

<https://lemag.ird.fr/en/biodiversity-between-fragility-and-sustainability>

Biodiversity: between fragility and sustainability

The decline in biodiversity poses a threat for humans. What sustainability efforts are required to mitigate the fragility of biodiversity?

© IRD - Olivier Dangles

Updated 16. 07. 2021

All the indicators agree: erosion of biodiversity has now reached a level not seen in hundreds of thousands of years. Human activity is to blame, and its impact is not just being felt by such emblematic species and ecosystems as the polar bear or Great Barrier Reef. The major health, social and economic crisis caused by COVID-19 has confirmed that humanity is also in danger.

SUMMARY

The loss of biodiversity fosters pandemics

The plant world is also at risk

Knowledge to be safeguarded and mobilized

(Inadequately) Protected Areas

2020 should have seen the closure of the United Nations Decade on Biodiversity and major international events had been organised to mark the occasion. The world congress of the International Union for the Conservation of Nature (IUCN), the world benchmark for the conservation status of plant and animal species, was due to be held in Marseille, France in June 2020. COP 15, the 15th conference of the parties to the Convention on Biological Diversity (CBD), was scheduled to take place in China in October 2020.

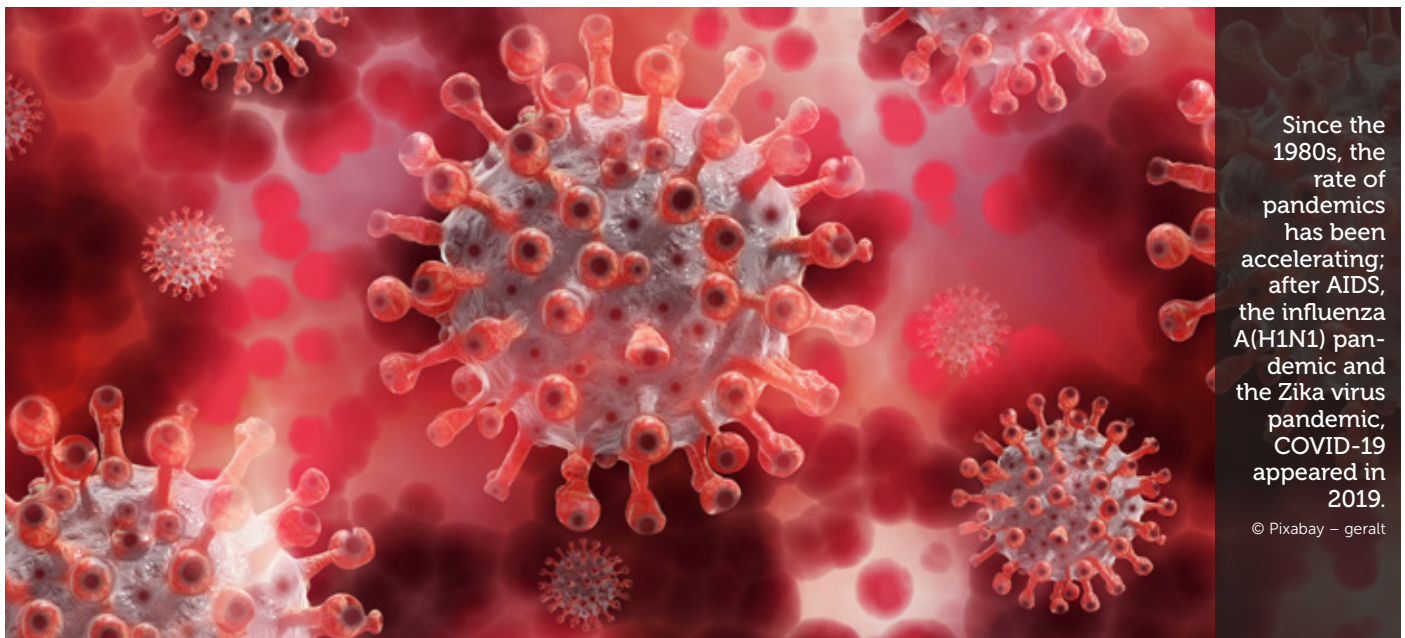
This international agenda was seriously disrupted by the emergence of a virus that came as a reminder of the major issues associated with the decline of biodiversity. SARS-CoV-2 first appeared on the radar just over a year ago (late 2019), has contaminated more than 147 million people and has led, directly or



What is the link between the COVID-19 pandemic and the loss of biodiversity?

© Pinte Linforth-Pixabay

indirectly, to the death of 3.2 million of them. It remains difficult at this stage to measure the social and economic consequences precisely, but the impact of the SARS-CoV-2 pandemic will be felt for a long time to come. How is the emergence of this infectious disease linked to the erosion of biological diversity?

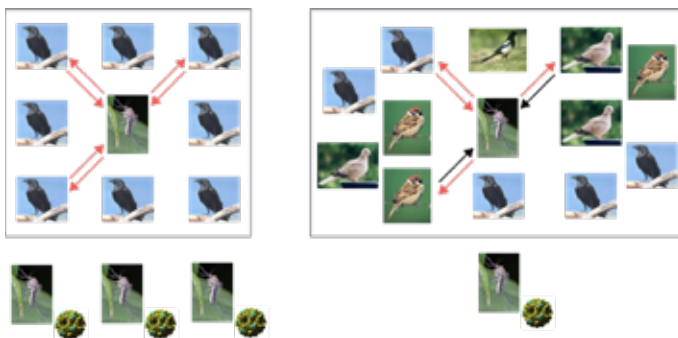


Since the 1980s, the rate of pandemics has been accelerating; after AIDS, the influenza A(H1N1) pandemic and the Zika virus pandemic, COVID-19 appeared in 2019.

© Pixabay – geralt

The loss of biodiversity fosters pandemics

'Through its causes and its consequences, the destruction of biodiversity is one of the main drivers in the emergence of zoonoses, diseases of animal origin which are transmissible to humans,' confirms Benjamin Roche, a biologist from UMI UMMISCO. Certain animal species are in fact a "dead end"; they host the microbes without transmitting the infection to other animals.

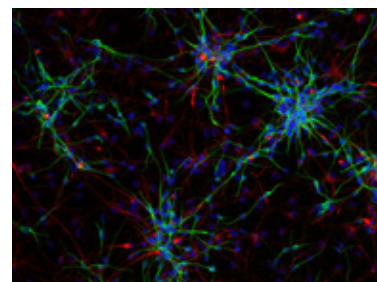


The presence of a large number of species (right) susceptible to infection, more or less effectively, dilutes the spread of the pathogen transmitted by mosquitoes.

© Roche et Guégan, CR Biol, 2011

'However, these "cul-de-sac" species are generally among the first to disappear when biodiversity is eroded. This in turn reduces the "dilution" of infectious agents in the environment,' the biologist explains. Transmission of micro-organisms among wild animals thus becomes more intense. Deforestation and changes in land use also increase contact between this wildlife with a potentially higher rate of infection and humans or domestic animals. This facilitates the direct or indirect transmission of infectious agents to the human population.

Globalisation and the connectivity of our modern societies enable these zoonoses to spread rapidly throughout the



Human neuronal cells infected by the Zika virus, observed by Evos® fluorescence microscope at the containment level 3 insectarium at Vectopôle IRD Montpellier.

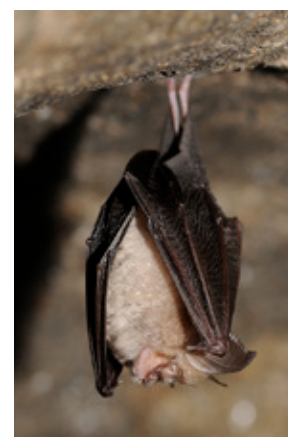
© IRD - Pauline Ferraris

planet. Pandemics have also become increasingly frequent. Up to the 20th century, around one major world epidemic (or "pandemic") emerged per century. Since the turn of the 20th century, however, six pandemics have been declared, including four since the 1980s: AIDS, caused by HIV, A(H1N1) influenza, the Zika virus pandemic

and, lastly, the current coronavirus-associated disease or COVID-19 crisis.

The animal origin of the virus

Determining the starting point of these zoonoses is key to preventing new pandemics. In the case of COVID-19, SARS-CoV-2 probably originated in bats. *'Like SARS-CoV-1, which was responsible for the SARS (Severe Acute Respiratory Syndrome) epidemic in China in 2003, the natural reservoir of this new virus would appear to be an insect-eating bat of the genus Rhinolophus,'* adds virologist



Are bats of the Rhinolophus type a natural reservoir of SARS-Cov-2?

© Flickr - Ján Svetlík

Éric Leroy from MIVEGEC UMR. *'The challenge at present is to identify the chain of events that led to the transmission of animal SARS-CoV-2 to humans. Was it due to direct contact between bats, or their biological fluids, and humans? Or did an intermediary species play a role in the spread of the virus?'* With an intermediary host, two different strains of coronavirus may have recombined by swapping genetic material. This recombination modifies some characteristics of the virus, such as its transmissibility, and may enable it to 'jump' over the barriers between species. The pangolin, a small mammal hunted for its scales and meat, was an initial suspect.



