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Reducing pesticide use in tropical agriculture for human and ecosystem health

• March 2026

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While pesticides[1] play an important role in safeguarding crop yields and securing farmers' incomes across diverse agricultural systems, they pose significant risks to human health (INSERM, Collective Expertise, 2022), farm workers, local communities and consumers facing increasing exposure to harmful chemicals. Their environmental impacts – such as water contamination, biodiversity loss and soil pollution – are also well documented[2]. Moreover, over time, pesticides erode the productivity they are supposed to enhance, as pests and diseases are becoming increasingly resistant in the medium to long term, threatening the sustainability of pesticide-reliant farming systems. Their widespread and increasing use therefore underscores the urgent need to rethink our dependence on these chemical inputs.

Despite growing international recognition of the need to reduce pesticide use while maintaining agricultural productivity, specific measures to meet these ambitious goals remain limited. Global frameworks, including the Aichi Biodiversity Targets (2010) and the Kunming-Montreal Global Biodiversity Framework (2022), as well as regional initiatives such as the European Union's Farm to Fork Strategy (2020) and China's Zero Growth Policy (2015), emphasise the urgent need to mitigate pesticide risks. However, these initiatives also show that regulatory action, though essential, is not sufficient on its own to drive the systemic changes required. Without access to affordable alternatives for producers, clear and measurable indicators, and robust support systems, farmers – particularly those in resource-limited settings – will not be able to reduce their use of synthetic pesticides.

By mitigating pest-related losses, pesticides have long been a cornerstone of modern crop protection strategies. In low- and middle-income countries (LMICs), where agricultural intensification remains limited, pesticide use is generally lower than in the highly intensive farming systems of the Global North, which emerged from the Green Revolution of the mid-20th century. The growing use of pesticides in agriculture in the Global South is nevertheless increasingly documented[3]. This trend is primarily driven by the intensification of farming systems to meet population growth and growing demand for food. The increasing use of pesticides in LMICs is also fuelled by high exposure to pests and diseases under tropical climates, combined with the rapid spread of infestations. Pesticides have also helped reduce labour requirements (weeding being particularly labour demanding under tropical climates) – a function that has become increasingly important as the agricultural workforce declines and younger generations turn away from farming. Finally, institutional weaknesses such as limited regulatory oversight and insufficient public resources, impede efforts to improve the sustainability of farming systems using pesticides.

Building on its long-standing commitment to sustainable agriculture, the French Agricultural Research Centre for International Development (CIRAD), in collaboration with a number of partners from the South and the North, and with the support of Agropolis Fondation and the FARM Foundation, launched the "PRETAG" (Pesticide Reduction for Tropical Agricultures, pretag.org/) initiative in 2022 to address the challenge of reducing synthetic pesticide use in tropical farming systems while maintaining the farm's viability. PRETAG aims to pave the way for effective pesticide reduction across key tropical value chains, particularly banana, cocoa, coffee, rice and vegetables. The initiative examines the technical, institutional, organisational and partnership-related barriers as well as the drivers of a transition towards reduced synthetic pesticide use in tropical agricultures. It brings together multiple research-action pathways designed to develop and implement sustainable alternatives that reflect the realities and constraints faced by producers and decision-makers in LMICs. ■

pretag.org/

1. The term "pesticides" used in this document refers to synthetic herbicides, fungicides, and insecticides used in the field or `after harvest for food preservation.
2. Sharma *et al.*, 2019.
3. Fuhrimann *et al.*, 2022; Olguín-Hernández *et al.*, 2024

Key messages

- In countries with high population growth, the urgent pressure to increase food production and competitiveness, combined with intensive lobbying and poor access to information, often overshadows the short- and long-term risks of pesticide use, including for the direct users.
- Farmers' realities must be placed at the heart of regulatory frameworks and public policies to support the widespread adoption of alternatives to pesticides. Efforts should strike a balance between economic viability, social equity and environmental sustainability.
- Pesticide use in many tropical countries remains poorly regulated, in terms of both sales and on-farm practices. Raising awareness through the growing body of scientific evidence – on the risks as well as the alternatives – will be key to helping all stakeholders shift priorities and move jointly towards the co-construction of sustainable pathways.
- Reducing pesticide use is rarely a matter of one-to-one substitution. It requires the development of integrated, phased strategies grounded in systemic thinking. Agroecological approaches combining technical measures (monitoring and prevention, biological control, resistant varieties, physical control and use of biopesticides), organisational innovations and support for public policies offer significant potential for developing alternatives to synthetic pesticide use.
- A fair and sustainable transition away from synthetic pesticides requires mechanisms that share costs, benefits, risks and responsibilities across all actors of the value chain. Multi-stakeholder initiatives such as PRETAG – linking farmers, policymakers, businesses, researchers and civil society – are essential for designing viable alternatives and aligning market incentives with sustainability goals.
- Existing knowledge and experience already offer the possibility of immediate, practical and affordable alternatives for phasing out the most hazardous pesticides. We propose initiating the transition with this first step and then continuing it through dialogue, according to a timeline discussed with the various stakeholders.

