Projects

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Sustainable development: the ANR takes action

TARA PACIFIC & THE GREAT DIVERSITY OF CORAL REEFS
FEEDING CITIES SUSTAINABLY
IN OASES, PALM RESIDUES TO FERTILISE SOILS
TOWARDS MORE RESILIENT AGRICULTURAL SYSTEMS
GLOBAL CHANGE & EMERGING INFECTIOUS DISEASES

ACCELERATING
THE TRANSITION TO SUSTAINABILITY

Emerging infectious diseases, climate change, erosion of biodiversity, changing ecosystems, food safety... Scientists are mobilising across all disciplines and beyond national borders to provide keys for understanding how to address global change and risks, as well as local pressures. From adaptation to resilience, what sustainable solutions are needed to meet the major challenges of our century?
This booklet presents five projects funded by the ANR in which basic research contributes to sustainable development.

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SUSTAINABLE DEVELOPMENT: THE ANR TAKES ACTION

The Human Frontier Science Program (HFSP) is hosting an international summit and symposium "Fundamental Life Science Meets Climate, Environment and Sustainability" from 27-29 June 2023 at the Académie des Sciences in Paris, in collaboration with several partners including the French National Research Agency (ANR). This event brings together the life and environmental science communities, decision-makers, and funding agencies with a view to taking stock of the contributions made by basic research to sustainable development. The French National Research funding Agency is actively committed to supporting all of the research required to address the major environmental, ecological, social, digital, and energy transitions we face. This effort is in line with the areas defined in the European Commission's Horizon Europe plan, as well as the 17 Sustainable Development Goals (SDGs) identified by the United Nations.

In France, research stakeholders have massively worked to implement the United Nations 2030 SDG calendar, within the framework of a 2020-2030 roadmap aiming to mobilise all public and private research stakeholders. For Thierry Damerval, President and CEO of the ANR, "helping to achieve sustainable development goals is one of the Agency's top priorities. This commitment, which is reflected in its Work Programme, is demonstrated in its calls for proposals supporting research and innovation backed by basic research, leaving scientists complete freedom."

In practical terms, its funding instruments help support sustainable development research through its investigator-driven Generic Call for Proposals, as well as project-based research through specific, European, and international calls for proposals. As part of the ANR Work Programme, topics associated directly with the ecological transition and transformation cover the following areas: sustainability science, One Health, ecological and environmental transition, energy transition, technological transition, digital transformation, and socio-technical system transformation.

In addition, in order to raise awareness among researchers from all disciplines, in 2020 the ANR included SDGs in its Work Programme by asking project coordinators to specify if their proposal, regardless of the field, meets one or more SDGs. In 2022, 77% of proposals mentioned at least one SDG, representing 1,195 funded projects, a number that has grown since 2020. At the same time, the ANR is contributing to several European initiatives pursuing sustainable development, such as Joint Programming Initiatives, and is involved in international initiatives such as the Belmont Forum on Sustainability Science, and the IA-Biodiv Challenge, a French-African cooperation.

The ANR also operates, on behalf of the French State, the major France 2030 Investment Plan in higher education and research. France 2030 is an unprecedented plan for innovation, the decarbonisation of the economy, and reindustrialisation. It has a €54 billion budget, and aims to help us live better, produce better, and understand the world better.

This booklet presents several ANR-funded projects in which basic research supports sustainable development. ■

DECARBONISATION AT THE HEART OF FRANCE 2030

France 2030 aims to devote 50% of its expenses to decarbonising the economy, and 50% to emerging actors driving eco-friendly innovation (based on the Do No Significant Harm principle). Among the 10 objectives set out in France 2030, some are unequivocally aligned with the decarbonisation of society and sustainable development:

Making France the leader in **green hydrogen** and developing cutting-edge renewable energy technology

Decarbonising industry and the production of inputs

Manufacturing **2 million electric and hybrid vehicles** in France by 2030

Achieving net **zero emissions** and developing mobility that is efficient, independent, and resilient

Manufacturing **the first low-carbon aircraft in France** by 2030

Innovating to make **healthy, sustainable, and traceable food**

Creating **small and innovative nuclear reactors** with better waste management in France by 2030

“WE NEED TO ADDRESS CLIMATE CHANGE FROM A SYSTEMIC POINT OF VIEW”


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To mark the “Fundamental Life Sciences Meets Climate, Environment and Sustainability” international Science Summit and Scientific Symposium, hosted by the Human Frontier Science Program (HFSP), Pavel Kabat, the Secretary-General of the HFSP, will present the issues and expected outcomes of the event.

How can basic research in the life sciences help accelerate the sustainability transition?

Pavel Kabat: Climate change and unsustainable lifestyles are two of the greatest challenges facing humanity in the 21st century. We are tackling these two topics in the international summit and symposium because this is where basic life science can make a substantial difference. For example, most of the climate science conducted since the 1980s has focused exclusively on atmospheric science and ocean science. Forty years ago, scientists believed they could fully characterize the scope of the threat posed by climate change by studying just these two areas.

