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Achieving long-term food security in the face of crises: the pathways offered by research

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The crises currently affecting food systems worldwide were not primarily triggered by the conflict in Ukraine, although it has exacerbated tensions on global markets. They are actually a result of older, more structural factors that must be put into perspective if they are to be tackled effectively. CIRAD's researchers suggest concrete actions to foster long-term transformation of food systems in order to achieve food security without jeopardizing biodiversity or the environment, worsening climate disruption or increasing socioeconomic inequalities.

Key messages

- The past five years have seen a historic reversal of global food security trends. After a constant but slow fall in the number of people suffering from undernourishment since the 1960s, the figure is now rising, notably as a result of climate, health or political crises.

- The rise in wheat and maize prices had already begun well before the Russian invasion of Ukraine. In particular, it is linked to the post-Covid-19 economic recovery. It is set against a backdrop of increasing market instability, due to the cumulated effect of various crises, whether environment-, health- or security-related.

- The food security situation varies from country to country – particularly in Africa – and calls for bespoke solutions. Food security depends on global markets, countries' ability to produce enough to feed the population, and food security policy (accessibility, distribution, storage, etc). It is particularly sensitive to price spikes in highly dependent countries with limited means to pay their food bills.

- To be sustainable, increased food production must be achieved by means of ecological intensification of agriculture, and not at the expense of biodiversity.

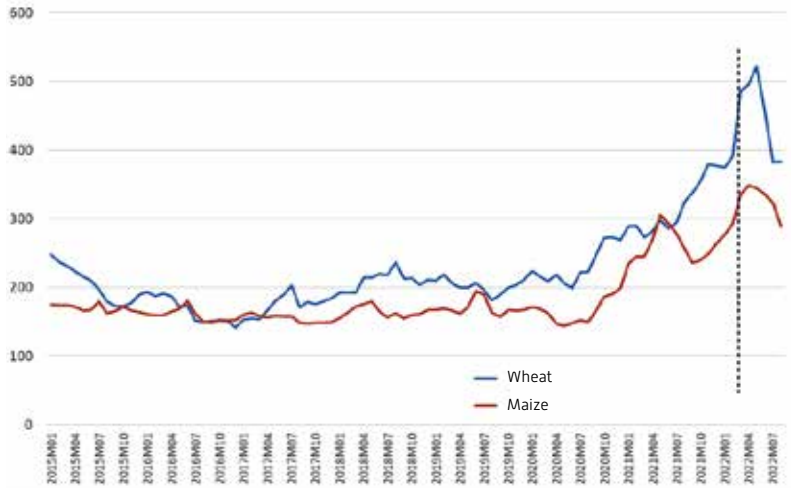
- Based on its almost forty years of experience of agricultural research for development in tropical and Mediterranean countries, CIRAD recommends priority lines of action to boost global food security long term. They include the agroecological transition, crop diversification and more effective governance of food systems.

Point 1 • The current food crisis is the result of several factors

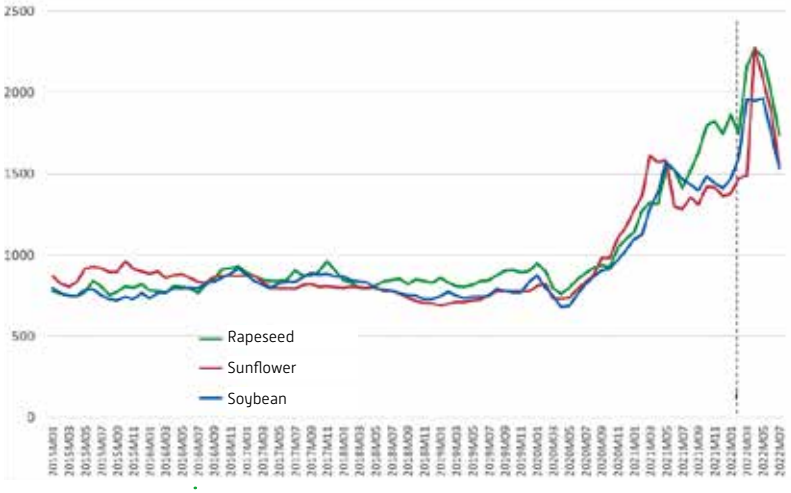
What crisis?

