ANNUAL REVIEW 2021

RAIZ

Forest and Paper Research Institute

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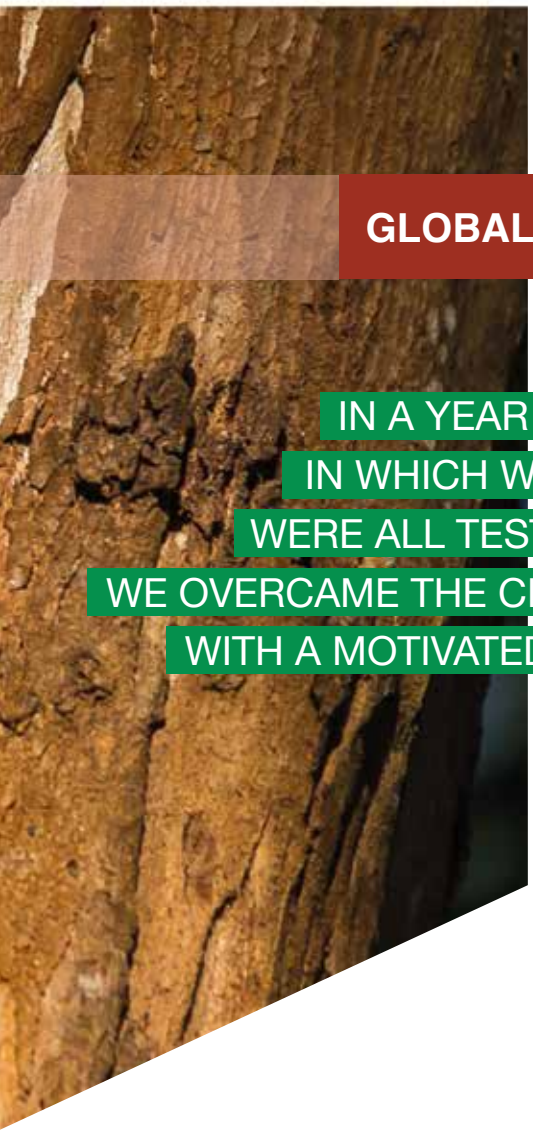

GLOBAL VISION 2021

IN A YEAR IN WHICH WE WERE ALL TESTED, WE OVERCAME THE CHALLENGES WITH A MOTIVATED TEAM.

JOÃO LÉ
RAIZ
Chairman

CARLOS PASCOAL NETO
RAIZ
General Diretor

Instability, resilience and overcoming are the words that best characterize 2021, in terms of both our personal and collective lives, as well as the activity carried out. In this second year of the pandemic, SARS-COV-2, with its advances and setbacks, forced us to rethink and reorganize the way we relate to each other and how we work, mostly in telework and delayed shifts, with defined schedules to reconcile in the best way possible personal and work life, alternating with some brief truces between waves of the virus. Despite everything, we kept the team motivated and the results appeared, in what was a remarkable year for **RAIZ**.

The targets set in **RAIZ'** Action Plan, in this second year of its five-year Strategic Plan (2020-2024) were essentially achived or even exceeded.

In the industrial and technological area, **RAIZ** has developed new packaging papers from brown pulp, an area in which it has played a fundamental role in supporting product development within The Navigator Company. The development of solutions for the barrier properties and mechanical properties of these papers was an important purpose and is still ongoing. Equally important was **RAIZ**' contribution to the development of new tissue products, two of which are already on the market. At the same time, efficiency in the use of resources, namely water and wood, and by-products valorization, were transversal concerns of the team in its support to the production areas.

The inpactus project, currently in its fourth year, developed in close cooperation with universities, is achieving or exceeding its objectives in its four main areas of activity - pulp, UWF paper (printing-writing), tissue and biorefinery/bioproducts - as reflected in the external audit process carried out. New products or proposals for process improvement are emerging from this project, as well as business opportunities, particularly in the field of bioproducts, which are undergoing a scale-up and technical-economic evaluation phase, now leveraged by the new Biorefinery and Bioproducts Pilot Laboratory.

In the forestry area, the objectives of developing and producing improved eucalyptus plants were pursued, with the delivery of two new clones and seed, for production in nurseries. Climate vulnerability was studied and classified, as well as the impact of climate change on the hydrological behavior of forested basins belonging to the industrial associate of **RAIZ**. The nutritional state of eucalyptus stands was also monitored on selected plots, in order to optimizing fertilization plans and

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developing a tool to support nutritional management in production nurseries. Significant advances were also made on the biological control front against national eucalyptus pests with tests and the release of natural enemies of these pests. The development and use of remote sensing tools and geographical information systems have been a crucial element in supporting forest management. The transfer of knowledge to third parties, through forestry extension activities or dissemination of e-globulus platform, gained new impetus this year.

In the cross-sector area of specialized services, **RAIZ** has provided technical support for forestry, in support of harvesting and production operations, as well as the laboratory, in support of the industrial and commercial areas.

The disclosure and dissemination of knowledge are part of **RAIZ**' mission, as Interface Center, Business Innovation Center and UNESCO Club. In 2021, the Floresta do Saber project was launched, taking advantage of the natural and built heritage of Quinta de São Francisco, in partnership with the Calouste Gulbenkian Foundation and support from the UNESCO National Commission. The knowledge dissemination platform "florestas.pt", boosted with the technical and scientific coordination of **RAIZ** and support from national academia, has gained new life, with a substantial increase and diversification of its content.

Preparing the future, **RAIZ** has already positioned itself in 2021 within the PRR - Recovery and Resilience Plan, in various consortia, expanding its network of partnerships with external entities, academia and companies.

As a corollary to this activity, **RAIZ** submitted 8 new patent applications in 2021, an absolute record in the nearly 25 years of its existence and published or participated in 86 scientific publications or presentations at conferences!

All of this was only possible with a dynamic team, strongly motivated, focused and committed to the goals that lie ahead, but also thanks to a solid and competent network of academic and R&D partners. This is **RAIZ**' distinctive mark!

To all, thank you, with good health!

João Lé
Chairman

Carlos Pascoal Neto
General Diretor

INDUSTRIAL RESEARCH, DEVELOPMENT AND CONSULTING

In 2021, **RAIZ**'s Industrial Research and Consulting Areas remained focused on supporting the The Navigator Company's industrial activity, by supporting initiatives to optimize processes and products quality, such as for pulp, paper and tissue.

2021 was also marked by the launch of The Navigator Company's new range of gKraft products, whose development has been supported, since its start, by **RAIZ**'s Research and Consulting Areas.

WOOD AND ITS IMPACT ON THE PROCESS

The continuous monitoring of specific wood consumption of the different Industrial Complexes of The Navigator Company, was once again assured by **RAIZ**, using an internally developed model for forecasting and monitoring such consumption.