But as scientists have progressed in their thinking, especially in the area of climate change risk management, it has become clear that many other scientific disciplines are essential to fully understanding how the Earth system works as a whole, such as the key role

played by vegetation in the climate cycle via the regulation of available water vapor in the atmosphere. We need to address climate change from a systemic point of view, which means inviting a diverse range of scientists to contribute their expertise and insight. This is precisely what our three-day event intends to do. It will be a significant event that we hope will foster a long-term working method that will be more productive in addressing global challenges.

Let us also consider sustainability. Currently there are more than 7 billion people in our world. As climate change raises the temperature in many regions, to the point that farming becomes difficult or impossible, one of the threats will be food security. How will we feed people if large areas of land are affected by torrential flooding or extreme heat and drought? Photosynthesis, the ability of plants to absorb sunlight and grow plant mass, is a central concern. As it turns out, it is an unbelievably inefficient process, as only 1% of the available sunlight is actually used in photosynthesis. Is there a way to make plant photosynthesis more productive? These are questions for molecular biologists to research, and we need this new knowledge to make important decisions.

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"WE HOPE THE INTERNATIONAL SCIENCE SUMMIT AND SCIENTIFIC SYMPOSIUM WILL CATALYSE A WHOLE NEW APPROACH THAT CAN HELP OVERCOME THE ADVERSE EFFECTS OF CLIMATE CHANGE, ONE THAT USES THE FULL RANGE OF SCIENTIFIC EXPERTISE TO DEVELOP A MORE THOROUGH PICTURE."

What are the expected outcomes of the event?

P.K: We hope the International Science Summit and Scientific Symposium will catalyse a whole new approach that can help overcome the adverse effects of climate change, one that uses the full range of scientific expertise to develop a more thorough picture. We have to understand how living organisms contribute to Earth's systems. To do so, we need a more transdisciplinary perspective to research that engages a diverse range of scientific disciplines. This involves basic research on systems of which there frankly has not been enough. The answers provided by such efforts will yield a much fuller picture of our world, one that can help policymakers understand how the habits of plants, animals, people, and communities affect the core systems that make planet Earth a liveable place.

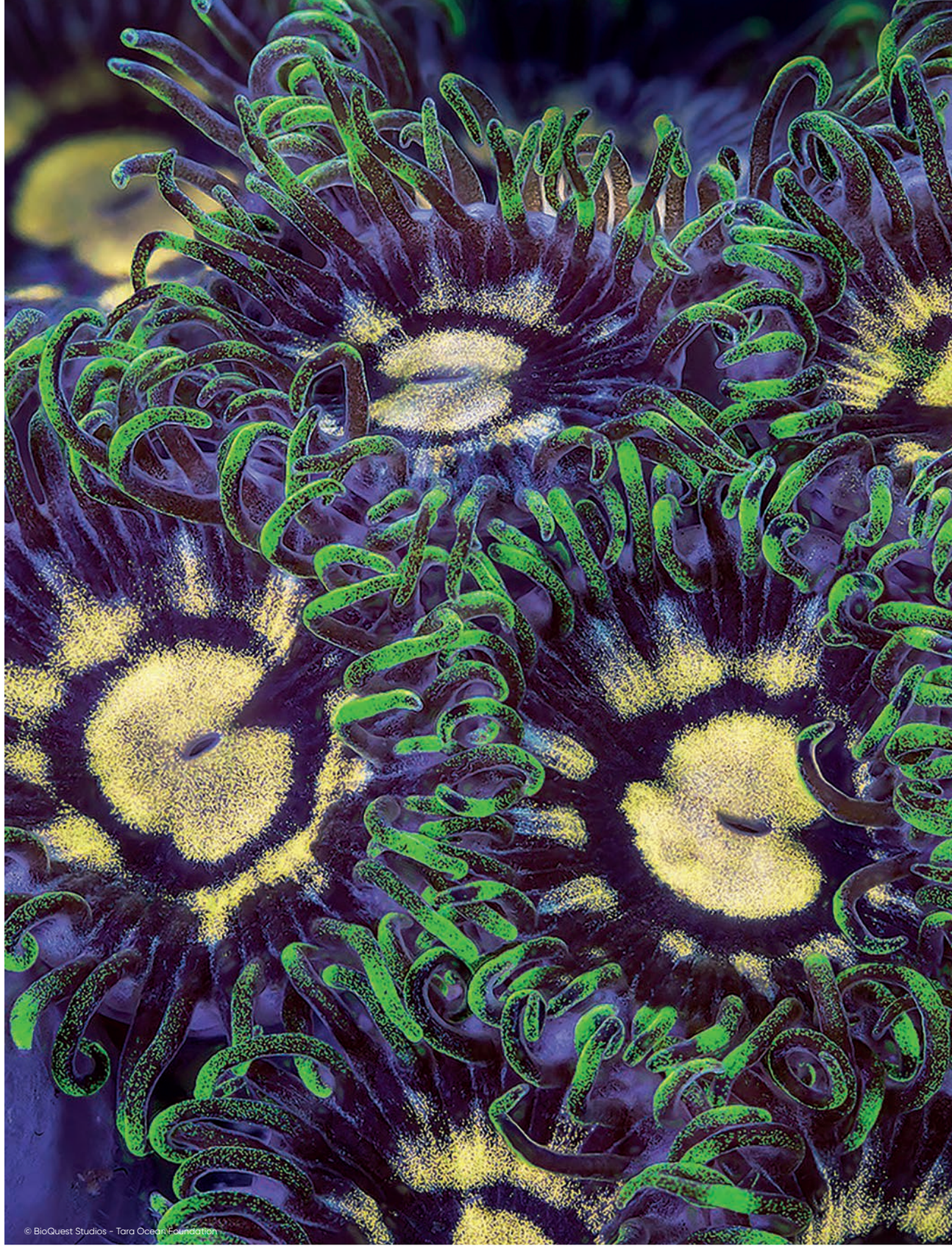
What are the main objectives of the Human Frontier Science Program Organization?

