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FOOD SYSTEMS AT RISK

NEW TRENDS AND CHALLENGES





FOOD SYSTEMS AT RISK

NEW TRENDS AND CHALLENGES

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PREAMBLE

We are living in unprecedented times; as attested by recent headlines some of the positive trends observed in past years are kicking in reverse with ever more people affected by new combinations of risks and trends: climate crisis, conflicts, resource scarcity (water), inequality, food insecurity, malnutrition and obesity, environmental degradation, affect particularly people living in marginalized rural communities or poor city dwellers.

After decades of steady decline, the trend in world hunger reverted in 2015, remaining virtually unchanged in the past three years at a level slightly below 11 percent. Meanwhile, the number of people who suffer from hunger has slowly increased. As a result, more than 820 million people in the world were still hungry in 2018, underscoring the immense challenge of achieving the Zero Hunger target by 2030.

Today, over 110 million people are suffering from food crisis. It will only get worse if current trends cannot be reversed. Why is this happening?

Multiple drivers are causing these trends and can be grouped in three clusters:

- Socio-economic factors: demographic change, urbanization, growing inequality, unequal access to resources, unhealthy eating habits. Poverty.
- Environmental factors: climate change, soil degradation, over-exploitation of natural resources, water scarcity. Reaching the limit.
- Peace and security: armed conflict, good governance, rule of law. Fundamental rights.

Deepen a common understanding of the underlying dynamics of these trends was the reason why the European Union and the Food and Agriculture Organization of the United Nations co-organized the High Level Event "Food & Agriculture in times of crisis: working better together for long-term solutions" (1-2 April 2019). First in its kind, the event was organised on behalf of the Global Network against Food Crises.

For this event, CIRAD prepared a booklet with key maps and facts¹ to be complemented with a scientific report on critical drivers & trends, system components, interactions and critical challenges as regards food and nutrition security. Upon request of the European Commission, through the FAO Agrintel project (GCP/GLO/948/EC), CIRAD developed also an analytical framework on the trends that are shaping current food systems as well as to realize an assessment of the risks they are subjected to and which may lead to food crises (or worse) in the future.

While the event represented a strategic opportunity for the international community and civil society to start tackling some of the key challenges posed by food crisis and the fundamental injustice of about 800 million people facing hunger, the scientific report hereunder takes stock of the current and future risks and challenges as regards food systems. In a next step FAO and CIRAD project to develop an approach and toolkit to realize diagnostics of food systems at sub-national, national, sub-regional or regional level in order to identify and formulate transformative interventions improving their welfare benefits and environmental sustainability.

Solutions exist and new approaches for efficient joint work are possible.

There must be no more food crises.

1. **Bendjebbar P., Bricas N. and Giordano T.**, 2019. *Food systems at risk. A scientific handout for the High Level Event of the Global Network on Food Crises: Food and Agriculture in Times of Crisis*, Brussels, 2-3 April 2019, Montpellier, CIRAD, 48 p. (<https://www.cirad.fr/media/documents/actualites-doc/food-systems-at-risk-a-scientific-handout-cirad-2019>).

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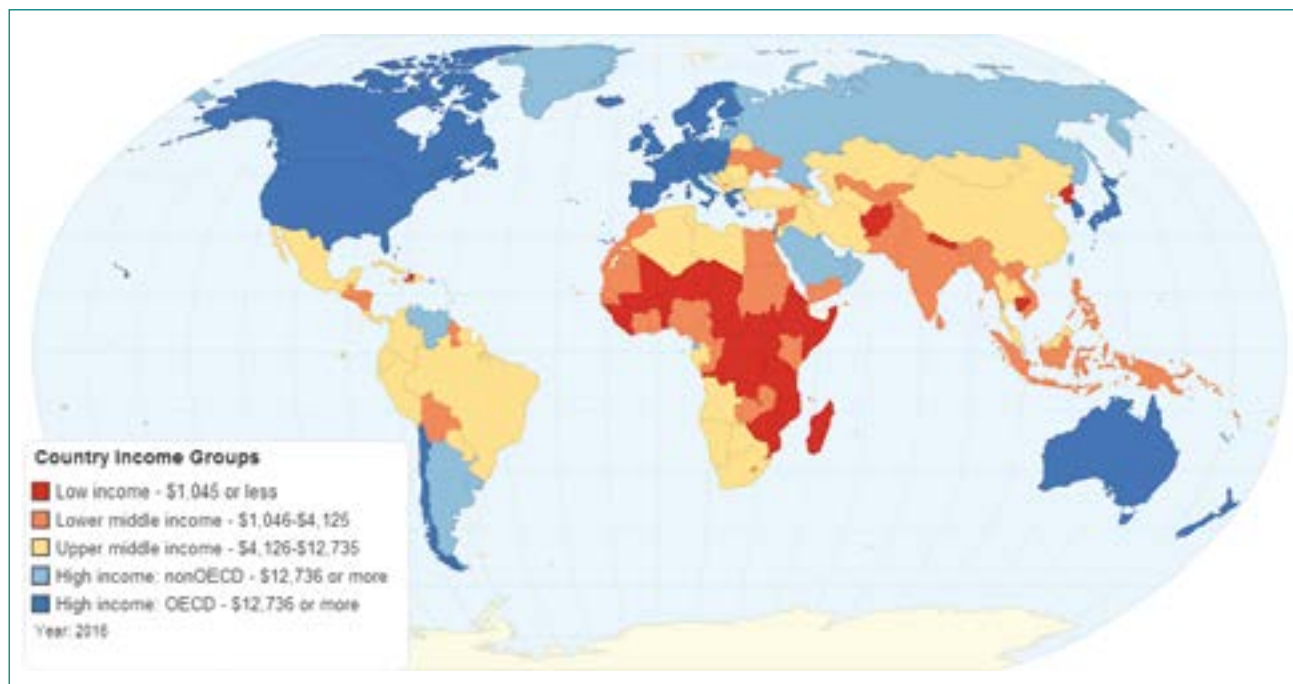
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INTRODUCTION

The origins of this book lay in a series of questions raised by the European Commission's Directorate-General for International Cooperation and Development (DG DEVCO) as a contribution to a High Level Event of the Global Network Against Food Crises. This event, addressing 'Food and Agriculture in Times of Crisis', was held in Brussels on 2-3 April 2019 and asked whether food crises will be more or less likely in the coming decades, especially in Low-Income (LI) and Lower Middle-Income (LMI) countries. Through Agrintel, CIRAD was commissioned by FAO to provide an analytical framework of the main drivers which might influence the occurrence of food crises and their trends. A booklet was produced for the event with maps and key figures¹, with this report presenting the full narrative.

In this report we concentrate on what is problematic if nothing is done. Even though many of us were tempted to suggest ways forward and spend our working lives seeking more sustainable food systems, this is not the scope of the report. Instead, we have tried to bring together the most up-to-date scientific assessment of the danger humanity faces if present trends continue, with priority being given to food systems in LI and LMI countries (*cf.* Map 1).



Map 1: *Country Income Groups.*
Source: World Bank.

Specialists in different domains were asked to summarise in a short chapter the latest information they could compile. Strong scientific evidence is now well established for many food system drivers and their various trends. For example, it is now widely accepted that climate is highly affected by different forms of food production, transport and marketing. It is also well known that changes in diets towards the consumption of more animal products is contributing to deforestation in Amazonia because of the growth in the international market for soybean for animal feed across the world. There is no doubt that existing food systems are associated with a pandemic of obesity and non-communicable diseases, which are responsible for more deaths than cardiovascular diseases.

1. **Bendjebbar P., Bricas N. and Giordano T.,** 2019. Food systems at risk. A scientific handout for the High Level Event of the Global Network on Food Crises: Food and Agriculture in Times of Crisis, Brussels, 2-3 April 2019, Montpellier, CIRAD, 48 p. (<https://www.cirad.fr/media/documents/actualites-doc/food-systems-at-risk-a-scientific-handout-cirad-2019>).

However, it is often difficult to be precise about the magnitude of past (and even more so future) changes. Furthermore, they cannot be estimated because many mechanisms of action and retroaction are very closely interrelated and it is difficult to know how each driver contributes to one specific variable, input or output of the food system (yield, pollution, food security, diets, etc.).

Moreover, we are working in the domain of uncertainty. Many problems (or opportunities if we take a positive stance) have never previously existed. Even if it was possible to look backwards, to analyse the details of the dynamics of systems, it might not be very useful to do so, because most food system drivers (economic, environmental and demographic) are changing too fast and the dynamics in coming years might be different to those of the past.

Furthermore, interconnections between the different elements of food systems have never been so obvious. Every day, new scientific evidence is published about these cumulative risks, which are very hard to predict. One of the latest, published in *The Lancet*, even suggests creating a new framework for the synergy of epidemics, or 'syndemic'. The authors (Swinburn *et al.*, 2019)² include under this unique concept the three global epidemics (pandemics) of obesity, undernutrition and climate change, because they share common underlying societal drivers.

Therefore, different visions of the past, and even more so of possible futures, co-exist. For many aspects, we must accept that we have limited information and to acknowledge that we have a very partial knowledge of the different mechanisms (biophysical, social or economic) underlying the functioning of sub-systems, together with their interactions. This is why the report's authors have assessed the evidence and scientific controversies and provided their own points of view. Because of the complexity of systems, there is also a difficulty in the division of specific chapters. Some aspects are repeated several times while some others may not be so visible (for example, there is no specific chapter on the question of food loss and waste, nor for governance issues, nor conflicts and migrations) but we did our best to include the most important issues in other chapters.

The first section provides the framework of what comprises a food system, its drivers and outcomes, and how the main drivers have changed in past decades and are expected to change in coming years. There are multiple ways for dealing with the modelling/representation of food systems and our choice was based on our own experience and on the latest scientific literature and studies by international organisations. Our choice was also motivated by the need to assess, in the future, food systems on a local basis, where many political decisions will have to be designed and implemented.

Section 2 deals with the interactions between food systems and climate change. It concerns both the contribution of existing food systems to climate change (their carbon footprint, the specific contribution of the increase in animal production and deforestation), and one specific consequence of climate change on food systems, with a chapter dedicated to the emergence of new pests and diseases.

Section 3 deals with the environmental consequences of existing food systems: over-exploitation of natural resources, irreversible biodiversity loss and pollution of water, air and soil. It also assesses the possible feedback effects of these degradations of natural resources on food systems.

Section 4 considers the social and economic dimensions of food systems. It reviews the implications of current trends for job creation, for the inclusion of small-scale actors, women, minorities and territories into food systems, and the implications of modern digital technologies. It shows that while food systems could be a major building block for prosperity and stability in many LI and LMI countries, current trends are threatening the ability of countries to meet this potential. There are inequalities between actors within food systems, including women and minorities, between territories, there are difficulties in making labour-intensive food systems a priority and there is a high risk of excluding many stakeholders from the benefits of digital technology, which may trigger further civil conflicts and food crises.

Finally, Section 5 concerns food and nutrition security, an outcome determined by two other food system outcomes (environmental and social and economic). It deals first with the difficult question of food production which is sufficient to meet needs, then two chapters are devoted to the question of the international market for food products and its price instability. Finally, the last two chapters address the negative effects of changing diets on health and the increase in safety risks. ●

2. Swinburn, B.A., Kraak, V.I., Allender, S., Atkins, V.J., Baker, P.I., Bogard, J.R., Brinsden, H., *et al.* 2019. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. *The Lancet*, 393(10173): 791–846 [online]. [https://doi.org/10.1016/S0140-6736\(18\)32822-8](https://doi.org/10.1016/S0140-6736(18)32822-8)

SECTION

01

CONCEPTUAL
FRAMEWORK



SECTION 1
Conceptual framework

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CHAPTER 1.1

THE SCOPE OF THE ANALYSIS: FOOD SYSTEMS

Nicolas Bricas¹

SUMMARY

This chapter presents the framework used in this report. Food systems generate not only food but also environmental and socio-economical outcomes.

Food is much more than a means to meet nutritional needs

Food is essential in all societies. Gathering, hunting, fishing and agriculture have always been activities that provide the majority of the rural population's livelihood. With job diversification and urbanisation, these activities have also become important sources of income, alongside the food processing and marketing that has developed to feed cities. But food functions are not limited to meeting biological needs, even though this is a fundamental one. Food is the first means of social interaction through meal sharing. It is a creative and artistic activity that gives pleasure through cooking and gastronomy, and again through meal sharing. Food is a fundamental way of building and displaying one's identity. It passes through the body, which gives it a special symbolic status (Fischler, 1998). Finally, food is a way of connecting humans to their environment. To produce food, humans transform the landscape and interact with plants, animals and microbes. Although the hierarchy between food functions depends on the society in question, all of them, including food-insecure ones, are concerned about the origins of their food and its sensory and symbolic quality. This means that food does not deal only with nutrition and health but also with well-being and the way human beings live together and interact with their environment.

Food systems approach: a way to take into account all activities, from production to consumption and their outcomes

Since the dawn of humanity, food systems have changed profoundly. From mainly domestic activities organised inside the household, food production, processing and consumption, and even cooking, have become commercial and specialised activities. Post-harvest activities make it possible to stabilise products in order to store and transport them long distances, to extract their useful parts, to facilitate their use by incorporating services, to improve their nutritional, organoleptic or sanitary quality, and to make them available as close as possible to consumers, especially when they move away from production areas. The ways societies process and, even more so, cook products are expressions of their culture. The importance of post-harvest activities is growing with urbanisation and the development of market economies in rural areas. Today, all these activities generate added value, jobs and incomes in both rural and urban areas. The food sector is currently the world's largest economic sector in terms of employment, with more than 2 billion people working in it. In Low-Income (LI) and Lower Middle-Income (LMI)

1. CIRAD, UMR MOISA, F-34398 Montpellier, France; University of Montpellier, F-34090 Montpellier, France.

countries, agriculture represented 68 percent and 39 percent of employment respectively in 2016 (ILOSTAT, 2019). In these countries, food processing, catering, transportation and distribution represent a growing share of employment in services and industry. For example, in Eastern and Southern African countries, agriculture represents 91 percent of employment in the food sector while in Brazil, agriculture represents 49 percent, food services 26 percent and food processing 25 percent of food jobs (Townsend *et al.*, 2017).

The increasing importance of post-harvest, processing and marketing activities in job and income creation, their role in feeding non-farmers, in nutrition and health, in the consumption of energy and resources, in loss and waste, in biodiversity and pollution issues etc. have led to the scope being extended beyond agricultural production to entire food systems.

By food systems, we first mean the chains of market and non-market activities and actors connecting food production, aggregation, transportation and storage, processing and catering, distribution, preparation and consumption, waste and resources management, as well as agro-input suppliers (seeds, fertilisers, packaging etc.) and the associated regulatory institutions and activities (adapted from Pothukuchi and Kaufman, 2000; FAO, 2018a) (*cf.* Figure 1). While these activities and actors are inter-connected by the circulation of food, each of them can be considered as sub-systems with specific interactions with other activities and actors that are not part of agriculture or food (Pothukuchi and Kaufman, 2000). Each sub-system evolves in its own way, with some more industrialised than others, and general drivers may have an influence on some sub-systems but less so on others.

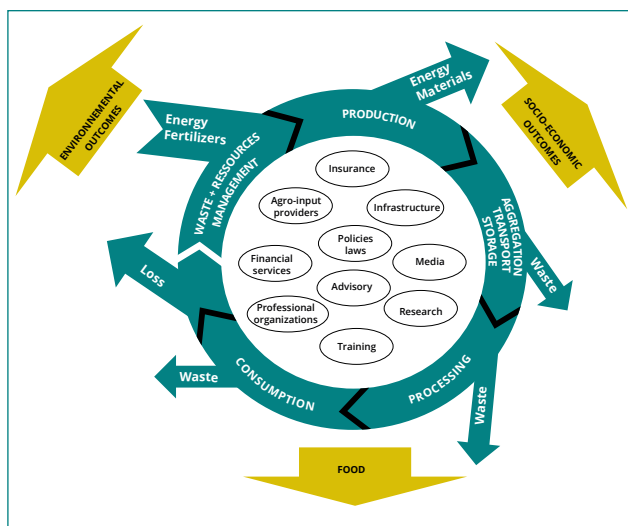


Figure 1: Food systems and their outcomes.
Source: Author.

Taking a systems approach is more complex but it means we can take into account the interactions, influences and feedback between different activities, actors and institutions. Each sub-system includes actors whose sole purpose is not only food. Food systems do not cover all agricultural activities and some of its products are part of a larger bioeconomy: agriculture produces not only food but also energy (firewood and charcoal, draught animals and oils), materials (timber, straw, wood, latex, fibre and leather). Fertilisers can be provided by biomass (straw, leaves and animal manure) or chemicals and mining (chemical nitrogen phosphates and potash). Transportation, energy and consumption apply not only to food. Changes in these sub-systems have an influence on food systems.

A huge diversity of food systems

As a combination of numerous crops, multiple transformation processes, cooking and gastronomic cultures, levels of capital, technology etc., food systems are incredibly diverse. This diversity has been fashioned throughout the ages by human innovations, to take the best advantage of the locally available resources and products and better cope with local constraints. They are also constantly evolving and open to the incorporation of exotic products or experiences. Extending the notion of food systems, we can say that human microbiota have also been shaped by this diversity. Nothing is static in food systems: there are strong dynamics at work in an innovative context, resulting in an ever-evolving mixture of different models of production, processing, distribution, consumption and waste management.

One way of developing agriculture, widely used in industrialised countries and promoted in developing countries, has been based on specialisation, mechanisation and the massive use of non-renewable energy sources (coal and oil) and fertilisers (chemical nitrogen and mining phosphates) and chemical solutions (pesticides) in place of biomass cycles (Daviron and Allaire, 2019). In the post-harvest sector, large-scale processing and mass production, commoditisation and globalisation of trade and large-scale distribution (supermarkets) have developed.

This development model saw an unprecedented improvement in productivity which translated into a large increase in food availability and better access (through economic growth and lower food prices). However, this 'industrialised agriculture' comes with environmental damage (pollution, resource depletion, biodiversity erosion and climate change) and social costs (inequities in accessing healthy diets and in income generation and sustainable livelihoods, and non-communicable diseases) that question the desirability of its spread around the globe.

Awareness of these effects has led several authors to pay attention to the outcomes of food system activities (Ingram, 2011; van Berkum, Dengerink and Ruben, 2018). Food systems do not provide only food but also jobs, income, infrastructure, skills (socio-economic outcomes) and ecological services (environmental outcomes) (cf. Figure 1). This means that food systems can make a significant contribution not only to food and nutrition security, but also to inclusive development and a viable environment for fighting climate change.

Food systems are strategic for inclusive development

Since Amartya Sen's contribution, food security has long been recognised as a matter of access to the means to produce or buy food and not just a matter of producing enough (Sen, 1982). This is even more crucial now as the planet produces significantly more food than is nutritionally required. Food abundance alone does not guarantee food security. One of the main drivers behind the food security we observe today is a lack of access to food, either through the ability to produce enough food to cover all food needs, or physical access to food, or enough resources or money to purchase food. While food systems are therefore strategic in contributing to food security through the jobs and income sources they represent, the ways in which this development takes place have a strong influence on social inclusion. With the commodification of post-harvest activities, power relations and income distribution between men and women are changing more-or-less equitably (Enete, Nweke and Tollens, 2004; Harriss-White, 2005). Conditions of access to land and means of production are also an important determinant of inequalities in access to food.

The choice in industrialisation between capital-intensive and labour-intensive companies determines the speed of job creation. The regulation of competition between actors, within value chains, or between big and small companies, the conditions for applying product standards, the organisation of access to training, advice, credit etc., all affect income inequalities, or even the integration or marginalisation of certain activities. The ways traditional and indigenous food knowledge are considered (or not) in research and intellectual property policies may threaten food diversity and food cultures. In the absence of regulation, the modernisation of forms of food distribution, with the development of supermarkets and now electronic commerce, can result in the marginalisation of the poorest people's access to quality food.

In countries where food activities account for the bulk of employment and income sources, the approach

taken to developing food systems is therefore crucial in promoting more inclusive development.

Food systems are strategic to building a viable environment and fighting climate change

The way people have organised their food systems has profoundly shaped their environment: the ways in which they have cleared or included forests in their agricultural production system, whether production has been specialised or not, how they have employed renewable or fossil energy resources, closed or unclosed nutrient cycles, whether animals are used for food or not etc. have fashioned landscapes and changed biodiversity. Some development models are found to have environmental impacts so significant that they threaten its equilibrium. The pollution food systems cause or their contributions to climate change have an impact not only where these production approaches are used, but all over the world. However, the negative environmental effects we have highlighted also reveal that other production methods can have positive effects, by recycling as much as possible the materials produced, creating biodiversity and capturing carbon (Frison and IPES-Food, 2016; Mason and Lang, 2017). Food systems therefore have an important positive contribution to make in building a sustainable environment and combating climate change.

Three objectives for food systems

During the twentieth century, the aim of food systems was to increase food production and it could be argued that this has been spectacular. However, it has come with a heavy cost in terms of negative externalities: the increase in social inequalities and environmental degradation. This explains why the international community set itself Sustainable Development Goals (SDGs) in 2015; food systems can contribute to these goals well beyond the sole objective of eradicating hunger. Fourteen important contributions of these systems can be identified out of the 17 SDGs (Caron *et al.*, 2018; FAO, 2017, 2018b) and these can be grouped into three main goals: (a) food security and improved nutrition; (b) inclusive development; and (c) the creation of a sustainable environment and the fight against climate change (cf. Figure 1 and Figure 2). These three goals are interrelated: food and nutritional security cannot be achieved without combating impoverishment and reducing the effects of environmental degradation. ●

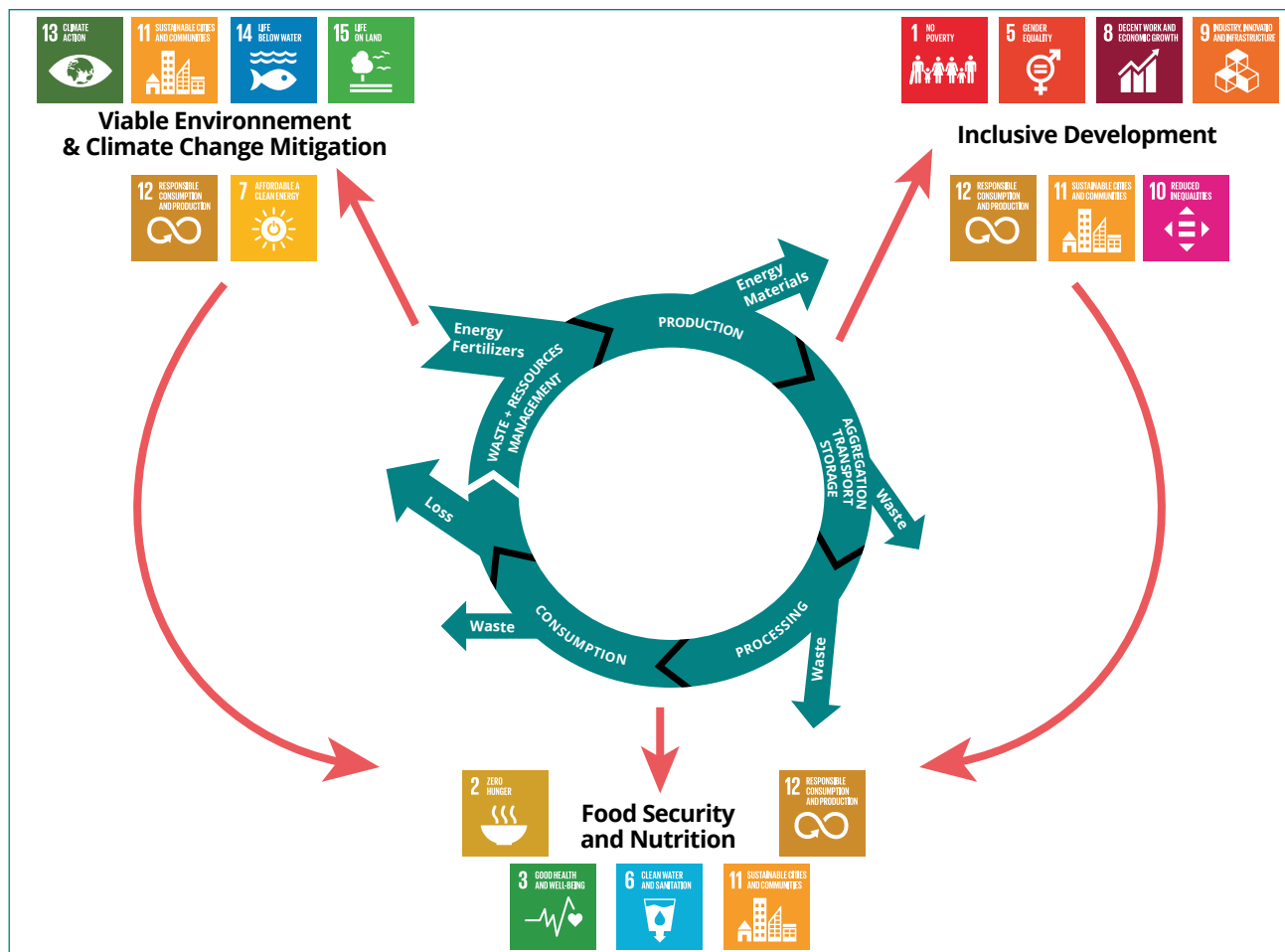


Figure 2: Food systems and the SDGs.
Source: Author.

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CHAPTER 1.2

THE SIX MAIN CATEGORIES OF DRIVERS SHAPING FOOD SYSTEMS

Pauline Bendjebbar¹ and Nicolas Bricas¹

SUMMARY

This chapter explores the different drivers that might affect the future of food systems, their role and impact on food systems and their outcomes..

In the near future, many different drivers are going to challenge food systems. Until now, many reports have emphasised the future trends and challenges for food systems around the world (Caron *et al.*, 2018; Claquin *et al.*, 2017; FAO, 2017; HLPE, 2017; Jahn *et al.*, 2018; van Berkum, Dengerink and Ruben, 2018; WRI, 2018), while this report concentrates on the future risks for food systems in Low-Income (LI) and Lower Middle-Income (LMI) countries, which might be the most vulnerable nations in the years to come.

Depending on how they look at food systems, authors define different types of drivers (Caron *et al.*, 2018; Claquin *et al.*, 2017; FAO, 2017; HLPE, 2011). Some authors consider two sets of drivers (socioeconomic and environmental) (van Berkum, Dengerink and Ruben, 2018), while others consider five groups of drivers: (1) biophysical and environmental; (2) innovation, technology and infrastructure; (3) political and economic; (4) socio-cultural; and (5) demographic drivers (HLPE, 2017). We will define and describe how these can affect food systems.

For our study on risks, we will distinguish six main categories of drivers shaping food systems in LI and LMI countries: demographic, biophysical and environmental, innovation, technology and infrastructure, sociocultural, economic and political (*cf.* Figure 3). We choose six over five, because we prefer to separate political drivers from economic ones as they refer to different dynamics.

Biophysical and environmental drivers

These drivers refer to the natural resources available, pollution and climate. They shape food systems mainly on the production side because food production is highly reliant on the availability of natural resources (water, land, biodiversity etc.).