To meet the need for diversification of wood supply sources, several laboratory studies were carried out to characterize the most promising species. At the laboratory level, the behavior of these species was studied in the Kraft cooking process, and their performance in the bleaching process and their papermaking suitability evaluated, essential information for the decision-making concerning the most promising species to be incorporated into the production process.

REDUCTION OF PROCESS WATER USE

The use of water is increasingly becoming a pillar of The Navigator Company's sustainability strategy, with **RAIZ** continually supporting the Company in its ongoing effort to reduce its water consumption.

In this area, **RAIZ** followed the introduction of different measures for reducing the use of water in the different Industrial Complexes, of which we highlight the reduction of water consumption in the bleaching stage of pulp production, in order to monitor and ensure its effectiveness.

The study for the reuse of bleaching filtrates in the washing of unbleached pulp was also concluded, with a view to its implementation in 2022.

Also noteworthy is the monitoring of the performance of the ultrafiltration test of clarified water from the paper production process, with a view to its reintroduction in various stages of the production process.

ENVIRONMENT AND ENVIRONMENTAL COMPLIANCE

In 2021, the analyses planed for the WWTP of the Industrial Complexes were concluded. The collected information will allow, in 2022, the optimization of its operation, reducing the operational cost, as well as to contributing to an increased procedural stability of these facilities.

As part of a CEPI (Confederation of European Paper Industries) initiative, **RAIZ** took over the national coordination, in articulation with CELPA - Associação da Indústria Papeleira, of samples collection from several companies in the sector for identifying microplastics, either in supplied water or in industrial effluents, concluding a first survey of this kind in these procedural streams.

RAIZ also took over the coordination of the CEPI Issue Group for the revision of the Industrial Emissions Directive (IED) for the sector in the European Community.

INCREASED MECHANICAL STRENGTH OF PAPER

Microfibrillated Cellulose is a product with a high potential for obtaining paper products with increased mechanical strength. At the laboratory level, different fibrous raw materials were tested and their impact on resistance properties proven, for different microfibrillated cellulose incorporation.

The introduction of new chemical additives in the pulp and paper production process to increase products' mechanical strength has also been extensively evaluated in the laboratory.

NEW PACKAGING PAPERS

RAIZ's Industrial Research and Consulting Areas supported The Navigator Company in the development of products associated with the new range of gKraft packaging paper, recently announced by the Company, by carrying out several laboratory studies aimed at defining the best production conditions for these new products, including the selection of the most suitable chemical additives for their production.

The optimization of the production process and the quality of the new packaging papers have also been monitored by **RAIZ**, in coordination with The Navigator Company's internal teams.

In addition, methodologies were developed for determining the compostability of the new packaging papers, as well as studies related to their recyclability.

PAPER BARRIER PROPERTIES

The ban on the commercialization of single-use plastic-based utensils and packaging, due to the entry into force of European Directive EU/2019/904, represents a new opportunity for the pulp and paper sector and in particular for The Navigator Company.

For deepening the knowledge concerning packaging products with barrier properties, already on the market, an extensive benchmarking of these products and the identification of the barrier properties that those new packaging materials should guarantee, were carried out.

Several laboratory studies have been carried out with the most promising fibrous matrices and chemical additives for the development of these barrier properties, in order to assess the different alternatives already on the market.

New laboratory methods were implemented to characterize barrier properties, providing **RAIZ** with the means for supporting The Navigator Company in future projects for developing packaging products.

NEW TISSUE PRODUCTS

Supported by **RAIZ'**s Research and Development activity, The Navigator Company launched two new products on the market: Amoos Naturally Soft™ and Amoos Air Sense™. Amoos Naturally Soft™ is an innovative product made with unbleached eucalyptus pulp, a process for which **RAIZ** holds the patent PT115563.

Amoos Air Sense™ stands out by maintaining a long-lasting fragrance in the product, through the incorporation of microencapsulates, which prolong the aroma in the final product, also allowing a more intense aroma to be obtained when handling the product.

RAIZ also has, within its portfolio, an extensive list of products under development, in cooperation with the business areas, which aim to contribute to the diversification of the Company's tissue product offer.

CIRCULAR ECONOMY: PROCESS WASTE VALORIZATION

RAIZ's Industrial Research and Consultancy Areas continued to evaluate the waste generated in the process and to identify strategies to mitigate its environmental impact and to reincorporate it in new products.

The reintroduction of biological sludge in the pulp production process was studied at the laboratory level, and the most promising conditions for this reintroduction to occur effectively were identified.

FUNDED PROJECTS

LIFE_NO WASTE PROGRAM LIFE EU (H2020

The introduction into 1200 m2 of land located in Minas de São Domingos in Mértola, of ash granules and secondary sludge stabilized by previous composting carried out in 2019, was monitored in 2020 by **RAIZ**, through a soil, leachate and vegetal cover monitoring plan. The spontaneous vegetation growth was confirmed, demonstrating the ability of these materials to correct pH, fix heavy metals (making them less available to be assimilated by plants) and to regenerate soil functions. This funded project was completed in 2021.

PAPERCHAIN (H2020)

In this project, the application of dregs and carbonate sludge in building materials was demonstrated, through the implementation of two demonstrators - a section of sidewalk where the bituminous material incorporated dregs or grits and precast concrete porticos incorporating carbonate sludge.

In 2021, as foreseen, the demonstrators and leachate mechanical properties were successfully monitored. This funded project was completed in 2021.

B2-SOLUTIONS (PT2020)

2021 marked the beginning of the B2-Solutions funded project, which aims, among other things, to obtain new packaging papers with increased resistance to water vapor, through the application of more sustainable materials by the extrusion process. **RAIZ**, a partner in this project, has contributed to the development of a reference framework for packaging papers to be used in the development of formulations that will enable the development of these materials, according to the requirements defined in the project.

TOXAPP4NANOCELFI (FCT)

In this project, which includes the evaluation of the cytological effects of nanocelluloses, **RAIZ** has contributed by making these materials available. In 2021, it was proven that the nanocelluloses evaluated in the project do not present genotoxicity.

BL2F (H2020)

The project BL2F - Black Liquor to Fuel by Efficient HydroThermal Application integrated to Pulp Mill - aims at applying hydrothermal liquefaction technology, including salt separation, for the production of aviation and navigation fuel from black liquor. During 2021, the characterization of the black liquor that will be used as raw material for the production of biofuel was carried out and preparatory studies began for the installation of a pilot unit for the production of this biofuel, at one of the Industrial Complexes of The Navigator Company.

WOODZYMES BBI (H2020)

This funded project developed industrial applications for kraft lignin and the fractions were tested in polyurethane foams and resins for MDF (medium density fiberboard). It was also proven that chlorine dioxide is saved in bleaching with an enzymatic stage, with an enzyme produced by the Consortium. This funded project was completed in 2021.