The pangolin was initially alone in being accused of enabling the emergence of SARS-Cov-2, but is no longer the only animal on the list of suspects.

© Flickr - Budak

'This is a probable hypothesis, based on the retrospective genomic sequencing data (identification of nucleotide chains, the basic links in DNA and RNA) that is available, but numerous other possibilities are feasible,' the researcher emphasises. A number of elements currently point to farm animals bred for their fur, and more specifically mink, which can contract COVID-19 and transmit it to both their own species and humans. This is a lead which remains to be substantiated by scientific results duly scrutinised by the research community. In order to gain clearer insight, numerous research projects are being carried out across the world, particularly in South-East Asia, a region close to the epicentre of the current pandemic. Such is the case of Lacoviss and DisCoVER projects (*Disentangling the SARS-Cov-2 Origins: Emergence & Reservoir*) bringing together virologists, evolutionary biologists, ecologists, modellers and researchers in human and social sciences from IRD, Caen-Normandy University, the CNRS, the Lao-Christophe Mérieux Center for Infectiology and Mahidol and Kasetsart Universities in Thailand. *'Together we are examining recent viral sequences in animals found in north Thailand and Laos, to compare the findings with socio-ecological factors linked to human activity, such as poaching, deforestation, farming techniques or population movements,'* Éric Leroy explains.

Partnerships with the South

Along with Lacoviss and DisCoVER, a multitude of partnership projects between France and countries in the Global South have been launched to gain a better understanding of the origin and dynamics of the pandemic.



In order to review and coordinate these projects, a multi-institutional consortium has been set up, composed of IRD, the French National Agency for AIDS Research (ANRS) and INSERM's REACTing consortium (the merger of the latter two led to the creation of ANRS | Emerging Infectious Diseases in January 2021). *'In association with researchers from the South, this task force ensures that French actions abroad are in line with the priorities of these countries,'* explains Éric Delaporte, Professor of Infectious Diseases at Montpellier University and Director of the UMI TransVIHMI. He co-chairs the strategic committee of this consortium, alongside Nicolas Meda, Professor of Public Health at Ki-Zerbo Ouagadougou University, Burkina Faso.

One example of the initiatives coordinated by this task force is the BatCov project, overseen by Martine Peeters, a virologist at UMI TransVIHMI and Alpha Keita, Deputy Director of the Guinean Centre for Research and Training in Infectiology (CERFIG). The project examines the frequency and diversity of coronaviruses hosted by wild bats in Guinea, Cameroon, the Democratic Republic of Congo and [Zimbabwe](#). *'The*



Taking an intravenous blood sample from a bat in Cameroon.

© I. Ndong Bass

aim is to evaluate future risks, as these coronaviruses represent potential starting points for new epidemics' says Éric Delaporte. This study will highlight more specifically which species excrete coronaviruses and during which season the risk of transmission is at its highest. In some African regions,

there is a certain level of promiscuity between humans and bats, particularly in West and Central Africa, where some species are hunted for their meat. The consumption of wild animals is a recognised factor in the transmission of infectious diseases from animals to humans.

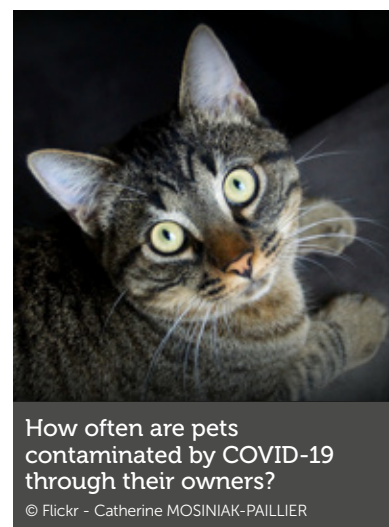


To assess this risk in Africa, the AFRICov project, steered by Philippe Gaubert from EDB UMR and Sery Ernest Gonedélé Bi from the genetics laboratory of Felix Houphouët-Boigny University in Abidjan, is monitoring the genomics of viruses in bush markets throughout Côte d'Ivoire, Cameroon and Benin. Similarly, ZooCov aims to implement a coronavirus monitoring system for the bush meat sector in Cambodia. Led by CIRAD [French Agricultural Research Centre for International Development], this project, which also involves IRD, the Pasteur Institute in Cambodia, Hong Kong University and the NGOs Wildlife Conservation Society and Fauna & Flora International, hopes to contribute to the prevention of future pandemics.

From humans to animals

Anticipating new epidemics is also the aim of the SPILLBACK study, the fruit of collaboration between IRD and the Brazzaville national public health laboratory in the Republic of Congo. 'With our partners, we have already demonstrated the existence of coronavirus strains in bats in Gabon,' explains Éric Leroy. 'We're now looking to find out whether SARS-CoV-2 can adapt to the wildlife of African tropical forests with a similar climate to that of South-East Asian forests.' For example, native bat species could become new virus reservoirs and potentially trigger a second pandemic. Farmed animals are also concerned by COVID-19, as shown by the transmission of the disease in mink farms in several fur-producing countries, such as Denmark or the Netherlands. The risk is that 'the promiscuity of thousands of individuals fosters the emergence of long-term mutations which are transmissible to humans,' Éric Leroy explains. One such mutation, known as Cluster 5, contaminated several people working in breeding farms.

There is also a threat for companion animals. 'While few serious forms have been observed to date, cats and dogs of COVID-19 patients present a high risk of contracting the disease,' comments the virologist, whose team was the first to assess transmission of SARS-CoV-2 from pet owners to their animals in France. Further to this study, the same researchers launched the COVET project, in partnership with the VEBIO veterinary analysis laboratory in Arcueil, the vets from the Paris Vision Institute, and the International Centre for Research in Infectious Diseases (CIRI) in Lyon. 'The aim is to carry out a serological survey on the infection of several thousand pets, such as dogs, cats and small rodents, across Metropolitan France,' explains Éric Leroy. Researchers hope to assess the rate of contamination of these animals via their owners, in addition to the variability of infections according to the species. These studies reiterate the [relevance of the One Health approach](#) which associates human, animal and environmental health in the fight against zoonoses and their emergence.



Prevent rather than cure

Let's be clear, COVID-19 will not be the last pandemic to hit our society. A report by IPBES (see insert), published last year, shows little optimism: future pandemics may be more frequent, spread more rapidly, and have bigger impacts on the world economy. Above all, they will claim more victims than COVID-19! In addition, mammals and birds carry hundreds of thousands of viruses which have yet to be discovered and are potentially transmissible to humans. Benjamin Roche, who contributed to drafting this report, notes that 'solutions do exist, such as the creation of an international institution to fight against pandemics, the institutionalisation of the One Health approach, and the reduction of contact between humans, wildlife and domestic animals.' In practical terms, this may mean managing the wildlife trade, creating protected areas, particularly in regions with the highest levels of biodiversity, or taxing pro-pandemic activities such as deforestation or intensive farming.

Yet urbanisation and deforestation seem inextricably linked to economic growth in many countries in the South. What strategy can be adopted to develop the local economy while preventing the emergence of zoonoses? This is the question that Benjamin Roche and his team are working on. 'Using mathematical models based on large-scale work carried out in the field, we are studying the transmission

IPBES, the IPCC of biodiversity

Founded in 2012, under the aegis of the United Nations, IPBES is an inter-governmental platform for biodiversity and the services provided by nature. *'IPBES is to biodiversity what IPCC is to climate change,'* Yunne Shin, a marine biologist at MARBEC UMR and scientific expert for IPBES, explains. *'It acts as an interface between science and public policy, providing decision-makers with scientific assessments for the preservation and sustainable use of biodiversity.'* Its latest global report on biodiversity was published in 2019. *'It took three years' work to produce results which have made a dramatic impression'* adds the marine biologist, who coordinated the drafting of six chapters of the report. The first striking fact is the scientific proof that the loss of biodiversity has reached an unprecedented level. One million animal and plant species are threatened with extinction. This situation can have a negative impact on our societies which depend on the multiple benefits of nature, known as ecosystem services. This includes, for example, climate regulation by oceans, water filtration in wetlands or the pollination of crops. Lastly, the report specifies that a set of solutions could offset this loss of biodiversity. *'But our societies must undergo a critical transformation,'* Yunne Shin warns.



Building roads is necessary to open up certain villages (such as here, in Lenggurru, West Papua). How can we reconcile developing communities and preserving biodiversity?

