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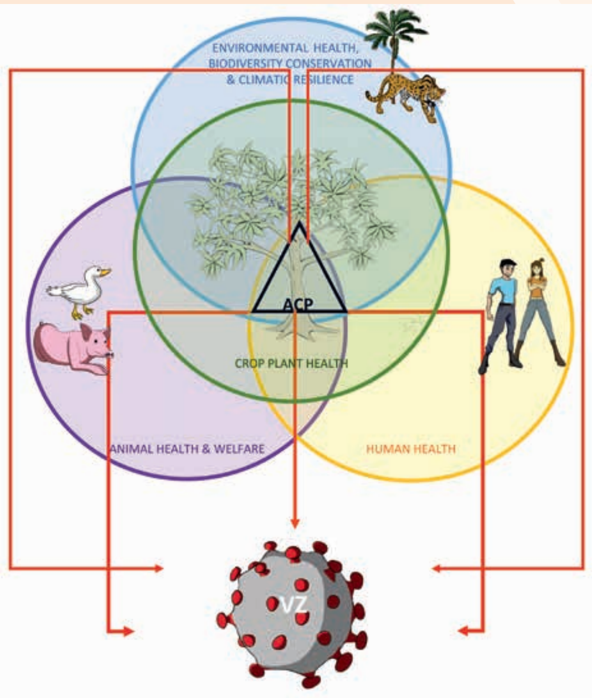
Enhancing biological interactions

Agroecology for crop protection and zoonotic disease control

Recent viral zoonotic outbreaks have been partially attributed to the negative impact of human activities on ecosystem biodiversity. A review of the scientific literature on interactions between crop protection (CP) practices and viral zoonoses (VZs) encompassed over 200 references. This review highlighted actual or potential interactions between VZ and CP practices based (for the latter) on efficiency improvement (conventional practices with agrochemical insecticides and rodenticides), substitution (physical/mechanical or biopesticide-based methods), or redesign (biological control via habitat conservation and management, including some forms of crop-livestock farming integration). CP practices covered in the literature review primarily targeted vertebrate pests (rodents and bats) and insects, but also plant pathogenic microorganisms and weeds. Methods based on efficiency improvement and substitution (partly), as well as some crop-livestock integration practices, have shown negative, mixed or conflicting impacts on VZ risks. Conversely, **redesign-based practices in the agroecological crop protection (ACP) framework generally resulted in VZ prevention via different processes** (Figure). Several examples concerned cropping systems studied by research units of the Occitanie region scientific community, e.g. rice cropping-duck rearing integration, the fostering of vertebrate predators in oil palm plantations, or of weaver ants in fruit tree orchards. The literature review also revealed that ACP, while helping integrate plant health within the broader One Health concept, also addresses other major global challenges, given its positive impacts in terms of enhancing climate resilience, animal welfare and biodiversity conservation (Figure).



◀ ***Agroecological crop protection (ACP) (central black triangle): direct or indirect reduction (red arrows) of viral zoonotic risks (VZ), contribution to the One Health concept extended to the four health types (circles), including global climatic resilience, biodiversity conservation and animal welfare challenges.*** *Adapted from Ratnadass & Deguine (2021)*

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Biodiversification enhanced by service plants

A lever for the agroecological transition of banana agrosystems

In the 1980s, banana agrosystems in the French West Indies were based on intensive monoculture systems with little diversity and heavy use of synthetic pesticides (particularly nematicides and insecticides) and mineral fertilizers. The necessary agroecological transition of these systems first involved prophylactic cropping strategies based on the use of healthy planting materials (micropropagated plantlets) combined with fallowing and crop rotations that had a sanitizing effect against soilborne pests. The plant biodiversity initially introduced in these systems was underpinned by crops or herbaceous plants initially selected for their service plant role to control the endoparasitic nematode *Radopholus similis* thanks to their non-host status.

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▲ ***A banana-*Crotalaria *association.*** *© R. Domergue*

A generic approach was then developed, based on the functional traits of these plants, i.e. their individual features related to their functioning in the agrosystem. The aim was to select these so-called 'service plants' for a supplementary broader range of ecosystem services, and to combine them as multifunctional cover crops for weed control, nitrogen resource optimization, soil structure enhancement, erosion mitigation, etc. **This new pathway has oriented French West Indian banana systems towards plurispecific agrosystems spatiotemporally combining plant species with complementary traits.** These banana systems—enriched by this chosen functional biodiversity—are shifting to an increased extent towards organic agriculture, conservation agriculture and agroforestry while seeking functional complementarity with trees. This transition is under way in a partnership framework involving banana growers' groups and their R&D technical services. It could also concern, in a contextualized manner, countries of the Global South in a quest for banana agrosystem sustainability.

▲ ***A banana*-Desmodium ovalifolium-Arachis repens *association*.** *© H. Tran Quoc/GECO*

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Ecological engineering-based interventions for sustainable pest management in rice-based cropping systems

▲ ***Habitat manipulation with marigolds to maintain natural enemies in rice ecosystems.***
© Chitra Shanker/IIRR, Hyderabad India

Ecological engineering is a habitat management approach aimed at providing shelter and food for natural pest control agents while promoting biodiversity and structural complexity within the agroecosystem. Ecological engineering involves modification to enhance biological control for sustainable pest management. It includes habitat management to foster natural enemy survival and action via increased floral diversity on rice field bunds, for instance. Unlike other flowering plants, rice lacks floral and nectar resources to attract natural enemies. **Planting additional floral/nectar-rich flowering plants on rice bunds can ensure year-round resources for natural enemies.** Border plants have been shown to increase parasitization of yellow stem borer and leafhopper egg masses[1,2].

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