Wheat[1], maize[2] and vegetable oil[3] prices on global markets have been rising since mid-2020 and spiked between February and May 2022 due to the halting of Ukrainian exports. Prices have now returned to the level they were at prior to the war in Ukraine, in other words a very high level (around double the average price for the period between 2015 and mid-May 2020). What will happen in future is unclear, but there are a range of factors that could cause new rises: a possible collapse of the agreement between Russia and Ukraine to free up Ukrainian exports, a likely fall in production in Ukraine (as a result of the war), poor global harvests due to the disruption of agricultural input markets (as a result of sanctions against Russia and Belarus), and the energy price spike. This rise in agricultural prices goes against the steady falls seen for almost a century.

Cereal prices (US$/t)



Vegetable oil prices (US$/t)



Source of both graphs: World Bank

In many world regions, these price rises are threatening access to food. Wheat plays a major role in food security in in North Africa and the Middle East, and maize in sub-Saharan Africa and parts of Latin America. As for vegetable oils, they provide vital nutrients and their share in household spending is far from negligible.

Rising food prices have been accompanied by a marked increase in the cost of energy[4] and of numerous agricultural inputs (fertilizers and pesticides) whose production is reliant on gas and oil. This inflation is exacerbating food insecurity for populations already suffering as a result of the Covid-19 crisis. The increase in nitrogen fertilizer[5] and maize[6] prices is making life very difficult for those crop and livestock farmers whose activity depends on these inputs.

This abrupt crisis has exacerbated the already worsening global food security situation. After falling steadily, albeit too slowly, since the 1960s, the number of people worldwide classed as undernourished has been rising for the past five years, as a result of multiple climate crises and conflicts. While 805.5 million people were undernourished in 2005, the figure was "just" 573.3 million in 2017, but back up to between 701.9 and 828 million by 2021[7] .

Why a crisis?

This part looks firstly at general observations worldwide (**A** and **B**), before focusing on Africa (**C**).

A. A food model that has reached its limits

The industrial food production model that has been rolled out across the world since the 20th century, and particularly since the Second World War, is based on low fossil fuel costs, biotechnology-based specialization and intensification (selected seeds), mechanization and chemical inputs (fertilizers, pesticides and veterinary drugs), and the large-scale processing and distribution of standardized- mass-market products. Agricultural commodities are produced where they are cheapest, and traded on global markets. This model has allowed us to produce and distribute cheap food, and has reduced the number of large-scale famines. However, while the planet now produces much more than it needs in terms of energy and protein, it wastes a significant proportion of what it produces (almost 20% of the food available per inhabitant in 2021, according to UNEP). This food model, summarized by Dale Allen Pfeiffer as "eating fossil fuels[8]", is now reaching its limits. The environmental, health and social externalities[9] have become too costly for society and are threatening our future capacity to produce food:

- The specialized, monocrop-based types of industrial agriculture promoted since the 20th century have caused deforestation and habitat loss and fragmentation, with adverse effects on biodiversity. That biotic shrinkage and homogenization is compounded by the direct toxic effects of our use of vast amounts of chemical and artificial products (fertilizers, pesticides, plastics, veterinary products, etc). In return, biodiversity loss has had a negative impact on the production capacity of our farming systems[10] (natural biological control of pests and diseases, pollination, soil fertility, water quality, etc).
- Massive use of fossil fuels (oil for mechanized farming, gas for nitrogen fertilizers), mined fertilizers and electronic components made using rare earth elements is exhausting non-renewable resources that could be shared with future generations. Our food system, from agricultural production to waste, is responsible for around a quarter of greenhouse gas (GHG) emissions[11], notably as a result of industrial animal farming.
- The abundance and low cost of calories from sugar and fat, animal proteins, and highly processed foods containing numerous additives, and the presence of pesticide and plastic residues are a threat to human health. Obesity is a global issue affecting every country in which industrial food consumption is rising. The increase in heart disease, some cancers, and neurodegenerative diseases is partly linked to the overabundant, unbalanced and unhealthy foods we consume. The growing disconnect between consumers and food production and the increasing corporate concentration seen in recent years have triggered concerns, an impression of powerlessness over our food system, and a loss of confidence.
- Jobs in agricultural production, transport, mass distribution, catering and waste management are amongst the most precarious. Paradoxically, the highest food insecurity rates are often seen among agricultural producers in poor and middle-income countries.

There is now a scientific consensus[12] on the need for an in-depth transformation of our food systems to guarantee their long-term environmental viability, notably ending our reliance on fossil fuels and synthetic chemicals, better human and animal health, and fairer distribution of added value[13].

The planet now produces enough food to feed the population expected by 2040 (around ten billion inhabitants, compared to roughly seven billion today)[14]. Lester Brown[15] made this observation as much as two decades ago. Various foresight exercises[16] agree that such a balance would even be possible with much more environmentally friendly production methods, provided food consumption habits become more diverse and frugal, with no over-consumption of animal products, fat and sugar and using fewer ultra-processed products.

B. Food systems are under pressure in an increasingly unstable world

Food systems are increasingly reliant on other systems over which they have no control and which are increasingly unstable: climate, the energy market, finance, transport, and mineral resources. Their resilience, in other words their ability to continue to function, even in the event of crises or intermittent resource availability, is now a major concern.

They are also under pressure from environmental, economic and social factors.

Environmental pressure

Climate change has had a major impact[17] on food systems. Increased GHG emission, higher global temperatures, glacier melt and an increase in the number of extreme climate events are already affecting agriculture worldwide. These phenomena are exacerbating variability in terms of yields and of national and global market prices.

Shrinking biodiversity is threatening both ecosystem viability and agricultural production capacity.

Current food systems, which are both responsible for and victims of the damage they cause, are suffering the effects of resource degradation: soils are increasingly impoverished[18], water is in short supply, climate disruption is increasing the pressure on plants and animals and threatening the ecosystem balance required to produce food. The most common alternatives (increased synthetic fertilizer use to restore soil fertility, artificial pollination, greater pesticide use, etc) are only a short-term solution, and indeed serve to sustain and exacerbate the damage already caused.

Market tensions

The post-Covid-19 recovery has disrupted regional and global trade circuits, pushing up commodity prices (cereals, oils and fertilizers)[19] and triggering inflation and increased food insecurity worldwide.

Oil price rises, combined with inflation, due to the Russian invasion of Ukraine and the subsequent war, have contributed to the dramatic increase in certain food prices. Wheat topped an average of US$ 492 per tonne between April and June 2022 (after the start of the war), compared to just under US$ 288 between June and September 2021, a 70% rise[20].

Food prices are highly volatile and are generally rising. This is down to several factors, including an increase in supply shocks (partly due to climate change) and rigid demand. That rigidity in terms of demand is compounded – as far as maize and vegetable oils are concerned – by policies aimed at bolstering agrofuels, notably incorporation mandates imposing a minimum proportion of agrofuels in the fuel sold at petrol stations. This is accompanied by a lack of mechanisms guaranteeing sufficient stock levels to be able to absorb supply or demand shocks.

Social tensions

Armed conflicts often trigger food crises in certain world regions, including the Sahel. The likelihood of future conflicts will probably increase with growing migration due to climate change and increasing pressure on resources such as land and water. An analysis of existing conflicts shows that they can affect food supplies by reducing production, disrupting trade or triggering stock thefts or destruction. They are also likely to reduce market activity, even if there are no armed attacks in the immediate vicinity of the markets concerned[21].