© IRD - CENOTE - Guilhem Maistre, Lenggurru 2014

dynamic of several zoonoses in the Yucatan peninsula in Mexico, according to the modification of habitats,' the specialist in infectious disease modelling explains. The researchers are particularly interested in certain hantaviruses that are transmitted to humans by wild rodents and cause infections of varying severity; in arboviruses such as Dengue fever, spread by mosquitoes, or in coronaviruses. The aim of this study is to identify the proportion of natural areas to be preserved in order to minimise the spread of these

zoonoses in the human population. This pilot project is being carried out in the framework of a partnership with the EcoHealth Alliance non-governmental organisation. *'This is the first in a series of studies on a world level which will enable us to shape a broad vision of the influence of habitats on the spread of zoonoses.'* In response to the risks of emergence of these potentially pandemic diseases, many actions have been launched. Such is the case of the recent PREZODE international initiative which has already brought together more than a thousand researchers in some fifty countries. *'PREZODE is aimed in particular at strengthening cooperation with the regions in the world which have the highest risk of emerging zoonoses,'* says Benjamin Roche, One Health scientific advisor at IRD and a member of the preparatory committee for this initiative, *'but also at integrating the One Health approach on a global level to limit the emergence of a pandemic.'*

Contacts

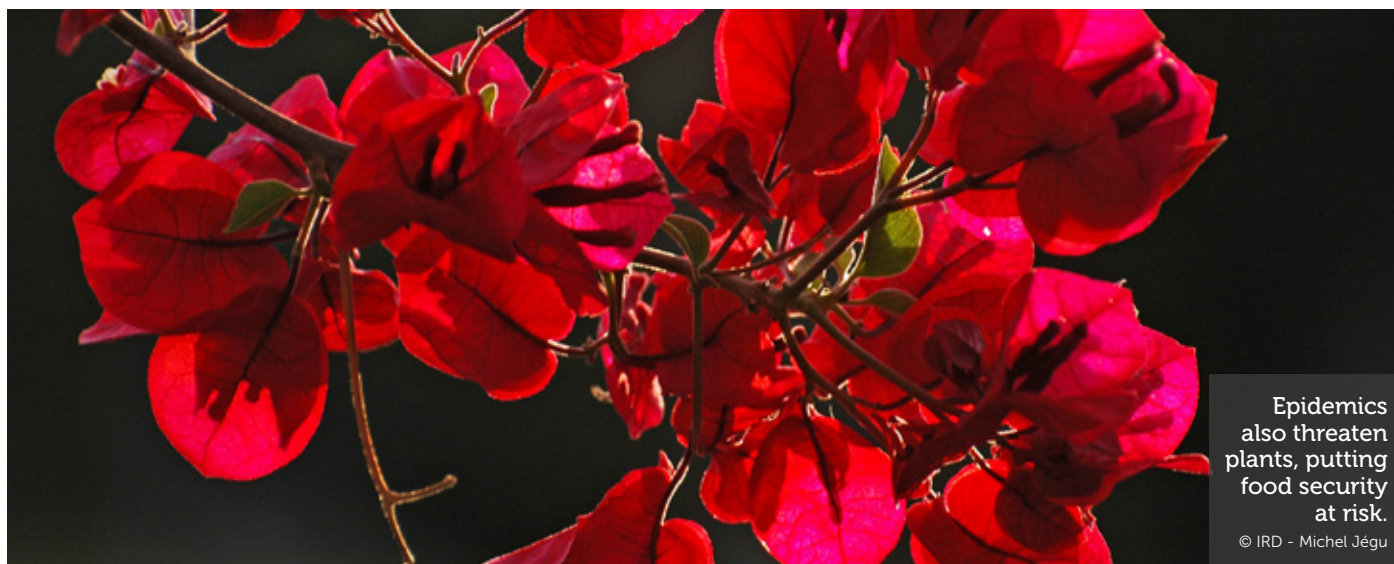
Éric Delaporte, UMI TransVIHMI (IRD/Inserm/ Université de Montpellier)
Philippe Gaubert, UMR EDB (CNRS/IRD/Université de Toulouse III)
Éric Leroy, UMR MIVEGEC (CNRS/IRD/Université de Montpellier)
Martine Peeters, UMI TransVIHMI (IRD/Inserm/ Université de Montpellier)
Benjamin Roche, UMR MIVEGEC (CNRS/IRD/Université de Montpellier)
Yunne Shin, UMR MARBEC (IRD/Ifremer/CNRS/Université de Montpellier)

Publications

Diversité génétique et écologie des coronavirus hébergés par les chauves-souris cavernicoles au Gabon
Gael Darren Maganga, Anaïs Pinto, Illich Manfred Mombo, Mankomra

Madjitobaye, Antoine Mitte Mbeang Beyeme, Larson Boundenga, Meriadeg Ar Gouilh, Nadine N'Dilimabaka, Jan Felix Drexler, Christian Drosten & Eric Maurice Leroy, *Genetic diversity and ecology of coronaviruses hosted by cavedwelling bats in Gabon*, Scientific Reports, 30 avril 2020 ; doi:10.1038/s41598-020-64159-1

Prévalence élevée d'anticorps anti-SRAS-CoV-2 chez les animaux de compagnie provenant de foyers Covid-19+
Matthieu Fritz, Béatrice Rosolen, Emilie Krafft, Pierre Becquart, Eric Elguero, Oxana Vratskikh, Solène Denolly, Bertrand Boson, Jessica Vanhomwegend, Meriadeg Ar Gouilh, Angeli Kodjo, Catherine Chirouze, Serge G. Rosolen, Vincent Legros, Eric M. Leroy, *High prevalence of SARS-CoV-2 antibodies in pets from COVID-19+ households*, One Health, 4 novembre 2020 ; doi:10.1016/j.onehlt.2020.100192



Epidemics
also threaten
plants, putting
food security
at risk.

© IRD - Michel Jégu

The plant world is also at risk

Humans and animals are not the only species threatened by the emergence of global epidemics, plants are also at risk, and with them our food security. According to the FAO (Food and Agriculture Organization of the United Nations), plants represent more than 80% of human food, and also feed livestock, poultry and certain farmed fish.



The Great Famine was caused by potato blight and left an indelible mark in Ireland, as this memorial in Dublin testifies.

© Flickr - Loic Pinseel

Pathogenic episodes have devastated agricultural crops in the past. Such is the case of blight, which appeared in Ireland in 1845. This disease is caused by a parasite, *Phytophthora infestans*, and attacks potato plants in particular. *'Monoculture of this tuber allowed the pathogen to spread rapidly throughout the country,'* explains Jean-Louis Pham, a plant geneticist at DIADE UMR. *'The demographic and cultural consequences were dramatic.'* The fall in crop yield due to blight played a major role in triggering a famine which lasted for several years. Current studies estimate that it caused at least a million deaths and the mass migration of two million Irish people. More recently, a variety of banana was affected by an epidemic. Known as Gros Michel, this was the main variety grown

up to the 1950s. Around this time, an outbreak of Fusarium wilt, or Panama Disease, caused by the *Fusarium oxysporum* fungus, spread throughout the majority of the world's banana plantations. These cloned monocrops were unable to resist. Today, a new strain of this fungus (TR4) is threatening the Cavendish variety which replaced Gros Michel. The economic consequences could be catastrophic for certain Southern countries

which have already been hard hit by the current COVID-19 pandemic. And there are many other dangers for our crops. Examples include wheat rust, bacterial rice blight, bacterial cassava blight, viral cassava mosaic disease, maize lethal necrosis, or *Xylella fastidiosa* bacteria, which can be fatal for numerous plants such as olive, almond, coffee, vine, citrus plants, avocado, oak, alfalfa or lavender. *'We are at risk of a plant pandemic,'* the researcher warns.



Bacterial blight in rice, a re-emerging disease in Africa

© IRD/Valérie Verdier

Preserving agrobiodiversity

Nevertheless, solutions exist to minimise this risk and preserve plant health. This is the aim of the International Plant Protection Convention (IPPC). This international treaty was adopted in 1952 to protect the world's plant resources by preventing the introduction and spread of harmful organisms. However, the IPPC does not avail of a truly operational international network to monitor plant disease similar



Safeguarding crops relies on the diversity of the varieties that are grown. Here, a banana stall at a Bolivian market.

© IRD - Michel Jégu

to that set up by the World Health Organisation to raise the alert in the event of human epidemics. In addition to heightened vigilance, the choice of local intra-varietal lineages, instead of pure lineages, limits the emergence of epidemics. *'Domesticated species generally present little genetic diversity and are therefore more vulnerable to diseases,'* Jean-Louis Pham explains. As a recent study on sweet potato has confirmed, genetic diversity is the foundation stone which enables a species to adapt to disease and changes, in climate for example. Several initiatives have been launched to preserve this diversity. One such is ARCAD, the resource centre for the conservation and study of diversity in tropical and Mediterranean crops. Based in Montpellier on the Agropolis campus, ARCAD rallies the support of IRD, CIRAD, INRAE and Montpellier SupAgro around a common project focused on transdisciplinary agro-biodiversity. *'Scientists from all backgrounds, geneticists, bioinformaticians, agronomists, botanists, anthropologists and political science researchers, work together to bring new momentum to research in agro-biodiversity,'* says Jean-Louis Pham, a co-founder of the project. *'One of the aims is to innovate in the use of plant biodiversity, in particular by promoting the wealth of Southern seed production.'* A building has been created for this purpose, and will eventually conserve up to 40,000 seeds. ARCAD also acts as an exchange platform between the academic world and civil society, both nationally and internationally. *'It's vital to re-establish the flow between seed collections and farmers' fields.'*

The move towards agro-ecological transition

In fact, it is in a certain number of these fields that part of biodiversity is being undermined. The industrialisation of agriculture, characterised among other factors by growing use of petrochemical-based inputs (all plant treatment and

fertiliser products added to soil and crops which do not come from farming operations) and the creation of vast plots through land consolidation, result in standardisation of rural landscapes and the species that are cultivated.

