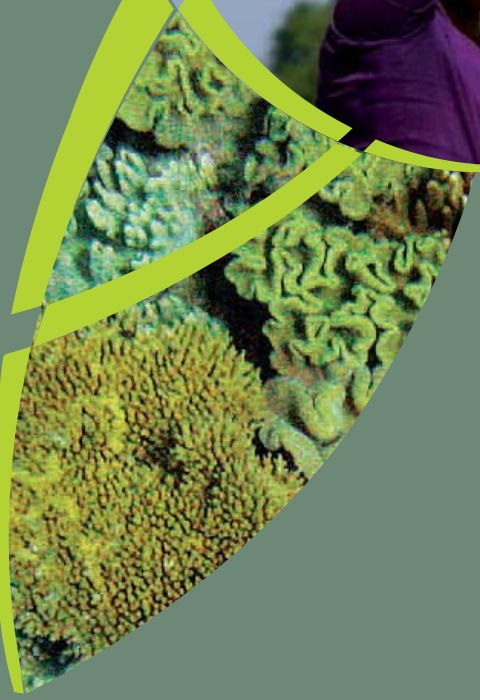

Excellence in research

Science in the service of development

Six research programmes

① Natural hazards and climate ② Sustainable management of Southern ecosystems
③ Water resources and access to water ④ Food security in the South
⑤ Public health and health policy ⑥ Development and globalisation

Science in the service of development

●● For more than 65 years the IRD has been working to improve the living conditions of vulnerable populations and to foster self-reliance in Southern countries' scientific communities. Today, research for development is pursued through close North-South partnerships.

Societies, health, environment and resources are the three fields of study through which the IRD sets out to address the world's great development challenges. ●●

Hydroecology / Morocco.

Exploring and understanding the terrains of the South

From Sahelian desert, volcanic regions and seafloors to tropical rainforests, Andean glaciers and mega-cities, IRD researchers explore a host of physical environments and societies.

There are teams studying ongoing change in socio-ecological systems, the emergence of new pathologies and nutritional problems in different parts of the world. Others are investigating population movements and urban dynamics, for example changes in infrastructure, governance and spatial organisation of the great metropoles' outskirts. Cities, heritage recognition, identity issues and the fight against infectious diseases are among the development aspects crucial to the health and social sciences agenda. Across the world's oceans, every year IRD surveys monitor ecosystems and measure the physical-chemical parameters of the environment, pushing back the frontiers of knowledge a little further each time. A real-time ocean weather monitoring network has been set up with stations at a dozen key points of the tropical Atlantic. A programme tagging large fish in the high seas is part of the European MADE[1] project whose aim is to reduce the negative impact of fishery on marine ecosystems. On land, areas still unexplored are arousing huge interest among scientists.

Cooperating for the South

In 2010 the Institute's research structures continued to develop, forging closer, fruitful links with universities and other research bodies. Now 95% of the Institute's research units are joint units (UMRs). As of 1 May 2011, the IRD had 58 units including three international units. The joint service unit FOF[2] was formed in 2010, in partnership with the CNRS, Ifremer and the French polar institute IPEV to implement the program plan and investment policy of the French oceanographic fleet.

As well as its involvement in joint research units, the IRD played a full part in the development of the French research landscape. It became a member of several research and higher education clusters. Already a partner in two research alliances – AVIESAN on life sciences and health and ANCRE on energy research – it took part in setting up the AllEnvi environmental research alliance. AllEnvi's mission is to improve synergy among research teams working on scientific issues connected with food, water, climate, ecology and land use planning. The IRD also takes part in the work of the ATHENA human and social sciences alliance.

[1] MADE: Mitigating ADverse Ecological impacts of open ocean fisheries.
[2] Flotte océanographique française.

●● Lengguru-Kaimana expedition 2010 ●●

The Lengguru-Kaimana expedition, involving some fifty French and Indonesian scientists, was co-organised by the IRD. In the north of Western Papua, this is one of the least-known parts of the world in terms of its biology, archaeology and geography. Five sites around the Lengguru range were studied to trace the geological history of the area, explain the diversification of its habitats and make a preliminary assessment of surface and underground biodiversity. From the preliminary inventory drawn up by the expedition's biologists, new species of fish including one cave-dwelling fish, insects, bats, crustaceans and gastropods were identified. The archaeologists and palaeontologists also discovered vast scope for research into the trade and migration routes of the ancient inhabitants. The 2010 Lengguru-Kaimana mission marks the start of a close collaboration between France and Indonesia to study karst environments. The scientific network now established intends to conduct major programmes focusing, for example, on the mechanisms that structure and regulate biodiversity in inter-tropical karst mountains.

Under the 'future investments' programme run by the national research agency ANR, the IRD was involved in several joint project applications and is now a partner in three facilities (*équipements d'excellence*), 15 laboratories (*laboratoires d'excellence*) and one *institut hospitalo-universitaire* funded by the programme.

Partnerships launched in Metropolitan France on food security issues met with an international response. Montpellier hosted the first World Conference on agricultural research for development, and has now been chosen as home for the CGIAR[3]. The success of the French candidacy to house the CGIAR is the result of vigorous efforts by scientific bodies, the Montpellier agglomeration, the Languedoc-Roussillon regional authorities and the ministries concerned. The Fondation Agropolis International, of which the IRD is a founding member, was mandated to coordinate and promote Montpellier's candidacy.

One important collaboration was the IRD's decisive participation in setting up the Pôle Eau, a competitiveness cluster with global ambitions, working for better management of water resources and use in response to climate change. Contributing to the cluster will be the ILEE water and environment research institute in Montpellier, with nearly 750 scientists from twelve partner institutions including the IRD.

Advancing knowledge through publications

The ever-growing number of publications is a reflection of the research teams' drive and energy. Articles published by IRD researchers rose by some 7% to 1,640, including 1,320 cited on *Web of Science* and nearly 320 other articles included in the *Horizon* human and social sciences database. Taking UMR members into account, output amounted to 3,000 articles. In human and social sciences, the number is rising constantly: over 400 articles, nearly 400 book chapters, 67 books written and 75 books edited.

At 44%, the proportion of co-publication with Southern institutions was slightly up on the previous year. The partner countries mainly concerned were Cameroon, Senegal, Brazil, Burkina Faso, South Africa, Thailand and Benin. The increase is particularly notable in West Africa, North Africa and Asia-Pacific.

Publication visibility was high: 62% of articles appeared in journals with a high impact in their field and more than 10% in top journals. Twelve articles were published in *Emerging Infectious Diseases*, 9 in *Clinical Infectious Diseases*, 8 in *Remote Sensing of Environment*, 6 in *Journal of Hydrology*, 5 in *PNAS*, 5 in *Plos Pathogens*, 4 in *Nature*, 4 in *The Lancet* and 3 in *Science*.

Joint and international research units accounted for 84% of publications, up from 70% in 2009 and 58% in 2008. On average, each researcher contributes to 2 publications a year and of the 771 researchers and non-research staff who published, nearly 14% signed more than 5 articles.

These are the ways in which the IRD works with the Souths to perform high-quality research centred on humankind and our relationship with the environment.