Point 1 • Insights into pesticide use: challenges and opportunities in tropical agricultural systems

Challenges

Diversity of the productions systems. Pesticide use in tropical agriculture varies widely, from minimal or no application to heavy reliance, reflecting differences in local conditions, economic realities, crop requirements and value chains. This variation mirrors the diversity of farming systems, which range from subsistence farming and small-scale commercial farms to large-scale agro-industrial operations. However, since the 2000s, the increase in pesticide use affects all production systems encountered in tropical agricultures[4]. Alternatives to pesticide use adapted to each context are needed, in addition to generic rules applicable in different locations.

Agro-climatic factors. Crops are particularly vulnerable to pests and diseases in areas with high temperatures and humidity and the absence of a marked cold season that would break the cycle of pest and disease development. Climate change in tropical countries also exacerbates pest and disease pressures by expanding their geographic range and increasing their impact on crop productivity.

Socio-economic factors. On the one hand, rising labour costs, coupled with falling pesticide prices (driven by the global restructuring of the phytosanitary industry and policies that support pesticide use) have significantly shifted the economic balance in favour of chemical inputs. Farmers have therefore been encouraged to make pesticide use a profitable strategy to reduce crop losses. On the other hand, in the context of deep demographic transitions, low- and middle-income countries are under increasing pressure to scale up food production in order to address urgent food security needs and ensure food

4. Côte *et al.* 2025

sovereignty. In this context, pesticides are often perceived as necessary for domestic production systems to remain competitive in global agricultural markets dominated by industrialised and emerging economies that rely heavily on pesticide-intensive agricultural models.

Lack of awareness and hidden pesticide costs. Little knowledge or information is available in tropical contexts on the hidden costs of pesticides (associated with impacts on human health, biodiversity loss, soil and water quality degradation, and other long-term sustainability issues), particularly in LMICs. Many smallholder farmers, especially in areas with high illiteracy rates, struggle to access accurate information on pesticide risks and safe practices. This lack of access, along with inadequate training and regulatory oversight, contributes to unsafe pesticide use practices that increase risks to human health and generate negative environmental impacts.

Public policies. In many LMICs, existing policies continue to promote pesticide use through a range of direct subsidies, tax exemptions and support programmes, as well as indirectly through technical extension services. Meanwhile, limited investment in R&D and regulatory frameworks continues to impede the development and adoption of sustainable alternatives.

Regulatory factors. Weak or nascent regulatory and legal institutions in LMICs, coupled with limited enforcement capacities, imply that banned pesticides and highly hazardous pesticides (HHPs) often remain in use. This situation can be further exacerbated by fraud and counterfeiting. The export of HHPs from high-income to low-income countries highlights persistent global inequalities and hinders progress towards sustainable agricultural transitions. In addition, the implementation of the so-called "mirror clauses" by the European Union (EU) – which require that imported agricultural products comply with standards equivalent to those enforced within the EU, particularly in relation to pesticide use – raises important political, economic and technical challenges. Adopted in 2023, the regulation prohibits since January 2026 the import of agricultural products treated with certain active substances that are banned in the EU. For producers in the Global South, this could create opportunities to access premium or environmentally-conscious markets. However, these clauses also pose substantial challenges for innovation and compliance, particularly in settings with limited institutional capacities and public support.

Solvency of the transition. The financial feasibility of the transition often emerges as a critical factor in pesticide reduction. Moving towards systems that are less reliant on pesticides requires new knowledge, learning and risk-taking. Key questions then arise: How can transition costs be assessed? How can markets and consumers recognise these additional costs? And how should these costs be shared among producers, downstream actors and consumers? While the answers depend on the sector and the production context, addressing these questions is essential to enabling effective change[5].

Opportunities

Despite the significant challenges, there are tangible opportunities for reducing synthetic pesticide use. One of the key drivers of this transition is the growing awareness of the associated health and environmental risks. Farmers, whether smallholders or larger operators, are increasingly concerned about pesticide exposure, fuelling interest in safer and more sustainable alternatives. In parallel, national regulatory frameworks are beginning to recognise and promote responsible practices such as agroecology and certified organic farming.

Another important opportunity lies in the wealth of underutilised knowledge held by smallholder farmers and Indigenous Peoples and Local Communities (IPLCs). These groups possess deep-rooted empirical expertise in low-input farming systems such as agroforestry, intercropping and integrated fertility management, as well as in the production and use of local biological inputs. Recognising and incorporating this valuable knowledge, which could potentially offer practical alternatives, can play a vital role in shaping effective strategies to reduce pesticide dependence.