P.K: HFSPO is an international collaboration of 17 member states working together to promote global cooperation in life science research. Established in 1989, HFSPO funds basic life science research that is high-risk, interdisciplinary, intercontinental, and collaborative, with a philosophy of "science without borders". It encourages innovative and novel thinking in support of transformative and paradigm-shifting research. ■

TARA PACIFIC

THE GREAT DIVERSITY OF CORAL REEFS REVEALED

Between 2016 and 2018, the schooner Tara sailed the Pacific Ocean, drawing as close as possible to coral reefs. The objective was to explore the biodiversity that composes and surrounds them, from genes to the ecosystem, and obtain a better understanding of their mechanisms of adaptation to local pressures and global disruptions. This scientific and human journey carried on after returning to the mainland. The reef microbiome is at the heart of the CORALGENE project, which relies on the data collected during the expedition. An update from Serge Planes, Tara Pacific Co-Director, CNRS senior researcher at Criobe (CNRS/EPHE - PSL/Université de Perpignan Via Domitia), and project coordinator.

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More than 30% of known marine species are located in coral reefs, which act as genuine biodiversity reservoirs and marine primary forests, but barely covers 0.2% of ocean surface area. They also provide ecosystem services through fishing and tourism, and serve as a natural barrier against swells. But reefs, which are very sensitive to climate change and subject to numerous forms of anthropic pressure, are now threatened from all sides. In recent decades, nearly 20% have irretrievably disappeared as a result of extreme marine heat waves, ocean acidification, and other local pressures linked to human activity. As a result, by the end of the century there could no longer be reefs as we know them. *"These ecosystems are dynamic, they evolve, they change. While they are accustomed to continuous change, what is problematic today is the recurrence and intensity of the disruptions they endure. Reefs have less and less time to recover between these disturbances"*, explains Serge Planes, the coordinator of the ANR CORALGENE project and CNRS research director.

100 000
kilometres covered

32
islands providing a wide range of environmental conditions

249
sampling stations

58 000
samples collected

200
scientists on board

An ecosystem-based approach to tropical coral reefs

With over 100,000 kilometres covered, 32 islands providing a wide range of environmental conditions, 249 sampling stations, and 58,000 samples collected, the schooner Tara sailed throughout the Pacific for two years, getting as close as possible to corals. The approximately 200 scientists on board—experts in marine ecology, molecular and cellular biology, genomics and bioinformatics—focused in turns on the holobiont, doing so for the first time on such spatial and temporal scales. *"The holobiont consists of all the micro-organisms that make up reefs: a multitude of viruses, fungi, bacteria, and microalgae, such as the* zooxanthellae *stored by corals in their tissues, and which give them their bright colours. The idea was to better understand the complex links that unite these organisms, as well as their interactions and their role in ensuring the good health and resilience of reefs"*, says Serge Planes. To do so, scientists looked very closely at certain species: three coral species (the massive *Porites lobata*, the branch coral *Pocillopora meandrina*, and the fire coral *Millepora platyphylla*) in addition to two kinds of fish (*Acanthurus triostegus* and *Zanclus cornutus*). What also distinguishes this expedition is the methodology and protocols implemented by the scientists. In order to discover the full genomic, genetic, viral, and bacterial diversity of a reef—and reveal the nature of these microscopic interactions—scientists systematically collected not only the target species but also the surrounding water at varying depths, along with sediments.

From the gene to the ecosystem, scientists have established an unprecedented inventory, the largest ever created for coral.