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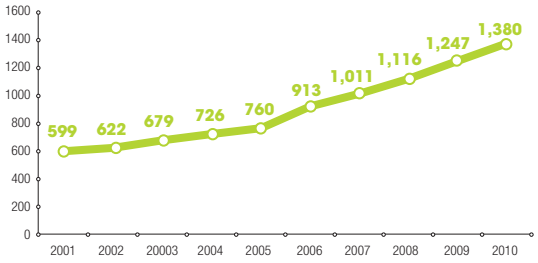
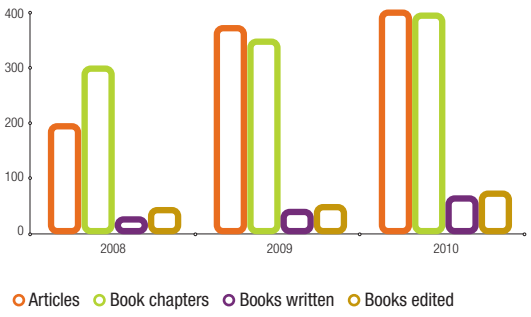
Lengguru expedition / Papua New Guinea.

[3] Consultative Group on International Agricultural Research.

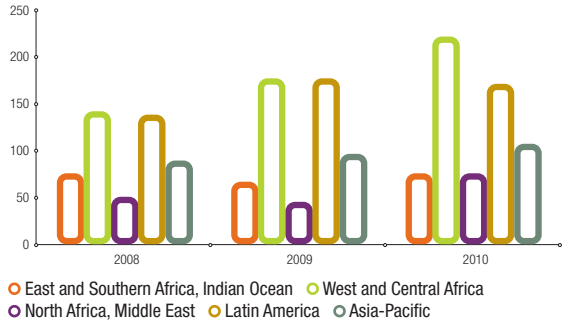
PUBLICATIONS WITH AN IRD AUTHOR
(WEB OF SCIENCE)



HUMAN AND SOCIAL SCIENCES PUBLICATIONS
(HORIZON DATABASE)



CO-PUBLICATIONS BY MAJOR SOUTHERN REGION



Natural hazards and climate

●● Extreme natural events such as earthquakes, tsunamis, volcanic eruptions and landslides happen in North and South alike. But in Southern countries, people and infrastructure are even more vulnerable to the often disastrous consequences. The study of these hazards and the attendant risks is therefore a priority issue for the IRD and its partners. By describing the phenomena, analysing the physical processes involved, monitoring and modelling, we improve capabilities for prediction, early warning and prevention. The work includes studying people's perceptions of risk, understanding societal vulnerability and analysing public policy on civil defence and crisis management.

Climate variability and the impact of climate change occupy a central place in scientific and political agendas. In order to describe and model these phenomena, remotely-sensed and *in situ* observation systems monitor atmospheric, oceanic and continental dynamics and their interactions in tropical regions. These approaches further our understanding of the processes at work and improve our ability to predict regional climatic variability, refine climate change scenarios and make clear the consequences at different scales ●●

Landslide / Bolivia.

40 RESEARCHERS	€5.4 MILLION	97 ARTICLES

Seismic activity in the Andes

Earthquakes and volcanic eruptions regularly occur in the Andes, causing many victims and enormous damage. After the Pisco earthquake in Peru in 2007, a severe seismic event struck Chile in February 2010. Researchers from the IRD and its partners have for some years been studying the dynamics of this subduction zone where the Nazca oceanic plate is pushed beneath the South American continental plate, in order to more accurately estimate the likelihood of these earthquakes recurring, their location and magnitude.

Earthquakes are complex phenomena that it is still impossible to predict. In the Pisco region, a French-Peruvian-US team[1] installed a network of GPS stations and characterised the entire seismic cycle, throwing new light on the dynamics of the faults and the physical mechanisms at work. Although the timing of earthquakes cannot be predicted, this progress makes it possible to say where future major events will occur and what their magnitude will be. On the social science side, an in-depth survey was carried out with Peruvian colleagues and an Italian NGO in one of the most affected areas. This research showed the great vulnerability of disadvantaged communities, who are hit hardest by the destruction of their homes and also find it most difficult to get involved in the rebuilding work.

In Chile, IRD researchers and their Chilean and German colleagues carried out a series of observations for a month following the earthquake and reconstituted a map of ground level uplift and subsidence along the coast, revealing a fracture zone some 500 kilometres long. This research suggests that the earthquake released a major part of the energy stored in the South American western plate for nearly 170 years. Build-up and release of stress are the characteristics of the seismic cycle, whose timing is provided by historical observations. As the stress was released, the plate was pushed up at the side, lifting the coastal zone by up to 2.5 metres and causing the coastline to advance up to 500 metres in places. Inland, the plate subsided, lowering the ground level by nearly a metre. This catastrophic earthquake appears to have released a major part of the energy built up in this segment of the Chilean subduction zone. This may explain why there have not to date been any strong aftershocks, which is rare for events of this magnitude.

In Chile as in Pisco, the main movement zones may correspond to places where the plates are stuck, a phenomenon that seems to recur from one event to the next. This observation suggests that it may be possible to identify zones with high seismic potential, as opposed to zones where the plates glide smoothly with no risk of earthquakes.

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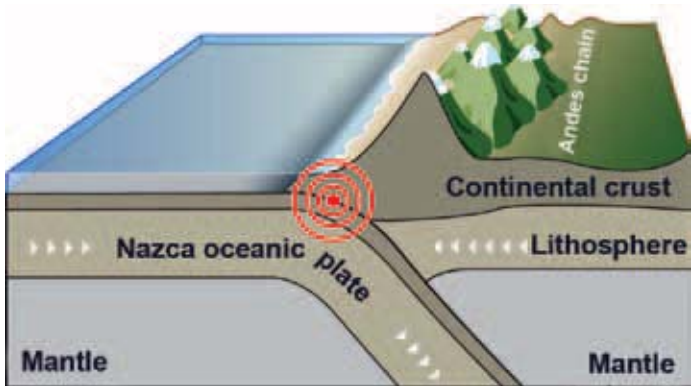
Publication : *Science*

[1] Under an agreement between the Instituto Geofísico del Perú (IGP) and the IRD.

Taking geodesic measurements / Chile.



Subduction / Chile.

PARTNER

Department of Geology of the University of Chile

The department works on natural hazards, precious metal resources, geothermics and Andean tectonics. In the last twenty years, close cooperation has developed with the IRD on topics of common interest, and twelve doctoral degrees in geosciences have been awarded. Geological, geophysical and geomorphological research is carried out under the joint programme *Geodynamics and tectonics of the Andean chain*.

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Climate and public health: dengue fever

Because of its impact on vector insect populations, climate plays an important role in the spread of diseases like dengue fever. Every year, dengue affects 100 million people and causes 25,000 deaths, mainly in tropical and subtropical regions. So gaining a more thorough knowledge of the climate factors that affect the arbovirus[1] is important for many Southern countries. To achieve this the IRD and its partners in Brazil[2] and the South Pacific[3] launched a multidisciplinary programme.

The four dengue viruses have spread in the past decade and are now found in over 100 tropical and subtropical countries. They are among the viruses most frequently transmitted to humans by arthropods. The geographical distribution of the disease reflects that of its main vector, the *Aedes aegypti* mosquito. In the absence of a vaccine, vector control is the only real way to combat dengue. To understand how climate acts on the spread of the disease, the IRD and a number of partners joined forces to produce an index of climate risk that can be used operationally by the countries concerned.