'This standardisation has catastrophic environmental consequences,' protests Jean-Louis Pham, who advocates a change in the food production system. Changes in soil use, the destruction of hedgerows, tree-felling and the use of fertilisers and pesticides negatively impact biodiversity and thus compromise its ecosystem services (see insert). These impacts on ecosystems threaten our food security in the same way as crop diseases. Yet there are methods which are more respectful of the environment, such as conservation agriculture, zero-tillage cultivation, organic agriculture or agro-ecology. These various forms of more sustainable agricultural practices seek to restore diversity in fields with regard to landscape, crops or varieties, in order to revive the health of eco-systems, and above all, the soil.



In the Sahel, *Faidherbia Albida* is the most widely-known 'useful tree' and farmers maintain the trees in their fields to provide shade and fodder.

© IRD - Tiphaine Chevallier

Looking after the soil

Soil is a living resource which contains 25% of our planet's biodiversity. *'Numerous organisms, such as bacteria, fungi, mites, nematodes or centipedes and so on, live in or on the surface of the soil,'* explains Sébastien Barot, a soil ecologist at the Paris Institute of Ecology and Environmental Sciences (IIES) and a biodiversity scientific advisor at IRD.

Among these organisms, there is one emblematic species for soil health: the earthworm. The earthworm plays several key roles. *'Earthworms contribute to soil structure and recycling organic matter, as well as providing plants with the minerals they need to grow, such as nitrogen and phosphorus,'* the ecologist explains. This underground world works in harmony to change the dynamics and composition of soils, making them more fertile, minimising erosion and facilitating rainwater drainage. How can we protect the soil and the services it



One of nature's benefits? Its beauty, quite simply, as in the Tana delta, in Kenya..

© IRD - Olivier Hamerlynck

Ecosystem services or the benefits of nature

Ecosystems, commonly called 'nature', provide a significant number of services to our societies. They produce the oxygen we breathe, the food and water we consume, and the fuel and materials that our societies use on a daily basis. Nature thus provides us with food and lodging, as it does for the animal and plant kingdoms. Furthermore, healthy ecosystems help to regulate climate and air quality, fertilise the soil and prevent erosion. They also contribute to the filtration and depollution of water, participate in the pollination of crops and carbon storage; they control the spread of infectious diseases and recycle nutrients, etc. Lastly, nature provides us with non-material benefits such as inspiration, spirituality, the sense of belonging or simple well-being in its presence.

provides to agriculture? First, 'sowing cover plants after the harvest avoids exposing bare ground for a large part of the year,' says Sébastien Barot. One plant family, the fabaceae, known more familiarly as legumes, is particularly well-suited to this task. This large plant family, which also includes clover, alfalfa, soya, peanut and numerous other pulses, enriches



Earthworms fulfil many functions which ensure soil health.

© IRD - Sébastien Barot

the soil naturally by fixing nitrogen from the air, thanks to a symbiotic relation with the soil bacteria *Bradyrhizobiums*. In addition to producing plant-based protein which feeds livestock, poultry and humans, these plants also reduce the need for fertilisers.

The specificity of legumes means they can be used widely in crop rotation. This technique consists in alternating various crops or fallow on the same plot, according to the seasons and years. In addition to the beneficial effects for biodiversity, crop rotation improves soil structure and disrupts the reproduction cycle of pests, plant diseases and adventitious flora (plants growing on a plot which were not deliberately sown), in other words, weeds. This explains the need to limit the use of pesticides which are harmful both for soil micro-organisms such as earthworms and overground insects, in particular pollinating insects. Reducing tillage is also beneficial

for biodiversity. 'While it makes the soil softer and controls weed growth by burying them, deep and systematic tillage has a negative impact on larger soil organisms,' Sébastien Barot comments. Depending on the land, crops and climate, other methods, such as intercropping (several species, for



A combination of cereal and legume crops improves soil quality thanks to the capture of nitrogen in Nalongue (Nadjoundi canton, near Dapaong) in Togo.

© IRD - Tiphaine Chevallier

Promoting agro-ecology in the South



A typical yam field in the Baoulé region of Côte d'Ivoire. Traditional methods maintain a wide variety of cultivated and non-cultivated plants.

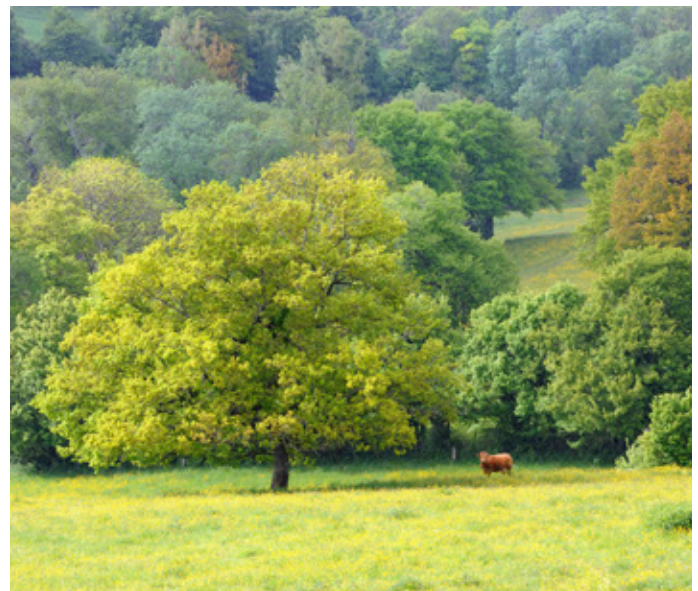
© IRD - Sébastien Barot

In temperate regions, awareness of the impacts of agricultural industrialisation has led to the development of more sustainable farming practices. In developing countries, however, the social and economic context is completely different. *“Traditional subsistence farming already uses a form of agro-ecology. However, productivity is not always guaranteed and food security is sometimes at risk. But should we still encourage practices which are harmful for the environment?”* Sébastien Barot asks. Actions have thus been implemented in the South to encourage production methods based on agro-ecology, particularly in Morocco, but also in Sub-Saharan Africa. For example, the international joint laboratory ‘Ecology and sustainable development - Biodiversity, agro-ecology and urban ecology’ recently launched in Côte d'Ivoire by Sébastien Barot and Souleymane Konaté. *‘One of its objectives is to promote agro-ecology in this country, based on biodiversity research carried out since 1962 at the Lamto Ecology Station’* the ecologist explains. One particular aim is to increase subsistence farming yields without compromising either ecosystems or the climate.

example a cereal and a fabaceae, are grown and harvested on the same plot), or the addition of organic matter, can complement these environmentally-respectful farming techniques. By applying these principles, farmers thus contribute to the preservation of biodiversity, and reap its rewards in turn. According to a [report by the IUCN](#) [International Union for the Conservation of Nature] published last year, farmers can significantly increase their productivity by encouraging the diversity of the underground world. Even better, these farming techniques can play a key role in mitigating climate change. Land with rich biodiversity helps to store atmospheric carbon in the soil. This is the idea behind the [4 per 1000 initiative](#), launched during the COP21 in 2015: to act for the climate by raising the level of organic carbon in soils through sustainable farming methods.

Humans and trees

Trees can additionally help to reduce climate change by capturing carbon. They also play a primordial role in agro-ecological transition. Trees and hedgerows are havens for crop auxiliaries, from pollinators to predators of harmful organisms and pests. In addition to this aspect of bio-control (all crop-protection techniques based on natural methods), trees and shrubs also fight against soil erosion, improve the quality and infiltration of water, provide shade in summer, regulate plant pollution, and boost productivity



Is the bocage, here in France's Morvan region, to make a comeback in temperate areas?

© IRD - Geneviève Michon

by protecting crops from wind, etc. Trees can be inherently associated with crops or pastures. This is known as agro-forestry, which ethno-botanist Geneviève Michon from SENS UMR defines as *‘a highly-varied series of farming techniques which benefit from the presence of trees.’* These benefits can be direct, via the production of fruit, fodder or wood, and/or indirect. Trees provide numerous environmental services to farmers.

Plants in the city

At present, more than half of the world's population lives in the city, a proportion that continues to rise. Is there a place for biodiversity in our urbanised world? *'This is a subject of recent interest which is gaining momentum,'* believes Sébastien Barot, who coordinated a research agenda on urban ecology dealing with this issue. Trees and plants in particular can help cities to become more resilient. The ecologist points out that *'plant cover reduces the urban heat island effect.'* In city centres, temperatures can be two to three degrees higher than suburban levels. Water evaporation from the leaves of trees and other plants helps to cool the atmosphere of our cities. And that's not all! *'In particular, plants help to regulate water flow in the event of heavy rain and generate mental well-being for inhabitants.'* The revival of urban agriculture and community gardens also plays its part in making biodiversity more visible in the city. *'City-dwellers can reconnect with nature.'* Some even become its fervent defendants.



Plant diversity enables enhanced management of this argan orchard in Morocco.