Moreover, research institutes, universities, small and medium-sized enterprises in tropical regions and NGOs are producing an increasing body of evidence on the effectiveness of certain agricultural practices and natural inputs derived from local biodiversity. These include biofertilisers, biostimulants and biocontrol agents, as well as the selection of appropriate crop species and varieties with enhanced tolerance to pests and diseases, either drawn from conserved natural diversity or developed through breeding programmes, all of which can promote plant health and enhance disease resistance. These innovations have enabled the development of technical pathways based on agroecological principles, which are now being implemented in various production contexts.

International frameworks – such as the EU's Farm to Fork Strategy and the introduction of mirror clauses – are beginning to create new incentives for producers in the Global South to adopt more sustainable practices and access higher-value markets. Finally, both public and private funders increasingly condition financial support for agricultural initiatives on the adoption of sustainable practices. This context is also reinforced by private certification schemes and labels, which frequently set higher environmental standards than public regulations. While creating additional obligations for producers, these funding and market pressures also create strong incentives for a global shift towards more sustainable and less chemical-intensive farming systems.

5. Côte *et al.* 2025

Point 2 •

Levers for advancing pesticide reduction

Work conducted by CIRAD and its partners as part of the PRETAG initiative highlights the main levers for action to support transitions towards reduced pesticide use in tropical farming systems.

Technical levers and their combination

Agroecological practices offer practical, on-the-ground solutions to reduce or even eliminate different pesticide categories while promoting biodiversity and ecosystem resilience at various spatial scales: from the plant to the plot, combined with strategies at the landscape and territorial levels[6]. The PRETAG initiative has identified 20 technical levers for integrated crop protection[7]. This framework organises these levers into a five-step, holistic and adaptive progression:

1. Building system health: foundational actions that create levers for resilient, pest-suppressive agroecosystems that promote overall agricultural system health (for example, intercropping and agroforestry);
2. Monitoring and prevention: proactive tools to detect and prevent pest emergence at an early stage, providing levers for monitoring and preventing the development of pests and diseases;
3. Biological control: harnessing natural enemies and ecological interactions as levers for the biological control of pests and diseases;
4. Physical control: using barriers, traps and mechanical interventions for the physical control of pests and diseases;
5. Biopesticide intervention: using natural biopesticides to control pests and diseases.

The first two levels establish a preventive, systems-level foundation, while the remaining three act as responsive tools tailored to evolving pest dynamics. This stepwise, context-sensitive approach contrasts with existing models, which often consider pest control as a fixed toolbox rather than a strategic sequence.

Development of indicators and risk assessments

Measurements and multi-criteria assessments are essential to guide pesticide reduction. Using established methodologies such as IRSA, BROWSE, Life Cycle Analysis (LCA) and I-PHY, recent analyses across five value chains (banana, cocoa, coffee, vegetables and rice) have identified 92 active substances used as pesticides in tropical countries. Alarmingly, 40% of these substances pose significant health or environmental risks, including for example five highly hazardous substances: chlorpyrifos, endosulfan, terbufos, chlorothalonil and cyproconazole[8].

Public policy levers

While technical solutions are critical for reducing pesticide use, they are not sufficient on their own to achieve effective change. Transitions towards reduced pesticide use need to be supported at the regional or national level by robust, well-enforced policy frameworks that are informed by scientific evidence – and above all, tailored to the socio-economic and market realities of the developing country contexts in which they operate[9]. Public policies at both the national and territorial levels need to evolve in order to:

- Improve the economic viability of alternatives. This requires investments from both public and private sectors in specific support infrastructures (for example, epidemiological surveillance systems and observatories) and support services (training for farmers and agrodealers, extension services, digital tools, small-scale mechanisation, etc.);
- Strengthen institutions that regulate pesticide use to ensure the proper enforcement of policies, including mandatory reporting of pesticide use, risk assessments and appropriate penalties for non-compliance, while simultaneously modernising regulatory frameworks to facilitate the registration of biological alternatives;
- Highlight and increase transparency regarding the public cost of existing policies that continue to support pesticide use, as these policies create distortions in technological competitiveness and hinder the development and use of viable alternatives.

Harmonisation of international and regional standards

Cross-border cooperation at the international level is also essential, and several international frameworks contribute to the regulation of pesticide use in agriculture (the Rotterdam Convention, the Codex Alimentarius, or "Food Code", developed by FAO and WHO, the Stockholm Convention on Persistent Organic Pollutants, the FAO/WHO International Code of Conduct on Pesticide Management). These frameworks provide valuable levers for harmonising standards, supporting national regulation and guiding sustainable pesticide reduction from global to local levels. However, they must be implemented through prescriptive regulation at the regional and national levels.