Starting from observation, the researchers collected and assessed entomological data and homogenised country data on dengue epidemics over time, to establish a usable scorecard. By epidemiological modelling based on the laws governing the insect's growth and the development of the virus inside it in relation to surface temperature, relative humidity and precipitation, it proved possible to estimate the density of infectious female mosquitoes, i.e. those capable of transmitting the disease. Then, taking relations between humans and the vector into account with an index commonly used in epidemiology, the epidemic risk was mapped using current and estimated future climate data. The results show that the conditions with a large number of days early in the year when temperatures are above 32°C and relative humidity is over 95% favour the development of the disease.

By 2100, areas with these conditions could spread northward and southward beyond the currently identified geographical range. In countries already affected by dengue the risk could increase, as the model indicates a more rapid circulation of the virus.

While the results open the way to a better overall knowledge of the impact of climate, it remains to be shown whether this kind of model can also be used to analyse the seasonal and interannual dynamics of the disease at a regional level. In the long run, with a better understanding of the influences of phenomena like El Niño and the Southern Oscillation on countries of the Southwest Pacific, it should be possible to introduce effective preventive measures.

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Publication : *Climatic Change*

[1] Arbovirus: viral disease transmitted by an arthropod.
[2] Federal University of Rio Grande do Norte (Natal-RN), Federal University of Campina Grande and Paraiba State University (Campina Grande-PB), National Meteorology Insitute (São Paulo), National Space Research Institute (Cachoeira Paulista-SP).
[3] CNRS, Météo France, Institut Louis Malardé, Institut Pasteur in New Caledonia, University of New Caledonia, New Caledonia Department of Health and Social Welfare.

PARTNER

CPTEC-INPE - Centre for Weather Forecast and Climate Studies at the National Institute for Space Research

in Brazil, has been in existence for ten years. Its mission is to make and broadcast weather forecasts and to model atmospheric phenomena by analysing the satellite data it produces. Its research covers numerous topics including surface hydrology, soil science and vegetation-atmosphere interactions. Its work with the IRD concerns climate change, its consequences for the environment and human health, and adaptation strategies for agriculture, rural development, hydroelectric power production, river transport and management of water resources and wetlands. Some of this research is conducted under European projects: CLARIS, CLARIS-LPB and more recently DEEPER. For the latter, CPTEC-INPE is coordinating Brazil's participation.

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Dengue risk areas.

Harvesting mosquitoes / Bolivia.

Sustainable management of Southern ecosystems

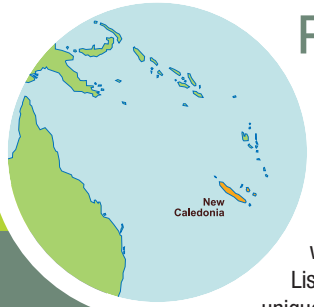
●● Southern populations and societies rely on tropical aquatic and land ecosystems for most of their resources and subsistence. But these richly diverse ecosystems, some of which have yet to be described, are under severe pressure from human activity. This, combined with climate change, is causing environmental degradation.

Studying biodiversity, agrosystems and marine, coastal and continental aquatic ecosystems in the tropical zone, IRD scientists and their partners are developing approaches to maintain the viability of biotopes and their uses. In doing so they provide answers to major global challenges in emblematic fields ranging from coral reefs and aquaculture to tropical rainforests, desertification, land use and drought resistance in plants. They also add to scientific knowledge by taking part in biodiversity inventories and encourage sustainable ecosystem management – for example by recommending changes in behaviour or practice and the use of protected areas as a conservation measure ●●

122 RESEARCHERS	€22.4 MILLION	261 ARTICLES

Frog / Costa Rica.

Protecting New Caledonia's lagoons



New Caledonia possesses the world's second largest coral reef lagoon, which Unesco added to its World Heritage List in 2008. The island itself possesses a unique and diverse ecosystem but also one of the world's largest reserves of nickel. Nickel mining during the 20th century tripled the rate of sedimentation on the lagoon floors in some places. To understand the functioning of the lagoons and protect them, scientists from the IRD and its partners[1] ran an ambitious ten-year multidisciplinary research programme under the National Coastal Environment Programme (PNEC).

As with most island environments, cultural and economic ties to the sea are strong in New Caledonia. The richness of its marine ecosystems is of great interest to scientists, who have been amassing knowledge of its coral reefs for fifty years now. The Caledonian strand of PNEC ran from 1999 to 2007, taking an innovative multidisciplinary approach. The aim of the research was to improve knowledge of the structure and functioning of New Caledonia's lagoons and assess the impact of human activities. The topics covered included the physical-chemical composition of the water and marine sediments, the currents responsible for dispersing input from the land, ciguatera, marine habitats, fauna and flora, and the effects of metal contaminants on living things. For example, scientists tracked the sedimentary history of the lagoon by a series of measurements on the particles that accumulate on the lagoon floor. Apart from the influence of extreme weather such as cyclones and tropical downpours, this research has shown the important role played by the hydrodynamic system – i.e. all the mechanisms involved in the movement of water masses including currents, swell, tides and turbulence – in the distribution and fate of soil particles and metals washed from the land. An atlas of currents and maps of residence time in the lagoon waters were produced, tools that can be used in developing integrated management of the zone. Other results define avenues for further research, under GOPS[2] particularly, on the effects of atmospheric phenomena on ocean circulation in the open sea offshore.

These findings will be of use to specialists on other lagoon areas of the world's oceans as well as researchers and students doing further work on New Caledonia's lagoons. Beyond the scientific prospects, these investigations have kindled an awareness among political decision-makers and mine operators. The industry is now setting up a number of measures to limit soil erosion and pollution of the lagoon, such as less destructive mining methods, retention basins to hold effluents and revegetation of degraded areas. The big challenge for local stakeholders is to reconcile development goals based on mining, which is the island's leading economic activity, with protection of this unique place, a gem of marine biodiversity.

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Publication : Special issue of *Marine Pollution Bulletin*

[1] This work was conducted mainly by teams from the IRD, CNRS, Ifremer, the EPHE (École pratique des hautes études, Perpignan), and universities in New Caledonia, Metropolitan and overseas France and elsewhere, under the National Coastal Environment Programme (PNEC). It also enjoyed the support of the New Caledonian ZoNéCo Programme.
[2] Leading monitoring centre for land and marine environment and biodiversity in the South Pacific.

PARTNER

The missions of New Caledonia's **Direction de l'environnement, Province Sud** include acquiring knowledge about coastal, reef and lagoon environments, protecting these ecosystems, managing the Unesco World Heritage Site dossier and publicising the Province's work towards protecting the marine environment. Since 2006, the Sea department, in charge of these activities, has used the expertise of the IRD scientists to introduce a responsible management system for these ecosystems. The researchers also play a part in actions to raise user awareness of the ecological value of the mangroves, coral reef biodiversity, etc.

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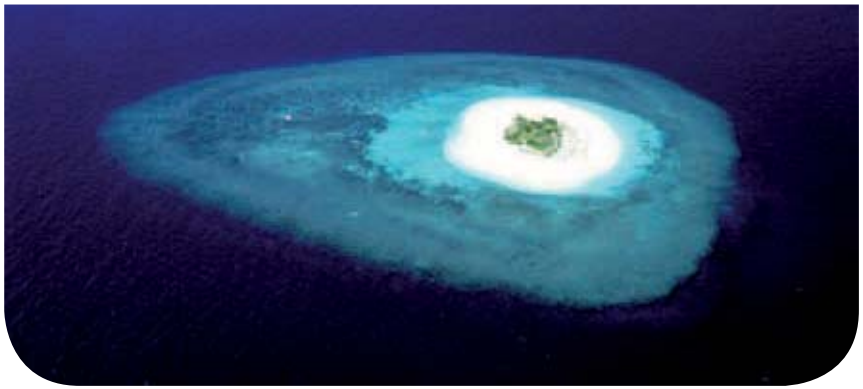

Lagoon / New Caledonia.