Natural resources refers, according to the UN, to all “natural assets (raw materials) occurring in nature that can be used for economic production or consumption.” These elements are soil, land, water, fish, biodiversity (plants, animals, microbes etc.), forest and the minerals present in nature. The UN definition distinguishes four categories: mineral and energy resources, soil resources, water resources and biological resources. Some are fossil-based and can be considered as a finite stock and non-renewable (for example, mining phosphate). They are “exhaustible natural resources such as mineral resources that cannot be regenerated after exploitation.” Some others are renewable, which means that these natural resources “after

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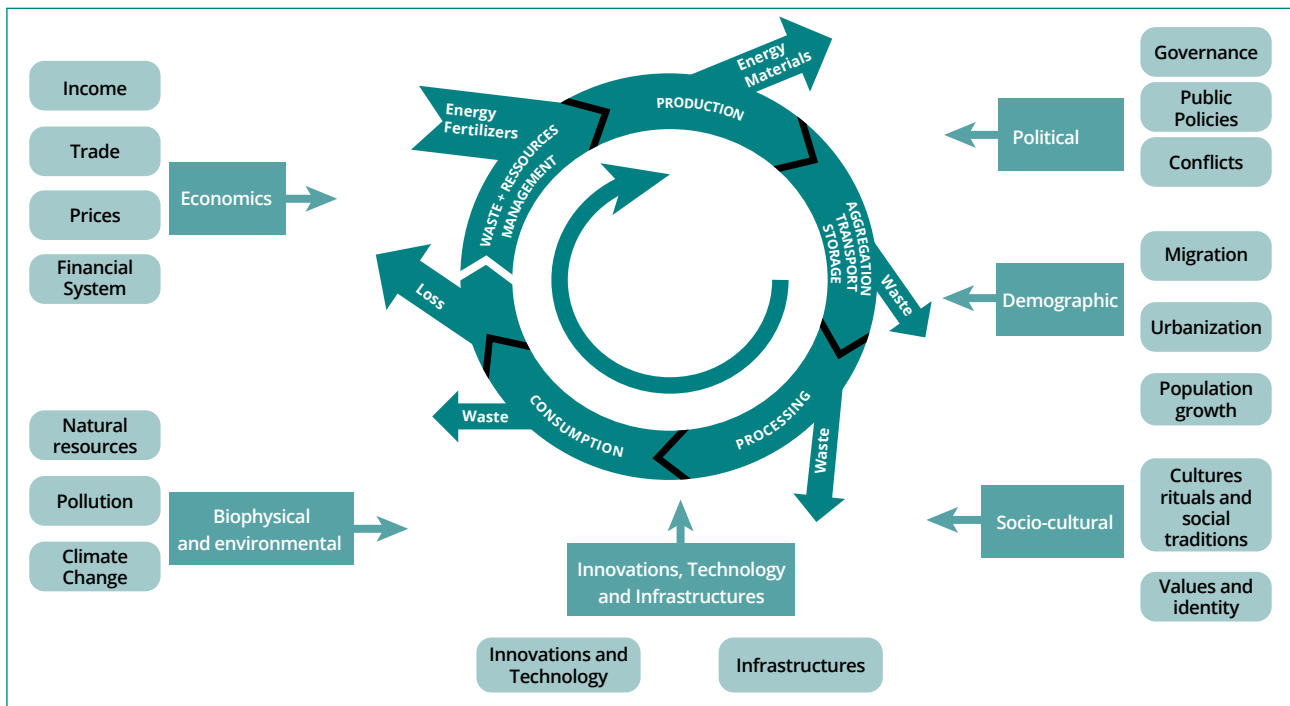


Figure 3: Blueprint of the drivers affecting different parts of the food systems.
Source: Authors.

exploitation, can return to their previous stock levels by natural processes of growth or replenishment.” Among renewables, the UN definition distinguishes two types: conditionally renewable, which refers to natural resources that “after exploitation eventually reaches a level beyond which regeneration will become impossible” (for example, forests and fish) and fully renewable (for example, sunlight). The availability and cost of these resources determine the shape and nature of food systems since many of them are inputs in the agricultural production process (UN, 1997).

Climate refers to “the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.” The IPCC defines climate change as “a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties... typically decades or longer” (IPCC, 2018). We choose to define it using the United Nations definition: climate change is “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (United Nations, 1992). It affects food quality and availability. Climate change also affects the geography of food production and of plant and animal diseases. This might affect agricultural outputs since it will reduce and put pressure on the resources available for production.

This means it might reduce crop yields and forest and animal productivity (FAO, 2017).

Demographic drivers

These drivers refer to population growth, urbanisation, migration and population displacement. They have a crucial influence on demand, in terms of the quantity of food needed, but also on the quality and type of food consumed, as well as the food environment.

Population growth refers to the increasing number of people in the world. This will have an impact on future food demand (FAO, 2017).

Urbanisation refers to the concentration of populations in cities and the way of life it induces: reduced agricultural production for self-consumption, access to food mainly through the market and high-density population. Urbanisation is a big driver that shapes consumer behaviour and the food environment. Urbanisation induces changes in diets (more processed food, animal products and diversity) and in food habits (more purchases and out of home consumption). Urbanisation also has consequences for consumers’ food environments as well as for the organisation of the supply of food (FAO, 2017).

Population displacement and migration will shape food systems. Displacement of people can be defined as “an individual who has been forced or obliged to flee from his home or place of habitual residence... in particular as a result of or in order

to avoid the effects of armed conflicts, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border (according to the Guiding Principles on Internal Displacement)" (UNHCR, 2019). There are many causes of displacements: armed conflicts, natural disasters, famine, and developmental and economic changes. Displacements can be internal and external. A migrant is defined by the International Organization for Migration (IOM) as "the movement of a person or a group of persons, either across an international border, or within a State. It is a population movement, encompassing any kind of movement of people, whatever its length, composition and causes; it includes migration of refugees, displaced persons, economic migrants, and persons moving for other purposes, including family reunification" (FAO, 2019).

Innovation, technology and infrastructure drivers

Innovation, technology and infrastructure are major drivers of food systems. They influence both supply, for example, by improving system productivity, and demand (van Berkum, Dengerink and Ruben, 2018). They can produce major shifts in food systems.

Innovation, technology include a wide range of more-or-less sophisticated 'tools' affecting agricultural and post-harvest activities and the productivity of labour and land. They also include new ways of managing and organising production, processing and marketing, and waste management, all along food chains and food systems (HLPE, 2017).

Infrastructure as a driver of food systems refers to transport and water and energy supply as they facilitate access to inputs and provide an outlet for produce. Infrastructure also includes marketplaces, storage warehouses, harbours, slaughterhouses and communication networks (mobile phones and internet). The nature of infrastructure provides different opportunities for some specific food systems to extend their operations: for example, cooling devices (cold stores and freezers etc.) providing long-term conservation of minimally processed fresh products (fish, vegetables and meat) (HLPE, 2017).

Economic drivers

Economic drivers include different elements such as incomes, globalisation and trade, prices and financial systems. These drivers affect all aspects of food systems from production to demand. They provide opportunities that enable supply to meet demand or, on the contrary, can disrupt systems, for example through price crises.

Incomes have a big influence on diet composition. When incomes increase, consumption of more expensive food, such as animal products and processed food, also increases. Incomes also includes that of farmers and food producers, affecting their ability to invest in order to increase productivity. Many technologies are widely available but are not broadly disseminated because of the poverty among a major portion of the rural population. Finally, incomes can also concern State revenues. In this case, it determines a government's capacity to invest in the agricultural sector, to implement policies and to regulate the sector.

Trade and globalization refer to the exchange of agricultural and food products at the local, regional and international scales. Trade not only takes place on physical markets but can also operate through virtual ones, such as futures markets. Trade has an impact on food and nutrition security because it affects different key variables such as food production prices, employment and government revenues. It also affects private and public investment in the longer term (FAO, 2016). International trade has grown strongly thanks to the standardisation of products and the definition of grades, making it possible to exchange goods without seeing the product. Such commoditisation exists mainly for products exchanged on international markets. Globalisation shapes the food environment, in particular through the development of standardised industrial food products and the expansion of supermarkets through companies with a global reach (Claquin *et al.*, 2017; HLPE, 2017).

Prices of inputs, such as energy and fertiliser, have a big influence on the way food systems develop. The level of food prices and their fluctuation also affects different parts of food systems, determining not only income and labour costs, but also consumption and investment decisions.

Financial system refers to the exchange of funds in which food systems are embedded and is linked to non-food markets. This means that a crisis in a financial system has consequences for agricultural and food products in terms of both prices and investments.

Socio-cultural drivers

These drivers refer to culture, religions and rituals, social traditions, education and health and values and identity. They affect mainly diets and the food environment by influencing lifestyles, social norms, attitudes and cultures embedded in food.

Cultures, rituals and social traditions: Food is a means of building and promoting one's identity, of expressing one's belonging to a community. All societies are defined as much by their diet and foodways as a language. Social norms, values and

practices evolve with increasing influences between societies. These acculturation processes have a strong influence on the organisation of food systems. They affect not only consumer demand but also the way business is done and the values attached to production or processing processes (HLPE, 2017).

Values and identity: Food is “central to individual identity, in that any given human individual is constructed, biologically, psychologically and socially by the food he/she chooses to incorporate” (Fischler, 1988).

Education and healthcare are also drivers of food systems (FAO, 2017). Education refers to the level of educational programme the person has completed, through school or training. Education has a strong impact on food systems, especially for consumers seeking access to information about products. In addition, education also has an impact on production, affecting farmers’ practices, and on economics in terms of employment and innovations. Health refers to “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2019). If this state is not attained, food systems are under threat, either through the provision of agricultural labour or in support of consumer health. Healthcare is also important for food systems, driving the general health of consumers and labour forces, and ensuring well-functioning employment.

Political drivers

These drivers refer to governance, public policies, conflicts and humanitarian crises. They affect many of the drivers in food systems.

Governance “mechanisms at different scales are crucial for the design, enforcement and implementation” of food system support policies. Governance refers to the ways public decisions are discussed and considered. But governance also involves multiple stakeholders from the private sector and NGOs (HLPE, 2017).

Public policies influence food systems through many tools, such as regulations and laws, investments, subsidies and taxes, information and legitimation or support for actors involved in food systems. While most countries have agricultural policies, few have food policies, or limit these policies to food availability and food safety (HLPE, 2017).

Conflicts and civil unrest refer to political crises and civil or international wars with violence. Conflicts are a key driver of severe food crises and recently re-emerged famines, while hunger and undernutrition are significantly worse where conflicts are prolonged and institutional capacities are weak. But conflicts also play an important role in population migration and displacement. Regions that welcome migrants can experience a rapid rise in population with a disruptive effect on food systems (HLPE, 2017).

Drivers can be internal to food systems and are interrelated

These drivers are intimately interrelated. These interrelations induce possible synergies, which amplify or accelerate their effects.

While external drivers shape food systems, development options and the kinds of food systems chosen by some countries also have an impact on drivers. For example, production based on the massive use of energy and non-renewable resources, which prevails in industrialised countries, depletes natural resources, contributes to climate change and greenhouse gas emissions and increases inequalities. These drivers affect food systems, not only in the countries that have chosen these economic development options, but globally. These food system pathways can be considered as internal drivers. Food system configurations create path dependency, such as routines, social habits, infrastructure, food habits, organisational logics etc. This can cause inertia and halt potential changes in food systems.

External drivers evolve and some of their trends drive food system pathways. However, while they are evolving, food systems have their own intrinsic inertia, innovative pathways and trends which influence their own potential to change.

In this report, we focus mainly on the major consequences and risks caused by external drivers to actual food systems. We focus on drivers that put food systems under pressure. We assume that some parts of the world, such as LI and LMI countries, are under a specific threat due to the unprecedented combinations of trends in drivers. ●

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CHAPTER 1.3

MAJOR TRENDS IN FOOD SYSTEM DRIVERS

Pauline Bendjebbar¹ and Nicolas Bricas¹

SUMMARY

This chapter explores the trends in major external drivers that will probably present major challenges and raise risks for food systems in the world over the next 20 years. This chapter focuses on only three main categories of trends because they are the easiest to predict and the least uncertain: environmental, demographic and socio-economic. This chapter describes some of the major trends for which we have some data available, although they are still debated by scientists. It will show how Low-Income (LI) and Lower Middle-Income (LMI) countries will experience some of the major challenges.

Demographic trends

A fast-growing population in some countries. Based on the United Nations Population database, the world population is expected to increase from 7.7 billion in 2019 to 8.5 billion by 2030 (*cf. Map 2*). By 2050, this growth is expected to be particularly large in Africa, with an increase of 1.3 billion people, and in Asia, up 750 million people (UN, 2017a). The populations of 33 countries are expected to triple between 2017 and 2100. These are mainly LI and LMI countries (FAO, 2017). Africa will experience an increase in the proportion of young people, while Europe and Asia will see their population age (FAO, 2017).

In particular, population growth will be in urban areas. According to UN Population data (2019), urban populations in LI and LMI countries will grow at an annual rate of 3.9 percent and 2.4 percent respectively over the next 10 years. This means a 50 percent increase in the urban population between 2019 and 2030. *Map 3* shows the countries where urban populations will be larger than rural populations in 2030.

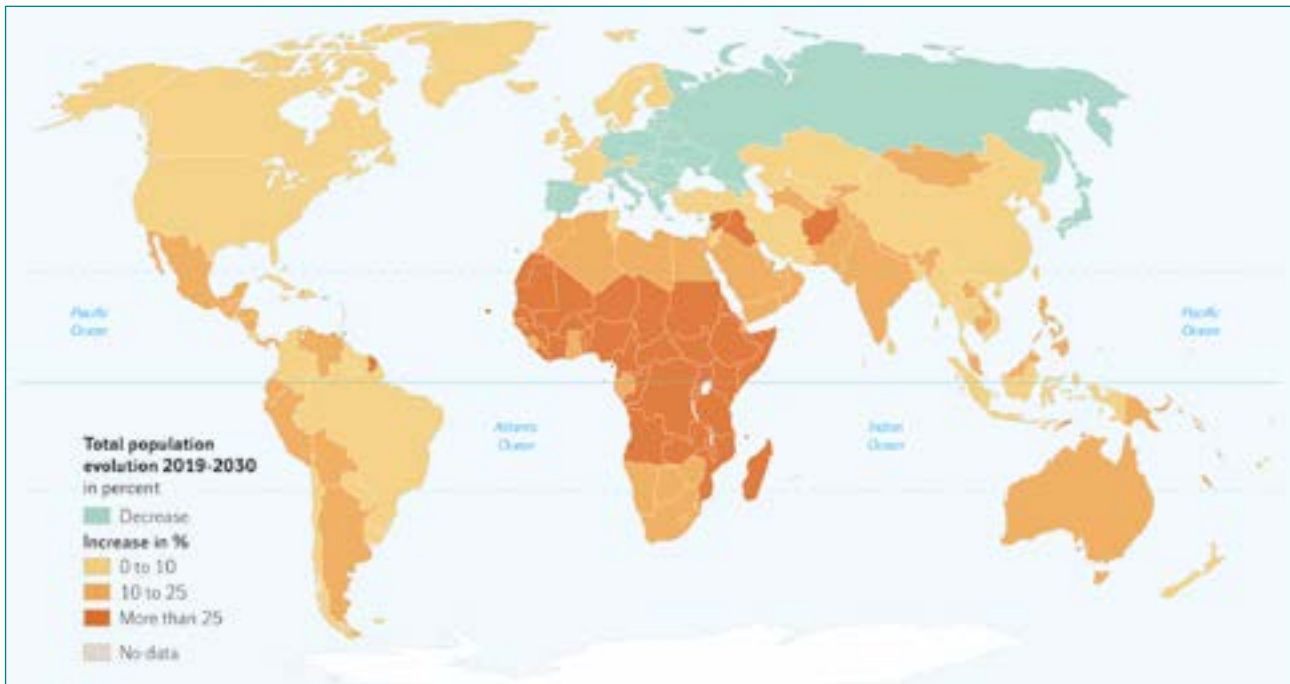
Between 2010 and 2050, the number of cities will grow by 75 percent (*cf. Map 4*). In 2050, 66 percent of the world's population is expected to be urban. The pace of urbanisation is faster in LI and LMI countries than in the rest of the world. Some 56 percent of the population in Africa and 64 percent in Asia will be living in cities in 2050 (HLPE, 2017). India, China and Nigeria are predicted to account for 37 percent of the projected growth in the world's urban population between 2014 and 2050.

The population will also grow in rural areas in some countries. Again referring to UN Population data (2019), urbanisation should not mask the major increase in rural populations in some countries (*cf. Map 5*) and in particular in sub-Saharan African countries. Between 2019 and 2030, the rural population will increase by more than 20 percent in some of these countries. Rural population growth means there will be a quantitative increase in food demand and a need to create jobs in rural areas (UN, 2017a).

Migration and forced displacement are increasing both internally and internationally. In 2017, there were 30.6 million new internal displacements driven by conflicts and disasters across 143 countries and territories (IDMC, 2018). Natural disasters remain the main cause of population displacements at the global level, but conflicts are the main cause in Africa (*cf. Map 6*) (IDMC, 2018).

The projected growing impact of global warming will certainly increase disaster-related displacements and potentially fuel social unrest and conflicts as populations migrate in the search for new land, water and food.

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Map 2: Total population evolution from 2019 to 2030 (in %).
Data source: UN Population database 2019.

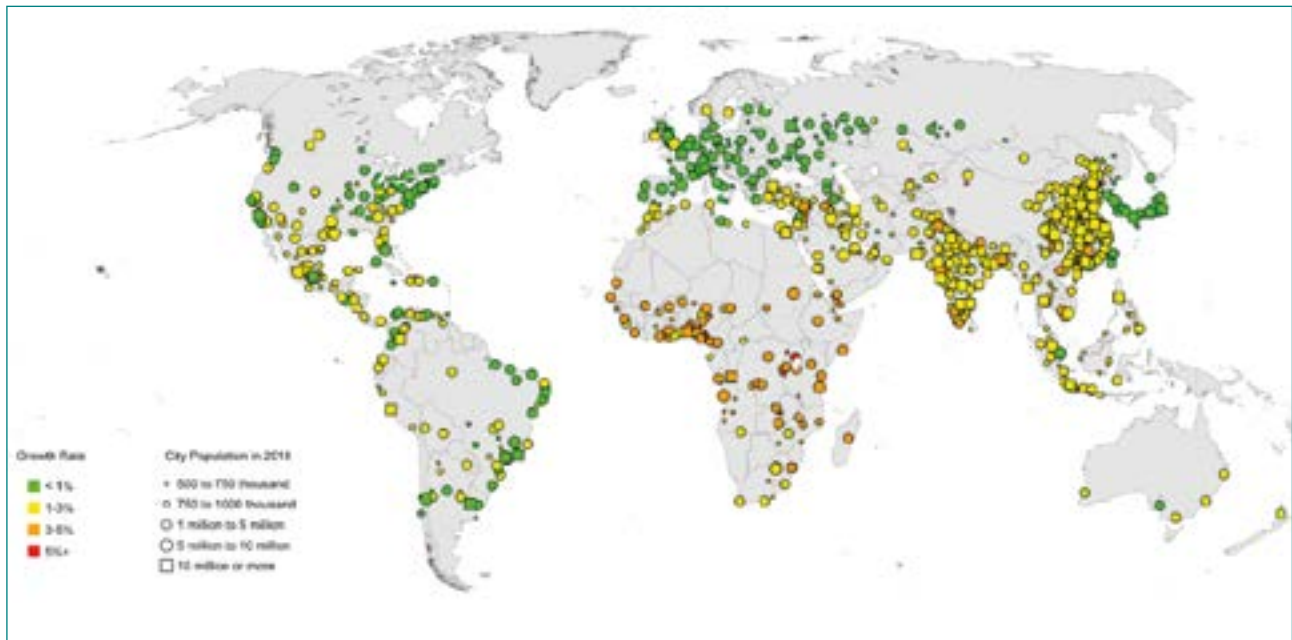


Map 3: Projected share of urban populations in 2030 (in %).
Data source: UN Population database 2019.

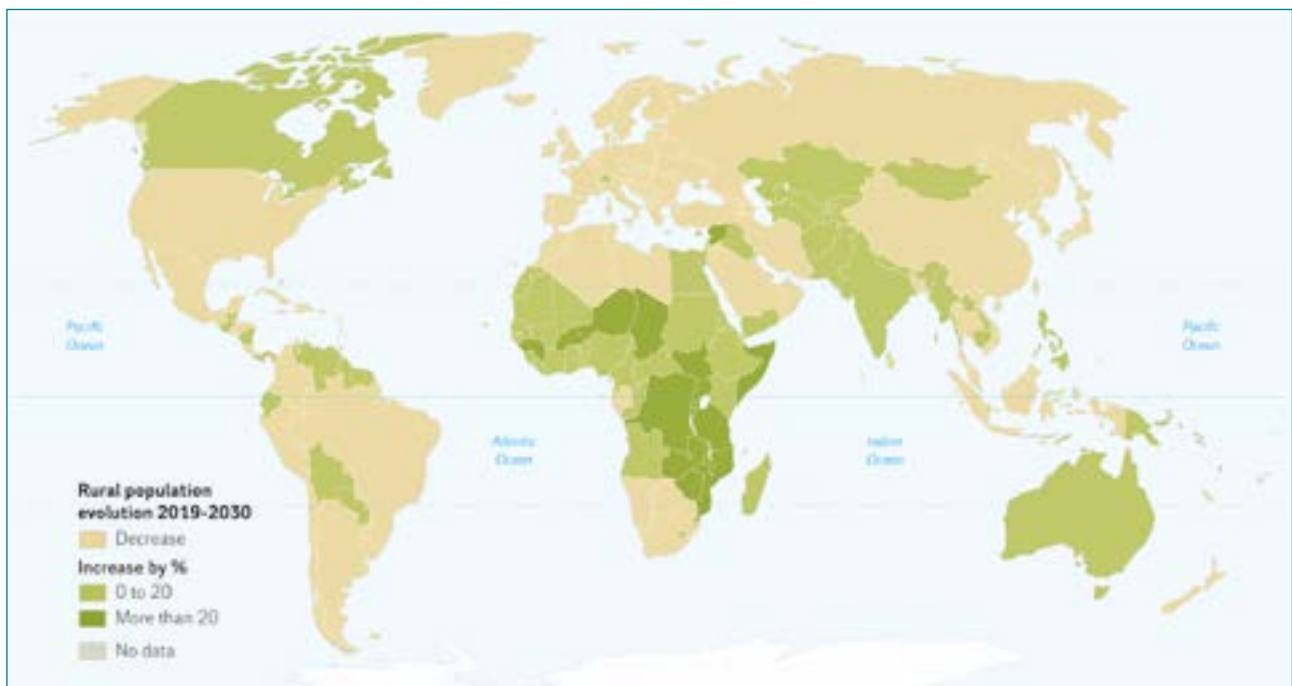
International migrations are also increasing in some parts of the world, mainly motivated by the search for a better life and employment (UNHCR, 2018). International migrants move primarily between developing countries and often within the same region. Migration flows from Asia totalled more than 30 million people between 2010 and 2015, out of which only 4 million migrated to Northern America

and 4 million to Europe. Migration flows from the African continent totalled 10 million people between 2010 and 2015, out of which only 2 million migrated to Europe (cf. Figure 4).

In general, food systems which are unsteady due to low food production capacities, low resilience, high pressure on resources and political insecurity generate more migrations and displacements.



Map 4: Cities in 2018 and their growth rate 2018-30.
Source: UN World Urbanization Prospects; The 2018 Revision.

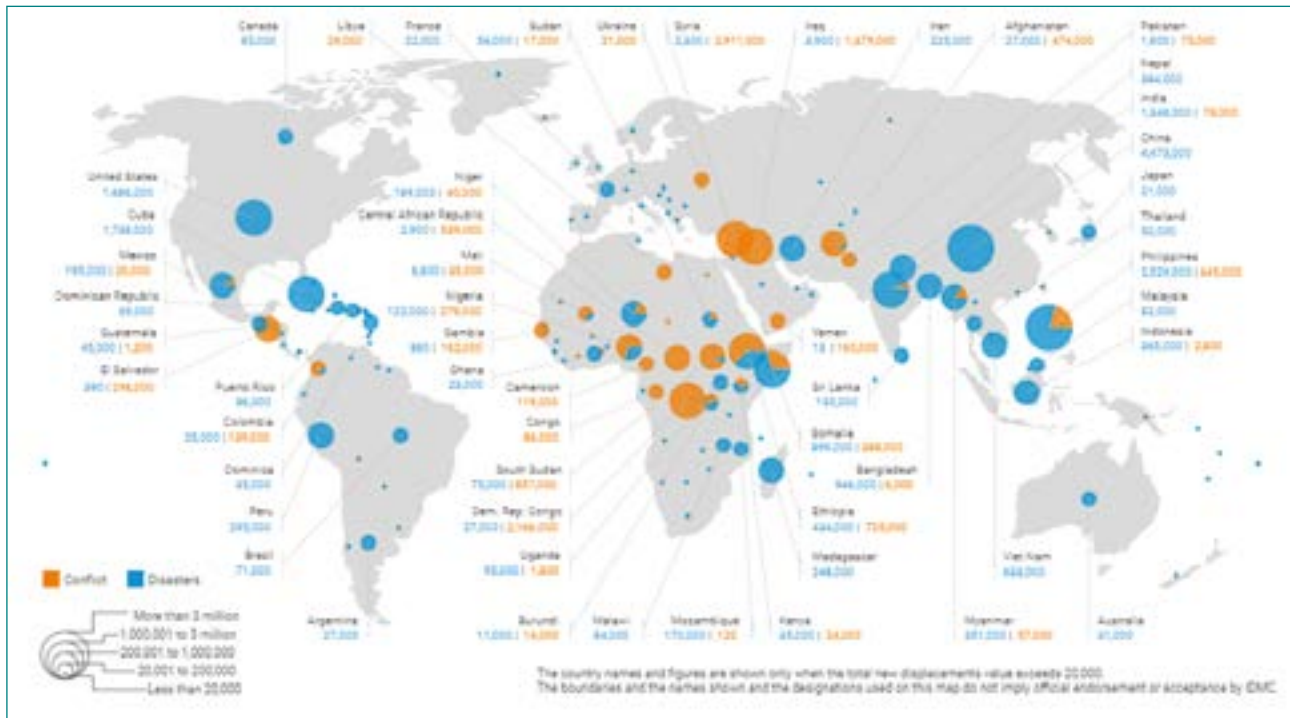


Map 5: Expected rural population growth from 2019 to 2030 in %.
Data source: UN Population database 2019.

Major environmental trends

Major environmental trends show that humanity is facing an alarming situation. This was already apparent in 1992 when 1,700 independent members of the Union of Concerned Scientists joined together for the 'World Scientists' Warning to Humanity'. Many

researchers came together again in 2017 to reiterate the warning about potential irreversible damage to the planet. This damage concerned "ozone depletion, freshwater availability, marine life depletion, ocean dead zones, forest loss, biodiversity destruction, climate change, and continued human population growth" (Ripple *et al.*, 2017) (*cf.* Figure 5).



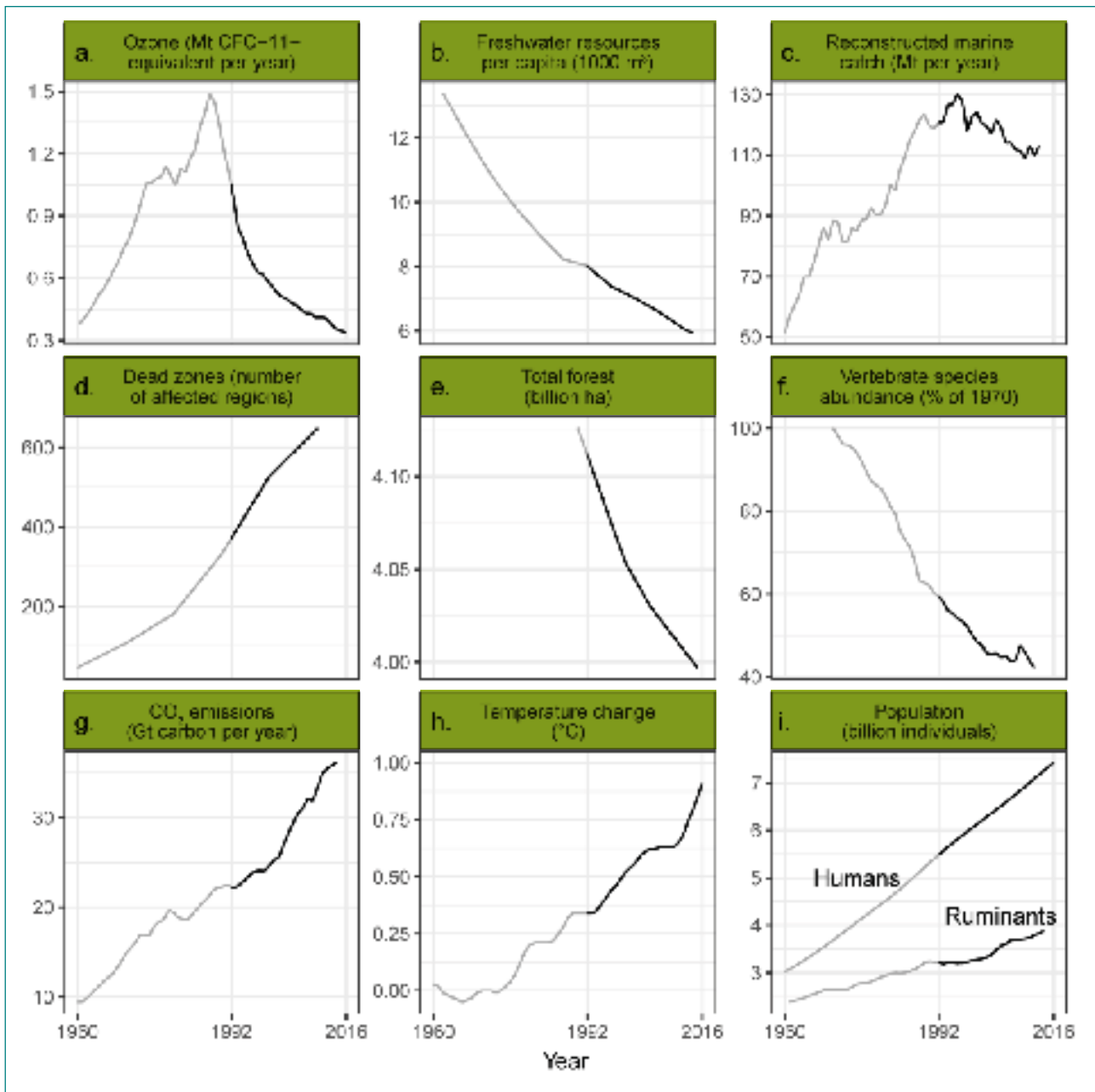


Figure 5: Trends over time, environmental issues identified in the 1992 scientists' warning to humanity. Source: Ripple et al., 2018.

