

Horticulture roadmap summary

The road to sustainable horticulture [2024-2034]



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Fruits and vegetables are vital for health: they help to combat the vitamin and micronutrient deficiencies and unbalanced diets linked to increased consumption of ultra-processed foods. However, horticulture worldwide faces major challenges: high synthetic pesticide use, dependence on water supplies, decreased soil fertility and high pre- and postharvest losses. CIRAD is supporting the sector's agroecological transition, to allow it to produce sustainably while improving working conditions and incomes, notably for the most vulnerable. ■

This roadmap concerns CIRAD's research on fruit, vegetable and spice crops, and aromatic and medicinal plants. In particular, it includes certain small-grain pulses. However, it excludes monocultures from other value chains, such as dessert and plantain bananas or roots and tubers such as potato, cassava or yam, which have their own specific roadmaps. Horticultural farms are less characterised by their size than by how work is organised, and vary widely, from family farms to agricultural firms, with many models in between.

A diverse value chain making constant progress

The horticulture sector has progressed steadily over the past 50 years, and is now the world's largest food market in value terms. However, global statistics hide the many differences between industrial value chains in developed countries and local horticultural systems in low-income tropical countries. In the latter, production is often family-run and informal. Despite their low visibility, such systems play a major role in rural incomes, territorial

development, jobs and food and nutrition security for people in both rural and urban areas. According to FAO, most tropical fruit comes from low-income countries, and only a small share is exported: most is sent to local markets. Horticulture is vulnerable to climate, health and economic crises. The sector has long suffered from a lack of support from agricultural policy, and from the wide range of species and production systems it encompasses, which limits its institutional weight. However, that diversity is an asset for agroecological transition, as it makes food systems more resilient.

A sector-based approach specific to CIRAD

In addition to the range of crop species it covers, horticulture is of major scientific interest by virtue of its multi-sectoral approach, which spans several value chains. Horticulture systems are complex, as they often associate short-cycle vegetable crops and tree crops, and play on the interactions between species, making use of a range of disciplines such as agronomy, agroecology, genetics or the

social sciences. The sensitivity of horticultural crops to pests and diseases necessitates research on integrated crop protection, surveillance and biological control, while their high dependence on water calls for sustainable soil and resource management. Within CIRAD, horticulture is an ideal field for building knowledge of ecological intensification, biodiversity management, crop associations, soil-plant relations and the interactions with other value chains such as rice, bananas, coffee, or roots and tubers. It also serves to study the links with livestock production, landscapes and societies, notably within family, urban and island farming systems. By associating producers, researchers, consumers and territories, horticultural value chains foster the co-construction of innovations in the fields of agroecology and organic farming, for sustainable food systems. In this respect, CIRAD's originality lies in its capacity to combine those forms of expertise in tropical, sub-tropical and Mediterranean areas and the French overseas regions, outdoors and under cover, to understand and support the transition to sustainable production systems. ■



© T. Martin, CIRAD

| The ways in which anti-insect netting is used are adjusted depending on the context, in this case in southern Benin.



© R. Kahane, CIRAD

| Managing water is vital for tropical horticulture. It requires resources, labour and territorial governance if it is to be both sustainable and equitable. Here, in Maputo (Mozambique).

Promoting the horticulture of the future: five ambitions to frame our research

For several decades, CIRAD has been conducting multidisciplinary research on the horticulture sector, combining agronomy, genetics and genomics, plant health, quality and processing, socioeconomics, etc. It has research infrastructures in the French overseas regions and a number of laboratories in Montpellier, and works with a wide range of partners from the academic and socio-professional worlds. The organisation has ten research units doing research on horticulture, under the umbrella of its three departments, focusing on biological systems (BIOS department), tropical production and processing systems (PERSYST department) and the environment and societies (ES department). Those departments' resources will serve to work towards the five ambitions set.

Ambition 1

Improve water use and efficiency in horticulture systems

Tropical and Mediterranean horticultural production systems face unfavourable conditions exacerbated by climate change. Addressing those constraints means developing innovations that support better water management and preserve its quality. The aim is to develop impact analysis methods (life cycle assessment) and multi-scale and multi-species strategies to improve water use and distribution, to foster biodiversity on every scale (from plant to landscape). This ambition aims to analyse the role of water and irrigation in the agroecological transition of family horticultural production in the global South.

