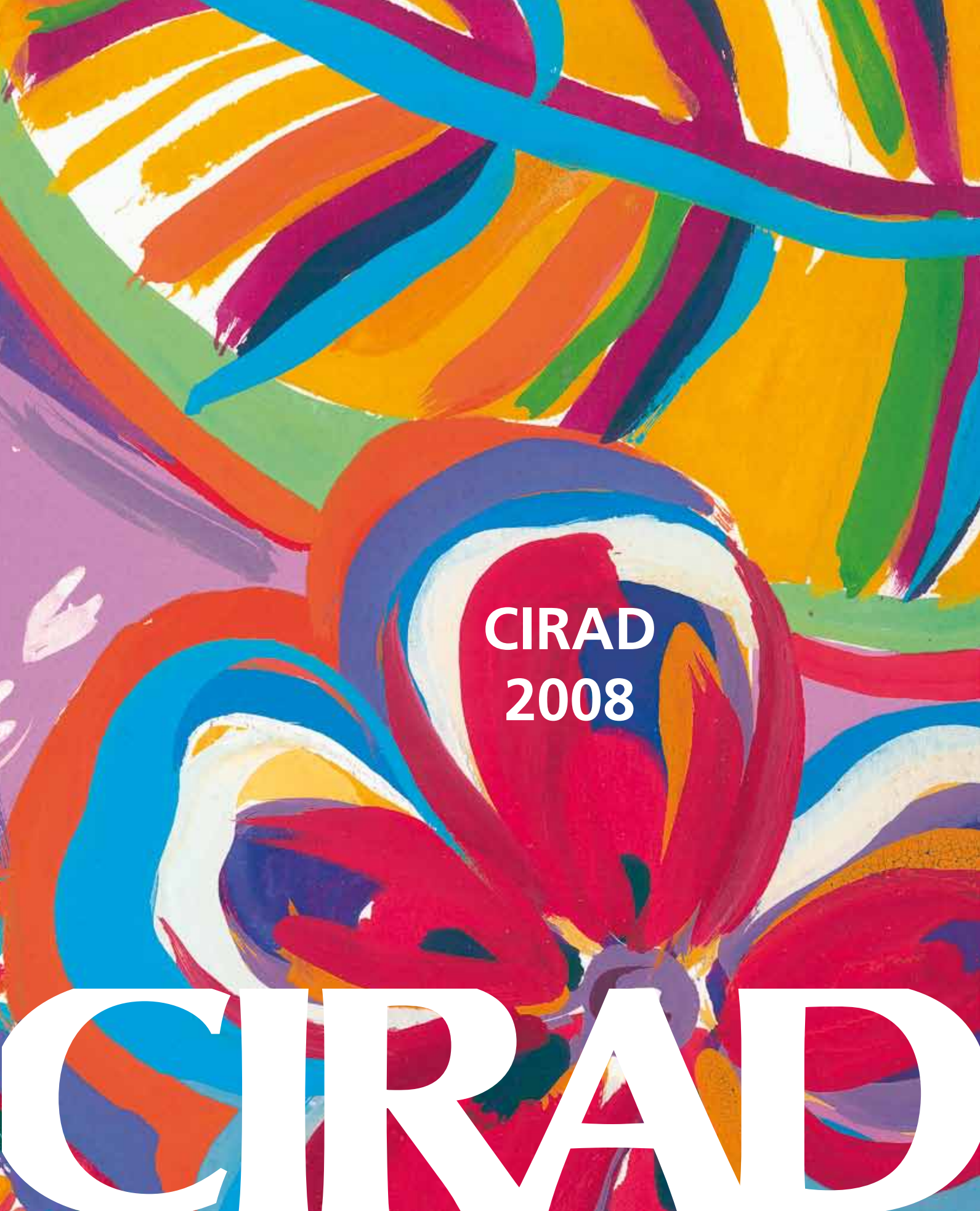
CIRAD
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CIRAD is a French public establishment specializing in tropical and Mediterranean agriculture, placed under the joint authority of the Ministry of Higher Education and Research and the Ministry of Foreign and European Affairs.

Its operations encompass the life and earth sciences, social sciences and engineering sciences, applied to agriculture, forestry, animal production, food, natural resources and rural territories.

CIRAD has three scientific departments: Biological Systems (BIOS), Performance of Tropical Production and Processing Systems (PERSYST), and Environments and Societies (ES).

It has a staff of 1800, including 800 researchers. It works with more than 90 countries worldwide and has scientific platforms with a regional scope in the French overseas regions. It receives and trains almost 800 researchers and technicians each year.

It has a budget of 203 million euros, with two thirds provided by the French government.

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FOREWORD

In December 2007, the Board of Trustees set new priorities for CIRAD for the coming five years. These priorities, which correspond to major development issues, are firmly anchored in CIRAD's history and have already produced tangible results. For instance, this applies to ecological intensification, which has for several years been the cornerstone of a large part of CIRAD's operations. It also applies to food security, a field in which CIRAD already has a reputation that enabled it to participate in a governmental think tank set up following the food crises of early 2008. Again, it applies to research on animal health, for which CIRAD has long been recognized by international bodies for its work on epidemiological surveillance and the development of vaccines.

Some other lines of research as yet involve smaller research teams but will be playing an increasing role in the organization's future operations. For instance, research on energy production from biomass, a sector in which CIRAD has many cards to play, is set to develop in the coming years: plant-based fuels have for some considerable time been the object of in-depth studies, but an interdisciplinary approach to the energy issue needs to be developed further. Public policy, which can help alleviate poverty and inequality, and studies of the dynamics at play in rural areas, are also growing in importance at CIRAD. Research on the former can rely on the progress made in several years' field work, and CIRAD now has a stock of experience of contrasting situations. The latter, which is directly linked to current concerns regarding the management and conservation of natural resources, will benefit from the modelling and community management studies in which CIRAD specializes.

CIRAD 2008 gives an overview of recent work by the organization's researchers. In particular, it highlights the operational, targeted nature of the results obtained. Further information on the organization's activities is available on its website (www.cirad.fr).

The need to adjust research practices and the move to focus operations on six clearly identified lines of research have resulted in changes in management methods. Several major operations were launched in 2008 to meet the challenges posed by this new vision. We wish to thank the Science Council and Programme Committees for their help in this matter.

Scientific partnerships are what mark CIRAD out from its peers, and they have been the object of considerable internal and external debate. The current relationships between CIRAD and its partners, particularly in developing countries, reflect the organization's history and the networks it has built up since it was founded. However, it was important to clarify its structures and partnerships, in order to build a new type of cooperation that tallies with CIRAD's scientific objectives and human and financial resources. The question was: how should CIRAD position itself geographically, and with which partners, in order to fulfil its mandate and implement the priorities it has set itself? The first discussions were devoted to Africa and the Mediterranean, and enabled the identification of a series of criteria intended to guide CIRAD's geographical and partnership choices.

Alongside this debate, the French Initiative for International Agricultural Research (FI4IAR), a public interest grouping set up by CIRAD and INRA, organized an international meeting on "Partnerships-Innovation-Agriculture" (PIA), held on 3 June 2008, which was attended by representatives of many international, regional and national organizations. The conclusions of the meeting were forwarded to the FAO Director General, who was at the time chairing the high-level meeting on global food security in Rome. In particular, they stressed the need to continue with foresight studies such as Agrimonde, and to share the results with the global

community. Furthermore, a fervent plea was made for greater public support of agricultural research, particularly on topics such as ecological intensification of agricultural production.

Currently, more than 90% of the high-level articles published by CIRAD researchers concern the six priority lines of research, albeit tackled via a wide variety of approaches and often highly individual pathways. To support the implementation of these new priorities by its research teams and units, CIRAD's management structure has revised its system of incentives. The whole of the allocated budget is now devoted to projects relating to the six priorities, and this applies to geographical partnership support and EU operations as well as to technology transfer and development operations, new interdisciplinary projects and long-term operations such as supporting research assistants.

The thirty new senior scientific posts created in 2008 also serve to back up CIRAD's strategy. Similarly, three programmed thematic projects (ATPs) were launched to foster the mobilization of research teams around the priorities set: "Emergence" (modelling and management of plant and animal health risks), "Energy for the South" (how the development of biomass energy could make a sustainable contribution to improving living conditions for rural populations in the South), and "Biodiversity and agricultures" (the impacts and services generated by agriculture and animal production in terms of biodiversity). They follow on from the policy adopted in 2007, which led to the launch of three projects ("Global agriculture observatory", "Range of characters involved in adaptation to water and heat stress in rice", and "Optimization of ecological pest management mechanisms with a view to sustainably improving the productivity of farming systems".

CIRAD's new priorities have also been the object of several scientific events. At its 2008 annual meetings, a workshop on the topic of biomass energy was organized for its entire staff, along with a seminar on development that was attended by 26 newly recruited junior researchers. The six priority lines of research were illustrated by public discussions led by CIRAD researchers. Science Council meetings were backed up by debates on topics of general interest, such as global public goods, or the organization's joint research practices. A selection of CIRAD's joint operations with partners in Africa was presented during the October 2008 Science Council meeting. In September 2008, the MOISA and ARENA Joint Research Units organized a school for researchers on "Taking account of poverty and inequality: what are the implications for CIRAD?", in partnership with the IMPACT network, a global network set up to support public policy in terms of reducing poverty and inequality.

More specifically, a new contract of objectives between the French State and CIRAD was signed in November 2008. It was the fruit of in-depth discussions with CIRAD's supervisory ministries, and was built on a set of objectives and operations, associated with indicators. It will serve to guide the organization in achieving its ambitious targets, and enable it to take stock of the progress made.

The year 2008 thus marks a new stage in CIRAD's history, with the implementation of its new strategic orientations. It lays the foundations of the organization's identity in the coming years, and of its place in the French, and also global, agricultural research system.

Patrice Debré,
Chair, Board of Trustees

Gérard Matheron,
Director General

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Research # Line 1

Helping to invent ecologically intensive agriculture to feed the world

In a setting in which efforts continue to be focused on boosting agricultural production, could new agricultural practices ensure erosion control, soil fertility preservation or restoration, symbiotic nitrogen fixation, nutrient recycling and pest control as the model based on intensive and massive use of pesticides, chemical fertilizers, water and fossil fuels is called into question? Ecological intensification—an alternative model whereby agricultural practices are reassessed with the aim of enhancing the use of natural ecosystem processes and functions—addresses this challenge!

To be able to invent such novel agricultural systems, we must thoroughly appraise our production strategies, focus specifically on environmental issues, gain greater insight into the physicochemical and biological mechanisms involved, and then integrate all of these aspects into a unit that works. The "black box" of living resources, whose complexity seems to be growing, first has to be analysed. This will enable us to gain greater insight into basic biological processes of plants (genome function, organ development, etc.) and ecosystem function (function of complex plant communities, sustainability of production systems, better use of natural resources, exploitation of useful species). Breeding new plant material that is higher yielding, disease resistantand adapted to different local ecosystems is still a key goal, while making effective use of the incredible currently known range of diversity. However, this is not enough, so production systems that are tightly meshed with natural ecological processes affecting agrosystems should also be designed, while analysing socioeconomic processes that promote or hamper the adoption of these new practices.

Ecological intensification spans many aspects of CIRAD's activities and areas of expertise. This includes the Centre's involvement in large international networks of stakeholders striving to achieve excellence. In 2008, CIRAD organized the first international conference of the ENDURE network, which is focused on designing innovative crop protection systems in line with sustainable development. Moreover, to achieve ecological intensification, genetic knowledge obtained on model species should be more efficiently used in order to be able to extend this knowledge to other less studied species. Modelling, which is an incredible tool for examining the complexity of living resources, is also clearly essential.

The quality of all results obtained by CIRAD—breeding new varieties, inventing new disease and pest control techniques, or designing sustainable production systems that require fewer inputs and are environmentally friendlier—depends on the exceptionally devoted involvement of its agents and on the close ties that have been gradually bound between CIRAD and its partners in both developed and developing countries.

PHYLOGENOMICS and information transfer between species

Comparative genomics studies are carried out to predict the function of a species' genes according to information available on another species through the identification of related genes, or orthologs, between species. CIRAD analysed orthologs between rice and Arabidopsis thaliana *and used the findings to develop a database and tools for automated prediction of functional equivalence between sequences from "orphan" species—for which few genomic tools have been developed—and those from model species. These tools are already being widely used by the scientific community.*

One aim of comparative genomics is to predict the function of genes of one species according to information available on one or several other species. Once related genes between these species are identified, the annotation, ie biological information attached to a sequence, can be transferred from one species to another, less characterized, species. For this prediction, orthologs—genes derived from a common ancestor that were separated by a speciation event and which are likely to have the same function—are identified to facilitate this prediction. Phylogenetic methods based on kinship between species are implemented to pinpoint these orthologs. A CIRAD research team first looked for all orthologs between *Oryza sativa* (model monocot species) and *Arabidopsis thaliana* (model dicot species), which enabled it to then predict the function of the obtained sequences in "orphan" species—for which few genomic tools have been developed but that are important for developing countries.

Automated prediction of functionally equivalent orthologs between species

The first phase of this study involved selecting a pipeline, ie a series of meshed software programmes that automatically reproduce a series of analyses that would be manually conducted by a biologist. These programmes save time

Phylogenomics serves to predict gene function in "orphan" species

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Partners

Biodiversity International (Italy), International Rice Research Institute (IRRI, Philippines), Centre informatique national de l'enseignement supérieur (CINES, France)

and enhance uniformity, but the results still have to be verified. A streamlined phylogenetic analysis of gene families was carried out via the selected set of programmes with the aim of predicting groups of orthologous sequences between *O. sativa* and *A. thaliana*. A dataset including all 69 families of transcription factors, ie proteins that regulate gene expression, was analysed and the automated analysis results were compared with published experimental data. The results of this analysis revealed that the chosen pipeline has significantly greater ortholog prediction performance than other popular prediction tools.

The GreenphylDB database was developed to manage gene family data and provide ready access to functional prediction data. It is currently the largest plant protein family database. GreenphylDB is linked with other databases to facilitate comparative functional analyses between *O. sativa* and *A. thaliana*. These public data are used by many research teams worldwide.

From model species to crop species

GOST (Greenphyl orthologous search tool) and i-GOST can be used for automated prediction of functionally equivalent genes between one (GOST) or several (i-GOST) sequences of orphan species and *O. sativa* or *A. thaliana*. These very easy-to-use tools can serve to easily transfer information from a model species to an agriculturally interesting species through a set of sequences of unknown function. To enhance predictions, all genomic sequences from 10 new plant species were inserted in GreenphylDB gene families with an 85–95% success rate. These were genomes from grapevine, *Populus trichocarpa*, the moss *Physcomitrella patens*, sorghum, *Selaginella molendoffori*, soybean, *Medicago trunculata* and three algae species (*Chlamydomonas reiinardti, Ostreoccocus tauri, Cyanidioschyzon merolae*). A global analysis is under way.

With new sequencing techniques and decreased costs, other genomes of plants of agricultural interest, especially tropical plants, will soon be completely or partially sequenced. Research is currently focused on a tool, supported by i-GOST, that is used for automated annotation of new plant genomes based on data available on model species. From a fundamental standpoint, these studies will enable researchers to determine when key genes appeared during the evolution of terrestrial plants and to test their function at different taxonomic levels ranging from lower plants, such as mosses, to angiosperms and gymnosperms. This research could eventually come up with a solution to Darwin's "abominable mystery" of flowering plants.

A CIRAD research team looked for all the orthologs between **Oryza sativa** *(model monocot species) and* **Arabidopsis thaliana** *(model dicot species)*

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For further information

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GreenPhylDB: greenphyl.cirad.fr

GOST: greenphyl.cirad.fr/cgi-bin/gost.cgi

A UNIFIED AUXIN TRANSPORT MECHANISM explains the formation of new plant organs

In plants, the formation of new organs in apical meristems is controlled by an auxin transport mechanism. Auxin is transported between cells by membrane proteins, which are located in a polar way within each cell, thus enabling the plant to accumulate auxin at specific sites. This accumulation process triggers organogenesis. However, what mechanism controls the polarization of these proteins? A research team used an integrated modelling strategy to demonstrate that a unified flux-enhancement-based mechanism could generate both vascularization and organ initiation patterns.