Marine biodiversity / New Caledonia.

Agrarian transition in Indonesia

The rubber agroforests on the island of Sumatra, Indonesia, are exceptionally biodiverse ecosystems. These domesticated forests rich in commercially useful species are a source of diversified income for farmers and usually combine subsistence resources and cash crops. Since the 1990s, rubber and oil palm monocropping have been replacing the agroforests at an unprecedented rate. IRD researchers and their partners studied the functioning and evolution of the agroforests.

Until the late 19th century, the island of Sumatra was almost entirely forested. The first use of the forest was for hunting and gathering, later combined with swidden farming and upland rice. With the industrial revolution in Europe and North America came high demand for natural rubber. Sumatra's farmers responded to the opportunity by planting rubber seedlings among the rice in their swiddens; the rubber agroforest came into being.

The agroforests continued to expand until the 1990s, when they began to decline as single-species rubber and palm oil plantations took their place. To encourage sustainable management of these new 'landscape mosaics', IRD researchers and their partners joined forces under a project financed by the Swiss Agency for Development and Cooperation and conducted jointly with CIFOR[1] and ICRAF[2] in five Asian and African countries. The aim was to make a socio-economic and biophysical assessment of the agroforests and study possible ways to pay for the environmental services they provide. During four years of work the researchers compared the landscape combinations and designed an online tool for studying complex landscapes.

In Indonesia, the researchers found that there is no social pressure to maintain the agroforests. Farmers, government and industry, all the players in the Indonesian farm sector want to expand single-species plantations, of oil palm especially. The reason is that plantations provide much higher incomes than rice farming or agroforests. In addition, oil palm requires little labour and has a shorter production cycle than rubber. Sentimental or cultural attachment to the less profitable agroforestry systems is a luxury that local people cannot afford. And yet the agroforests have many advantages. They not only bring security against economic crises by diversifying farm incomes, they can also act as a buffer zone around the national parks. To promote a sustainable agrarian transition that will benefit Indonesia's people, the researchers have been exploring systems of payment for environmental services and other ways to make biodiversity profitable.

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Publication : *Ecology and Society*

[1] Centre for International Forestry Research.
[2] World Agroforestry Centre.

Oil palms / Indonesia.

Harvesting rubber / Indonesia.

PARTNER

CIFOR, Centre for International Forest Research

Formed in 1993, CIFOR is an international research body based in Bogor, Indonesia. Its aim is to work for the conservation of tropical forests and the improvement of local living conditions. It is one of the fifteen institutes that make up the CGIAR, a global consortium of centres working in agricultural research for development. Its research and expertise aid decision making in tropical forest management in Asia, Africa and Latin America. IRD researchers have been working at CIFOR for the past fifteen years, on topics of common interest. An IRD researcher directed one of CIFOR's three major programmes between 2009 and 2011.

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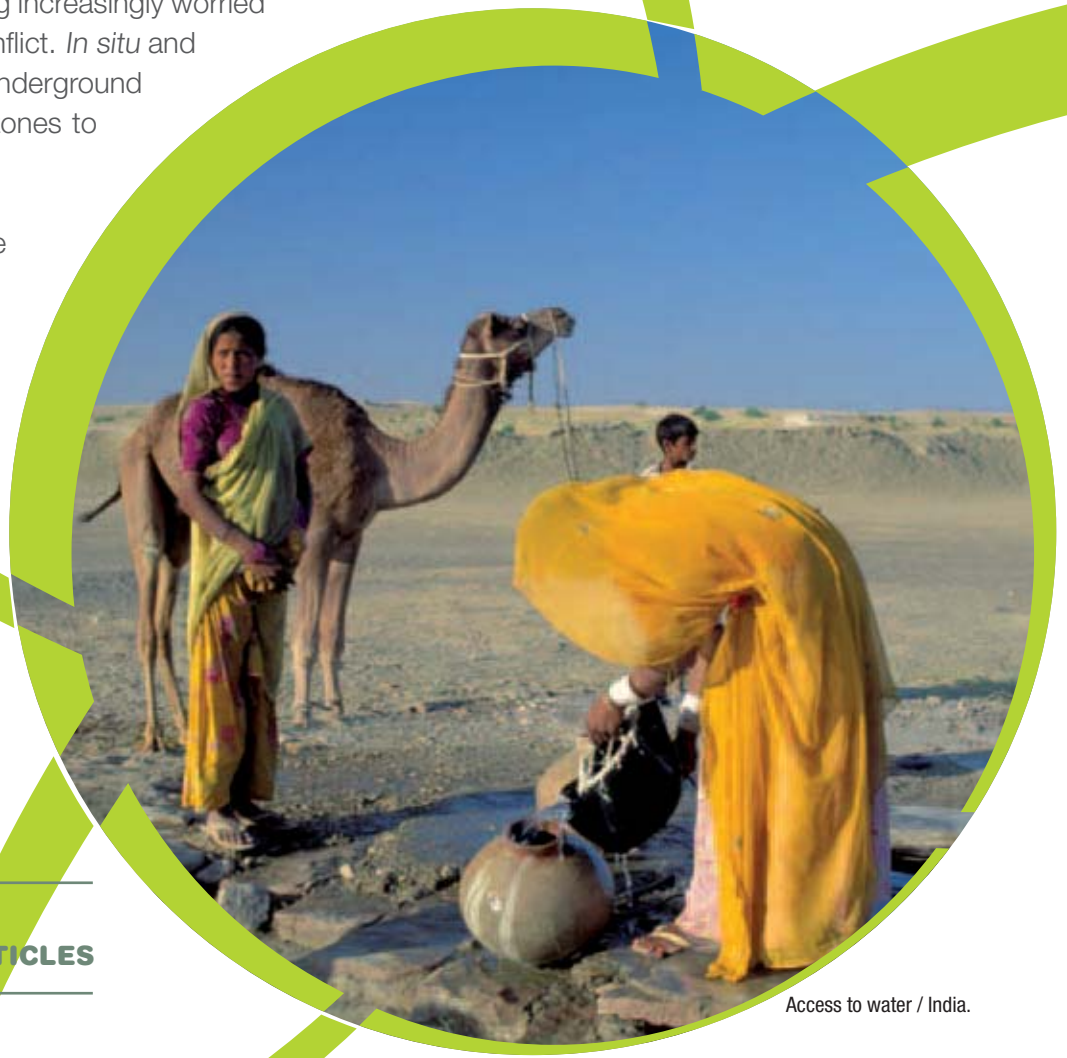
Water resources and access to water

●● Access to and the sharing of water resources are fundamental issues in Southern countries. Around the world, 2.6 billion people have no access to clean water. Climate change is creating increasing scarcity and competition for water for domestic and agricultural use. Societies are becoming increasingly worried about the future of these resources and their accessibility; this can lead to conflict. *In situ* and space-based observation systems are being used to monitor surface and underground hydrologic dynamics in a number of areas ranging from Sahelian-Sudanian zones to tropical glaciers.