Ambition 2

Promote the agroecological transition of horticultural production systems

Horticultural plots are very frequently treated with chemicals, which jeopardises the health of producers, consumers, and the environment. This ambition involves seeking cropping solutions without synthetic inputs, to guarantee workers' health and product nutritional and sanitary quality, and preserve natural resources. This means identifying and assessing the agro-economic, economic and ecological advantages, constraints and risks of farmers' practices, from plot to territory. That knowledge will be used to support the co-construction of solutions with field players, by making use of and preserving biodiversity and the interactions between plants, soils and microorganisms.

Ambition 3

Give vulnerable people better access to a healthy, varied diet

Horticultural products, headed by fruits and vegetables, have high nutritional and economic value. Because of the diversity they bring to diets, they are vital for health. However, their consumption is hindered by the standardisation of food supplies, production constraints, accessibility, and quantity and quality losses during processing, storage and transport. The aim is to understand the obstacles to and levers for horticultural product consumption, to boost the diversity that is essential to the diet of people in the global South, whether in urban or rural areas, and subsequently to work with value chain stakeholders to study, design and roll out the social, technical and organisational innovations required to strengthen those levers.

Ambition 4

Consider the multi-functionality of horticulture within territories

In addition to its food and nutrition functions, horticulture provides many social, economic, environmental and cultural services, the impacts of which are poorly defined, be they positive (waste recycling, climate change mitigation in urban areas) or negative (insalubrity, various forms of pollution). This ambition sets out to define criteria to measure and assess that multi-functionality in tropical and Mediterranean contexts. The aim is to document and trigger levers (technological innovations, public instruments) that make optimum use of multi-functionality to support the principles of agroecology, for sustainable management of rural and urban territories in the global South.

Ambition 5

Build stakeholder capacity in the light of the digitalisation of horticulture

The growing digitalisation of modern society is impacting significantly on the horticulture sector, in terms of managing the multiple items of information to be sorted, hopes for better working conditions, and the quest for rapid returns on investment. There is a risk that stakeholders in the sector in the global South may not benefit from the advantages linked to smart farming. This ambition resonates with all of the others in the roadmap, and will help to build the capacity of stakeholders to preserve their freedom of choice and autonomy. More generally speaking, it is fuelling a debate on CIRAD's position as regards digital technology. ■



Details

Agroecological transition, water quality, access to healthy, quality food, etc. The roadmap addresses many key subjects. We look at the key details with CIRAD horticulture research coordinators Victoria Bancal, quality research engineer; Rémi Kahane, breeder and agronomist; and Cica Urbino, plant virology researcher*.

Why and how is CIRAD looking at quality in horticulture?



Photos - RR

Victoria Bancal:

Quality has several facets: (i) economic, since horticultural product quality and freshness are what makes their market value, (ii), sanitary, since those prod-

ucts may contain pesticide residues and pathogens, and (iii) nutritional, since the sector covers a vital share of people's nutrition requirements. To improve horticultural product quality, CIRAD has adopted an integrated approach that involves looking into low-tech solutions, adapted to each crop and context, for every stage. Improving horticultural product quality requires transverse actions at the crossroads between the five ambitions, for instance by means of agroecology and replacing pre- and postharvest synthetic treatments.

Why do you feel we need to improve water use and quality in horticulture systems?



Rémi Kahane:

One thing is clear: without water or water management, there is no horticulture. And the question of water means taking account of several aspects, notably proximity, quantity and quality. We can produce fruit and vegetables in the desert, provided we build innovations to provide access to water.

This topic is related to climate change, both short- and long-term. Water is a vital resource that we can't create and that we must

increasingly learn to share. For CIRAD, this issue is related to various research challenges, whether agro-technical (finding and distributing water, storing it, and developing varieties and practices that consume less water) or linked to the human and social sciences (organisation, community structuring, water governance on different scales).

How can we promote an agroecological transition of the horticulture sector?



