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From natural process regulation to agroecosystem design

Agroecological solutions for the Global South – an example of service plants

Intensive agrosystems systematically eliminate some natural ecosystem characteristics, especially by drastically reducing biodiversity and species interactions through deep and frequent tillage, woody species removal, use of a narrow range of crops at the field and landscape scale, etc. The agroecological approach therefore consists mainly of (re)introducing and managing functional, cultivated and associated biodiversity within agrosystems in order to enhance ecosystem services.

The diversity of communities that prevail in agrosystems likely helps ensure provision of a number of ecosystem services[1,2]. For instance, the introduction of a service plant will modify the composition of the plant community, thereby promoting weed control. Service plants must satisfy a set of sometimes contradictory characteristics[3] (Figure). They are increasingly used in various monospecific cropping systems, such as banana plantations and fruit orchards, to control weeds (Photo), thereby curbing herbicide use. Furthermore, the inclusion of a cover crop modifies the system's overall functioning in terms of water and nutrient cycles, as well as interactions between insect and microorganism communities. Introducing a new resource in the system is an effective food web modification lever. Service plants are also used with annual crop species via numerous techniques to fulfill various objectives, i.e. plant protection through attractive and repulsive processes, or soil protection. For instance, service plants in mulch-based systems can help maintain permanent plant cover while limiting tillage. This practice reduces erosion and enhances the soil biological activity, hence contributing to sustainable soil organic matter management. Agroecological principles are based on natural ecosystem functioning analyses. For larger than plot scales, insight into several organizational levels is needed to implement these principles in agrosystems. Yet the agroecological approach must also be mainstreamed into more or less territorialized social systems, including value chains and, more generally, food systems.

▲ *Cover plants in a* Citrus *plantation, Réunion (France).* © *E. Malézieux*

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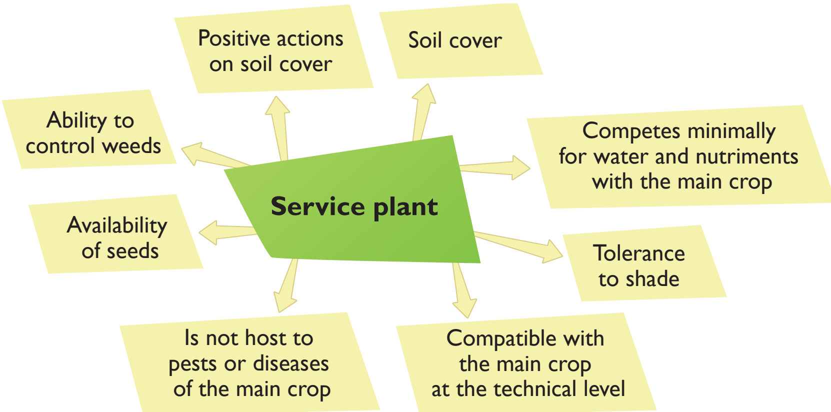

Antimicrobials in livestock farming in the Global South

Minimizing their use while curbing health and socioeconomic risks

Major changes in livestock farming methods that have taken place over the last 50 years have led to the widespread use of antimicrobials in livestock and aquaculture. In some countries of the Global South—due to the growing demand for animal protein and the absence of appropriate regulations—the volume of antimicrobials used continues to rise, which has led to the emergence of bacterial resistance. These bacteria spread through natural food webs and commercial food chains (Figure), from local to global scales via human mobility and trade flows. Resistant bacteria pose a threat to human and animal health and ecosystems. International organizations and governments are calling for interventions to reduce antimicrobial use in livestock. The effectiveness of such actions depends on the implementation of One Health approaches combined with agroecological principles.

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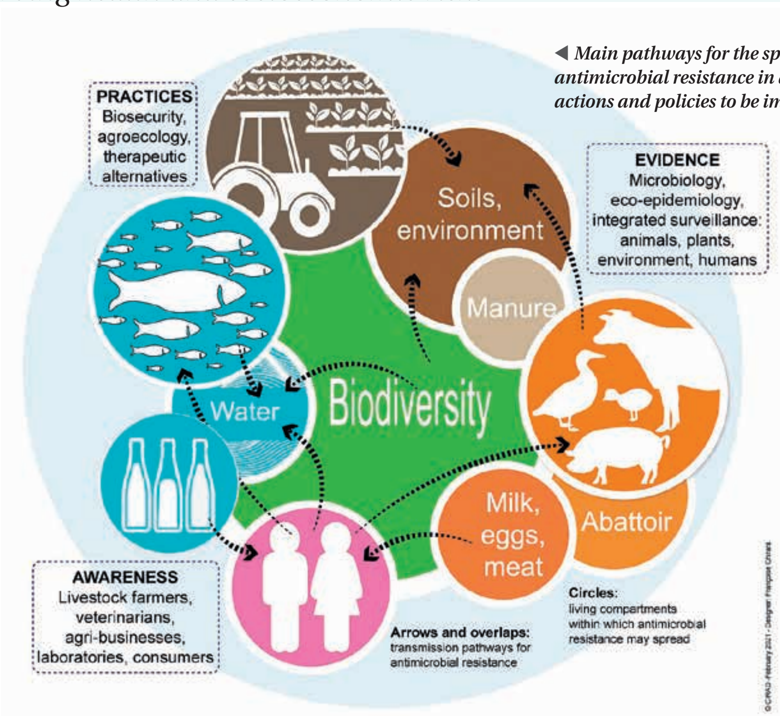

