Synthèses

SUSTAINABLE FOOD SYSTEMS FOR FOOD SECURITY

Need for combination of local and global approaches

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Chapter 14

Market gardening for African cities: contributions, challenges and innovations towards food security

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In many African countries, vegetable production has significantly increased since the early 2000s (FAOSTAT, 2016). This increase results from a rising consumer base as well as a greater share of vegetables in households' diets and budgets (Chauvin et al., 2012; OECD/FAO, 2016). The development of market gardening is particularly salient in peri-urban contexts. Vegetable production spreads within or in the outskirts of cities both large and small due to the products' perishability and difficult transport conditions (high transport and storage costs, lack of or poor cold chain and transport infrastructure). Market gardening also offers clear advantages for producers living in urban and peri-urban areas. Producers in peri-urban areas can make use of small agricultural plots, earn income on a short-term basis, combine agricultural production with off-farm activities, and more easily access both input and product markets. However, this type of market gardening development is challenged by growing land pressure, competition for access to water, and the use of increasingly expensive imported chemical inputs along with rising citizen demands regarding environmental and health issues.

Market gardening can directly and indirectly support urban and farm households' food security (through consumption for the first, and through self-consumption, incomes and jobs for the latter). Nevertheless questions arise regarding the sustainability of market gardening and the levers to promote its contribution to food security.

This chapter briefly presents the results of three projects funded by the GloFoodS metaprogramme between 2017 and 2019 (see Acknowledgments section). It addresses three questions linked with food (not nutritional) security. First, what is the effective contribution of intra- and peri-urban market gardening to urban food security for both producers and consumers? Second, how does vegetable production evolve with regard to land competition and social pressure to reduce negative environmental effects? And third, what are the technical and institutional innovations that are both relevant in agronomic and economic terms to reduce the use of inputs (chemical and organic) that are harmful to the environment and health?

This chapter examined case studies of market gardening at different scales in four African countries: the territory level in Madagascar, the farm level in southern Benin, and the plot level in Tanzania and Senegal. The analysis combines different disciplines (economics, geography, agronomy, etc.) and methodologies (analysis of satellite images, quantitative and qualitative surveys, analysis of value chains, agronomic experiments in stations and on farm, etc.). The examples provided are significant, although not exhaustive, considering the huge diversity of market gardening systems in Africa.

⏩ Contribution of market gardening to food security

Contribution to urban consumers' food security

Agricultural belts are known to often crop up near or around African cities (Moustier and David, 1996; Moustier and Renting, 2015). In the agglomeration of Madagascar's capital city, with a population of more than three million, this belt is particularly marked. In a perimeter of about 30 km around the city centre, 45% of the land (34,000 hectares) is still cultivated with rice, cassava, arboriculture and market gardening (the latter occupies 8% of cultivated land, about 2,700 hectares) (Dupuy et al., 2020). Thanks to this proximity and area, intra-urban and peri-urban market gardening plays a key role in urban households' food security in Antananarivo in terms of regularity, quantity and diversity of supply. It also provides produce to the Malagasy capital during the off-seasons of other production areas of the country and covers a large part of the urban market for vegetables (from 30% to 100% depending on the crop) (Defrise et al., 2019). Market gardening offers consumers a large range of products that has been increasing over the years (introduction of cauliflower, broccoli, asparagus, etc.) (Aubry et al., 2012). In Senegal, since the 2000s, the Niayes region, a coastal strip stretching from Dakar to Saint-Louis, provides 80% of national market gardening production and covers 60% of the capital's demand (Ba and Moustier, 2010). In south Benin, the vegetable sector supplies local markets as well as the main markets of the neighbouring countries: those of Accra in Ghana, and Lagos and Ibadan in Nigeria (PADMAR, 2015). However, in terms of food security and food safety, market gardening also comes with some drawbacks. First, the accessibility of products is limited by the extreme household poverty levels, despite relatively low prices in local markets. Second, the food safety of products and their environmental impact raise many questions due to the use of non-authorized chemical inputs, as well as misuse of inputs (over-dosage, post-harvest treatment on products, etc.) (Madagascar: Aubry et al., 2012; Senegal: Ba and Moustier, 2010; Benin: Assogba-Komlan et al., 2007) and wastewater irrigation (Madagascar: Dabat et al., 2010).

Contribution to urban producers' food security

Food production generally, and market gardening in particular, contributes to the food security of producers' households. In Antananarivo, one household in five is engaged in agricultural activities (full or part-time), either due to a lack of alternative job opportunities or as part of a diversification strategy (Defrise et al., 2019). Market gardening is a source of direct jobs[25] from which the income generated could potentially improve access to food.

