Science Horizon

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AGRICULTURAL RESEARCH
FOR DEVELOPMENT

Emerging infectious diseases,
health surveillance and agricultural transitions

The urgency of adopting systemic approaches

• June 2020

Recommendations

1. Understanding of the risk factors for emergence and the modes of transmission of zoonoses remains limited and requires considerable research efforts, in particular in terms of surveillance in high-risk areas.

2. Scientific and technical support for health governance at the regional and global levels can improve the use, by different actors, of research results and of national or international recommendations based on the platforms in partnership model developed by CIRAD and its partners.

3. Surveillance systems at all levels (local, national, regional and international), based in particular on epidemic intelligence mechanisms and tools, are key to the early detection of emerging infectious diseases and require an enabling framework for collaboration between researchers and policy-makers, built for the long term and covering the whole prevention and surveillance process.

4. The Covid-19 systemic crisis has revealed the unsustainability of our food and agricultural systems and their vulnerability to shocks, including health shocks. That unsustainability is also a risk factor for the emergence of infectious diseases. The radical transformation of food and agricultural systems is urgent. It should build in particular on innovations and opportunities at the territorial level, to meet the triple challenge of food systems: food and nutrition security, economic and social equity, and environmental protection.

5. Increasing the sustainability of agricultural models, especially through the development, dissemination and adoption of innovative, locally adapted agroecological intensification practices, including digital innovations, provides major opportunities to reduce the risk factors for the emergence of zoonoses and other infectious diseases, to increase the resilience of local production systems and to address changes in food practices, linked in particular to urbanization, population dynamics and trade globalization.

6. New public policies, and their territorial forms, are essential to support and accelerate the changes urgently required in food and agricultural systems.

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Introduction

The ongoing pandemic was originally a health crisis. It very rapidly revealed the fragility of development models, causing a global systemic crisis with economic and social consequences of unprecedented magnitude. Almost all sectors of activity – goods and services – are affected.

This crisis is not surprising: there is no doubt about either the acceleration of the emergence of infectious diseases recorded in the last few decades, or the fact that this acceleration is directly due to global human-induced changes. Nevertheless, there is limited clear understanding of emergence mechanisms and knowledge of natural reservoirs, which creates substantial uncertainties about the places and times of emergence of new infectious diseases, as well as about the extent of the crises that could result from them. The Covid-19 systemic crisis is a perfect illustration of this.

CIRAD is in a unique position particularly suited to the systemic nature of this crisis and to the global responses to it.

This singularity is based on a combination of three characteristics:

- Its geographical position: CIRAD is present in numerous tropical countries with highly varied situations, where the risks of emergence of new infectious diseases are real;
- Its diverse partnerships in the global North and South: CIRAD is at the interface between developed and developing countries, and draws on its research in partnership with French and European research institutes, institutes in tropical countries, regional and international organizations, civil society and the private sector;
- Its scientific diversity: CIRAD mobilizes all of its multidisciplinary, multisector expertise to integrate health-agriculture-environment into its analyses and recommendations.

CIRAD insists on the importance of working simultaneously on two fronts in both developed and developing countries.

1/ to prevent such health crises by seeking to fully understand their origin, their emergence and their spread,

2/ to recover from such crises, particularly by transforming our food and agricultural systems.

To better identify the different actions to be conducted, we structure our proposals around the four epidemic stages for emerging infectious diseases: knowledge and modelling of risk factors for emergence and high-risk areas, preparation for emergence **(Point 1)**, early detection of emergence (which is rare), and management of emergence **(Point 2)**.

Point 1 •

The determinants and trigger factors of emerging infectious diseases call for the protection of ecosystems and the revision of health prevention and surveillance models

The various pressures on ecosystems and zoonoses: studying determining factors and exploring new research areas

Numerous existing and ongoing studies in complementary scientific disciplines, to which CIRAD's researchers actively contribute, address the determinants, factors and trigger mechanisms of emerging infectious diseases, of which 60% are zoonoses.