Table 1.
Countries not significantly vulnerable to global wheat price rises

Country	Population 2020	Wheat consumption in 2020 (100% of wheat is imported)		
	In million inhabitants	In kcal/ person/day (2018-2019 average)	In % of total calories	In kg/ person/ year
Benin	12.1	117	4%	2
Burkina	20.9	103	4%	7
Burundi	11.9	60	2%	8
Cameroon	26.5	207	7%	30
Central African Republic	4.8	24	1%	<1
Chad	16.4	29	1%	2
Comoros	0.9	192	8%	<1
DR Congo	89.6	39	2%	3
Ghana	31.1	139	4%	22
Guinea	13.1	155	5%	30
Guinea Bissau	2.0	115	5%	
Ivory Coast	26.4	177	6%	25
Lesotho	2.1	193	9%	22
Liberia	5.1	107	5%	7
Madagascar	27.7	108	6%	2
Malawi	19.1	57	2%	7
Mali	20.2	144	5%	17
Mozambique	31.3	170	8%	23
Niger	24.2	29	1%	<1
Rwanda	13.0	76	3%	12
Sierra Leone	8.0	103	4%	1
Togo	8.3	131	5%	12
Tanzania	59.7	126	5%	4
Uganda	45.7	82	4%	15
Zambia	18.4	65	3%	2
TOTAL	538.5			

C. In Africa: contrasting situations in the light of the Ukrainian crisis

Contrary to popular belief, the food situation in Africa differs significantly from one country to another, as regards both the products consumed and their origin (local, sub-regional or global). Most of the foods eaten in Africa are produced in Africa, although import volumes are increasing (FAO). According to FAO, on average, the continent imports around 25% of the calories it consumes.

Wheat is not a staple in sub-Saharan Africa

One good example of those differences, in the light of the 2022 price rises, is wheat: sub-Saharan Africa produces very little, and the continent's most vulnerable people generally do not rely on it for their food security. An in-depth country-by-country analysis shows that the wheat price spike caused by the halt to Ukrainian exports has not affected all of the region's countries equally. Their vulnerability depends on the one hand on the importance of imported wheat in their diet, and on the other on their capacity to pay this year's higher wheat prices. Since certain countries that import wheat export petroleum products (oil and gas), they have benefitted from the surge in oil prices.

Except in North Africa, Djibouti, Mauritania, Mauritius and Sudan, wheat does not provide more than 20% of total calories. Its importance is even more marginal in the countries of sub-Saharan Africa. Depending on the countries, rice, maize and cassava are the most widely consumed staple starches. Increased wheat prices concern only those countries in which it is a secondary staple, except in urban areas.

Certain countries are not reliant on imported wheat for their food security

In 25 sub-Saharan African countries (see table 1), which total almost 540 million people, wheat provides less than 10% of the calories. Those countries are therefore not significantly vulnerable to wheat price rises.

In a further twelve countries totalling almost 320 million people, wheat is a supplementary food: it provides between 10 and 33% of the total calories consumed. It may also be replaced by other starches, making these countries moderately vulnerable.

In both cases, it is worth noting that while wheat consumption remains relatively marginal, it is generally higher in urban areas, where people are thus more vulnerable to price rises than those in rural areas.

Some importing countries export oil, and are able to ride out the crisis

Countries such as Algeria, Azerbaijan, Iraq and Libya are highly dependent on wheat imports (wheat accounts for between a third and half of the calories available, and imports for between 25 and 90% of

Table 2.
Vulnerable countries: large-scale wheat importers and consumers that do not export petroleum products