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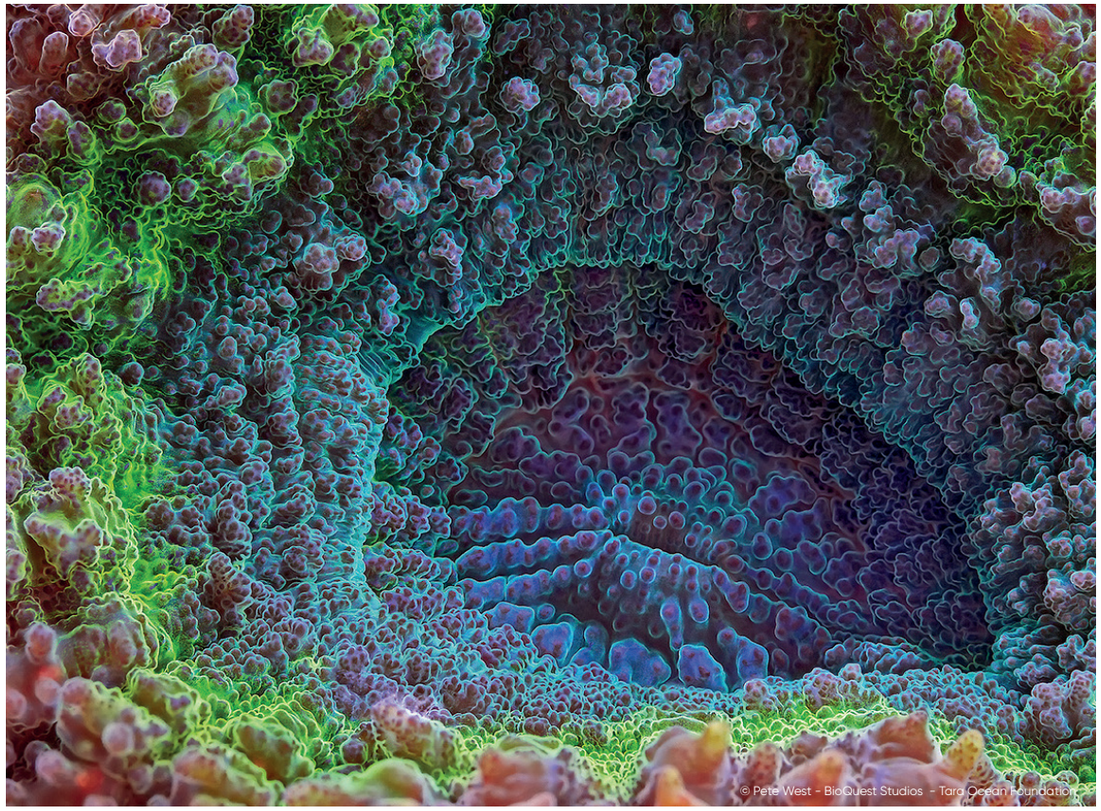
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“Although we are not seeing the extinction of coral species today, in the future we can expect a transformation and reconfiguration of landscapes, with certain species probably supplanting others.”

The data collected represents an unprecedented resource for the scientific community, providing an increasingly clearer idea of the global diversity of these environments, as well as their response to climate change and anthropic disturbances. Scientists used several high throughput sequencing approaches to examine the genetic material found in the 58,000 samples collected, including metagenomics, metatranscriptomics, and metabarcoding, along with satellite observations. *“Each sample is thus connected to a biological and physicochemical contextual environment, which can now be studied by scientific communities interested in exploring it”,* concludes Serge Planes.

From the gene to the ecosystem, scientists have established an unprecedented inventory, the largest ever created for coral.

United we stand

“Coral health depends on their environment but also on the holobiont, as well as on the relationships and symbiotic interactions—largely unknown—of these microorganisms within a coral reef ecosystem,” adds Serge Planes. Scientists notably focused on the composition of a microbial community associated with corals, *endozoicomonadacea*. Their theory is that various coral species may have evolved towards different host-bacteria relationship strategies. Analyses indicate that this symbiotic relationship, the result of a very old co-evolution between the bacterium and its coral, provides not only amino acids, but also an essential vitamin, vitamin B, which acts as the coral’s immune response. The expedition’s most surprising result was the discovery of the unprecedented diversity of the coral reef microbiome, which had previously been greatly underestimated: it could come close to the estimated total diversity of microorganisms on Earth, prokaryotes. *“These fundamental results, which highlight the diversity of the microbiome connected to the coral, show the crucial importance of maintaining a diverse microbiome, which probably serves as a reservoir of resources for resisting stress and/or the loss of part of this microbiome”,* says Serge Planes. For the scientist, who emphasises the long-term nature of research, the issue of overall reef health is complex, and marked by wide disparities across the Pacific, notably due to local anthropic pressures. *“Although we are not seeing the extinction of coral species today, in the future we can expect a transformation and reconfiguration of landscapes, with certain species probably supplanting others”,* he concludes. ■

[1] View the partners' list on the project summery page: https://anr.fr/Project-ANR-17-CE02-0020

UNDERSTANDING THE RELATIONSHIPS BETWEEN **CROP DIVERSITY AND FOOD SECURITY**

At the interface between agroecology and ethnoecology, the ASSET[1] (AgrobiodiverSity for a food-Secure planet) project was selected as part of the MOPGA (Make our Planet Great Again) international call launched in 2018 under PIA - France 2030. It focuses on the resilience of agroecosystems when dealing with extreme climate events. In the five years since the project was launched, four sites in France, Morocco, and Senegal were used as privileged observation posts, both locally and nationally, to assess the benefits of agrobiodiversity on crop yields. An interview with Delphine Renard, CNRS researcher and project coordinator.

ASSET © E.Menguy, IRD

How did the project come about and what were the challenges that led to its creation?