© IRD - Geneviève Michon

'trees are still being cut down and hedgerows uprooted.' Nevertheless, the situation is changing and methods inspired by long-abandoned know-how have been revived in certain areas, with bocages, orchard meadows or pairings between trees, vine or hops.

In the South, agro-forestry systems are still very much present, with acacia or shea parks in the Sahel, where mixed farming is used; Saharan oases, where fruit trees grow in the shade of palm trees; argan plantations in Morocco, grown for their oil, or agro-forests in wet tropical zones (see the video in the article below), etc. These agricultural practices ensure security, quality and diversity in the food, economy and culture of the local population. However, these small farming structures are also at risk. *'The majority of agro-forestry systems I studied in South-East Asia have disappeared due to the generalisation of production-driven and capitalist agricultural methods,'* Geneviève Michon regrets. *'Yet these forests, which I call "domestic", contribute to preserving biological and cultural diversity while ensuring both productivity and sustainability.'*

'Agro-forestry systems act in complement and symbiosis to produce differently and better. Sustainable livestock rearing in farmland woods, for example, has less impact on climate and produces meat with a higher nutritional quality,' the ethno-botanist adds. In temperate regions, these agro-forestry production methods were largely abandoned following the industrialisation of agriculture. In France, for instance, 70% of hedgerows have disappeared from bocages since the 1950s. Geneviève Michon deplores the fact that

Contacts

Sébastien Barot, UMR IEES-Paris (CNRS/IRD/Inra/ Université de Paris/ Université Paris Est Créteil)

Jean-Louis Pham, UMR DIADE (IRD/Université de Montpellier)

Geneviève Michon, UMR SENS (Cirad/IRD/ Université Paul Valéry Montpellier 3)

Publications

M. Carvajal-Yepes, K. Cardwell, A. Nelson, K. A. Garrett, B. Giovani, D.G.O. Saunders, S. Kamoun, J.P. Legg, V. Verdier, J. Lessel, R.A. Neher, R. Day, P. Pardey, M.L. Gullino, A.R. Records, B. Bextine, J.E. Leach, S. Staiger, J. Tohme, *A global surveillance system for crop diseases*, Science, 28 juin 2019 ; doi : [10.1126/science.aaw1572](https://doi.org/10.1126/science.aaw1572)

Bettina Heider, Quentin Struelens, Emile Faye, Carlos Flores, José E. Palacios, Raul Eyzaguirre, Stef de Hann, Olivier Dangles, *Intraspecific diversity as a reservoir for heat-stress tolerance in sweet potato*, Nature Climate Change, 5 octobre 2020 ; doi : [10.1038/s41558-020-00924-4](https://doi.org/10.1038/s41558-020-00924-4)

Sébastien Barot, Luc Abbadie, Apolline Auclerc, Carole Barthélémy, Etienne Bérille, Philippe Billet, Philippe Clergeau, Jean-Noël Consales, Magali Deschamp-Cottin, Ambre David, Cédric Devigne, Véronique Dham, Yann Dusza, Anne Gaillard, Emmanuelle Gonzalez, Marianne Hédont, Dorothee Labarraque, Anne-Marie Le Bastard, Jean-Louis Morel, Yves Petit-Berghem, Elisabeth Rémy, Emma Rochelle-Newall, Marion Veyrières, *Urban ecology, stakeholders and the future of ecology*, Science of the Total Environment, 27 février 2019 ; doi : [10.1016/j.scitotenv.2019.02.410](https://doi.org/10.1016/j.scitotenv.2019.02.410)



Villagers from Yaneshas,
Peru, a community which
harbours knowledge of the
traditional pharmacopoeia.

© IRD - Mohamed Haddad

Knowledge to be safeguarded and mobilized

These types of relationships between local societies and their environment were long derided. Yet the interactions between these populations and nature helped to culturally enrich indigenous communities, their vision of the world and the rites and languages transmitted by their traditions. It also enabled them to develop many skills and acquire intimate knowledge of their environment. Consequently, indigenous communities are now considered essential partners in the sustainable management of their environment. While

is committed to perpetuating some of this expertise, specifically in Guiana or with the Yaneshas of Peru. *'In this Amerindian community, the transmission of knowledge comes up, among other factors, against a certain degree of disinterest on the part of young generations,'* explains

Partners for the present and the future

Southern countries, and particularly those along the intertropical belt, are home to most of the planet's richest biodiversity zones. Yet many of these States are severely lacking in equipment and qualified staff to study and protect their biodiversity. *'We invest heavily in strengthening local academic expertise. The aim is to develop a virtuous circle of high-level research and train people in the use of cutting-edge equipment, in chemical analysis for instance,'* explains Mohamed Haddad, a chemist whose work focuses specifically on promoting the natural substances used by local communities. Through discussion, training and partnerships with universities, NGOs, civil society and governments, or the creation of International Joint Laboratories (LMI) and Young teams associated with IRD (JEA), IRD contributes to reinforcing the abilities of these developing countries. *'In Peru, Laos and Benin, our unit works to train people in the inventory and study of plant and fungal biodiversity,'* the chemist adds. The hope is that these new researchers find potentially useful molecules for human medicine.



Collecting medicinal plants in the Upper Amazon

© IRD - Mohamed Haddad

they represent just 5% of the world population, the United Nations estimates that their lands are home to almost 80% of the biological diversity observed across the planet. Furthermore, the IPBES recognises the importance of this local knowledge in the preservation of biodiversity. However, certain forms of orally-transmitted knowledge, such as traditional pharmacopoeia, are in danger. IRD

Mohamed Haddad, a chemist specialised in the study of natural substances at PHARMA-DEV UMR, who has lived with the Yanésa on several occasions. *'With a view to conserving their heritage, these Amerindians have accepted, in partnership with the scientific community, to catalogue a part of the plants they use for medicinal, cosmetic or ritual purposes.'* Initiated in 2005 by ethno-pharmacologists Geneviève Bourdy and Céline Valadeau, this collaboration culminated in the publication of a freely accessible book, 'Yato' ramuesh'. Financed by public funding with the consent of the Peruvian authorities, *'this work, which was widely-acclaimed by the community, has allowed us to record a part of their knowledge.'* This is a perfect example of mutual trust between researchers and a local community. However, the potential value of some biological resources and associated local knowledge can be subjected to abuse and unilateral exploitation. The principle of 'access to genetic resources and associated traditional knowledge and the fair and equitable sharing of the benefits arising out of their use,' or ABS, was established to avoid this form of illegitimate monopolization

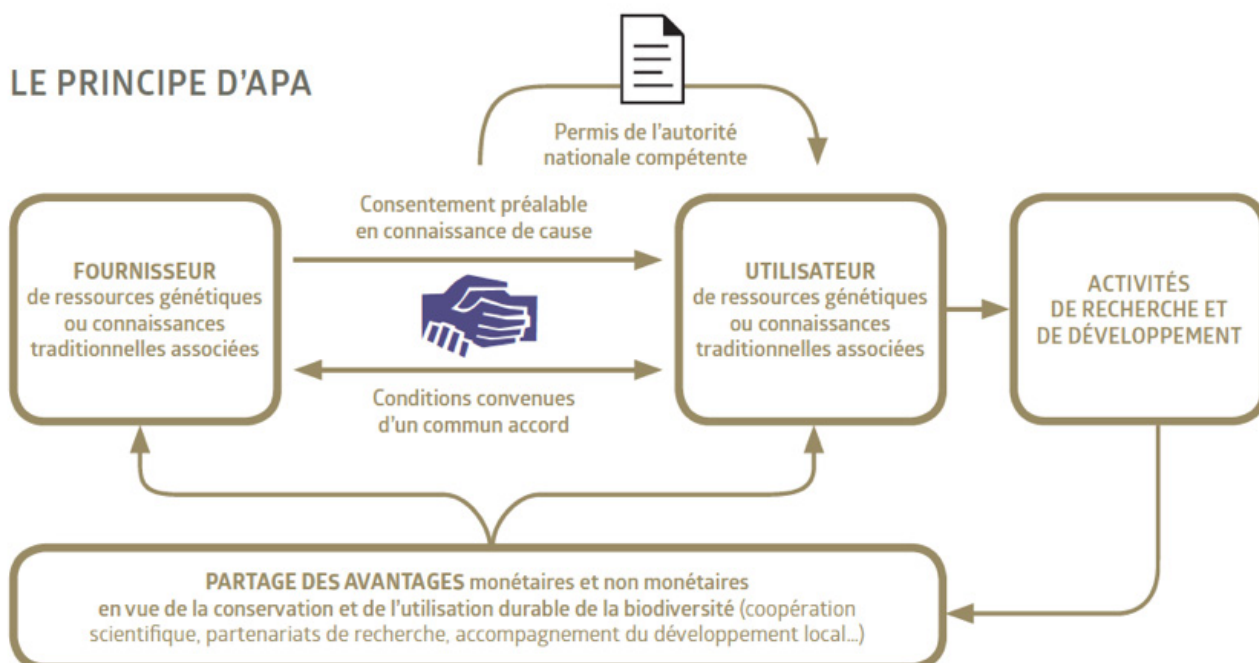
Justice and equity

The principle of ABS was first put forward at the Rio de Janeiro Earth Summit in 1992, and was legally implemented in 2010 during the 2010 World Conference on Biodiversity in Nagoya. *'Its aim is to contribute to the conservation of biodiversity through fair and equitable sharing of the benefits arising from its use for research and development activities,'* says plant geneticist Jean-Louis Pham, who is also IRD's Nagoya advisor.