Country	Population 2020	Wheat consumption		Rice imports in 2020	
	In million inhabitants	In kcal/ person/day (2018-2019 average)	In % of total calories	In kg/ person/ year	En % of total wheat consumption
Armenia	2.9	932	31%	105	>90%
Cyprus	1.2	961	32%	56	57%
Djibouti	0.9	983	35%	146	100%
Egypt	102.3	1162	35%	106	79%
Georgia	3.9	1044	37%	132	>90%
Jordan	10.2	824	32%	94	>90%
Lebanon	6.8	1026	36%	85	65%
Mauritania	4.6	947	33%	156	>90%
Morocco	36.9	1384	41%	121	60%
Tunisia	11.8	1543	44%	166	83%
Yemen	28.8	937	47%	102	87%
TOTAL	210.3				

consumption). However, those countries, which also produce oil and /or gas, have and will have the ability to cope, due to their oil revenue. Likewise, in Angola and Gabon, wheat accounts for between 10 and 17% of calories, but their substantial oil revenue renders them less vulnerable.

Some countries are more vulnerable and need help

Eleven countries in North Africa and West Asia (see table 2), totalling around 210 million people, are particularly vulnerable. Wheat accounts for around a third of total calories, imports provide between half and 100% of what is consumed, and the countries concerned do not have any oil or gas resources.

Point 2 • Coping with crises and building more sustainable food systems

Wheat is not the staple food for the entire world population. It is therefore not the only food on which efforts to respond to food crises worldwide should be focused. It is clear that the price rises seen recently also concern other major food products, such as maize and vegetable oils, as well as petroleum products. All the world's consumers are affected.

It is possible to use economic policies in agro-industrial countries to relieve pressure on global food commodity prices, by limiting the use of those commodities to produce agrofuels.

Cutting consumption of animal products is a second way of limiting the rise in global prices, by reducing demand for animal feed.

Any steps taken to regulate global markets will complement those that must be taken on a more local, national or regional level, for a specific territory.

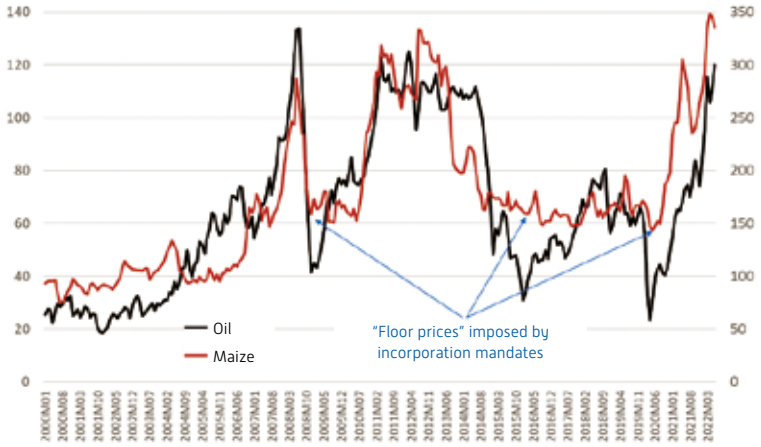
Acting on agro-industrial food systems to reduce the pressure on poor countries

Food security in poor countries is subject to pressures that are both growing and interrelated, the causes of which often lie in the production and consumption systems of industrialized countries[22]. Food systems are not self-contained. Analyses on a global level, for instance by CIRAD, have highlighted the links between them. The price of broken rice, for instance, increased temporarily when some countries used it to feed livestock, to replace by-products of other cereals that had become too expensive. Similarly, diets rich in animal products have huge effects on demand for cereals and oil and protein crops, which in turn has consequences for markets, land use, deforestation in the tropics and biodiversity loss[23].

Capping the use of agricultural products to produce fuel could help to balance currently unstable global markets

"Agrofuel" value chains were set up at a time when prices were low and supplies plentiful. Agrofuels now play a major role, linking cereal and vegetable oil prices to those of fossil fuels: the higher fossil fuel prices are, the more likely industrialists are to use agrofuels, and consequently the more food commodity prices will rise. Limiting the use of maize and vegetable oils to produce fuel in times of crisis would bring the price of those commodities back to pre-crisis levels, hence would also help to bring wheat prices down, since this sector uses vast quantities of both maize and vegetable oils. Slashing demand from industry in half would increase vegetable oil supplies on the world market by 20% and those of maize by 50%[24].