In south Benin, one hectare of market gardening generates between three to four full-time equivalent jobs, with the investment in labour covered by farmers (30%) and workers (70%) (Avadí et al., 2020). The socio-economic profile of producers reveals that they are of all ages, and may be locals or migrants, and men or women. Although market gardening is more risky than growing other agricultural crops (due to climate, pest pressure, perishability) and comes with substantial expenditures (seeds, fertilizers, treatments), it is a profitable activity for producers with access to small plots, irrigation water and markets (inputs and products). It generally offers quick monetary returns (thanks to short production cycles), is frequently off-season compared to main staple crops, and the margin per hectare for market gardening (more systematically than the remuneration per working day still for market gardening) is generally higher than for other crops (cereals, legumes, etc.) (Schreinemachers et al., 2018). These regular cash contributions and the consumption of unsold products within the household thereby contribute to producer household food and nutrition security.

In the agglomeration of Antananarivo, the producers use from 5% to 12% of the volume of their production for self-consumption (green onion: 4%, tomato and carrot: 7%, green bean: 8%, green pea: 10%, leafy vegetables: 12%) (survey on 634 households, in Defrise, 2020).

⏩ Evolution of production systems and reduction of environmental impacts

Evolution of production systems due to land pressure

Although vegetable production systems are subject to various pressures, they are still continuing to spread. In the agglomeration of Antananarivo, like in many capitals, urban area is expanding as agricultural area decreases (3.2% per year) (Defrise et al., 2019). Quite unexpectedly, despite this agricultural area[26] reduction, cultivated area is also expanding. Built-up and cultivated areas are simultaneously expanding as pasture, rangeland and wasteland are decreasing (Defrise et al., 2019). This progression of cultivated area results in part from the flexibility of market gardening systems. In the agglomeration of Antananarivo, where public policies on urban agriculture are virtually absent, but where demand for vegetable products is growing, different factors contribute to the development of market gardening according to the area (Defrise et al., 2019). Where population and urban densities are high (5,000 to 40,000 inhabitants per km^2), the increase in built-up land limits the area of cultivated plots, alters access to water and organic matter, and forces farmers to intensify their agricultural practices in terms of labour and capital. Moreover, wastewater runoff contributes to the over-fertilization of plots, which damages rice production (growth of tillers to the detriment of the grain), but benefits leafy vegetables, especially watercress (Dabat et al., 2010). Finally, land tenure insecurity encourages producers to cultivate their land year-round, and market gardening contributes to this territorial marking. However, when land pressure becomes too strong, market gardening disappears in favour of buildings

25. It is also a source of indirect jobs (collectors, transporters, and resellers).
26. Agricultural area includes cultivated and non-cultivated area, such as pasture, rangeland and wasteland.

and infrastructure (including new roads in the lowlands to open up the city). Where population and building densities are lower (300 to 1000 inhabitants per km^2) in the agglomeration of Antananarivo, the development factors for market gardening differ (Defrise et al., 2019). Buildings develop on the hilltops, whereas market gardening takes place in the lowlands in the off-season, and on the hill slopes in season. Farmers inherit small plots and struggle to buy lowland (opportunities to buy lowland, dedicated to rice, are scarce and land prices are high). Thus, they are forced to progressively develop market gardening at the base of the slopes, on family land obtained through the reactivation of land rights, or on cheaper, lower-quality land.

In Senegal and Benin, market gardening in the capital cities has disappeared to make way for urban services (housing, office, roads, etc.) (Benin: Alinsato and Yagbedo, 2018). In the Niayes region of Senegal, market gardening is still going strong despite considerable urban sprawl (up to 5.5% per year) (see Figure 14.1, map by Jolivot, 2021). The practice is experiencing a dynamic of relocation and expansion. As we observed it in Antananarivo, cultivated areas are expanding and areas dedicated to market gardening and orchards are developing (up to 300 ha per year) (Figure 14.1), and innovative methods such as micro-production on roofs or in building courtyards are also becoming more widespread (Ba, 2007; Ba et al., 2018). This growth is driven by household food needs and profitability (farmers and urban elites invest in this activity). As a result of population growth, built-up areas and irrigated agriculture, water resources are increasingly used and, according to current hydrogeological models, becoming depleted (DGPRE, 2014).