INPACTUS PROJECT

KEY DEVELOPMENTS IN 2021 IN THE RESEARCH AND DEVELOPMENT AREAS OF INPACTUS:

During 2021 inpactus had its first external mid-term audit. The auditors, AICEP and ANI were present at **RAIZ**, along with the project co-promoters, and all technical-scientific developments and financial execution were presented. A reflection was made on the valorization of the knowledge produced during the four years of project execution. There was a technological showcase of inpactus' RDI results, with an exhibition of materials/ prototypes, with opportunities for interactions with the researchers. The audit culminated with a visit to Navigator's tissue factory, in Aveiro, an opportunity to learn about one of the technological implementations already underway in our industry.

The project saw its extension request approved until October 2022 due to the Sars-Cov-2 pandemic.

The main highlights and achievements in the 4 areas of inpactus are here presented: **Pulp, UWF Paper, Tissue and Bioproducts** and **Biorefinery**.

In the Pulp area, process check computer models were made available for the bleaching area, as well as the most favorable kraft conditions for cooking wood mixtures up to different delignification degrees. The effects of using co-adjuvants in the kraft cooking of wood mixtures were evaluated. A provisional patent application was submitted for the design and construction of a laboratory-scale former for the aerodynamic formation of sheets of non-woven fabric, equipment that has been used to study the best conditions for the production of this type of product.

The viability of incorporating fly ash in mortars was proven, and the most appropriate pre-treatment defined. The technical-economic evaluation of some of the solutions developed has begun.

In the UWF Paper area, the development of an innovative method for the production of cationic starch from native starch and its impact when applied to paper stands out, with a provisional patent application. The use of microfibrillated cellulose and formulations combining various additives for improving paper properties were studied. Paper-applicable sensors were designed with the purpose of detecting specific components such as metals and explosives, and can also be used in document authentication. This work resulted in a provisional patent application.

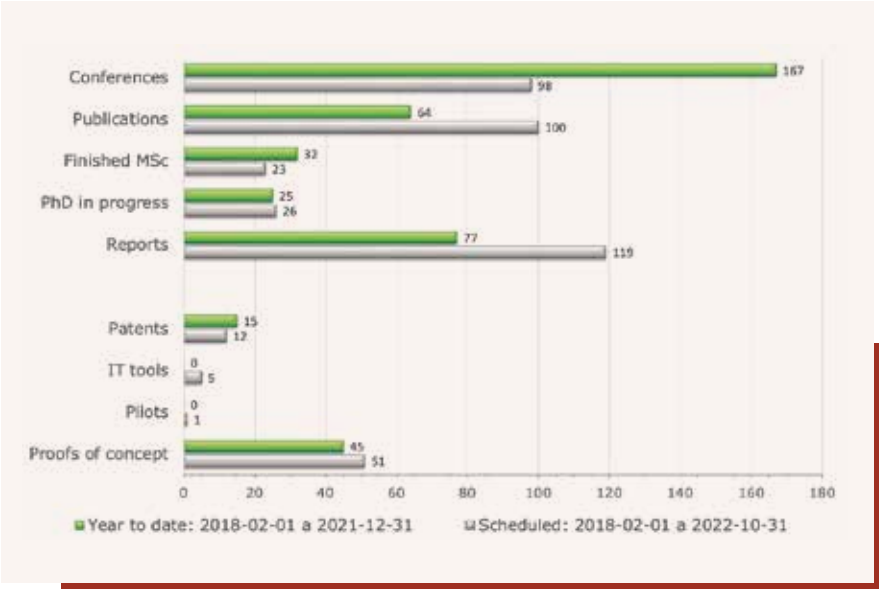
In the Tissue area, a simulation and prediction platform was developed for key Tissue properties, such as softness and strength, considering data and characteristics of the fibrous composition of raw materials and additives. Industrial trials were performed following the established strategies for product differentiation. Of note is the development of the study that led to the production of Tissue prototypes with microencapsulated fragrances, which culminated in a new Navigator product, Amoos AirSense™. Also noteworthy are new solutions for increasing the strength of tissue papers, one of which is in the process of a provisional patent application. Also developed within the scope of the inpactus project, a new product was launched this year, the Amoos Naturally Soft™, produced with unbleached eucalyptus kraft pulp. Finally, the life cycle analysis of the tissue production process was completed, providing a measure of the impacts associated with various scenarios, including integrated and non-integrated pulp and paper production.

In the Bioproducts and Biorefinery Area, new applications were developed with bacterial cellulose produced from cellulosic sugars, from two perspectives: a product for dermal application combining a bioactive extract obtained from eucalyptus biomass, and a product for the food sector, namely as a stabilizer or thickener or as a meat replacement ingredient. In the thermochemical biomass conversion processes for fuel production, a biomass gasification plant was developed for pilot-scale studies and an improvement in the quality of the gases produced for direct combustion was achieved through the use of low-cost catalysts. Xylooligosaccharides (XOS) were produced at semi-pilot scale from bleached eucalyptus pulp, studying the technical feasibility of pulp mill integration. The prebiotic activity of this product was confirmed to be at the level of a commercial product, and it was shown to favor the growth of bacteria beneficial to human health. Optimization of the production of polyurethane foams from Kraft lignin was performed. It was found that the resulting bio-foams have identical characteristics to those produced commercially, used for thermal and acoustic insulation, proving that lignin can be an alternative raw material to those of non-renewable origin for these applications. Also noteworthy is the production of biocomposites with high incorporation of cellulose that favored the tensile and flexural properties of the final product, opening new perspectives for its application.

In 2021, RAIZ, within the scope of the inpactus project, generated 8 new patent applications.

The year 2021 was essentially rich in the field of patent applications with 4 international applications, 7 European applications and 6 national applications, all in cooperation with Universities. Of note are the master's degrees completed, the number of scientific papers and posters presented at conferences, the relevant proofs of concept completed and the PhDs undergoing. The joint work with the invited Chairs was also a constant in this year of 2021.

INPACTUS: PERFORMANCE INDICATORS



FOREST RESEARCH, DEVELOPMENT AND CONSULTANCY

The forestry research, development and consultancy activities carried out at **RAIZ** cover the main aspects related to the production and conservation of forest resources.

The main lines of action include:

Silviculture and forest management in its productive and conservation dimensions, with emphasis on the study of forest interactions with water, carbon, fertility and soil conservation, offering management solutions for reducing environmental impacts and for creating better and more resilient forests;

Genetic improvement of eucalyptus, providing clones and seeds of the best possible quality;

The development of remote sensing technologies and new information processing and systems, in order to improve forest monitoring and for supporting management decision-making;

Measures for preventing and controlling the main pests and diseases of eucalyptus, including the study and introduction into nature of new natural enemies;

Support for forestry extension programs, together with The Navigator Company's initiatives in Portugal, Spain and Mozambique, as in a number of initiatives providing direct support to forestry producers and their associations, service providers, society and academia in general;

Strengthening contacts and strategic partnerships with universities and research institutions in Portugal and worldwide.