However, knowledge about the origins of the crisis is limited. Although it is a zoonosis originating in wildlife (like most zoonoses), assumptions about the mechanisms of its transmission from animals to humans are currently unverified (the likely role of bats, known coronavirus reservoirs, unidentified intermediate hosts, etc). Likewise, the factors that fostered its emergence in China in December 2019 are unknown. This research on emergence is essential and must be pursued.

Concerning the issue of wild animals as natural reservoirs more specifically in tropical countries, CIRAD wishes to set the record straight on several aspects:

- The problem is not the consumption of bushmeat, but illegal hunting (especially of protected species) and the lack of health standards in the preparation of this meat, which are at the core of transmission;
- The consumption of bushmeat is rooted in the habits and customs of some populations and is essential for a balanced diet, since they may not have access to other sources of protein.

The SWM (Sustainable Wildlife Management) programme, led by a consortium of partners including CIRAD, the Center for International Forestry Research (CIFOR) and the Wildlife Conservation Society (WCS), specifically deals with these questions and works to develop innovative solutions to ensure the sustainable use of wildlife. A new component of this project is aimed at further exploring the issue of hunting and poaching of bushmeat as possible sources of zoonoses and of the emergence of new pathogens for the human populations exposed.

Where transmission mechanisms are concerned, CIRAD's researchers also contribute with their partners to research focusing on human/animal interfaces, for example:

- In West and Central Africa, to understand how the Ebola virus is transmitted between reservoir species, intermediate species and humans (Ebo-Sursy project - Ebola virus surveillance and capacity building);
- In Southeast Asia, to develop tools and methodologies for the surveillance of animal diseases and control systems: REVASIA (Research for Evaluation of Animal Health Surveillance and Control in South East Asia) project, whose end goal is to produce generic tools for the assessment and modelling of influenza virus surveillance systems, which are applicable in the South but also in the North.

Regarding the conditions for emergence, the researchers have identified and regularly warned of the risk factors for the emergence of zoonoses that should be taken into account – agricultural intensification, land use change, population dynamics, environmental degradation, biodiversity loss, climate change, etc –, without succeeding in identifying the complex mechanisms governing them. For example, tropical deforestation has been put forward as a possible factor for the emergence of infectious diseases. We nevertheless note that there are a very few studies on this subject and further research needs to be conducted in order to test this assumption, which is not yet proved by any data in our possession.

Regarding the linkages between biodiversity and Covid-19, we invite you to consult the very informative document published recently by the French Foundation for Biodiversity Research (FRB), of which CIRAD is a member, to which researchers at CIRAD contributed: *"The Link Between Covid-19 and Biodiversity: A Report Commissioned by the French Public Authorities"*.

Our capacity to prevent the emergence of infectious diseases is thus strongly affected by this lack of knowledge and understanding of emergence mechanisms, which justifies our ongoing efforts to fill this gap.

Emergence and propagation mechanisms: the importance of appropriate, co-developed and early surveillance

Since we do not yet know how to prevent them, it is important to monitor diseases in order to detect them as early as possible and to halt their spread. Indeed, the main factors that foster the rapid spread of emerging infectious diseases are well known: urbanization (population concentration and land use change) and movements of people and goods. Although it is possible to limit them (e.g. through lockdown and distancing measures), the economic and social consequences are extremely serious. **It is thus essential to identify outbreaks as early as possible in order to stem the spread and to minimize the use of these measures in space and time.**

Focusing on the surveillance and early detection of outbreaks thus seems essential. The identification of risk factors for emergence (see point 1) helps to pinpoint the geographical areas with the highest risk of emergence of new infectious diseases (no continent is spared), and to concentrate our surveillance and early warning efforts in those areas.

CIRAD is working to develop instruments for local, regional and international surveillance, in partnership with health workers and stakeholders in local agricul-

tural and food systems in tropical countries, and with international agencies such as the World Health Organization (WHO), the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO).