Evolution of production systems towards the reduction of environmental impacts

In general, three main types of vegetable farming systems coexist in the different countries mentioned above. The first type of system is referred to as conventional, and is based on the use of organic and mineral fertilizers and chemical pesticides. These systems generally predominate in terms of cultivated area and number of households. The second type may be called 'lean'. These systems use chemical inputs but aim to control the input quantities and the quality of agricultural practices (timing, dosage, appropriate equipment) for financial reasons. The third type refers to organic farming systems, or those engaged in agroecological transition. These systems use only natural inputs (i.e., organic fertilizers and biopesticides) and avoid the use of chemical fertilizers and pesticides (or, in the case of agroecological transition, they are in the process of phasing them out). In practice, there is a productive continuum with conventional and organic farming systems at both ends, and many other systems in between, such as lean systems. In Benin, Senegal and Madagascar, the number of market gardeners exploiting organic and agroecological transition systems is still small,[27] and often certification occurs under participatory guarantee systems[28].

27. Those who have adopted these systems belong respectively to the network Association pour le Maintien de l'Agriculture Paysanne (AMAP-Benin) and the Fédération Nationale pour une Agriculture Écologique et Biologique (FENAB-Senegal).
28. The group of producers controls and guarantees the production on a peer to peer basis and according to different specifications. Thus, they do not have to resort to an expensive and complex third-party certification.

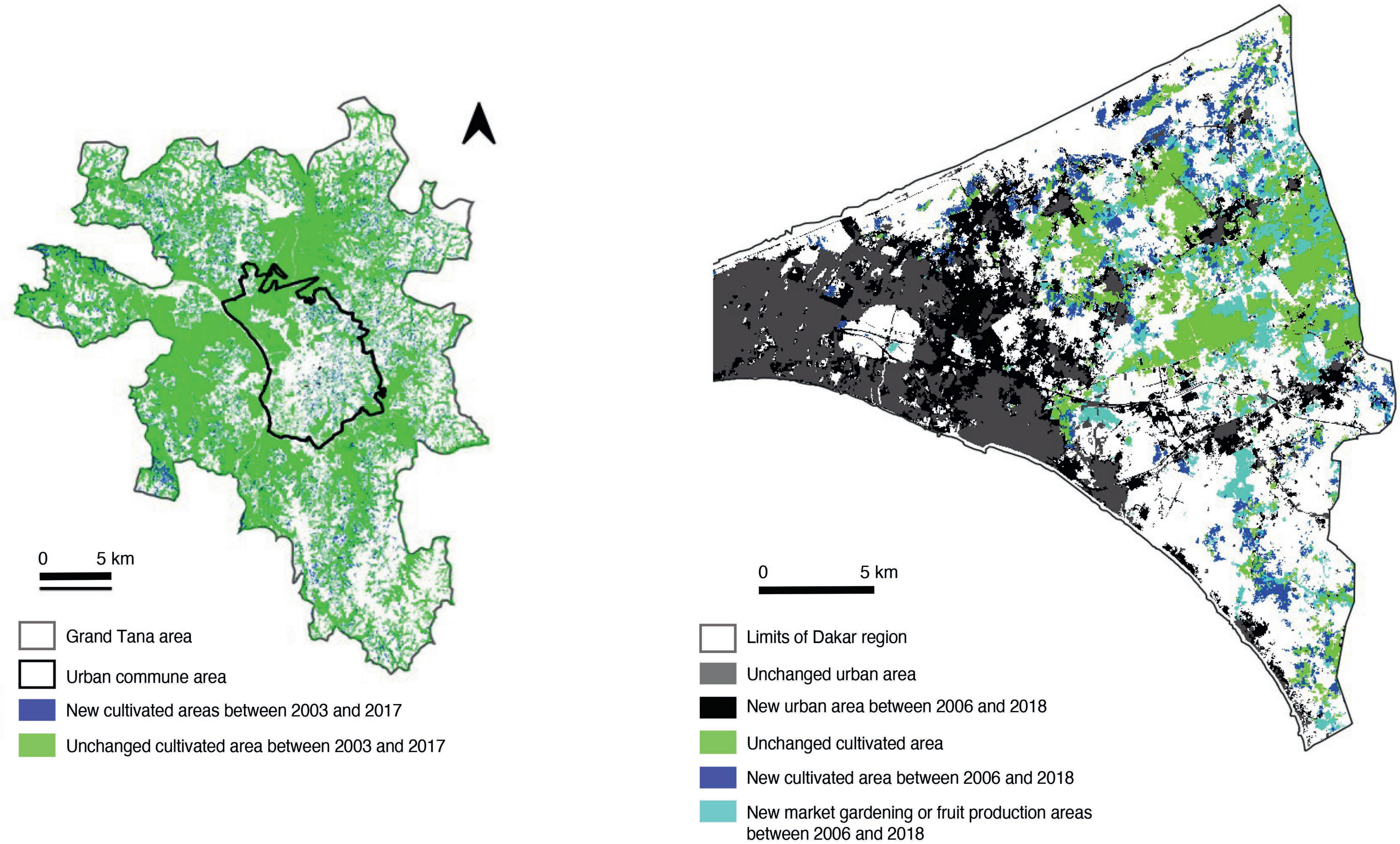

Figure 14.1. Evolution of cultivated area in the agglomeration of Antananarivo (Madagascar, left) and irrigated area in the Dakar region (Senegal, right). Source: for Madagascar, based on Dupuy et al., 2020; for Senegal, created by Jolivot, 2021.