GENETIC IMPROVMENT

In 2021 two new clones were delivered, with special focus on their high resistance to nursery diseases, facilitating a successful rooting and lowering plant unit costs. As part of the recurring activities of the Genetic Improvement Program, a new global genetic analysis (viz. BLUP Analysis) was carried out, with some improvements made to the calculation methodology. The genetic merit of the current elite materials was estimated at 65% in volume/ha in relation to the traditional plant.

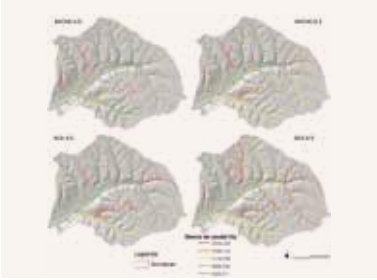
The year was also marked by the completion of the installation of the new seed orchard (PSE2) and improvements to the old one (PSE1). The 2021 campaign made it possible to deliver around 3 kg of seeds to Viveiros Aliança, equivalent to approximately 1 million plants, with estimated gains of 35% over the traditional plant.

PLANT PROPAGATION AND BIOTECHNOLOGY

The highlight in 2021 was the conclusion of the iPlant project "Innovation in the identification and production of improved eucalyptus plants to face current challenges", the result of a partnership between Navigator Forest, Navigator Paper Figueira, **RAIZ** and Viveiros do Furadouro (Altri). The project allowed to test and select several clones specifically for dryness and cold characteristics and to update some critical aspects in the clonal production system, including recommendations on the use of artificial lights, alternatives to hormones and the impact of different substrates.

ADAPTIVE SILVICULTURE

A methodology was developed to classify the Navigator heritage in terms of its climate vulnerability, according to different climate change scenarios. Around 4,000 ha of forest were identified as "very vulnerable" under current environmental conditions. However, the study predicts that this number could double in 30 years. A mortality risk model associated with the foracanta pest was also developed, based on environmental information and population variables. This model makes it possible to obtain a list of which areas of Navigator's heritage are most likely to be attacked by this pest, enabling better operational management.

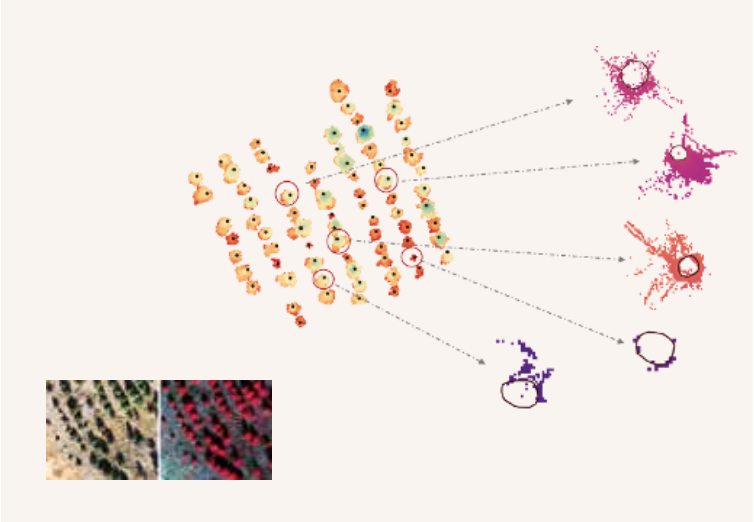


USE OF SWAT (SOIL AND WATER ASSESSMENT TOOL) TO ASSESS THE IMPACT OF CLIMATE CHANGE SCENARIOS ON WATER AVAILABILITY

In order to assess the impact on the hydrological behavior of forested basins, under different climate scenarios, the SWAT model was validated and applied in a eucalyptus-forested area within the Tagus Valley region. The results showed a differentiated response of flows to precipitation, an increase in evapotranspiration and a small reduction in forest productivity.

NUTRITIONAL MONITORING OF EUCALYPTUS STANDS AND FERTILIZATION RECOMMENDATION

In 2021, in order to make an inventory of the nutritional status of eucalyptus stands and to allow quality control and guidance for the operational fertilization program, 41 stands representing the 10 main classes of lithology, climate and soil classes were monitored during 2021. The results show that, in general, the stands had an adequate nutritional status, confirming that the current fertilization program is well adjusted. **RAIZ** was also responsible for making adjustments to fertilization and fertigation plans in irrigated stands, seed orchards and in the nursery.



REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS

Remote sensing technologies and geographic information systems (GIS) have increasingly been used as tools to support the company's forest management and research and consultancy activities. In 2021, **RAIZ** has developed several proofs of concept, over a total area of more than 8,500ha, such as the mapping via drone of the mortality caused by foracanta or the fire hazard, the updating of the time cartography response of the terrestrial means of fire combat by AFOCELCA, and the cartography for supporting the elaboration of forestry projects in Portugal and Mozambique.

RELEASE OF NATURAL ENEMIES OF EUCALYPTUS PESTS

The bronze bug is an important pest in Portugal. It causes discoloration of the canopy of eucalyptus trees and defoliation. It mainly affects some hybrid clones, widely used in reforestation of areas with lower aptitude for E. globulus. After 3 years of studies and consultations, in 2021 we have received an official authorization from the Instituto da Conservação da Natureza e das Florestas to release one of its natural enemies, the parasitoid Cleruchoides noackae, into nature. Colonies of this parasitoid have been kept in quarantine at **RAIZ**, and releases began in October 2021.

RAIZ has also begun the first studies with a new parasitoid of the eucalyptus weevil, *Anagonia lasiophthalma*. This insect is especially promising because it attacks weevil larvae, which have no natural enemies in Portugal. It is a dipteran (fly) virtually unknown to the scientific community, whose biology, ecology and behavior need to be known before it can be released into the wild. In 2021, important developments were achieved within this area, with the characterization of the biology and behavior of the species, which suggests a good adaptation to the weevil, parasitism capacity and survival. The first tests for assessing the risk of introduction, by studying the specificity of A. lasiophthalma, indicated that the parasitoid did not attack any of the eleven non-target organisms offered. These tests are expected to be completed in 2022 for proceeding with the request for release into nature with the Institute for the Conservation of Nature and Forests.

CONTROL STRATEGY FOR THE NEW EUCALYPTUS PEST, *Trachymela sloanei*

A new insect defoliated from the eucalyptus, the trachymela, was found in Portugal in 2019, and began in 2021 to be a major pest of eucalyptus trees. As such, several actions have been initiated to monitor its expansion and impact, and to start developing possible control methods. A Control Plan has also been drawn up which will form part of the Forest Health Operational Program coordinated by the Institute for the Conservation of Nature and Forests. In the specific case of the T. sloanei pest, several actions are planned, some already underway, including continuous monitoring of the pest, the availability of insecticides, the characterization of the host range and the development of a biological control program.