The link between oil and maize prices



Source: World Bank

Reducing (but not ending) animal product consumption in industrialized countries would benefit markets, food security and the environment

As things stand, 40% of the cereals produced worldwide are used as animal feed, including 20% of wheat and almost two thirds of maize. There is a broad scientific consensus, relayed by various UN bodies, calling upon western (but not only western) countries to cut their excess animal product consumption, in view of its proven effect on both health and the environment[25]. To quote just one example, the global livestock production sector alone accounts for 14.5% of manmade GHG emissions.

Besides its effects on health and GHG emissions, cutting animal product consumption would ease the tensions on international food commodity markets.

Engaged science for sustainable farming systems

The research CIRAD and its partners are doing to build more sustainable farming systems rests upon several principles: inclusive governance, agroecology, and integrated food value chains on a territory scale[26].

Supporting and co-building inclusive food system governance on a territory scale

Establishing and sustaining food systems that guarantee food security and a social and economic balance between producers and consumers, in rural and urban areas, and employees and businesses within value chains, all while safeguarding natural resources, means allowing for a range of very contrasting situations. It requires a territory-based approach. Players within territories face various issues centring on food security, employment, and quality of work in all food-related activities. Ensuring food sovereignty, in other words including the different stakeholders in decisions that concern them, is a vital part of building and maintaining sustainable food systems.

Collective, participatory diagnoses are vital to assess the constraints and the ways of overcoming them.

Food policy building can be supported by means of a number of varied but complementary operations: modelling, territorial foresight exercises, participatory diagnoses of food systems, living labs, consultation platforms, serious games[27], etc.

Agroecology, a much-needed transformation to guarantee food security and sovereignty

Agroecology promotes agriculture based on environmentally friendly biological processes, which includes farmers and consumers in the choices that concern them, in the aim of building sustainable food systems. It makes maximum use of all the interactions between the different components of the living world, to reduce our reliance on fossil fuels while sustaining efficient, profitable farming systems. It is not merely an alternative agricultural model, but an in-depth transformation of our development models. CIRAD has been working for many years on a range of research and full-scale trials to document and assess whether agroecology constitutes an economically and socially viable alternative to conventional intensification models.

First and foremost, the aim is to work in a range of environments to co-design bespoke agroecological solutions combining traditional and scientific knowledge. That knowledge, backed by a strong commitment on the part of the political and institutional environment surrounding farming systems, provides the ten levers for the agroecological transitions required[28]: crop complementarity and diversity, to optimize resource mobilization; functional biodiversity, to exploit biological control of pests and diseases more effectively; biodiversity management, from an agricultural plot to a rural landscape level; more targeted genetic improvement; strengthening and renewal of local support for producers, through advice and training in which they participate actively; renewal of targeted, bespoke national and territory-based institutional frameworks; organizing producers on relevant levels; development of more suitable value chains; adaptation of performance evaluation methods; and recognition of trans-generational and gender issues.

The challenge is to build agroecological production systems that are sufficiently productive in terms of both quantity and quality. Setting aside the controversy surrounding yields from agroecology compared to "conventional" agriculture, it is important to promote systems with high productivity per surface area. That productivity should be measured with respect to indicators suited to what is produced in agroecological systems and on an appropriate scale, since plots

in such systems are not just planted with one crop, but are intercropped, rotate crops or combine crops with livestock production. It is that overall productivity that should be assessed[29].

Our work shows that we need to activate individual and collective technical and policy levers to establish food systems centring on agroecological principles[30]. Those levers could be biological regulation processes, such as using repellent plants, which serve to control pests, introducing legumes into cropping systems to boost soil fertility, improving soils using organic matter (linked to recycling and the circular economy), creating ecological corridors to improve biodiversity, or setting up multi-stakeholder innovation platforms or participatory guarantee systems to encourage players to play a more active part in decision making.