In Tanzania, a fourth type of farm focused on exporting to the European market and complying with EU regulations (e.g., green beans) also exists. The necessary proximity to an airport contributes to its development in peri-urban areas.

Several factors account for the differentiation of production systems and, in particular, the development of organic and agroecological transition systems. Some factors influence the demand for organic products, such as greater awareness among consumers and producers regarding environmental and health issues, or the emergence of more profitable niche markets and shorter supply chains. Other factors influence supply, such as the increase in the cost of imported inputs, campaigns to raise producers' awareness of the dangers of pesticides, and in African contexts, the lower difference in terms of yield between organic/agroecological transition systems and conventional agriculture for fruits and vegetables than for cereals (De Bon et al., 2018). Finally, some factors modulate supply and demand jointly, such as advocacy and training provided by civil society organizations (agricultural development NGOs, consumer associations, specific markets).

A difficult trade-off between social, economic and environmental impacts

In southern Benin, the impacts of different production systems, located at three different sites, were analysed using life cycle assessment (LCA) and a selection of socio-economic indicators, based on a sample of 69 production units and a set of crops of interest (carrot, tomato, leafy vegetables, and cucurbits) (Figure 14.2). For the LCA, all inputs (resources consumed) and outputs (products, waste, emissions) per ha of vegetable production were considered (see Avadí et al., 2021, for more details).

Two main results were obtained. Firstly, for all crops, the differences between the environmental impacts of conventional and lean systems are not statistically significant (Figure 14.2). However, the differences are significant between conventional/lean system types and organic systems. Organic systems produce lower yields, and due to a limited price differential, generate lower revenues than conventional systems. Moreover, and counterintuitively, organic systems required less paid work than conventional systems, probably due to higher levels of family work associated with the former. Moreover, contrary to all expectations due to the absence of chemical inputs, organic systems generate larger negative environmental impacts. This is explained by the fact that farmers tend to apply excessive amounts of organic fertilizer to offset yield losses on sandy soil, which generates direct field N emissions, for instance (e.g., Perrin et al., 2015).

Secondly, environmental differences among farms within the same production system type (conventional, organic and lean; not represented at all sites), and even among production sites (Ouidah, Sèmè-Kpodji and Houéyiho), are also substantial. Differences are explained by the technical level of irrigation, fertilization practices, types of crop rotations and the association with crops with phytosanitary value (e.g., lemongrass), as well as by different soil characteristics, etc.

Trade-offs between negative and positive impacts can be addressed, for instance, on the basis of the priorities of authorities (local, national). If the main goal is to improve socio-economic conditions, systems that maximize these elements should be promoted, but if the objective is to minimize environmental impacts, systems with lower impacts should be favoured. From a sustainability point of view, one should seek Pareto optimality, i.e., systems where no dimension of sustainability can be improved without degrading another.

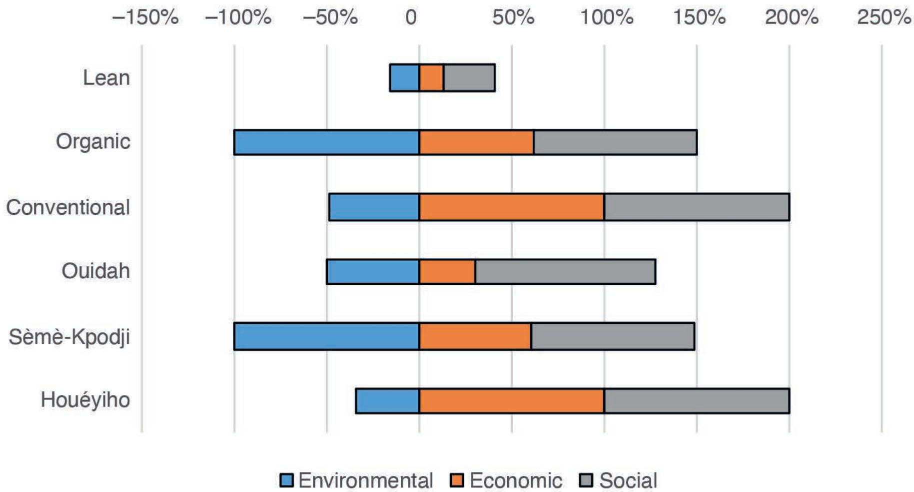

Figure 14.2. Comparison of the sustainability of market vegetable gardening systems in southern Benin, by type of production system and by production site (positive socio-economic and negative environmental impacts). Source: Avadí et al., 2020.