Armed with quantitative and qualitative resource assessments, adequate modelling and a better understanding of the processes and mechanisms at work it becomes possible to propose water resource management systems at catchment and hydrosystem level. Incorporated in public policy these proposals lead to management methods that are more sustainable, more equitable and therefore more socially acceptable ●●



Access to water / India.

141 RESEARCHERS	**€26.3** MILLION	**247** ARTICLES

Snow and water management in Morocco

Snow is a major water resource for the mountainous countries around the Mediterranean. The High Atlas in Morocco receives most of the country's precipitation, much of it as snow, and acts as a reservoir for the flat farmlands below. As precipitation has dwindled, this resource is now under threat from higher consumption. Monitoring snow cover with the use of satellite imagery is now of crucial importance in providing decision-making tools for local water managers.

In the Tensift region, west of the High Atlas mountains, pressure from agricultural and socio-economic development requires rational water use rules and better seasonal forecasting. To that end, since 2002 a major cooperative project has involved research and higher education bodies[1], the Tensift basin agency (ABHT) and the Haouz Regional Agricultural Development Office. The partners run the SudMed programme for integrated agricultural water management. Using imagery from the Spot-Vegetation satellite, the scientists mapped the snow-covered areas of the mountain range. They analysed spatial and temporal variations in snow cover in the High Atlas from 1998 to 2005, discovering wide fluctuations from year to year[2] in snow cover area and duration and the number of snowfall and snowmelt episodes during winter. These variations directly impact streamflow in the wadis and the availability of water in the dry season. To supplement these general observations, the research team also uses higher-resolution (10 m) images. These new data appear to offer encouraging scientific prospects for refining the monitoring of snow cover dynamics. The challenges facing water managers are all the greater since climate change threatens a reduction in total precipitation, especially snow, which is a reserve stored during the winter and available during low streamflow periods in summer.

The Tensift plain is typical of water management problems in the arid and semi-arid zones around the Mediterranean. Researchers are currently extending their work to the north and east of the Mediterranean in order to use satellite remote sensing to monitor variations in snowmelt and their connections with river basin dynamics.

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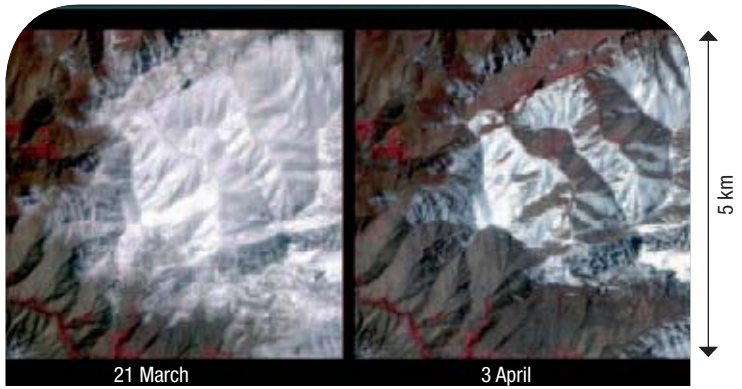
Publication : *International Journal of Applied Earth Observation and Geoinformation*

[1] Cadi Ayyad University Marrakesh (UCAM) and the French CESBIO joint research unit (CNES-CNRS-IRD-UPS).
[2] The work was done as part of Abdelghani Boudhar's doctoral thesis "Remote sensing of snow cover areas and modelling the contribution of snowmelt to streamflow in the wadis of the High Atlas in Morocco" - Cadi Ayyad University Marrakesh, faculty of science and technology.

Atlas mountains / Morocco.



Snow melt in the Atlas mountains/ Morocco.

PARTNER

Georesources laboratory, Gueliz faculty of science and technology, Cadi Ayyad University Marrakesh, Morocco

The laboratory carries out research intended to contribute to the sustainable, integrated management of natural resources in arid and semi-arid environments. It aims in particular to set up multidisciplinary research into water resources in the Tensift/Al Haouz region and to transfer the results for use in management tools and decision-making aids. Together with the CESBIO unit in Toulouse it formed CREMAS, an emerging IRD partner team, with a major research area in mountain hydrology and snowcover monitoring: rainfall/flow modelling, erosion measurement, characterisation of aquifers. This partnership also involves joint supervision of doctoral students on these topics.

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Water, agriculture and poverty in West Africa

Crop water is poorly productive in the Sahel: one cubic metre of water produces only one-tenth as much grain as in France's prime wheat region, the Beauce. As part of the Challenge Programme on Water and Food, international research has been launched in the major river basins.

Multidisciplinary analysis of the relationship between water, farm production and poverty has been carried out for each river basin. The surveys on the Volta and Niger basins were coordinated by IRD researchers. The two basins have similar climatic conditions and food crops are basically rainfed: in the northernmost areas grain can only be grown during the rainy season. The rest of the year, farmers are forced to seek seasonal work elsewhere and the land is left unfarmed. An initial factor for improvement is accurate forecasting of rainfall at the start of the season in order to plant the crops. Mapping of the agro-climatic zones reveals considerable spatial variability in rainfall, with a clear aridity gradient from south to north. In the Volta basin, rainfall variation depends on the seasonal shift of the Intertropical Convergence Zone between the warm, wet south-westerly monsoon and the harmattan, the extremely dry Saharan wind from the north-east. The researchers made several recommendations including rainwater collection systems that reduce evaporation loss in areas where nearly 90% of the precipitation returns to the atmosphere. Small dams can be used to develop local irrigation, share the water resource more fairly and introduce off-season crops. Analysis of the volumes and uses of water (draw-off for direct consumption, hydro-electric generation, etc.) contributes to a comprehensive understanding of the operation of these river basins. In addition to technical solutions, it is also essential that the water resource should be managed by proactive policies and regional consultation between countries.

The efficiency of public policies depends heavily on socio-economic factors, and consequently the region's position on the development gradient from predominantly farming to transitional to predominantly industry. For the Volta and Niger basins, which are mainly at the farming stage, the role of local authorities outweighs that of national or river basin authorities. At the transition and industrial stages, the authorities cover wider areas and may play a major role in preventing the emergence of pockets of poverty, correcting inequalities between social groups and preserving the environment.

By 2050, the major challenge will be to supply quality domestic water and develop farming practices that can meet the needs of a population which may have doubled or tripled by then. Prevention of water-borne diseases is also a development issue.

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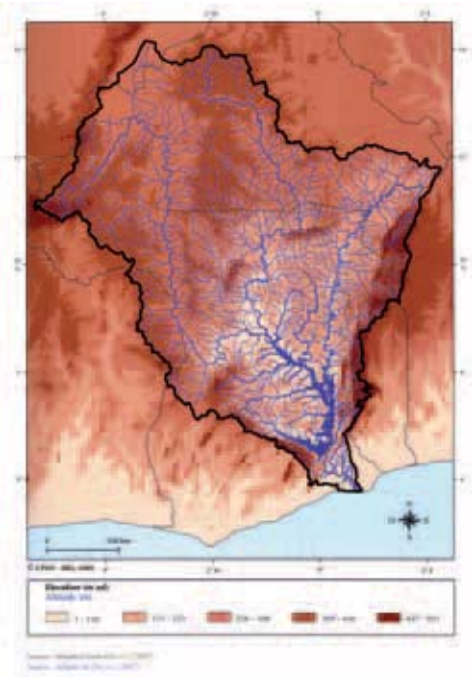
Publication : *Water International*

Market gardening / Burkina Faso.