For instance, agroforestry, intercropping and crop rotation significantly improve yields per surface area, due to the complementarity of the different crops grown, while providing more ecosystem services thanks to biodiversity: soil quality, pest and disease control, and water quality and use. Combining crop and livestock farming ensures optimum biomass exchanges between the two activities, ensuring more efficient processes and nutrient recycling, including carbon.

These combined effects create synergy on a local level, where they increase crop diversity, resulting in a broader range of products, foods and revenue sources for the areas concerned. As the number of crop species increases, so does the range of available food products. Diversifying crops can therefore have a positive effect on the different aspects of food security on a local level, in other words on the stability of food supplies, food availability, and access to food. This is of particular benefit to vulnerable population groups (both marginal groups in cities and poor rural inhabitants). Crop diversity also boosts the quality of the food on offer, by correcting the current market situation, in which "junk food" is the most affordable diet for poor population groups in industrialized countries.

Developing food value chains linking production and consumption within territories

The research CIRAD and its partners are doing is specifically aimed at improving cropping systems and varieties for foods of vital importance in the diets of people in the global South. The objective is to develop varieties and co-build cropping systems that are tailored to the constraints imposed by climate change and productive in relation – among other things – to demographic changes. It is important to take into account demand from urban markets, consumers and processors, and agronomic constraints. Methods are being developed to reconcile the range of different expectations (quality criteria, yields, adaptability, etc) for products of vital importance for food self-sufficiency, in Africa and elsewhere, such as roots, tubers and plantain bananas[31].

The aim is to work on storage and processing systems, which are vital links between production and consumption, focusing on increasing the shelf life of agricultural products and on satisfying consumer demand. CIRAD is working on bespoke technology for specific local situations, to process products and help to produce healthy, nutritious foods. This sector also helps to provide jobs and include women and young people, who are often involved in processing.

Considerable research is also being done on highly nutritious foods such as fruit and vegetables or dairy products, on a range of scales: zero-pesticide cropping systems, support for producers' organizations[32], etc.

Lastly, CIRAD is working on the conditions in which value chains create jobs within territories, and the quality of those jobs[33]. It is studying systems that empower family farmers or small-scale processors to organize markets and boost their income, thanks to specific public policies and instruments to recognize their products (labels, participatory guarantee systems, etc).

Illustration: D. Guard-Lavastre, CIRAD

Recommendations

1. Act in rich countries to reduce pressure on global prices, by limiting agricultural food commodity use for non-food purposes and as animal feed.

2. Steer consumption habits and production methods towards healthier diets with less impact on resources: avoid excessive consumption of animal products, sugar and fat.

3. Encourage participation and build citizens' capacity to participate, and involve the authorities more in projects, to build more sustainable agricultural and food territories.

4. Map pathways to a transition to sustainable food systems through critical systemic assessments using tried and tested participatory methods.

5. Develop more agroecological production systems, to build healthier, truly sustainable food systems. To this end, make use of technical know-how (farming practices, rational fertilizer use, etc) and organizational methods (enabling the involvement of and uptake by a broad range of stakeholders within territories) generated by research projects (such as FAIR Sahel or ASSET) that have proved their work on a local level, to foster change on a larger scale.

6. Develop more environmentally friendly processing and food systems logistics activities. In particular, work on circularity and recycling, reduce losses, improve eco-processing and make processes more ecoefficient, and optimize waste and wastewater treatment.

7. Increase food and nutrition sovereignty, which will also alleviate poverty and fight climate change, by supporting more sustainable local food value chains.

8. For Africa, support products such as roots and tubers (cassava, yam or cocoyam), plantain bananas, sorghum, millet, fonio and rice, market gardening, and domestic horticultural value chains as a diversification activity.

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2. US$ 165.5/tonne as an annual average in 2020, US$ 289.8 as a monthly average in August 2022 (Source: World Bank, September 2022)

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