The years before and after the 1992 scientists' warning are shown as grey and black lines respectively. Panel (a) shows emissions of halogen source gases, which deplete stratospheric ozone, assuming a constant natural emission rate of 0.11 Mt CFC-11-equivalent per year. In panel (c), marine catch has been falling since the mid-1990s, but at the same time, fishing efforts have increased (supplemental file S1). The vertebrate abundance index in panel (f) has been adjusted for taxonomic and geographic bias but incorporates relatively little data from developing countries, where there are the fewest studies; between 1970 and 2012, vertebrates fell by 58 percent, with freshwater, marine, and terrestrial populations decreasing by 81 percent, 36 percent and 35 percent respectively (file S1). Five-year means are shown in panel (h). In panel (i), ruminant livestock consists of domestic cattle, sheep, goats and buffaloes. Note that y axes do not start at zero and it is important to inspect the data range when interpreting each graph. Percentage change, since 1992, for the variables in each panel are as follows: (a) -68.1 percent; (b) -26.1 percent; (c) -6.4 percent; (d) +75.3 percent; (e) -2.8 percent; (f) -28.9 percent; (g) +62.1 percent; (h) +167.6 percent; and (i) humans: +35.5 percent, ruminant livestock: +20.5 percent.

Food production per capita has never been higher. Food production has increased faster than population growth, even in those regions undergoing rapid demographic growth such as Africa (cf. Figure 8). As a result, food insecurity has improved but remains high despite food production that currently exceeds

average caloric needs at the global level and should remain so. However, a turning point was reached in 2015 (cf. Figure 9). Many reasons explain this reverse and many more might threaten food security in LI and LMI countries in the decades to come.

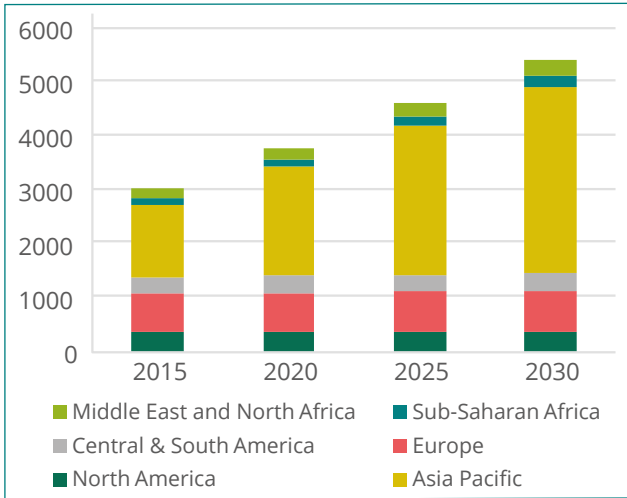


Figure 6: The expansion of the global middle class (in millions).
Source: Kharas, 2017.

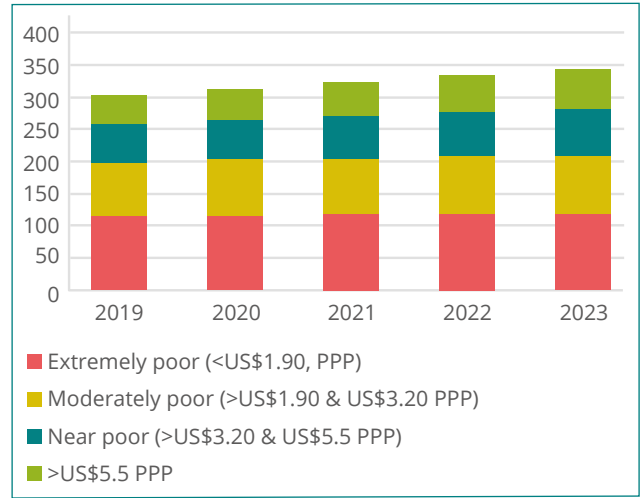


Figure 7: Distribution of employment by economic level in Low-Income countries (in millions). Source: ILOSTAT, 2019.

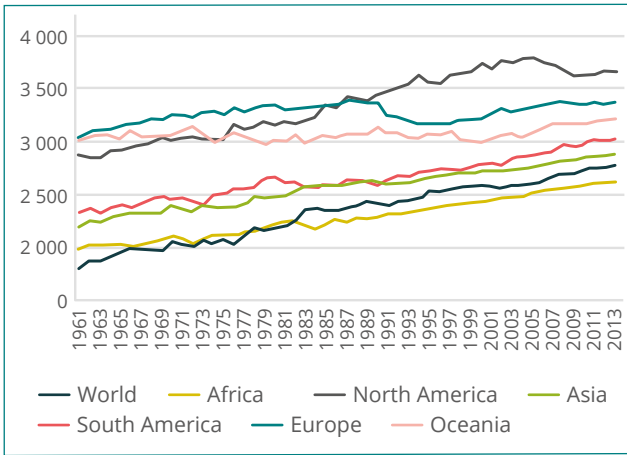


Figure 8: Dietary energy supply in kcal/cap/day.
Source: FAOSTAT, 2019.

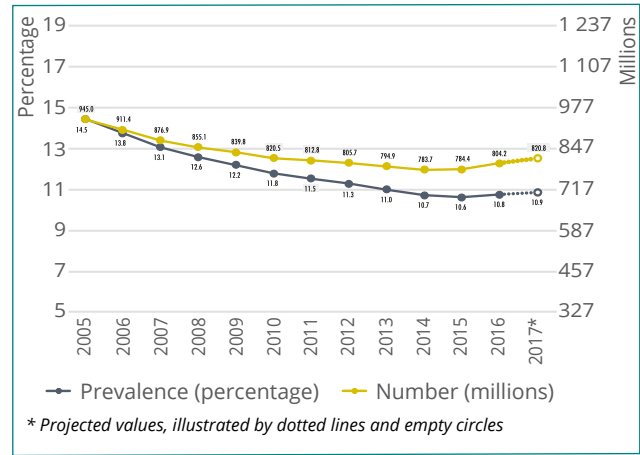


Figure 9: Undernourishment.
Data source: FAO, 2018.

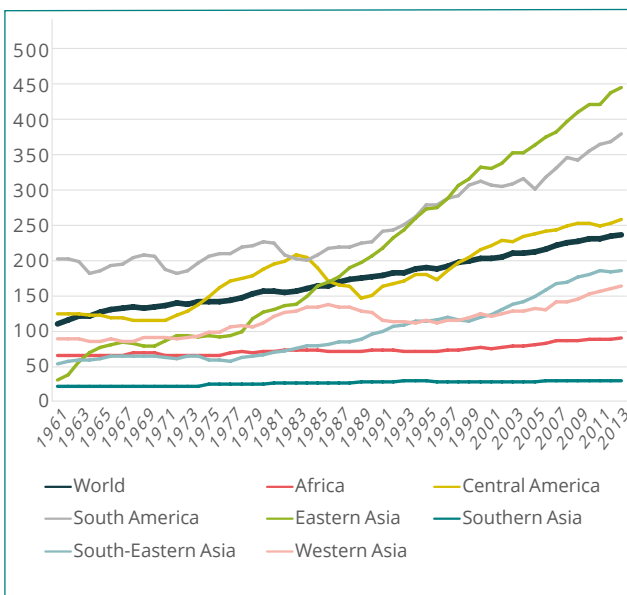


Figure 10: Meat availability in kcal/cap/day.
Source: FAOSTAT, 2019.

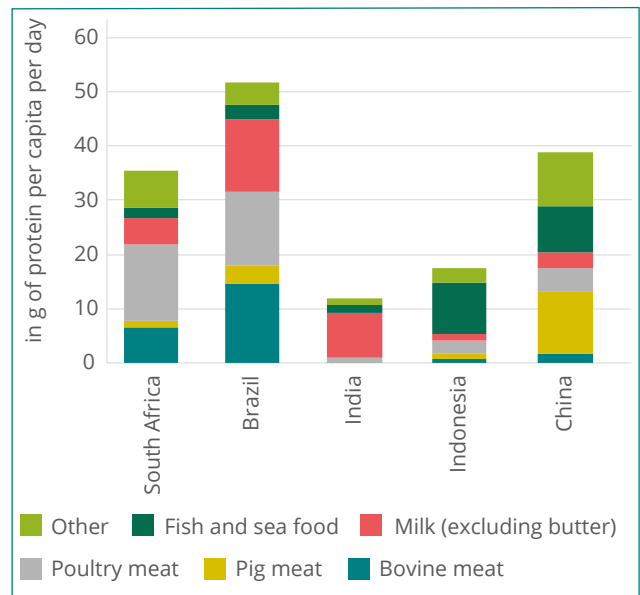


Figure 11: Structure of animal product availability in selected countries in 2011-13.
Source: FAOSTAT, 2019

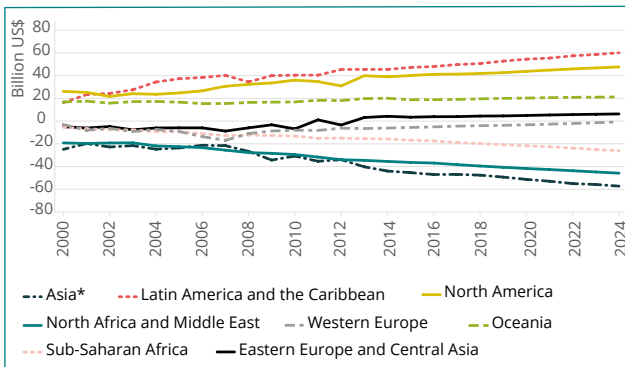


Figure 12: Evolution of net trade in agricultural products by region, 2000-24 (in billion US\$).

Source: OECD-FAO *Agricultural Outlook 2015-2024* cited in FAO, 2015.

Notes: Net exports of cereals, oilseeds, sugar crops, meats, fish and dairy products evaluated at 2004-06 constant international reference prices. Data from 2014 onward are projections.

*"Asia" covers all Asia except for Central Asia and includes Southeast Asia, South Asia, and East Asia (including China).

Another major socio-economic trend is changes in food diets around the world. Food diets are evolving towards increased meat consumption. This growth will be particularly important in Eastern Asia (cf. Figure 10).

Although meat availability is increasing all over the world, the diversity of animal products consumed demonstrates the persistence of dietary differences between countries (cf. Figure 11).

More processed food is being consumed around the world due to the increasing industrialisation of food processing (Claquin *et al.*, 2017). This has led to the extensive spread of some highly industrialised and standardised 'global' products, such as sodas and sugar.

Another major trend is the evolution of food markets. National and local market trends show a

commoditisation of agricultural products. In sub-Saharan Africa, for example, part of the food consumed in rural areas is self-produced. Nevertheless, markets have tended to expand everywhere. In Western Africa, around half of the value of food consumption in rural areas comes from markets. Around half of the starch products consumed by rural populations in the 16 countries studied by Bricas, Tchamda and Mouton (2016) are purchased, not self-produced. This proportion is even higher for animal and other products (Bricas, Tchamda and Mouton, 2016). Furthermore, supermarkets continue to spread across the world, with high growth trends in all LI and LMI countries (Reardon *et al.*, 2003).

International trade is expected to increase at the global level. Based on trends between 1995-1996 and 2012-2013, transcontinental trade has increased, with more exchanges between Asia and Pacific countries (Claquin *et al.*, 2017). Processed products will increase their share in the world market, while products historically traded internationally, such as cocoa and coffee, will remain so (Claquin *et al.*, 2017). In Least Developed countries (LDC), between 2001-04 and 2009-12 the share of raw commodities in the total value of agricultural exports increased from 37.8 to 48.5 percent (cf. Figure 12) (FAO, 2015). However, the share of processed products in LDC agricultural exports shrank "from 31 to 26 percent" (cf. Figure 12) (FAO, 2015).

Conclusion

This description of some of the major trends is not exhaustive. We have chosen to focus on trends that may pose major risks for the future of food systems. These trends highlight the fact that LI and LMI countries might be the most vulnerable regions in the world. The following chapters and sections explore these trends in more detail and examine their consequences for food systems in LI and LMI countries. ●

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SECTION

02

FOOD SYSTEMS
CONTRIBUTE TO AND
ARE IMPACTED BY
CLIMATE CHANGE



SECTION 2

Food systems contribute to and are impacted by climate change

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CHAPTER 2.1

FOOD SYSTEMS EMISSION AND CLIMATE CHANGE CONSEQUENCES

Julien Demenois¹, Géraldine Chaboud² and Vincent Blanfort³

SUMMARY

Food systems are responsible for up to one-third of anthropogenic greenhouse gas (GHG) emissions. These emissions include carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) and are therefore a major driver of climate change. The environmental pressures on food systems are likely to intensify, as humanity is arguably already operating beyond planetary boundaries. The projection for changes between 2010 and 2050 shows that these pressures will result in an increase of between 80 and 92 percent in GHG emissions in the absence of technological change and other mitigation measures. Apart from being a significant source of GHG emissions, food systems are significantly impacted by climate change. Uneven climate change effects, in combination with differences in adaptation capacity, could exacerbate existing inequalities between High-Income (HI), Low-Income (LI) and Lower Middle-Income (LMI) countries.

Contribution of food systems to climate change

Food systems are a major driver of environmental effects, including climate change. They have contributed to the crossing of several of the proposed 'planetary boundaries' that attempt to define a safe operating space for humanity on a stable Earth system, in particular those concerning climate change (Springmann *et al.*, 2018). The Agriculture, Forestry and Other Land-Use sector (AFOLU) is responsible for just under a quarter (≈ 10 – 12 GtCO₂eq/yr) of anthropogenic GHG emissions, mainly from deforestation and agricultural emissions from livestock, soil and nutrient management (Smith *et al.*, 2014). Annual direct GHG emissions from agricultural production in 2000–2010 have been estimated at 5.0–5.8 GtCO₂eq/yr (Smith *et al.*, 2014), including emissions from biomass burning (12 percent) and energy use in agricultural machinery (Vermeulen *et al.*, 2012). Indirect GHG emissions from the pre-production stages (mainly the manufacture of fertilisers) have been estimated at 0.35–0.77 GtCO₂eq/yr and post-production stages (processing, packaging, transport, refrigeration, retail, catering, food management and waste disposal) at 1.1 GtCO₂eq/yr (Vermeulen *et al.*, 2012). So, food systems contribute between 19 and 29 percent of total anthropogenic GHG emissions. Agricultural production is by far the main source of emissions in LI and LMI countries, while post-production stages emit GHG emissions equal to the production stages in HI countries (Vermeulen *et al.*, 2012).

Although there is little information available, an estimated one-third of the food produced in the world for human consumption is lost or wasted during the production to consumption stages (Gustavsson *et al.*, 2011; HLPE, 2014). In HI countries, most food loss and waste (FLW) occurs at the downstream stages of the food supply chain (retail and consumption) and is related to patterns of over-production and over-consumption. In LI and LMI countries, FLW is supposed to mostly occur at the upstream stages (harvest, storage, transport and processing) due to infrastructural, financial and technical constraints (Gustavsson *et al.*, 2011). FLW represents a significant use of natural resources along food supply chains and pollution is emitted in vain. FLW contributes to GHG emissions in two ways: through waste management activities (for example, disposal in landfill) and through the embedded emissions associated with its production, processing, transport, retailing and consumption. The latter are far more important in terms of impact than the former. The carbon footprint of FLW has been estimated at 3.3 GtCO₂ equivalent (excluding GHG emissions from land-use changes). Reducing FLW by one half would reduce environmental pressures by between 6 and 16 percent compared with the baseline projection for 2050 (Springmann *et al.*, 2018).

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Impact of climate change on food systems

Apart from being a significant source of GHG emissions, climate change is affecting people and the environment around the world, as shown by the 2018 report of the Intergovernmental Panel on Climate Change (IPCC). The State of Food Security and Nutrition in the World (FAO, 2018) also found climate change to be one of the key drivers behind the rise of hungry people in the world, reaching 821 million people in 2017. By the middle of this century, higher average temperatures, changes in precipitation, rising sea levels, as well as the possibility of an increase in damage from pests and diseases, are expected to affect several agricultural sectors.

In particular, the number and frequency of recorded natural disasters are increasing significantly. These events often destroy critical agricultural assets and infrastructure, disrupting production cycles, trade flows and livelihoods. This affects food security and causes additional disruptions throughout value chains (FAO, 2017). Indeed, extreme weather events and geopolitical crises are the dominant drivers of food production shocks, even if their relative importance varies across sectors (Cottrell *et al.*, 2019). Over half of all shocks to crop production systems have been the result of extreme weather events, reinforcing concern about the vulnerability of arable systems to climatic and meteorological volatility around the globe.

In addition, climate change will impact livestock production, as well as fisheries and aquaculture, the performance of small- and medium-sized food and agribusinesses, transportation infrastructure with consequent disruption to food supply chains and the exodus of climate refugees. This impact will be uneven across regions and countries. Arid and semi-arid regions will be exposed to even lower precipitation and higher temperatures and, consequently, experience yield losses. Conversely, countries in temperate areas are expected to benefit from warmer weather during their growing season.

Faced with climate change, LI and LMI countries are the most vulnerable and it could exacerbate the food security challenges they already experience. For example, South Asia and sub-Saharan Africa, particularly West Africa, have been found to be the hardest-hit regions, partly due to higher climate-induced crop yield losses and because their national economies depend on agriculture for a significant share of GDP and employment. Simultaneously, small-scale family farmers have little access to innovative technologies, services and inputs, which limits their capacity to adapt to a changing climate. As a result, these regions are expected to experience a significant drop in agricultural production due to climate change (*cf.* Map 7) and imports of agricultural

products are expected to increase. Uneven climate change effects, in combination with differences in adaptation capacity, could exacerbate existing inequalities and further widen the gap between HI and LI and LMI countries (FAO, 2018). ●

BOX 1

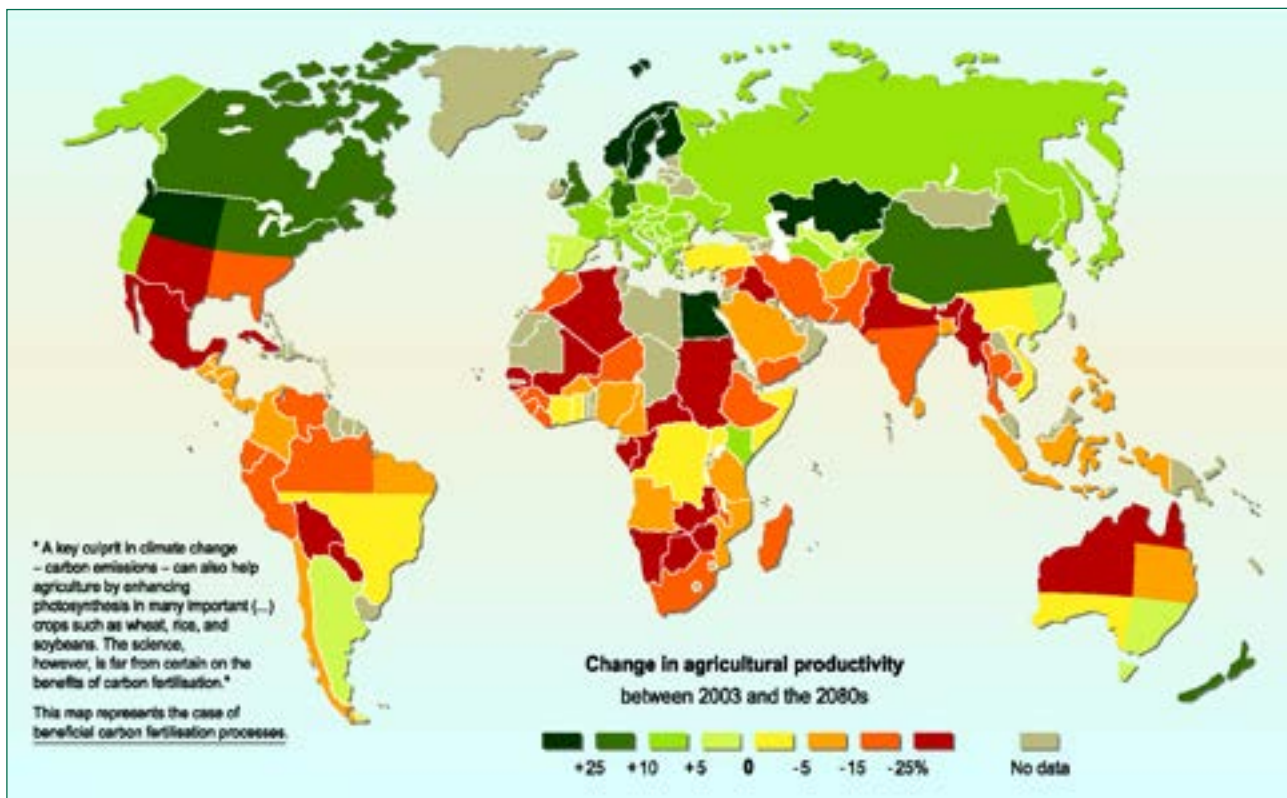
FUTURE CLIMATE RISK IN SOUTHERN MALI¹

Crop yield losses caused by climate change are expected to be high in many regions of sub-Saharan Africa and smallholder farmers, who rely heavily on agriculture for their livelihoods, have been identified as highly vulnerable to climate change. In southern Mali, a study has assessed the future climate change risk according to farm type and degree of food self-sufficiency. It shows that cereal crop production in the region of N'Tarla in southern Mali is gravely threatened by climate change. Some 40 percent of the country's population lives in this region, which represents half of Mali's cultivable land.

The current climate is typical of the Sudano-Sahelian zone of West Africa with conditions that are already drier and temperatures, which are warmer. Predictions suggest that the current climate warming trend will continue and even accelerate. By mid-century (2040-2069) annual maximum and minimum temperatures are expected to increase by 2.9 °C and 3.3 °C respectively compared with the climate trend of the past 30 years (1980-2009). Rising temperatures are expected to have a critical impact on crop yields by reducing the length of the crop growth cycle and increasing the intensity and duration of droughts due to larger soil water evaporation losses. Under these future climate conditions and without changing current cropping practices, simulation models predict crop yield losses and a reduction of food availability for all farm types, and this is in an area where most of the population is already facing food insecurity problems.

However, the adverse impact of climate change will differ among farmers if coping strategies are adopted. Projections show that large- and medium-sized farms can offset the yield losses induced by climate change and remain food self-sufficient with crop management solutions such as early planting and increased fertiliser use. In contrast, results show that any of these adaptive crop management measures would not be enough to protect small farms from the negative consequences of climate change on crop productivity and food self-sufficiency. These smallholders will remain food insecure. Farmers will need off-farm employment or other forms of social support to cope with climate change. The results of this study are in line with many other studies and model predictions showing that agricultural performance in sub-Saharan Africa is likely to be strongly affected by future climate change.

1. Based on Traore *et al.*, 2017



Map 7: Projected impact of climate change on agricultural productivity.

Source: Cline, 2007.

Projections include the effect of CO₂ fertilisation. No effects of technical progress on agricultural productivity were assessed.

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SECTION 2.
FOOD SYSTEMS CONTRIBUTE TO AND, ARE IMPACTED BY, CLIMATE CHANGE

CHAPTER 2.2

CLIMATE CHANGE, ANIMAL PRODUCT CONSUMPTION AND THE FUTURE OF FOOD SYSTEMS

Guillaume Duteurtre¹, Mohamed Habibou Assouma¹, René Pocard-Chapuis², Patrice Dumas³, Ibra Toure¹, Christian Corniaux⁴, Abdrahmane Wane⁵, Alexandre Ickowicz¹ and Vincent Blanfort¹

SUMMARY

The livestock sector contributes around 14.5 percent of total anthropogenic greenhouse gas (GHG) emissions. Developing mitigation strategies is a serious challenge, especially if we anticipate a rapid growth in the consumption of animal products in Low-Income (LI) and Lower Middle-Income (LMI) countries. Across the planet, livestock systems are highly diverse and the livestock sector offers many possibilities for carbon sinking that can help to reduce emissions. In particular, carbon sequestration in grasslands, rangelands and feed crop fields and manure recycling are crucial in the assessment of the carbon efficiency of livestock value chains. Supporting sustainable livestock production systems, together with sustainable animal product market chains and consumption, requires the completion of GHG inventories based on landscape carbon balances.

Livestock and GHG emissions: how the rise in demand for animal products is generating risks for food systems

Over the past 40 years there has been a huge increase in demand for animal products, driven by demographic changes, economic growth and urbanisation. Between 1977 and 2017, the world's population almost doubled and per capita consumption of animal products increased by 50 percent. This resulted in a leap in world meat production from 122 to 330 million tonnes and milk production soared from 317 to 811 million tonnes (FAO, 2019). The latest projections predict that these trends will continue at the global scale, in particular in emerging countries where household incomes are rising and increasing the demand for animal products.

Market growth has resulted in major environmental impacts. Throughout the world, intensive animal production and industrialised value chains have emerged (Steinfeld, de Haan, and Blackburn, 1997). This 'livestock revolution', together with cropland extension for feed and food, have exacerbated the human pressure on land and natural resources. Twenty billion animals make use of 30 percent of the terrestrial land area for grazing, 33 percent of the global cropland area for producing animal feed and 32 percent of freshwater resources (Herrero *et al.*, 2016).

These changes have had a big impact on the rise in GHG emissions, consequently accelerating climate change. The world's livestock sector generates around 7.1 GtCO₂eq/yr, which represents 14.5 percent of global anthropogenic GHG emissions. The GHG emissions depends on the regions of the World but are not fully correlated with livestock production volumes (Figure 13). The sector is associated with enteric fermentation (2.8 GtCO₂eq/yr), feed production, processing and transportation (3.2), manure management (0.7) and land-use change emissions (0.6) (Gerber *et al.*, 2013). These figures are still debated in the scientific community. In particular, the contribution of livestock in land-use change-related emissions and carbon sequestration is not yet properly assessed. Among all livestock related GHG emissions, fossil fuel consumption in itself (from production to distribution) accounts for a significant share, at an estimated 1.4 GtCO₂eq/yr.

Chemically speaking, about 44 percent of GHG emissions are in the form of methane (CH₄) and 29 percent in the form of nitrous oxide (N₂O). The rest (27 percent) is due to carbon dioxide (CO₂) (Gerber *et al.*, 2013).

Because of enteric fermentation, emissions per unit of protein produced are higher for ruminant meat and milk than for pork, poultry and aquaculture. In particular, beef and cattle milk

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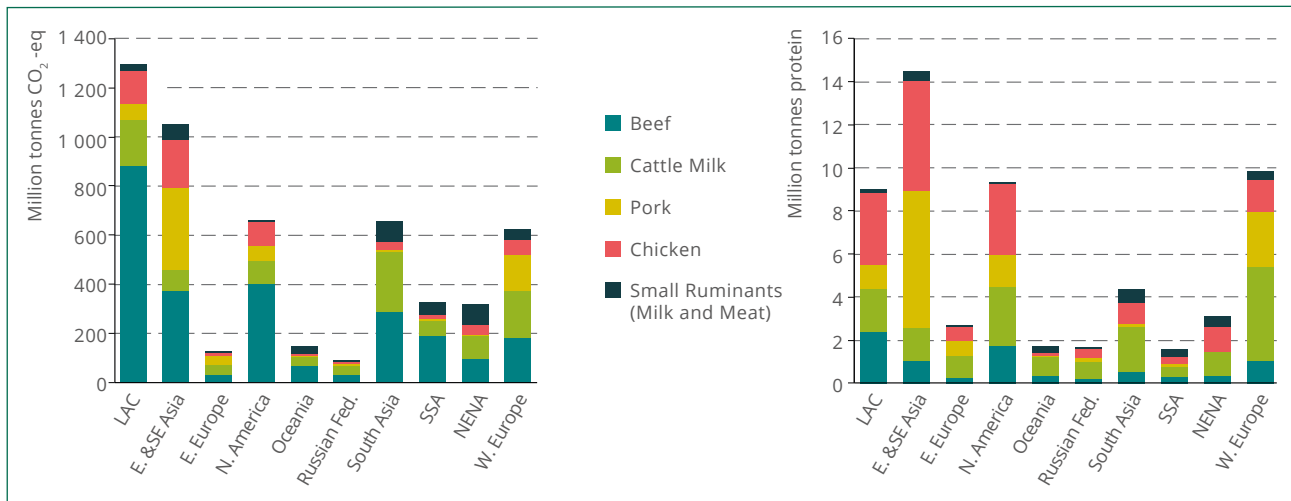


Figure 13: GHG emissions from livestock and livestock production by commodity and regions.

Source: Gerber, P.J. et al., 2013.

production account for 64 percent of the sector's GHG emissions, while pigs and poultry account for 9 percent and 8 percent respectively. Among the huge diversity of livestock sub-systems, some are less carbon costly. Grassland systems, based on the use of natural pastures and cultivated meadows, together with integrated crop-livestock systems, generally generate lower emissions than landless systems based on industrial feed (cf. Box 2). In order to manage the roles of these different livestock sub-systems, trade-offs must be made taking into consideration their multiple functions.

Multi-functionality of livestock systems requires an understanding of the trade-offs between climate mitigation and other ecosystem services

Livestock provides direct livelihood and economic benefits to at least 1.3 billion producers and retailers. As an economic activity, livestock contributes up to 50 percent of agricultural GDP globally (Herrero *et al.*, 2016). Animal breeding is well adapted to many areas with restricted resources or to harsh environments. It offers opportunities for a wide diversity of communities and social groups in nearly all ecosystems. Milk production, for example, contributes to the livelihoods of more than 121 million families throughout the world. Most of these are very small farms, with an average of three cows (IFCN, 2015).