Delphine Renard: The ASSET project addresses the impact on agriculture of extreme climate events, which are by nature both unforeseeable and destabilising for agricultural production. In the future, these extreme climate events will become more frequent and intense. In 2018, when the project began, we were beginning to better understand the effects of these extreme climate events on agriculture, but efforts focused more on the longer-term impact of climate change on crop yields.

ASSET grew out of an initial study published in *Nature*[2] in 2019. By using FAO statistical data, I demonstrated, on a national basis and over a period of five decades, that the greater the crop diversity in a particular country, the more stable its food production over time.

The three main objectives of ASSET were to get a better sense of what lay behind this statistical link. The research sought to test whether agricultural biodiversity, particularly that of crops, could help stabilise crop yields and develop more resilient agriculture in the event of extreme climate events.

How did it work, in practical terms?

D.R: Two disciplines were at the interface of this problem: agroecology, which applies ecology to agricultural issues, and ethnoecology, which assesses the relationships between societies and their environment.

The project focused on droughts, but we also worked on grapevines in France, impacted by late frost and hail. We conducted our research in four specific locations. In France, we focused on the Tarn region of Gaillac, using a "vine" model, and on the Trièves region (Vercors), with its many varieties of barley used for local whisky production. In Morocco, we are working according to a "polyculture: olive trees, cereals, legumes" model, and in Senegal on a "cereals and legumes" model.

What objectives and methods were used? What were the main results?

D.R: The first objective was to better

understand the mechanisms through which diversity leads to steadier production, at diverse spatial scales. The methodology was based on statistical and mathematical modelling using FAO and simulation data. We also implemented two field observatories for long-term monitoring at the smallest scale, that of the household. To measure stability, we need data that can be tracked over time, but they are never collected on the overall basket of species or varieties grown. We are trying to fill this gap.

Locally, we are measuring productivity on four vine varieties in the Gaillac region, and on 6 species/17 varieties grown at our 3 sites in Senegal. This year, we are conducting our 4th data collection in France, and our 5th in Senegal. The yield data acquired for each species/variety will help us test diversity-stability connections, as well as identify plant combinations that promote greater stability in agricultural production. We will be able to answer this question once the data collection is complete[4]. Through mathematical modelling, we were able to compare the benefits of agricultural diversification on the regulation of two wheat pathogens, using different practices (rotation, mixtures of species/varieties), doing so from the level of the plot to that of the landscape, and under various climate conditions. An article was published in *Landscape Ecology*.[5]

Finally, the objective was to better decipher how and why farmers choose a diversity of plants in the field. For instance, in Senegal we found that farmers combine a great diversity of species and varieties within the same plot (37 different forms of association), and that these combinations are not, at first glance, those recommended by agronomists. From an ethnoecological perspective, through interviews and an analysis of literature[6], we sought to understand what motivates farmers to make these combinations, and how they mobilise local knowledge to address climate constraints. More broadly, we are interested in the socio-cultural, scenic, medicinal, gustatory, agronomic, and ecological values associated with the diversity of these plants. All these values coexist, and are not at all separate in the minds of farmers.


ASSET © E.Menguy, IRD


ASSET © E.Menguy, IRD

“IN SENEGAL WE FOUND THAT FARMERS COMBINE A GREAT DIVERSITY OF SPECIES AND VARIETIES WITHIN THE SAME PLOT (37 DIFFERENT FORMS OF ASSOCIATION), AND THAT THESE COMBINATIONS ARE NOT, AT FIRST GLANCE, THOSE RECOMMENDED BY AGRONOMISTS.“

From an agroecological perspective, how can we explain the role agrobiodiversity plays in stabilising agricultural food production?

D.R: Our approach is based on a simple mechanism, known as “insurance”, in connection with the unpredictability of these extreme climate events. To put it simply, this would be a phenomenon akin to the saying: “don’t put all your eggs in one basket”. Sowing a variety of plants with different responses to various climate events, or with more or less sensitivity to stress from pests or diseases, can make harvesting more secure through a compensatory effect. Depending on the year and the weather, a species will flourish to a much greater extent compared to another, and the overall production will remain “stable on average” over time. Our results show that this process is at play, especially on the national level, and could complement the stabilising effect of irrigation, mainly used for field crops. ■

[1] View the partners’ list on the project’s website https://www.asset.cnrs.fr/

[2] *National food production stabilized by crop diversity* | Nature

[3] The Food and Agriculture Organization (FAO) https://www.fao.org/home/en

[4] The project will end in April 2024.

[5] https://doi.org/10.1007/s10980-022-01545-2

[6] Initiated as part of a contribution to the most recent IPBES Values Assessment, of which M. Demongeot, a Ph.D. student of the project, is a contributor (10.5281/zenodo.5656910). The data extracted from the literature are currently being assessed in greater detail as part of a scientific article.


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SOUTHEAST ASIA FACES GLOBAL CHANGE AND EMERGING INFECTIOUS DISEASES

Southeast Asia is undergoing major changes in land use affecting biodiversity, including growing urbanisation, increased livestock, the expansion of agricultural land, and the loss of forest cover, among others. What links are there between these changes and emerging zoonotic diseases and vector-borne infectious diseases?