These surveillance systems operate at different levels. They include:

- **Local/national surveillance systems** with surveillance issues at the animal/human interface. For example, the **ZooCov project** launched recently and coordinated by CIRAD is aimed at developing a flexible, integrated system for early detection of virus transmission between wildlife and humans in Cambodia. **It was selected by the French National Research Agency (ANR)** in the context of a specific call for research on coronaviruses.
- **Regional surveillance systems:** CIRAD draws in particular **on four regional "platforms in partnership for research and training" (dPs) that it has set up since 2009,** mobilizing key actors in the health sector to improve the impact of research: in the Caribbean (CaribVet regional network), the Indian Ocean (One Health network - Indian Ocean), Southeast Asia (Emerging Diseases in Southeast Asia network – GREASE) and in Southern Africa (Production and Conservation in Partnership research platform).
- **Supranational surveillance systems such as the innovative digital surveillance mechanism being designed as part of the MOOD project (MOnitoring Outbreak events for Disease surveillance in a data science context). Coordinated by CIRAD and involving 25 partners, its aim is to exploit innovative data analysis and mining techniques linked to big data from multiple sources,** in order to improve the surveillance of emerging infectious diseases in Europe, including antimicrobial resistance. **Ultimately, the MOOD project will set up an open-access platform to enable real-time analysis and interpretation of both data from spatio-temporal analysis and social networks, and epidemiological data and genetic sequences associated with climate, environmental and socioeconomic variables.**

The findings of our research thus show that in order to increase the reliability and effectiveness of surveillance systems, some factors are decisive, such as:

- **Acknowledging and drawing on the active participation of all actors** (public authorities, patients, livestock farmers, health professionals, intermediate bodies, local elites) to co-construct surveillance systems tailored to local circumstances;
- **Collecting high-quality data** on biodiversity, climate and land use change, which are considered as weak signals in the assessment of risks of emergence, paying special attention to the sovereignty of health information;
- **Making use of untapped sources of information, using digital surveillance (see MOOD project);**
- **Connecting regional One Health networks** – especially the four platforms for research and training in partnership – **to build a global structure.**

The advantages for health, ecology and society of a new holistic approach to health

CIRAD has extensive experience of working on emerging infectious diseases (Ebola, MERS-CoV, avian and swine influenza viruses, Rift Valley fever, Nipah) in partnership with research institutions in tropical countries, as well as with French institutes (Institut Pasteur, IRD, etc) and regional and international organizations.

Very early on, our researchers adopted and adapted the One Health approach, a systemic socio-ecological approach that takes account of relationships between health, environment and human activities with a view to long-term sustainability. This holistic approach has enabled us **to renew our vision of health and to foster collaborations between professionals in these different fields, from different scientific disciplines, at the national and regional levels,** in order to also improve the transfer of research results to decision-makers.

The EBO-SURSY project, for example, focusing on early detection of the Ebola virus in West and Central Africa, **takes an integrated approach** including: **1/** participatory surveillance protocols for the early identification of diseases originating in wildlife; **2/** awareness raising among local communities about the risks linked to bats and to bushmeat; and **3/** capacity building for local health and veterinary services and national park employees.

Despite considerable progress in the last 20 years, the integration of health-environment-human activity issues still requires further efforts. Our researchers therefore go further to apply this integrated approach at the territorial level. The health sector can no longer be considered independently of agricultural dynamics. On the contrary, it needs to be closely integrated with other rural development dynamics and should become a key issue in territorial dynamics, in connection with the agroecological transition.

As part of a project currently being prepared with AFD (Agence Française de Développement), for example, CIRAD and its partners are working in different areas (Europe, Africa, Asia and the Caribbean) with territorial actors – State representatives, local authorities, NGOs, producers' associations – to develop methods to assess the impacts of livestock farming, agriculture and natural resource use on territorial health and to identify and collectively negotiate healthier alternatives. On this basis, they are establishing alternative practices in territorial systems ("Living Labs") and are monitoring the impacts of these practice changes using indicators co-developed with the local communities. This approach is based on cooperation between public and private actors in the fields of health, agriculture and environment.

Point 2 •

A pandemic crisis such as Covid-19 reveals the weaknesses of food and agricultural systems and calls for their immediate revision

From the management of emergence to the paralysis of economies and societies: towards a major food crisis?