Plants grow via their stem tips in small cellular areas called meristems. These areas contain undifferentiated cells that divide throughout the plant's life and give rise to different organs, including leaves, sepals, petals, sexual organs, etc. In most plants, these organs show remarkable organization patterns, ie spirals or combinations of several spirals. Such arrangements, called phyllotaxis, have been studied by scientists for decades. These studies have shown that it is possible to explain most phyllotactic motifs by a simple geometric law. This is based on the hypothesis that recently formed organs hamper the formation of new organs in their immediate vicinity. It is as if these new organs emit an "inhibitory field" around them to hinder the development of new organs in their immediate vicinity. The explanatory capacity of this model was successfully tested for many motifs, and the scientific community now considers it to be the "standard model" of phyllotaxis. Scientists are now seeking to determine the physical or biochemical origin of these inhibitory fields. This research is

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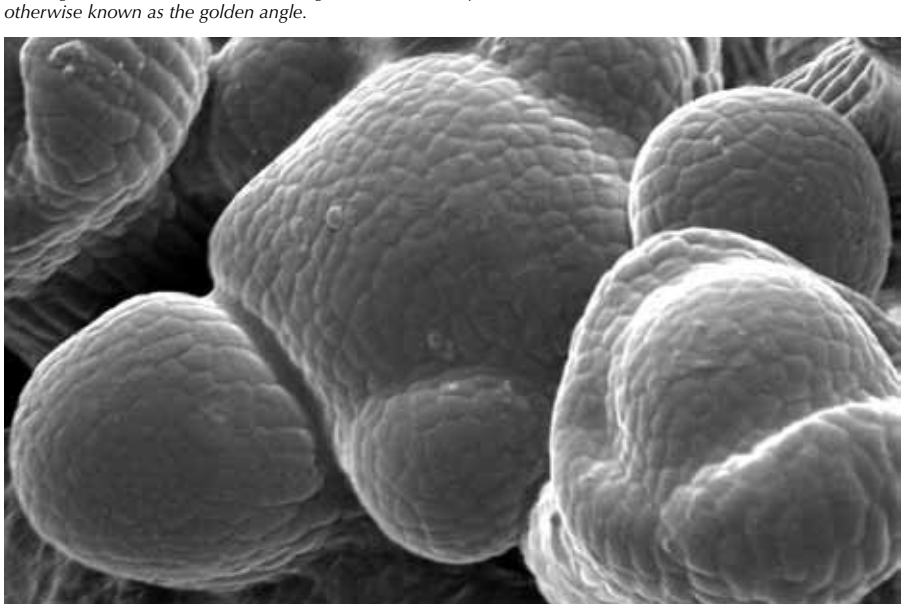
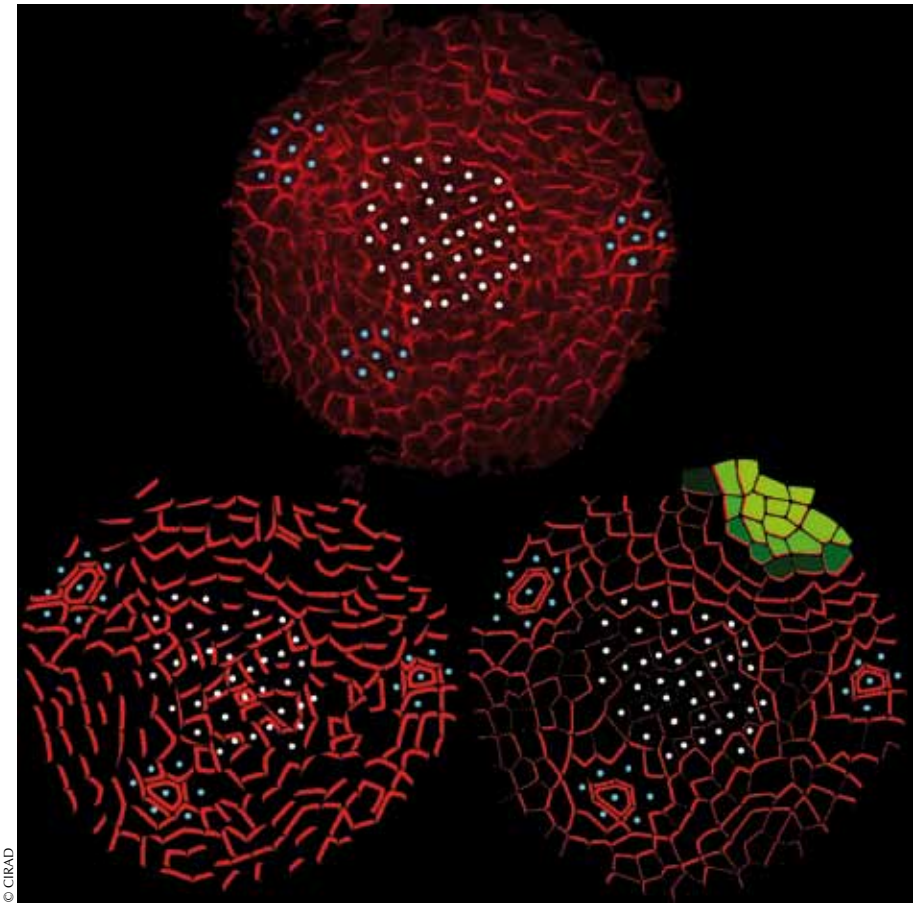
Arabidopsis *floral apical meristem viewed under an electronic microscope. Around this central area, organs (here new flowers) are formed at regular intervals. They are usually organized in a spiral pattern. The angle between two consecutive organs is almost always close to the famous 137° value, otherwise known as the golden angle.*





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Auxin transport in a virtual meristem: comparison between simulations and experimental data

Top: top view of the observed distribution of membrane transporters (PIN1 proteins) in Arabidopsis thaliana *apical meristem cells. This image was obtained by immunolabelling PIN1 proteins and viewing them under a confocal microscope.*

Bottom left: digital version of the top image where the transporters (red) were manually positioned around each digitized cell wall.

Bottom right: simulation of the distribution of transporters in cells based on the flux-enhanced polarization hypothesis. The two transporter motifs (real and simulated) are complex and, as can be noted, quantitatively very similar.

The site of auxin accumulation (green) predicted by the model is located far from the previously formed organs (light blue dots).

focused on molecular and cellular biology and on microscopic imaging techniques. Over the last decade, several multidisciplinary teams of biologists and modelling specialists have been investigating the fundamental features of this mechanism.

Two hypotheses to explain polarization regulation

The findings of these studies revealed that the formation of new organs in apical meristem regions is regulated, on the cellular scale, by an auxin transport mechanism. Auxin is transported between cells by the coordinated action of membrane transporters of the PIN family located in the polar regions of each cell. These proteins create transport pathways that enable the plant to accumulate auxin around shoot tips. This accumulation triggers organogenesis.

Two main hypotheses have been put forward concerning the PIN protein polarization regulation mechanism. One, which is based on the notion of enhancing auxin fluxes, can explain the formation of a vascular network to transport nutrients to organs, like the formation of veins in leaves. The other is based on local increases in auxin concentrations, and can explain the positioning of organs on the meristem surface.

A mechanism that unifies auxin transport

A joint team of researchers from CIRAD, INRIA and INRA, in collaboration with the Ecole normale supérieure de Lyon, using a system biology approach integrating imaging, molecular biology and modelling, has just demonstrated that an approach based only on the flux enhancement hypothesis is actually enough to give estimates of both organ initiation and vascularization phenomena. The team has managed, for the first time, to accurately reproduce complex PIN protein motifs observed in the meristem.

These findings were based on a comparison of the distribution of membrane transporters in apical meristem cells of *Arabidopsis thaliana,* as detected by monitoring immunolabelled proteins under a confocal microscope and simulating the distribution with a model based on the flux-enhanced polarization hypothesis. The two real and simulated motifs are complex but quantitatively very similar.

This approach to assessing the unification of auxin transport in plant tissues will be the focus of experiments carried out to check the validity of these different hypotheses.

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DigiPlante project team

The Digiplante project, which jointly involves INRIA, ECP and CIRAD, is focused on architectural and ecophysiological aspects of plant production with the aim of modelling interactions between plant growth and development under different environmental conditions. The environment is modelled in the form of a "functional landscape". The current project team includes five permanent members and around 15 students. It collaborates with the Sino-French Laboratory for Computer Science, Automation and Computer Mathematics (LIAMA) and with agronomists from the Chinese Agricultural University in Beijing, while also benefiting from collaborations with mathematicians from INRIA and ecophysiologists from CIRAD, INRA and the University of Wageningen. The GreenLab model was developed through this research and is being field- and greenhouse-tested with many plants cultivated in China, France and the Netherlands. Inverse assessment methods and control techniques developed through the Digiplante project offer new agricultural applications from plant breeding to streamlining crop management sequences. The GreenLab model has been showcased in many publications and PhD theses. Digiplante has been a co-organizer of the Sino-French International Symposium on Plant Growth Modeling, Simulation, Visualization and Applications from the outset—the third edition is upcoming.

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Website

www.amap.cirad.fr

Preserving and utilizing vanilla diversity—a germplasm collection in Réunion

Vanilla is the product of the processing of the aromatic fruit of an orchid of the *Vanilla* genus. This genus comprises over 100 species, including *V. planifolia,* which is the most cultivated species, originally from Mexico and highly esteemed worldwide. Little is currently known about wild and cultivated vanilla species, of which most are threatened in their native area. A vanilla germplasm collection was thus set up in Réunion to safeguard and characterize these genetic resources, which are essential for improving this crop.

This world collection, which now hosts over 400 virus-free clones, includes around 30 species spanning the different sections and subsections of the genus. Genetic markers have been developed, and revealed that most cultivated *V. planifolia* varieties are derived from a single genotype. Some degree of diversity, due to rare occurrences of sexual reproduction and polyploidization, was nevertheless noted. This diversity is still weak, which makes cultivated vanilla varieties highly vulnerable to varying environmental conditions. The studies under way are aimed at preserving and increasing vanilla genetic diversity, identifying accessions with traits of agricultural interest, such as disease resistance and aroma, and clarifying the evolutionary history of the complex vanilla taxonomic group..

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Virus-free vanilla preserved in vitro

The flower morphology is essential for identifying vanilla species

HEVEA TRANSGENESIS— a tool for gaining insight into stress response mechanisms

Rubber trees are tapped to harvest latex, but this process is highly stressful for the trees. A reverse genetic analysis method was used to gain insight into the molecular mechanisms underlying the tolerance to this tapping stress and rubber production. Functional analysis of genes potentially involved in these mechanisms was carried out. A CIRAD team developed a transgenesis process to highlight the expression of transgenes and study their functions. This is a first step in investigating stress response in rubber trees.

Latex synthesized in latex cells is expelled from the bark of rubber trees after tapping. Latex production is stimulated by applying ethephon on the tapping panel, which enhances latex flow and regeneration between tapping operations. This exploitation sometimes causes the flow of latex to stop. This tapping panel dryness syndrome (TPD) is related to endogenous ethylene production and oxidative stress.

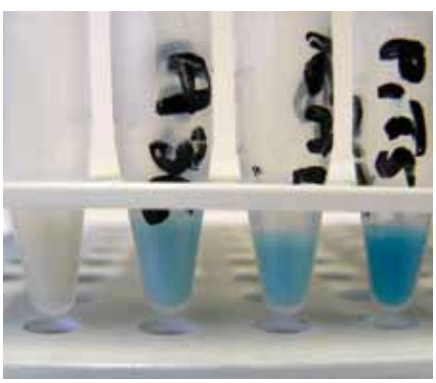
A reverse genetic analysis was conducted to gain insight into the molecular mechanisms underlying the tolerance to tapping stresses and rubber production. This involved the production of transgenic rubber plants over- or under-expressing a candidate gene. In these studies, the candidate genes were involved in ethylene and jasmonate biosynthesis and signalling and in the cell response (ie rubber biosynthesis, detoxification of reactive oxygen species, etc.). They were characterized with respect to the stress response in three Hevea clones with contrasting metabolisms.

Partners

Universities of Mahidol and Kasetsart (Thailand), Institut français du caoutchouc (France), Chinese Academy for Tropical Agricultural Sciences (CATAS, China)

Genetic transformation— a gene function assessment tool

Modified transgenic plants are a source of essential information on functional mechanisms involved in crop production. CIRAD, in collaboration with the Universities of Mahidol and Kasetsart (Thailand) and the Institut français du caoutchouc, has been developing a Hevea genetic transformation procedure for several years. This procedure has been used to carry out an in-depth study on controlling natural rubber production.The process is based on an efficient *Agrobacterium tumefaciens*-mediated gene transfer method for use with high quality embryogenic callus lines. Friable callus lines with a high plant regeneration capacity via somatic embryogenesis were used for transformation of clone PB 260. Several thousands of transforma-



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Comparison of GUS activities in latex from a wild plant and from three transgenic plants containing the gusA gene under control of the cauliflower mosaic virus 35S promoter

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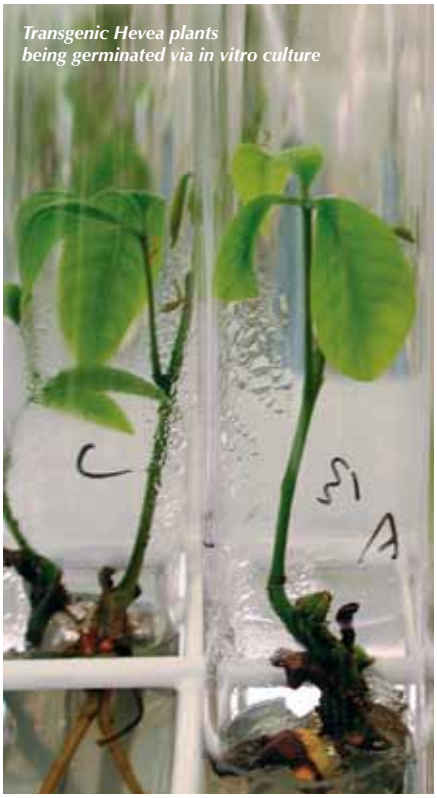
Fluorescence under UV light in a transgenic plant expressing a reporter gene encoding the green fluorescent protein (GFP)

tion events per gramme of calli can be obtained by culturing these embryogenic calli with bacterial strain EHA 105 at low temperature. The transgenic callus lines are then isolated, cryopreserved and the number of transferred DNA copies is analysed by Southern molecular hybridization. Hundreds of plants have already been regenerated via this process—they are derived from dozens of lines bearing the reporter gene encoding ß-glucuronidase (GUS) under control of the 35S promotor of the cauliflower mosaic virus. The transgenic cell selection phase was thus shortened from 6 to 3 months and its efficacy was increased twofold by using the green fluorescent protein (GFP) as visual marker combined with antibiotic selection. More recently, transgenic lines were visually selected with GFP without any antibiotic input.

Directing transgene expression

Transgene expression was targeted in latex cells using the promoter of the *HEV2.1* gene encoding hevein, an agglutinin protein involved in the coagulation of rubber particles. Functional analysis of this promoter showed that the *HEV2.1* gene, which was assumed to be specifically expressed in latex, was actually only expressed in non-photosynthetic tissues. In leaves, its expression was located in all tissues by in situ hybridization, which is related to light induction of this promoter. Other promoters will be studied to target transgene expression in suitable tissues.

Transgenic plant development is the basis of studies on hormonal stress signalling and oxidative stress tolerance. For instance, overexpression of the gene coding for superoxide dismutase, an enzyme involved in the detoxification of reactive oxygen species, can lead to high phenotypic variability under characterization. Research is under way to develop a gene silencing technique through RNA interference. Moreover, studies will be conducted in partnership with CATAS (China) to characterize transcription factors that might coordinate a network of genes involved in tapping and cold stress tolerance and, in liaison with European and Asian teams, to investigate latex allergy and abiotic stress resistance.



Transgenic Hevea plants being germinated via in vitro culture

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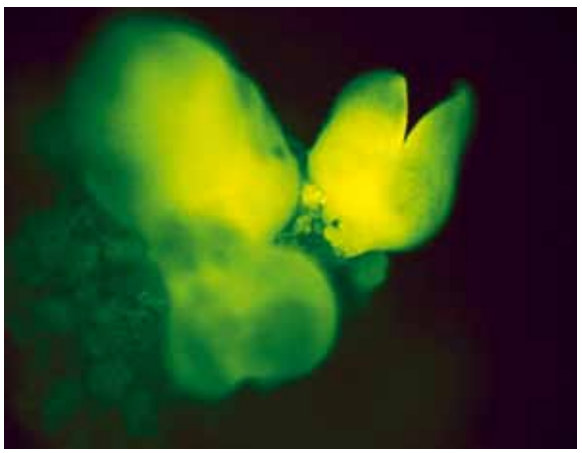

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Fluorescence in a Hevea transgenic somatic embryo containing the reporter gene encoding the green fluorescent protein (GFP)

A RELIABLE METHOD for the detection of the banana bract mosaic virus

Crop protection services diagnosed banana bract mosaic virus in micropropagated banana plantlets during their introduction in the French West Indies. This virus, which is responsible for a serious banana disease, prevails in a few Asian and Pacific countries, but not in the Caribbean or Latin American regions. As there is a high risk that this virus could be introduced in the French West Indies, CIRAD developed in less than a year a molecular test that is more efficient than other detection methods available to date.

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Banana bract mosaic virus on a Cavendish cv Petite Naine banana plant and flexuous filamentous virus particles

Banana is naturally infertile and therefore propagated vegetatively as micropropagated plantlets. This intensive propagation method facilitates the exchange of disease-free plant material, but it can also lead to widespread dissemination of the virus when the source plant is infected. Most viruses are actually not eliminated by conventional pathogen cleaning techniques, such as heat treatment, shoot-tip micropropagation or in vitro culture. It is thus essential to have ready access to effective detection methods when plant material is being introduced in a new area, or exchanged between areas or countries.

Partners

Ministry of Agriculture and Fisheries (France), Laboratoire départemental d'analyses de Mâcon (France), Laboratoire de la protection des végétaux de Martinique (France), Laboratoire national de la protection des végétaux d'Angers (France)

Banana bract mosaic virus

Prior to the introduction of micropropagated banana plantlets in the French West Indies, routine ELISA tests carried out by the crop protection services revealed the presence of banana bract mosaic virus (BBrMV). This potyvirus causes a serious banana disease, especially in plantain, and prevails in a few Asian and Pacific countries, but not in the Caribbean or Latin American regions. This virus is transmitted by aphids that are all present in the French West Indies. Infected cv Cavendish bananas generally do not display any symptoms of disease until the onset of typical mosaic symptoms on bracts.

CIRAD confirmed the presence of BBrMV on micropropagated plantlets using molecular detection methods complementary to the serological approach used by the crop protection services. CIRAD also highlighted that the molecular detection tests available were not very powerful and thus, in response to an urgent request from the French Ministry of Agriculture, developed a reliable and sensitive BBrMV molecular detection method.

A reliable and sensitive detection method

The aim was to propose a suitable detection technique tailored to meet the requirements of quarantine and plant material exchanges, for which the virus rate in the tested samples is mostly relatively low. The developed method involves a BBrMV-specific immunocapture (IC) step followed by two molecular reactions, ie reverse transcription (RT) and polymerase chain reaction (PCR), to amplify the RNA viral genome. The entire assay is simultaneously performed in the same tube. Molecular primers are located on the central and C-terminal parts of the capsid protein gene, which is a highly conserved region in all isolates of the same potyvirus. In order to obtain a broad virus detection spectrum, primers were selected from the multiple sequence alignment for 23 isolates available in GenBank. The developed method is based on commercial assay kits using reliable and efficient enzymes.

This method enables BBrMV detection in single samples of ground banana leaf extracts at up to 1 x 10^{-10} dilution, and in bulked samples of 10 plants, for which the virus concentrations are low and undetectable by ELISA.

This technique, which was developed in less than a year, now provides crop protection service laboratories with a reliable and sensitive BBrMV molecular detection method that is effective even for low virus concentrations. Experiments are under way to validate the performance criteria of this method so as to be able to propose it as a new international BBrMV-detection standard.

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For further information

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New methods for taxonomic classification and identification of *Xanthomonas* spp. bacteria

Taxonomic classification of bacteria of the *Xanthomonas* genus is difficult for two reasons. First, the species concept is highly controversial with respect to bacteria, and secondly, because of the narrow host specificity of *Xanthomonas*, it is essential to introduce the pathovar concept in this classification. CIRAD plant pathologists applied the latest international bacterial taxonomy committee recommendations to clarify the taxonomic status of *Xanthomonas* pathogens of Anacardiaceae.

The adopted method combined genotyping genomic hybridization, sequencing, and pathogenicity tests. This led to the identification of three different diseases caused by three pathovars, each specific to a single host. The *mangiferaeindicae* pathovar is responsible for mango bacterial canker, pv *anacardii* causes cashew bacterial spot, while pv *spondiae* induces ambarella dieback. The first two pathovars belong (along with several others) to the *X. citri* species, whose description was amended on the basis of the findings of this study. The latter pathovar belongs to the *X. axonopodis* species. The evolutionary relationships suggested by this classification are in line with the pathogenicity features of these bacteria.

This new approach is more reliable and technically easier than conventional methods, so it should now be adopted for bacterial disease diagnosis.

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Partners

Institut Pasteur (France), Claude Bernard University (France). Funding: Conseil régional de la Réunion (France), European Union

For further information

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Most known representatives of the *Xanthomonas* genus are responsible for plant diseases. Bacteria of this genus are highly specialized, and generally only attack one plant species or family. Plant pathologists thus had to invent the pathovar concept to pool bacteria that cause a single disease on a plant. There are more than 140 pathovars in the *Xanthomonas* genus, some of which are responsible for serious crop diseases, such as pv *citri*, which causes *Citrus* canker, and pv *oryzae*, which induces rice leaf blight.