The increasing emergence of infectious agents in human populations and the Covid-19 pandemic crisis show how important it is to understand the factors behind the emergence of zoonotic diseases (diseases for which the agent, a bacterium, virus or parasite, may also be passed from animals to humans). The same is true for vector-borne infectious diseases such as Chikungunya. That is the purpose of the ANR FutureHealthSEA[1] project, coordinated by Serge Morand, CNRS and CIRAD senior researcher. Scientists have developed retrospective models for the dynamics of epidemics, both internationally and in Southeast Asia, taking into consideration climatic factors and changes in land use.

To this end, they collected the available international data on the impact of infectious diseases in recent decades on humans and animals, as well as changes in land use, climate, biodiversity, and farming, along with a national data set from hospital monitoring of three major diseases through their cooperation with the Thai Ministry of Health. *"These include dengue fever transmitted by mosquitoes, leptospirosis, caused by an environmental bacterium whose main reservoirs are rodents, and scrub typhus, caused by rickettsia (bacterium), whose vectors and reservoirs are mites"*, explains Serge Morand. A series of texts on public policies and legal instruments was also created. This modelling effort seeks to provide a better understanding of epidemic dynamics in time and space with respect to interactions with socio-environmental factors.

10 years of collaborative research in Saen Thong

The project is based on the experience acquired in two ANR projects, as well as cooperation since 2012, with Thai scientists, communities, and local administrations in Saen Thong. *"The demand to study various local issues, such as the exposure of livestock to pesticides, called for expertise in ecological sciences, human and health sciences, and the social sciences. In my opinion, such an interdisciplinarity approach was one of the project's main achievements, and took concrete form with the creation of a socio-ecological observatory for biodiversity and health in Saen Thong".* It brings together research projects conducted under a One Health approach.

"OUR RESEARCH HAS SHOWN, ON A GLOBAL SCALE, A CORRELATION BETWEEN EXPANDED LIVESTOCK BREEDING AND INCREASING ZOONOTIC AND VECTOR-BORNE INFECTIOUS DISEASE EPIDEMICS; AND A CORRELATION BETWEEN THE DEFORESTATION OR EXTENSION OF OIL PALM PLANTATIONS AND INCREASING EPIDEMICS IN RECENT DECADES."

Studying the factors behind emerging infectious diseases

Based on data from the global infectious diseases and epidemiology network GIDEON, the team has seen an increase, during recent decades, in infectious epidemics within populations internationally. *"Monitoring systems have enhanced detection capacity, but that does not explain such an increase,"* stresses Serge Morand.

"Our research has shown, on a global scale, a correlation between expanded livestock breeding and increasing zoonotic and vector-borne infectious disease epidemics; and a correlation between the deforestation or extension of oil palm plantations and increasing epidemics in recent decades. It should be noted that countries with the lowest rate of biodiversity loss also have the lowest rate of epidemics, which suggests that biodiversity has a protective effect against epidemic risk. In Thailand, commercial plantations appear to increase the risk of zoonotic and vector-borne disease epidemics such as dengue fever. Landscape fragmentation and climate variability, with El Niño / La Niña climate events, appear to encourage the growth of scrub typhus, while cattle density increases the risk of leptospirosis", Serge Morand continues.

Protecting the health of ecosystems, animals and humans

The team stresses the importance of protecting ecosystems and the services they provide in reducing epidemic risks. It also emphasises the role of observatories in understanding the dynamics behind evolving health and environmental risks, as well as the implementation of nature-based solutions. In this respect, it is crucial to involve health and biodiversity actors in the field. Research will continue as part of the France 2030 PREZODE programme. ■

A French research programme at the heart of an international mobilisation

The France 2030 PREZODE Programme, which was launched in 2021 under the "Emerging Infectious Diseases" national strategy, and extended the EID research programme, aims to expand knowledge of risks factors associated with the emergence of zoonotic diseases, and the development of strategies focusing on risk reduction and early emergence detection. Co-led by the IRD, CIRAD, and INRAE, and operated by the ANR, it has a budget of €30 million over 5 years.
The PREZODE community now has more than 160 members from the worlds of science, academia, and NGOs, with 14 member states and over 1,500 researchers.

[1] The ANR FutureHealthSEA project (2017-2022) brought together scientists from various French laboratories, including UMR Animals, Health, Territories, Risks, Ecosystems (CIRAD, INRAE), the Institute of Ecology and Environmental Sciences of Paris (SU, CNRS, INRAE, IRD, Université Paris Cité, UPEC), the Institute of Evolutionary Science of Montpellier (CNRS, UM, IRD, EPHE, CIRAD, INRAP) and the UMR Geosciences Environment Toulouse (CNRS, IRD, Université Toulouse 3, CNES), as well as from Thai laboratories, including the Faculty of Tropical Medicine - Mahidol University, and the Faculty of Veterinary Technology - Kasetsart University.