FORESTRY EXTENSION

The number of initiatives to support forest owners under the Premium Program doubled in relation to the previous year, covering 2,180 ha, with 78% of these areas relating to forest maintenance processes and 21% to reforestation. More than 25 technical training sessions were also held, involving more than 130 professionals from the sector. New contents were developed for these sessions, with emphasis on the topics of waste licensing and carbon footprint. A new manual on Eucalyptus Nutrition was also published to support the fertilization of stands carried out by Certification Groups and Forestry Producers' Associations.

E-GLOBULUS PLATFORM - NEW FEATURES, MORE DISSEMINATION, MORE USERS

The e-globulus platform (www.e-globulus.pt) aims to encourage the implementation of management practices in national eucalyptus forests, providing the "when, how and what to do" and technical-scientific knowledge on silviculture, among other content. The platform, developed by **RAIZ**, has three patent applications (Portuguese, European and international) and has been accessible since the end of 2019. In 2021, new features and content were made available. Users registered at the platform now have at their disposal a notebook and a new audiovisual support with more information on land preparation options (collaboration with the GOIEPE project – Efficient installation of eucalyptus stands for small areas). More than 50 news, events and updates were broadcasted during the year. New articles on GIS, the use of remote sensing in forest management and a guide for diagnosing the nutritional status of the stand, among others, are avaiable in the online library. Usage indicators have had a consistent growth, counting at the end of 2021 with more than 10 thousand users and 44 thousand views by the end of 2021.

SERVICES

FORESTRY TECHNICAL SUPPORT

Through its Forestry Technical Services team, **RAIZ** has conducted a number of activities to support The Navigator Company's forestry chain and its various internal forestry R&D projects. The main activities are as follows:

The assessment of forest suitability, soil and climate zoning and productivity estimates conducted in Portugal and Spain, which made possible to sustain forestry investments, define silvicultural management models and prepare different forestry reforestation projects. The 12,509 hectares evaluated at the request of The Navigator Company should be highlighted.

Increased knowledge of forest productivity in Galicia, by expanding **RAIZ** network of forest inventory plots installed and monitored in E. globulus and E. nitens stands in Galicia. This knowledge was used to reduce the risk of uncertainty associated with productivity estimates and their relationship with soil characteristics, local climatic conditions and the existence of forest pests and diseases.

The macro assessment of forest suitability of 1,200 hectares, under the national project of the AIGP (Integrated Areas of Landscape Management), specifically in the AIGP of Alvares. In this study, information was produced that allowed the assessment of the different potential forest aptitude in this territory and served as support for decision making in the AIGP. Thus, this work allowed, not only to estimate the different potentials of forest suitability, but also tried to give indications in order to reduce the risk associated with forest investment decision making and support management decisions at the landscape level.

The technical support given to **RAIZ** different forestry R&D projects, from the selection of areas for the installation of new field trials, the responsibility for installing these same trials, the monitoring and maintenance of **RAIZ** network of trials installed from north to south of Portugal, carrying out biological harvests to certify clones, harvesting soil and leaves for the nutritional assessment of our populations, to monitoring pests and forest diseases.

LABORATORY

RELEVANT POINTS DURING 2021

Despite the improvements when comparing to 2020, the year of 2021 continued to suffer some restrictions due to the pandemic. To respond to these constraints, methodologies were implemented that made it possible to respond to a greater number of requests, as well as to carry out a greater number of tests than expected, contributing to a more productive service. The support given to the following activities should be highlighted:

Support for industrial tests for the production of unbleached eucalyptus pulp, as well as the biometric, chemical and papermaking characterization of the unbleached pulp produced.

Evaluation of the alkali metal content in biomass of agricultural origin in order to prevent sintering phenomena in the sands of the company's biomass boilers.

Characterization of non-fossil fuels used to feed the biomass boilers of Navigator Company.

Support to the weekly and monthly characterization of factory effluents resulting from legal obligations (TURH). Specific support in the calibration of online TOC (Total Organic Carbon) measuring sensors.

Assessment of water quality in the scope of hydrological monitoring of hydrographic basins.

Technological characterization of wood from several eucalyptus species for supporting the prospection of new markets.

Support to Navigator's wood supply company in the technological characterization of imported wood.

Characterization of new wood species to assess alkali consumption, specific wood consumption, bleaching behavior and respective papermaking assessment.

Analysis of soils in the scope of ongoing research projects.

Analysis, identification and characterization of impurities in the produced packaging paper using electron microscopy, FTIR and Py/GC-MS techniques.

SCALE-UP AND NEW POTENTIAL BIOECONOMY BUSINESSES

With the purpose of valorization the knowledge generated by **RAIZ** R&D, particularly in the biorefinery and bioproducts areas, scale-up and technical-economic feasibility studies were initiated or continued. The following projects stand out:

BIOCOMPOSITES

The year of 2021 continued to show market interest in biocomposites, with **RAIZ** and The Navigator Company receiving contacts expressing interest from companies and R&D centers. Companies are mainly looking for finished products that they can test in injection machines and in their molds, following the roadmaps for reduction / substitution of plastics. The R&D centers were mainly looking for the supply of cellulose fiber for development work, leading to the signing of partnership agreements. Sensing the dynamics of this market, and seeking a faster development of products to market, it was decided to install a biocomposites pilot unit at **RAIZ**. The civil works and the utilities installation are ready. Part of the equipment has already been delivered and is awaiting assembly and it is expected to have the unit operational in the 1st quarter of 2022.

EUCALYPTUS EXTRACTS

The recovery and evaluation of eucalyptus extracts has been the object of study by **RAIZ** in the recent years. In 2021 it was possible to acquire some pilot equipment to increase the scale of compound extraction, allowing a gain in sensitivity over pre-industrial operation and the collection of quantities which will allow market testing, as well as application in new products of The Navigator Company. These facilities will also allow validation work to be carried out on a sequential extraction process patented by **RAIZ** in 2021.

XYLOOLIGOSACCHARIDES

Work continues on scaling up the extraction of XOS from cellulose pulp (prebiotics that stimulate the development of beneficial intestinal flora), either for the development of flowsheets and balances of what could be a commercial unit, or to obtain greater amounts of product for studies and commercial validation.

The biological activity of XOS was evaluated.

BIOETHANOL

During 2021, studies continued for the possible implementation of an industrial unit for the production of cellulosic bioethanol, with a capacity of 25.000 ton/year, from eucalyptus bark. Results of pilot tests with 15 ton of bark were analyzed, in pilot industrial facilities, allowing CAPEX and OPEX estimates to be obtained, not only for the base technology but also for integration within the pulp mill. The project has been analyzed jointly with other industrial groups.

TECHNOLOGICAL SCOUTING AND INDUSTRIAL PROPERTY

RAIZ's Technological Scouting aims at providing information on technologies, processes and products in the Forest, Pulp and Paper, Tissue, Packaging and Biorefinery areas, developed and/or marketed by companies from these sectors, as well as by start-ups, universities and research centers.