Due to its multi-functionality, livestock plays an important role in the sustainable development of rural territories. It provides meat, milk and eggs which contribute to nutrition and balanced diets, particularly in LI countries through self-consumption.

Livestock also provides energy for transportation and ploughing, and manure for organic fertilisation. Moreover, cattle and other livestock have an important role in household economics in LI and LMI countries as they often serve as a form of savings and a mechanism for managing economic risk, used by rural households to ensure survival and overcome periods of food insecurity (Alary, Duteurtre and Faye, 2011). This is at the core of some peoples' livelihoods, as illustrated in pastoralism. In addition, livestock has always played a crucial role in agricultural intensification processes (HLPE, 2016). In particular, livestock systems based on grazing have the ecosystemic capacity to store carbon in the long term in the form of organic carbon, which contributes to carbon sequestration at the global scale (Soussana, Tallec and Blanfort, 2010).

Animal products also have a high cultural value and significance in many LI and LMI countries, as demonstrated in many religious and cultural practices. They contribute to food security through their participation in local and international trade. At the same time, the consumption of animal products may result in nutritional disorders.

Designing low-carbon livestock systems that contribute to sustainable food systems

The serious challenges posed by global warming mean that we have to address both the transition to low-carbon livestock systems and sustainably satisfy the growing demand for livestock products in LI and LMI countries. These transitions must consider the various roles livestock plays in local ecosystems and communities and the importance of the carbon sequestration process (Vigne *et al.*, 2017).

On the production side, the carbon balance must improve at the landscape level. Understanding potential synergies between adaptation, activities designed to sustainably increase production and mitigation are important. Climate-smart agriculture (CSA) approaches will help to guide the actions needed to transform and reorient livestock systems (FAO, 2017).

In the humid tropics, where livestock systems have developed over forests, efforts to curb deforestation are a priority in order to preserve forest biodiversity and carbon stocks. Grasslands are good candidates to increase carbon uptake in soil while still ensuring basic food production in these ecosystems (Stahl *et al.*, 2017). Tropical pastures, often established after deforestation, can be exploited with CSA practices. Those include no fires and no overgrazing, grazing rotation plans and the use of mixtures of grasses and legumes to reduce nitrate use. A better integration of livestock activities in forestry and agricultural landscapes (agro-sylvo-pastoralism) can also be a source of carbon mitigation (Vigne *et al.*, 2016).

In drier tropical regions dominated by rangeland ecosystems, livestock plays an important role in the reorganisation of nutrient and carbon cycles through the recycling of dry matter to the soil in the form of manure. Harvesting surplus forage at the beginning of the dry season also has the potential to reduce the risk of bushfires and increase livestock productivity (Assouma *et al.*, 2019).

Downstream innovations must also be promoted. Several studies have investigated the large mitigation potential of dietary changes. For example, vegetarian or 'flexitarian' diets could substantially reduce the burden of livestock in carbon emissions. In LI and LMI countries, however, animal product consumption is on the rise. In this context, low-carbon labels, climate mitigation certification mechanisms or short value chains could be efficient tools for reducing GHG emissions. These market mechanisms require the completion of GHG inventories based on landscape carbon balances in order to inform consumers. ●

BOX 2

PASTORALISM IN THE SAHEL: A ZERO-CARBON LIVESTOCK SYSTEM?¹

The environmental impacts of intensive and extensive livestock systems are highly debated in the scientific community. Extensive pastoral systems are assumed to be responsible for the highest rates of GHG emissions per unit of animal product, despite their small contribution to global GHG emissions. In fact, the carbon balances available for tropical agro-ecosystems are based on default emission factors provided by the IPCC, with high degrees of uncertainty due to the lack of in situ measurements in tropical systems.

To better assess the carbon balance of African pastoral systems, a study has been conducted in Ferlo, an open rangeland region in northern Senegal. The assessment took an ecosystemic approach. All the main sources of GHG emissions were considered, such as methane emissions due to enteric fermentation and emissions from manure, soil, surface water ponds, termites, bush fires and pump motors, and all sources of carbon sequestration were taken into account, including natural carbon sequestration by soil, trees and livestock. Carbon balance components were assessed monthly to account for the highly seasonal monsoon climate and the mobility of pastoral herds.

The study concluded that the annual carbon balance of the pastoral ecosystem was -0.04 GtCO₂e/yr. This shows that total GHG emissions were mitigated by carbon accumulation in trees, soil and livestock. The carbon balance varied considerably with the seasons. This seasonality is explained by both pastoral practices and environmental factors. The negative carbon balance found in this study contrasts with the traditional reputation that African livestock systems have a major impact on climate change because of their low productivity per animal.

The other benefits of this ecosystemic approach are a better understanding of the drivers of the carbon balance, making it possible to identify appropriate and effective mitigation options with reference to the seasonal and between-year dynamics of the carbon balance. More widely, these new results call for more ecosystemic approaches to be applied to the analysis of carbon balances in agricultural systems worldwide. The challenge is to fully account for both negative and positive effects of agricultural activities on climate change.

1. Based on Assouma *et al.*, 2019

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CHAPTER 2.3

DEFORESTATION FOR FOOD PRODUCTION

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SUMMARY

Deforestation contributes to carbon emissions and therefore to climate change. Within food systems, agricultural production is the stage which plays the largest role in deforestation and forest degradation, and it is therefore the focus of this chapter. There is a critical link between food systems and deforestation. Arable lands most often have a forested past. It might be ancestral, with deforestation having happened in the early occupation of land by humans or be very recent on current forest frontiers. Over the past two decades, commercial agriculture has overtaken subsistence agriculture as the main driver of deforestation in LI and LMI countries, especially in tropical areas.

There is a critical link between food systems and deforestation. Because of their climate and soil characteristics, potential arable lands are usually covered with forests under natural conditions. In LI and LMI countries, commercial agriculture is the most important driver of deforestation, followed by subsistence agriculture (FAO, 2016). Hosonuma *et al.* (2012) estimated that commercial agriculture contributed to 68 percent of deforestation in Latin America between 2000 and 2010, and to about 35 percent in Africa and Asia, while subsistence agriculture contributed to 27 percent and 40 percent of deforestation in each continent. Agriculture is also involved in forest degradation, though timber extraction and logging drive most forest degradation, followed by fuelwood collection and charcoal production, uncontrolled fires and livestock grazing (Hosonuma *et al.*, 2012; Carter *et al.*, 2018).

Deforestation, forest degradation and loss of ecosystem services

Forests provide multiple ecosystem services, such as carbon sequestration, biodiversity preservation, soil protection and regulation of water resources. More specifically, tropical forest evapotranspiration cools the local climate through feedbacks with clouds and precipitation. Deforestation (complete destruction of forest cover) and forest degradation (modifications of forests due to the accumulation of disturbances over time) threaten the provision of forest ecosystem services. Massive deforestation would lead to a decrease in carbon storage and an increase in GHG emissions. It also leads to the reduction of convective clouds involving a significant reduction in precipitation and an increase in average temperatures (Bonan, 2008).

Currently, one-third of the planet's forests are considered as primary or intact while the other two-thirds are subject to human activities and degradation. In tropical areas, carbon gains from forest growth are cancelled out and exceeded by carbon losses from deforestation and degradation, leading to a net emission of 425.2 ± 92.0 Tg C year⁻¹. Forest degradation affects about 60 percent of the world's tropical forests and accounts for 68.9 percent of the current overall tropical forest carbon loss (Baccini *et al.*, 2017). The evolution of tropical forests will play a key role in the possible mitigation of climate change.

Song *et al.* (2018) have reported that the global tree cover area (including all agroforestry systems, much degraded forests and plantations) increased by 2.24 million km² from 1982 to 2016, an increase of 7.1 percent. The overall gain is mainly due to an increase in forest cover in the subtropical, temperate and boreal climate zones (green pixels, *cf.* Figure 14) balancing the net loss of tree cover in the tropics (pink pixels, *cf.* Figure 14). These

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estimates do not consider imported deforestation, caused by the production of imported agricultural and forestry products. FAO (2015) agrees on the estimate of tree canopy loss. However, it reported a net forest loss between 1990 and 2015.

In rural landscapes, forests provide ecosystem services essential to agriculture, such as habitat for pollinating species and beneficial insects, maintaining soil stability and fertility, facilitating water infiltration into the soil for better renewal of groundwater reserves, acting as a buffer zone transforming heavy rainfalls into networks of small rivers with limited erosive impact, protection against strong winds and regulation of the micro-climate. Forests, when appropriately planned and managed, can withstand and protect against natural disasters of varying degrees and types (FAO and RECOFTC, 2013; Carter *et al.*, 2018). Forest spatial organisation is recognised as a key factor in providing these ecosystem services. Small-scale farming allows for discontinuity in production areas. Plots usually range from less than one to a few hectares in size. Corridors of forests and buffer zones around hydrologic networks might be easier to protect in landscapes dominated by this production system.

The role of agriculture in deforestation

Recently, high resolution imagery and fast image processing have been used to address the question of which type of agricultural systems have the largest influence on deforestation, looking at the size of clearing as a proxy of the type of production. Austin *et al.* (2017) have provided an analysis of deforestation evidence from 2000 to 2012, examining the trends in forest clearances of different sizes by country, region and development level. Their findings suggest that, in general, tropical deforestation increased between 2000-2006 and 2007-2012. More than 50 percent of this increase related to the expansion of medium, large and industrial-scale clearings (10-100 ha, 100-1,000 ha and >1,000 ha respectively), with a more pronounced trend in South East Asia (especially in Indonesia, Malaysia and Cambodia) and South America (especially in Bolivia and Paraguay). The opposite trend was observed in Brazil, where deforestation decreased, with more than 90 percent of this from a reduction in medium and large-scale clearings. Austin *et al.* (2017) also provide evidence that the deforestation profiles in most Central American and African LI and LMI countries continue to be dominated by small clearings (more than 80 percent of the country's deforestation). In South East

Asia, Philippines and Thailand show the same trend with 90 to 92 percent of the increased deforestation related to small clearings.

Small-scale agriculture includes family farming for subsistence and sales of surpluses, as well as managerial farming mixing family labour with permanent hired labour for commercial production. These farms might be included in informal value chains and their importance on the market at the national and global scale is therefore often underestimated, even though they are key players for certain crops. For example, smallholders of less than 2 ha produce 70 percent of all rice but only 10 percent of maize at the world level (Samberg *et al.*, 2016). Taken together, they represent a huge population and are a priority target for SDGs tackling poverty alleviation, food security and access to health services and education.

Where there is a growing population, small-scale farmers consume forest land to expand the productive agricultural area, use timber for housing construction and wood for fuel. Agricultural conversion of forests might also be a means to land appropriation and transmission. In LI countries, small-scale agriculture is mainly organic and labour-intensive by default⁴, mostly because of the lack of cash or access to inputs and materials. Farmers benefiting from technical advances in agriculture sometimes expand to sell more agricultural products rather than spare land. This means agricultural intensification does not systematically lead to less pressure on forests (Rudel *et al.*, 2009; Byerlee, Stevenson and Villoria, 2014). Besides, De Fries *et al.* (2010) have shown that tropical deforestation is more closely correlated with urban population growth and the development of export-oriented agriculture rather than growth in the rural population.

Austin *et al.* (2017) have demonstrated that industrial-scale agriculture played an increasing role in deforestation during the 2007-2012 period in Paraguay, Bolivia and Peru in South America, and in Indonesia, Malaysia, Cambodia and Vietnam in South East Asia. Agriculture in these countries is increasingly directed towards the export of commodities. When the price of the commodity is high enough, it becomes profitable to stretch the agronomic limits of the ecosystem by huge installation investments. When replacing forests, these costs might be partially covered by the sale of timber and wood.

Large-scale land-based investments in agriculture are also an answer to political strategies seeking to diversify national economic resources, populate national border areas, boost the national economy and balance imports and exports of food, fibre or energy. While they might be a great economic

4. However, this might not always be the case in main cash crop agricultural systems nor in peri-urban agriculture (see Chapter 3.3).

opportunity for host countries, they may also be a threat to natural forests and possibly to access to land by local populations. They create new living areas, with a local increase in the human population which increases pressure on natural resources and creates high local demand for food crops and animal proteins, for fuelwood and for timber for housing. Adjacent forests might suffer from higher pressure from hunting and gathering, slash and burn for agriculture and small-scale logging (Feintrenie, 2014).

They are a frequent target for activist NGOs. However, industrial companies must meet requirements from the governments of host countries of their production sites as well as in the countries of origin where the companies are registered. A consequence of these pressures is the definition of strategies and commitments by many agri-business companies towards responsible production schemes such as certifications or zero-deforestation pledges (Tonneau *et al.*, 2017). ●

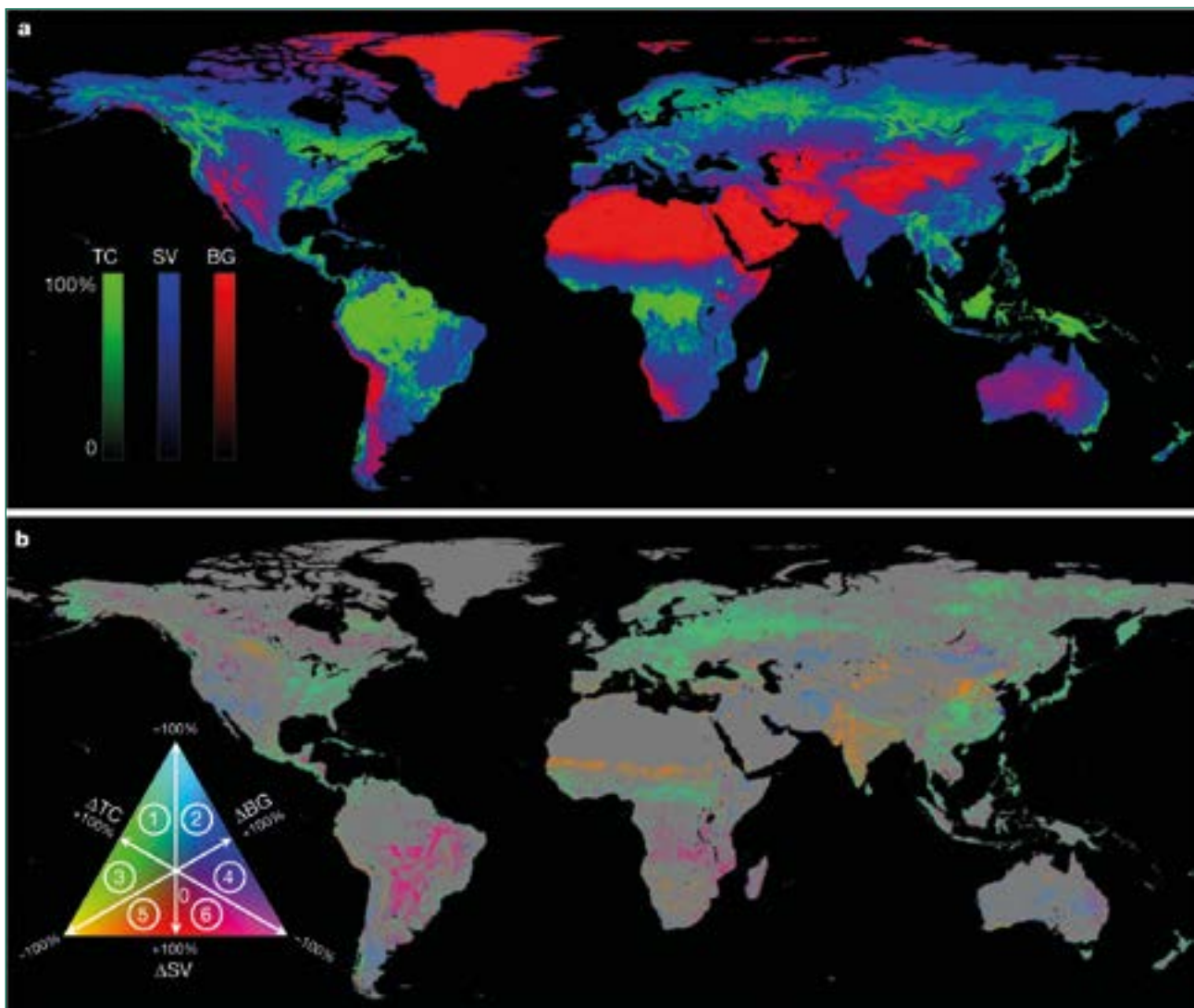


Figure 14: Satellite-based record of global tree canopy (TC) cover, short vegetation (SV) cover and bare ground (BG) cover from 1982 to 2016. Source: Songe *et al.* 2018.

A satellite-based record of global TC, SV and BG cover from 1982 to 2016. a, Mean annual estimates. b, Long-term change estimates. Both mean and change estimates are expressed as per cent of pixel area at $0.05^\circ \times 0.05^\circ$ spatial resolution. Pixels showing a statistically significant trend ($n = 35$, two-sided Mann - Kendall test, $P < 0.05$) in either TC, SV or BG are depicted on the change map. Circled numbers in the colour legend denote dominant change directions: 1, TC gain with SV loss; 2, BG gain with SV loss; 3, TC gain with BG loss; 4, BG gain with SV loss; 5, SV gain with BG loss; and 6, SV gain with TC loss.

BOX 3**NON-INDUSTRIALISED FAMILY FARMING MIGHT NOT ALWAYS BE FOREST FRIENDLY:
THE EXAMPLE OF AGROFORESTRY IN INDONESIA**

Sourisseau et al. (2015) have described the diversity of family farming systems and their interactions with the environment. Many examples of non-industrialised family farming are given to argue that where forests are available for agricultural conversion and where labour is not a limiting factor, expansion is the main strategy to increase family agricultural income.

Indonesia is well known for its complex agroforestry systems, also called agroforests, and when dominated by rubber, 'jungle rubber'. These agroforests preserve most forest ecological functions (FAO, 2016). They protect soils, regulate hydrological resources and micro-climates and preserve a high level of biodiversity. Farmers who develop and manage them are sensitive to the complexity of plant, insect and animal interactions and recognise their aesthetic quality. Behind this pleasant picture hides the deforestation of natural forests in response to commercial opportunities. Coffee, cocoa and rubber were first planted in medium and large-scale plantations according to industrialised agricultural practices. Local farmers, often working in these plantations, began intercropping these cash crops in their upland rice and food crops. They have added commercial agriculture to their subsistence farming. The complexity of the

botanic composition in these agroforests is mostly spontaneous: after three years of rice and food crop cultivation, the plot is abandoned until trees become productive. In the case of coffee or cocoa this is only a matter of a few years, while in the case of rubber, it might be up to 15 years. Then the farmer returns to the plot, cleans it, preserving useful trees (valuable timber trees and fruit trees) and opens a path to the cash crop trees. Useful trees might be planted to enrich agroforests where space allows it (Feintrenie, Schwarze and Levang, 2010).

The environmentally friendly practices in agroforests do not compensate for the forest and wildlife habitat losses necessary for their establishment. Other features of these agroforests translate into lower agricultural yields and income generation compared with mono-specific plantations. Because of this, agroforests are increasingly being converted into more productive mono-specific plantations. Feintrenie, Schwarze and Levang (2010) analysed this common trajectory in three sites: Sulawesi (cocoa), Lampung (coffee and damar) and Eastern Sumatra (natural rubber). They found that the main drivers of conversion of forests to agroforests or agroforests to mono-specific plantations are identical: economic opportunities.

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CHAPTER 2.4

RISKS OF NEW PESTS AND DISEASES

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SUMMARY

Climate change will affect the social and environmental determinants of the health of human, animal and plant populations around the world. It will challenge the social and biological capacities of food systems to regulate the emergence of pests and pathogens. Especially in Low-Income (LI) and Lower Middle-Income (LMI) countries, food systems will be dealing with new pests, diseases and emerging pathogens (viruses, bacteria, mycoplasma and fungi) severely threatening the health of vulnerable people and potentially exacerbating social and economic inequalities.

Effects of climate change on the emergence and prevalence of health risks

Climate change induces the disruption of ecological and sociological patterns. In particular, climate change has the potential to affect disease emergence (Watts *et al.*, 2017) because of its effects on annual and seasonal cycles affecting the spatial distribution of climate-sensitive pathogens. Regarding diseases strongly linked to ecological dynamics, such as vector-borne diseases, climate variations determine the presence and density of pathogen vectors and hosts (whether plant, animal or human) at any given place (Roger *et al.*, 2016). For instance, climate change allows mosquitoes, ticks and other parasites transmitting diseases to move to areas where they were previously unknown, threatening new food systems and populations. Diseases such as malaria, severe acute respiratory syndrome (SARS), dengue and Rift Valley fever are likely to emerge or re-emerge in disease-free areas, threatening the safety and health of human and animal populations.

A recent study has highlighted that most of the important pathogens among protozoa and helminths, vector-borne, food-borne, soil-borne and water-borne transmission routes are sensitive to climatic factors (ranging from 63 percent to 82 percent), particularly temperature and rainfall. Among them, zoonotic pathogens seem to be more sensitive to climate than exclusively human or animal pathogens (McIntyre *et al.*, 2017).

Climate change combined with other global changes such as the intensification of food farming systems, the globalisation of trade and the erosion of biodiversity will undeniably accelerate the emergence of these new health risks, in particular infectious vector-borne zoonotic diseases, crop pests and antimicrobial resistance. Taking into consideration that higher local temperatures are associated with increased rates of resistant infections (Blair, 2018), antibiotic resistance combined with climate change is probably one of the major crises to be faced in the future.

Cascade of impacts on livestock and crop production

These changes induced by climate change in host/pathogen interactions generate a cascade of impacts on livestock and crop production, affecting food security, livelihoods and potentially leading to migrations and social disequilibrium, with a subsequent impact on host/pathogen interactions (Figure 15). In addition, the increase of sanitary and phytosanitary threats resulting from climate change would hamper regional and international trade,

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especially for LI and LMI countries, if appropriate risk management is not developed (FAO, 2008).

In the case of plants and crops, insect pests are also an important plant health problem, for example locusts in the Sahel zone. Pests and diseases reduce crop productivity, compromise sustainability, reduce food availability and affect the quality of production. These threats are particularly present in tropical agrosystems. Climate change, coupled with global change (such as globalised trade, increased human and animal mobility, biodiversity erosion and drastic land-use change), alters the behaviour of pests and diseases on plants and their geographical distribution (War *et al.*, 2016). There is a genuine risk that pest and disease pressure will increase as a result of environmental and agrosystem disturbances. This is a concern for all agricultural stakeholders, including those in temperate countries where the introduction of new pests, diseases and weeds is widespread.

It is common knowledge that the list of such introductions in Europe is becoming ever longer, with the onset of disturbing phenomena that are a real threat to food security, but it is also the case in tropical countries, where pest and disease distribution areas are increasing at an alarming rate. The impact of climate change on pest populations and their natural enemies in the tropics is even harder and more complicated to grasp; changes in pest status, insect lifecycles, exotic introduction and the dramatic development of diseases or insect populations and extension of their ranges are being observed. Based on examples of insects and diseases affecting several tropical agrosystems, it is clear that the impact of climate change on these pests is important and it is essential to develop new agroecological protection

strategies while promoting the conservation of natural regulation services to sustainably reduce pest and disease risks (Carvalho, 2017).

Despite the fact that pest and disease management have made a substantial contribution to the increase in food production over recent decades, plant pests and diseases still reduce the global harvest by between 10 and 16 percent, and are particularly problematic in LI and LMI countries (Chakraborty and Newton, 2011; Campbell *et al.*, 2016). To better assess the effect of climate change on pests and diseases and on food production, more modelling studies are needed (Cilas *et al.*, 2016; Donatelli *et al.*, 2017).

To minimise, prevent and manage the impact of diseases, some breeding programmes are developing disease-resistant varieties to contain the spread of disease and minimise its effects on crops. The introduction of shade trees could be effective for maintaining the air temperature at field level and to protect crops from multiple pests and diseases. Moreover, shading could reduce sudden temperature changes, which are detrimental to the biological balance of agrosystems, thus contributing to the agroecological regulation of pests. Such ecological services can be preserved while mitigating the impact of climate on biodiversity.

With regard to zoonotic diseases (infectious diseases transmitted between animals and humans) drug resistance and environmental pollution are now major public health problems worldwide. They will be exacerbated by climate change because it affects environmental and socioeconomic equilibriums. Social and ecological disruption caused by climate is so complex that it cannot be accurately predicted.

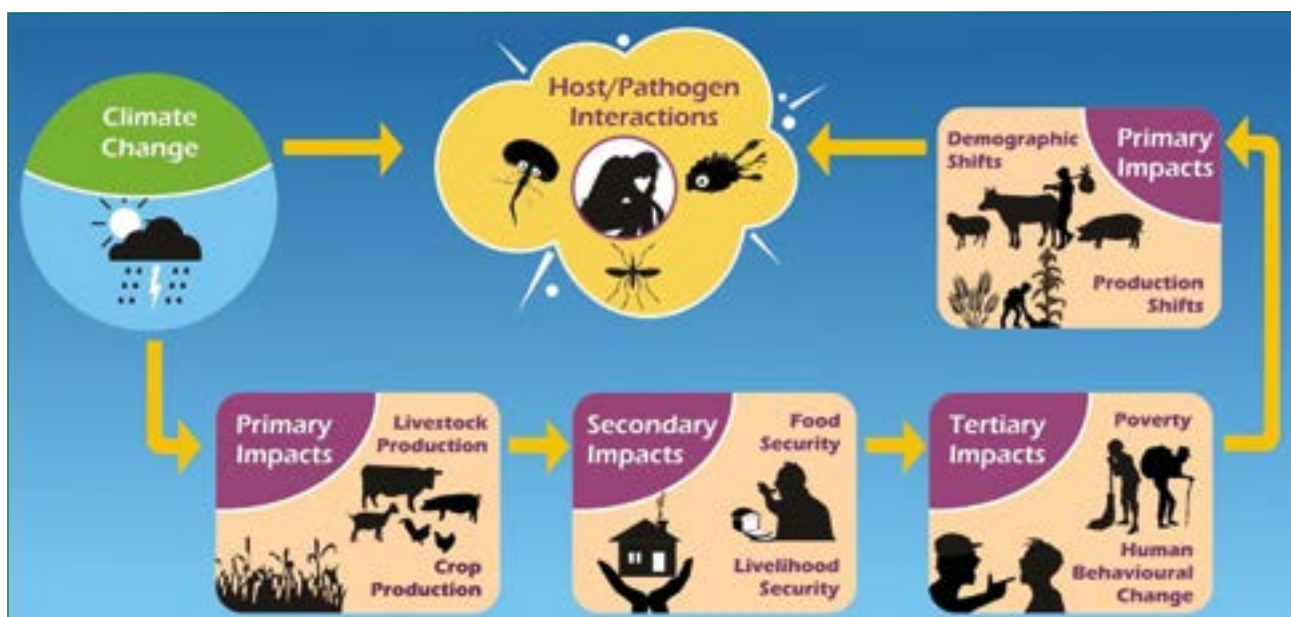


Figure 15: The infectious disease climate change cascade.

Source: Heffernan, 2018.

Despite the large proportion of climate-sensitive pathogens, their response to climate change depends on complex drivers (McIntyre *et al.*, 2017). Therefore, such risks are particularly difficult to address through conventional sectoral approaches. Given the framework of food systems threatened by climate change and its cascading impacts on health and livelihoods, there is an urgent need for a comprehensive integrated risk mitigation approach to address zoonotic and antimicrobial resistance-related diseases.

Managing such emerging risks requires conceptual and innovative methodological frameworks promoting integrated approaches to health, such as the 'One Health' or 'Ecohealth' approach (Duboz *et al.*, 2017). These integrated approaches acknowledge that human, plant and animal health are interdependent and bound to the health of the ecosystems in which they live. It aims to foster improved cross-sectoral collaboration and involve stakeholders at different levels. It is both a science-based and an institutional movement, promoting systems thinking and involving social and technical sciences sharing knowledge to support and strengthen integrated risk management actions at the agrosystem level.

Addressing the health impacts of climate change directly implies increasing the resilience of human and animal populations — and the underlying economic and food systems such as livestock and crop production — at an ecosystem level. ●

BOX 4

RICE CROPPING: CLIMATE CHANGE-RELATED DISEASE SPREAD

Rice is the most important food crop in LI and LMI countries and the staple food of more than half of the world's population. This cereal is grown in many countries under a variety of climatic conditions, from the wettest areas in the world to the driest deserts. Based on population projections from the United Nations and income projections from the Food and Agricultural Policy Research Institute (FAPRI), global rice demand is expected to rise from 490 million tonnes (milled rice) in 2018 to 555 million tonnes in 2035.