SUSTAINABLE ecological intensification in Nordeste, Brazil

*In the semi-arid northeastern region of Brazil, the native vegetation—*caatinga*—is being deforested by farmers who want to cultivate the land for fodder crops for their livestock. This unique vegetation type has completely disappeared in some areas. With the aim of assessing the sustainability of these farming systems, CIRAD and EMBRAPA researchers analysed biomass flows within a sample of farms and evaluated their functioning throughout a farming season. This study highlights the importance of focusing research on making more effective use of* caatinga *vegetation.*

In the semi-arid regions of Brazil, farmers have few financial resources, which reduces their possibilities for purchasing inputs, especially fertilizers. Moreover, the high population growth in this region has increased pressure on natural resources, thus resulting in clearance of the native vegetation, ie *caatinga*. CIRAD and EMBRAPA researchers studied the impact of soil fertility management practices on the sustainability of production systems with the aim of developing intensification strategies that would make more effective use of farm resources. It was assumed that the analysis of biomass flows could facilitate the characterization of management practices and the development of sustainability indicators. These biomass flows, which are usually converted into mineral balances, have an impact on other farm resources that should also be estimated.

Identifying and describing biomass flows

This approach involves identifying areas of production and concentration of biomass, as well as biomass flows between these areas, such as biomass transfers, imports and exports. The analysed sample consisted of 14 farms with diversified production structures. For each farm, the different biomass areas and flows were described and quantified on the basis of the farmers' monthly logs of their practices, GPS measurements of areas and biomass production on crop fields (seeds, straw, faeces) and semi-structured interviews with farmers.

The main flows were converted into sustainability indicators on the basis of the descriptions of production systems. A simple model was then developed to analyse the sustainability of the studied systems. It simulates multiannual changes in production systems and indicators. Potential areas for improvement based on the simulations were discussed with the farmers.

Clearing caatinga *to plant* C. ciliaris

A method for assessing farm sustainability

Each biomass flow involved a negative or positive balance concerning the farm's resources, such as mineral, fodder, livestock or forest resources. The impacts of farmers' decisions on a farm's resources could be analysed after identifying these flows and converting them into balances.

The developed model was used to estimate long-term changes in these balances. It runs on a seasonal time step and simulates biomass production according to the type of year (good or bad) for four types of fodder areas—pastures sown with buffel grass (*Cenchrus ciliaris*), sorghum cropped for silage, Indian fig prickly pear (*Opuntia ficus-indica*), which is harvested and fed to the livestock during the dry season, and *caatinga* vegetation. It also simulates changes in mineral reserves for each area, in livestock numbers, and in *caatinga* areas. Regional references were used to model these processes. Four types of decision regulate changes in these different balances: stockpiling fodder, clearing native vegetation, using the different fodder resources, and selling livestock. This simulator was validated with farmers who were not part of the survey network.

These indicators and this simulation model served as a basis for discussions with the Brazilian researchers. They highlighted the importance of continuing the research on management of *caatinga* vegetation by exploiting useful species. Discussions with farmers were focused on the impact of farming practices on the the sustainability of production systems.

Improving production system performance

Several levels of complexity between production systems were also identified, resulting in variable performances, from systems at the installation stage with little area and low biomass flows to long-standing diversified systems able to cope with climatic and economic risks.

Specific options were discussed and tested with each type of farmer. For dairy farmers, for instance, who are not very self-sufficient in terms of fodder production and do not make effective use of *caatinga* fodder resources, techniques aimed at selecting *caatinga* forest species were proposed.

Partner

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Enclosed Cenchrus ciliaris*-based permanent prairie in Nordeste, Brazil*

Designing PESTICIDE-FREE banana plantations—modelling contributions

To design non-polluting high performance cropping systems, pesticide treatments must be replaced by targeted use of ecological mechanisms. But how can these complex systems, in which there are more biological interactions than in chemical-based systems, be managed? And what system is best for achieving high crop productivity while preserving the environment? These issues could be addressed by using models to integrate all knowledge on agrosystems and predict the effects of innovative practices on its functioning. This approach is being used by CIRAD to design environmentally friendly and economically efficient banana-based systems.

Ecological mechanisms must be implemented at specifically targeted times and points in cropping systems instead of pesticide treatments. For banana plantations, CIRAD has developed modelling tools to integrate knowledge on ecology, agronomy and crop protection and to simulate agrosystem functioning. These tools can predict the impacts of innovative combinations of cropping practices and provide assistance in selecting the most promising production systems from both environmental and economic standpoints. When used in this way, modelling also helps to pinpoint areas in which further knowledge is required for developing new production methods.

Integrating knowledge in prediction tools

Many physical, chemical and biological processes interact within banana plantations, as in all agrosystems. Some of these processes have to be modified when designing innovative cropping systems, which generally leads to changes in the overall functioning of the agrosystem. For instance, adding cover crops leads to major changes in water and mineral flows and in pest and pathogen dynamics. A systemic approach to relationships between the plant, pests and the environment is required to gain insight into and describe the functioning of these new systems, which are more complex than those based on massive use of inputs. Models are a systemic representation of the agrosystem function, which can be parameterized as a function of the value of the studied variables, is a model. Such models are tools that can assist researchers in representing these ecological functions and in designing new cropping systems.

A CIRAD team designed a specific model, called SIMBA, which simulates banana plantation functioning and performance. This model can be parameterized according to different variables, such as climatic data (temperature, radiation, rainfall), soil data (porosity, organic matter level) and initial parasitic nematode population levels (*Radopholus similis*, *Pratylenchus coffeae* and *Helicotilenchus multicinctus*). The model can simulate banana crop growth and yield, pest development dynamics, soil moisture and nitrogen levels, as well as the growth and impact of cover and weed vegetation. Moreover, it assesses the environmental risks of simulated systems, including nitrogen losses, pesticide water pollution and erosion. This model, called SIMBA, generates agronomic, environmental and economic data (eg gross margins). Output simulations can be used for multicriteria assessment of virtual or real cropping systems.

Partners

Union des groupements de producteurs de bananes de Guadeloupe et Martinique (UGPBAN, France), Centre africain de recherche sur les bananiers et plantains (CARBAP, Cameroon), European Regional Development Fund (ERDF), Direction régionale de la recherche et de la technologie de Guadeloupe et de Martinique (France)

A cropping system integrating cover vegetation (grass). The SIMBA model simulates nitrogen flows in this system and helps optimize sowing date, cover mowing date and fertilizer application date, thus minimizing competition with the banana trees

A special feature of this model is that it accounts for changes in the plant population structure, which becomes less homogeneous over cropping cycles: this key point affects all the system dynamics. Moreover, the SIMBA model includes plant-parasitic nematode dynamics and the interactions with plant growth, soil structure and nematicide treatments; this is a major element in simulating the agroenvironmental performance (sustainability) of simulated banana plantations. Finally, the model can be used for in-depth studies on certain ecological mechanisms, such as host-parasite relationships, and for developing and optimizing new control strategies, such as crop rotations or no-till systems based on cover crops.

Plot schemes to reduce epidemics

Inter- and intra-plot spatial organization and spatialization of crop protection resources have long been overlooked, even though these are key elements for pest and disease control. Because of its moderate dispersal, the banana weevil is a good example for studying the effect of the spatial organization of cropping systems on its epidemiology. CIRAD researchers have thus developed a spatially explicit model, COSMOS, which simulates the insect's movements, reproduction and mortality in interaction with banana trees, crop residues, cover plants and pheromone traps. The COSMOS model can be used to optimize trapping, and proposes landscape plot patterns that hamper the development of banana weevil populations.

Towards simulation of the overall ecological functioning of banana plantations

Current agroecological research shows that it is essential to design new agroecosystem study methods in order to be able to monitor the ecological processes occurring in more complex cropping systems. In this setting, interactions between plants and communities of pests, beneficial organisms and non-productive organisms are crucial. Researchers are thus prompted to combine standard agronomic tools (crop models) with new formalisms, such as food web models, which can be used to simulate many complex interactions. These new tools should make it possible to predict performances in terms of production and emerging properties of different communities in banana plantations; this includes their stability and resilience. Such tools allow the simulation of the emerging properties of cropping systems, especially the one including pest and disease control and feedback of the communities on soil properties. The prospects of applying these ecological mechanisms are especially promising in the case of plantain-based cropping systems.

Contact

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Crop protection—CIRAD organized the first ENDURE network conference

ENDURE, the EU-funded Network of Excellence on diversifying crop protection, held its first international conference on this topic, with over 120 talks presented, from 13 to 15 October in southern France. CIRAD organized this event and 27 CIRAD scientists presented their results. A special workshop was focused on links the network intends to make with research teams in developing countries.

ENDURE was launched in 2007 and is coordinated by INRA. It brings together over 300 researchers from 18 European institutions. It is aimed at structuring fundamental and applied research forces in order to develop innovative crop protection strategies that are compatible with sustainable development (around 60% of all pesticides have been withdrawn from the European market over the last 10 years). It intends to become the world leader in the field of crop protection strategies. CIRAD is substantially involved in this network through its long experience in developing countries, and several of its research units are directly involved in network projects. It is participating especially in a study on tomato and in a horticulture thematic project, while coordinating a case study on banana via one of its research units. As part of the ENDURE executive committee, CIRAD is specifically in charge of relations with developing countries and communications.

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International conference:»Diversifying crop protection», 12-15 October 2008, La Grande-Motte, France.

ENDURE: European Network for the Durable Exploitation of Crop Protection Strategies. www.endure-network.eu

Research # Line 2

Analysing conditions for the development of bio-energies and ensuring that they benefit people in developing countries

Do currently spotlighted bio-energies represent a new opportunity for agriculture or a competitive risk for food production? Fuel bills of energy-dependent developing countries could be reduced by adopting biofuels to replace petroleum products, while also developing income-generating subsectors in rural areas. However, developing agricultural systems devoted to energy production will give rise to new constraints and tensions. Is this a development opportunity for developing countries or a further risk of impoverishment associated with a potential reduction in traditional subsistence crops?

Generating fuel from lignocellulosic biomass–wood and crop residue such as straw, bagasse and rice husks–is by far the main source of energy with a promising future, but several other plants already have a real agronomic potential, eg physic nut, cotton, sunflower, groundnut, soybean, sorghum (stems), sugar-cane, etc. In West Africa, for instance, around a third of all cotton seeds produced are not processed, especially by smallholders who are unable to utilize all of the cotton seed they harvest. This by-product is a highly interesting raw material for local production of energy for generating electricity, motive power and heat, especially in Burkina Faso, a country that now wishes to implement energy policies to boost its independence and make more effective use of fuels. Unused seeds could thus produce oil to replace the wood used by small-scale oil mills or the distillate diesel oil (DDO) used by bakeries. CIRAD also coordinated a large-scale multidisciplinary study on the potential of biofuels in Burkina Faso—a country that is highly dependent on hydrocarbon fuel imports for transportation and motive and electric power production.

Great hope is thus being placed on biofuels. To fulfil these expectations, it is essential to come up with scientifically relevant analyses to provide a basis for drawing up sustainable policies and determining relevant focuses of research in this broad field within specific agricultural, ecological and economic settings. However, energy production systems have to be studied in the rural community framework within which they operate. Plant fuels have long been the focus of research at CIRAD, which sets up research programmes to deal with technical (new varietal ideotypes, maximization of fuel biomass production, etc.), social (land use, land management, subsector and market restructuring, changes in conventional uses, impact on diets, etc.), environmental (energy efficiency of itineraries, eco-balances, farming practices, etc.) and economic (distribution of income to different itinerary stages, comparison with other cropping systems, impact on farmers' income, food/fuel competition, threats to food crops, etc.) issues.

COTTONSEED OIL as fuel

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In West Africa, cotton fields generate 1 t/ha of seed cotton, consisting of equal parts of fibre and seed. From these seeds, 100 l of edible oil that is consumed by households throughout the region can be produced, along with oilseed cake for livestock feed and seed hulls that are used as fuel in cotton mills. However, only part of the production is completely processed—remaining seeds could be crushed to extract oilseed cake and oil, a small portion of which could be used as fuel for the seed crushing operation.

Cottonseed oil ranks fifth in vegetable oil consumption worldwide. It is the main oil consumed in Mali, Chad, Burkina Faso and Togo, and one of the main ones consumed in Côte d'Ivoire and Cameroon. On average, 10 kg of seed cotton, which contains 43% fibre and 54% seeds, is required to produce 1 l of oil. In West Africa, 1 t of seed cotton, or 100 l of oil, is generally yielded per cropped hectare. As compared to oilseed rape or sunflower, which produce 1 000–1 200 l/ha, it would clearly be beneficial to mill cotton seeds, which is simply a fibre by-product. Fibre represents 85% of the seed cotton market value. Moreover, industrial-scale crushing of cotton seeds generates 250 kg of oilseed cake for livestock feed and slightly over 200 kg of seed hulls that are used to fuel the cotton mill. About two thirds of all seeds produced are utilized worldwide, which leaves the last third unused, especially on smallholdings, where farmers are generally struggling to turn a profit on their farms. These seeds are usually just fed to livestock, whereas they could generate oil and oilseed cake if crushed.

The CIRAD-Riello boiler using palm oil to dry rubber in Cameroon

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A high-energy oil

The energy required for crushing these seeds could be generated from a small amount of the produced oil (less than 10% overall), which is utilized locally, as also are oilseed cakes produced for livestock feed. On smallholdings, the use of vegetable oils, pure or mixed with diesel fuel, is interesting for short-circuit applications, eg electricity and motive power production, heat production, etc. Tests and research are under way in all cotton-producing African countries to assess the use of these oils in diesel motors for rural electricity production, and for pumping, irrigation and post-harvest processing. Particularly in Burkina Faso, cottonseed oil mixed with fuel oil or distillate diesel oil (DDO) could be used in boilers to produce water vapour and hot water for small-scale oil mills (which use wood for these purposes) or bakeries (which use DDO).

In-depth studies have been conducted on the use of rape seed, sunflower seed and copra as fuels, whereas no studies have been published on fuel applications of cottonseed oil. A CIRAD team thus assessed the fuel qualities of this oil and determined optimal conditions for its use as fuel.

Fuel qualities and usage conditions

The physicochemical characteristics, particle-size distribution of the injected jet and the evaporation of fuels are key aspects required for predicting and optimizing their combustion quality in motors or burners. First, the impact of the physicochemical characteristics of domestic fuel oil, various vegetable oils, and their mixtures on their combustion in diesel motors or boilers was determined. It was necessary to work under the same jet viscosity and particle-size distribution conditions in order to obtain

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Testing a diesel motor fueled with vegetable oils in the 2IE biofuel laboratory in Burkina Faso

relevant results when comparing these fuels. This study also highlighted correlations between the physicochemical characteristics, pre-combustion phenomena (particle-size distribution and evaporation) and vegetable oil combustion.

Partners

University of Ouagadougou (Burkina Faso), Centre national de la recherche scientifique et technique (CNRST, Burkina Faso), Institut international d'ingénierie de l'eau et de l'environnement (2IE, Burkina Faso), French aid services

A conceptual model was designed to predict the oil evaporation characteristics. The results, which were consistent with the experimental data, showed that there is a mean reaction temperature (around 500°C) beyond which the oil and petroleum fuel oil are comparable. Conditions favourable for good combustion of vegetable oil or mixtures with fuel oil were thus applied to mixtures of cottonseed oil (raw, semi-refined and refined) and domestic fuel oil (0–100% cottonseed oil). The oil combustion was found to be comparable to that of fuel oil with respect to CO and NO_x emissions, in both diesel motors and boilers. Experimental emission data were in agreement with the theoretical results calculated with a combustion equation based on a global chemical mechanism.

These research findings logically led to the adaptation of diesel motors and boilers. A range of boiler models was developed with the boiler manufacturer Riello. The results of tests conducted with an 80 kW boiler were conclusive and in line with those obtained in diesel motors at suitable combustion temperatures. Consumption increased slightly (5–8%) with vegetable oils as compared to fuel oil, and there was very little variation in the results regardless of the cottonseed oil treatment investigated. However, the phosphorus content of the raw oil could be detrimental for long-term applications, and scouring operations could thus be necessary for this type of boiler.

Research is under way to assess the use of cottonseed and physic nut (*Jatropha curcas*) oils in diesel motors.

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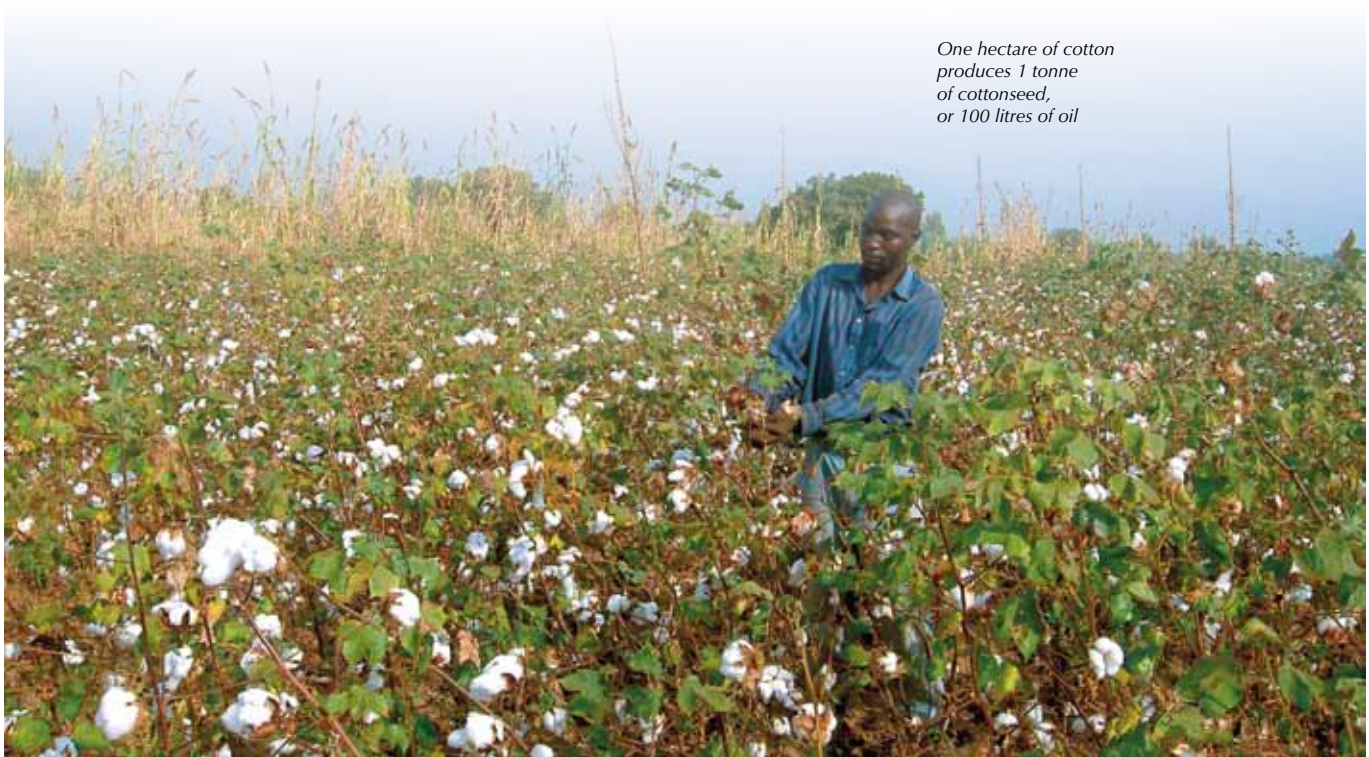

One hectare of cotton produces 1 tonne of cottonseed, or 100 litres of oil

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BIOFUELS in Burkina Faso—a multidisciplinary approach

Burkina Faso depends on hydrocarbon fuel imports for transportation, as well as for motive and electric power generation. This country now intends to introduce an energy policy to achieve energy independence and improve its fuel-consumption sustainability. It is thus interested in the potential of biofuels. Fuel bills could be reduced by adopting biofuels to replace petroleum products, while also developing income-generating subsectors in rural areas. CIRAD coordinated a large-scale multidisciplinary study on possibilities for development of this sector.