The Technological Scouting activity, also during 2021, took the form of 12 Newsletters, issued on a monthly basis, disclosing, in a structured and informative way, new developments of products and/or processes and initiatives by companies, start-ups, universities and research centers whose activities in the Forest, Pulp and Paper, Tissue, Packaging and Biorefinery value chains were relevant in a particular month.

The support to projects on the areas of product development and technological and forest consulting and research continued in 2021 with the Technological Scouting on-demand activity, consisting on the report of information of relevance concerning particular technologies, processes and products of interest to the mentioned areas.

PROJECT	INPACTUS	CELSMARTSENSE
New inventions Patent applications **Portugal**	8	-
Patent applications **International**	4	-
Patent applications **Europe**	7	-
Granted patents **Portugal**	1	1

Concerning Industrial Property assets, resulting from **RAIZ**'s technological and forest research activities, and in collaboration with Portuguese and International universities, **RAIZ**'s partners, it was possible to proceed with the submission of 8 national patents applications. Patent applications submitted in previous years were also considered, during 2021, for subsequent International and European patent applications, resulting in 7 patent applications to the European Patent Office and 4 International patent applications to the World Intellectual Property Organization. The number of national, european and international patent applications currently in progress for inventions resulting from technological research and development activities at **RAIZ** was thus extended to a total of 35. Two national patent applications were also granted, previously submitted in 2018 and 2019, and related to the CelSmartSence and Inpactus projects.

One of the patent applications submitted at 2021 concerns a biocomposite consisting of bioplastics and micronized fibers of bleached eucalyptus Kraft pulp, resulting in a simple and sustainable alternative to biocomposites with petrochemical-based components, for applications in the automotive, furniture, household appliances and electronics.

Another patent application submitted at 2021 concerns essential oil products or extracts with phenolic compounds obtained from the residual water from the hydrodistillation of Eucalyptus globulus leaves and bacterial cellulose membranes and face masks integrating them.

2021 was the year with the highest scientific production of **RAIZ**, with a total of **86 PUBLICATIONS**:

Scientific Journals	**16**
Article Publications	**4**
Posters	**27**
Oral Communications	**31**
Book Chapters	**8**

DISSEMINATION AND SOCIAL RESPONSIBILITY

DIGITAL PLATFORM FLORESTAS.PT

THE DIGITAL PLATFORM FLORESTAS.PT CELEBRATED ITS FIRST ANNIVERSARY IN JUNE 2021.

The Florestas.pt platform's mission is to collect, systematize and disseminate information and comprehensive knowledge about the Portuguese forestry and agroforestry spaces, making known their relevance, challenges and opportunities, in a clear and accessible way.

KNOWING, VALUING AND DISCOVERING

By the end of 2021, the platform received more than 465,000 visits, becoming a reference in knowledge sharing.

ACADEMIC AND COMMENTS

The collaboration with renowned national and international academic personalities allowed 19 seminars to be held.

The collaboration with several entities allowed the availability of 22 articles with reflections on themes across national forestry and agroforestry areas.

IN SUMMARY,THE PLATFORM CONTAINS:

143 articles in Knowing, Valuing and Discovering;
109 questions and answers on Learn More;
551 News and events in the Agenda;
207 R&D Projects and Teams;
766 knowledge Resources;
166 Glossary Entries.

RELEASE OF A BI-MONTHLY NEWSLETTER BOOSTING CONTENT DISSEMINATION

QUINTA DE SÃO FRANCISCO AND THE FLORESTA DO SABER PROJECT

RAIZ benefits a location in a unique forest area at European level, Quinta de S. Francisco.

Its 14 hectares are a true biodiversity hotspot, with more than 400 plant species, 70 species of birds, hundreds of monumental trees and one of the largest centenary eucalyptus arboretums outside Australia. The Quinta is, therefore, a historic site, rich in natural and cultural heritage, combining modernity with the scientific knowledge generated by our institute. More than a thousand new trees and shrubs have been planted, as well as a new area of 2.000 m^2 with the recommended clones, and the restoration of more degraded natural habitats, such as the riparian vegetation by the water line.

In addition to the conservation activities of Quinta de S. Francisco, it is absolutely essential to share this space with society, allowing it to be a living testimony of the history of the place, and also of the Portuguese forest and the science here developed. More than anything, it is the ideal space for establishing contact with the forest, the Earth and nature, especially by the school community and our Generations of the Future. To this end, the Floresta do Saber was inaugurated in October 2021, a space restored in the former centennial residence of Jaime Magalhães Lima, with more than 20 practical activities available for the dissemination and deepening of knowledge, forest literacy, bio-economy and sustainability.

Inauguration of the Floresta do Saber, with the presence of Filipa Saldanha, representative of the Calouste Gulbenkian Foundation, João Castello Branco, Chairman of the Board of Directors of The Navigator Company and Anna-Paula Ormeche, of the National Commission of UNESCO in Portugal.

Exhibition “Visões da Floresta” and fossils from the Portuguese forest, on display at Galeria Jaime de Magalhães Lima, in Floresta do Saber.

The activities of Floresta do Saber take place in a forestry, laboratory and virtual environment, on the project's webpage (https://florestadosaber.pt/). This **RAIZ** project has the financial support of the Sustainable Development program of the Calouste Gulbenkian Foundation and has contributed to **RAIZ** recognition as a UNESCO National Club. Floresta do Saber allowed **RAIZ** to participate in several high impact external events, such as Eco Aventura 2021, an event organized by the Aveiro City Council and the 19th National Meeting of the UNESCO Associated Schools Network and to establish important partnerships with the Neuroscience Center of the University of Coimbra, the Department of Geosciences of the University of Aveiro, Fábrica da Ciência and the Science Center of Coimbra.

In late 2021, Floresta do Saber was also nominated for the National Celpa Awards, in the "Civil Society Engagement" category.

As in the previous year, dissemination activities, and especially the reception of visitors, were greatly affected by the SARS-Cov-2 pandemic and respective contingency measures. Despite this, **RAIZ** received more visitors than in 2020, a total of 401 visitors, with 344 visiting Quinta de S. Francisco, representing 47% more than in the previous year. A total of 41 events were organized, in which 85 activities were developed, from guided tours to the Quinta, visits to **RAIZ** laboratories and visits to the Floresta do Saber. Publicity abroad allowed the promotion of Quinta de São Francisco in the activities carried out, which involved more than 350 people. Also noteworthy was the increase in the number of publications promoting and publicizing Quinta de S. Francisco, eucalyptus and the forest, in all, 11 news and chronicles were produced on The Navigator Company's intranet, on the **RAIZ** webpage and on the Florestas.pt platform.