Cica Urbino:

Promoting the agroecological transition means developing production systems capable of addressing the issues surrounding agriculture on an environmental, social and economic level. To that end, CIRAD is working on reducing synthetic pesticide use in horticulture, to protect the health of producers, consumers and the environment. Several approaches are being promoted, such as anti-insect netting and pest- and disease-resistant varieties. The aim is to combine genetics and agronomy through good practice. Diseases such as citrus Huanglongbing (HLB) pose major problems worldwide. Climate change and production intensification are determining factors in managing phytosanitary problems: we must produce better, by diversifying. CIRAD is promoting access to more resistant, local seeds tailored to specific contexts, rather than production systems that privatise the living world. The term for this is seed sovereignty.

Complex questions require multiple answers. There can be no agroecological transition without a multidisciplinary approach associating breeders, agronomists, crop protectors, socioeconomists and anthropologists. In the field, producers will not accept agroecology unless it is cost-effective for them. We therefore need to build multi-criteria indicators, to measure different performance factors, be they environmental, agronomic, social or economic. Agroecology is based on both wild and crop biodiversity, which is under threat because of increasingly globalised food systems that have driven down supplies of and demand for traditional species and varieties and made producers

more dependent. CIRAD aims to characterise and promote the genetic and cultural heritage linked to seeds and plants, particularly for fruit and vegetable species.

What do you mean by access to healthy, varied foods?

R.K.: The question of access to food has two often antagonistic aspects: production (producing more and better, making consistent, sufficient supplies of quality products available on markets) and consumption (finding sufficient choice, quality, and transparency as regards production methods). In terms of prices, producers want to sell at the best possible price, while consumers want to buy cheaply. We need to strike a happy medium, and research is working to optimise that compromise, so that producers can make a decent living by producing quality products and consumers can find good value, healthy products and access such products regardless of their means or social standing.

C.U.: There are major public health issues underlying fruit and vegetable consumption (food safety, obesity and diabetes). In Réunion and Martinique, for instance, CIRAD is studying the role of school meals in terms of food and nutrition (providing schoolchildren with one quality meal a day), education (familiarising children and their parents with nutrition issues linked to their diet), and production (involving local stakeholders). ■

Find out more: horticulture@cirad.fr



* Victoria Bancal replaced Cica Urbino as coordinator as of 01/06/2026.



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Farmers in Benin assessing the leaves and seeds of an African basil (*Ocimum gratissimum*) crop

MARIGO: a structuring project for the agroecological transition of Ivorian market gardening

Carried out between 2020 and 2025 in Ivory Coast, the Peri-Urban Agroecological Market Gardening (MARIGO) project supported the agroecological transition of periurban market gardening systems through extensive diagnostic work, experimentation and co-construction with stakeholders in the sector. Coordinated by CIRAD and funded

by the European Union, the project made it possible to identify sustainable solutions to the challenges of production, soil health, pest management, food safety and postharvest losses.

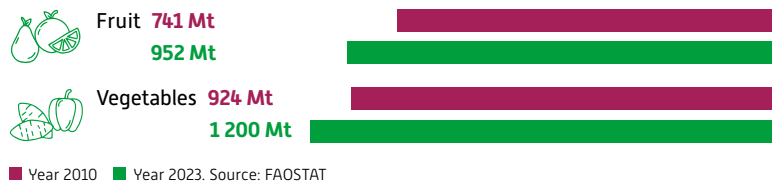
Find out more:



Inventing the sustainable horticulture sector of the future

CIRAD is addressing the challenges facing the value chain

Constantly growing global production



An attractive sector facing multiple challenges

Benefits

- ✓ Vitamins and minerals
- ✓ Rich in fibre
- ✓ Low in calories
- ✓ Reduction in non-transmissible chronic diseases*
- ✓ Boost the immune system
- ✓ Sensory enjoyment



Challenges

- ✗ Contamination by pesticide residues
- ✗ Water requirements
- ✗ Microbes
- ✗ Limited accessibility in urban areas
- ✗ Perishability
- ✗ Competition with ultra-processed products

*eg obesity, type II diabetes, cardiovascular diseases

Market gardening: over-use of synthetic pesticides

CIRAD is working on alternatives to synthetic pesticides, which harm human and environmental health.