In Burkina Faso, hydrocarbon fuel consumption is low but still weighs heavily on the country's trade balance. The government therefore intends to implement a sustainable fuel use strategy, while also seeking to achieve energy independence, especially through the use of biofuels. Drawing up such a policy is complicated. A CIRAD team, in collaboration with Burkinabe researchers, thus carried out an economic, agronomic and technical study on the biofuel development potential for the purposes of policy-making support.

Biofuels and economic development

This study focused on the potential of biofuels as an economic development factor, in terms of employment, rural activities, revenue savings and desertification control. It also identified several types of risk, especially social and ecological, associated with different potential options, while focusing especially on possible competition between food and energy production.

A dynamic analysis of the country's fuel consumption patterns revealed that imported hydrocarbon fuels could be replaced by biofuels in two activity sectors: electricity generation and diesel- and petrol-fueled light and heavy vehicle haulage. The findings also indicated that the biofuel development strategy should enhance fuel access in fuel-deprived rural areas, thus promoting the emergence of new activities.

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Sweet sorghum, a crop with a combined food and fuel production potential

Technical and agricultural potential of biofuels

An assessment of the technical potential of biofuels highlighted the advantages of using raw vegetable oils produced from oilseed plants—the techniques are simple and accessible for small village- and large industrial-scale users. However, it also pointed out the production problems that are currently being encountered in producing biodiesel fuel, since the industrial ethanol esterification process has yet to be perfectly controlled. It also stressed issues with bio-ethanol fuel production, which is a highly energy-consuming process with many drawbacks, including high crop water supply needs, competition for land, export risks, the need to standardize products and organize the subsector.

Several plants have been assessed for their agricultural potential, but also for the associated risks: physic nut, cotton, sunflower, groundnut, soybean, sorghum (stems) and sugar-cane. The study findings toned down the physic nut advantages that are often showcased: few agricultural data are available, its cultivation immobilizes fields for several years before harvest, and its oilseed cake

is toxic, which means that the plant can only be processed to produce fuel. Most vegetable oil and biodiesel fuel production processes are currently based on physic nut, but it seems risky to consider developing a national biofuel development strategy based solely on this plant since the prices of other oilseed crops are rising.

Two biofuel development scenarios

This analysis was action-oriented in order to be able to provide decision support. It focused on two scenarios: one which was aimed at promoting energy generation in rural settings (motive power, rural electrification, agrifood processing), while the other was aimed at using raw vegetable oil as a substitute for imported hydrocarbon fuel so as to generate electricity in thermal power plants supplying the national network and decentralized networks. These scenarios were evaluated on the basis of several criteria: the arable land area required to run the multifunctional platforms depending on the target substitution level, the subsector organization possibilities downstream from the agricultural production, stakeholder capacities, the rapidity of operational implementation and the technical and market flexibility (sensitivity to production level variations, usable plant diversity, outlets for current production, effective use of by-products, etc.).

The government should—irrespective of the planned strategy—tailor its energy price policies to ensure food security and foster oilseed crop production rather than continuing to subsidize petroleum companies.

Partners

Institut international d'ingénierie de l'eau et de l'environnement (2IE, Burkina Faso), University of Ouagadougou (Burkina Faso), Institut national de recherche agronomique (INERA, Burkina Faso), Centre national de la recherche scientifique et technique (CNRST, Burkina Faso), ICI (Burkina Faso), Sonabhy-Sonabel (Burkina Faso), Geres (France), KFW/GTZ (Germany), Luxembourg aid services, European Union, UEMOA, CEDEAO.

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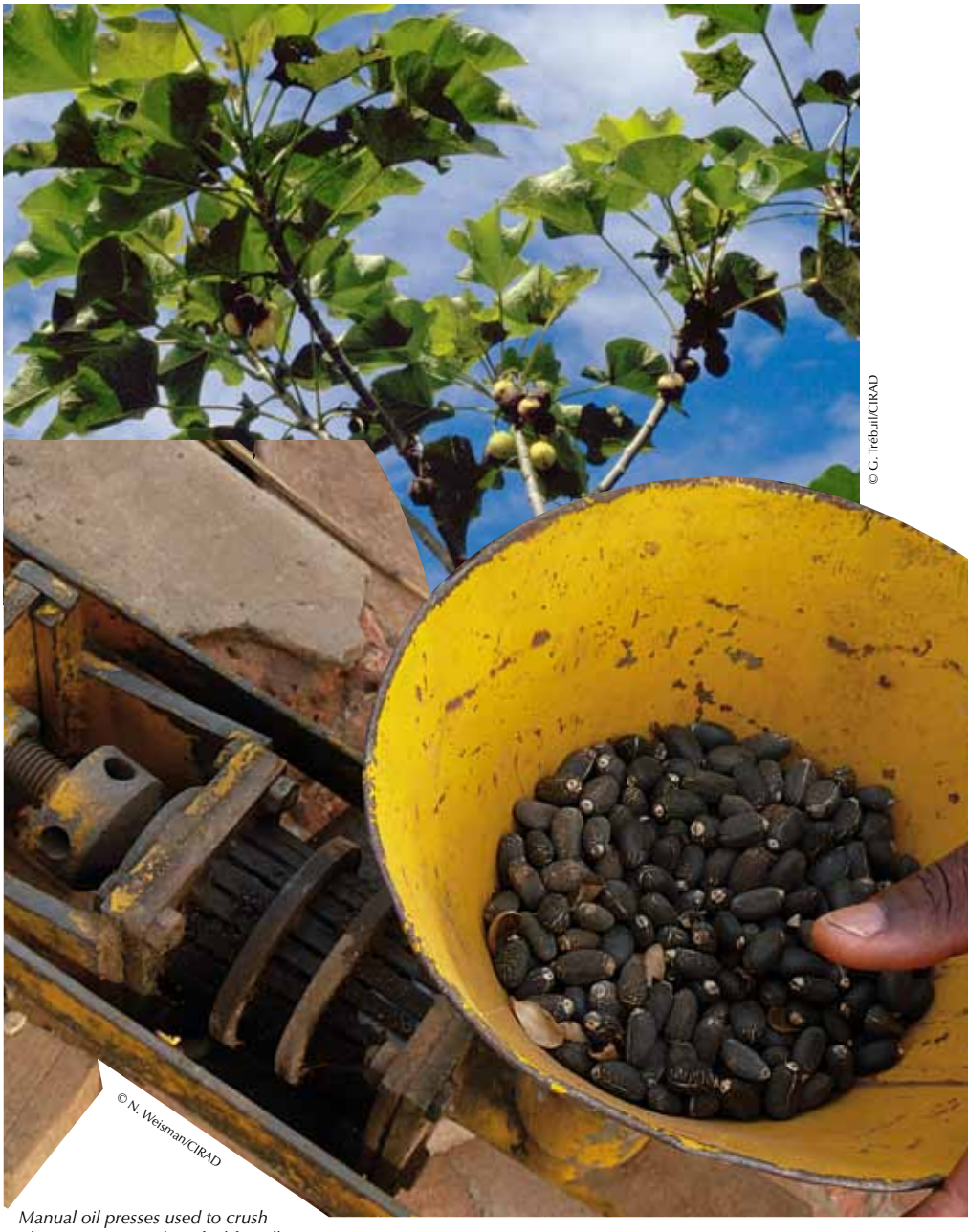
Jatropha curcas *leaves and fruits*



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Manual oil presses used to crush physic nuts to produce fuel for villages

Research # Line 3

Innovating to make food accessible, varied and safe

Economic growth, urbanization and lifestyle changes are altering consumers' food habits. New public health problems are arising as a result of food-related diseases. Competitiveness, subsector organization and exclusion issues are coming to the forefront as the agrifood sector evolves. Food security is thus a major challenge of our time, with the spotlight being placed on the healthiness, practical features of processed products, origin, environmental and social conditions of food production and trade.

Following the food crises that occurred in conjunction with the sharp increase in staple produce prices in 2008, the French government put forward a proposal to set up a global partnership for agriculture and food security. CIRAD was associated with this initiative and marshalled its expertise to conduct various analyses to interpret the situation, assess the impacts and gain insight into the mechanisms underlying agrifood markets and their economies. A model developed in collaboration with INRA proved effective in this task—it reproduces the crisis scenario according to the "natural" functioning of recently deregulated markets. This model showed that losses due to market volatility were greater than gains achieved through enhanced use of global resources due to market liberalization.

CIRAD, by designing crop management sequences tailored to the constraints facing farmers in developing countries, is constantly striving to contribute to the production and marketing of good healthy foods. Promoting local produce on domestic and export markets is a key challenge. A CIRAD team thus used a model which showed that ripe mango quality could be predicted on the basis of the growing conditions, harvest stage and fruit storage methods. This is an essential tool for improving marketed produce quality and farmers' income. As another example, what alternatives are there to antibiotics that are massively used in aquaculture to control infectious diseases? Malagasy essential oils were found to have interesting antimicrobial properties that could prevent the development of resistant bacterial strains, thus reducing consumer health risks.

In the field of technology innovation, it is now crucial to integrate all cost and quality constraints in order to strike a balance between technical processing performance, subsector competitiveness and food security, while also fulfilling consumers' taste expectations.

THE RISING PRICE
of agricultural products

World market prices of many agricultural products soared by around 60% in 2008. This sharp rise, combined with that of petroleum, caused riots in cities in around 30 poor countries. This widespread reaction threatened global stability. It boosted awareness on the strategic role of food and agriculture. The French government put forward a proposal to set up a global partnership for agriculture and food security. CIRAD was associated with this initiative and conducted various analyses to interpret the situation and assess the impacts.

Two approaches were adopted to gain insight into the price rise: correlation of long-term supply, demand and stock data on the one hand, and implementation of the ID3 global balance model designed by CIRAD on the other. The joint findings of these two analyses showed that the price escalation was the result of a slowdown in agricultural production growth in the main producing countries and of the reduction in stocks worldwide. This situation could be explained by the fact that fewer incentive policies have applied to the agricultural sector over the last 20 years. A few damaging but limited-scale climatic events have occurred since 2000, which depleted global stocks whereas the demand remained high. This high demand was associated with the economic growth of emerging countries and the new rising demand for agrofuels, especially derived from maize. These accidental factors triggered a price boom in late 2007 in a tight market setting with very few resources available to meet supply needs with stocks. This situation was further worsened by future market speculation and export restrictions instituted by some countries to ensure the supply of their own domestic markets.

Reduced food access for the urban poor

Most foodstuff-importing countries focused considerable efforts on minimizing the impact of this price escalation on their consumers by reducing import taxes, while merchants reduced their margins. However, the poorest people, especially in urban areas, were still hard hit by the price rise for staple produce such as rice, wheat, maize and oil.

An analysis carried out in six sub-Saharan African countries and Madagascar focused on month-to-month variations in imported and domestic cereal prices on urban and rural markets over a period of around 15 years. It revealed that the price rise applied only to world market products, not to produce from the studied countries. It did not highlight a shortage or slowdown in food production in vulnerable countries but rather a crisis in food access for urban poor people. Food production in most peaceful countries increased at a pace close to the population growth rate, contrary to many preconceived notions, eg that it has been declining over the last 20 years or so. This finding indicates that greater insight is required into the factors underlying this agricultural growth and its sustainability.

French interministerial food security group

In response to the soaring prices and to the riots that this situation has caused, the French Ministry of Agriculture and Fisheries, as well as the French Ministry of Foreign and European Affairs, decided to found the *Groupe interministériel sur la sécurité alimentaire* (GISA). This interministerial food security group includes administrative representatives from these two Ministries, as well as environmental, financial, research and NGO representatives. CIRAD has been a member of this group since the outset. The multisectoral aspect of this group is innovative and essential for dealing with an issue concerning food availability, peoples' access to this food and the regularity of its availability. GISA proposed to establish a global partnership for agriculture and food security, based on three main political, scientific and financial pillars. This initiative has now been adopted by the international community.

Increased price volatility in the coming years

Prices dropped considerably after a few months of rising. The future trend is hard to foresee because of the unknown factors affecting food demand and input price patterns in economic crisis situations. However, two points suggest that there will be greater price volatility in the coming years. First, climate change is likely to produce more intense and frequent rainfall-related events (drought or flooding). Secondly, poor harvests could result in renewed price hikes because of the low global stocks and the lack of speculative market regulation. Such a situation should promote strategies to minimize risks, which would not be conducive to increased production. The situation is therefore likely to remain tight, with a high risk for poor populations whose budget is mainly devoted to food expenditures.

World market prices have been relatively stable over the last 20 years. Many countries are reliant on this market for low-cost staple product supplies, and thus for part of their food security. The 2008 crisis weakened confidence in the world market, especially since a major financial crisis is taking shape. Several countries lacking farmland are investing in land in foreign countries to grow crops for their own markets. Other countries are refusing to open their borders, preferring to fulfil their own security and supply needs domestically. This retreat into national areas is a sign of change that should be constantly monitored as it is a sign of new potential risks as well as opportunities.

Contacts

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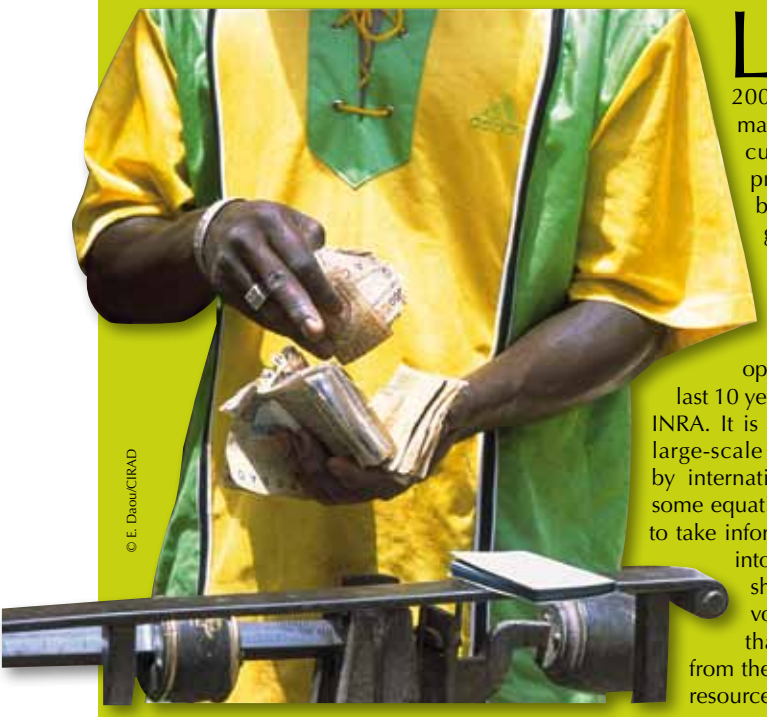
ID3—towards an alternative world economy model



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Overall price rises are solely attributable to products sold on the global market, according to a study by CIRAD

The escalation in world agricultural prices that occurred over the 2006-2008 period highlights a major feature of free agricultural markets—high price volatility. This has been overlooked in several global economic models, which indicate the global benefits to expect from liberalization. A new model has been developed by CIRAD over the last 10 years, in collaboration with INRA. It is of the same type as the large-scale models implemented by international organizations, but some equations have been modified to take information of mixed quality into account. This model can show that losses caused by volatile markets are greater than the gains to expect from the enhanced use of global resources via liberalization.

This model has just proven its efficacy—it simulated the crisis scenario surprisingly well on the basis of 2000 data, even without taking into account the climatic conditions or biofuels, just the "natural" functioning of markets that have been substantially deregulated in the last 10 years. However, there are still several mathematical and conceptual problems to overcome, which is a major avenue for future research.

Contact

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ESSENTIAL OILS
as alternatives to antibiotics in aquaculture

Antibiotics are massively used to control infectious diseases in aquaculture. This practice has given rise to resistant bacterial strains, which represent a risk to ecosystem balances, fish farm sustainability and consumer health. CIRAD is investigating alternatives by conducting research on utilizing essential oils from certain plants endemic to Madagascar that have antimicrobial properties.

Aquaculture is a booming sector that has been growing at a rate of 8.9% since 1970, as compared to only 1.2% for capture fisheries and 2.8% for terrestrial animal production systems—it is therefore the fastest growing of all animal food production sectors. However, infectious diseases are a major risk and responsible for substantial economic losses in this sector. Fish farmers widely use antibiotics for the prevention or treatment of bacterial diseases. Unfortunately, intensive antibiotic use can lead to the development and selection of bacterial strains that are resistant to one or more antibiotics. This environmental contamination by resistant pathogenic strains threatens fish farms as well as human health, since the resistance genes can readily propagate to other pathogenic microorganisms. Consequently, measures have been taken on national and international scales to reduce or even halt the use of antibiotics in aquaculture. It is therefore essential to develop alternative treatments in all producing countries in order to ensure the sustainability of aquaculture. CIRAD has been conducting research for many years on the flora of Madagascar and its diversity. In this framework, it has studied the resources of a native tree species whose essential oil is known for its antimicrobial properties in traditional medicine.

Farmed prawns, Penaeus monodon

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Partners

University of Antananarivo (Madagascar), Centre national de la recherche appliquée au développement rural (FOFIFA, Madagascar), Ecole supérieure des sciences agronomiques (ESSA, Madagascar), Centre national d'application des recherches pharmaceutiques (CNARP, Madagascar), Institut français de recherche pour l'exploitation de la mer (IFREMER, France), OSO Farming: Les Gambas de l'Ankarana (LGA, Madagascar), Agence universitaire de la Francophonie (AUF)

Cinnamosma fragrans, a tree that produces essential oils

Malagasy forests include many essential oil-producing species, some of which are already used in traditional medicine for their antimicrobial properties, eg *Cinnamosma fragrans*, a species that grows in forest stands on the western side of the island. A study was carried out on the chemical composition of its essential oils extracted from leaves collected in two areas within the distribution range of this species. The findings revealed two distinct chemical compositions, with either linalool or 1,8-cineol being the major constituent.