NATIONAL AND INTERNATIONAL COOPERATION

PRR - RECOVERY AND RESILIENCE PLAN

In 2021, **RAIZ** joined two consortia that applied for the PRR area dedicated to the Climate Transition dimension - component 12, aimed at strengthening the sustainable, circular and carbon neutral Bioeconomy, which will be managed by the Environmental Fund. Applications integrate a complete consortia with the participation of business entities in the critical stages of the value chain of products or processes, based on biological resources. The first consortium addressed the priorities of the Textile and Clothing sector, with the participation of 54 entities and a total investment of €132M.

The second consortium was formed within the Footwear Sector and had 68 partners and a total investment plan of €75M. The applications of these two consortiums were evaluated with merit, and considered eligible, and will now be developed in 2022.

RAIZ was also part of another 5 consortiums that applied to Component 5 - Capitalization and Business Innovation, integrated in the Resilience Dimension of the Recovery and Resilience Plan (RRP), which aims to increase the competitiveness and resilience of the economy based on R&D, innovation, diversification and specialization of the production structure, through investments in Mobilizing Agendas for Business Innovation and Green Agendas for Business Innovation. Of these 5 consortia, 3 were evaluated with merit, considered eligible, and will be developed in 2022.

RAIZ, INTERFACE CENTER

RAIZ, as a recognized Interface Center, applied for funding for CENTRO2020's R&D Infrastructure for the construction of a new Forest-Based Biorefinery Pilot Laboratory, and saw its application approved in the last quarter of 2020, starting the construction of the new infrastructure and the acquisition of pilot equipment in 2021. Work on this new unit will start in early 2022.

This new pilot unit will be a unique infrastructure on the Iberian Península, due to its size and the scale of the pilot equipment to be there installed, and will enable **RAIZ** to develop future projects in the area of biomaterials and scale up the use of Bioplastics and Biopolymers with incorporation of cellulose.

INTERNATIONAL COOPERATION

Internationally, in 2021, **RAIZ** closed three European projects. Two of which in the area of Circular Economy and the third in the Biorefinery area.

The first was the LIFE-No-WASTE project (Management of Biomass ash and organic waste in the recovery of degraded soils: a pilot project set in Portugal) financed by the LIFE Program of the European Union and led in Portugal by the University of Aveiro. This project also had the participation of **RAIZ**, The Navigator Company, EDM – Empresa de Desenvolvimento Mineiro, the Polytechnic Institute of Beja and BLC3.

Project website
https://www.lifenowaste.pt/s/

The second European project of Circular Economy was the PAPERCHAIN project (New Market niches for the Pulp and Paper Industry waste based on circular economy approaches), which ran for 4 years and was developed by a consortium led by ACCIONA (ES) with 19 partners from 5 EU countries (Portugal, Spain, France, Slovenia and Sweden) including RAIZ and The Navigator Company, SPRAL, Megavia and the University of Aveiro (in the Portuguese Demo Case).

Site do projeto
https://www.paperchain.eu/

The third project was WOODZYMES (Extremozymes for wood based building blocks: From pulp mill to board and insulation products) which was developed in the area of Biorefinery, was led by CIB-CSIC (ES) and included the participation of 9 partners from 4 European countries (Portugal, Spain, France and Finland).

The project was part of the portfolio of initiatives funded under the BBI-JU (Circular Bio-based Europe Joint Undertaking) partnership, of which RAIZ has been a member since 2018 (https://www.bbi.europa.eu/).

Project website
https://www.woodzymes.eu/

RAIZ is involved in 27 national and international funded projects, in partnership with Universities, Research and Development Centers and Companies, of which, 5 have been contracted and started in 2021.

APPLICATIONS PREPARED / SUBMITTED / APPROVED IN 2021				
R&D CONSORTIA	SUBMITTED	APPROVED	REJECTED	IN EVALUATION
Total	15	6	8	1

PROJECTS IN PROGRESS IN 2021				
INTERNATIONAL CONSORTIUM	NATIONAL CONSORTIUM	INFRASTRUCTURE FINANCING	COLLABORATIVE LABORATORY	IN PROGRESS
4	17	3	3	27

CONTRACTED AND STARTED PROJECTS IN 2021			
ACRONYM	DESCRIPTION	LEAD PROMOTER	CO-PROMOTERS
IDFoods (project started in 2020 and contracted in 2021)	Food System of The Future - Research and Development in Sustainable Agrifood Systems and Healthy Nutrition	SONAE	**RAIZ**, INIAV, SILVEX, INL, UMinho, UPorto, Prgrupo, Frulact, Mendes Gonçalves, INEGI
Bio4Portugal	Biorefinery for advanced fuels from forest residues	LNEG	PETROGAL, **RAIZ**
FirEProd	Controlled fire, fire hazard and eucalyptus productivity: from research to practice	UA	**RAIZ**
B2Solutions	Biobased and Biodegradable Composites	United Resins	NAVIGATOR Brands; **RAIZ**, United Biopolymers, Plastaze; CELBI; UA, UC
InovC+	Central Region Smart Innovation Ecosystem	UC_CFE	UA; UBI; InstPolitViseu; InstPolitGuarda; InstPolitCastelo Branco; InstPolitTomar; InstPolitCoimbra; InstPolitLeiria; BIOCANT; OBITEC - AssÓbidos Ciência&Tecn; TAGUSVALLEY; Itecons; Inst Pedro Nunes; ASSOCIAÇÃO BLC3; AEMITEQ; **RAIZ**; AIBILI; SerQ - Centro de Inovação e Competências da Floresta

Of the projects that began in 2021, we highlight the INOV C+: Intelligent Innovation Ecosystem of the Central Region, which was approved.

INOVC+ is a Special Strategic Program for the valorization of scientific and technological knowledge, consisting in the implementation of a pilot project of regional scope, which, in a networking context, involving non-corporate entities of the regional R&I system and companies, enhances the valorization and transfer of knowledge and results from R&TD activities for the regional economy.

Within this Program, **RAIZ** will promote a Co-creation Program, a Technologies Radar, an impact assessment tool and will be involved in regional technology shows for knowledge valorization.

EXTERNAL RECOGNITION AND CERTIFICATION

RAIZ in 2021 saw renewed its BIC recognition, the quality and innovation certification from the European Commission and the recognition as a UNESCO Club. It additionally started a partnership with the Network of Schools for UNESCO to promote its Floresta do Saber project.

Florestas.pt was distinguished with two honorable mentions in the M&P Communication awards.