For example, ABS applies when a research laboratory wishes to develop a drug from an active ingredient sourced from the pharmacopoeia of an indigenous community. The user of this genetic resource, i.e., the laboratory, must inform the supplier, in other words the community which traditionally uses this plant, and the country where it is found, via a prior informed consent procedure. Both parties then contract the sharing of monetary or other benefits arising from the use of this biodiversity resource. *'The Nagoya Protocol is a major international convention based on a strong ethical and legal principle, which recognises the right of indigenous people and the sovereignty of States to their biological diversity.'* Nevertheless, the researcher is concerned that *'de facto, its application slows research requiring access to biodiversity, due to regulations which are often strict and complex.'* Estienne Rodary, an expert in biodiversity conservation policies, does not share the same view. He argues that *'complex bureaucracy cannot serve to challenge the importance of sharing for indigenous populations.'* Even more worrying, according to Jean-Louis Pham, is that *'the financial result for supplier communities and States appears paltry compared to expectations, and the ABS has little impact on the conservation of biodiversity.'* The modification of this legal framework is thus currently under review, without calling into question its principle of fair and equitable sharing.



<https://youtu.be/AvG40ePA8WE>



Observing environmental policies from above

For an accurate overview of land development over time, nothing beats satellite images. This technology is thus a logical way to assess the effectiveness of environmental conservation policies. Anne-Elisabeth Laques, a landscape geographer at ESPACE-DEV UMR, examined the relevance of protected zones in the heart of the Amazon Forest. *'Using analysis data of forest cover from 2002 to 2016, our trans-disciplinary collaboration developed a tool to measure forest fragmentation.'* Whereas some protected areas were severely affected, in the Brazilian states of Mato Grosso and Pará in particular, these conservation measures did contribute to reducing the degradation of forests for the period prior to the election of Jair Bolsonaro to the Brazilian presidency. On another level, the geographer also participated in the assessment of the Bolsa Floresta project on a sustainable reserve in Brazil. *'This grant from the Brazilian government to families living on the reserve was conditioned by their compliance with a development plan aimed at minimising the deforestation linked to family farming,'* Anne-Elisabeth Laques explains. Satellite data showed that a vast majority of families complied with the development plan.

payments help to prioritise conservation over over-exploitation, which, while offering short-term economic benefits, causes harmful ecological and social consequences in the long term.' In practical terms, PES can take on various forms, but they often imply the prevention of deforestation in order to protect bio-diversity, capture carbon or maintain the water quality and drainage in the downstream parts of river basins. Although highly popular among NGOs and donors around a decade ago, this tool has since lost its appeal. *'Payments can alter the intrinsic motivations of individuals to preserve their environment and can aggravate issues of equity between generations,'* observes the expert in environmental policies, *'but above all, it is not a lever for development, contrary to other income-generating activities such as craftwork, medicinal and herbal plant harvesting, or eco-tourism.'* Depending on the context, this type of economic incentive for biodiversity may be more suited to reconciling environmental conservation and socio-economic growth. This is also the case for community management, which is based on a sustainable use of resources thanks to agreements between users. In addition to moderate economic growth, another limiting aspect of PES is their funding. To ensure long-term funding, the trust fund is a useful lever. *'In this case, a significant sum of money from an NGO or donor is placed in a foundation and only the interest earned is used for environmental protection,'* the economist explains. *'This system secures the investment, but is a relatively complicated mechanism which raises ethical issues.'* As the funds are floated on the stock market, interest depends on the volatility of rates and the capital invested may be lost in the event of a market crash. However, trust funds have gained in popularity in recent years, not only to ensure the funding of PES, but also that of protected areas and other economic tools for the conservation of biodiversity.

Pay to preserve

In addition to the Nagoya Protocol, other international procedures strive to foster environmental conservation by rolling out economic and financial tools. 'Debt-for-nature' swapping is one such example. In this case, a debtor State has a portion of its debt converted by a creditor State and/or an intermediary such as an NGO, in exchange for biodiversity protection measures in the country in question. In the 1990s, the US government thus cancelled part of Jamaica's debt in exchange for the creation and funding of a foundation for the environment. *'There is a renewed interest in this tool due to growing debt linked to the pandemic, and it is also a benchmark device in the fight against climate change,'* says SENS UMR economist Philippe Méral. On a local level, there is a whole array of public policies to promote the preservation of nature, such as Payments for Environmental Services (PES). *'The idea is to remunerate people, either individually or collectively, who can maintain ecosystems in a healthy state for those who benefit from their ecosystem services,'* Philippe Méral explains. *'These*

A tree guardian in Ecuador

On another level completely, one person can sometimes make a difference. In the west of Ecuador, along the Pacific Coast, more than 80% of the forest has disappeared to create space for livestock and banana or palm plantations. In this region, a 53-year-old Ecuadorian, Anelio Loor, owns a small plot of a few hectares, which he is safe-guarding from intensive farming. Located in the Manabí province, almost 200km west of Quito, 'La Esperanza' or the 'Reserve of Hope', as Anelio Loor calls it, lies on a small hill crossed by a river. *'It feels like a rainforest in the heart of this reserve,'* says Thomas Couvreur, a botanist at DIADE UMR, who met the farmer during a mission to collect palm tree samples. *'Hundreds of animal and plant species, including endangered species, have been observed there. It's hard to believe it's just 500 metres from a tarmac roadway.'* For 23 years, with neither funding nor aid from an NGO, Anelio Loor has put his heart and soul into



Anelio Loor, the guardian of 'La Esperanza'

© IRD - Thomas Couvreur

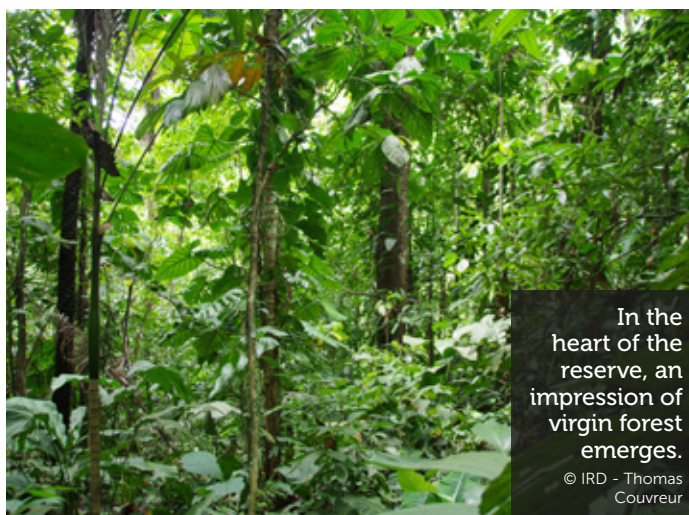
protecting this small haven of nature that he bought with his own savings. He would like to go further, however, and turn his reserve into a tool for science. 'Anelio has built a research station to work with botanists and zoologists, and has installed facilities to welcome students.' Projects are already under way, in close collaboration notably with the *Pontificia Universidad Católica del Ecuador* in Quito, for whom he has already worked as a para-taxonomist (a local expert in the collection and inventory of biodiversity, without official scientific or academic training) in the Yasuni National Park. 'Anelio is a very humble person, but is driven by fascination and love for biodiversity,' Thomas Couvreur adds. This nature lover is also actively looking for funds to save a plot of forest next to his reserve from deforestation, and thus perpetuate 'La Esperanza'.

Hope at the heart of 'La Esperanza'



The station built by Anelio Loor in 'la Esperanza', Ecuador, photographed by a drone.

© Nān



In the heart of the reserve, an impression of virgin forest emerges.

© IRD - Thomas Couvreur



Outside the reserve preserved by Anelio, the landscape presents a completely different aspect.

© IRD - Thomas Couvreur

Recently discovered, this flower of the genus *Guatteria* is already threatened.

© IRD - Thomas Couvreur



Contacts

Thomas Couvreur, UMR **DIADÉ** (IRD/Université de Montpellier)
 Mohamed Haddad, UMR **PHARMADEV** (IRD/Université de Toulouse III)
 Anne-Élisabeth Laques, UMR **ESPACE-DEV** (IRD/Université de Montpellier/
 Université de Guyane/ Université de la Réunion, Université des Antilles)
 Philippe Méral, UMR **SENS** (Cirad/IRD/ Université Paul Valéry Montpellier 3)
 Jean-Louis Pham, UMR **DIADÉ** (IRD/Université de Montpellier)
 Estienne Rodary, UMR **SENS** (Cirad/IRD/Université Paul Valéry Montpellier 3)

Publication

Ana I.R. Cabral, Carlos Saito, Henrique Pereira,
 Anne-Élisabeth Laques, *Deforestation pattern dynamics in protected
 areas of the Brazilian Legal Amazon using remote sensing data*,
Applied Geography, 31 octobre 2018 ; doi: [10.1016/j.apgeog.2018.10.003](https://doi.org/10.1016/j.apgeog.2018.10.003)



(Inadequately) Protected Areas

Whether through private or public initiatives, over vast areas or a few hectares, the Protected Area (PA) is undoubtedly the oldest nature conservation device. It remains a widely-used technique. In fact, the number and size of protected areas have soared in recent years. They currently represent almost 16% of land surfaces and 8% of sea areas. Despite this, biodiversity continues to decline. *'PAs have proven their worth in certain zones with high levels of biodiversity, but their impact on a world scale is more uneven. In addition, numerous areas are protected on paper only,'* regrets Estienne Rodary, an expert in biodiversity conservation policies and Head of the Society & Globalisation Department at IRD. *'Where regulations and legal obligations are lacking, there is little or no concrete impact on conservation.'*



30% of French oceanic territory is a protected marine area, but is unevenly distributed.