The antimicrobial activities of these essential oils were analysed in vitro on several bacterial species, including *Vibrio harveyi, V. fisheri, V. penaeicida, V. algynolyticus, V. anguillarium, Micrococcus luteus, Escherichia coli, Salmonella typhimyrium, Staphylococcus aureus* and *Bacillus subtilis*, some of which are specific to aquaculture. Preliminary trials were conducted on an organic shrimp (*Penaeus monodon*) farm in Madagascar to test their use in aquaculture and analyse their effects on shrimp larva survival and microbial flora in the rearing tanks.

Promising antimicrobial properties

The initial results showed that the essential oils of both chemical compositions protected shrimp larvae in hatchery tanks to about the same extent as could be achieved with the conventional antibiotic, ie an 80% larval survival rate. In the control trial without any essential oil or antibiotic treatment, the maximum larval survival rate at the end of the cycle was 10%.

This research, which is also aimed at fostering biodiversity preservation and sustainable management in Madagascar, is based on the hypothesis that biodiversity preservation may be achieved through its efficient management. Studies are ongoing within the framework of a regional hub of excellence—consisting of the Universities of Antananarivo, Comoros and Réunion, CIRAD, and several Malagasy research centres—that is promoting the effective use of plant resources of Madagascar and Comoros for food security.

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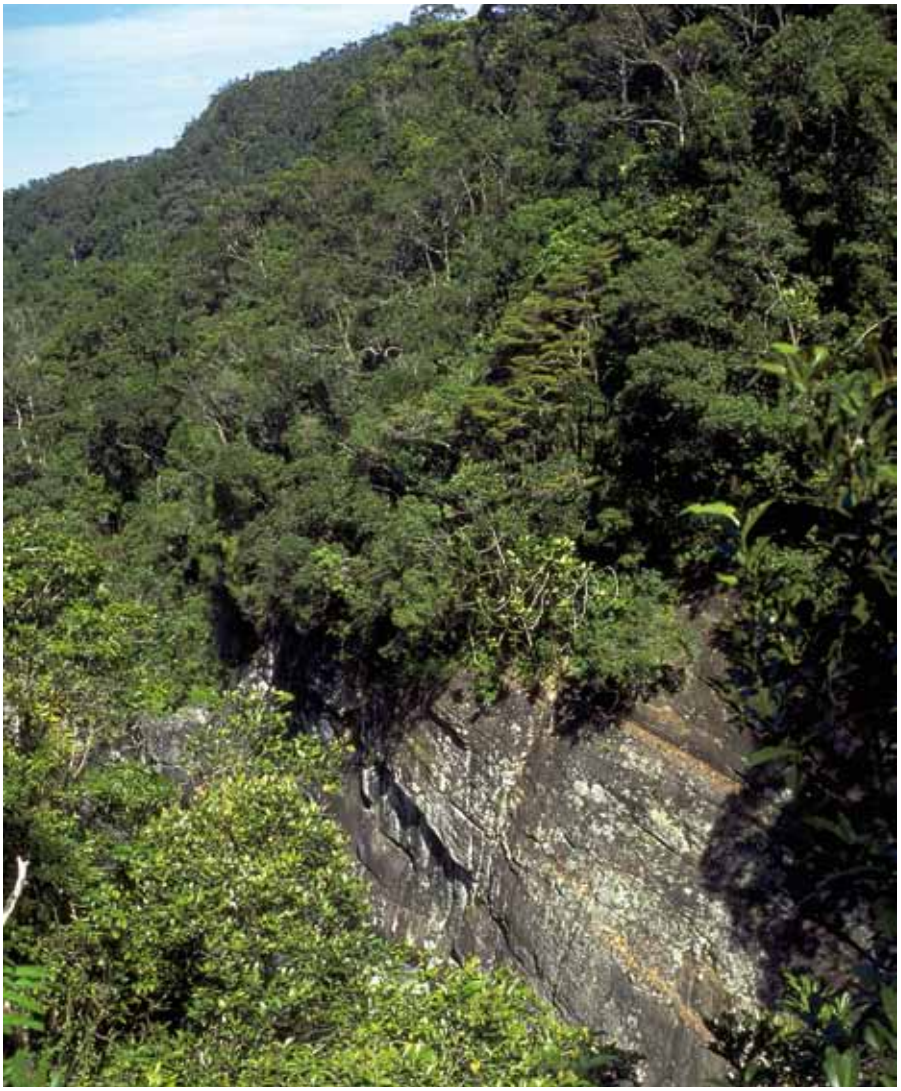
The forests of Madagascar are rich in species that produce essential oils



MANGO—
gaining insight into the fruit's past to foresee its future

Mango is harvested at a green-mature stage and subsequently ripens on the market, but the ripening times between harvest and consumption vary markedly. In these conditions, how can the quality of the mango on the consumer's plate be accurately predicted? A CIRAD team established a correlation between the fruit's development on the tree and its post-harvest function, and has just shown that ripe fruit quality can be predicted according to the growing conditions, maturation stage at harvest and storage method.

In tropical horticultural subsectors, the diversity of cropping conditions, choice of harvest date and sometimes unsuitable shipping and marketing conditions may lead to substantial differences between the target quality and the actual end product quality. A CIRAD team of ecophysiologists and post-harvest physiologists conduct research on the development and preservation of tropical fruit quality. These studies, which are focused especially on mango, aim to reduce pre- and post-harvest losses and to ensure that fruits sold on domestic markets are of high nutritional, sensorial and sanitary quality, while also facilitating their access to world markets.

A model to predict fruit quality and enhance harvest planning

Environmental factors such as light, temperature, carbon and water levels have an impact on the physiological processes involved in fruit development on the plant. The effects of these factors on the moisture content and structural and nonstructural dry matter growth were identified and quantified for cv Cogshall mangos. This information was then inserted in a model of environment-dependent mango fruit function in order to come up with a representation of the development of the mango fruit and fruiting branch. This model was extended to the tree scale by varying the fruit-bearing branch lighting environment and carbon assimilate supply factors. The outputs of this model highlight the variability in the initial fruit quality criteria on the same tree, such as the grade, sweet or acidic taste, as well as the harvest date variability. This type of representation can be used to predict the effects of cropping practices -, which modify the studied pre-harvest factors such as the fruit size -, thinning and irrigation management, and to schedule harvests under actual field conditions.

Monitoring fruit quality development and preservation

Little research has been focused on assessing the impact of the pre-harvest environmental conditions, stage at harvest and storage conditions on the development and preservation of tropical fruit quality. However, these relationships are important when seeking technical solutions to improve the final fruit quality. This is especially true in the case of climacteric fruits, which are harvested at a green stage and ripen during the marketing phase, with variable harvest to consumption times and channels.

The fruit functioning model serves to plan mango harvesting operations

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Harvesting mangos using a pole

This pre- to post-harvest relationship was studied in mango through four steps: analysis of the fruit function on the plant (control of environmental factor levels), characterization of fruit quality (physicochemical components impacting its sanitary status, sensorial quality and nutritional value), choice of a suitable harvest stage according to the target market, and assessment of the impact of storage techniques on variations in this initial quality.

The development of mango fruit on the tree can thus be represented in relation to the modelled variations in its storage quality components to obtain an integrated overview of the development and preservation of this quality. This continuum revealed that variations in the fruit load or fruit position on the mango tree in relation to the light conditions will lead to modifications in the ripe mango composition. Different maturation stages at harvest, associated with storage in cold rooms or at ambient temperature will thus affect the final sugar content, carotenoid synthesis capacity, aroma synthesis and thus the fruit quality offered to consumers.

More generally, this pre- to post-harvest continuum could be integrated in the design of new agroecological management strategies for horticultural systems so as to facilitate identification of the most suitable combinations that will ensure the nutritional qualities of the fruit and its sanitary status as naturally as possible.

Partners

Association réunionnaise pour la modernisation de l'économie fruitière, légumière et horticole (ARMEFLHOR, Réunion), Chambre d'agriculture de la Réunion, Institut national de la recherche agronomique (INRA, France), Universities of Réunion and Avignon, Centre national de recherche agronomique (CNRA, Côte d'Ivoire), Conseil régional de la Réunion, French Ministry of Agriculture and Fisheries

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Producers usually harvest Cogshall mangos at the yellow-spot stage

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Crate of mangos packed for air freight

Research # Line 4

Foreseeing and managing infectious disease risks linked to wildlife and domestic animals

Sanitary constraints concerning contagious bovine pleuropneumonia or avian influenza are a daily concern for livestock farmers in the tropics. Emerging and reemerging animal diseases, which are regularly spotlighted in the international news, are constantly progressing. This includes zoonotic diseases which represent serious risks for human societies in developing and developed countries. The increase in world trade, climate change, ecological disturbances, urbanization, inadequacy of many health systems and intensification of livestock production have created favourable conditions for these diseases, with major concomitant epidemiological and economic impacts.

Besides veterinary sciences, a range of different disciplines such as ecology, epidemiology, modelling and, to an increasing extent, economic and social sciences, are involved in integrated disease management. CIRAD is thus participating in developing international animal health and veterinary public health networks. Other tools, such as remote sensing, make it possible to identify areas conducive to virus survival - especially the avian influenza virus - and to classify them according to biophysical parameters. Within the framework of an FAO surveillance programme, coordinated by CIRAD in collaboration with Wetlands International, a natural infection by a highly pathogenic avian influenza virus strain was, for the first time, detected in healthy wild ducks in Nigeria. The virus' dispersal patterns were thus monitored by tracking the movements of these birds by satellite telemetry.

Controlling contagious bovine pleuropneumonia, a serious cattle disease in Africa, is a major challenge for CIRAD. Knowledge on this disease has increased considerably in recent years with the sequencing of several of the pathogen's genomes and the unravelling of the protective immune mechanisms. Substantial advances have been achieved in the last year, such as the development of new diagnostic, molecular epidemiology and vaccination methods.

CIRAD is acknowledged by international bodies as an important stakeholder in disease surveillance and vaccine development. Its presence in developing countries is a major advantage, ie it has in-depth knowledge of the areas from which most of these diseases originate. It has privileged relationships with its partners in the Mediterranean Basin, Africa and Southeast Asia, and has invested heavily in training activities over the last 40 years. It is also involved in solid collaborations with institutions in developed countries.

CONTAGIOUS BOVINE PLEUROPNEUMONIA— new diagnostic, molecular epidemiology and vaccination methods

Controlling contagious bovine pleuropneumonia, a serious cattle disease in Africa, is a major challenge for CIRAD. In recent years, knowledge on this disease and its causal mycoplasm has increased considerably with the sequencing of several of the pathogen's genomes, the development of new detection tests, the unravelling of the protective immune systems and the development of vaccination strategies.

Contageous bovine pleuropneumonia (CBPP), caused by the *Mycoplasma mycoides* subsp. *mycoides* small colony (MmmSC) biotype, is a respiratory disease of cattle in Africa, where it has a serious socio-economic impact. Sporadic outbreaks have also occurred in southern Europe, with the last case detected in Portugal in 1999. In Africa, this disease is hard to control—sanitary measures such as controlling cattle movements and slaughtering infected animals are complicated to set up and implement and annual vaccination campaigns are expensive (moreover, the vaccines have limited efficacy).

Partners

Laboratoire central vétérinaire de Bamako (LCV, Mali), Laboratoire national vétérinaire de Garoua (LANAVET, Cameroon), Onderstepoort Veterinary Institute (OVI, South Africa), Institut de la recherche agronomique (INRA, France), Ecole vétérinaire de Toulouse (France), Centre de bio-informatique bordelais (CBIB, France), Agence française de sécurité sanitaire des aliments (AFSSA, France), Genoscope (France)

As reference CBPP laboratory for the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO), CIRAD has been investigating ways to control this disease for several years. Recently, sequencing data on several genomes of MmmSC and other related strains paved the way to the development of new diagnostic, molecular epidemiology and vaccination approaches.

A more sensitive detection technique

CIRAD has developed a real-time polymerase chain reaction (rtPCR) technique to improve conventional PCR detection of the mycoplasm. With this technique, the detection sensitivity for field samples can range from 3 to 80 colony forming units, or from 4 to 80 femtogrammes (fg) of DNA (1 fg = 10^{-15} g). From a practical standpoint, this technique reduces the risk of contamination, enables mycoplasm quantification and improves quality assurance.

Determining the geographical origin of strains

Epidemiological progress has also been achieved. Eight polymorphic loci were thus selected by comparing two complete genomes. An analysis of these multilocus sequences was applied to 51 strains of various origins. It revealed three geographical groups: the first is mainly from West and Central Africa, the second is present in South and East Africa, Australia and India, and the last is located in Europe. This study also proved

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Zebu infected with contagious bovine pleuropneumonia

that European pleuropneumonia foci in the 1990s were not of African origin, ie they were probably resurgence cases. This highlights the issue of the persistence of these strains in an unknown reservoir, or in a potentially virulent apathogenic form. Moreover, by revealing a genetic link between the European strain of 1967 and strains isolated in Africa and Australia, the study confirmed historical data which indicated a correlation between colonization in the 19th century and the introduction of CBPP in southern Africa and Australia.

A large-scale project to sequence 22 genomes of several animal-infecting mycoplasm species is under way. It should help to identify gene flows between phylogenetically remote species that share the same ecosystem, and to compare genomes of species or strains with markedly different degrees of pathogenicity.

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Colonies of the Mycoplasma mycoides *subsp.* mycoides *small colony biotype*

More efficient vaccines

No major virulence factors were identified through the sequencing studies. The vaccinology research was thus based on other approaches, such as immunology and functional genomics.

The first vaccine-oriented strategy involved developing vaccine subunits consisting of antigen proteins of the microorganism that causes the disease. The vaccine protein selection criteria were determined through characterization of immune parameters that provide cattle with pleuropneumonia protection. Two antigens were thus identified: lipoprotein A (LppA) and PtsG, a protein associated with glucose transport. Each of these antigens induce antibody production and a memory immune cell response, which is based on CD4 lymphocytes that secrete gamma interferon. Their association in a recombinant vaccine with a capripoxvirus vector will be the focus of a first trial in the spring of 2009, conducted in collaboration with veterinary laboratories in South Africa and Mali. As CBPP is a respiratory disease, studies on more efficient mucosal (oral, intranasal) vaccine administration techniques are under way.

The second strategy involves the development of attenuated vaccines. Functional genomic tools tailored for mycoplasms and developed by the French Institut national de la recherche agronomique (INRA) are used by CIRAD teams to obtain mutants from a pathogenic MmmSC strain. The aim is to identify genes potentially linked with virulence and to delete genes encoding proteins that may induce strong antibody responses . In collaboration with African producers, this research will lead to the development, by deletion of virulence genes, of attenuated vaccines that will be "labelled" so that infected animals can be distinguished from vaccinated animals.

The overall research findings highlighted the interest of using a multidisciplinary approach for controlling this major cattle disease.

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EMERGING DISEASES—
assessing the epidemiological and socioeconomic risks

Integrated disease management is based on an accurate understanding of risk systems, areas and periods, and on the assessment of their impact and the socioeconomic impact of control measures. In addition to veterinary science, a range of disciplines such as ecology, epidemiology, modelling and, to an increasing extent, social and economic sciences, are involved. CIRAD and its partners have implemented this strategy for several emerging or spreading diseases in Africa and Asia.

Our modern societies could now be on the brink of the fourth major global epidemiological change, following that of the neolithic era, which was associated with animal domestication, and the two changes associated with urbanization and trade exchange, which led to "microbial unifications" in Eurasia, beginning in the 5th century, and in the Old and New Worlds, as of the 15th century. Panzootic, pandemic influenza and diverse viral haemorrhagic fever in animals and humans are emerging or feared "microbial storms" induced by a broad range of environmental and socioeconomic factors, but especially by the increasingly frequent and intense contacts between humans and animal reservoirs. In this setting, all epidemiological dynamics factors must be assessed, including not only biological factors, which are too often the only ones taken into account, but also environmental, economic and societal factors. It is essential to develop surveillance and control systems based on risk assessment that include human and social dynamics, in particular the cost-effectiveness of these systems and how they are perceived and accepted

Partners

SNRA Ethiopia, Mali, Cambodia, Vietnam, Thailand, Madagascar, University of Kasetsart (Thailand), University of Pretoria (South Africa), University of Murdoch (Perth, Australia), Institut Pasteur (Cambodia, Madagascar), The Royal Veterinary College (UK), Food and Agriculture Organization of the United Nations (FAO, Italy), World Organisation for Animal Health (OIE, France), International Livestock Research Institute (ILRI, Kenya), Institut national de la recherche agronomique (INRA, France), Institut de recherche pour le développement (IRD, France), Agence française de sécurité sanitaire des aliments (AFSSA, France), Centre de recherche et de veille sur les maladies émergentes de l'océan Indien (CRVOI, France), Ecole nationale vétérinaire in Toulouse and Maisons-Alfort (France), Agronomes et vétérinaires sans frontières (AVSF, France), etc.

Vietnam, avian influenza vaccination

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Ethiopia (Debre Behran), livestock

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by livestock farmers, health professionals and the entire society.

An integrated approach

This integrated approach is implemented by CIRAD and its partners for several emerging or spreading diseases. A corpus of methods and tools, which combine ecology, quantitative epidemiology, socioeconomics, statistical and mathematical modelling, is applied to several diseases: avian influenza, African swine fever, bovine tuberculosis and haemorrhagic fever, along with ovine catarrhal fever, which serves as a model of climate-related disease emergence. In addition, CIRAD is developing epidemiological outcome research applied to vaccination strategies and to innovative surveillance system assessment methods. This dual research and risk management issue is crucial in developing countries where human and financial resources are limited and where communication networks hamper interventions. This is the case in sub-Saharan Africa (especially southern Africa and Sahelian West Africa), in the Mediterranean Basin, where diseases threatening Europe may be kindled, and recently also in Southeast Asia.


Thailand, pig farm

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Southern Africa and Southeast Asia—two hard-hit regions

In southern Africa, research is under way to assess risks of disease transmission between wild and domestic species and human populations. The studies are focused on outbreak sites, while considering transmission between species in settings of high ecological pressure—habitat fragmentation and transformation, dwindling biodiversity, etc.

In Southeast Asia, where several disease drivers are found (ie ecological, agro-industrial, socioeconomic and political), there is an increase in the number of areas conducive to disease outbreaks. Because of the current panzootic avian influenza of Asian origin and the risk of it developing into a pandemic outbreak, stricter veterinary control measures are being implemented in countries where the disease is recurrent and enzootic, especially in continental Southeast Asia. In this region, several other animal reservoir diseases have appeared in recent years, such as swine viral diseases and severe acute respiratory syndrome (SARS), or are beginning to emerge, such as Japanese encephalitis, surra and PPR (*peste des petits ruminants*). Others could also be introduced from elsewhere, especially from Africa, including African swine fever and Rift Valley fever.