IN OASES

RECYCLING DATE PALM RESIDUES TO IMPROVE SOIL FERTILITY


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In the oases of North Africa, Tunisia, and Algeria, growing date palms is a major source of local production, but it is now threatened by a number of factors. Based on a participatory approach, the ISFERALDA project aims to recover palm residues and use them as new assets and tools to increase the resilience of crops to ongoing disruptions.
An interview with Xavier Morvan, project coordinator and researcher at the University of Reims Champagne Ardenne[1].

How did the ISFERALDA project come about, and what were the challenges that led to its creation?

Xavier Morvan: First of all, there is the socio-economic background. In semi-arid and arid areas, and particularly in oases, date palm farms are most often small properties of just a few hectares, requiring high productivity to be profitable. Although it is traditionally intensive, it is still subsistence agriculture with low inputs and very low mechanisation. The ecosystems of these agrosystems are also affected by many factors that endanger their sustainability: the lack of surface water, soil and groundwater salinisation, low soil fertility, excessive soil use without significant return or rotation, and especially climate change, which may accelerate pest invasion and emerging diseases, and reduce water availability. Finally, date palm production leads to a large amount of agricultural waste - each tree produces approximately 10 palm fronds a year - that is little used today, but could become a major renewable, sustainable, and local resource.

Speaking of which, from waste to resource, how precisely are these agricultural residues used?

X.M: By following the principles of a circular economy. We want to study the conversion of


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local date palm residues into organic matter for improving infertile soils. To do so, we actively involved local farmers to develop farmhouse composting and pyrolysis methods for date palm residues. Pyrolysis involves burning biomass, in this case palm fronds, at high temperature without oxygen in order to reduce it to biochar. Applying these soil improvers will help improve the soil's fertility and properties such as water retention, and should provide comparable or greater income for local farmers.

What results have you achieved so far?

X.M: The project began in 2021. There are still many experiments to be conducted or currently underway, in both the laboratory and the field, and the results we have achieved are still incomplete. However, we can draw from our analysis of the interviews we conducted with farmers. While few farmers are currently using date palm compost or biochar, around two-thirds are ready to use compost made from date palm residues, as long as the product is available in local markets in quantity and quality, on a permanent basis and at reasonable prices. The other third of farmers remains reluctant to use these products, but is willing to rethink their position if the results achieved are satisfactory. Another result is the increase of water retention in soils when we add organic soil improvers. This increase is even greater with sandy soils. For instance, adding 3% of biochar to soil with 85% sand helps increase the soil's useful reserve by 78%, compared to unimproved soil.

"APPLYING THESE SOIL IMPROVERS WILL HELP IMPROVE THE SOIL'S FERTILITY AND PROPERTIES SUCH AS WATER RETENTION, AND SHOULD PROVIDE COMPARABLE OR GREATER INCOME FOR LOCAL FARMERS."

How did you ensure that these project results are passed on to the stakeholders?

X.M: We conducted many communication campaigns - with farmers, date palm producers, farm advisors, policymakers, and the local population in general - through a website, messages on social networks, and scientific conferences at national and international congresses, in order for everyone to benefit from the results achieved by the project. We also hosted demonstration days at agricultural sites, and open days at research institutes and at the project's partner company. The purpose was to obtain feedback from people in the field. Farmers were also consulted in realigning the project's innovation process. For that matter, they are also involved throughout the process, from preparing and maintaining soil quality to crop harvesting.

How is transdisciplinarity, ranging from the human to the life sciences, fundamental to your project's key issues?

X.M: Each consortium partner involved in the ISFERALDA project[1] is crucial to achieving the objectives. This project is transdisciplinary because it addresses socioeconomic and scientific issues. The socio-economic aspect, based on surveys and cost-benefit analysis, is essential for farmers, because it helps identify the problems they are experiencing and the solutions currently being pursued, and determines the economic interest of producing and using the organic improver studied. Scientific issues are also essential, because they help generate reliable and thorough information, based on statistically significant results that can be transferred and disseminated to the relevant stakeholders. The scientific fields and expertise involved vary, including the study of soil organic matter, producing and characterising organic soil improvers (compost and biochar), soil physics, soil chemistry, and soil microbiology, agronomy, and plant physiology, among others. Combining these socio-economic and scientific aspects will help to understand the needs of farmers, to assess the economic interest of the agricultural practices being proposed, and to disseminate reliable and thorough scientific results in line with the needs of the relevant stakeholders. ■

[1] The ISFERALDA project consortium brings together six research institutes, one technical institute and one company: URCA - GEGENAA University of Reims Champagne Ardenne - Study Group on Natural, Anthropogenic and Archaeological Environments and Geomaterials; UMKB - University Mohamed Khider of Biskra; IRA Arid Regions Institute of Medenine (IRESA) – University of Gabès; HAO-DEMETER Hellenic Agricultural Organization – DEMETER; INRAA National Institute of Algerian Agronomic Research; University of Batna Hadj Lakhder; ITDAS Technological Institute for the Development of Saharan Agriculture; and Palm Compost.

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Growing social demand for more eco-friendly food has prompted the emergence of new food supply systems (organic farming, local distribution networks, etc.). The URBALIM project[1] is working on a new and unique framework to assess the environmental performance and resilience of our systems from a "life cycle" perspective. An interview with Eléonore Loiseau, Engineer at the Bridges, Water, and Forestry Corps of Engineers at INRAE, and project coordinator.