© IRD - Bastien Preuss

A recent study by the CNRS of protected marine areas (PMA) in France paints a similar picture. While 33.7% of French maritime space is covered by a PMA, only 1.6 % of this surface benefits from a legal status ensuring adequate protection. Furthermore, many protected areas are located in places where the socio-economic context can afford them, which often corresponds to very remote and/or sparsely

populated regions. 80% of French high-level PMA are thus located in the French Southern and Antarctic Territories (TAAF, in French), while the coastline of Metropolitan France enjoys little protection and is particularly affected by pollution and over-exploitation. There is an urgent need, therefore, to change the selection criteria for the implementation of protected areas, especially marine areas. This said, the notion of wrapping nature in cotton wool, sometimes by evicting indigenous populations and other communities that rely on the land, is no longer a viable solution. *'The local population must participate politically and economically in the implementation of protected areas to avoid social consequences and the illegal use of resources,'* Estienne Rodary argues. The present challenge is ultimately to manage natural resources sustainably in order to reconcile nature conservation and development.

The crab with golden claws

This is the challenge Madagascar has set itself with the Corecrabe project. *'The rural communities living along the Grande Ile coast are often extremely vulnerable,'* explains Marc Léopold, project coordinator and specialist in small coastal fisheries at ENTROPIE UMR. *'Mangrove crab fishing represents an essential source of income for some of these people.'*

At present, this activity is threatened by over-exploitation of stocks and the degradation of mangroves. To protect it, new regulations have been implemented in recent



Monitoring the size of captured crabs helps to measure indicators on the state of resources in various production areas, thus guiding decisions on the regulation of the fishing effort.

© IRD - Marc Léopold

years, including a total ban on the use of mangrove wood, an annual fishing closure and an increase in the minimum size of crabs authorised for sale. *'Are these measures effective, sufficient and legitimate? They raise questions, particularly among poor populations for whom crab fishing is a matter of survival,'* Marc Léopold emphasises.

The Corecrabe project thus aims to define a new strategy and tools to manage this resource sustainably. *'Thanks to an approach which involves all the players of the sector,*



As part of a participative approach, a young fisheries scientist explains the fishing and sales data to be recorded to a young woman working in commercial mangrove crab-fishing in a village of Madagascar.

© IRD - Marc Léopold

from fishermen to private operators, researchers, NGOs and government, we're working towards the emergence of better governance and management practices to enhance the economic performance of this activity. These are complex issues which must be tackled through an innovative and collaborative research method.'



A fisherman in the Mangoky estuary (south-west Madagascar) raises one of his crab scales, a technique introduced in the 1980s to develop fishing for export and which has become a widespread practice today.

© IRD - Marc Léopold

The current market has shifted towards high-added-value exports of live crabs, primarily for the Chinese market. However, fishermen and small-scale operators believe that the local economic benefits are insufficient. *'A collective survey of the sector's organisation, regulations and local management methods, in addition to the socio-economic impact*

The coral reef in their small hands



The Mareco kit, a game to raise awareness on the protection of coral reefs.

© IRD

We cannot protect something we know nothing of. Involving young generations in environmental protection is therefore crucial. It is with this in mind that Jocelyne Ferraris and Pascale Chabanet came up with the idea of the MARECO educational kit. It contains several games to teach pre- and primary school children about the protection of coral reefs. The 'Happy Families' card game, role plays and colouring activities help these future adults to discover the wealth of the coral reefs and the dangers that threaten them. A recent study examined how this unique ecosystem is perceived by children from several schools in Overseas and Metropolitan France, and from various socio-cultural backgrounds. *'We compared drawings of reefs by 7 to 8-year-old children, before and after the two-month period of working with the kit,'* explains Catherine Sabinot, an ethnologist at ESPACE-DEV UMR, based in New Caledonia. The study revealed that the children have a consistent perception and particularly detailed knowledge of the reef. Moreover, the drawings done after the period of kit use illustrate what the children learned: *'The children use more colour to represent the coral and fish of the reef. They also include more signs of pollution.'* This educational kit helped to strengthen the children's connection to this fragile ecosystem and to raise their awareness of the risks it faces. The study reinforces the notion that children's drawings are a means of assessing the impact of such awareness campaigns.

on households is under way,' says the researcher. With regard to the environmental aspect, awareness will be raised among fishermen and operators on the limits of biological regeneration of the crab population and on the links between fishing practices and the mangrove. The ultimate aim is that improved management all along the chain will enable vulnerable communities to gain from this resource without degrading its natural environment.

The move towards sustainable marine aquaculture in Africa

On another level, marine ecosystems are also at risk from industrial fishing. Fishing catches have stagnated in the last thirty years, due in particular to overexploitation of stocks. However, fishery products represent a key source of nutrition to feed a growing world population. Fish farming has been widely developed in response to this need. At present, aquaculture production is on a par with fishing. However, like over-fishing, the intensive development of fish farming has also impacted marine environments. Fish excrement and uneaten feed contribute to eutrophication of water, for example; algae flourish and the amount of oxygen in the water decreases. Farmed species can also escape into the natural environment and become invasive. Furthermore, the high density of specimens in farming ponds facilitates the spread of pathogens. One solution is to administer antibiotics, but their residues cause hormonal disorders in aquatic species and contribute to the phenomenon of antibiotic resistance. Lastly, some farmed fish are fed on industrial fish catches. A case of the fish biting its own tail!



Red tilapia in intensive fish farming pools in Sumatra, Indonesia

© IRD - Marc Legendre

[AfriMAQUA](#) aims to tackle all these challenges facing marine aquaculture in Africa, a continent where such activity is still very limited. *'This research consortium is hoping to develop sustainable aquaculture by exchanging knowledge, building partners' capacities and pooling research efforts,'* Maria Darias, the scientific coordinator of the network, explains. AfriMAQUA has already brought together teams from Senegal, Côte d'Ivoire, Namibia, South Africa, Tanzania, Kenya and Mauritius.

Together, these members are seeking to develop healthy, sustainable feed for farmed species, or to promote environmentally-friendly farming systems, such as Integrated Multi-Trophic Aquaculture (IMTA). *'IMTA mimics the natural environment by raising several species together. For example,*



A diver equipped with a subsea pump to detect eDNA, attached to a water scooter.

© Laurent Ballesta - Andromède Océanologie

An inventory of the silent world

Cataloguing marine biodiversity is not an easy task. Marine biologists have long had to make do with fishing catches or diving observations to assess the diversity of marine life. *'The results obtained by divers are limited,'* says David Mouillot, marine ecologist at MARBEC UMR and a professor at Montpellier University. *'To start with, their observations are not replicable and small species are as difficult to inventory as bigger ones.'*

In recent years, technology has helped to overcome these hurdles. Underwater video systems, robots, drones and artificial intelligence are being used to take stock of the silent world.

But the unrivalled star of the moment is environmental DNA. *'This is a technology of*

the future,' the biologist says enthusiastically. *'eDNA analysis allows us to carry out a complete inventory rapidly, regardless of environmental conditions such as water turbidity or light.'* All flora and fauna species, whether small or large, rare or omnipresent, and even some land animals, leave traces of DNA in the aquatic environment. The game is up for rare or timid animals which can no longer elude marine biologists!



Harvesting Nile tilapia (*Oreochromis niloticus*) that have been bred in sea water at an experimental fish farm in the cooperative community of Kibokoni Umoja, Kilifi Creek, Kilifi County, Kenya

© Kenya Marine and Fisheries Research Institute - David Mirera

we can combine fish with mussels and algae which will recycle the farm water by feeding on fish waste,' the researcher explains. Shellfish and algae are also new forms of economic resources. In addition, this aquaculture system is not intensive; the number of species farmed in a single pool is limited, which contributes to their health and well-being. Beyond the sustainability of marine aquaculture, the nutritional aspect of farmed species is also a key factor in Africa. Some vulnerable populations, more particularly children and pregnant women, suffer from deficiencies in trace elements, vitamins and essential fatty acids. In response to this issue, an inter-disciplinary and cross-sectoral partnership has been set up recently between South Africa and France. *'One of the aims is to take into account the nutritional quality of farmed species in order to compensate for these deficiencies,'* the fish nutritionist explains. The partnership also works to promote a circular economy via the [Nutritious project](#). *'Fishing and aquaculture by-products, such as bones and offal, can actually be recycled for human consumption and/or animal feed.'* The results of this work in South Africa will eventually be shared with other African countries, in particular via AfriMAQUA. The project will contribute to promoting this nutrition-based aquaculture and strengthen the continent's food and nutritional safety.