GOVERNANCE

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PAULA NETO ALVES

SECRETARY
ANTÓNIO ALEXANDRE DE ALMEIDA E NORONHA DA CUNHA REIS

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CHAIRMAN
JOÃO PAULO CABETE GONÇALVES LÉ

GENERAL EXECUTIVE DIRECTOR
CARLOS DE PASCOAL NETO

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NUNO MIGUEL MOREIRA DE ARAÚJO SANTOS

STATUTORY AUDITOR

KPMG & ASSOCIADOS, SROC
REPRESENTED BY:
RUI FILIPE DIAS LOPES
(ROC Nº 1715)

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LEONOR GUEDES

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RICARDO JORGE

FORESTRY RESEARCH AND CONSULTING DIRECTOR
NUNO BORRALHO

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GENERAL DIRECTOR
Carlos de Pascoal Neto

DEMONSTRATION, SCALE-UP, NEW BUSINESSES
Alexandre Gaspar

TECHNOLOGICAL SCOUTING
Mariana Oliveira

TECHNOLOGICAL RESEARCH AND CONSULTING
Ricardo Jorge

FORESTRY RESEARCH AND CONSULTING
Nuno Borralho

ADMINISTRATIVE AND TECHNICAL SUPPORT
Leonor Guedes

OUTREACH AND STRATEGIC PROJECTS
Cristina Marques

GENETIC R&D AND FORESTRY CONSULTING
Daniela Ferreira

SILVICULTURE RESEARCH
Sérgio Fabres

TECHNOLOGICAL RESEARCH
Paula Pinto

TECHNOLOGICAL CONSULTING
Luís Machado

ADMINISTRATIVE SUPPORT
Leonor Guedes

FOREST TECHNICAL SERVICES
Cláudio Teixeira

SERVICES AND R&D LABORATORIES
Manuela Marques

PERSONNEL

The year of 2021, although with some improvements compared to 2020, continued to be a year of great challenges, requiring adaptations in the way **RAIZ** operates, maintaining the use of telework, shift work in the laboratory, a year that was also marked by moments of almost normal/regular activity.

Throughout this period, the various **RAIZ** teams have shown themselves to be resilient, motivated and active in the pursuit of goals and targets set for 2021. With the approval of the extension of inpactus until October 2022 and of Interface until September 2022, the staff structure remained virtually unchanged compared to 2020.

We highlight the inauguration of Florestas do Saber, the Magusto celebration with an internal presentation of the new Floresta do Saber's space and the inpactus audit, as moments of more intense collaborative work. The **RAIZ** Friday Seminars, that took place almost every Friday at **RAIZ**, were also relevant to the dynamics of group unity.

RELEVANT FACTS OCCURRED AFTER THE END OF THE YEAR

FUTURE PROSPECTS

No significant changes in the Company's activity are expected for 2022.

BUSINESS CARRIED OUT BETWEEN THE COMPANY AND ITS DIRECTORS

No business was carried out between the Company and its Directors.

PROPOSED IMPLEMENTATION OF RESULTS

The Direction of **RAIZ** - Forest and Paper Research Institute, proposes to its partners that the net result of the 2021 financial year, in the amount of € 273.673, be allocated to the item Results carried forward.

BOARD OF DIRECTORS

João Paulo Cabete Lé
Carlos de Pascoal Neto
Adriano Augusto da Silva Silveira
João Paulo Araújo Oliveira
Nuno Miguel Moreira de Araújo Santo

FINANCIAL STATEMENT

BALANCE

Amout in €	Note	2021	2020
ASSET			
Non-Current assets			
Tangible fixed assets	7	2 786 867	1 832 836
Intangible assets	8	16 199	10 351
Financial Investments - equity method	9	2 139 733	2 170 258
Financial investments - other	9	5 000	5 000
Other financial investments	11	23 719	18 787
Deferred income tax assets	12	115 500	77 000
		5 087 018	**4 114 231**
Current assets			
Costumers	13	20 415	745 172
State and other public entities	14	10 196	57 358
Other receivables	13	10 552 562	12 666 483
Cash and bank deposits	5	270 537	62 636
		10 853 710	**13 531 648**
TOTAL ASSETS		**15 940 728**	**17 645 880**
SHAREHOLDER'S EQUITY AND LIABILITIES			
SHAREHOLDER'S EQUITY			
Funds	15	9 000 000	9 000 000
Results carried forward		352 839	254 128
Adjustements/Other equity changes	15	1 009 188	942 635
		10 362 027	**10 196 763**
Net profit		273 673	99 081
TOTAL SHAREHOLDER'S EQUITY		**10 635 700**	**10 295 845**
LIABILITIES			
Non current liabilities			
Responsabilities for post-employment benefits	17	95 249	171 306
Liabilities by deferred taxes	12	406 130	425 150
		501 379	**596 456**
Current liabilities			
Suppliers	16	119 488	547 295
State and other public entities	14	118 368	129 488
Other payables	16	2 567 231	2 435 754
Deferrals	18	1 998 562	3 641 042
		4 803 648	**6 753 579**
TOTAL LIABILITIES		**5 305 028**	**7 350 035**
TOTAL SHAREHOLDER'S EQUITY AND LIABILITIES		**15 940 728**	**17 645 880**

FINANCIAL STATEMENT

INCOME STATEMENTS

Amout in €	Note	2021	2020
Sales and rendered services	19	4 479 213	4 536 937
Operational subsidies	20	2 045 742	1 994 727
Profit/(loss) incomes imputed from subsidiaries, associates and joint ventures	9	(30 525)	15 618
Supplies and external services	21	(1 597 014)	(2 309 385)
Staff costs	22	(4 390 485)	(3 916 865)
Other income	23	34 095	10 824
Other expenses	24	(64 889)	(23 347)
INCOME BEFORE DEPRECIATION, FINANCING EXPENSES AND TAXES		**476 137**	**308 509**
(Expenses)/reversals of depreciation and amortization	7	(175 657)	(181 824)
TRADING INCOME (BEFORE FINANCING EXPENSES AND TAXES)		**300 480**	**126 685**
Interest and similar income obtained	25	25 246	36 311
Similar interest and expenses incurred	25	(18 575)	(19 868)
RESULTS BEFORE TAXES		**307 151**	**143 127**
Income tax	12	(33 478)	(44 046)
NET PROFIT		**273 673**	**99 081**

ECONOMIC AND NON-ECONOMIC ACTIVITIES

	ACTIVITES		
	Economic	**Non Economics**	**Sums**
COSTS	**4 011 703**	**2 336 789**	**6 348 492**
Current Activities	3 836 046	-	-
Financed Projects	-	2 265 441	-
Depreciations	171 657	71 347	-
INCOMES	**4 538 554**	**2 117 088**	**6 655 643**
Services Rendered to Clients	4 479 213	-	-
Interests and similar incomes	25 246	-	-
Other Incomes	34 095	-	-
Subsidies			**-**
for Operations	-	2 045 741	-
for Investment	-	71 347	-
SUMS	**526 851**	**-219 700**	**307 151**

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RAIZ

PART OF THE NAVIGATOR COMPANY

RAIZ - Forest and Paper Research Institute
Quinta de S. Francisco,
Rua José Estevão (EN 230-1)
3800-783 Eixo, Aveiro,
Portugal

(+351) 234 920 130
raiz@thenavigatorcompany.com
www.raiz-iifp.pt