⏩ Innovation paths of market gardening

Agronomical innovation

Reducing the environmental and health impacts of market gardening involves supporting farmers, as underlined in the case of Benin for better management of organic fertilization. This also implies innovations to 1) have reliable and inexpensive tools to monitor soil composition, 2) drastically reduce the use of chemical pesticides to fight against flying and soilborne pests, and 3) encourage the sound use of local organic residues as a substitute for imported mineral fertilizers. This both restores soil health and reduces dependence on imports. The key factor for farmers to develop agroecological practices is the possibility of limiting production costs.

With regard to fighting flying pests (e.g., locusts), an alternative is the use of reusable insect nets. In Tanzania (Table 14.1), this technology, tested by 50 market gardeners on locally manufactured bamboo tunnels, led to 1) a gain in cabbage yield for all producers (between 17% and 44%, depending on the season), and 2) a marked reduction in pesticide use (2.8 to 3.5 times fewer applications; Nordey et al., 2020a, 2020b). In Senegal, this technology, adapted to locally manufactured shelters made from concrete reinforcing bars (materials available locally), has also resulted in reduced pesticide use and increased yields (for cabbages in particular). However, to prevent the proliferation of very small insects that can pass through the netting (e.g., aphids), it was necessary either to open the nets three days a week to allow in natural enemies (e.g., local ladybugs), or to release locally-reared natural enemies (e.g., *Nesidiocoris tenuis*).

Table 14.1. Comparison of the number of pesticide applications in Tanzania between production methods. The data are averages ± standard deviations. Different letters indicate that there were significant differences ($p<0.05$) between the traitements (from Nordey et al., 2020, courtesy of Crop protection).

Season	Treatment	Number of pesticide applications	Number of fungicide applications
1	Tunnel + reusable insect net	1.9 ±1.2 b	0
	Open field	6.2 ± 1.6 a	0
2	Tunnel + reusable insect net	1.5 ± 0.6 b	2.9 ± 0.8
	Open field	4.3 ± 1.1 a	3.0 ± 0.8

With regard to preventing root-knot nematodes (major soilborne parasites in market gardening), an innovation comprising two application methods was tested in Senegal at an experimental station field plot. This innovation consists in introducing annual legumes that control nematodes in the cropping system. With the first method, based on the use of these plants in rotation during the rainy season, two varieties of groundnut and three species of rattlebox (genus *Crotalaria*) were introduced. *Crotalaria* have been shown to be effective in controlling *Meloidoygne sp.* nematodes at the population level both in bulk soil and in the roots. Two of the three rattlebox species (*C. spectabilis* and *C. retusa*) have also, in addition, controlled other species of plant-parasitic nematodes (e.g., *Pratylenchus, Tylenchorhynchus* and *Ditylenchus*). In the case of *C. retusa* in a previous crop, tomato roots were completely free from galls three months after planting and the fruit yields were higher (using natural fallow as a control, and in comparison, with groundnut as the precedent crop). The second method was to combine eggplants with these same nematicidal plants, the association being directed at producers who were unable to perform a sanitizing rotation during the rainy season. This combination has been shown to be very effective in controlling *Meloidogyne sp.* and more efficient than the standard chemical treatment (MOCAP® EC). To avoid lower eggplant yields, the tests concluded that two sanitizing plants per eggplant offered the best compromise between nematode control and crop yield, compared with the control.

Regarding improved yields, the latest innovation tested in Senegal was the use of beneficial indigenous microorganisms (BIMs), produced from litter from different non-cultivated sites. The soil microorganisms colonizing the litter in decomposition on natural areas were multiplied through a simple acid lactic fermentation before being used as a complex and locally-originated microbial inoculum on agricultural soils where soil biodiversity had been depleted by agricultural practices. For some of these BIMs, the tests confirmed a genuine biostimulant potential on plant production and plant vigour, as well as the potential for biocontrol of certain crop pests (aphids, cabbage moths and root-knot nematodes; see Figure 14.3). These effects may be due to the presence of useful microorganisms in the BIMs used as well as some metabolites produced by these complex microbial consortia (e.g., phytohormones, biocidal compounds), which must still be isolated, identified and quantified.