Changing climatic conditions are helping diseases to spread to new localities and exacerbating their impact. In addition to the already widespread diseases affecting rice, emerging diseases are increasingly becoming serious threats. Apart from the major diseases already established (Rice Yellow Mottle Virus in Africa, blast everywhere, tungro and bacterial blight in Asia, hoja blanca in South America, green coal in China, Rhizoctonia in Asia and South America), we are faced with the worldwide re-emergence of helminthosporiosis (caused by the fungus *Bipolaris oryzae*). This disease caused a famine in Bengal in the 1950s, and its currently high global prevalence is worrying. In South America, a bacterium is expanding (*Burkholderia glumae*). Many pests also exist in rice and are proliferating; to control them, research has shown the existence of a mechanism in tropical irrigated rice systems that supports high levels of natural biological control (Settle *et al.*, 1996; Sester *et al.*, 2014). These results have supported a management strategy that promotes the conservation of existing natural biological control through a massive reduction in insecticide use and a corresponding increase in habitat heterogeneity.

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CONCLUSION OF SECTION 2

FOOD SYSTEM ADAPTATION AND MITIGATION: MANAGING TRADE-OFFS

Céline Dutilly¹ and Étienne Hainzelin²

Food systems contribute to climate change with 19 to 29 percent of the total 50 GtCO₂eq/yr of anthropogenic emissions. These can be categorized in direct emissions from agricultural production and indirect ones from agriculture-driven land use change, as well as emissions resulting from the activities of pre-production (manufacturing and distribution of inputs) and post-production (processing, storage, transport, refrigeration, retailing and catering). Agricultural production is by far the main source of emissions in LI and LMI countries. Although the presence of significant barriers to adopting climate-resilient and low-carbon practices, faced mainly by smallholder food producers (FAO, 2017), has been noted⁹, Smith *et al.* (2008) estimated that the total mitigation potential of agricultural production could be 1.5-1.6 GtCO₂eq/yr, with a great share (70 percent) coming from LI and LMI countries. However, mitigation benefits and greater GHG efficiency might be slashed by growing emissions resulting from rising consumption in these countries.

Indeed, climate change will have growing implications in LI and LMI countries. By the middle of this century, higher average temperatures, changes in precipitation, rising sea levels, and an increase in the frequency and intensity of extreme weather events will result in a decline in food production and increased food insecurity, but also in more unstable yields resulting in price instability and related crises (Chapter 5.3). In addition, LI and LMI countries' food systems will have to cope with new pests and diseases, emerging pathogens – viruses, bacteria, mycoplasma and fungi – severely threatening the health of vulnerable people and exacerbating social and economic inequalities, leading to global health crises (Chapter 2.4).

In a context of increased climate stress, no global solution exists to improve the ability of LI and LMI countries' agriculture to mitigate its contribution to

global GHG, and simultaneously supply a growing demand for food. If certain actions can be developed to mitigate climate change in certain ecosystems, regions or food systems (i.e. limiting agriculture-driven land use change, reducing methane emissions from rice cultivation or limiting the consumption of animal products in High Income Countries (HIC)), most of the efforts in LI and LMI countries will have to be dedicated to the necessary food system adaptations to climate change. First of all, governments will need to anticipate these drastic changes in production systems and their transformation to plan for action. Research and development institutions are essential in this dynamic process. They must provide short-term decision support and long-term perspectives, by forecasting trends and proposing measures that may be applied without social costs. Second, technical and policy interventions must be situated within a broad holistic approach, maintaining the multiple roles and functions of agriculture in rural areas. Simultaneously, it seems essential to develop resilient landscapes to reduce the dispersion of pests and diseases affecting plants and animals. Finally, HIC policies (agriculture, industry, trade, migration regulation, investments and health) have effects on LI and LMI countries situations, and improved policy coherence is necessary to facilitate action in LI and LMI countries. Moreover, concerns around regional mismatches between responsibility for climate change and adaptation costs call for global mechanisms to prevent poor producers and consumers to support most of the consequences of climate change.

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SECTION

03

ENVIRONMENTAL
INTEGRITY



SECTION 3

Environmental integrity

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CHAPTER 3.1

RESOURCE OVER-EXPLOITATION AND RUNNING OUT

Éric Malézieux¹ and Lionel Dabbadie²

SUMMARY

Food systems around the world are highly dependent on both renewable and non-renewable resources. Drivers such as population growth, urbanisation and climate change put a lot of pressure on resources that have become core issues for the future of food systems. Cropland availability is limited in most parts of the world, adding pressure for cropping intensification. Fossil energy and phosphorus shortages are expected to occur within a few decades, with particular impact in Low-Income (LI) countries where farmers are more vulnerable to volatile prices. The availability of very unevenly distributed freshwater resources shows a similar picture, with an increasing number of regions reaching alarming levels of water scarcity. Some world fish stocks have been over-exploited and are now depleted. But the situation is not without hope. While we need to intensify food systems to meet the challenge of a growing population, new ways to produce with less impact on the environment and more resilience to climate change need to be widely adopted.

Food systems around the world are highly dependent on both renewable and non-renewable resources. Given the growing population, maintaining and displaying available and sufficient cropland, energy, phosphorus, freshwater and biological resources to provide adequate food for humanity has now become a major challenge.

Land-use and land-use changes

Land-use and land-use changes have become core issues for the future of food systems. Most of the world's soil resources are in fair to very poor condition and their condition is getting worse. In particular, 33 percent of land is already degraded due to erosion, salinisation, compaction, acidification and chemical pollution (FAO, 2015). Most lands that have been recently cleared of natural vegetation and forests to grow crops or graze livestock, suffer from increased erosion and losses of soil carbon, nutrients and soil biodiversity. Intensive non-sustainable agriculture has degraded wide areas, including the contamination of soils through excessive use of inorganic fertilisers and pesticides. In traditional agriculture, intensification can also result in soil degradation, a particularly significant threat in sub-Saharan Africa where yield gaps are high. In this region, agricultural land is especially prone to erosion and nutrient depletion: soil erosion accounts for more than 80 percent of land degradation, affecting more than 20 percent of agricultural land (FAO, 2015).

Moreover, with the exception of some parts of Africa and South America (Le Mouél, de Lattre-Gasquet and Mora, 2018), there is little opportunity for the expansion of agricultural areas. And much of the additional land available is not suitable for agriculture, with the ecological, social and economic costs of bringing it into production being very high, sometimes with acute competing claims. In addition, demand for alternative liquid fuels has driven the diversion of cropland to biofuel production, reducing cropland for food production. Biofuels produced from agricultural crops may reduce food supply and boost price volatility, increase CO₂ emissions and hold back rural development in LI countries (HLPE, 2011, 2013).

Pressure on land has numerous impacts. Understanding the impact of land-use change on both food production and climate requires new indicators and metrics (Searchinger *et al.*, 2018). Biodiversity is under particular threat, with an erosion of the ecosystem services it provides, due to land-use changes and unsustainable agricultural practices. A considerable number of species are under threat due to over-exploitation of habitats or pollution. Tropical forests are already reduced and fragmented. Marine ecosystems are threatened and freshwater biodiversity

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is decreasing. Agriculture, through land pressure, contributes significantly to these changes and, in return, is itself impacted. Agricultural intensification has led to a strong homogenisation of agricultural landscapes and the loss of natural and semi-natural habitats (Foley *et al.*, 2005), leading to serious biodiversity losses.

The impacts of land-use change on biodiversity and carbon sequestration are greater in LI countries and closely linked to international trade, which is the main driver. Between 2000 and 2011, the erosion of biodiversity can be linked to cattle and cereal production, while the reduction in carbon sequestration can be mainly linked to forestry and cattle. The regions experiencing the greatest biodiversity loss are Central and South America, Asia, and Africa. When looking at the relative change over this period, the impacts in Asia are striking for both biodiversity loss and carbon sequestration, and are mainly linked to oil production and the forestry sector (Marques *et al.*, 2019).

Fossil fuels

Fossil fuels are used in large quantities in food systems. The food sector (including input manufacturing, production, processing, transportation, marketing and consumption) accounts for approximately 30 percent of global energy consumption and produces more than 20 percent of global GHG emissions (FAO, 2016a). However, subsistence producers around the world have very low energy inputs, with energy usually derived from human and animal power. Industrial agriculture requires lots of energy for chemical inputs, farm machinery, heating protected crops and irrigation systems. But industrialising agricultural systems by increasing fossil fuel inputs may no longer be a feasible option. Finite supplies and increasingly difficult access to fossil fuel have already impacted fuel and food prices in most parts of the world (HLPE, 2011). Their impact will certainly increase in the coming decades.

Phosphorus

Phosphorus (P) is another critical non-renewable resource for agriculture. Currently, nearly 90 percent of extracted phosphorus is used in the global agri-food system, most of it used unsustainably as a crop fertiliser (Childers *et al.*, 2011). Inefficient phosphorus use in agri-food systems is a threat to the global aquatic environment and people's health. The Green Revolution required a large increase in the use of inorganic phosphorus. Projections show that economically viable mineral reserves will become depleted within a few decades and, as a major nutrient,

there is no substitute (Cordell and Neset, 2014). Phosphorus-induced food shortages are therefore a possibility, particularly in developing countries where farmers are more vulnerable to volatile fertiliser prices. Indeed, Africa is the world's largest exporter of mineral P but, compared with Europe, P fertiliser is more expensive in sub-Saharan Africa, both in terms of its real price and as a percentage of a farm's budget. This means that P accessibility for a sub-Saharan African farmer is considerably lower than for a European farmer, even though both are using mineral P from the same source (Cordell, Dranger and White, 2009). Soils depleted in P are already responsible for lower crop yields and increased inter-annual variability in food production in sub-Saharan Africa (Vitousek *et al.*, 2009). Sustainable solutions to such future challenges exist and involve closing the loop in the human phosphorus cycle (Childers *et al.*, 2011).

Freshwater resources

Freshwater resources and irrigation are important for adapting to climate variability and moreover for climate change, as well as for increasing land productivity. More than 70 percent of all available freshwater in the world is used by agriculture (HLPE, 2015; FAO, 2018a). Although irrigated areas occupy less than 20 percent of the world's total arable area, they generate more than 40 percent of the total production value globally (HLPE, 2015; FAO, 2018a). This disproportionate contribution is attributed to greater productivity in irrigated areas as a result of higher and more stable yields and more intensive cropping, as well as to the cultivation of higher value crops compared with rainfed cultivation (FAO, 2018a).

How much cropland can be irrigated under future conditions is therefore a key question for determining food production. Only 6 percent of the cultivated area is equipped for irrigation in Africa. This figure falls to only 3.4 percent in sub-Saharan Africa, compared to 40 percent in Asia (FAO, 2016b). Ultimately, the potential for converting rainfed land to irrigated land is determined by the water resources available. However, freshwater resources are very unevenly distributed across the planet, with an increasing number of regions reaching alarming levels of water scarcity. Over-withdrawal of surface and groundwater has already led to depletion of water resources and environmental damage in some regions in India, Pakistan and China. The pressure on renewable water resources from irrigation will increase slightly, especially in countries that already suffer from water scarcity in the Near East/North Africa and South Asia (FAO, 2018a). The right incentives and technologies to use less water and increase water use efficiency (such as using drip irrigation, reusing wastewater, water harvesting and storage etc.) will be necessary (FAO, 2018b).

Fish

Fish is an important component of healthy diets throughout the world, providing 20 percent of the average per capita intake of animal protein to nearly 3.2 billion people (FAO, 2018b). As a result of demographic growth and dietary changes, global demand continues to increase, leading to a growing pressure on the resource (cf. Box 5). Inland fisheries also play a major role in food security and nutrition in many developing countries and their importance is probably underestimated. Inland fisheries continue to grow in several countries, especially China, India, Cambodia, Indonesia, Nigeria, Russian Federation and Mexico, but given that freshwaters are one of the ecosystems most heavily impacted by humans (pollution, habitat loss and degradation, draining of wetlands, river fragmentation and poor land management), concerns have emerged with regards to their sustainability (Funge-Smith, 2018).

Could aquaculture be a solution for reducing pressure on wild stocks? Currently, 70 percent of aquaculture production is fed using home-made or commercial feed. Although fishmeal and fish oils are still used to feed farmed fish, new technologies and progress have allowed aquaculture to become a net fish producer: for every kilogramme of wild fish consumed, 4.5 kg of fish is produced (IFFO, 2017). The challenge now is to fill the demand gap, while maintaining environmental and social impacts within boundaries that do not affect the sustainability of the system. Agroecology and exploiting the synergies between aquaculture and agriculture are promising options.

Sustainable agricultural methods and reduced dependence on fossil fuels are essential to address the food security challenge and critical for the transition to sustainable food systems based on renewable energy. Becoming 'energy-smart' along the food chain by reducing the high dependence on fossil fuels will require new policies and institutions and significant investments in new agricultural practices and clean energy technologies.

For the future, it is also important to consider the evolution of food diets. As incomes rise, one generally predicts a shift towards a higher proportion of non-staples in the diet (FAO, 2018c). At the level of food systems, this means that one can expect a disproportionate growth in the supply chains of non-staples such as fruit and vegetables, meat and fish, dairy and edible oils, thereby contributing to changes in local cropping systems. Meeting the challenge of feeding the world's population will require new agricultural pathways that combine efficient use of arable land without deforestation, restoration of soils, mindful choices between the use of agriculture for food, animal feed and energy, efficient multiple uses of water, attention to global nutrient cycles, protection of biodiversity and ecosystem services, as well as adaptation to climate change in a context of increasingly limited supplies of fossil energy and correspondingly rising energy prices. While we need to intensify our food systems to meet the challenge of a growing population with evolving diets, we must do so in a way that preserves resources and is more resilient to climate change. ●

BOX 5

FISH RESOURCES: IS IT TOO LATE?

FAO has been monitoring the status of the world's marine fish stocks since 1974, highlighting that the share of stocks unsustainably harvested has regularly increased, representing one-third of the total in 2015 (cf. Figure 16, from FAO, 2018b). The production of capture fisheries has stagnated since 1990 at around 90 million tonnes, while aquaculture production has increased from less than 10 million tonnes in the 1970s to more than 80 million tonnes in 2015 (FAO, 2018b). Some over-exploited fish stocks can recover when sustainable fishery management systems are implemented, as highlighted by the bluefin tuna fishery in the Mediterranean (Rouyer *et al.*, 2018), but once an ecological threshold has been passed, changes cannot be reversed (Ben Rais Lasram, Menard and Cury, 2018). For the future, new threats are likely to create fresh pressure on wild stocks: climate change, pollution (including plastic nanoparticles), habitat degradation etc.

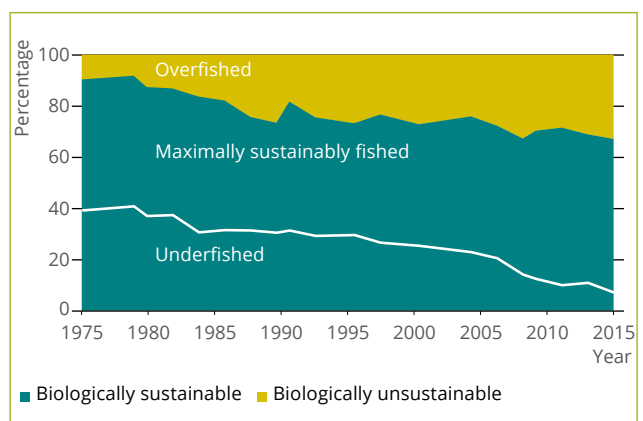


Figure 16: Evolution of the sustainability of capture fisheries production (1975-2015). Source FAO, 2018b.

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CHAPTER 3.2

RISKS OF IRREVERSIBLE BIODIVERSITY LOSSÉtienne Hainzelin¹**SUMMARY**

Biodiversity is the driving force of ecosystem services and has been the foundation of agriculture for many, many years. The drastic evolution of agriculture over the past century in industrialised and some developing countries, based on improved varieties and synthetic inputs, greatly increased production but has led to the artificialisation of agroecosystems and great losses of specific and genetic diversity. In turn, these losses have hampered food systems in different ways: degraded ecosystem services affecting crop yields and resilience, reduced crop biodiversity, and highly specialised industrialised food processing, which has decreased the diversity of the food supply and its nutritional value.

Biodiversity as a foundation for food systems

Biodiversity encompasses all “living organisms from all sources and the ecological complexes of which they are part, including diversity within species, between species and of ecosystems” (United Nations, 1992). It is the driving force of ecosystems and at the origin of many goods and services and, indeed, of human existence and well-being. However, biodiversity is facing major challenges: most human activities make use of biodiversity and, simultaneously, threaten its integrity directly or indirectly, for example through anthropogenic climate change.

Food systems represent a very large part of human activity, responding to very basic human needs and mobilising biodiversity at all stages. Primary food production depends on ecosystem functions and services on 40 percent of emerged land. Food processing uses many services provided by biodiversity, such as fermentation, and consumers, through their intestinal microbiotas, process food into well-being and health.

At the same time, food systems are putting real pressure on biodiversity through several drivers and pathways, the main one being the conversion of natural ecosystems to agriculture. These interactions between food systems and biodiversity, with multiple feedback loops, generate risks that might be severely aggravated by the way food systems operate and evolve. Some authors estimate that agriculture represents one of the major threats to biodiversity through land-use and ecosystem artificialisation at three embedded and interacting scales: ecosystemic, specific and genetic diversity (FAO, 2019).

How does industrialisation of food systems affect biodiversity?

For years, agriculture has comprised of harnessing biodiversity, domesticating and combining plants, animals and microbes in a very wide range of agricultural systems on all continents and shaping agricultural landscapes. Innovation was mainly rooted in biodiversity at different scales. At the beginning of the twentieth century, agriculture in the northern hemisphere went into a process where production was based on selected varieties, synthetic fertilisers and pesticides, in addition to mass mechanisation heavily reliant on fossil fuels. It has led to industrialised agriculture and food systems, and resulted in the artificialisation of agricultural fields; biodiversity is reduced to a uniform and synchronous canopy, usually consisting of a single genotype of some major species, with the rest of the living organisms being systematically eliminated as ‘limiting factors’.

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This transformation has affected not only most of the agricultural land in developed countries, but also some sections of agriculture in Low-Income (LI) and Lower Middle-Income (LMI) countries, the Green Revolution being based on the same rationale and principles. This has been reinforced by the globalisation of markets, which tends to lead to regional specialisation, the segregation of crop and animal production, and the industrialisation of the processing and distribution of food products (Martin *et al.*, 2019). The link between biodiversity and agriculture has somehow been broken. Because these transformations provide large increases in yields and economies of scale, they have been very attractive to developing countries as a pathway for modernisation. Although agriculture in these regions remains very diverse, in terms of production systems, farm size and intensification levels, with the cohabitation of multiple trajectories and models, this modernisation process is making progress (Bosc *et al.*, 2015).

This evolution affects biodiversity in agroecosystems and beyond in several ways:

- When the production process draws more resources than the ecosystem can sustainably provide, species populations and biodiversity are depleted. When cropping systems get simpler (i.e. mono-cropping at large scales) and regions more specialised, the diversity of species is eroded, not only for crop species but also for the other compartments of above- and below-ground biodiversity. This is particularly true for the complex soil-living communities which, for the most part, constitute a “hidden biodiversity” yet to be described (FAO, 2019). This erosion is irreversible and affects trophic chains and ecosystem services (De Clerck, 2017).
- The use of pesticides has a direct effect on biodiversity, at the plot scale and on auxiliary species, such as pollinators and soil biota. Through trophic chains, it leads to a drastic reduction of the ecosystem services that agricultural production needs (van Lexmond, 2015). Because of the multiple connections between natural and cultivated areas, this pressure reaches beyond agricultural land to natural areas, at the landscape and regional scales, decreasing the resilience of these areas.
- The impact on crop genetic diversity is the subject of concern and controversy, partly because there is no consensual tool to measure it (van de Wouw *et al.*, 2010). However, there is clearly a loss of diversity when traditional varieties or races are replaced by improved varieties (Khoury *et al.*, 2014). This can generate a genetic homogenisation at the global scale and possible weaknesses to pests, as historically illustrated by many examples in maize, banana and wheat (Bioversity International, 2017).

Most of the time these losses of biodiversity are irreversible, with many studies showing that the state of degradation of biodiversity across the planet has long passed the boundaries of sustainability (Springmann *et al.*, 2019).

What risks for food systems in LI and LMI countries?

Eroded biodiversity hampers food systems in different ways:

- The first major risk is the degradation of the capacity of ecosystems to support production, especially soils. Plateauing yields have been reported in several crops and 20 percent of the world’s cultivated land has lost productive capacity (FAO, 2019). Eroded agrobiodiversity also triggers a vicious circle where more external inputs are needed to maintain yields, making farmers more dependent (Frison and IPES, 2016). Documented collapses in insect populations and diversity at a rapid rate (biomass declining at an annual rate of 2.5 percent for three decades), exemplify this fast-growing risk for agriculture and food production (Sánchez-Bayo, and Wyckhuys, 2019).
- Reduced diversity in production decreases the diversity of the food produced in a given region and it is not easy to compensate for this on markets (de Clerk, 2017; Jones, 2017). In southern countries, the industrialisation of agriculture, with its larger and more specialised farms seeking economies of scale, might degrade the nutritional value of products (Herrero, 2017). Most public policies and incentives designed to increase production accentuate the risk of poorly diversified diets, food systems and landscapes (*cf.* Box 6).
- At the processing stage, besides clear advantages (efficiency, labour productivity, cost per food unit etc.), industrialisation and a high degree of specialisation reduce food chain biodiversity, therefore decreasing nutritional quality and diversity (Remans, 2014).
- Ever-evolving and ever-adapting agrobiodiversity represents the creativity of life; its irreversible erosion means less capacity to innovate and adapt in the future, especially to climate change. Living in the ‘Anthropocene’ epoch, we already recognise biodiversity’s finiteness in the form of impoverished landscapes and precarious ecosystems.

The market globalisation of agriculture has been a reinforcing driver in biodiversity erosion, as several researchers have shown (Khoury *et al.*, 2014). By increasing product fluxes and genetic material exchanges, it has reinforced these perturbations, either by erosion (i.e. reduced number of commodity species) or outbreak risks (i.e. invading species and exotic pests). Furthermore, the wide use of pesticides

and antibiotics has generated very serious problems in antibiotic resistance (Morand and Lajaunie, 2018) and pesticide resistance (Heap, 2014).

What are the emerging solutions?

In their diversity, food systems have the resources to counter these risks, provided their actors can innovate based on new foundations:

- Production systems should reintegrate diversity at the plot, farm and landscape scales, not only to boost ecosystem services supporting crop production and protection, but also for the benefit of environmental integrity and health. Diversification is one of the best options to improve the nutritional value of production (Herrero *et al.*, 2017; Remans, 2014).

- Plant, animal and microbial agrobiodiversity, in and around the plot, above- and below-ground, must be preserved and valued as a precious capital. *In situ* conservation involving farmers would powerfully leverage their resilience and innovation capacity. This could lead to a new biotechnology based on complex specific combinations instead of an over-simplification (HLPE, 2017).

- A radically new approach of all food system actors and policy makers focused on performance at each step of the value chain, not limited to yields and productivity, but encompassing nutrition and environmental footprints (Frison and IPES, 2016). ●

BOX 6

DIVERSIFYING CROP SYSTEMS TO IMPROVE THE FOOD SECURITY AND NUTRITION OF SMALLHOLDERS IN MALAWI

Increasing intra- and interspecific diversity in cropping systems results in enhanced ecosystem services linked to crop nutrition (closing nutrient cycles, capture of atmospheric nitrogen, reduced leaching and run-off etc.), weed control (mulching, allelopathy etc.) and pest management (breaking pest cycles, biocontrol etc.). It also improves the diversity of products available, although the way agricultural diversity translates into dietary diversity at the farm household level is not always straightforward nor easy to demonstrate.

In Malawi, a country in semi-humid tropical Africa, more than 70 percent of rural people live below the poverty line, with serious food security challenges. Almost one-third of Malawian households experience severe food insecurity and calorie deficiencies, 50 percent of children under the age of five are stunted, 60 percent of pre-school age children are deficient in vitamin A and nearly three-quarters are anaemic (Nyantakyi-Frimpong *et al.*, 2017).

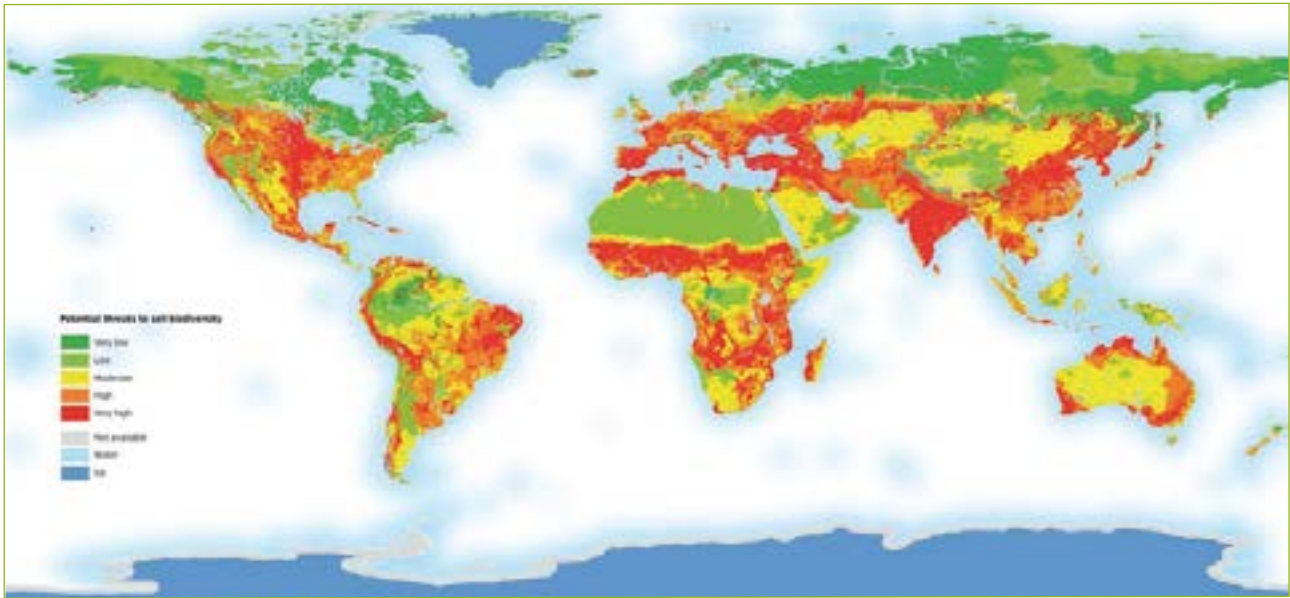
Through a large cross-sectional household survey (1,000 diversified smallholders with farm sizes of less than three acres) in two districts in Malawi, Nyantakyi-Frimpong *et al.* (2017), compared their health, food security and nutrition status. Household heads, spouses or another well-informed adult within the household were interviewed using a structured questionnaire specifically designed for the study, including questions on their self-perceived health and a Household Food Insecurity Access Scale (HFAS) module to explore household food insecurity. The key independent variable was the use of agroecology (adopted by 571 households and not adopted by 429 households), understood as a set of farming practices mimicking natural systems, diversifying crops and increasing agrobiodiversity with attention paid to interactions with adjacent natural landscapes and taking particular care of soil by mulching and legume cropping.

The results showed that households which had adopted agroecology were more likely to report optimal health status and the

average treatment effect showed that adopters were 12 percent more likely to be in optimal health. The paper concludes that with the adoption of agroecology in the semi-humid tropics it is possible for households to diversify their crops and diets, which has strong implications for improved food security, good nutrition and human health.

At the country level, Jones, Shrinivas and Bezner-Kerr (2014) explored plausible causal mechanisms that may operate between farm production diversity (crops and livestock) and diet diversity, based on data from a nationally representative sample of farming households in Malawi. The combination of increased farm diversity with dietary diversity was significantly greater in households lead by women compared to those headed by men, and in wealthier households. There was an especially strong link between legume, vegetable and fruit consumption with greater farm production diversity. More diverse production systems may contribute to more diverse household diets. However, this relationship is complex; it may be influenced by gender, wealth, control of household decisions, the relative market-orientation of a household's agricultural production and the specific nature of farm diversity.

Jones (2017) has also explored how agricultural biodiversity, diet quality and anthropometric outcomes are associated in LI and LMI countries. A comprehensive review of five databases revealed that agricultural biodiversity has a small but consistent link with more diverse household and individual diets, although the magnitude of this association varies with the extent of the existing diversification of farms. Greater richness in on-farm crop species is also associated with small, positive increments in linear stature in young children. Agricultural diversification may contribute to diversified diets through both subsistence and income-generating pathways and may be an important strategy for improving diets and nutrition outcomes in LI and LMI countries.



Map 8: Map of potential threat to soil biodiversity.
Source Orgiazzi et al., eds. 2016. European Union, 2016.

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CHAPTER 3.3

THE EFFECTS OF AGRICULTURE'S ENVIRONMENTAL EXTERNALITIES ON FOOD SYSTEMS

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SUMMARY

A healthy environment is essential for the proper functioning of both natural and cultivated ecosystems and, as such, plays a major role in food systems. Many different sources, including the agricultural sector itself, emit and accumulate pollutants in different environmental compartments (soil, water and air). When there are excessive pollutant levels, ecological functioning is hampered by eroded biodiversity, disrupted nutrient cycling, toxicity and depleted soil fertility, and can lead to reduced yields and contaminated food products. Many pollutants end up in water through leaching and run-off and have negative impacts on aquatic ecosystems, reducing fish and seafood stocks. Pollutants can also contaminate the food chain and cause food toxicity risks, and this is particularly true when pollutants undergo gradual biological concentration along the food chain.