FEEDING CITIES SUSTAINABLY
AN ENVIRONMENTAL ASSESSMENT CHALLENGE

Why is an assessment framework necessary now?

Eléonore Loiseau: Feeding cities sustainably involves reducing the environmental impact of food, which accounts for a quarter of global greenhouse gas emissions, and consumes many resources. It also entails creating supply chains that are resilient to global change.

To support the deployment of new territorial food systems, we need to develop environmental impact assessment methods to quantify their impacts and their ability to fully meet the needs of territories. The URBALIM project therefore aims to provide a complete diagnosis of food supplies in cities with a view to identifying the main levers for improving environmental performance; to characterise, from a life cycle perspective, the system's vulnerability to environmental or socio-economic disturbances (resource depletion, climate change, economic crises, etc.); and, finally, to compare the eco-efficiency of different strategies.

How can we assess food supply systems?

E.L: Methodological developments are based on the Life Cycle Assessment (LCA) framework, a standardised and recognised method for assessing the environmental impact of food. Its multi-criteria perspective - "from the cradle to the grave" - helps identify pollution transfers between stages in the life cycle and the categories of environmental impacts. Initially designed to study systems at the "micro" scale, the LCA framework has been adapted to assess overall territorial environmental performance. To deepen and operationalise territorial LCA approaches, we are striving to develop new metrics including concepts such as planetary limits and system vulnerabilities to several disturbances, and to propose simplified methods for collecting data.

This involves integrating various concepts within a single assessment framework, and applying it to a case study, the French city of Montpellier, in order to provide local decision-makers with objective information for co-developing more sustainable food supply schemes.

The project's success rests upon the mobilisation of different disciplines (environmental sciences, agronomy, economy, applied mathematics, etc.) as well as the involvement of territorial stakeholders.

What analyses did you make for Montpellier?

E.L: Our initial results have shown the possibility of applying these processes at city and regional level, with a view to identifying the primary opportunities for reducing the impact on food supply. The main impacts are caused by agricultural production (70-90% of impact for animal products), while that of logistical chains (excluding the last few kilometres) can be low, even if they extend over very long distances. In a more preliminary stage, new metrics on food supply vulnerability were proposed, based on resource criticality assessment methods (minerals, water, land). Their application helps identify potential compromises between environmental impact reduction and system vulnerability. For instance, with respect to bread, it was shown that some supply chains can be more efficient environmentally, but they depend on more critical resources.

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"THE MAIN IMPACTS ARE CAUSED BY AGRICULTURAL PRODUCTION (70-90% OF IMPACT FOR ANIMAL PRODUCTS), WHILE THAT OF LOGISTICAL CHAINS (EXCLUDING THE LAST FEW KILOMETRES) CAN BE LOW, EVEN IF THEY EXTEND OVER VERY LONG DISTANCES."

How can territorial stakeholders use these results?

E.L: Our initial results presented to the city of Montpellier provide objective information to identify courses of action. One of the key levers is a behavioural change in terms of food consumption, namely moving towards less meat-based diets. Another promising avenue is to rethink the last few kilometres, from the point of sale to the consumer, by using soft mobility and new routes. The next stages aim to complete the existing metrics and apply them to Montpellier on alternative networks, in order to discuss with local officials regarding potential compromises between environmental performance and system vulnerability. ■

Understanding Territorial LCA in 4 minutes

[1] The ANR URBALIM project (2021-2024) brings together scientists from 4 institutes: INRAE, the Institut Agro de Montpellier, CIRAD, and the Joint Research Centre. It is also supported by the ELSA-PACT Industrial Chair, and the UNESCO Chair on World Food Systems, and has a partnership with the city of Montpellier.

The French National Research Agency: Funding research in all its diversity

A public institution under the authority of the French Ministry of Research, the French National Research Agency (ANR) is the funding agency for project-based research in France. It aims to fund and promote the development of basic and targeted research in all disciplines at national, European, and international level. It also funds technological innovation and technology transfer, partnerships between research teams from the public and private sector, and strengthens dialogue between science and society.

The ANR is also the main operator of the France 2030 Investment Plan in higher education and research, for which it selects, funds, and monitors projects in connection with initiatives of excellence, research infrastructure, and support for the advancement and technology transfer of research.

The ANR is ISO 9001 certified for all of it"project selection" processes.

France 2030: Bringing the future forward

Announced in 2021 by the President of the French Republic, the France 2030 Investment Plan furthers the commitments made under the Investments for the Future Programmes (PIA) established in 2010, notably by supporting the evolution of the research ecosystem, and by funding structuring projects over the long term.

France 2030, a comprehensive plan designed to decarbonise industry and invest in priority and growth-generating areas, has a total budget of €54 billion, of which approximately €12 billion is managed by the ANR.

To address these challenges, the programmes and projects operated by the Agency cover a wide variety of research areas with countless possible and future applications (green hydrogen, artificial intelligence, health, healthy and sustainable food, training for the occupations of the future, deep sea and space exploration, decarbonisation, recycling, etc.).

Projects

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