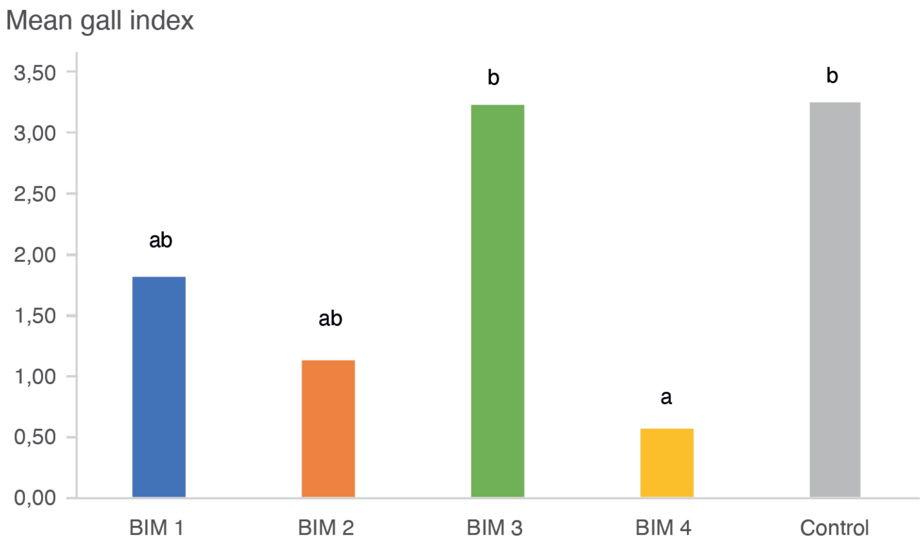

Figure 14.3. Effects of four beneficial indigenous microorganisms (BIMs)s originating from three different ecological regions of Senegal on root-knot gall index of lettuce when applied in farmers' market gardening fields near Baba Garage, Senegal.

Different letters indicate that there are significant differences ($P<0.05$) between the treatments (from Papa Samba Diagne, 2020, masterthesis, ISFAR). The higher the gall index, the higher the pressure of the root-knot gall nematode on the crop.

Institutional innovations

The development of market gardening and its support towards sustainable systems involve the deployment of technical as well as socio-economic and institutional policy measures.

To support producers in their agroecological transition, insect nets and adapted irrigation systems (small sprinkling or drip irrigation) are two key technical levers, but they represent considerable investments for family farms. In Tanzania, the investment in tunnels covered with insect nets is recovered only after about two years of production (i.e., after the sixth crop cycle), despite tunnels being manufactured at low cost from locally available materials (bamboo). This is due to the vegetables' low selling prices as well as consumers' inability to distinguish cabbages from each other based on health and visual quality criteria. Likewise, the use of local organic fertilizers is currently low due to the lack of knowledge of the actors in the sector, the low availability of raw materials to produce composts or organic fertilizers, and poor product competitiveness. The production costs of organic fertilizer are often greatly increased by transport costs of the raw materials to be recycled, which makes them more expensive compared to some imported or chemical fertilizers. Finally, local farmers often have little knowledge of biological inputs and biopesticides, and these products are often not readily available from agricultural input dealers.

In Madagascar, in the peri-urban area of Antananarivo, agroecological transition has been promoted by a project (ASA-EU) that encouraged organizational innovations at both the production and market levels. 'Leader' farmers were first trained and then tested agroecological production practices; after one or two crop seasons, each leader started training other farmers in their communities (David-Benz and Mino, 2018). These informal groups foster exchanges of experiences and mutual learning. To be able to sell their products in better conditions, each of these informal producers' groups coordinate with local collectors. On this basis, a participatory guarantee system was initiated. Such shifts, including changes in production practices and new institutional arrangements, are facilitated by the geographical proximity that characterizes peri-urban market gardening. But the learning process is long, adjustments are necessary from all sides, and farmers need sustained support.

The courses of action are therefore multiple and complementary. They can impact production through subsidies and subsidized loans to producers (to initiate investments such as micro-sprinkling irrigation), knowledge sharing and training (such as technical information sheets on fertilizer production). They can relate to upstream development of bioproduct production at the local level (subsidizing the transport costs of recycling raw materials) and rearing natural enemies, based especially on the enhancement of indigenous biodiversity (investment in action research). Finally, other actions can occur downstream through such initiatives as the establishment of participatory certifications to distinguish products on the market, consumer guarantees that production complies with food safety specifications, and increased selling prices. However, in low-income countries, these products are not affordable for most consumers and remain intended for limited niche markets. Without the emergence of a large middle class able to acquire these products at higher prices, widespread adoption of these modes of production would require policy measures to reduce production costs rather than increase selling prices.