Pollutant diversity and sources

The environment is a major sink for numerous pollutants, derived mainly from human activities. All environmental compartments are concerned (soil, water and air), with specific and complex dynamics. Pollutants belong to two main categories (Edwards, 2002; OECD, 2017; FAO, 2015):

- Inorganic pollutants are mainly heavy metals (arsenic, cadmium, lead, mercury etc.). Cadmium is the most serious heavy metal likely to contaminate agricultural soils. Due to its high mobility in the soil, it can be easily absorbed and transferred to the food chain.
- Organic pollutants are highly diverse (hydrocarbons, phenolic compounds, fertilisers, pesticides, micro-plastics etc.) and their accumulation in the environment is due to the absence of any biological process to degrade them (xenobiotic molecules) or to the relative slowness of the degradation process. 'Chemicals of Emerging Concern' are new challenges, including products such as nanoparticles, pharmaceuticals, cosmetics, hormones, detergents and certain industrial chemicals whose effects are not always understood and/or measured.

Pollution may come from different sources (Thangavel, 2017); it can be a single discharge point, which means control strategies can be employed, or a more diffuse source at the landscape level via air-soil-water systems, which requires complex analyses involving these three compartments in order to tackle the pollution (IPES-Food, 2017):

- Large quantities of urban solid waste, mostly treated in landfills or incinerators, can eventually affect groundwater and the soil quality of cultivated ecosystems in the vicinity. Sewage sludge, sometimes applied on cropland, can also be highly contaminated with heavy metals and pesticides (Rodríguez-Eugenio, 2018).
- Many industrial chemicals pollute land near their production sites but can also be transported to other systems through discharges into aquatic systems or wind dispersal. These chemicals include heavy metals, inorganic gaseous emissions, and volatile organic compounds (Rojas *et al.*, 2016).
- Agriculture is a major contributor to pollution in many regions of the world through the use of synthetic inputs, such as fertilisers and pesticides, and animal waste (Lelieveld *et al.*, 2015). When applied in excess, only a fraction of fertilisers are absorbed by plants and the rest can contaminate groundwater or river systems through leaching or run-off. Phosphates generally also bring heavy metal contaminants, such as cadmium. Agrochemicals are also a major pollutant affecting soils and water. Organochlorine insecticides that can persist in the soil for decades can be bioconcentrated from the soil to final consumer along the food

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chain. Antibiotics, used on a large scale in animal and fish production, are causing growing concerns for the resistance they can generate (Rodríguez-Eugenio, 2018; IPES-Food, 2017)

Effects on food systems

There are two main impact pathways on food systems: through degradation of the productive capacity of land or aquatic ecosystems and through contamination at different stages of food production. The impact of a pollutant will depend on its toxicity and its persistence. This means heavy metals have much more serious effects than relatively transient chemicals. An ecosystem's resilience to the effects of a pollutant depends in part on its biodiversity, stability and the existence of alternative processes for performing essential functions.

Agroecosystem degradation and reduction of production potential

While some degradation processes can be observed directly, soil contamination cannot, making it an insidious hazard, a 'hidden danger' (FAO, 2018). The analysis is further complicated by the diversity of contaminants (in particular persistent organic pollutants, constantly changing due to developments in agrochemistry), their random circulation, their transformation through biological activity in soils and the ability of soils to store, immobilise and degrade. However, the effects may appear suddenly after changes in land use that alter environmental conditions.

The impacts of soil pollutants are highly diverse and chemicals such as pesticides can have direct toxicity effects on surface and subsoil biota. These in turn can have major influences on soil ecology by changing the availability of organic matter that provides nutrients to other living organisms, modifying the plant rhizosphere or altering the soil pH. These changes can have an impact not only on population size but also on the functions of terrestrial ecosystems that affect production (Rodríguez-Eugenio, McLaughlin and Pennock, 2018).

Impact on aquatic ecosystems and fish resources

Acute or chronic pollution with a wide range of organic and inorganic compounds entering the aquatic ecosystem is likely to impact both wild and farmed aquatic species through direct (toxicity) or indirect effects (Ryder, Karunasagar and Ababouch., 2014). Aquaculture might allow for better control of the risk through ensuring the composition of fish feed and monitoring water quality.

Another source of pollution likely to affect ecosystem and production systems is eutrophication, which results from organic and inorganic nutrients rich in

nitrogen and phosphorus being released into water bodies. Depending on its intensity, eutrophication can lead to changes in the assemblage of species (with micro- or macro-algae proliferation), reduced biodiversity, changes in trophic food webs or massive fish kills as a result of deoxygenation and the release of toxic gases by anoxic bacteria (van Beusekom, 2018).

A rapidly growing concern is plastic pollution, especially micro- and nanoplastics, as they have become ubiquitous in inland waters and oceans and are of growing significance. Evidence is still lacking on their real impact and additional research is required for nanoplastics, as their size could allow some of them to cross cell membranes and enter blood circulation (Lusher, Hollman and Mendoza-Hill, 2017).

Food system contamination

Food represents the main source of human exposure to some of these pollutants and, despite the lack of comprehensive data, food contamination is a serious threat to human health (WHO, 2015). Heavy metals are ubiquitously distributed in the environment, reach plant and animal-derived food and can cause chronic or acute toxicity and serious human pathologies (Rodríguez-Eugenio, 2017). Numerous organic pollutants can contaminate human food, even at very low concentrations, exemplified by endocrine-disrupting chemicals (EDCs). The risks can increase through the biomagnification process, where some pesticides stored in the fatty tissues of animals are gradually concentrated along the food chain until their consumption by humans.

Synergic effects

In nature, organisms are exposed not only to a single pollutant but often to many chemicals in large quantities or in trace amounts. Interactions between various chemicals (for example, antibiotics and cadmium) can increase or decrease the overall effect (Wang *et al.*, 2018). In other words, the resulting effect may be greater or lesser than the simple combined effect or be unchanged. It is also possible that a compound may not be toxic itself but may become so in the presence of another compound. Ecotoxicology struggles to address these possible complex cocktail effects.

Trends in developing countries

Asian countries experiencing rapid industrialisation are confronted with considerable contamination of their agricultural soils. For example, large quantities of mercury from the chemical industry and gold mines are released into the environment (Sari *et al.*, 2016). Arsenic is also naturally present in groundwater in many parts of Bangladesh and western India (Rahman, Dong and Naidu, 2015; Mojid *et al.*, 2016).

This poses a threat to agriculture, particularly in rice fields. Intensive pesticide and fertiliser use has also resulted in the accumulation of organic pollutants in the region's soils and eutrophication in water. In China alone, heavy metal contamination may result in a reduction of more than 10 million tonnes of food supplies each year (FAO, 2015). Many studies have shown the existence of high levels of organochlorines in vegetables and other food products (Lam, Pham and Nguyen-Viet, 2017).

In Africa, mining, the oil industry and poor urban waste management are highly significant sources of pollution. According to a study of ten Ogoni communities in southeast Nigeria, pollution from oil spills has led to concentrations of hydrocarbons and heavy metals in water, air and soil that are 900 times higher than allowable levels (UNEP, 2007). However, soil pollution through agrochemicals is of less concern than in other parts of the world because of their low level of use, with the exception of intensified peri-urban horticulture where groundwater is often contaminated (Sorensen *et al.*, 2015). There are also several examples of mismanagement, as illustrated by reported cases in Botswana and Mali, where more than 10,000 tonnes of pesticides, including very dangerous organochlorine compounds such as dichlorodiphenyltrichloroethane (DDT), aldrin and heptachlor, have leaked from damaged containers and contaminated the soil (Cachada *et al.*, 2018).

The growing threat of lead pollution, through petrol additives or battery recycling, also illustrates contexts where regulations are weak or absent (Gottesfeld *et al.*, 2018).

In the Near East and North Africa, in addition to the excessive use of chemical fertilisers and pesticides, a frequent source of soil and water pollution is the use of wastewater for irrigation and sewage sludge as a fertiliser (Mekki and Sayadi, 2017). ●

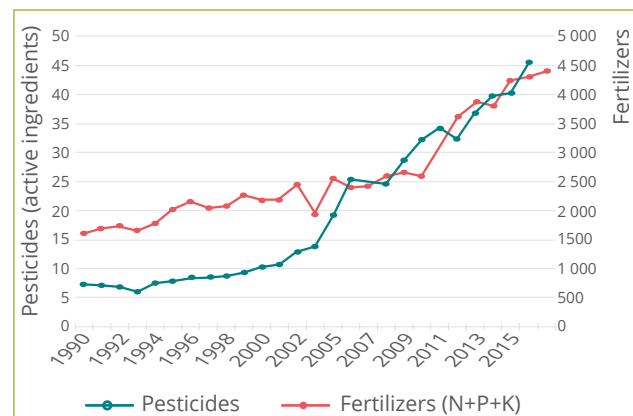


Figure 17: Least Developed Countries: chemical inputs used in agriculture from 1990 to 2016 (1,000 tonnes). Source: FAOSTAT, consulted on February 15, 2019.

BOX 7

PESTICIDE USE IN HORTICULTURE IN SUB-SAHARAN AFRICA: AN INCREASING RISK FOR FOOD SYSTEMS¹

Even though sub-Saharan African countries are the smallest users of pesticides in the world, African agriculture is far from being 'organic by default'. Since the 1970s, farmers have been using pesticides on their crops to prevent pest invasions and crop losses. Back then, the use of pesticides was mainly dedicated to export crops, such as cotton, coffee, tea, bananas and other tropical fruits. Driven by urbanisation and changes in diet as well as the growing population, the demand for fruit and vegetables in urban markets is continuously increasing. In order to meet this demand, peri-urban horticulture is increasing and the import value of pesticides in Central, East and West Africa grew by 261 percent between 2000 and 2010.

The risks associated with this growing pesticide use are being increasingly documented. First, there are risks in terms of the quality of the pesticides used. Indeed, they are often not adequate for the crop targeted. For instance, studies have shown that farmers in Benin generally spray cotton pesticides on vegetable crops in Cotonou. In addition, most of the time the products used are not good quality pesticides; sometimes they come from international out-of-date stock, which means they are no longer effective. Sometimes products used by farmers are forbidden on international markets, but still sold in African markets.

The study on market gardens in Cotonou showed that of 15 pesticides used, only two were officially allowed by the national regulations. Furthermore, the study reports inadequate farmers' practices and misuse of pesticides that are a threat to their own health and for their families and final consumers. Pesticides are often sprayed at the wrong moment and the period between spraying and sale is often not respected. This means that consumers buy vegetables on the market that should not be consumed. Additionally, farmers' lack of awareness, poor equipment and reuse of pesticide containers for other family uses, the absence of instructions (sometimes due to repackaging or illiteracy) and the difficulty for farmers in converting dosages usually prescribed for hectares for their small farms generate high risks for human and environmental health. Finally, the overuse of pesticides on certain crops can cause a high risk of pest resistance, as has been illustrated with tomato bollworm in Benin.

The increasing use of pesticides in horticulture, combined with urban sprawl, competition for land (involving the production of more food on smaller plots), as well as industrial and transport pollution, are aggravating risks for food systems seeking to comply with food security objectives and environmental integrity.

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CHAPTER 3.4

LARGE-SCALE LAND AND WATER ACQUISITIONS: WHAT IMPLICATIONS FOR FOOD SECURITY?

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SUMMARY

Since 2007, the world has seen a rush towards natural resources, particularly land as well as water. It resulted from a convergence of the 2007–2008 food price crisis in a context of growing populations and changing diets, and the search for alternatives to financial investment products. Although data is scarce, recent estimates show that about 42 million hectares have been acquired (Nolte, Chamberlain and Giger, 2016). Contrary to what is often highlighted, these lands are not the most marginal, underused and unowned, but are close to other resources, especially water, as well as infrastructure (roads and transport) and services. This means the resource acquisition phenomenon is embedded in a complex matrix of resources and processes which is increasingly under pressure. That said, attention has so far mainly been sectoral, focused on land issues and neglecting this interconnectedness. However, the water implications of these land deals are starting to surface.

Large-scale land and water acquisitions for food production

Although these acquisitions of land and water are aimed at a wide range of production, most - and a still growing number of them - are focused on agricultural and food production (Land Matrix, 2018). Adding to earlier concerns about the land footprint of large-scale agribusiness plantations, a fuller consideration of the wider range of economic consequences is now mushrooming, leading to questions related to their broader impacts on sustainability, food security, competition with local farming systems, delocalisation of production and virtual water use etc., which may lead to potential food crises.

Even though the 'global land rush' that peaked in 2007–2011 has now slowed (mainly resulting from lower commodity prices and the large number of failing large acquisition projects), the evidence suggests that the squeeze on natural resources, especially land and water, is currently being felt more acutely in many places, as new deals continue to be concluded and many existing deals enter the implementation phase (Cotula and Berger, 2017).

Looking beyond the role of transnational corporations, local actors and national processes are currently also driving land acquisitions for natural resource investments, highlighting beyond international land acquisitions, national dynamics, with speculation, corruption and domestic concentration becoming increasingly prominent. Other trends emphasise how national strategies to promote economic growth are driving land acquisitions not only for agriculture but also for industrial use and the construction of infrastructure to improve connectivity for international trade. In addition, there is the role of urbanisation and the increasing pressures on water and rural land from land-use conversion and natural resource use. Urbanisation not only entails the expansion of big cities, but also the concentration of people into smaller towns, where schools and health services, water and communications are more readily available. It is often associated with the spread of unregulated land markets and land speculators (Cotula, Anseeuw and Baldinelli, 2019).

The underlying land water nexus

In light of the fact that the majority of global freshwater is used for agricultural purposes, the complementary analysis of global food and water systems is essential. 'Water for food' has become an important slogan in the current debates on poverty reduction, food security and climate change in sub-Saharan Africa. Water is both a target and a driver of the popularly known phenomenon

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of land acquisitions. This key factor has been largely ignored despite the interconnectedness of water and land (Mehta, Veldwisch and Franco, 2012). Land is not always valuable from an investor's point of view. Land requires added properties such as access to water that turn land deals into lucrative businesses. In some regions, particularly in the Sahel area, land investors would face a high degree of risk in drought periods and securing access to water is critical. Every land acquisition is also a 'green water grab', which becomes a 'blue water grab' if land is irrigated (Dell Angelo *et al.*, 2017).

Unlike land acquisitions, water acquisitions have no commonly accepted definition in either the academic or international development arenas. Water acquisitions can be abstractly defined as a circumstance where powerful actors are able to appropriate water resources at the expense of traditional local users, often with negative impacts on the environment (i.e. loss of environmental services, discharge of untreated wastewater into the environment, water and soil pollution or degradation, etc.).

The underlying dynamics in the 'acquisition' of irrigation water might differ from those driving land investments because they may involve more varying levels of consent and power relations. For instance, in regions characterised by abundant land but scarce water, communities might favour land acquisitions but be reluctant to allow investors the rights to withdraw water from rivers or aquifers. Often, water remains the hidden dimension of large-scale land deals. Agreements upon water are rarely included in land acquisition contracts and, when included, they are inadequately valued. The loss of water rights for smallholder farmers and the potential impacts of large-scale land use, occasioned by the agricultural production activities of investors, are other dimensions that are not adequately considered when lands are leased out (Woodhouse and Ganho, 2011).

Large investment projects as drivers of conflicts over natural resources

Although significant investments in the agricultural sector are needed, acquisitions of land, water and other natural resources are all the more problematic with regards to food security since many of these large investment projects have not delivered on their promises, not only in terms of production, but also in terms of job creation and service/infrastructure development. So not only have local communities

tended to lose access to their resources, but the promise of feeding the world through these large-scale investment models remains unfulfilled.

The consequences are numerous and not restricted only to driving conflict over land, water and other natural resources. In this changing context, new questions are being raised about the values that rural people attach to land, natural resources and small-scale farming. The ways that natural resource disputes are playing out affects different users in different ways. In some countries, for example, pastoral communities have been hit by an increasing number of land and water conflicts, the loss and fragmentation of grazing land, barriers to mobility, drought and the breakdown of customary institutions. Such factors have fuelled conflict in areas where farming and herding overlap, for example, in many parts of East and West Africa. Similarly, the continued expansion of agri-business continues to squeeze the rights that indigenous peoples and farming communities claim to the territories they depend upon for their livelihoods, food systems and social identity. People have also raised concerns about the exacerbation of poverty and dependency associated with large-scale investment projects. This trend has been reported to have severely affected collective property rights over the land, water and other natural resources of indigenous and farming communities (Anseeuw *et al.*, 2012).

Indeed, competition over resources may change the institutional arrangements for their management in these new investment areas and far beyond in the case of water. While land is fixed, water is fluid and part of the hydrological cycle. Water acquisitions can therefore potentially affect greater numbers of water users (Franco, Mehta and Veldwisch, 2013) and can certainly have consequences for communities and populations living far away downstream, even in different countries. Negotiating water-use rights allocations should therefore involve not only local communities, but also national governments and regional bodies, especially international water basin organisations or agreements between countries (for example, the dispute over Nile River water, involving Egypt, Ethiopia, Uganda and Sudan, relying on treaties signed in the early twentieth century between colonial powers) (Cascão and Nicol, 2016).

Developments in international policy arenas, including the "voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security"⁴ or the "principles for responsible investment in agriculture and food systems"⁵, present new opportunities for organisations, communities and social movements

4. <http://www.fao.org/cfs/home/activities/vggt/en/>

5. <http://www.fao.org/cfs/home/activities/rai/en/>

to advocate for systemic reforms to land and water governance. However, these international frameworks have only been mildly harnessed to advance their implementation and promote equitable and sustainable development and food security.

There is a high risk that without the uptake of these principles at the heart of national policy processes in the coming years, further civil conflicts may arise with dire consequences on food security and nutrition. ●

BOX 8

RISKS ON WATER ISSUES: CASE STUDY OF THE OFFICE DU NIGER AREA IN MALI

In the Office du Niger (ON) region in Mali, while around 100,000 ha is currently being cultivated, mostly by smallholders, a total of 600,000 ha of land has been allocated in the past ten years to investors for large-scale farming (Adamczewski *et al.*, 2013). This process has largely bypassed the official procedures established by the local state body (Office du Niger) at the regional level (Adamczewski-Hertzog *et al.*, 2015). Between 2010 and 2012, the allocation of new land shifted to the national level, with an attempt to recentralise the management of land deals and associated benefits at the highest level, despite contrary efforts by foreign donors to strengthen the ON institution. The Ministry of Agriculture (and even different ministries and the Presidency itself) allocated land on political and other grounds rather than on technical considerations.

ON experts (former directors, consultancy companies, etc.) and donors (foreign development agencies involved in the very costly funding of land development for irrigation) understand the contradictions attached to land allocations, but they are not key decision makers and have been side-lined. Hydrological realities and natural limits are not adequately considered and challenges

continuously arise. Competition for water in the dry season is likely to rapidly become a source of tension, notably in dry years when the issue of priorities will be critical. Furthermore, they also signal that accessing land does not mean accessing water. Investors (even if investments are not always visible in the field) have deployed different strategies to negotiate priority access to water in order to avoid or limit the occurrence of future water shortages.

After 2012, ON, whose decision-making power was strengthened, decided to renegotiate the water rights granted with different investors. The negotiations focused on projects that had not started. Planned land development in the Office du Niger area is likely to result in water reallocation. Without the availability of public capital to develop new irrigated land for farmers, the state has opened up irrigable spaces to investors. To secure their private schemes, access to water is a priority. Water allocated to new investors would directly or indirectly lead to a decrease in water allocation to other users within and downstream of the ON area and deeply impact their water-based livelihoods (Adamczewski-Hertzog *et al.*, 2015).

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CONCLUSION OF SECTION 3

MUCH-NEEDED FOOD SYSTEM TRANSFORMATIONS TO RESPECT AND RESTORE ENVIRONMENTAL INTEGRITY

Étienne Hainzelin¹

Some evolutionary paths taken by food systems, especially industrialised ones which have been spreading since the beginning of the twentieth century, have caused and are still causing serious environmental problems. These problems relate to the finiteness of natural resources used in the production process (land, water, fossil fuels, phosphorus etc.), the irreversible loss of biodiversity and erosion of ecosystems, and the contamination of different environmental compartments, especially water and soils.

The industrialisation of agriculture has affected the environment at many levels, even in LI and LMI countries. First, the status of the world's soils is alarming, with one-third of agricultural soils degraded. Soils are crucial to environmental integrity; they are a non-renewable resource with a high degradation potential and slow regeneration rates. They represent the habitat of precious - and mostly unknown - ecosystems and they are clearly a key resource to productive and healthy food systems.

Biodiversity, the real engine of above- and below-ground ecosystems, has been severely eroded virtually everywhere in the world, with differentiated kinds of pressure. In LI and LMI countries, pressure on land and natural habitats, along with water and soil contamination, have played a major role in this erosion. Although most production systems in these regions are still biodiverse (Herrero *et al.* 2017), intensification processes based on artificialisation and simplification are gaining ground, raising new and intense threats.

Finally, the non-renewable resources needed by such food systems, such as land, fossil fuels and phosphorus with different time horizons for when they will run out, will eventually collide with the finiteness of the planet. There are no substitutes for these resources and their dwindling will hamper food systems. Some essential renewable resources, such as freshwater, should not theoretically follow this finiteness, but in reality they are also badly affected by the degraded environment and are dwindling in many regions. Large-scale land and water acquisitions in various parts of the world are frequently worsening these problems.

Simultaneously, eroded biodiversity and dwindling resources are drastically affecting the capacity of food systems to meet food security objectives. These risks threaten the integrity of the environment on which all food systems depend, from production through to consumption and waste, to produce adequate food in terms of quality and quantity. In LI and LMI countries, food production capacity is already affected by these risks, such as soil degradation due to intense pesticide and synthetic fertiliser use.

Under the pressure of several imperative constraints, food systems must produce more and better food. Industrialised agriculture managed to reach incredible yields but the environmental price paid has been very high and will be felt by generations to come in the form of impoverished and contaminated environments. A transformation of food systems is much needed, allowing for the intensification of production based on healthy and biodiverse environmental matrices. Some of these transformative intensification pathways are already known; in short, they should seek to close nutrient cycles by avoiding losses, erosion and leaching, managing agriculture effluent, building new solutions against pests and competitors in place of pesticides, such as biological control, and drastically reducing contaminant sources.

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SECTION

04

INCLUSIVE
DEVELOPMENT



SECTION 4

Inclusive development

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CHAPTER 4.1

RISKS OF MASS UNEMPLOYMENT AND WORSENING OF WORKING CONDITIONS

Thierry Giordano¹, Bruno Losch², Jean-Michel Sourisseau¹ and Pierre Girard¹

SUMMARY

In sub-Saharan Africa (SSA), demographic growth, climate change, low manufacturing levels and even premature deindustrialisation are paving the way for a massive increase in the number of informal, vulnerable and extremely poor workers, especially among young people. This is fertile ground for food crises, social unrest, violent conflicts and migration, as seen in the Sahel and other regions around the world. The challenge is to find decent jobs for the 730 million people who will join the potential labour force between 2020 and 2050, in addition to the 600 million currently making up the working age population.

Examining the labour markets in most developing countries is a sobering experience: underemployment is a common feature and jobs are often precarious and provide very low incomes. Vulnerable employment rates³ stand at 76 percent. Added to this vulnerability is the extreme and moderate working poverty rate⁴, which amounts to 66 percent in developing countries and is even higher amongst women and youth (ILO, 2018). These averages mask highly diverse situations. Sub-Saharan Africa (SSA), home to the majority of the world's poor and vulnerable workers, is the region of greatest concern, but different dynamics are underway.

The boom of the labour force in SSA

SSA deserves specific attention due to the expected massive growth of its working age population in the coming decades, resulting from an unachieved demographic transition (*cf.* Figure 18). By 2050, 69 percent of the expansion in the world's potential labour force is expected to be in SSA⁵. This represents around 730 million new workers and a total potential labour force of 1.35 billion. One-third (410 million) is expected to consist of young people aged 15-24 (UN, 2017). Meanwhile, the rural population is forecast to increase in absolute numbers from 648 million in 2020 to 909 million in 2050, although its share is expected to fall from 59 percent to 42 percent (UN, 2018). SSA is the only world region where the rural population is expected to continue to grow well after 2050.

Providing decent employment is SSA's challenge of the century. Crises are already widespread in the region and many more are looming. Creating enough jobs would unleash the potential of a significant demographic dividend⁶ and boost the continent's economic transformation. But how can this be achieved? Historically, the answer in most developed and emerging countries has been conducive institutional and economic policies

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3. Vulnerable employment is defined as the sum of the employment status groups of own-account workers and contributing family workers (ILO, 2018).

4. Extreme working poverty includes workers whose per capita household income or consumption is less than US\$1.90 (PPP) per day. Moderate working poverty includes workers whose per capita household income or consumption is between US\$1.90 (PPP) and US\$ 3.1 (PPP) (ILO, 2018).

5. The potential labour force corresponds to the working age population, i.e. the 15-64 population group. According to ILO, the labour force *sensu stricto* only includes persons in employment and in unemployment.

6. The demographic dividend is the "extra economic growth owing to falling dependent population/workforce ratios, or slower natural increase, or both" (Eastwood and Lipton, 2011).

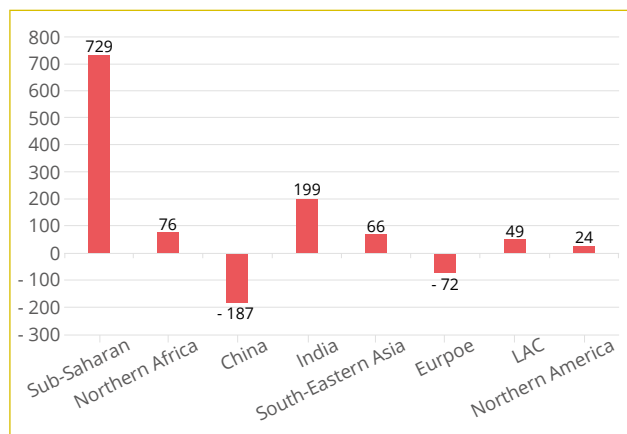


Figure 18: Projected increase of the working age population by major regions and countries (2020-2050). Source: Losch (2016) updated with the *World Population Prospects 2017*.

along with the rapid modernisation of agriculture and industrialisation. However, the slow speed of both demographic and economic transitions in SSA seems incompatible with such a trajectory (Losch, 2016; Richard, John and Finn, 2018). New answers need to be developed in line with the current dynamics of African economies, their underlying employment structure and household adaptive strategies.

Mass unemployment is looming

In Low-Income (LI) countries, 63 percent of workers were still employed in the agricultural sector in 2018, down by only eight percentage points since 1991 (ILO, 2019). In SSA, agriculture in a broad sense (including pastoralism, agroforestry and fishing) remains the mainstay of livelihoods, with 57 percent of the active population working in the sector (ILO, 2018). Most of these people are small family farmers, struggling to make a decent living and thereby falling into the vulnerable and working poor category.

Alternatives to agriculture are limited and offer opportunities which are little better. On the one hand, SSA is facing premature deindustrialisation (a decrease in the secondary sector's share of GDP, with the exception of construction) limiting job creation in the manufacturing sector (Rodrik, 2016). Some 9.3 percent of the active population was employed in manufacturing in 2010, reaching only 11 percent in 2018, many of them in the food industry (ILO, 2018)⁷. On the other hand, the service sector is gaining

ground, rising to 32 percent of the active population, but the vast majority of these are low productivity and informal jobs. Even if the current institutional and structural challenges are addressed, the general trend towards automation in the coming years is likely to limit manufacturing and service jobs.

In response to such difficult employment conditions, households have developed income diversification strategies, including various mobility patterns, blurring the boundaries between rural and urban areas and combining different types of activities and sources of income. In rural areas, while non-farm activities are rapidly expanding, not always leading to higher productivity jobs, on-farm activities remain the backbone of rural economies (Losch, Fréguin-Gresh and White, 2012). These dynamics must be acknowledged in designing and implementing new job creation strategies.

Without adequate policies supporting a stable and conducive economic and institutional environment, SSA risks ending up with limited economic growth coupled with massive unemployment and underemployment. This situation could dramatically worsen if family farmers were forced away from agriculture because of the effects of climate change, continuing concentration in agriculture and inadequate rural development policies. There is an urgent need to plan for a new type of structural transformation which pays close attention to the decent job creation potential of food systems.

Decent job creation potential at risk

In SSA, the food economy is the biggest employer. In West Africa, for instance, it accounts for 66 percent of total employment (82 million jobs). Some 78 percent (64 million) are in agriculture, 15 percent (12 million) in marketing and 5 percent (four million) in processing. Among employed women, 66 percent work in the food economy, especially in segments such as street food, food processing and food marketing (Allen, Heinrigs and Heo, 2018).