International expertise networks

As most emerging diseases are transborder phenomena, a regional approach is required to assess the factors involved. CIRAD has thus made agreements with hubs of excellence, which include South African and Australian universities and regional reference centres, with the aim of launching international expertise networks with associated institutional and scientific partners. Through comparative strategies, these networks will be better able to gain overall insight into emerging diseases and to compare the medical and economic efficacy of disease control systems. A key challenge will ultimately be to bring together medical and veterinary teams working in the public health sector, as has already been achieved in South Africa and Thailand, and to draw up health policies that are in line with the social and economic expectations of local populations.

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Monitoring avian influenza viruses in wild ducks and in the environment

The World Organisation for Animal Health (OIE) considers that the current avian influenza situation is critical. This disease is still present in several regions, and there are many yet unanswered questions concerning the transmission cycles of the viruses, their survival in the environment and the role of wild birds in their dispersal. As part of an FAO surveillance programme coordinated by CIRAD in collaboration with Wetlands International, a natural infection by a highly pathogenic avian influenza virus was, for the first time, detected in healthy wild ducks in Nigeria. The survival capacity of viruses in water depends on the environmental features of this medium. CIRAD used remote sensing tools to pinpoint wet areas that could potentially harbour viruses and then classify them according to biophysical parameters. It also assessed the potential dispersal range and rate of H5N1 viruses hosted by migratory ducks by tracking these birds' movements by satellite telemetry. These environmental end ecological data will be included in more general virus persistence and dissemination models.

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A white-faced tree duck fitted with a satellite tracking sensor

Research # Line 5

Helping to reduce structural inequality and poverty

Since the 2002 World Summit on Sustainable Development and the recognition of the Millennium Development Goals, structural inequalities linked to under-development have been a priority for the global community. Reducing these inequalities inevitably means introducing political regulation and mobilizing civil society. Public policy is thus a major research topic with a view to understanding what lies behind resistance to change and development levers.

Since 2000, the knowledge CIRAD has built up in Madagascar as regards public decision support in the rice supply chain and studies of public policy has led to a review of the regulatory methods applied since Independence. An analysis of rice prices revealed the chain's inability to accumulate capital long-term, which condemns the players involved to poverty. A new framework has been proposed, which reinstates public policy and gives the State the possibility of creating the conditions that favour effective market functioning.

Nevertheless, it is still vital to ensure that all the players involved understand the aim of any proposed changes. For instance, the move to make fish farming in the Philippines comply with EU standards rapidly benefited the main economic players, who were convinced by the idea of seeing the opening of economic highways to Europe. However, other players, who failed to see the importance of the issues relating to better management of health risks, have not changed their practices in any way. The *consignaciones* (which act as shrimp landing stages, sorting and grading stations and fish auction sites, and provide producers with funding and inputs) are more sensitive to local consumers' views, and have continued to ignore EU standards... To seduce them, it would have been better to play on other expectations: those of local consumers, who are also on the lookout for safer products. However, the link between local players and *consignaciones* has been broken by the various intermediation processes.

The case of the Philippines highlights the new issues surrounding trade globalization: problems need to be tackled globally, taking account of local aspects and mobilizing all the players concerned. This is what prompted the founding in Thailand of the Hevea Research Platform in Partnership, which set out to improve the rubber supply chain. The platform involves the whole range of players, centring on CIRAD, Kasetsart and Prince of Songkla Universities, and the Thai Ministry of Agriculture.

For around a decade, CIRAD has been working on public policy with universities in the South: University of Pretoria in South Africa, Cheikh Anta Diop and Gaston Berger Universities in Senegal, etc. Based on the data acquired over several years of field work, CIRAD now has expertise that can be transposed to other situations.

PUBLIC POLICY in Madagascar: ten years of research

CIRAD has been working for several years on public policy in Madagascar. It has built up a store of knowledge that sheds light on the country's situation and provides a clearer understanding of the issues relating to family farming, what players mean by sustainable development, and the mechanisms for finding a way out of poverty.

How is public policy established on different time scales? What are the social and economic processes underlying structural policy? What impact do these processes and policies have on rice market functioning or management of urban areas? In working on agrifood supply chains and markets in Madagascar, CIRAD has had to ask itself these questions and to take a long-term look at public policy, which governs sectoral performance and, more generally, economic and social development. This type of analysis is vital if we are to understand what lies behind resistance to change and development levers.

Rice policy and new regulatory systems

Since 2000, CIRAD has been working on public decision support for the rice supply chain, through research on sustainable rice growing, appraisals for donor agencies, training seminars in supply chain analysis, and its involvement in a think tank on the rice supply chain and rice policy. This work has resulted in official rice policy documents and recommendations concerning the economic measures required in the event of consumer price rises. The results were used in 2008 for an analysis of the rice "price paradox", which highlighted the supply chain's incapacity to accumulate capital long-term, condemning most of the stakeholders involved to a life of poverty.

This retrospective look at regulatory measures within the supply chain also resulted in proposals concerning its organization and the distribution of roles between the State and the market. For instance, a rice observatory and a consultation and supply chain management platform have since been set up to ensure the circulation of economic information and the transparency of sectoral management methods.

The historical diagnosis casts doubt on the two regulatory systems that have existed since Independence: widespread State intervention, which was hindering the market, and enforced liberalization of both production and prices, despite the fact that the market was not sufficiently mature. The proposed new framework favours determined public policy (infrastructures, public goods, etc) in order to facilitate private investment in specific assets and secure the economic environment so as to allow farmers to take measured risks. The State's role is restricted to creating the conditions that favour the free market currently being set up.

Risks linked to population growth

CIRAD has also looked at the impact of policy on rural development. Agriculture in Madagascar long provided enough work and jobs to be able to absorb population growth in rural areas, even those with a high population density. This is no longer the case, and the country is now heading towards a demo-economic dead end. According to an analysis conducted under a research programme on the structural implications of liberalization, the land in some rural regions

Partners

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This work was conducted under research programmes on sustainable farming and rice cropping systems (SCRID), the structural dimensions of liberalization on agriculture and rural development (RuralStruc), and policy production and institutional compromises surrounding sustainable development (PROPOCID).

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The aim is to redefine the role the State could play in supporting the market with a view to finding sustainable ways out of poverty. Public policy needs to provide effective support for increased agricultural productivity. It has taken 40 years for relatively simple technical innovations such as planting in rows to be adopted in some villages in Madagascar.

is already saturated and the agricultural sector is having trouble providing work for the younger generations, in an increasingly global market. Thanks to the solutions recommended depending on the different situations—proposing agricultural innovations, developing multi-activity, developing new areas or integrating agriculture into markets—it should be possible to target public policy more effectively.

Sustainable development and public policy

In the light of the vicious circle of rural poverty and environmental degradation, it is vital to look at the sustainability of production methods and public policy. Under a research project centring on sustainable development, CIRAD has studied how this concept emerged in Madagascar and how it has changed both the way in which agricultural policy is drafted and its content. In relation to other countries, where it is seen as being directly linked to rural development, in Madagascar, sustainable development is judged in terms of what it can do as regards deforestation and preserving biodiversity. The first phase of the study ended with the organization, in December 2008, of a workshop open to decision-makers. The aim was to compare the results obtained with the experiences of the people involved in drafting and implementing the policies studied, at a time when sectoral policies relating to the Madagascan plan of action were being drawn up.

Whether the aim is to understand the impact of rice policy or the ways in which agricultural and rural policy are drafted, it is vital to analyse public action in the long term. The knowledge acquired since CIRAD began working in Madagascar has also demonstrated how indispensable family agriculture is: it is the central element of public policies aimed at alleviating structural inequalities and poverty. Decision-makers have a tendency to forget this and to rely on the private sector, which is quicker to react, in the hope of achieving faster results. However, sustainable development is a complex process, which research is working to explain in order to support more effective policies.

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The central issue of public policy is that of long-term employment. In Madagascar, growing numbers of insufficiently educated young people are entering the job market in rural areas, whereas agriculture and other sectors of the economy are incapable of providing them with appropriate employment.

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WHAT CAN WE DRAW
from the operation to make fish farming in the Philippines comply with EU food safety standards?

In 2006, the operation to make fish farming in the Philippines comply with EU food safety standards was completed in record time, thanks to the country's considerable political determination, and with support from CIRAD. However, players in the supply chain have seen the process as just another constraint, which disrupts local strategies and balances. What can we draw from the experience?

Globalization of the farmed fish product market has resulted in the introduction and development of trade and regulatory systems centring on international food safety standards intended to respond to what is currently one of the western world's major concerns: food safety. Between 2004 and 2006, the operation to make the shrimp supply chain in the Philippines comply with EU food safety law was a shining example of mobilization and a great success, but it also raised questions about its sustainability. CIRAD, which used its expertise to support the operation, has launched a study to gain a clearer understanding of the ins and outs of these new North-South trade practices.

An original fish farming system

The study was conducted in the Pampanga delta, in the North of the Bay of Manila, where most export-oriented shrimp production is concentrated. The area is exposed to many types of natural disaster, but extensive fish farming has been practised there for over a century. Recent trends have suggested that the zone is becoming poorer, with a reduction in the means of subsistence for local communities and increased tension. However, fish farming in the area is based on a highly original social structure, the Mangangapa-Degaton system. The Mangangapas are poor fishermen who catch aquatic animals with their bare hands in rivers and recover rejects from fish farms before selling them on to the Degatons, who organize the operation. Some 80% of families in some villages rely on the system to survive.

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Crab harvesting from a polyculture pond in Pampanga province, Philippines

The players excluded by compliance

Of the players in the fish farming sector, the main beneficiary of compliance with EU law has been the Filipino food safety authority, whose competence is now recognized and whose authority has been boosted. For private operators, however, the process has led to a marked split in the sector. Three exporters have made the necessary investments and maintained their capacity to export to Europe, while enjoying the prestige brought by their accreditation, which is more or less the same as a quality label. However, most of the other players have been excluded from the circuit, for reasons which are often neither economic nor technical.

Partners

Bureau of Fisheries and Aquatic Resources (Philippines), Centre de sociologie des organisations, CNRS, Sciences Po Paris (France), University of Stirling (United Kingdom), Municipality of Sasmuan (Philippines), French Embassy (Philippines)

This is the case of the *consignaciones*, which act as shrimp landing stages, sorting and grading stations and fish auction sites, and provide producers with funding and inputs. Their exclusion from European markets was entirely justified in food safety terms, but is more problematic when it comes to sustainable development.

Choices guided by local strategies

Despite the international nature of the supply chain, players generally base their choices on local balances and strategies, which are heavily influenced by the Filipino system of values that favours non-conflictual personal relations *(pakikisama)* and loyalty to partners *(suki)*. This situation may be due to the loss of the links between producers and consumers inherent in any globalized supply chain: when such links are broken, each end of the chain becomes an abstract concept for the other end. While it has been clear for some years that consumer confidence is greater the more producers are able to use market intermediation to put across a message on the quality of the products and the conditions in which they are produced, the latest work seems to be suggesting a similar trend in the opposite direction: producers are more aware the better consumers are able to put across their expectations. If this is not the case, the local situation plays a determining role and producers develop a way of thinking that is highly influenced by their daily cultural environment. The *consignaciones*' latent opposition to more hygienic practices is not so much due to an inability or a refusal to conform as to a mistaken idea of the importance of the issues. Remedying matters by constraint is not much of a solution in the current situation, since this would only exacerbate the split in the supply chains concerned, which would not be satisfactory for either producers or consumers. The only solution would apparently be a global approach, taking care to re-establish the market intermediation links between developing countries and consumer markets.

The case of the Philippines highlights the new issues surrounding global trade in tropical aquacultural products. Although imposing increasingly strict quality standards is essential, it is unlikely to provide a long-term solution to the rise in the number of food crises unless the problem is tackled globally, while taking account of local aspects. From this point of view, the Filipino shrimp supply chain is a promising study framework for developing and proposing innovative practices that respond to this challenge.

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Prawn, fish and crab harvesting by hand in a polyculture pond in Pampanga province, Philippines

A hevea research platform in Thailand

For many years now, CIRAD has been conducting rubber research in Thailand, with all the various development stakeholders: growers, processors, agricultural development organizations, research centres and universities. To boost the synergy between these stakeholders, CIRAD, the University of Kasetsart and Prince of Songkla University, and the Thai Ministry of Agriculture set up the Hevea Research Platform in Partnership (HRPP) in May 2008. They have since been joined by eight associate members.

The aims of the platform are to improve the productivity and sustainability of smallholder plantations, assess the impacts of and the environmental services rendered by the supply chain, and adapt production and product processing to demand, in a sustainable way. The scientific project drawn up by the various partners centres on an integrated approach, with four components: socioeconomics of rubber-growing practices; agronomy, physiology and environment; biotechnology and planting material performance; and technology and rubber quality. An international Masters-type training component is to complete the platform.

The platform, which is based in an intermediate-income country, offers the possibility of taking an "international public good" approach within a major supply chain and of fostering regional cooperation.

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Research # Line 6

Understanding the relations between nature, agriculture and society better, so as to manage rural areas in the tropics sustainably

Establishing methods for the sustainable management of rural areas and ecosystems, which are under threat in many regions, means knowing about resources and how they have changed on the one hand, and the interactions between their various components, be they biological or social, on the other.

Participatory management of territories is a good example. It involves a multitude of players and viewpoints that have to be reconciled, since if one or another party feels cheated, that party's support is likely to falter at the first hurdle... In the case of water management or land allocation, the stakes can be vital and the various viewpoints extremely difficult to reconcile, as has been seen with attempts to manage protected areas and their fringes.

In the field of water management, CIRAD supports managers and users of irrigation schemes and drinking water services. It has worked hand in hand with these players to develop analysis, simulation and management tools. Its participation in the 13th World Water Congress enabled it to present several projects being conducted jointly with its partners, on the collective management of a resource that is frequently a source of tension.

In the same spirit, CIRAD has designed and developed a set of tools to enable players to express and share their points of view and facilitate a prospective approach to land allocation. This "adaptive modelling" approach has been tested in two different situations: in Réunion, where it fitted in with an institutional reform of territorial planning documents on regional, intercommunal and communal levels, and in Senegal, as part of an initial plan to manage Lake Guiers.

In a very different field, the chemical composition of soil organic matter has been used in India to reconstitute the changes in former plant covers. The aim was to gain a better understanding of how mountain forests and meadows evolve. The results obtained have meant that forest preservation is no longer the only priority: it is also possible to take account of older meadows.

Threatened rural areas and ecosystems, agricultural extension exerting considerable pressure on the environment that can even lead to conflict, etc., etc.; the challenge now is to develop a land planning method built on both agricultural production and the restoration of the ecological services rendered by ecosystems. Since 1999, several structures set up on CIRAD's initiative have been enabling researchers or teams from a range of institutions to work together on these multidisciplinary issues.
For instance, one such structure, the Grand Sud Cameroun research platform, which is one of the main components of CIRAD's operations in Africa, involves several teams working on integrated management of family farms within the country's agroforest ecosystems.These structures illustrate the spirit in which CIRAD conducts its research: research in partnership, for which the priorities are established with all the various partners, with a view to sharing both responsibility and benefits.

"REGARDS CROISÉS sur la Tapoa": an assessment of community management of natural resources in Africa

Over the past 15 years or so, community management of natural resources has been tested many times in Africa, and French-speaking organizations have built up significant expertise, particularly in the management of protected areas and their fringes. A workshop organized by CIRAD and its partners made it possible to assess recent operations in this field and to compare of the views of African specialists from different horizons.

Several fruitful operations aimed at community management of natural resources have been conducted in southern Africa (Campfire programme in Zimbabwe), West Africa (W regional park) and central Africa (village management of hunting zones in the Central African Republic). They have made it possible to identify the principles that should govern community involvement in natural resource conservation.

A workshop to compare the various approaches

While these approaches are now globally the object of assessments and critical studies, exchanges between English- and French-speaking countries are still too few and far between, despite the merits of comparing the founding principles and the results obtained in different situations.

In view of this, and of their long experience of community management of biodiversity in Africa, CIRAD and its partners organized a pan-African workshop on the topic in March 2008. It was held in Niamey, Niger, and attended by 74 participants involved in community management of natural resources and protected areas, from a dozen or so African countries–both French- and English-speaking–and six European countries. Some 40 case studies were presented and discussed. The varying geographical and institutional origins of the participants gave rise to lively discussions about the issues and practices surrounding biodiversity conservation,

Partners

World Wide Fund for Nature (WWF), International Union for Conservation of Nature (IUCN), International Institute for Environment and Development (IIED), Ministry of Foreign and European Affairs, Fonds français pour l'environnement mondial (FFEM)

Maize field in the Campfire communal zone

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How can communities be involved in natural resource conservation?

the participation and strengthening of communities living around protected areas, and rural development in general.

Using differences and similarities to fuel the debate

The workshop revealed that the main sticking points in community conservation operations in English- and French-speaking Africa were the same: the difficult cohabitation between man and fauna, the coexistence in a given area of agricultural production and biodiversity conservation–particularly in the case of agricultural pioneer fronts, as is the case with cotton–and the complexity of the common law and legal institutions involved.

Differences also appeared. For instance, in French-speaking Africa, most conservation initiatives are based on an approach aimed at developing the land on the fringes of protected areas. This poses particularly acute problems regarding land delimitation–zoning, access rights and land tenure. However, in English-speaking Africa, the issue is generally tackled via economic incentives–developing tourism–and by building skills, for instance through training. There are plans to involve local people as part of a theoretical approach: community-based natural resource management (CBNRM).

Based on these observations, CIRAD, in partnership with IIED, has carried out an in-depth sub-regional comparison using publications and case studies to define the CBNRM approach and how it is applied across the continent. This analysis of sub-regional specificities should lead on to recommendations that will enable decision-makers to look again at how they tackle such issues and plan new operating strategies, since the impact of community conservation operations in Africa does not always live up to expectations in terms of integrating rural development and conservation.

A controversial approach

In the field of environmental governance, defining and implementing participatory approaches is still a real challenge for researchers, field operatives and decision-makers. The efficacy of such approaches, which only a few years ago were still seen as a universal solution, is now largely being questioned. There have been numerous criticisms of the risks of poorly managed operations for both local development and biodiversity.

In terms of conservation, the priority is to develop standard ways of organizing participation, which fails to take account of the complexity and institutional, legal and socioeconomic specificities of each situation. The "real" beneficiaries of and "eligible parties" in community-based approaches are difficult to identify. An in-depth analysis of these stumbling blocks should make it possible to pinpoint how such participatory operations should be run, with a view to improving their local impact, notably in economic terms, and to moving towards making local communities fully responsible for conserving protected areas.

A pan-African skills network

The dynamic triggered by CIRAD with the workshop entitled "*Regards croisés sur la Tapoa*" is to continue, with the creation of a pan-African skills network on participatory conservation. This fits in with the current debate on environmental governance in Africa, while taking account of sub-regional specificities. The main results of the workshop were presented at the IUCN World Conservation Congress in October 2008, and several publications covering the various projects and debates are due out shortly.