African sub-regions	Pesticide use trends in market gardening between 2000 and 2025	Country	Presence of pesticides in market garden products between 2010 and 2024 (contaminated samples)	Samples above MRLs (maximum residue levels)
North Africa	+120-180%	Egypt	88%	56%
Coastal West Africa	+100-220%	Ivory Coast	100%	13%
East Africa	+60-140%	Ethiopia	45-60%	15%
Southern Africa	+40-90%	South Africa	9%	1% and 8% with unauthorised pesticides

Source: FAOSTAT

HLB: a threat for Mediterranean countries



Huanglongbing disease (HLB) affects many continents. It is a colossal threat for the as-yet unaffected Mediterranean countries. To address that threat, CIRAD recommends agronomic, biotechnological, social and communication action.

Find out more: FruiTrop no. 301 2025. Citrus close-up: 2025-26 Mediterranean production forecasts- Huanglongbing knocking at the doors of the Mediterranean. <https://www.fruittrop.com/en/media/Publications/FruiTrop-Magazine/2025/fruittrop-301>

Our ambitions...



... in partnership

Several platforms in partnership for research and training (dPs) work on the horticulture sector:



DIVECOSYS and IAVAO in West Africa, Forests and Biodiversity in Madagascar, MALICA in SE Asia, Biocontrôle-OI in the Indian Ocean, and SIRMA in North Africa.

CIRAD has numerous partnerships, whether national (INRAE, IRD, Institut Agro) or international (World Vegetable Center, CGIAR centres [Alliance of Bioversity & CIAT], FAO, FiBL) and European universities (notably WUR, ZEF, Hohenheim University, IVIA, UNIB, etc).

Our means and resources

12

research units

10

research disciplines, from genomics, through agronomy, to governance support

90

number of horticulture projects carried out by CIRAD in 2018-22

2009

Since 2009, CIRAD has been promoting the **All Africa Horticultural Congresses** organised by the International Society for Horticultural Science (ISHS), with the support of FAO

Partnerships, at the heart of CIRAD's research

CIRAD's horticulture operations rely on a wide range of international partnerships. They include those with the International Society for Horticultural Science (ISHS), the FAO Plant Production and Protection Division, icipe, the World Vegetable Center and the Alliance of Bioversity and CIAT, to promote agroecological horticulture within food systems in the global South. The establishment is also a member of several platforms in partnership for research and training (dPs) relating to horticulture: DIVECOSYS (www.divecosys.org) in West Africa, Forests and Biodiversity in Madagascar (www.forets-biodiv.org), MALICA (www.malica.org) in Southeast Asia, the new dP Biocontrôle-OI in the Indian Ocean (www.dp-biocontrôle-oi.org), and SIRMA (www.rcp-sirma.org) in North Africa. ■



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| Farm-gate packing and loading of dragon fruits to supply urban markets in Ho Chi Minh City, southern Vietnam

A word from our partners



Interview with Enoch G.

Achigan-Dako,

Professor of Genetics and Plant Breeding, Head of the Plant Science Department at the Genetics, Biotechnology and Seed Science Centre, Abomey Calavi University (Benin) and South coordinator, PEA-BIOVALOR PROJECT

How did you first partner up with CIRAD?

I have been teaching at Abomey Calavi University for around 15 years, after having headed the African Plant Resources of Tropical Africa (PROTA) programme in Nairobi, funded by the Dutch government, from 2009 to 2012. I first came across CIRAD through Rémi Kahane [Director of the Global Horticulture Initiative, based in Tanzania] in Nairobi, in the early 2010s. Our relationship continued via several continental projects, then when he was posted to FAO in Rome. We maintained contact when I returned to Benin, and in 2015, he put me in touch with some CIRAD researchers with whom I set up the

MoBreed [Mobility for Breeders in Africa] project, funded by the European Education and Culture Executive Agency and launched in 2016 with several African universities and Institut Agro Montpellier. As for the PEA-BIOVALOR project (2021-26), funded by France, CIRAD has played a major role since its co-construction.

What do you think of the ambitions in this roadmap?