By limiting the concentration and movement of people, measures to manage/control the spread of the epidemic destabilize all sectors of the economy that depend on regular, close physical exchanges. In tropical countries, the food and agricultural sector is the one that is most dependent on these exchanges and is at the same time a leading factor in the emergence and spread of emerging diseases.

The crisis has thus revealed the weaknesses of food systems in developing and industrialized countries. Our research shows that these weaknesses are exacerbated because societies now require that these systems ensure:

- **Food and nutrition security (producing and distributing healthy, diversified food that is accessible to all),**
- **Social and economic equity (providing decent jobs and incomes),**
- **Environmental integrity, a lower carbon footprint and greater resilience to risks.**

Those three objectives are threatened by the crisis:

- **Agricultural practices and changes in land use cause the rapid and irreversible deterioration of social and environmental systems** (indiscriminate use of chemical inputs and pesticides, drugs, antibiotics and veterinary products; poor effluent management; biodiversity loss; food, soil and water contamination, etc), and accentuate the risks of the emergence of new infectious diseases;
- **The structure of food and agricultural systems determines food sanitary quality and may increase the risks of the emergence of infectious diseases** (live animal markets, local and international trade in contaminated food products, people gathering in markets, etc);
- **Measures to limit the spread of the epidemic have badly shaken food and agricultural systems,** depriving many actors in these sectors of jobs and income: agricultural producers, transporters, processors, retailers and restaurateurs, thereby causing problems of access to food.

A marked increase in food insecurity at the global level is looming in both developed and developing countries, even if it is currently difficult to estimate the number of people that will be added to the 820 million already food-insecure worldwide. In West Africa and the Sahel, a priority area for French cooperation, 11 million people now require food aid following the security crisis in the Sahel; this figure could rise to 51 million in the coming weeks and months due to the combined effects of the Covid-19 health crisis, the threat of locust swarms, and the expected impacts of climate change (according to projections by the Food Crisis Prevention Network in the Sahel and West Africa -RPCA).

Supporting local innovation within a systemic, territorial approach

Since the beginning of the crisis, thanks to its expatriate researchers and their network of partners, CIRAD has been analysing the consequences of this crisis for actors in food and agricultural systems: jobs in India, inequalities between producers in Colombia, access to food for the poorest in Brazil, the crisis in demand, the dairy sector in Madagascar, Burkina Faso and Senegal, and the cocoa sector in Ivory Coast. The signals are surprising for non-specialists: subsistence farming in Africa, which is criticised for its poor performance, could prove far more resilient than many other agricultural models. Understanding what is actually happening in the countries in which CIRAD works is the first step in supporting the necessary transformation of food and agricultural systems.

CIRAD's expertise has helped to reveal the factors that determine the resilience of agricultural sectors to such shocks: agricultural producers organizing collective alternative solutions (storage capacity for goods that can no longer be sold, new marketing methods in short supply chains, for example); limited dependence on imports of agricultural inputs (a specific weakness of poultry sectors, which are often dependent on imports of chicks and feed); diversified marketing methods (for example international and local markets); and the capacity to maintain jobs for farm workers (their dismissal destabilizes local economies and increases the risk of infection when these workers are forced to return to their region of origin).

In the medium to long term, strengthening food systems in the South and the North requires a better structuring of local food sectors based on SMEs that can supply domestic markets at a moderate cost and provide jobs for the most vulnerable. **Sustainable, resilient food policies call for greater consideration of town-country links, urban food insecurity, food systems based on agroecological principles** (which will be spelled out in point 3) that mobilize local resources (natural, financial, human capital), the socioeconomic development of territories through processing activities, and the challenges of jobs and income.

Some of these proposals were identified during the 2014 Ebola virus (MVD) epidemic in West Africa. After assessing the impact of the crisis on agricultural value chains, CIRAD called for the establishment of travel corridors for safe regional trade in goods, and support for post-crisis recovery (information systems, distribution of seed and fertilizers).