◀ *Main pathways for the spread of antimicrobial resistance in agriculture: research, actions and policies to be implemented.*

CIRAD is implementing a set of interdisciplinary approaches, drawing on qualitative and quantitative research in Asia (Vietnam, Cambodia) and Africa (Mozambique, South Africa, Senegal):

- **participatory approaches** aimed at identifying potential changes in livestock farming practices to enhance animal disease prevention and reduce the use of antimicrobials, while using them rationally and curbing the negative health and socioeconomic impacts on the livelihoods of livestock farmers, particularly in the most vulnerable regions
- **research on therapeutic and preventive alternatives**
- **design and assessment of integrated surveillance systems (One Health)** to detect the emergence of resistance and evaluate the effectiveness of implemented measures
- **research on resistance circulation between human, animal and environmental compartments**
- **research on antimicrobial supply chains and on the regulatory and institutional frameworks for their use.**

In Vietnam, for example, a stakeholder analysis and companion modeling generated a conceptual and methodological framework for implementing the One Health concept in antimicrobial resistance surveillance. Farmers and other key stakeholders are involved in research and innovation processes to support the transition to safer antimicrobial use.

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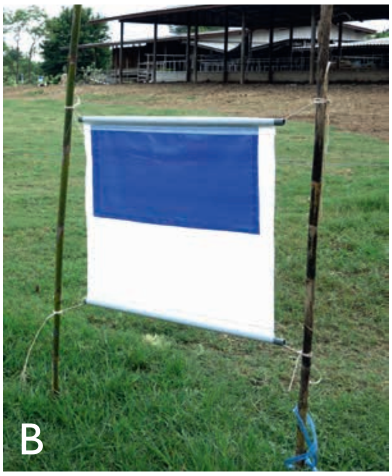
Controlling hematophagous flies while curbing insecticide dissemination

Development of attractive screens and traps

Hematophagous flies (tabanids, *Stomoxys* spp., tsetse flies) are a major scourge for humans and animals because of their bites and the transmission of parasitic (trypanosomosis, besnoitiosis), bacterial (anaplasmosis, Q fever) and viral diseases (bluetongue, West Nile, African swine fever). These pests are conventionally controlled through massive insecticide treatments (sprays, pour-ons), which are not very effective and result in insecticide uptake in foods and dissemination in the environment. To reduce this pollution, the FlyScreen research program, conducted by CIRAD in collaboration with the University of Montpellier and Kasetsart University (Bangkok), the National Veterinary School of Toulouse (ENVT) and the AtoZ company, has developed blue and blue-and-white polyethylene screens (Photos A and B), which are specifically attractive to all hematophagous flies (Photo C). **These FlyScreens—pyrethroid-impregnated in an innovative way (patent pending)—enable targeted destruction of pest insects without insecticide dissemination in the environment.** A proof of concept of control efficacy by the Multi Targets Method (about 20 screens per farm) (Photo A) has been reported. FlyScreens will be used in Africa for controlling tsetse flies and in Asia against other hematophagous flies. This major breakthrough cannot, however, be implemented in Europe and America due to the widespread pyrethroid chemoresistance of flies. The new BioFlyTrap program (modelled on FlyScreen) set up by CIRAD, IRD, INRAE, ENVT and a private partner, aims to develop simple, light, insecticide-free, biodegradable and inexpensive capture traps to be used on farms within a "Multi Targets Method"—a promising project for efficient agro-ecological control, without plastic or insecticide pollution of the environment.



▲ ***Photo A.*** *Multi Targets Method: installation of 20 attractive FlyScreens for controlling hematophagous flies.* © *M. Desquesnes*

◀ ***Photo B.*** *A Polyethylene deltamethrin-impregnated screens used in Thailand.* © *M. Desquesnes*

▲ ***Photo C.*** *A FlyScreen coated with a sticky film, illustrating the high attractiveness to hematophagous flies (here* Stomoxys *spp., in Réunion).* © *Y. Grimaud*

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