The expected demographic growth should lead to an increase in food demand and continuing urbanisation to an increase in the urban/rural population ratio. A proxy for the urban market potential for rural producers, this ratio should double from 0.71 in 2020 to 1.38 in 2050. Alongside this, a common pattern of urbanisation in every region of the world is its impact on eating practices, with people moving from starchy staple foods towards more diversified diets

7. There is considerable controversy over the data. While the ILO estimates are based on labour market information provided by countries, Fox *et al.* (2013) based on various national surveys provide an estimate of only 2.6 percent.

including fruit and vegetables, meat and processed products⁸. As a result of these shifts in both quantity and quality, the value of the food market is expected to increase threefold by 2030, growing from US\$ 313 billion in 2010 to US\$ 1 trillion in 2030 (Byerlee *et al.*, 2013). In addition, boosted by falling transport and communication costs, this dietary shift could also provide export opportunities in both processed products and high-value crops for African countries.

However, these changes in demand could either offer tremendous opportunities for job creation or lead to the massive shedding of jobs in food systems because of major productivity and competitiveness issues. Indeed, Africa suffers from a significant yield gap. Capital-intensive agriculture and agribusinesses could be a short-term answer but force many workers out of agriculture, with dramatic consequences on income generation and access to food. Labour-intensive solutions through agroecology, for example, are another option and would simultaneously provide answers in terms of both sustainability and natural resource management. Similar considerations about the importance of the development model and its degree of labour intensity exist for agri-industries, where small and medium-scale processing of agricultural products could provide significant employment opportunities, particularly in rural areas.

But employment policies generally target supply-side constraints through the development of skills, particularly among youth and women. They usually lack an integrated strategy aimed at identifying job opportunities within food systems and do not provide enough focus on the need for an enabling environment which would help small and medium-size businesses to grow through adequate fiscal policies, entrepreneurship services and ad-hoc training programmes.

An integrated strategy would also require the improvement of working conditions within food systems. Under-performance in the agri-food sector is related to poor working conditions, the continuation of child labour, gender and age inequalities, partial labour laws and their poor enforcement (resulting in the neglect of occupational safety and health (OSH)) and a lack of promotion of workers' organisations.

Food systems will not be the only engine for structural transformation, but they could significantly contribute to inclusive economic growth, poverty reduction and food security, and have significant spill-over effects on the rest of the economy and society. What is currently missing to support the definition of adequate strategies is a better understanding of the labour content in agriculture and food systems and the impact of different development models and modernisation policies on job creation. ●

BOX 9

UNEVEN ECONOMIC DIVERSIFICATION AND EMPLOYMENT CHALLENGES AT THE LOCAL LEVEL: ILLUSTRATED IN TWO REGIONS IN MALI AND MADAGASCAR¹

The Ségou region in Mali (62,500 km²) and the Vakinankaratra region in Madagascar (19,000 km²) are, like most rural regions in SSA, characterised by a demographic boom in their regional capitals (Ségou and Antsirabe). However, in both regions, villages are mushrooming and the landscape is becoming increasingly densely populated.

In spite of the Office du Niger's irrigation project in Ségou and the special economic zone targeting industries in Antsirabe, the local economy is based on the informal sector (97 percent of jobs identified), dominated by family farming and, to a much lesser extent, by small urban businesses and handicrafts. Along with the lack of basic public facilities, inhabitants highlight the need for security for property and people. Large families, with at least four children per woman, are regarded as the best safeguard against uncertainty. The agri-food industry is the main prospect for industrialisation and growth (the mostly informal craft sector facing cheap imports) but opportunities remain limited.

Between 2015 and 2035, the population of the Ségou region is forecast to increase from 2.5 to 4.2 million people, and from 2 to 3.1 million in the Vakinankaratra region. By 2035, a total of one million new jobs will need to be created in Ségou and 700,000 in Vakinankaratra. The rate of job creation is expected to double. Even if migration is expected to increase, it will certainly remain out of step with the population boom. Without increases in land and labour productivity and outwards migration, the Ségou and Vakinankaratra regions will have to expand their cultivated areas from 1.4 to 2.5 million ha and 221,000 to 300,000 ha respectively, which will increase competition for natural resources and produce potential conflicts.

In both regions, priority should be given to family farms, which are more likely to offer employment opportunities. The prospects for labour-intensive agroecology practices, which are likely to improve economic and social performance, should be explored, as well as the strengthening of value chains supporting upstream and downstream activities in secondary cities. This will require a rebalancing of urban policies towards rural towns and intermediary cities, and a consolidation of regional capitals which can offer the services and infrastructure required to make diversification of activities and jobs possible. Achieving the decentralisation process and empowering local bodies is crucial.

1. Based on Sourisseau *et al.*, 2017.

8. See Chapter 5.4 on the risks related to changes in diets.

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CHAPTER 4.2

RISKS OF SMALLHOLDER EXCLUSION FROM UPGRADING FOOD CHAINS

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SUMMARY

Large agri-industries fuel the upgrading of certain food chains. This chapter presents the risks of smallholders not benefitting from this upgrading. The first risk is that upgrading does not spread to all food value chains, generating territorial inequalities. The second is that the most endowed smallholders are included while the poorest are excluded. The third risk is that those smallholders who are included tend to be in a weak bargaining position against large agri-industries. As a result, most smallholders do not get higher incomes from upgrading food chains.

Poor smallholders in traditional food chains

In 2013, the extremely poor represented 10.7 percent of the world's population (World Bank, 2016). Of these, 50.7 percent lived in sub-Saharan Africa and 33.4 percent in South Asia. Of extremely poor workers aged over 14, 65 percent worked in the agricultural sector (World Bank, 2016).

Smallholders are characterised by limited productive assets, management implemented at the family level and an often informal legal status (Bélières *et al.*, 2015). This definition mainly concerns agricultural producers, but it can be extended to downstream operators, who carry out trade, processing and retailing activities with limited assets. Smallholders include socially marginalised groups, such as women, young people and ethnic minorities. These groups have reduced access to resources and fewer opportunities than others (De La O Campos *et al.*, 2018).

Smallholders operate in uncertain environments and have limited access to productive resources (Devaux *et al.*, 2016). This constrains their innovation, quality management and access to output markets. As a result, they participate in traditional food chains, which provide products of heterogeneous quality and generate low incomes. This is particularly the case for domestic and staple chains.

The upgrading of value chains

Large agribusinesses are investing in new technologies in production, storage and processing, including in LI and LMI countries. They have access to bank credit, technology and information. They define the attributes of final products and develop new business models to control their supplies. They implement contract farming, which is "a sales arrangement between a farmer and a firm, agreed before production begins, which provides the farmer with resources or services" (Ton *et al.*, 2018). Contract farming often includes the setting of standards, i.e. a set of quality criteria for product attributes. Some large agribusinesses also choose to control their supplies hierarchically.

Large agri-industries are diverse in their origins, activities and the segments in which they operate. As a result, different patterns of upgrading coexist. The supermarket revolution relates to large-scale investment in retailing, the centralisation of supply systems and the implementation of vertical coordination. The quiet revolution relates to investments in improved processing and storage, and direct sourcing from smallholder farmers (Reardon *et al.*, 2012; Soullier and Moustier, 2018).

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It is still unclear whether smallholders manage to grasp the opportunities offered by the upgrading of food chains. This chapter discusses the risks that smallholders do not benefit from the upgrading of value chains and questions the contribution of food chain upgrading to the reduction of poverty and inequality.

Risk 1: Upgrading does not affect all food value chains

Upgrading does not affect all food value chains, contributing to territorial inequalities. Several factors in certain territories generate costs and uncertainty which discourage agri-industry investments (Barrett *et al.*, 2012). These comprise infrastructure quality (such as roads, irrigation and storage), degree of insecurity, institutional context, agroecological conditions and proximity to markets for quality products.

As a result, many food chains are not upgrading. Several domestic food chains in sub-Saharan Africa have received little investment or innovation (Soullier and Moustier, 2013). Indeed, domestic chains target national demand, do not benefit from a shift in demand for quality products, face various uncertainties and generate little income. Some traditional chains may also disappear when faced with a reduction in demand and competition from imported products or from agribusinesses. This has been observed in the milk sector in Brazil, where 60,000 small dairy farmers went out of business in the second half of the 1990s, unable to invest in pasteurisation (Reardon and Berdegue, 2002). Consequently, the unequal geographical coverage of upgrading food chains tends to increase inequalities between territories. This is particularly the case in some parts of sub-Saharan Africa and South Asia, which represent a major risk since these two regions are home to 84 percent of the world's extremely poor population (*cf.* Chapter 4.3).

Risk 2: Less endowed smallholders are being excluded from upgrading food chains

Large agri-industries select business models and suppliers that best meet their quality standards and reduce their costs and uncertainties (Barrett *et al.*, 2012). They often prefer better endowed smallholders, who have access to technology, generate economies of scale and present lower transaction costs. For example, most farmers supplying supermarkets in Vietnam were found to be above the poverty level (Moustier *et al.*, 2009). Poorer smallholders often do not have access to credit and cannot invest to meet

agribusiness contract requirements.

The number of smallholders included in upgrading chains is therefore very limited. Through a meta-analysis of 26 case studies, Ton *et al.* (2018) have shown that in 61 percent of the cases studied contract farmers had larger landholdings or owned more non-land assets than non-contracted farmers. However, exceptions do exist, particularly when operations are labour-intensive and collective action is possible (Reardon *et al.*, 2009). But these cases are rare and in developing countries "the proportion of farm households involved in contract farming is probably in the range of 1-5 percent" (Devaux *et al.*, 2016, p. 136). While poorly documented, the inclusion of smallholders downstream may show similar results.

In some cases, agri-industries fuel an increase in agricultural production and smallholders excluded from upgrading can continue their activities in traditional food chains. However, they remain stuck in low-income activities. In others, production does not increase sufficiently and smallholders risk being replaced by large agribusinesses. This has happened in some Asian countries, where medium and large millers replaced smaller ones (Reardon *et al.*, 2012). In such situations, some become employees of large agri-industries (FAO, 2015) but not all, because these large agri-industries are capital-intensive rather than labour-intensive. Furthermore, smallholders do not necessarily gain higher incomes when they are employed.

Risk 3: When included, smallholders may not always benefit

Upgrading may lead to asymmetries of power. Indeed, large companies integrate activities that generate the most added value and outsource those that are riskier and less profitable (Gereffi, Humphrey and Sturgeon, 2005). They often outsource agricultural production to smallholder farmers where contracts include risk-transfer mechanisms. Large agribusinesses can also be opportunistic, with payment delays, no payment, purchasing price reductions or inappropriate rejection of products (Barrett *et al.*, 2012). Some policies seek to balance power relationships in value chains, for example through multi-stakeholder platforms or inter-professional associations. However, multi-stakeholder partnerships may also lead to exclusion practices (HLPE, 2018).

As a result, the incomes of those smallholders who are included may not improve. On average, contract farming increased farmers' incomes by 38 percent, thanks to access to improved inputs and quality management (Ton *et al.*, 2018). However, these figures hide a bias toward the studies showing positive impacts, which are more likely to be published and appreciated by donors and policy makers.

Nevertheless, some vertical coordination approaches can have no or negative impacts on smallholder welfare. For example, rice growers in Senegal committed to production contracts simply because it was their only way to fund rice growing, but they received an income almost 13 percent lower than producers using bank credit and marketing paddy with spot transactions. Why? Because the production contract included high interest and insurance rates (Soullier and Moustier, 2018). Furthermore, the impacts depend on the product and specificities of the value chain. Positive impacts are more likely in export chains of high-value products than in domestic staple chains. This can be a major obstacle to alleviating poverty because millions of family farmers only participate in domestic staple chains.

Finally, upgrading could increase income inequalities within food chains. The total value added increases with upgrading, but its distribution becomes less favourable to smallholders (Reardon *et al.*, 2009, 2012). When included, smallholders receive higher incomes in absolute value, but their share of the total value added within the chain generally decreases and income inequalities between smallholders and large agribusinesses increase. For example, the upgrading of the rice chain in Bangladesh made it possible to produce high-quality rice but decreased producer shares of the total value added from 69 percent to 38 percent (Reardon *et al.*, 2012). A similar trend has been observed in Senegal, where the upgrading of the rice chain decreased the farmers' share of the total value added from 60 percent to 37 percent (*cf.* Figure 19). In Nicaragua, the supermarket revolution in vegetable chains has highlighted a similar trend (*cf.* Box 10). There are, however, some exceptions, such as in Vietnam where farmers' organisations have contributed to improving the quality of lychee (Moustier *et al.*, 2010) and secured a 25 to 42 percent increase in the total value added (Moustier, 2009). These inequalities seem to differ from one type of food chain to another. Value may be more concentrated at the wholesale level when products can be stored rather than in chains comprising a few intermediaries and supplying perishable products. ●

BOX 10

DO SUPERMARKETS IN NICARAGUA STRENGTHEN INEQUALITIES?¹

In Nicaragua, horticultural production (tomatoes, green peppers, lettuce and cabbage) is conducted by farms with different structures. Around two-thirds are rainfed farms and the others are irrigated. Among irrigated farms, half are large, farming more than seven hectares. Before the 1990s, most of these farms marketed products in traditional value chains, made up of small collectors and retailers. Then two companies upgraded horticultural value chains by developing supermarkets: the national company La Colonia and the international company Walmart. In 2009, there were 65 supermarkets in Nicaragua. These supermarkets often used contracts to purchase horticultural products and set quality standards. They purchased horticultural products from those farmers that offered the lowest transaction and procurement costs. As a result, they preferred sourcing from the largest farms or from cooperatives, and from farms representing the lowest transportation costs. Supermarkets also preferred sourcing from irrigated farms, because they could continuously supply products throughout the year, in contrast to rainfed farms.

As a result, farmers located in very remote areas and growing rainfed produce on small farms were much less likely to be included in the upgraded chain. Furthermore, the supermarkets specified quality standards, defined in terms of variety, size, colouration, cleanliness, damage and weight. On average, supermarkets accepted 70 percent of the total production and rejected the remaining 30 percent. In contrast, the traditional value chain bought produce of all sizes and grades and provided outlets for produce rejected by supermarkets. Furthermore, the study has shown that farmers marketing to supermarkets did not receive higher prices than in the traditional value chain. La Colonia purchased vegetables at prices similar to those of traditional markets. Walmart even purchased tomatoes at prices 35 percent below the market price since Walmart's prices were steady compared to traditional markets. This price might, however, include an overly expensive insurance against price risk.

1. Based on Michelson, Reardon and Perez, 2012.

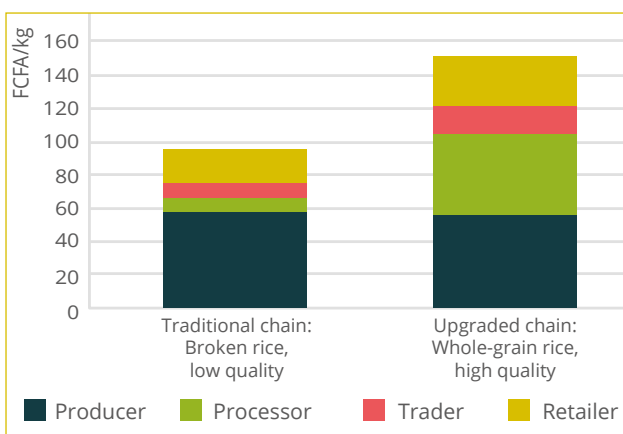


Figure 19: Distribution of value added in traditional and upgraded rice chains in Senegal. Source: Soullier, 2017.

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CHAPTER 4.3

RISKS OF INCREASING TERRITORIAL INEQUALITIES

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SUMMARY

In many countries, spatial inequalities are becoming so significant that they might compromise the prosperity, stability and security of entire regions trapped in poverty. Currently, in sub-Saharan Africa they result from unequal population, urban networks which reflect inherited colonial patterns and weak or uneven past development policies, with big cities rapidly developing and concentrating infrastructure and public goods. Intermediary cities and small towns have been forgotten, receiving little support from central governments. Territorial approaches to development barely exist, which means the multiple dimensions of inequalities cannot be addressed.

Spatial inequalities: from dormant threat to crises

Many countries face huge economic and social inequalities, particularly in incomes, job opportunities and access to services. However, in developing countries, data remain too scarce to quantify the spatial dimension of these inequalities beyond specific case studies. Looking at the distribution of multidimensional poverty between and within countries provides a proxy for these inequalities. For example, 1.1 billion people are left behind in sub-Saharan Africa (SSA) and South Asia alone, representing 83 percent of the multidimensional poor in the world⁶¹. Some 342 million people are severely poor⁶² in SSA, i.e. 56 percent of the world's severely poor (OPHI, 2018). At a territorial level, multidimensional poverty is more acute in rural areas, the starkest rural-urban difference being in SSA, where the level of wealth concentration in capital cities is another specificity. For example, in Chad "poverty ranges between 48 percent in the capital city of N'Djamena to 99 percent in Wadi Fira, a region located in the eastern part of the country." Similarly, in Mali "poverty in the southern capital city of Bamako is 30 percent, but it is three times higher in the region of Timbuktu up north" (OPHI, 2018).

This spatial imbalance may result from the historical structural transformation processes observed, where specialisation and agglomeration of economic activities maximised economic growth and lead to polarisation (World Bank, 2009). However, in SSA, where there are major constraints to growth, spatial inequalities are cumulative and can increase the incidence of civil conflicts (Ezcurra, 2018). When the security, stability and prosperity of countries and regions are at risk and instability spreads to more prosperous centres, which is happening in the Sahel region, there is a need for a clearer trade-off between spatially-blind economic growth and greater spatial justice (AfDB, OECD and UNDP, 2015; Barca, McCann and Rodriguez

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61. Multidimensional poverty is a complement to income poverty as it captures the simultaneous deprivations that each person experiences in 10 indicators clustered around health (nutrition, child mortality), education (years of schooling, school attendance) and living standards (cooking fuel, sanitation, drinking water, electricity, housing, assets) (OPHI, 2018).

62. Severely poor people are deprived in at least half of the weighted indicators in health, education and living standards.

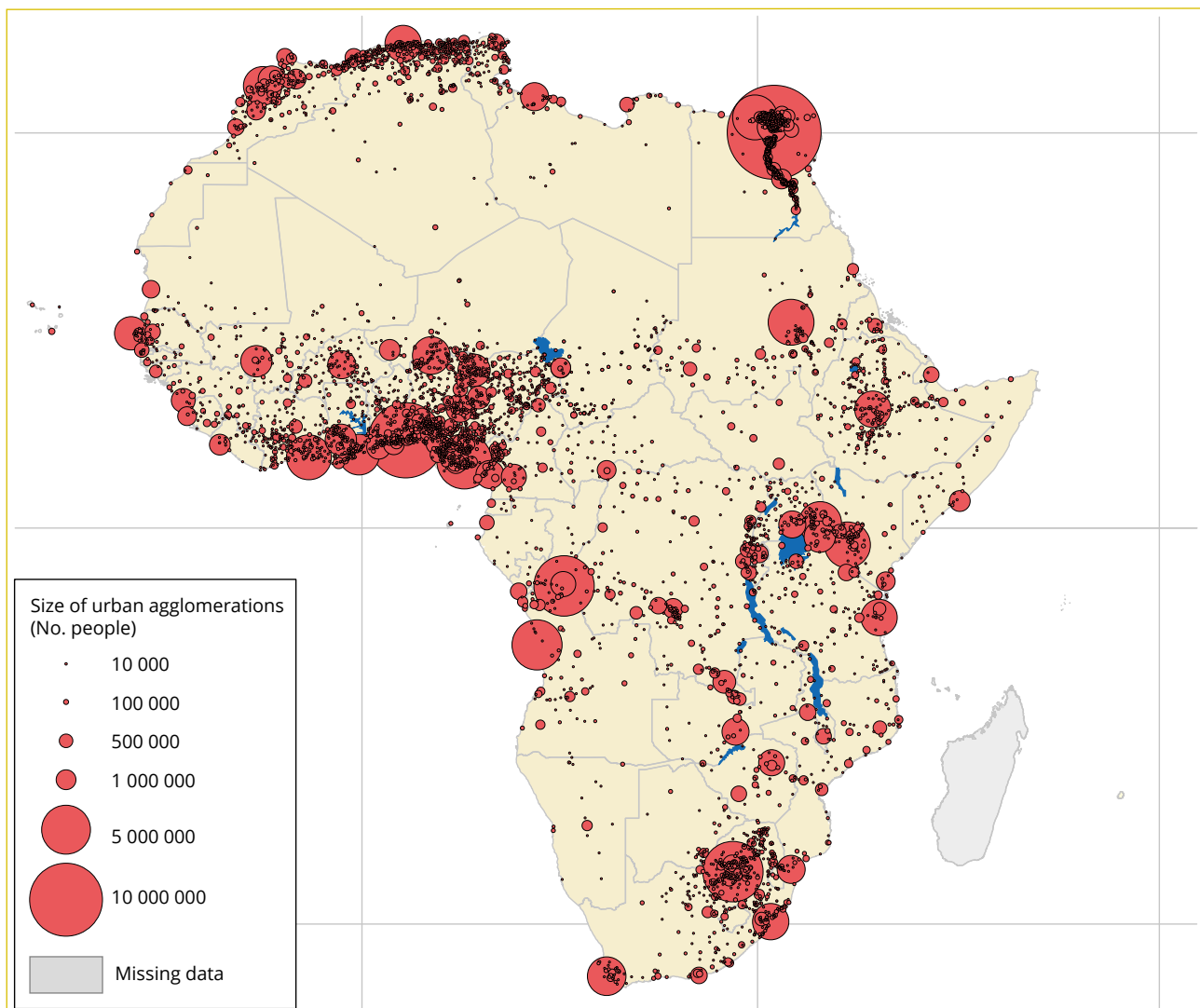
Pose, 2012).

An accumulation of causes

Uneven spatial development is a key feature of both developed and developing countries and is particularly evident in SSA, where the exploitation of natural resources has for many years been the main driver of spatial development. The colonial past has shaped territories through a series of infrastructure projects and investments aimed at extracting rents. The natural endowment was the main factor dictating investment plans: infrastructure was built to facilitate the flow of goods to the coast for export, cities were created to aid colonial control and coastal ports were made capital cities. This development pattern exacerbated spatial differences between territories stemming from their natural capital endowment, geography and climate. Sectoral policies

targeted high-potential regions, leading to the exclusion of large rural areas from significant public interventions and investments. These patterns have left a substantial footprint (Losch, 2016) that national policies and decentralisation efforts have not been able to balance (cf. Map 9).

The unique pace of urbanisation, coupled with the lack of industrialisation, has exacerbated this dependency on past territorial organisation (AfDB, OECD and UNDP, 2015). Urban development has been a clear focus of many policies, targeting mostly national and sometimes regional capital cities, neglecting intermediary cities and small towns and thereby strengthening inherited spatial inequalities. Better economic opportunities, infrastructure and services in large cities have contributed to rural out-migration flows directly targeting the main urban centres. However, urban growth has rapidly outpaced the management capacity of local and national governments. Urban development remains



Map 9: Population of urban agglomerations of over 10,000 inhabitants.
Source: Pesche, Losch and Imbernon, 2016.

largely unplanned due to a lack of resources and technical capacities, cities sprawling outward instead of upward in the absence of land policies and regulations, often on agricultural land and creating strains on natural resources. Informal settlements are expanding, increasing backlogs of essential service provision, especially network services such as water and sanitation, transport and electricity and infrastructure to access education, health and food.

Finally, climate change, land degradation and shortage, natural resource depletion and biodiversity losses have worsened the situation, becoming push factors for many communities. They fuel migration to less affected rural areas and big cities, and limit the growth potential of regions, thereby increasing the risks of unemployment, non-decent jobs and extreme working poverty (cf. Chapter 4.1).

The lack of territorial approaches to development

In SSA, food systems are increasingly seen as possible opportunities for economic diversification, growth and job creation, and for more sustainable development through their direct connection to natural resources. They benefit from the exploding domestic and regional food demand and their core position in the economic and social structure. From rural areas where the potential for productivity increases is still substantial, to urban areas representing a poor but huge domestic market, food systems could be one of the levers for spatial, economic and social rebalancing, in particular through the development of local agri-industries. They represent an untapped potential for all actors in food systems and could have leverage effects on the rest of the economy and society (Arnold *et al.*, 2019).

This would entail strengthening rural-urban linkages to make sure that food-related resources benefit both urban and rural food system actors (cf. Box 11). Intermediary cities and towns then become vital for bridging the rural-urban divide around which city-region food systems could develop (Blay-Palmer *et al.*, 2018). Highly embedded with rural economies and societies, emanating from the densification of what were previously rural areas (urbanisation from the bottom), intermediary cities and towns can create income and job opportunities by linking farmers to urban demand and input markets, and by stimulating non-farm sectors such as transport services and agri-processing.

However, spatially blind policies have had dramatic consequences on intermediary cities. Most lack the very features of capital cities, preventing their development and the rebalancing of urban networks: infrastructure development is weak and service provision is limited, as is the presence of the state

(devolved governance).

While many SSA governments acknowledge decentralisation as a priority, it remains rather ineffective in practice: when the transfer of remits exists, it lacks the symmetric transfer of human and financial capacities, or any level of fiscal autonomy for these cities to address their citizens' needs (Satterthwaite, 2017). Such a devolution of power is often seen as a threat to already weak central governments, which must retain their (for now limited) capacity to equalise development between regions. As a result, while intermediary cities could become critical economic, political and social hubs linking larger cities and backward rural areas, they struggle to attract and/or maintain industrial enterprises: many companies relocate to the capital city when they grow.

The absence of territorial approaches to development (TP4D, 2018) prevents differentiated strategies which would address the specificities of existing functional territories, i.e. geographical areas which can differ from administrative regions and where people conduct most of their economic and social life. This lack of territorial perspective jeopardises the ability of food systems to take up the challenge of growing food demand in SSA, increases the risk of food crises and misses a major opportunity for economic development. ●

BOX 11

THE CONTRIBUTION OF INTERMEDIARY CITIES AND SMALL TOWNS TO RURAL DEVELOPMENT IN ETHIOPIA¹

Urbanisation in Ethiopia has followed a similar pattern to many other SSA countries, with the urban population spread among many cities of very different sizes. While Addis Ababa, the capital city, houses one-quarter of the urban population, intermediary cities are on the rise and have undergone major growth over the past decade. How do urbanisation patterns affect output prices and farmers' agricultural practices in rural hinterlands? This relationship is poorly understood.

In terms of both production and consumption, teff is an important cereal in Ethiopia. It is considered a cash crop for most producers as one-third of the production is sold. Teff is domestically consumed, mostly in urban areas, by better-off households. Urban growth and the accompanying growth in incomes are thereby increasing demand for teff with significant consequences for local farmers, and very little influence from international trade and markets on prices. The closed economy nature of this value chain makes it particularly relevant for studying the impact of urbanisation on agricultural production and rural development.

Using large-scale survey data from teff producers, coupled with data on transport costs and road networks, it appears that the

proximity of farmers to a city and the type of city have a strong impact on farmers' incomes and behaviour, as described by the conceptual framework developed in this work. Not surprisingly, output prices and uptake of modern inputs and yields on farms decrease over distance (measured by transportation costs) to a primate city. However, the presence of an intermediary city introduces a change through the urban demand it represents, making it profitable for rural hinterland farmers located far away from primate cities – and therefore excluded from this market – to produce for and sell to the urban market in the intermediary city and become responsive to price signals. Simultaneously, the intermediary city facilitates access to modern inputs and farmers tend to intensify their production. However, the benefits farmers can get from their proximity to secondary towns are smaller than those obtained when closer to primate cities. Therefore, it appears that agricultural price behaviour and intensification is determined by proximity to a city and the type of city, putting a strong emphasis on the importance of transportation costs and thereby the quality of infrastructure.

1. Based on Vandecasteele et al., 2018.

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CHAPTER 4.4

EXCLUSION OF WOMEN AND VULNERABLE MINORITIES

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SUMMARY

Women and various groups of vulnerable minorities (i.e. indigenous peoples) are major stakeholders in food systems. They are under-represented in decision-making bodies and are not properly considered in various policies and interventions. Exclusion of these people in the design and implementation of public/private policies, development and economic programmes is a source of under-performance and conflicts in food systems and societies.

Women, key but underrated contributors to food systems, face inequalities in access to resources, services and remunerative opportunities

Women play a key economic role in urban and rural food systems. They cook for their families but also work in the food sector, as traders or processors. Due to their involvement in agriculture, they also play a role in natural resource management. According to FAO (2011), women comprise 43 percent of the agricultural labour force in developing countries and, in West Africa, they represent more than 70 percent of employees in the food processing and marketing sectors (*cf.* Figure 20).

Yet women have less access than men to productive resources and opportunities. The gender gap exists for many assets (especially land legal rights and ownership of livestock), agricultural inputs (for instance, inorganic inputs and animal traction) but also for advisory, extension and financial services. Inequalities in access to resources and services, as well as in their ability to seize emerging employment and entrepreneurial opportunities, cause differences in access to remunerative opportunities between men and women farmers (FAO, 2011). Furthermore, development programmes have difficulty in reducing the gender gap. From a review of the impacts of eight agricultural development projects on individual and household assets in seven countries in Africa and South Asia, Johnson *et al.* (2016) have shown that all projects were associated with increases in assets and other benefits at the household level, but only one contributed to reducing the gender asset gap.