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Transhumant animals and fishermen in Chad

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RECONSTITUTING
former plant covers using soil organic matter

The organic matter of soils can be viewed from other perspectives than that of fertility. For instance, the long-standing controversy in India concerning the origin of the forest-grassland patchworks found in mountain areas was resolved through its detailed study. The study showed that during the last glacial maximum, grasslands covered the whole of the highland area, and were supplanted by forests only later, as a result of global warming. This result is of critical importance in building a realistic paleoecological model and deciding on a scientifically sound environmental conservation policy.

Soil organic matter is often seen as a factor of fertility and sometimes considered a sink for storing atmospheric carbon dioxide. An in-depth analysis of its chemical composition, and more precisely of the isotopic composition of the carbon it contains, has shown that it also retains the signature of the vegetation types from which it is derived. It can therefore be analysed to trace the former vegetation types and hence the environments of the past. Organic matter thus acts as a veritable genetic fingerprint that can be used in paleoecology.

In southern India, a controversy had long existed about the origin of the patchworks of evergreen forests and grasslands found at heights of 2000 m and more. To the supporters of the pre-existence of a continuous forest cover, grasslands were interpreted as evidence of anthropogenic disturbance, or in other words, as resulting from deforestation. Studies of the pollen grains trapped in peat bogs had suggested that fluctuations in the patchwork composition might have occurred, as shown by time variations in the pollen diagrams. The predominance of forest species at some periods was followed by an increase in herbaceous species, with always a mix of both. However, for this type of survey, peat bogs have two disadvantages that affect the representativeness of the signal they give off: they are not uniformly distributed in the highlands and often only occupy the centre of mountain ranges and, moreover, they obviously occupy the lowest points in the landscape.

Soils, and the organic matter they contain, do not present these disadvantages. In the Nilgiri highlands, where the study was conducted, the humus layers

Partners

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The isotope analyses were carried out by the University of Nancy and INRA Nancy.

In the Nilgiri highlands, the humus layers are very thick

are very thick and the organic matter evolves very slowly due to the low temperatures in the mountains (annual mean of 15°C with a monthly mean of just 5°C in January). These conditions favour the constitution of organometallic complexes–andosolization–, which results in carbon stocks trapped in the soil reaching up to 80 tonnes per hectare in grasslands and 110 tonnes in forests; this latter value is well above the 64 tonnes per hectare found in low elevation evergreen forests, despite the fact that these are much richer in terms of biomass.

An analysis of the carbon isotopes in these humus layers revealed that, at the bottom of the layer, at a depth of about one metre, the organic matter that was formed 20 to 25 000 years ago retained a floristic signature of grasses, which signifies that it was formed under grasslands. As the soil cover in the area is almost continuous, the analyses were repeated in regions without peat bogs, and identical results were found for this period, which corresponds to the last glacial maximum (LGM). In the upper soil horizons, corresponding to more recent periods, the results differed according to the site where the analysis was performed, suggesting that the plant cover did not evolve in the same way throughout the mountain range. It is thus now clear that the plant cover in these mountains went through a stage of extensive grasslands at the time of the last glacial maximum; at the time, the climate of the highlands was too cold for forests, and the area was generally above the tree line (the elevation above which trees cannot grow). With the global warming that followed the glacial maximum, trees have gradually colonized the area, albeit at differing rates and to different extents from one place to another.

These results are of critical importance for the design of a new environmental management policy for the highlands with the same conservation value given to forests and grasslands. Recent afforestation programmes, implemented at the expense of grasslands, and based on the assumption that forests were the natural habitat in these mountains, are scientifically unfounded. Many studies of mammal ecology were also based on the erroneous hypothesis that there was once a forest continuum that is now breaking up (Island Biogeography theory). The comparison of our results with anthropological data concerning the human occupation of these highlands has also shed light on the role of some of the ecological factors at play.

Contact

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Patchwork of highland evergreen forests and grasslands

Adaptive modelling in support of consultation concerning land allocation

Participatory management of territories involves a multitude of players, hence of views on the processes at play. Under a research project aimed at providing an understanding of the ways in which land is allocated for various uses as part of a decentralization process, a set of tools has been designed with players to enable them to express and share their points of view and facilitate prospective studies prior to land allocation. This approach, known as adaptive modelling, has been tested in Réunion and Senegal.

In Réunion, the approach was part of the institutional framework for the revision of the existing land planning documents covering the region, districts and communes. The aim was to harmonize the different documents, and also to identify the intersectoral coordination issues and potential changes in agricultural land ownership. Geographical, economic and demographic data, generated independently by several organizations and by researchers, were used to model the changes in land occupation on a whole-island scale. An integrated simulation model designed by development staff and researchers was then used to illustrate the long-term impact of the prospective scenarios in the regional land occupation plan, which provided a framework for the drafting of the other documents.

Participatory mapping session during a prospective workshop with the users' committee in Senegal

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In Senegal, the approach was implemented as part of an initial plan to manage Lake Guiers. The information available on land allocation at rural council level was not sufficient to coordinate use or to assess the social and environmental impact of that allocation. A users' committee was thus set up to support decisions on two levels: that of users and that of rural councils. After a participatory diagnosis phase, the committee was trained in how to read and produce cartographic data, and then associated with the development of dynamic tools, ranging from role-playing games to an optimization model. These tools were tested by the users' committee during workshops, and then in real-life situations. They satisfied the requirements identified—critical mapping, monitoring-assessment, prospective studies—with a view to supporting the establishment of future consultation forums for the drafting of a lake management plan.

Contact

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Partners

Association pour la promotion en milieu rural (APR, Réunion), Réunion Chamber of Agriculture, Institut de recherche en mathématiques et informatique appliquées (IREMIA, Réunion), Centre de recherches et d'études en géographie (CREGUR, Réunion), Comité de pilotage de la canne (Réunion), Ecole supérieure polytechnique (ESP, Senegal), Laboratoire d'enseignement et de recherche en géomatique (LERG, Senegal), Ecole nationale d'économie appliquée (ENEA, Senegal), Groupe interdisciplinaire de recherche pour l'appui à la planification régionale et au développement local (GIRARDL, Senegal), Gaston Berger and Cheikh Anta Diop Universities (Senegal), Société d'aménagement et d'exploitation des terres du delta du fleuve Sénégal et de la Falémé (SAED, Senegal), Tropis, sub-prefectures of Keur Mounar Sar and Mbane (Senegal), Catholic University of the West a nd Universities of Saint-Etienne and Montpellier I (France), Centre d'études politiques de l'Europe latine (CEPEL, France)

For further information

Daré W., Aubert S., Bah A., Gaye I.D., Fourage C., Lajoie G., Leclerc G., 2008. Difficulté de la participation en recherche-action : retour d'expériences de modélisation d'accompagnement en appui à l'aménagement du territoire au Sénégal et à la Réunion. Vertigo, 8: 1-15.

Daré W., Fourage C., Gaye I.D., 2007. Positionnement des sociologues dans la démarche de modélisation Domino. Nouvelles perspectives en sciences sociales, 2: 103-127.

Mar N.F., Magrin G., 2008. Peut-on décentraliser des ressources naturelles stratégiques ? L'articulation des niveaux de gestion autour du lac de Guiers (Sénégal). Mondes en développement, 36: 47-62.

CIRAD at the World Water Congress

CIRAD participated in the 13th World Water Congress from 1 to 4 September 2008, in Montpellier. The congress, which was organized by the Institut fédératif de recherche-Institut languedocien de recherche sur l'eau et l'environnement (IFR-ILEE) under the aegis of the International Water Resources Association, was attended by specialists from more than 120 countries. This year's topic was "Global changes and water resources: confronting the expanding and diversifying pressures".

In the field of water management, CIRAD designs analysis tools and supports managers and users of irrigation schemes and drinking water services. It works with them to develop simulation and management tools. Several projects being conducted by CIRAD and its partners were presented at the congress: the EU Negowat project in Brazil and Bolivia, intended to reduce tension between users in periurban areas; the SafeWater ARISE project in South Africa, which set out to build participatory processes; the SIRMA project in the Maghreb, on how irrigators take on board imposed modes of organization; and the Echel-Eau project on management of the Mekong, Limpopo and Niger catchment areas.

Contact

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For further information

World Water Congress website: www.worldwatercongress2008.org

Indicators

Organization in April 2009

CIRAD worldwide

Indicators

On 6 November 2008, the Minister of Higher Education and Research and the Junior Minister with responsibility for Cooperation and French-speaking Countries signed the 2008-2010 CIRAD Contract of Objectives. The contract sets out four main priorities that will guide CIRAD in the coming years: ensuring shared science in response to the challenges faced by developing countries; producing varied, quality scientific output; opening up national agricultural research operations to Europe and the rest of the world; and tailoring the establishment's structure and resources to current issues. It includes ten objectives and thirty-three operations, linked to indicators and landmarks that will serve to monitor the progress made. CIRAD 2008 is a transitional report, and aims to ensure consistency by including some indicators from the previous contract and others from the new one.

The results obtained tally with CIRAD's scientific reorientation strategy–more publications, particularly in journals with an ISI impact factor, and a greater number of senior staff members–backed up by improved promotion of scientific results (appraisal missions to international organizations in industrialized countries, improved intellectual property results, greater contractual resources). They are also proof of a drive to strengthen CIRAD's scientific alliances within France (more joint publications with INRA and other organizations involved in French state programme 187) and Europe (more contracts) so as in turn to strengthen its international partnerships (staff assignments to international centres, missions) in favour of developing countries (more training operations and joint publications), with which it is renewing its scientific and geographical partnerships.

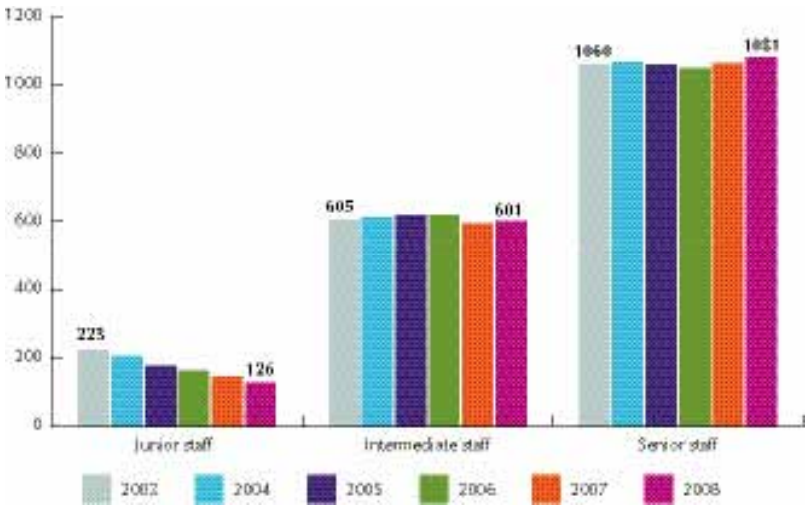

Figure 1. *Staff numbers and distribution*

Resources

Human resources

After a period of falling numbers from 2002 to 2007, CIRAD's total staff stabilized in 2008 at 1808 (figure 1). As regards senior staff members, the reversal in the trend seen in 2007 has continued: for the second successive year, senior staff numbers have increased, from 1047 in 2006 to 1063 in 2007 and 1081 in 2008. The number of intermediate staff members is relatively stable, with an additional six members, while the number of junior staff members has continued to decline (- 18). Moreover, CIRAD continues to benefit from the support of associate senior staff members, of whom eight have been assigned by INRA and five by the Ministry of Agriculture. In turn, CIRAD contributes to the activities of ten CGIAR (Consultative Group on International Agricultural Research) centres, to which 20 of its staff members were assigned in 2008.

On a geographical level, staff numbers overseas have fallen (- 20), and consequently those in metropolitan France have risen (+ 26). The fall in overseas assignments is split equally between the French overseas regions and other countries (figures 2 and 3). As the number of staff members in industrialized countries is stable, that of staff members in developing countries has thus fallen by ten, primarily in Africa (- 8).

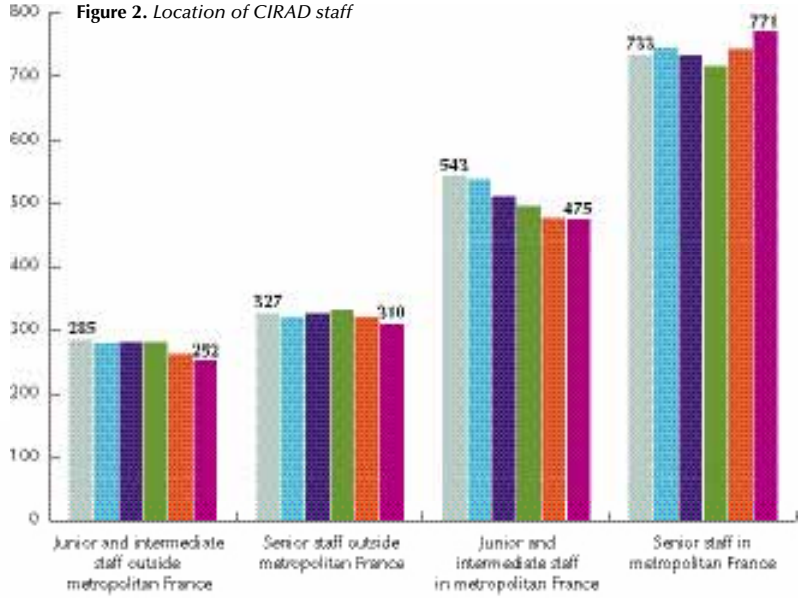

Figure 2. *Location of CIRAD staff*

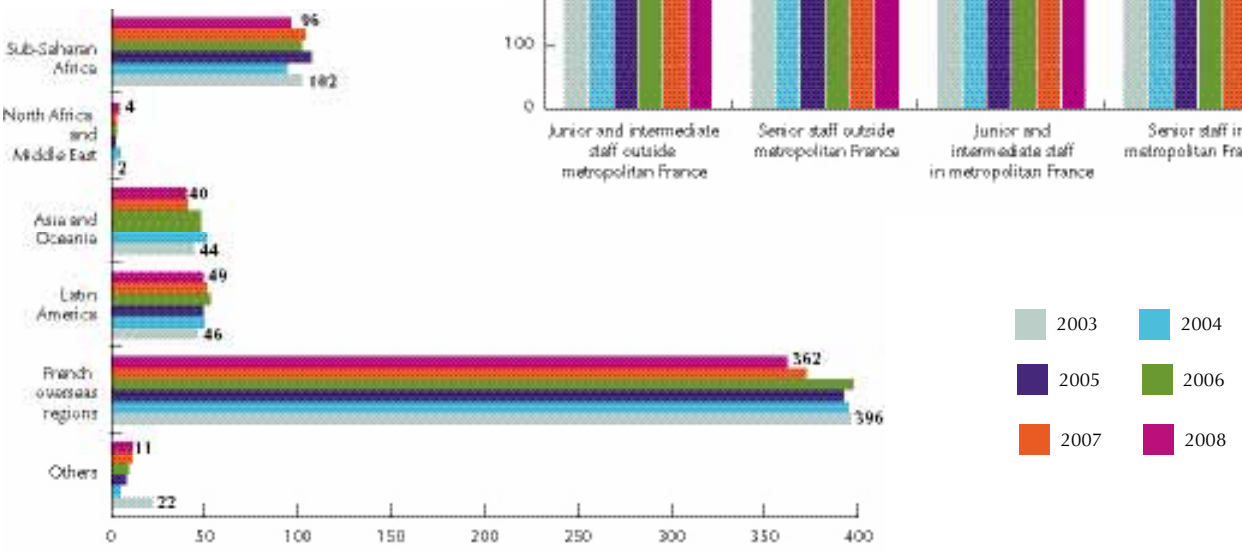

Figure 3. *Distribution of staff members on assignment*

Missions outside metropolitan France were up slightly in 2008 (figure 4). Missions to developing countries were down by six full-time post equivalents, while those to industrialized countries were up, by nine full-time post equivalents, and those to the French overseas regions were stable.

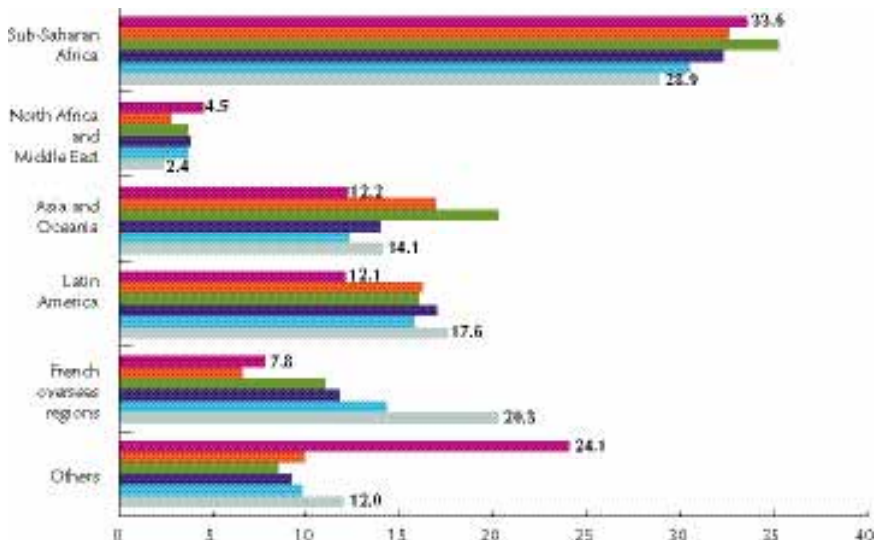

Figure 4. *Distribution of missions (full-time post equivalents)*

Financial resources

The public service operating budget (SCSP) accounted for 60.5% of total revenue in 2008, compared to 62.7% in 2007 (figure 5).

Contractual resources without co-contracting are quoted in figure 7, for an overall total of 50.8 million euros, 3.5 million euros up on 2007. After falling to 7.3 million euros in 2007, co-contracting on contracts of which CIRAD is the coordinator rose again in 2008 to 9.7 million euros, higher than the 2006 figure.

There were few changes in the distribution of external resources per source of funding. Foreign public funds fell by 2% and EU research and development funding by 1%, whereas the share of private funding, including oil palm seed sales, was up 3%.