Volta basin.

PARTNER

The Volta Basin Authority[1] covers six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo. This coordinating structure was set up in 2007 after being gradually developed since 2004 to manage water at river basin level. The VBA meets regularly to consult about the planning of resource use, and a monitoring system manages and connects hydrological databases. The multidisciplinary work and the literature produced by the basin project are providing useful knowledge to improve people's living conditions.

[1] A similar structure exists for the Niger river basin, the Niger Basin Authority.

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Food security in the South

●● Food security is still a major obstacle to development over huge areas, in Africa particularly, while world prospects for agricultural and fishery resources seem to be deteriorating. Tensions over prices, competition from energy crops, purchase of land in poorer countries and overfishing are especially problematic as they are coupled with sustained population growth.

To address these challenges, research focuses on improving yields while maintaining soil fertility. To this end, better scientific knowledge of plant biology and physiology can speed up plant breeding and identify those plants best suited to particular soils and climates. Innovative pest control projects complement this approach.

Eliminating hunger and malnutrition in its various forms will require integrated management of natural resources and fisheries; the sciences involved here are the environmental and social sciences. In Sahelian regions, vulnerability to food shortage is still a major problem. Researchers work to identify the most vulnerable populations, identify the policies and social mechanisms underpinning this vulnerability and assist players such as NGOs and policy makers. Only this way can government food security policies match real needs and be properly sustainable ●●

147 RESEARCHERS	€26 MILLION	238 ARTICLES

Granaries / Burkina Faso.

Improving rice-farming in Africa

Food security in the global South depends largely on growing varieties that are adapted to their environment against a backdrop of climate change. Cross-breeding with wild species or traditional varieties can produce plants that stand up better to drought, salty soil, disease and insect pests. To help improve rice varieties in Africa, IRD researchers thought of building genetic bridges between two species of cultivated rice. The project is an international cooperation effort supported by the Generation Challenge Programme of the Consultative Group on International Agricultural Research (CGIAR).

The Africa rice species *Oryza glaberrima* is particularly resistant to water stress and pathogens. It was crossed with *O. sativa*, the Asian-origin rice species most widely grown in the world, to create the New Rice for Africa (NERICA) cultivars. NERICA cultivars have been distributed by AfricaRice[1] since the early 2000s after years of selection to overcome the sterility caused by interbreeding. To address this problem the iBridges (interspecific Bridges) project was launched with CGIAR support. Research by the IRD targeted the *S*[1] gene, previously identified as a key determining factor in this sterility, and it was mapped in detail in partnership with CIAT. Using the work done in sequencing the genomes of all rice species (OMAP project, Tucson, Arizona), the researchers decrypted a chromosomal fragment of some million bases around the *S*[1] gene in *O. glaberrima*. All these results have led to the design of a genetic model that explains the sterility of interbred descendants and opens the way to research into the genes involved. From analysis of these genomic sequences, markers have been developed and will be used to facilitate genetic selection. Being able to identify the rare fertile individuals eliminates the many stages previously required for interspecific breeding. These advances mark the way towards varietal creation making greater use of African rice cultivars' natural biodiversity. They are the fruit of close cooperation since 2005 between CIAT, AfricaRice and African national agronomic research bodies such as the Institut d'économie rurale in Mali and the Institut de l'environnement et des recherches agricoles in Burkina Faso. The iBridges project is continuing as part of GRiSP[2], a new CGIAR programme launched in Hanoi in November 2010, in which the IRD will be supervising certain research fields such as interspecific breeding.

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[1] Africa Rice Center (http://www.africaricecenter.org).
[2] Global Rice Science Partnership.
[3] International Rice Research Institute.
[4] Japan International Research Center for Agricultural Sciences.

PARTNER

CIAT, Centro Internacional de Agricultura Tropical, is one of the fifteen international institutes that make up the CGIAR. It is based in Cali, Colombia, where it works on a large number of tropical plants of value for Latin America and Africa. Since 1995, its cooperation with the IRD has involved the permanent presence of IRD researchers at CIAT, working on fields such as cassava bacteriosis, fertility of tropical soils and the genetics and functional genomics of rice. The rice research now comes under the GRiSP programme, which aims to harmonise research globally, bringing together international research institutes (IRRI[3], AfricaRice, CIAT) with a large number of institutions in the global South and some in the North (IRD and Cirad in France, JIRCAS[4] in Japan).

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Planting rice / Mali.


Rice genetics.

Impact of Peru's anchovy industry

Anchovy fishing in Peru uses the largest national industrial fleet in the world that targets a single species of fish. It harvests an average of six million tonnes a year. These anchovies are used almost exclusively for fishmeal and oil. Although there is a small-scale fleet able to supply local markets, only one per cent of total catch goes to direct human consumption. In a country where malnutrition affects a quarter of the population, this is a paradox that has been studied by IRD researchers and their Peruvian partners.

Fishmeal and fish oil are used mainly in animal feed. In energy terms, this long processing chain, which also requires major goods transport, is less efficient than direct fish consumption in providing proteins and fatty acids. Because its catch rate is extremely high, however, Peru's anchovy industry is remarkably efficient in energy use and low environmental impact (greenhouse gas emissions, acidification, etc.). The question remains of how far this advantage compensates for the length of the production process.

A new research programme into the environmental and socio-economic impacts of the anchovy industry in Peru was launched in 2009 by the IRD and IMARPE, along with a large number of other partners from universities, companies and voluntary associations. The aim of the programme is to quantify and compare long and short industrial processes from one end of the chain to the other. Initial economic analysis reveals the greater profit available from the fishmeal-oil process, stimulated by growing demand from the fish farm sector. This trend is supported by current overcapacity in the processing factories. Concerning the environment, a comparative study of the industrial processes, using life-cycle analysis, shows that the consumption of fossil energy is by far the greatest impact, followed by the use of antifouling paint and metal in equipment construction. These initial results have already led the scientists to encourage the use of more environment-friendly practices: replacement of heavy diesel oil in processing factories by natural gas, use of low-copper and low-tin paint, reduction of liquid and solid discharge at sea, etc.

Forthcoming studies will examine the two ends of the chains: energy flows in the ecosystem for various exploitation scenarios and the impact of fish farms. Ultimately, all the production chains will be modelled in order to propose public policy choices for sustainable development. The methodology developed could be transferred to other sea- or land-based products.

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Publication : *Globec International Newsletter*

Fishery / Peru.

Anchovy / Peru.

PARTNER

IMARPE - Instituto del mar del Perú - has the mission of studying the marine environment and its biodiversity, assessing its resources and providing information and recommendations for decisions concerning fisheries, fish farming and the protection of the marine environment in order to actively contribute to Peru's development. The institute reports to the fisheries sector of the Ministry of Production and has for many years been working intensively with the IRD to assess and manage the stocks harvested on the basis of ecological and physical oceanographic studies. Data representation and analysis tools and models have been jointly developed. An international conference was jointly organised in 2006 and a Master's in sea sciences was launched in 2010 with support from the International Joint Laboratory (LMI) Dynamics of the Humboldt Current System (DISCOH).

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Public health and health policy

●● Improving the health of mothers and children and combating the world's main infectious diseases are three of the eight Millennium Development Goals. They are also the core of the IRD's health research work.