They address the major issues our countries are currently facing. For Benin, that includes developing productive horticultural value chains, promoting local resources and improving productivity while safeguarding natural resources. For instance, tomato is a strategic value chain: tomatoes are very popular in Benin, but domestic production is both insufficient and inconsistent. Improving production, storage and processing techniques is still a national priority, to secure the value chain. The agroecological transition is another vital issue. Horticulture, which is particularly common in urban and periurban zones, is often practised on limited areas and sometimes on fragile soils. It is becoming necessary to steadily reduce synthetic pesticide and fertiliser use, while developing practices that maintain competitive, sustainable levels of production. The roadmap must also take account of the main fruit crops, which have major potential for Benin, such as pineapple. Planting material is a crucial issue for those value chains. The horticulture roadmap's ambitions tally with stakeholders' centres of interest, provided we stick to an integrated approach that combines research, training, innovation and co-construction with all the players in the chain. ■



Interview with Boitshepo Giyose,
Senior Nutrition and Food
Systems Advisor, Special
Advisor to the CEO, New
Partnership for Africa's
Development of the
African Union (NEPAD)

Could you tell us about the history of your partnership with CIRAD?

I first came to know CIRAD through my involvement as a technical board member with the Global Horticulture Initiative. We had several interactions, both directly with CIRAD and with organisations working on horticulture and traditional African crops. Later, when I was working with the New Partnership for Africa's Development of the African Union, I had many opportunities to collaborate with CIRAD over a period of about ten years, including participating in meetings and making presentations. During my time at FAO, from 2014 to 2020, I was the nutrition focal point working with other units, including those dealing with plant production. I continued collaborating with CIRAD and other international horticulture organisations. What has always struck me about CIRAD is its deliberate effort to improve

the production, processing and preservation of fruits and vegetables, while also putting nutrition education at the centre. For me, this collaboration has always been about connecting research and evidence with policy. We need to help governments move beyond a focus on cereals and staple crops and give greater attention to fruits and vegetables.

CIRAD has identified five ambitions for the horticulture sector. What is your view of these ambitions?

I fully share these priorities. They are all important and, in fact, they are interconnected. Climate change makes water use and quality particularly critical, but there are innovative approaches such as hydroponics, water recycling, protected cultivation and adapted varieties. I would add one important dimension: public policy. Without the commitment of political leaders and parliamentarians, it will be difficult to achieve the other ambitions. Horticulture and nutrition are not only agricultural issues. They involve health, education, finance, trade and economic development. Responsibility therefore has to be shared across ministries and institutions. We also need to address access to healthy food. Fruit and vegetable consumption has not improved enough, partly because of physical and economic accessibility, but also because convenient, inexpensive processed foods are increasingly available. Nutrition education can help make healthier choices easier. Finally, implementation will require time and sustained investment. Donors often look for quick, easily measurable results, whereas transforming food systems and improving nutrition indicators takes time. ■



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| A wide range of fresh products available all year round, at a price that gives local producers a decent income and is affordable for consumers. A market in Antananarivo, Madagascar



© R. Kahane, CIRAD

| African indigenous vegetables (in this case *Ocimum gratissimum* and *Vernonia amygdalina*) are used in most traditional dishes and play a role in cultural identity, nutritional health and food sovereignty. Here, in southern Benin



CIRAD is the French agricultural research and international cooperation organisation working for the sustainable development of tropical and Mediterranean regions.

It works with its partners to build knowledge and solutions for resilient farming systems in a more sustainable, inclusive world. It mobilises science, innovation and training in order to achieve the Sustainable Development Goals. Its expertise supports the entire range of stakeholders, from producers to public policymakers, to foster biodiversity protection, agroecological transitions, food system sustainability, health [of plants, animals and ecosystems], sustainable development of rural territories, and their resilience to climate change. CIRAD works in some fifty countries on every continent, thanks to the expertise of its 1750 staff members, including 1200 scientists, backed by a global network of some 200 partners. It also supports French science diplomacy operations.

CIRAD is a public establishment (EPIC) under the joint authority of the Ministry of Higher Education, Research and Space and the Ministry of Europe and Foreign Affairs.

CIRAD hopes that multi-stakeholder partnerships and alliances will discuss, share and support its five ambitions for sustainable horticulture.

Contact us to find out more: horticulture@cirad.fr 

Working together for tomorrow's agriculture

Find out more about
the horticulture value
chain at CIRAD



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