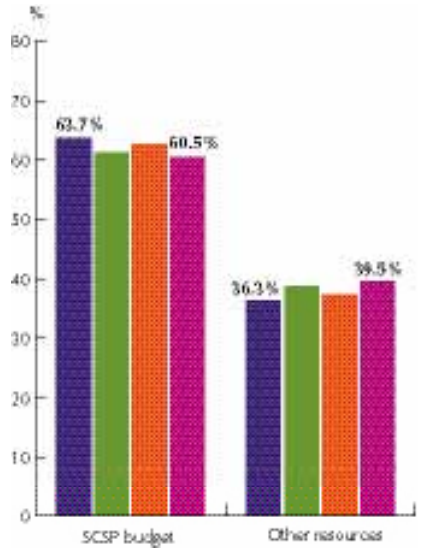

Figure 5. *Cost coverage by the public service operating budget*

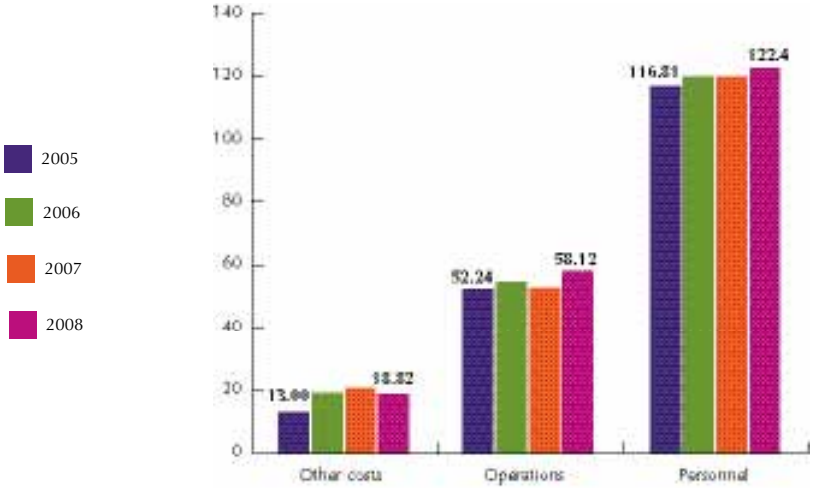

Figure 6. *Operating costs from 2005 to 2008, in million euros*

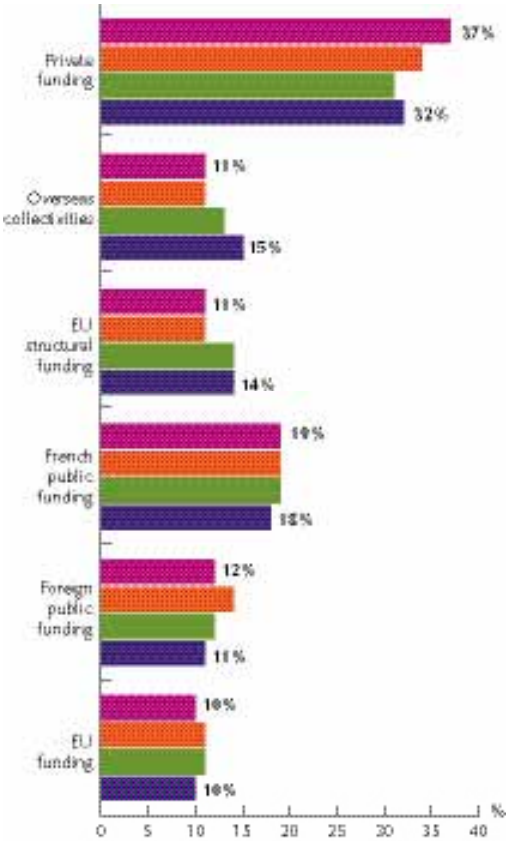

Figure 7. *Origin of contractual resources without co-contracting, in million euros, from 2005 to 2008*

Operations

The main aim of CIRAD's research is development in the South. This economic and societal objective explains the need, upstream, for a scientific approach built jointly with its partners in developing countries and, downstream, for wide-ranging, diversified outputs. Those outputs include scientific articles, particularly written jointly with researchers in developing countries, books, participation in scientific conferences, appraisals for national and international donors, management of intellectual property issues, and training. Training operations may take place in developing countries—CIRAD manages and provides teaching for some ten research Masters degrees—and in France, more precisely in Montpellier, where it supervises more than 250 PhD students, over 65% of them from developing countries. CIRAD provides a total of almost 4000 hours of higher-level teaching.

Scientific and technical publications

The figures concerning scientific and technical publications (figures 8 and 9) were drawn from the Agritrop database, the CIRAD reference base in terms of written scientific output. Due to the time that elapses before actual publication, only 50 to 70% of 2008 publications had been recorded by 31 January 2009 and were taken into account when calculating indicators.

The share of journal articles published in 2007 and 2008 ~~48% was~~ was much the same as that of all other types of publication—books, book chapters and conference proceedings; conference papers; theses and director of research (HDR) application documents~~,~~ which was 52% (figure 8). Between 2004 and 2008, the share of articles published in ISI impact-factor journals almost doubled (+ 99%), while that of articles published in journals without an impact factor fell by a quarter (– 24%; figure 9). These figures illustrate the efforts made at CIRAD in terms of scientific output and knowledge-sharing.

Intellectual property

CIRAD has a portfolio of 34 patents, half of them held jointly with at least one partner. By the end of 2008, it had registered 52 softwares, 43 plant varieties protected by a certificate (PVPC), 14 brands, a design and a *dossier technique secret* (trade secret).

Quality in research

CIRAD's quality policy, launched in 2002 and relaunched in 2008 with the new 2009-2011 Quality Plan, aims to bring the quality of its research products and processes into line with international standards. By the end of 2008, eleven structures, laboratories and research units, accounting for 265 people (more than 14% of CIRAD's total staff), had applied for certification or accreditation according to the ISO (International Organisation for Standardization) international system. Moreover, several structures have adopted a quality approach without applying for certification or accreditation.

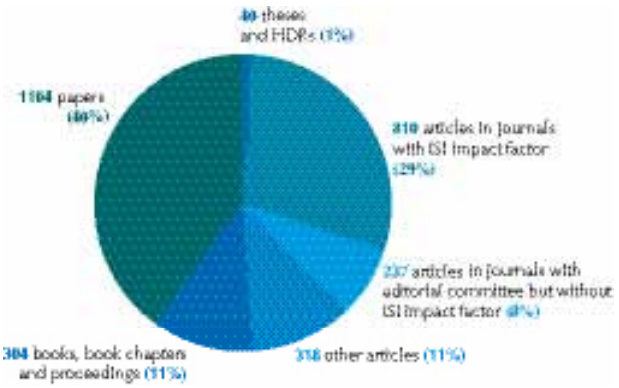

Figure 8. *Total number and share of publications in 2007 and 2008 according to the type of document*

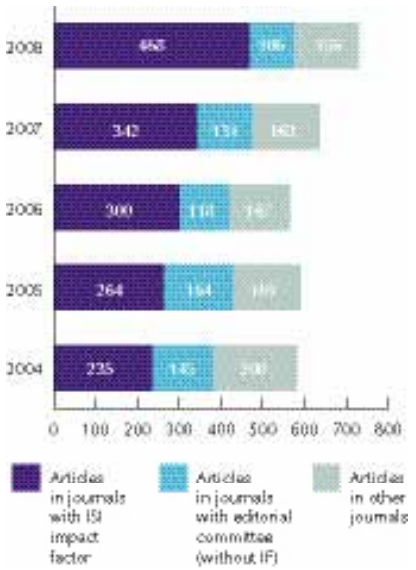

Figure 9. *Changes in the number of articles published in journals between 2004 and 2008 (2008 data are incomplete)*

Partnerships

Since 2006, the Boards of Trustees and Directors General of CIRAD and INRA have been required to work together on drawing up their scientific strategy and programming their research, to ensure that French agricultural research plays a greater role and is more visible on the world stage. This collaboration is being extended to other organizations and higher education establishments. At the end of 2008, a new type of partnership between agricultural research and higher education was launched with the drafting of a decree setting out the founding of a national consortium for agriculture, food, animal health and the environment. These national alliances should gradually come to strengthen CIRAD's European and international partnerships in favour of developing countries. Figures released by the *Observatoire des sciences et des techniques* (OST) bear witness to this trend (table I). In 2006, 53% of CIRAD publications were written jointly with at least one overseas laboratory, 12.1% with a EU country and 41.3% with a developing country.

Table I. CIRAD co-publications, from 2004 to 2006 (according to the OST, CIRAD indicators, 2008).

Type of publication*	2004	2005	2006
Internal co-publication	11	12.8	15.8
Co-publication with other French players	48.8	51	57.4
International co-publication	61.5	54.8	53
EU co-publication	27.5	20.5	12.1
Co-publication with developing countries	35.7	34	41.3

* Values calculated for each type of publication are not additive: a given article may have been written jointly with an EU laboratory and another in a developing country.

Partnerships in France

The share of articles published by CIRAD in journals with ISI impact factor in association with one of the partners in LOLF programme 187 (a French state programme associating CIRAD, INRA, IRD, CEMAGREF, IFREMER and BRGM) has been rising steadily since 2006 (figure 10). INRA is the organization with which CIRAD publishes most, followed by IRD. Co-publications with INRA rose by 78% between 2006 and 2008.

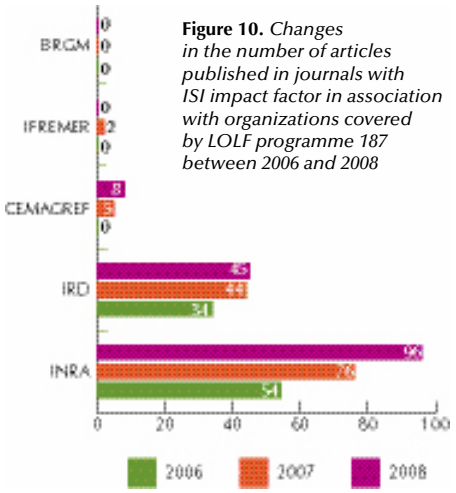

Figure 10. *Changes in the number of articles published in journals with ISI impact factor in association with organizations covered by LOLF programme 187 between 2006 and 2008*

EU partnerships

In addition to the co-publication figures quoted above, CIRAD's EU partnerships can be judged in relation to its participation in projects funded under the 7th European Community Framework Programme for Research and Development (FP7), or their coordination, for which the success rate rose between 2007 and 2008 (table II).

Table II. Changes in the number of EU projects selected between 2007 and 2008

	2007	2008
Number of projects submitted	36	23
Number of projects funded	10	7
Success rate (%)	28	30
Number of projects coordinated by CIRAD	0	4

Partnerships with developing countries

CIRAD has a mandate to contribute to development in the South. Its strategy, scientific topics and research questions derive directly from this, and its partnerships with research teams in developing countries are of vital importance in this respect.

These partnerships take the form of short-term joint projects in response to one-off requests, or structured, long-term projects. For instance, there are five research platforms in partnership (PCPs)—one in Mali, two in Vietnam, one in Costa Rica and one in Cameroon—and three international research units (URPs)—two in Madagascar and one in Senegal—in addition to four regional platforms in Africa: the Centre international de recherche-développement sur l'élevage en zone subhumide (CIRDES) in Burkina Faso, the Centre africain de recherche sur bananiers et plantains (CARBAP) in Cameroon, the Centre d'étude régional pour l'amélioration de l'adaptation à la sécheresse (CERAAS) in Senegal, and the Unité de recherche sur la productivité des plantations industrielles (UR2PI) in Congo. These partnerships with developing countries are promoted through co-publications. The share of CIRAD publications written jointly with at least one laboratory in a developing country rose from 35.7% to 41.3 % between 2004 and 2006 (table I).

CIRAD's determination to boost the quality and efficacy of its operations on an international level has led it to relate the priority lines of research set out in its new strategy to the reality in the field, so as to identify twenty or so main platforms from the many that exist. This operation, which was conducted with research teams, centred in 2008 on Africa and Asia. It is to be completed and presented to the establishment's governing bodies in its entirety in 2009.

Organization in April 2009

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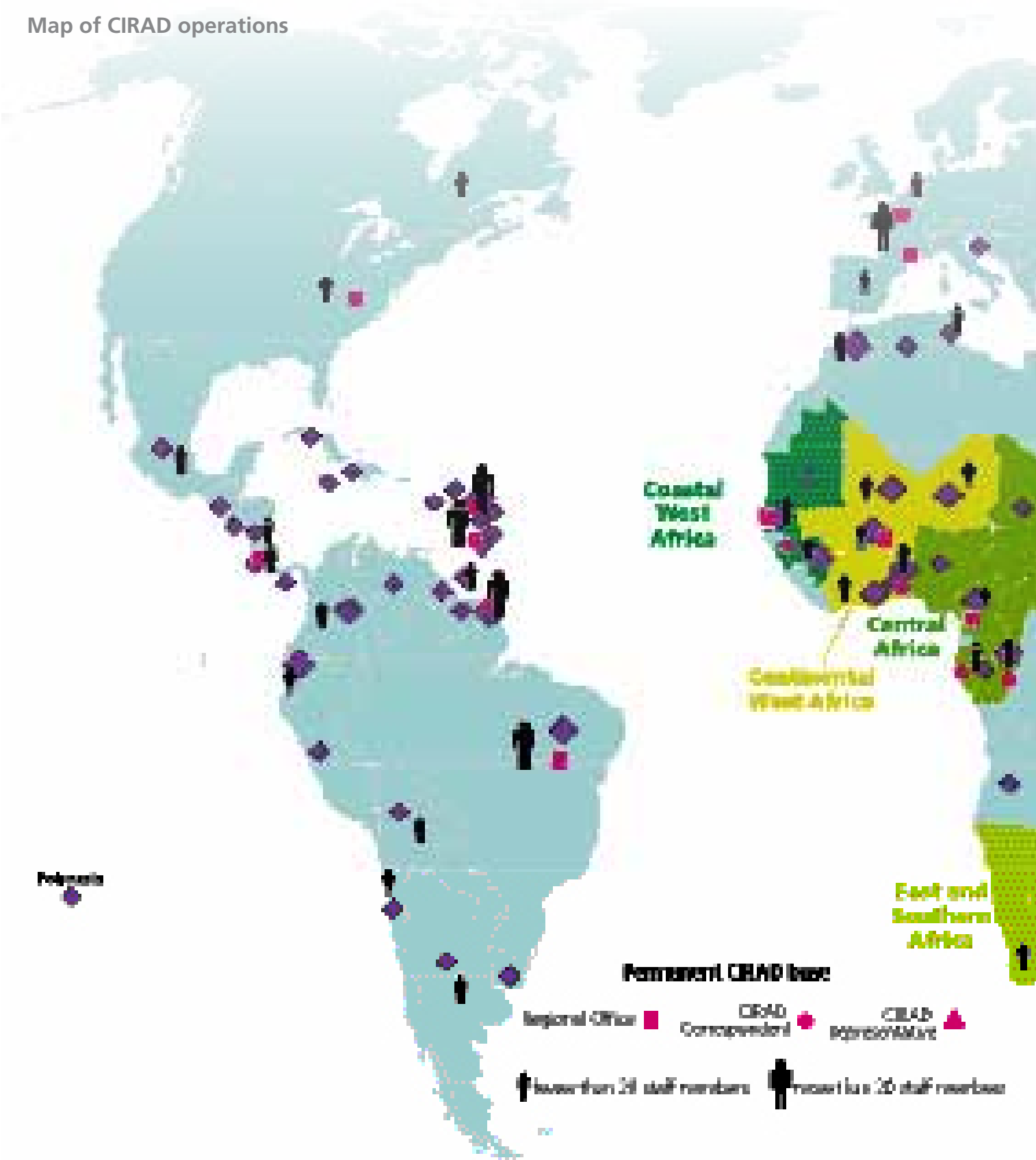
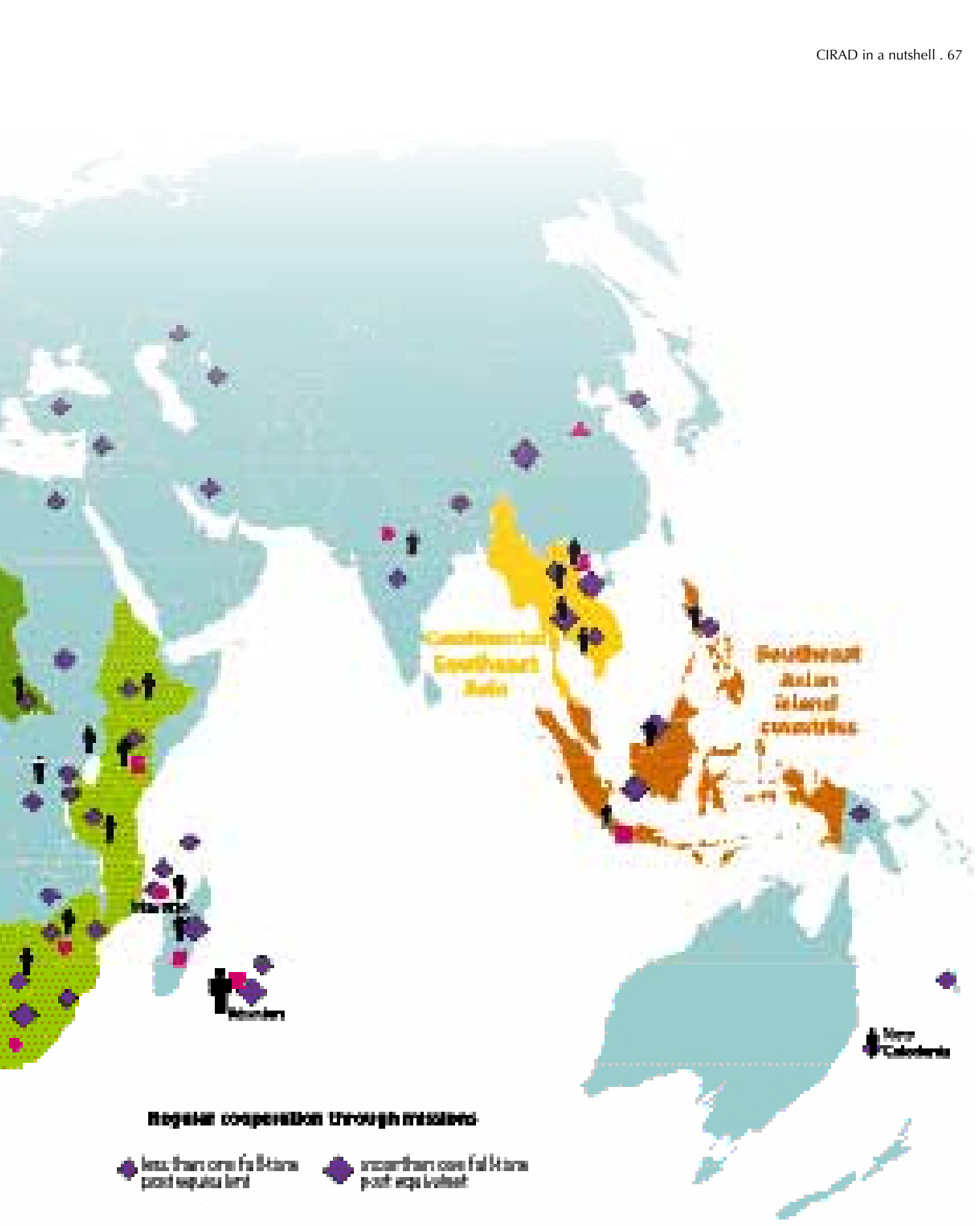
Map of CIRAD operations





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