The convergence of efforts

Initiatives such as CoreCrabe or AfriMAQUA will help to reach the goal of the Convention on Biological Diversity (CBD), i.e., to live in harmony with nature by 2050. There is still much to be done, however.

The [5th edition of the Global Biodiversity Outlook](#) published in 2020 by the CBD draws a bleak conclusion on the

United Nations Decade on Biodiversity. Not one of the twenty Aichi Goals set in 2010 in Nagoya to protect nature has been fully reached and the erosion of biodiversity continues. Yet the importance of biodiversity in ensuring the long-term food security of the world and limiting the emergence of future pandemics is an irrefutable fact. Time is running out, however. *'If ambitious action is not taken by 2030, either the damage inflicted on biodiversity will be irreversible, or the cost of restoring ecosystems will be too high for society,'* Yunne Shin warns. With a group of experts commissioned by Future Earth, a worldwide network of scientists devoted to sustainable development, the biologist participated in drafting an opinion piece for the journal 'Science' which puts forward more effective solutions than those of Aichi to ensure global protection of biodiversity and ecosystems. This is the real issue for COP15, scheduled from 11 to 24 October in Kunming, China: to define a bold strategy for the preservation of biodiversity in the coming decade.

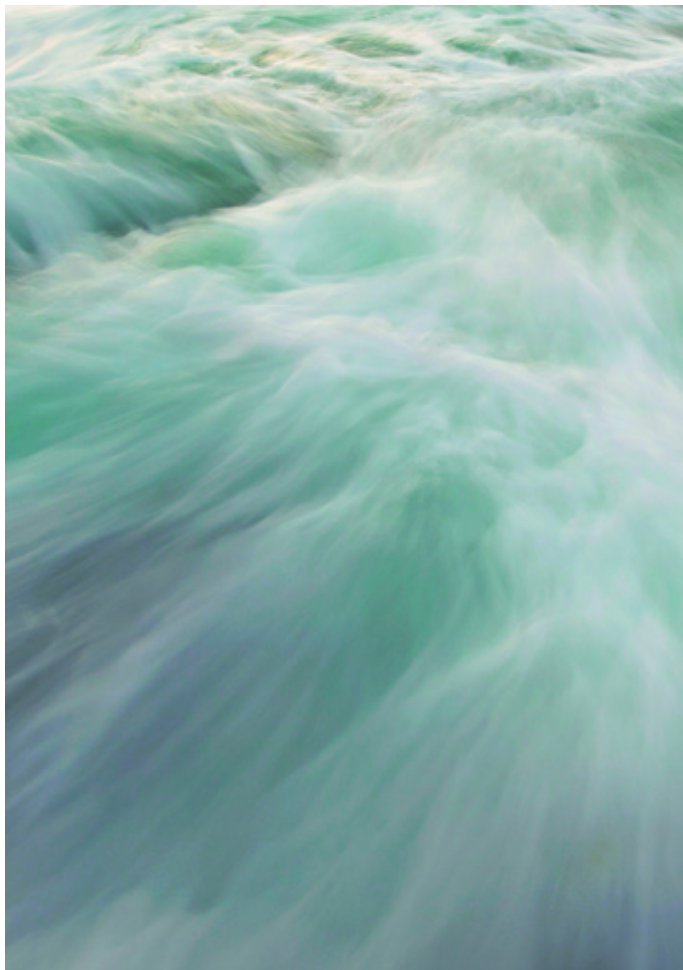
Whatever their form, these objectives must take into account the impacts of climate change which are already affecting the decline in biodiversity and will soon become the predominating factor in its erosion. *'Fortunately, the levers to combat loss of biodiversity, reduce climate change and achieve the sustainable development goals are generally the same: limit over-consumption, eliminate food waste and reduce the proportion of meat consumed, develop agro-ecology, fight deforestation and restore coastal eco-systems,'* Yunne Shin assures us. On a global level,



Sorghum, one of Africa's main subsistence crops is already suffering from climate change.

© IRD - Marianne Donnat

around 11% of CO₂ emissions are the result of tree-felling and the degradation of forests. Reducing deforestation would therefore have an impact not only on biodiversity, but also on worldwide levels of greenhouse gases (GHG). Another example is the fact that around one third of the food produced annually is wasted. Fighting against food waste would enable us to reduce our water use, preserve farming land and thus limit the production of GHG, among other things. IPCC and IPBES are currently preparing a joint report on the common issues of biodiversity conservation and climate change.



Rising seas levels in the Pacific will have serious consequences for many islands, biodiversity and ecosystem services.

© IRD - Olivier Dangles - François Nowicki / Une Autre Terre

Other sensitive issues are to be raised during COP15, including the protection of 30% of natural areas by 2030, brought to the table by NGOs and the [High Ambition Coalition for Nature and People](#), coordinated by France and Costa Rica. Yet serious doubts remain as to the relevance of this initiative, in particular with regard to its cost, proven benefits and practical implementation. *'The creation of protected areas does not solve the issues of climate change or pollution,'* geographer Estienne Rodary comments. He believes this conservation model may be obsolete. *'Does protecting a part of the planet mean we can damage the rest?'* Developing countries are nonetheless willing to accept the principle of 30% protected areas if compensation is granted to them on a sovereign level. In particular, they request that DSI or Digital Sequence Information (delocalised genetic sequences that can be used in the same way as genetic resources extracted directly from biodiversity) be taken into account in the Nagoya Protocol on the same level as genetic resources. The matter of protecting marine biodiversity outside exclusive economic zones (EEZ) will also be raised. However, it is the 'mainstreaming' of biodiversity that will remain the key issue. *'Like climate, biodiversity must be integrated into all areas of public policy,'* Estienne Rodary argues. Although the solutions may be local and depend on local conditions and needs, action on a global scale is essential to halt the decline in biodiversity and foster the hope that humans may live in harmony with nature by 2050.

Editor

Simon Pierrefixe



Biodiversity in the South - Research for a Sustainable World

A richly illustrated publication by IRD, geared towards a wide audience and coordinated by a scientific committee of more than 40 researchers.

In a modern world faced with climate change and pandemics such as COVID-19 linked to the decline of natural environments, how does research contribute to preserving nature?

Discover the key challenges in preserving biodiversity through 25 examples of multi-disciplinary studies, led by IRD researchers and their partners.

Contacts

Pascale Chabanet, UMR **ENTROPIE** (IRD/CNRS/ Ifremer/Université de La Réunion /Université de la Nouvelle Calédonie)
Maria Darias, UMR **MARBEC** (IRD/Ifremer/CNRS/Université de Montpellier)
Jocelyne Ferraris, UMR **ENTROPIE** (IRD/CNRS/ Ifremer/Université de La Réunion /Université de la Nouvelle Calédonie)
Marc Léopold, UMR **ENTROPIE** (IRD/CNRS/Ifremer/Université de La Réunion/ Université de la Nouvelle Calédonie)
David Mouillot, UMR **MARBEC**, IRD/Ifremer/CNRS/Université de Montpellier
Estienne Rodary, UMR **SENS** (IRD/Cirad/Université Paul-Valéry Montpellier)
Catherine Sabinot, UMR **ESPACE-DEV** (IRD/Université de Montpellier/ Université de Guyane/ Université de la Réunion, Université des Antilles),
Yunne Shin, UMR **MARBEC** (IRD/Ifremer/CNRS/Université de Montpellier)

Publications

Sandra Díaz, Noelia Zafra-Calvo, Andy Purvis, Peter H. Verburg, David Obura, Paul Leadley, Rebecca Chaplin-Kramer, Luc De Meester, Ehsan Dulloo, Berta Martín-López, M. Rebecca Shaw, Piero Visconti, Wendy Broadgate, Michael W. Bruford, Neil D. Burgess, Jeannine Cavender-Bares, Fabrice DeClerck, José María Fernández-Palacios, Lucas A. Garibaldi, Samantha L. L. Hill, Forest Isbell, Colin K. Khoury, Cornelia B. Krug, Jianguo Liu, Martine Maron, Philip J. K. McGowan, Henrique M. Pereira, Victoria Reyes-García, Juan Rocha, Carlo Rondinini, Lynne Shannon, Yunne-Jai Shin, Paul V. R. Snelgrove, Eva M. Spehn, Bernardo Strassburg, Suneetha M. Subramanian, Joshua J. Tewksbury, James E. M. Watson, Amy E. Zanne, [Set ambitious goals for biodiversity and sustainability](#), *Science*, 22 octobre 2020 ; doi: [10.1126/science.abe1530](#)
 Almut Arneth, Yunne-Jai Shin, Paul Leadley, Carlo Rondinini, Elena Bukvareva, Melanie Kolb, Guy F Midgley, Thierry Oberdorff, Ignacio Palomo, Osamu Saito, [Post-2020 biodiversity targets need to embrace climate change](#), *PNAS*, 8 décembre 2020 doi: [10.1073/pnas.2009584117](#)