AIDS, malaria and tuberculosis and particularly their perinatal transmission have major repercussions for the development of Southern countries. Poverty also favours neglected diseases such as leishmaniasis, Chagas disease, trypanosomiasis and onchocerciasis. 'Diseases of civilisation' such as cancer, heart disease and diabetes, predominant in Northern countries, now also account for an increasing proportion of illness in developing countries. The risk of emerging pandemics, viral pandemics especially, in the intertropical zone has created a need for epidemiological monitoring and diagnostic resources.

Against this background IRD researchers work in partnership with their Southern counterparts, taking a multidisciplinary approach and monitoring disease, developing suitable, effective diagnostic tools and treatments and seeking ways to combat or indeed eradicate some diseases. The success of these projects depends on close collaboration with the human sciences and also an ecosystem approach to health, proposing viable approaches that are properly applicable in local situations ●●

AIDS prevention / Togo.

151 RESEARCHERS	**€28.7** MILLION	**465** ARTICLES

Nutritional deficiency in Vietnam

Vietnam is an emerging country facing a double burden of malnutrition: overweight is a growing problem, while micronutrient deficiencies and delayed growth still persist. Prevention in this area is the responsibility of the National Institute of Nutrition (NIN) in Hanoi, with which the IRD has been working for over ten years.

Most of the joint research is in assessing the impact of measures taken with high-risk population groups, i.e. women of reproductive age, unweaned infants and young children. Most of these measures involve providing food supplements and micronutrient-enriched foods. The main aim of the work is to define appropriate long-term strategies for a situation where most people have very limited resources.

One of the most recent research findings is that in some cases the food supplement dosages recommended by international organisations are too high and can cause undesirable side effects. In a study among young women, the researchers showed that intermittent preventive supplementation for a few months before and during pregnancy, with smaller amounts of iron and folic acid, has a better impact on mother and infant health than the current practice of high doses during pregnancy. This research contributed to the recent WHO recommendation on preventive treatments for women of reproductive age.

Other studies assessed the impact of micronutrient enrichment of foods intended for the population as a whole (*nuoc mam*) or for specific groups such as small children and schoolchildren. These operations have significantly improved the nutritional status of the target populations and have shown that in Vietnam, several micronutrients other than iron are involved in anaemia. These results suggest that nutrition operations should be re-thought. Another study assessed the efficacy of breast milk supplements produced in Vietnam under the Fasevie project involving the National Institute of Nutrition, Hanoi medical school, the IRD and GRET[1]; it showed that regularly consuming these supplements protects infants from iron deficiency and reduces the prevalence of delayed growth.

The research has led to new international funding for district- and province-wide operations. Ongoing work in Vietnam and Cambodia is examining unresolved questions such as the ineffectiveness of vitamin A supplementation in breast-feeding women, the role of vitamin A in the absorption of iron, and micronutrient enrichment of rice. The question of the interaction between micronutrient deficiency and chronic, non-transmissible diseases such as obesity is an important research topic for the future.

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Publications : *Journal of nutrition, Food and Nutrition Bulletin*

[1] Groupe de recherche et d'échanges technologiques, a professional solidarity and international cooperation association.


Making noodles / Vietnam.


Feeding Infants / Vietnam.

PARTNER

The National Institute of Nutrition in Hanoi is a Vietnamese public body reporting to the Ministry of Health. Its missions are nutrition monitoring and research. It is responsible for ensuring public health and it evaluates the nutritional and functional properties of foods. The Institute also runs public awareness campaigns to combat mother-and-infant malnutrition and micronutrient deficiency. The partnership with the IRD began in 1995 and has strengthened over the years. It involves joint research and joint supervision of French and Vietnamese doctoral and Master's students.

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Malaria came from gorillas

Malaria is the most widespread parasite disease on Earth. It affects 250 to 500 million people each year and kills more than a million, usually young children and 90% of them in Africa. Although much progress in treatment and prevention has been made in recent decades, an international consortium of researchers[1] including a team from the IRD and the University of Montpellier, has just shown for the first time that the gorilla, greatest of the great apes, is an animal reservoir for the disease transmitted to humans by *Anopheles* mosquitoes.

The gorilla was the original source of human infection by *Plasmodium falciparum*, the parasite responsible for the most common form of malaria. This discovery refutes the findings of earlier studies which also suggested a simian origin but in the chimpanzee or the bonobo. Researchers from the CNRS and IRD[2] had recently detected *P. falciparum* in gorillas, but the origin of the infection remained to be clarified. The scientists have just shown the almost perfect genetic match between the parasites found in gorillas and those that infect humans. Using the single genome amplification technique they identified and characterised DNA sequences of the parasite found in faecal samples from wild animals. This extremely precise method also allowed them to prove that the parasite jumped species from gorillas to humans and not the reverse.

Another discovery with important implications for public health is that gorillas are still an animal reservoir for the disease. The research team analysed over 2,700 faecal samples from wild chimpanzees and gorillas collected at 57 sites in sub-Saharan Central Africa, from Cameroon through the Central African Republic to the Democratic Republic of Congo. Using this non-invasive method developed ten years ago by the IRD team and their partners at the University of Alabama, the researchers were able to bring together large amounts of genetic material without disturbing this protected species. The analysis results were unexpected: infection with *Plasmodium* is widespread among Western gorillas (*Gorilla gorilla*), with prevalence rates of 32 to 48% and in some communities over half of individuals being carriers. These results do not tell us whether the parasite causes an illness in gorillas, like malaria in humans, but carrier animals could constitute a pool of infection for contaminating humans. The work poses a new challenge for the fight against malaria. Given that contacts between humans and gorillas are increasingly common in Central Africa owing to large-scale deforestation and the resulting population movements, the existence of a *Plasmodium falciparum* reservoir among gorillas suggests that it will be even more difficult to eradicate the disease.

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[1] This work was conducted in collaboration with research teams from the University of Alabama in the United States, the Sanger Institute Malaria Programme in the UK and the Cameroon AIDS prevention project.
[2] Prugnolle *et al.* 2010 African great apes are natural hosts of multiple related malaria species, including Plasmodium falciparum *of the National Academy of Sciences of the United States of America*, 2010, 107 (4), *Proceedings*: 1458-1463.

Anopheles mosquito.

Gorilla / Cameroon.

PARTNER

Institut de recherches médicales et d'études des plantes médicinales du Cameroun (IMPM)

The virology laboratory at the IMPM, fruit of a partnership with the IRD and CREMER (Cameroon's centre for research into emerging and re-emerging diseases), coordinates all work connected with research on primates and the risk of emergence of new infectious disease in Cameroon. The laboratory, located at the Ministry of Research, is accredited by the WHO for monitoring resistance to anti-viral drugs. Since 1994 the research teams have been conducting collaborative projects in clinical research, assessing the first generic AIDS treatments, and on anthropozoonosis risk. The discovery of an HIV-1 reservoir in apes was a result of this work.

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Development and globalisation

●● Much of the IRD's human and social sciences research focuses on the many facets of urban and rural development in the South against the background of globalisation and climate change. Several teams are examining current and future changes in socio-ecological systems in North Africa, sub-Saharan Africa and Asia; others are looking at population movements, focusing for example on changes on the outskirts of major metropoles in terms of infrastructure, governance and spatial configuration. Other studies concern the determinants and consequences of migration for societies and their environments, and the resulting reshaping of territories and identities.