Collaborative multi-stakeholder platforms and market levers

Reducing pesticide use in agriculture in the Global South requires stronger engagement and coordination among stakeholders. Success depends on bringing together all stakeholders essential for scaling up pes-

6. Côte *et al.*, 2022; Jacquet *et al.*, 2022; Deguine *et al.*, 2023
7. André *et al.*, 2025
8. Le Bellec *et al.*, 2025

ticide reduction, while ensuring farmers remain at the centre, as they are directly affected by policies and bear the largest share of transition costs. Downstream stakeholders such as processors, marketers and retailers must also be involved to ensure a coherent and impactful approach. Five multi-stakeholder dialogue platforms associated with the five value chains studied in PRETAG (banana, cocoa, coffee, vegetables, rice) have provided valuable insights into the role of collective action in reducing pesticide use[10]. From our observations, four major steps appear to characterise the progression of these platforms towards agricultural systems with reduced reliance on pesticides:

1. Sharing knowledge on pesticide use and possible pathways for reduction, as well as identifying lock-ins and potential incentives to stimulate pesticide reduction at the stakeholder level;
2. Co-constructing a common vision of the transition and an action plan based on theory of change and impact pathway methodologies (using for example the ImpresS approach)[11];
3. Fostering co-innovation and scaling up based on genuine knowledge sharing;
4. Developing market strategies that can valorise the transition through process-based certification or company-level standards, for example.

Steps 3 and 4 are the most demanding, both financially and in terms of risk-taking. Today, only a small portion of stakeholders are willing (or able) to engage in them. These steps could be carried out in pilot production sites co-designed with farmers, private operators and markets. These pilot sites are key to integrating scientific and farmer knowledge, generating robust evidence, and ultimately producing alternative solutions that are both context-specific and adoptable at scale.

Training levers

Capacity building remains a critical yet underdeveloped lever for reducing pesticide use across the Global South[12]. Effective efforts require coordinated support, backed by political commitment and financial investment, to inform farmers and agrodealers. First, farmer training must be expanded to cover the risks associated with different categories of pesticides, safe usage practices (including protective equipment and proper application methods), validated alternatives, and the adoption of agroecological practices. Second, training for agrodealers is equally important to ensure they can provide accurate guidance and support. Finally, national research and innovation systems must be strengthened so that institutions can fully engage with their own pesticide reduction goals. This includes training researchers, engineers, and extension officers in agroecological approaches, the development of non-chemical pesticide alternatives, and integrated frameworks such as One Health. Strengthening interdisciplinary research – including strong contributions from social sciences – is essential to drive transformative change across agricultural and institutional systems. ■

9. Temple *et al.*, 2025
10. Blouin *et al.*, 2025
11. The ImpresS (Impact of Research in LMICs) approach developed and implemented by CIRAD serves to co-build plausible impact pathways with the players involved in interventions, and to define change-oriented monitoring and evaluation systems for those interventions.
12. Temple *et al.*, 2025

Recommendations

Frame pesticide reduction as a collective global challenge rather than a top-down requirement imposed on farmers. Strengthen collaboration practices that promote knowledge exchange, joint innovation and capacity-sharing across countries and regions.

Use evidence on pesticide toxicity to human health and ecosystems to better inform reduction strategies in Low- and Middle-Income Countries. These strategies should be carefully designed to balance sustainability with food security, and tailored to the specific constraints and opportunities of tropical agriculture, moving away from one-size-fits-all approaches towards context-sensitive, stepwise pathways.

Promote systemic reduction strategies that link human health, farming practices, biodiversity, pest surveillance and monitoring, early warning systems and market incentives, in line with the dynamic pest pressures faced by tropical agricultural systems.

Ensure that pesticide reduction follows a gradual and predictable trajectory, starting with the phase-out of the most hazardous substances and followed by the progressive reduction of other synthetic pesticides, to allow for broad acceptance and manageable adaptation by farmers.

Reform public policies to support the transition to safer alternatives by ensuring economic viability through targeted investments and farmer support services; strengthen regulatory institutions for effective enforcement and timely approval of biological solutions; and improve transparency on the public and societal costs of policies that currently favour pesticide use.

Establish multi-stakeholder sectoral consortia, involving public and private actors, with shared objectives and clearly defined scopes of action. Such platforms can generate systemic impacts at scale by aligning efforts, pooling expertise and supporting coordinated implementation.

We propose that these recommendations be enriched through feedback from the various institutions working directly or indirectly to reduce pesticide use, and widely discussed with stakeholders with the aim of continuing the PRETAG initiative in a collaborative approach adapted to the needs of farmers and agricultural systems across the Global South.

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