⏩ Conclusion

Market vegetable gardening is developing in the peri-urban (suburban) areas of African cities to meet growing consumer demand. Thanks to the adaptability of farmers, market gardening systems are very flexible and do well in both urban and peri-urban areas. The challenge is to support their development so that they are more sustainable from social, economic and environmental points of view (e.g., Temple and De Bon, 2020). Achieving this implies technical and institutional innovations at three levels. At the production level, support policies are needed to accompany producers in the use of technologies, strategies and materials that save water, protect biodiversity and recycle organic residues. At the sectoral level, public actions are needed to stimulate the development of new services (rearing of natural enemies, transport of organic materials to be recycled), to recognize and promote the implementation of product differentiation such as through participatory guarantee systems, and to raise consumer awareness regarding sustainable, environmentally-friendly production practices. At the local and regional levels, commitments from decision-makers are needed to ensure land-use planning that accounts for the coexistence of agriculture and the built environment, and to secure land rights and access to water for producers in increasingly competitive areas.

⏩ Acknowledgements

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Conclusion
GloFoodS: an actor and marker of deep transformations in the international agenda

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As INRAE and CIRAD were implementing the GloFoodS interdisciplinary programme in 2014, the international agenda was being completely transformed over the same period. Food security, which was formally set out as a key global priority at the World Food Conference in 1974, was gradually ceding its place to sustainable food systems. At a time of dizzying demographic growth in the second half of the 20th century, the emphasis on increasing supply and organising trade while stabilising prices was accompanied by growing criticism and calls for profound changes in ways of thinking and acting. Thus, MacIntyre et al. (2009) put the focus on learning systems, and Beddington et al. (2011) called on research stakeholders to address the challenge of climate change by modifying food systems. The concomitance of these two movements reflects a dual reality. First, scientific communities actively contribute to the evolution of international agendas, and second, they also are deeply impacted by such shifts. The GloFoodS programme thus appears to be an excellent marker of this global shift. While the projects funded by GloFoodS are concentrated in the area of food security, we can still clearly see the emergence of the food system concept.

From the beginning of the early 2000s, the world became more aware that food systems are an integral part of the complex and intersectoral issues of sustainability for the planet and humanity. The awarding of the 2007 Nobel Peace Prize to the IPCC highlighted the importance of climate change, and the call by IPCC chair Rajendra Pachauri to stop eating meat reaffirmed the significance of the issue. With the earthquake, and after a so-called hunger riot in 2008, global leaders put the issue of food back at the top of the international agenda. The aim is no longer to just produce more – a legitimate 20th-century priority – but to reposition food as we build our future world (Caron et al., 2018). These ideas were enshrined in the UN's Global Sustainable Development Report in 2019.

We can identify at least five major changes, which GloFoodS reported on. These changes did not suddenly appear as the food system concept gained traction. Rather, the research community prepared and developed them, along with the critical reflections that marked its own orientation, management and programming over the last decades. One of the major ambitions of research is thus affirmed: to produce knowledge that can help think and structure action.

The first of these five major changes concerns technical progress. Alone, it is no longer sufficient to address societal questions and meet the challenges facing institutions. Technical progress, productivity, production, increased income and food security no longer go hand in hand, as illustrated by the Sikasso Paradox (Dury and Bocoum, 2012). This is the case in all regions and countries, and not only in Mali. Any technique that increases crop yield is not systematically profitable or adopted by farmers (Sebillotte, 1996), as was previously the case. Technological performance and the relevance of technical change must now address much more complex questions, especially since they vary from place to place. Beyond the immediate crop yield, production system resilience (Bousquet et al., 2014) – particularly in the event of disruptive climatic conditions, hazards of all kinds and price uncertainties – becomes essential if actors are to implement new techniques. In this context, agricultural research institutions are increasingly looking to the human and social sciences (Goulet et al., 2022) and system-based approaches, which emerged in the 1980s to investigate innovation processes and support producers' behaviours and decision-making. The increasing attention paid to the institutional dimension of the innovation ecosystem (Coudel et al., 2012) reflects the issues associated with the conditions, modalities and consequences of technical change. The resulting tensions and crises, such as those surrounding genetically modified organisms (GMOs), mad cow disease, or glyphosate, mean that dealing with socio-technical controversies (Latour, 1987) is now a new major challenge.

A second change has resulted from a desire from some academics to overcome a dominant and prescriptive attitude from science and a view to limit its mission to inventing technologies for transfer. Echoing the first major change about technical progress, research teams are now interested in the design of innovation and the devices that enable it. Researchers engage in participatory science practices, working to strengthen their capacity to reflect upon the stated and promoted impact on an individual, collective and institutional basis. The development of a culture of innovation and impact is embodied in institutional initiatives such as the Socio-Economic Analysis of the Impacts of Public Agricultural Research (ASIRPA) and Impact of Research in the South (IMPRESS).