Based on regional-scale comparative studies, this research is arousing increasing interest because it fosters communication between different actors in society. The great priority issues addressed are development and governance; vulnerability, inequality and growth; poverty reduction; borders and social and spatial dynamics. These broad themes are well illustrated by the work on decentralisation, migration, public policy, religiosity and generating income and employment from local heritage ●●

Primary school / Vietnam.

176 RESEARCHERS	€27.6 MILLION	570 ARTICLES AND BOOKS

Biodiversity and cultural heritage in Brazil

The protection of plant genetic resources was long thought of in terms of conservation, mainly in off-site seed banks. Only recently has more attention been paid to the traditional farming systems that maintain a considerable proportion of the world's agricultural biodiversity. With climate change and globalisation under way, a better understanding of the ecological and sociological underpinnings of these systems is now essential. Ways are needed to ensure that the processes of innovation and experiment through which man-made biodiversity is constructed can continue. Finding such ways was the goal of research by the IRD and its partners in the Rio Negro region of Brazil.

Brazil has broken new ground in this regard. It has set up a national register of intangible heritage which opens avenues for generating income and employment from the biological resources and significant knowledge connected with traditional farming systems. In November 2010 IPHAN, Brazil's national institute of artistic and historic heritage, added the traditional farming system of the Rio Negro in central Amazonia to its list. Since 2000, 21 cultural goods have been listed but this was the first such registration to specifically refer to the notion of a system, and the first to concern a good that is both biological and cultural.

This registration is the result of synergy between scientific research, public policy and local communities. The work was part of the Pacta programme[1] in which the IRD is a partner along with Unicamp[2], environmental NGO Instituto Socioambiental (ISA), IPHAN and three Amerindian associations, the Association of Indigenous Communities of the Mid Rio Negro, the Federation of Indigenous Organisations of the Rio Negro and the Indigenous Association of Barcelos. The findings on the farming system concern local knowledge and practices relating to spatial management, crop diversity (especially the many varieties of bitter cassava), dietary heritage and the material culture (mainly wicker and basketwork) that is inseparably tied to the production and use of the crops. The research helped to achieve recognition of this collective good. While registration on this list does not provide legal protection, it does entail the application of conservation and valorisation measures defined by common agreement between IPHAN and the local communities as represented by their associations. The issue at stake is to keep alive a heritage shared by twenty ethnic groups living along the Rio Negro and its tributaries. The instrument is in line with agreements drawn up by Unesco in 2003 and 2005. It provides a way to preserve agricultural biodiversity taking into account the interdependence and dynamics of biological, ecological, sociocultural and economic factors.

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Publication : Symposium *Innovation and sustainable development in agriculture and food*

[1] *Populations, agrobiodiversité et connaissances traditionnelles associées* (populations, biodiversity and associated traditional knowledge).
[2] Universidade estadual de Campinas.

PARTNER

IPHAN, Instituto do Patrimônio Histórico e Artístico Nacional, is an institute under the Brazilian Ministry of Culture. In 2009, which was the Year of France in Brazil, it signed a cooperation agreement with the IRD to develop joint actions to preserve traditional farming systems and strengthen the ties between research and its development applications. France and Brazil possess complementary experience in promoting locally produced goods. While France has focused more on protected geographical indications, Brazil has more experience on the cultural heritage side and has laws on access to biodiversity and the associated traditional knowledge. One output of this collaboration was a jointly organised French-Brazilian seminar on cultural heritage and farming systems, held in Brasília in 2009.

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Rio Negro / Brazil.


Preparing cassava / Brazil.

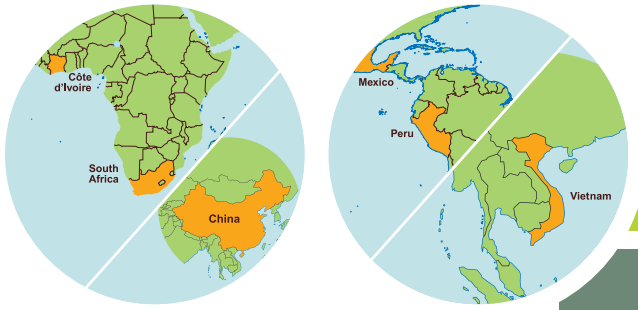
Urban fringes: coveted territories

In the South, the urban fringes where the two worlds of city and countryside meet have undergone profound changes in recent decades. With the explosive growth of the big cities and their changing role within globalisation there has been acute competition for land on city outskirts. By comparing the dynamics of this process in major agglomerations in Africa, Asia and Latin America, researchers have achieved a better understanding of these singular places and shed light on the vital role of public policy in their planning and management.

Scientific approaches to change in these areas have themselves greatly changed. In the 1960s and '70s city outskirts were often viewed as simple extensions of the city or rural areas in process of being absorbed, with no identity of their own. This changed during the 1980s: the idea of an either-or division between town and country gave way to a conception of these marginal areas as singular, dynamic spaces in their own right. As large cities became metropoles and their role in globalisation developed, researchers began to consider the concepts of fragmentation and increasing segregation.

The Perisud[1] research programme concerns Abidjan, Cape Town, Hanoi, Lima, Mexico City and Shanghai – six agglomerations very different from each other in terms of geography, economics and politics. Analysis of recent dynamics in their urban fringes shows that even where urban growth has slowed, they are still growing fast owing to redistribution of the population within the agglomeration, while the city centre populations are growing more slowly or shrinking. The urban fringes are used and partly recreated by mixed populations: alongside the lower socio-economic classes are the middle-class and rich, in neighbouring areas but with better infrastructure. In some cases surviving rural activities receive a fresh boost from the urban market nearby and improved transport facilities. Competition for space is ever more acute in these urban fringes and can give rise to conflict between different groups – as in Abidjan, for example, between property developers or individual purchasers and the traditional authorities.

In this situation the role played by national and local government policy can be crucial. The Cape Town authorities, for example, have opted for property development and are conserving green spaces and improving the living environment. In China and Vietnam, the State is very much present and still imposes zoning and strict land use regulations. In Abidjan, Lima and Mexico City, policy makers do little to control the extent and pattern of urban expansion. There is one point in common however: inadequate governance fosters political and administrative centralisation and the emergence of conflicts of competence between the different decision bodies concerned.



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Publications : *Atlas de Mexico*, Paris, Éditions Autrement / *Les métropoles des Suds vues de leurs périphéries*, Grafigéo

[1] Several institutions are involved in the project: Facultad Latinoamericana de Ciencias Sociales (Mexico); Universidad Nacional Mayor de San Marcos in Lima (Peru); Vietnam Academy of Agricultural Sciences in Hanoi (Vietnam); East China Normal University, Shanghai (China); University of Fort Hare (South Africa); University of Abidjan-Cocody (Côte d'Ivoire).

Urbanisation / Shanghai.

Bogota / Colombia.

PARTNER

Universidad Nacional Mayor de San Marcos, Lima, founded in the 16th century, is a public university with over 30,000 students. It holds an important place in Peru's university system. The geography school at San Marcos University has been working in partnership with the IRD for many years. Between 2005 and 2008, a joint research programme was conducted on land reform and territorial dynamics. The collaboration has been extended, with a master's course in geography and regional development partly funded by PREFALC , the regional cooperation programme currently financed by the French Ministry of Higher Education and Research and the IRD. Six students on the master's course are taking part in the Perisud work, which gives them the benefit of hands-on research training.

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