the dissemination video.			
Adaptação de edíficios e instalações	0,00 €	0,00 €	**0,00 €**
Aquisição de bens e serviços	8 000,00 €	8 000,00 €	**16 000,00 €**
Justificação do financiamento solicitado Expenses associated with the payment of the prizes to the four hackathon teams that will work on Tasks 3 and 4.			
Gastos gerais	3 752,48 €	6 198,47 €	**9 950,95 €**
Total	**18 762,38 €**	**30 992,33 €**	**49 754,71 €**

Orçamento global

Rubrica	2025	2026	Total
Recursos Humanos	5 709,90 €	7 993,86 €	**13 703,76 €**
Missões	800,00 €	800,00 €	**1 600,00 €**
Instrumentos e equipamento científico e técnico	0,00 €	0,00 €	**0,00 €**
Subcontratos	0,00 €	0,00 €	**0,00 €**
Registo de patentes	0,00 €	0,00 €	**0,00 €**
Demonstração, Promoção e Divulgação	500,00 €	8 000,00 €	**8 500,00 €**

Rubrica	2025	2026	Total
Adaptação de edíficios e instalações	0,00 €	0,00 €	**0,00 €**
Aquisição de bens e serviços	8 000,00 €	8 000,00 €	**16 000,00 €**
Gastos gerais	3 752,48 €	6 198,47 €	**9 950,95 €**
Total	**18 762,38 €**	**30 992,33 €**	**49 754,71 €**

Plano de financiamento

Rubrica	2025	2026	Total
Financiamento FCT	18 762,38 €	30 992,33 €	**49 754,71 €**
Autofinanciamento	0,00 €	0,00 €	**0,00 €**
Outros financiamentos públicos	0,00 €	0,00 €	**0,00 €**
Outros fundos privados	0,00 €	0,00 €	**0,00 €**
Total	**18 762,38 €**	**30 992,33 €**	**49 754,71 €**

Declaração de compromisso

Investigador responsável

Eu, investigador responsável da presente candidatura, declaro:

1- Ter conhecimento de todos os dados e informações constantes da presente candidatura e que me responsabilizo pelo seu conteúdo e veracidade.

2- Ter conhecimento das disposições expressas no Regulamento nº 999/2016, de 31 de outubro, que estabelece as condições de acesso e as regras de apoio a projetos financiados exclusivamente por fundos nacionais através da Fundação para a Ciência e a Tecnologia, I.P. e do Aviso de Apresentação de Candidaturas do Concurso.

3- Não me encontrar em situação de incumprimento injustificado dos requisitos regulamentares no que respeita à apresentação de relatórios de execução científica de projetos concluídos em que também tenha desempenhado o papel de Investigador Responsável.

4- Comprometer-me a assumir a liderança do projeto e responsabilidades decorrentes da sua boa execução.

5- Assegurar o acesso aberto a publicações cientificas (peer-reviewed) resultantes da investigação financiada no âmbito deste Aviso para a Apresentação de Candidaturas, de acordo com as Políticas de Acesso Aberto da Fundação para a Ciência e a Tecnologia, I.P..

6- Caso tenha identificado em candidatura ou venham a ser futuramente identificadas questões de ética relacionadas com a execução do projeto, comprometo-me a:

a) diligenciar junto das instituições beneficiárias no projeto que, durante o período de execução do projeto, terão as permissões necessárias para executar projeto;

b) recolher toda a documentação necessária e a disponibilizá-la à FCT;

c) cumprir e a fazer cumprir pela equipa de investigação do projeto, toda a legislação nacional e comunitária aplicável neste domínio a este projeto de investigação.

☑ Tomei conhecimento e concordo com os termos enunciados na declaração de compromisso

Instituição Proponente

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