The third change follows on from the above aims: ensuring food security, tackling the challenges of sustainable development, and guaranteeing decent and fair living conditions for those in the agricultural and food sectors. Achieving these aims will require doing more than focusing on agricultural production alone, and this applies to agricultural research institutions as well. This has been emphasized by the World Development Report 2008 by the World Bank (2007) but was already an issue of concern. The development of sector approaches, from the 1970s, seemed to mark the start of a new era. Research activities began to look beyond the food supply, to focus on food environments and consumer behaviours. For example, INRA created a new Department of Consumer Sciences in 1979. All these issues have been recognised more recently as essential pillars of food systems at the international level.

Similarly, agricultural research institutions began acknowledging the importance of work on environmental topics, propelled by the emergence of such issues in the 1970s. INRA added them to its research priorities in the 1990s, and their importance was further recognised in the international agenda with the creation in 1993 and 1994 of the three environmental conventions regarding climate (UNFCCC), biodiversity (UNCBD) and desertification (UNCCD) engagements. In the 2000s, the notion of nexus gradually came to the fore, in order to address the complex interactions between these different sectors. Similar shifts could also be seen in CIRAD's research agenda.

The fourth shift within our research institutions has been the strengthening of ties between INRA and CIRAD. This relied on the de-compartmentalizing between temperate and tropical spheres, maintained among other things by the previous justification of references to distinct commodities and value chains. This is consistent with heralding the erasure of north-south segmentations in the 2030 Agenda for sustainable development. This evolution has enriched the activities of each organization and allowed the analysis of global issues – whether environmental, climate-, health- or trade-related. The convergences between our institutions have been strengthened, as shown by GlofoodS. Scientific discussions and projects within joint research units have cultivated fruitful comparisons and, as a consequence, decentrations in scientific reasoning. They have helped to reposition each institute's activities and approaches by enhancing their specificities and taking into account international contexts and issues through scientific and development partnerships. This process of strengthening relations between INRA and CIRAD was not a straightforward one, and it was proactively encouraged through initiatives such as Agrimonde (launched in 2006) and Dualine (launched in 2009) before doing so through jointly sponsored research programmes such as GloFoodS.

Fifth, the growing importance of globale issues in our field and the widening of INRAE geographic mandate have fueled INRAE and CIRAD ambition to position their scientific advances in the world and to influence international thinking, as was explicitly expressed in CIRAD's strategy in 2014. The recognition of their contributions to the international agenda is not obvious. Louis Malassis's definition of food systems from 1994 is for example still overlooked despite insistence, even as the concept of food systems, now in vogue, is most often attributed to Ingram (2011); no matter its sustainability has been the center of DuALIne research program launched in November 2009 by INRA and Cirad. The same is true of the concept of multifunctionality, first defined in the 1990s, rejected by export countries because of the suspicions of distortion of international trade to which it would give rise, and which is now emerging again. However, some methods or approaches have been widely recognized as the affirmation of forward-looking reasoning via the conduct of Agrimonde foresight study or the exploration of possible futures of the world's agricultural and food systems up to 2050. Opening ourselves to the world implies to work together to join international programmes and initiatives and to make INRAE and CIRAD voices heard with our partners in these instances. This was undertaken on the occasions of our participation in the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) and the Global Conferences on Agricultural Research for Development (GCARD) as well as our involvement in the CGIAR global research partnership, Global Forum on Agricultural Research (GFAR) and the High Level Panel of Experts on Food Security and Nutrition (HLPE of the United Nations Committee on World Food Security – CSA). Such international experiences provide opportunities to better connect what is happening locally, nationally and globally.

Finally, in a context where negative externalities are attributed to globalisation, there is now a keen interest for all things 'local', and the pioneering work to re-territorialise agriculture attests to this. With the return of the concept of local or national food sovereignty, spurred by the Covid pandemic, we must avoid the trap of localism and strict confinement within national borders. We must not just 'think global, act local' but rather think and act *both* locally and globally in a coherent way. The interdisciplinary and interinstitutional GloFoodS programme showed that it was possible to do so, and thus offered a way to escape the pitfalls associated with scaling up, where by solutions that were designed and used in one place would simply be replicated elsewhere. With the United Nations Food Systems Summit 2021, an ambitious international agenda for the years to come and a renewed commitment to multilateralism after a several-year hiatus, it is up to us to make the most of these opportunities.

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