These potential changes are not applicable everywhere and in all conditions. Although they provide answers as to "what can be done", they do not propose any ready-made solutions as to "how to do it". Faced

with the multi-functionality of these systems, their vulnerabilities and the threats to them, and given their long-term unsustainability, **CIRAD's researchers focus on territorial approaches. Such approaches take account of the local food and agricultural system as a whole,** foster the participation of all actors, accompany and support their strategies and innovations, co-develop a shared vision of the future, identify the changes suited to local circumstances and define the roles and responsibilities of all actors, both public and private, in achieving this. Research should thus promote the concept of "smart territories", which associates knowledge engineering and the use of information technologies, capacity building, public policy assessment and the creation of territorial observatories..

Point 3 • Changes in agricultural practices to reduce the risks of emergence and to increase the resilience of food and agricultural systems: the benefits of agroecology

Among the risk factors for the emergence of new infectious diseases, including zoonoses, are agricultural intensification (livestock and plant production across vast areas, use of the same species and varieties, lack of diversification, etc), land use change (deforestation, urbanization, etc), and environmental degradation (biodiversity loss, ecosystem destruction, climate change, etc). **Limiting these factors means profoundly transforming our agricultural practices while continuing to fulfil the three functions of food systems:** food security, socioeconomic equity and environmental integrity (see point 2). This transformation should also work towards mitigating the risks linked to climate change, while addressing changes in food practices linked in particular to urbanization, population dynamics and trade globalization.

From this perspective, CIRAD focuses particularly on the development, dissemination and adoption of agroecological practices (which apply the concepts of ecology to agricultural systems) **in tropical and Mediterranean countries,** and the public policies that accompany them, which are applied and applicable in different ways in the North and the South.

Agroecology is based on the optimization of the biological and ecological processes involved in the regulation of natural environments, the rational management of resources and the sustainable management of nutrient cycles. **This has led us to identify three major principles that apply differently depending on the geographical area:**

- **Defining agricultural performance differently, beyond yield alone, integrating aspects such as nutritional quality, ecosystem services, negative externalities (disservices), jobs and income generated for producers, or their technological and financial dependence.**
- **Inventing intensification pathways that make use of the ecosystem services of biodiversity (ecological/agroecological intensification via different approaches), in order to limit the use of inputs in overexposed areas (especially developed and emerging countries), without prohibiting the use of inputs in under-resourced systems (especially in developing countries).**
- **Promoting public policies to support family farms – which make up the overwhelming majority of farming systems worldwide – including access to land, infrastructure, services, value chain development and added value, or market organization in rural territories.**

This is the objective of the FAIR project launched by CIRAD and its regional and international partners in 2020 in West Africa (Burkina Faso, Mali, Senegal), with the aim of promoting agroecological intensification in agriculture to increase the resilience of farms in the Sahel. This project is financed by the European Union DeSIRA (Development Smart Innovation through Research in Agriculture) programme, and by AFD.

Several lessons can be drawn from CIRAD's experience:

- Research on agroecological practices is based on adapting practices to specific local conditions, but it also enables the production of generic knowledge that can be transposed and adapted to other contexts;.
- Technical innovations are aimed at increasing the effectiveness of all factors in the system in question, whatever the scale, from the plot to the farm or the territory;
- Such innovations are only possible if they are co-developed with local stakeholders;
- The platforms in partnership for research and training (dPs) coordinated by CIRAD and its partners serve to structure the development, adoption and dissemination of these innovations.

Conclusion

The systemic crisis we are facing is having major consequences for all economic sectors, but also underlines – through its causes and trigger mechanisms, the structural weaknesses it reveals and the sustainability responses it requires – the systemic centrality of agrosystems.

Although there is no consensus about the new food and agricultural models to be built, or any dedicated forum on this issue, the design of ad hoc, contextualized solutions offers the possibility of responding, at least partially, to the questions raised by this crisis.

CIRAD is at the disposal of the public authorities and development players to discuss its research, to analyse the lessons drawn from the numerous projects conducted in partnership and to contribute to the current debate.

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