Women are also increasingly hired on industrial farms or in processing companies for high-value commodities. When women have paid work (which is already limited), they face less favourable employment conditions, such as lower wages and a higher prevalence of casual and seasonal work (FAO, 2011).

Women are also self-employed in many chain activities in food systems, from transport to processing and catering. Women tend to dominate local markets, retail and cross-border informal trade (FAO and African Union, 2018). In Low-Income (LI) and Lower Middle Income (LMI) countries, urbanisation has been accompanied by a rise in informal street food vending and catering. This provides a key source of employment and earnings for women as well as supplying the urban poor with inexpensive food. However, they endure unstable business locations and inadequate infrastructure and productive assets. Their operations are labour-intensive and characterised by low profit margins.

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Despite their huge contribution, women are under-represented in the governance of food systems and in the shaping of policies. Prevailing socio-cultural norms limit their ability to exercise power and autonomous decision-making within their households as well as in rural organisations and institutions, which therefore fail to represent their needs and interests as farmers and entrepreneurs. For instance, in 18 Latin American democracies, a study found only two women among 76 ministers of agriculture and forestry at the beginning of the 2000s (Escobar-Lemmon and Taylor-Robinson, 2005). A study of around 125 agricultural research and higher education agencies in 15 sub-Saharan African countries found that, on average, 24 percent of the total professional posts and 14 percent of management positions were occupied by women, with consistent differences across countries (FAO, 2011). Consequently, food system policies and interventions too often rely on gender-blind approaches. More than half of the national agricultural investment plans of 38 African countries do not include any gender dimensions (FAO and African Union, 2018).

In a context where food systems are under several serious, urgent and combined threats, this gender imbalance is a missed opportunity to make women-specific issues heard and make progress in domains such as nutrition and health (Duflo, 2012), natural resource management and conflicts. Studies have shown that gender inequalities tend to lead to inefficient food systems while improvements in gender equality and economic growth may strengthen each other (World Bank, IFAD and FAO, 2009). In fact, gender-blind policies and programmes often fail to offer the enabling conditions for maximising the role of women in meeting the growing demand for agricultural products and the sustainable use of natural resources, and fail to promote healthy diets and decent employment.

First, this exclusion prevents the implementation of effective research and development programmes. Improved varieties of sorghum (caudatum type), designed by research institutes between 1970 and 1990, showed improved yields but poor technological and culinary characteristics (Trouche *et al.*, 1999) that led to West African farmers refusing to use them. The fact that women, as researchers, farmers, cooks and final users have been absent from the breeding process is one reason for the failure of these programmes.

Second, agricultural interventions or modern value chains may increase women's unpaid workload, which is a risk for their own health and nutrition and for those of their children. In West African cotton producing areas, the so-called Sikasso paradox provides a tangible example of the simultaneous improvement of cotton-maize production together with a high level of stunting in children because of

women's excessive workloads (Dury and Bocoum, 2012). The same has been observed in contract farming. Where men control the contracts, women are often not well compensated in terms of control over additional income, yet their workload increases as family labourers (FAO, 2011). Coupling agricultural interventions with interventions to reduce the gender gap in agricultural activities is likely to make the former more effective in improving nutrition security, as has been highlighted in Nepal by Malapit *et al.* (2015) (*cf. Box 12*).

Third, even when they are visible in food and nutrition policies, women are very often considered as juveniles, incompetents or simply as bodies. Kimura (2013) developed this argument in her thesis concerning the fight against malnutrition in Indonesia. She showed that most policy makers, together with scientists, considered women as culprits, i.e. the source of their own and children's nutritional problems. They displayed bad habits, inadequate cooking abilities, food practices and breastfeeding patterns that needed to be changed through education. Overlooking women like this presents a clear risk of disempowering them and, in the long run, of creating more under-development, frustration and exclusion.

Fourth, the frequent exclusionary practices affecting street food vendors may endanger food and nutrition security and social equity in the urban food economy (Loc and Moustier, 2016). This might increase inequalities since these vendors are often themselves part of the poorest segment of the population and will lose a livelihood opportunity.

Exclusion of vulnerable minorities and its consequences: the example of indigenous peoples

The same exclusion from shaping public policies and development programmes holds true for vulnerable minorities, such as indigenous peoples. Indigenous peoples represent 5 percent of the global population but 15 percent of the poor (FAO, 2013). They share a strong connection to their environment, unique cultures and have developed exceptional adaptive knowledge to deal with natural resources (Reyes Garcia *et al.*, 2016; Eloy *et al.*, 2018). However, global agri-food markets and industrial projects induce many threats (FAO, 2013): (i) indigenous peoples are affected by displacement that divests them of traditional practices and livelihoods; (ii) indigenous peoples are suffering from reduced environmental quality and will be among the first affected by climate change; (iii) the diversity of food utilisation and food's cultural dimension are insufficiently recognised and the global food system contributes to the shift towards the consumption of more energy-dense

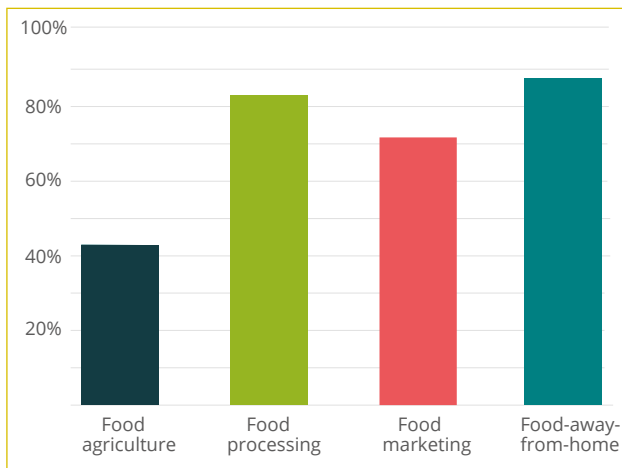


Figure 20: Share of women's employment by food segment in West Africa.
Source: Allen, Heinrigs and Heo, 2018.

and industrially processed foods; (iv) traditional food systems and a way of life based on shifting cultivation, pastoralism or hunting is disregarded. Most rural policies and agricultural programmes still seek to replace shifting cultivation or hunting, even though this type of agriculture is both climate-resilient and essential for the way of life of indigenous peoples.

Overlooking the considerations of indigenous cultures and livelihoods causes major disruption to traditional food systems, contributes to increased malnutrition and health problems in indigenous communities and homogenises foods and food practices around the world and risks exacerbating existing social vulnerabilities among indigenous peoples (Levang, Dounias and Sitorus, 2005). The overlapping axes of social differences (gender, rural status, class etc.) exacerbate the vulnerability of indigenous peoples.

Finally, for both women and vulnerable minorities, relative deprivation has been observed in multiple spheres, although these populations play a crucial role in food systems. Not giving them a voice and equal access to resources risks marginalising them still further and reducing their contribution to global food and nutrition security, mitigation of climate change, sustainable management of natural resources and prevention of conflicts. ●

BOX 12

WOMEN'S EMPOWERMENT MITIGATES THE NEGATIVE EFFECTS OF LOW PRODUCTION DIVERSITY ON CHILD NUTRITION IN NEPAL¹

The crucial role of women's empowerment in the achievement of food and nutrition security in LI and LMI countries is illustrated in a study conducted in Nepal. In Nepal, 25 percent of the population lives below the poverty line and 41 percent of children are stunted. Based on household survey data from 3,332 rural households, authors studied women's empowerment with a measure of the roles and extent of women's engagement in the agricultural sector in terms of decisions over agricultural production, access to and decision-making power over use of income and productive resources, leadership in the community and women's time use.

They first demonstrated that production diversity at the household level is positively associated with maternal and

under-five-year-old child dietary diversity and higher nutritional scores for children. Second, in areas and households with lower production diversity, women's empowerment (in particular lighter workloads and greater control over income) is found to mitigate the negative impact of less diverse production diversity on child diets and nutritional scores. Greater empowerment is also associated with greater maternal dietary diversity.

This finding suggests that women's empowerment is a key avenue for improving maternal and child diets and nutritional status, especially where the diversification of production may be limited by biophysical or agroecological conditions.

1. Based on Malapit et al., 2015.

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CHAPTER 4.5

UNCERTAIN IMPACTS OF NEW TECHNOLOGIES: THE CASE OF DIGITAL AGRICULTURE AND BLOCKCHAINS

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SUMMARY

Digital innovations are central to the transformation of food systems, from production and processing through to distribution. While they have the potential to enhance environmental and social sustainability across the value chain, they could also have disruptive effects on organisations and come with huge uncertainties in terms of access to these technologies, working conditions ('Uberisation') and governance. This chapter aims to briefly address the challenges associated with the diffusion of these technologies in developing countries. We focus on the examples of digital agriculture and blockchains.

Digital agriculture: promising but hardly accessible in Low-Income (LI) and Lower Middle-Income (LMI) countries

Digital agriculture makes use of information and communication technologies (ICTs) to enable farmers to improve their agricultural production and marketing. Currently, most farmers make decisions on subjects such as fertiliser use and marketing based on a combination of practical experience and general advice from public or private organisations (companies, public authorities, NGOs). Digital innovations can provide farmers with more accurate information based on the use of specific information and tools such as sensors, positioning systems and databases, modelling software, communication networks and robotics. ICTs may enhance their ability to make decisions and have the potential to foster agricultural production and reduce production costs, while reducing environmental impacts through the promotion of cost-effective input approaches.

Although widely employed in Northern America and expanding in Europe, digital agriculture is currently much less used in Low-Income (LI) and Lower Middle-Income (LMI) countries. However, some promising experiments are being conducted in sub-Saharan Africa. The most advanced of these (Ethiopia, Tanzania and Nigeria) are the ones conducted with the aim of providing farmers with site-specific information on fertiliser use decisions. In Ethiopia, major work has been underway since 2012 by the Ministry of Agriculture to map soil fertility through the interpretation of satellite images and the analysis of soil samples, and to deliver site-specific information to farmers through a toll-free mobile phone service. More than seven million text messages and calls were received in the first year of operation and local wheat production has increased from one tonne per hectare to three tonnes per hectare (ATA, 2019). In Nigeria, the information received resulted in higher fertiliser use and higher yields. However, the positive impacts were significant only for farmers who received a full range of specific information, rather than general guidelines (Oyinbo, 2018; cf. Box 13). There is a risk of a two-tier agriculture developing, with territories not covered on the losing end. The diffusion of ICTs should be supported by public service providers or development organisations in the field to avoid creating greater inequalities, which comes at a cost.

In the private sector, a variety of startups are emerging (Ekewe, 2017). For instance, several initiatives are seeking to connect farmers to credit (for example, for inputs), with service providers (to obtain accurate information about agricultural practices and marketing opportunities) and with food processors and/or distributors. Examples include the JAMI application in Senegal, FARMCROWDY in Nigeria and the ESOKO platform services in

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Ghana. In Kenya, the SunCulture company is selling solar irrigation kits in semi-arid areas that pump water, store it during the day and distribute it at night in order to optimise water use (AuSénégal.com, 2018).

Digital agriculture has the potential to help poor farmers in developing countries increase their agricultural production while optimising water and input use. It could also contribute to reducing women's workloads by enabling them to access key services (Treinen and van der Elstraeten, 2018). However, technology by itself does not ensure a move to greater equality and, depending on its implementation, also risks widening existing gaps. Costs for accessing technology are high and information on the long-term benefits is not always available. To secure its benefits and broad adoption by farmers, digital agriculture will require stronger collaboration among key stakeholders and need to be governed by inclusive policies, which address specific ICT needs and challenges. Further research is needed to assess the long-term impact of such innovations and the conditions required for scaling up and out.

Blockchains and food systems: risks of market exclusion and uncertainties about governance

Blockchain is being touted as one of the greatest technological revolutions available. It is catching the interest of a wide variety of industries and will soon penetrate the global market. Developing countries are not excluded from this technological development, especially as it provides great potential for food systems (Ge, 2017).

A blockchain is a decentralised digital accounting ledger that records all transactions made by its participants. Each user enters the data on the transactions he or she is involved in, for instance information about the goods they interact with. The data is shared and verified by all members using cryptography and collaborative verification algorithms. In comparison to traditional, centralised ledgers, the benefits are very high data security and disintermediation of transaction processing, in addition to speedier and automatically verified transactions. This technology therefore has the potential to facilitate trade and increase transparency, accountability and traceability.

It can be applied to long supply chains, land titles or creditworthiness. Blockchain is claimed to facilitate access to financial services and reduce transaction costs. In practice, each actor in a supply chain (producers, processors and distributors) enters the traceability data which concerns them for each batch

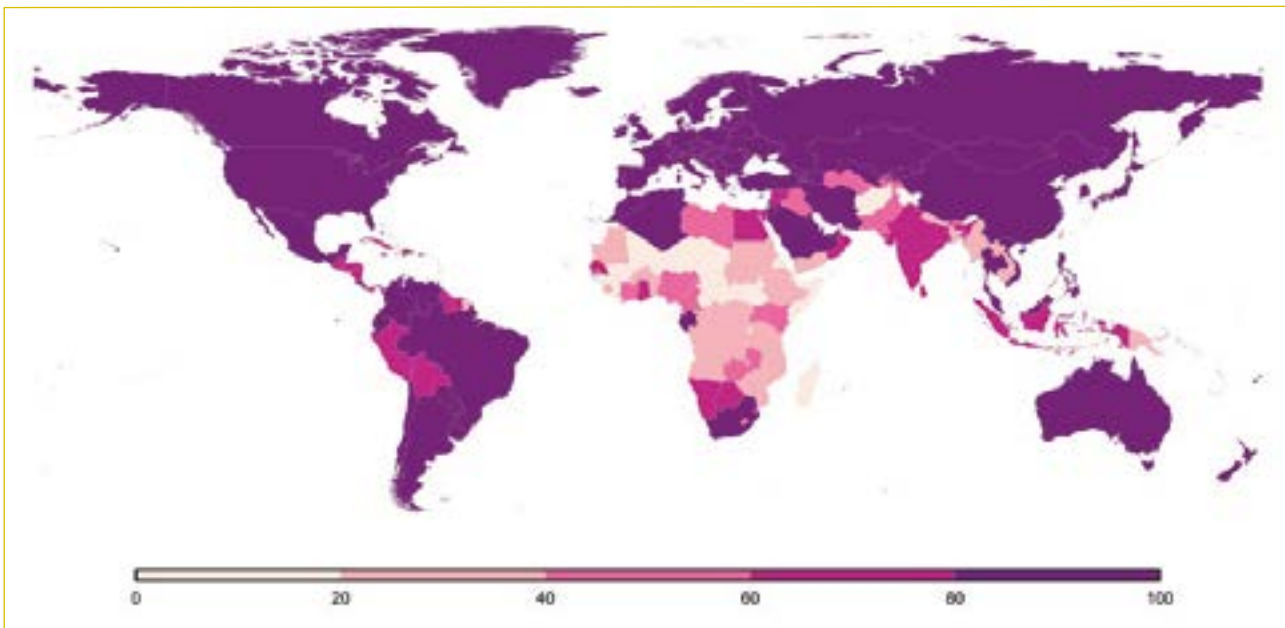
of information such as the origin, detailed attributes of products, dates for treatments, harvesting, processing, selling etc. It allows smart, self-executing contracts to be implemented, which can enhance trust between sellers and buyers. The transparency of the data can also improve food safety, since it allows for easier regulatory control to detect fraudulent behaviour, improved monitoring for compliance with sanitary and phytosanitary regimes, and even a strengthened ability to respond quickly to disease outbreaks and contaminated agri-food products (Tse *et al.*, 2017). Blockchain aims to strengthen the enabling environment for transactions with better informed policies. Some also say that it might replace certification for voluntary standards and reduce rejects at border crossings, especially for exports from developing countries.

Nevertheless, the required integration of all the actors in supply chains into blockchain is challenging, will take time and involves numerous social and economic risks in developing countries.

The main obstacles to the implementation of this technology are the paucity of resources and skills. First, this technology can only be used with a computer network and will thereby exclude billions of people who do not have access to the internet (Map 10). This is a particular problem in Africa and Asia where coverage is patchy, with only 25 percent of the population having access, and connectivity is the most expensive in the world (A4AI, 2018). Second, while blockchain promises to make it possible for participants to incorporate better analytics in their operations, most small enterprises in the world do not keep a clear handwritten accounting register as many operations and transactions fall within the informal economy. However, the fast rise of mobile payments in the region could facilitate the deployment of these technologies.

Until now, cooperatives or exporters have taken on responsibility for the complex and time-consuming red tape linked to transparency in the agri-food export sector. However, unless smallholder farmers, as well as micro-, small- and medium-sized enterprises, increase their capacity at least initially, blockchain may lead to greater marginalisation for some market participants. The reasons could be similar to those which tend to exclude diversified, small-scale farming from standards: third-party certification has a high cost, due to the work related to the certification procedure, the bureaucratisation and analysis of data, the cost of auditing, skills and travel expenses, which favours monoculture productions and agri-food industries; and the centralisation of the design of the system (Lemeilleur and Allaire, 2018). Depending on the precise blockchain characteristics, these could be more-or-less mitigated.

Finally, challenges appear at the public governance level, particularly with regards to data access. Access



Map 10: Access to the Internet: still patchy in most LMI countries.

to data in blockchains can be private or shared, depending on the rules adopted, the purpose of the platform and the preferences of the users. In some 'closed' blockchains, a central actor controls permission to enter the system and access the data, and could exert undue market power. The choice among these different tools must juggle data accessibility so that all users can enjoy the benefits of the tools and, simultaneously, manage the protection of confidential information, such as personal data. Inter-governmental organisations and governments require clear regulations on data protection to determine how data should be stored and shared between public and private actors (World Bank, 2019).

Most of today's innovations in ICT for agri-food systems are based on access to the internet. Although more than half of the world population is now connected, network coverage is still missing or limited in most LI and LMI countries, currently hampering their development. This map shows estimates of the percentage of individuals who do not use the internet (data from ITU, map from Tripoli and Schmidhuber, 2018). In most African and Asian countries, more than half of the population is absent from the network. The main reasons are the uneven coverage, as well as the high cost of equipment and lack of required knowledge (A4AI, 2018). ●

BOX 13

SITE-SPECIFIC SOIL FERTILITY MANAGEMENT RECOMMENDATIONS: GENERAL IMPROVEMENT BUT ALSO WIDENING OF THE GAP BETWEEN FARMERS¹

In sub-Saharan Africa soil fertility recommendations given to farmers are usually generic enough to be able to target a large area. In the maize belt of Nigeria, an ICT-based system has been tested, which tailors advice to make it site-specific at the farm or field scale. *Ex-ante* and *ex-post* surveys have been conducted to evaluate how this technology was received by farmers. According to the *ex-ante* study, most farmers were very interested by this tool, irrespective of their economic resources and farming model. They recognised the heterogeneity in their farming system and the use they could make of tailored recommendations. However, the *ex-post* survey shows that actual adoption of the technology varies widely, as is classically found in studies on the use of agricultural innovations.

The authors identified two groups of farmers. The first, which includes innovators and likely adopters of technology, are better-off, less sensitive to risk, more likely to invest in farm inputs and indifferent towards more-or-less intensive production techniques. The second group includes farmers with lower incomes, lower productive assets, who are more sensitive to yield variability and prefer less capital- and labour-intensive production techniques. They are also more reluctant to be early adopters of innovations. Therefore, the introduction of this new service tends to reinforce the existing gap in economic performance between farmers. Policies need to be designed to compensate for this effect, for instance by putting efforts into considering the specific needs of small-scale, diversified farmers.

1. Based on Oyimbo et al., 2018.

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CONCLUSION OF SECTION 4

PUTTING FOOD SYSTEMS AT THE HEART OF ECONOMIES AND SOCIETIES

Thierry Giordano¹ and Alexandre Hobeika²

Too many inequalities and vulnerabilities already exist within food systems in LI and LMI countries. Global socio-economic trends, whether they be rapid demographic growth, the expansion of upgrading in food chains, territorial imbalances, the increasingly acknowledged role of women and minorities or the emergence of new technologies, raise many questions on the future of food systems, most of them open-ended and leading to major uncertainties. There is a high risk of ending up with a massive increase in informal, vulnerable and extremely poor workers, especially young people, women and minorities. This will provide fertile ground for food crises, social unrest, civil conflicts and migrations. Food systems are therefore at a crossroads: shaping these trends through public and collective actions would transition food systems towards much-needed inclusive development.

In light of the massive increase in the working age population, it is likely that 730 million new jobs will have to be created in sub-Saharan Africa by 2030. The decent job creation potential of food systems will have to be fully harnessed: integrated strategies coupling education, training and capacity building with job opportunities within food systems will help subsistence smallholders become commercial smallholders, assist unskilled workers in becoming valuable employees and stimulate innovation capacity among stakeholders.

Decent job creation will contribute to poverty alleviation and the reduction of inequality, both multi-dimensional and spatial. Social protection, in all its dimensions, could complement the benefits of decent job creation within food systems and all along the rural-urban continuum. Large unplanned urban growth, especially in Africa and South Asia, and underinvestment in intermediary cities reinforce historical imbalances. Spatial poverty traps undermine the food security of both urban (slums) and rural households (hinterlands). For food systems to grow and have leverage effects on the rest of the economy, spatially planned investments in infrastructure and essential service provision are required to make intermediary cities and their surrounding rural areas economically and socially attractive.

Trade-offs should be found to balance the roles and responsibilities of large-scale and family farming, industrial agribusinesses and small entrepreneurs, global, domestic and local actors, and youth, women and minorities in the expansion of food systems. Labour- and/or capital-intensive food system options should be properly assessed. Upgrading of value chains offers opportunities that too many small-scale stakeholders are currently unable to seize due to limited access to financial services (credit, insurance or savings), and when they participate, they barely end up better off as they lack bargaining power. New technologies are critical in the upgrading process all along value chains, but the risks of exclusion are real: skills development, access to knowledge and affordability are among the key elements public policies should promote. Exclusion is even more pronounced for women, youth and minorities, despite the critical role they play in food systems. Gender equality and women's empowerment are critical factors for the expansion of food systems and inclusive development. Significant efforts are required to address the structural causes of gender inequality and ensure that women have access to and control productive resources such as assets, and agricultural and financial services, and to improve their capabilities and decision-making power. This would enhance their active participation in food system governance, policy and planning so they can benefit as equally as men.

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SECTION

05

FOOD SECURITY
AND NUTRITION



SECTION 5

Food security and nutrition

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CHAPTER 5.1

LIMITED FOOD AVAILABILITY

Éric Malézieux¹ and Marc Corbeels²

SUMMARY

While food security is a major worldwide issue, it is a much more serious problem in Low-Income (LI) and Lower Middle-Income (LMI) countries. Currently, sub-Saharan Africa is the sub-continent with the highest proportion of undernourished people, the largest gap between current and potential yields, and between cereal consumption and production. Looking to the future, population growth and climate change may worsen the situation, particularly in Africa. African countries are still facing rapid population growth with uncertain prospects about the ability of their agriculture to meet growing food demand. In addition, without sufficient adaptation measures, climate change will negatively impact food production in most African regions.

Increase in food demand

Although global food production has been increasing dramatically, the world still faces a persistent food security challenge. Currently, many consider that we are producing enough food to meet the dietary needs of today's global population. However, food security is one of the major issues worldwide and is a much more serious problem in LI and LMI countries, where 821 million people still suffered from undernourishment in 2017 (FAO, 2018). Most people who are not able to afford enough food live in Asia (515 million people were estimated to be undernourished in 2017) and in sub-Saharan Africa (256 million). The proportion of undernourished people remains highest in Africa, where 21 percent of people are suffering from hunger (FAO, 2018).

Looking to the future, population growth and climate change may exacerbate the situation, especially in Africa. Analysis of recent data confirms that the world's population is likely to continue growing for the rest of the century. World population, now standing at 7.7 billion people, would reach 10 billion in 2050 according to the UN's medium variant, compared to 9 billion in the lowest scenario and up to 11 billion in the high variant. It would increase to between 9.6 billion and 12.3 billion in 2100 (Gerland *et al.*, 2014). This projection hides important differences between continents. The Asian population is likely to peak around the middle of the century and then begin to fall.

The main reason for the increase in the projection of the world's population is the growth in the population forecast for Africa, with at least a 3.5-fold increase. In these conditions, how can the world be fed in 2050? First, we have to consider that global food needs will necessarily increase to satisfy the growing population. Looking at different scenarios in the literature, Le Mouél and Forslund (2017) suggest the range of expectations for future food needs will be an increase of between 29 and 91 percent over the 2010-2050 period, depending on the assumptions for population growth, economic growth and dietary changes. Hence, global food demand is expected to increase by 60 percent by 2050 compared with 2005/2007 (FAO, 2017), with the rise being much greater in sub-Saharan Africa.

The challenge of meeting the needs

Feeding the world in 2050 will be a challenge as we must consider that we shall face limits and barriers to increasing agricultural supply in order to meet these needs. Indeed, in addition to land degradation and the limits of land availability, scarcity of resources such as water and phosphorus (*cf. Chapter 3.1*) and climate change will also determine the future conditions and constraints in food production (*cf. Section 2*). Despite

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technological progress, maize, rice, wheat and soybean yields are stagnating or have even fallen in several world regions (Ray *et al.*, 2012). The causes are various and complex. In some cases they are linked to socio-economic and institutional constraints, whether these concern input availability in Africa or the intensification of rotations in the USA to increase incomes. It may also be explained by reasons doomed to persist in the long term, such as reaching physical limits in Bangladesh and parts of India and Europe, or the limitation on nitrogen inputs due to environmental concerns in Europe. Without sufficient adaptation measures, climate change will negatively impact food production in many areas (Lobell *et al.*, 2009). In addition, most of the large negative impacts are projected to be in very vulnerable areas that are highly dependent on agriculture in LI and LMI countries. This means climate change is a serious threat to crop productivity in regions that are already food insecure. Furthermore, it is projected that the impacts of climate change on food security are significant, with millions of additional people at risk of hunger by 2050.

Food availability in sub-Saharan Africa

Despite the importance of sub-Saharan Africa's domestic market (Bricas, Tchamda and Mouton, 2016), it is one of the sub-continent with the largest gap between current and potential yields (cf. Figure 21 and Box 14) and between cereal consumption and production, with current levels of cereal consumption already dependent on substantial imports. As climate change will exacerbate yield variability, with extreme weather events causing production shortfalls, the risks to food security associated with this productivity gap and market instability will continue to grow. Van Ittersum *et al.* (2016) have shown that nearly complete closure of the gap between current yields and yield potential will be needed to maintain the current level of cereal self-sufficiency (approximately 80 percent) by 2050, which is an extreme and improbable objective. As a result, massive cropland expansion with attendant biodiversity losses and greenhouse gas emissions and/or vast import dependency can be expected.

Another important reason to increase food production in LI and LMI countries is to improve local economies in areas where numerous poor small farmers and landless workers depend on agriculture and often already suffer from malnutrition. Agriculture-led growth and agriculture-based solutions can make significant contributions to reducing undernutrition. According to the World Bank, agricultural productivity is fundamental for reducing poverty, sustaining the nutritional and health status of billions of people, ensuring food security and generating the resources

required to access adequate care, health, water and sanitation services (World Bank, 2007). Because many poor and undernourished people are smallholder farmers, it is often assumed that diversifying production would improve dietary diversity within the household.

However, interactions between poverty, agricultural production and food security are complex. For example, a paradoxical situation has been identified in the Sikasso region in Mali where substantial agricultural production was concomitant with widespread child malnutrition (Dury and Bocoum, 2012). The authors have hypothesised that child malnutrition, reaching the highest level in this region, is linked to less diversified food consumption and probably to a lack of care, as a result of an overload of agricultural labour. Hence, the interactions between health, nutrition and agriculture are mutual: agriculture affects health and health affects agriculture, both positively and negatively. In the absence of conclusive links, both on-farm production and diversity, as well as access to markets, might matter for the diets of smallholder families (HLPE, 2017). Indeed, diversification of production at the farm scale can be both a sustainable pathway to increase productivity and incomes, but also a means to improving the food nutrition of poor smallholders.

So, in countries with a high prevalence of undernourishment it is very important to ensure the sustainable intensification of agricultural production in order to increase productivity and resilience to climate events that affect access to food. Moreover, increasing the incomes of poor populations, improving rural infrastructure and promoting local systems that ensure access to safe, affordable and varied foods are critically important for improving diets and reducing malnutrition.

Towards new solutions

By 2050, the world will face the challenge of producing enough food for a projected 9 to 11 billion people, while taking into consideration the impacts of climate change, the growing scarcity of water and land and a change in consumption patterns. Innovative systems are needed everywhere to increase productivity without compromising natural resources (FAO, 2018). Sub-Saharan Africa is expected to be the most vulnerable region since it has the highest prevalence of undernourished people in the world (FAO 2017), national economies are highly dependent on agriculture (and food imports) and most farmers are poor and have a limited capacity to adapt. There is an urgent obligation to find new pathways to guarantee harmonious agricultural development in rural areas, which is a necessary condition for ensuring food security. With regards to food security, and despite the fact conventional and biotechnological approaches

still appear to produce higher yields (but with high impacts on natural resources), new agroecological pathways, including organic agriculture, could be more efficient in meeting this goal (Schoonbeek *et al.*, 2013; Andriamampianina *et al.*, 2018). ●

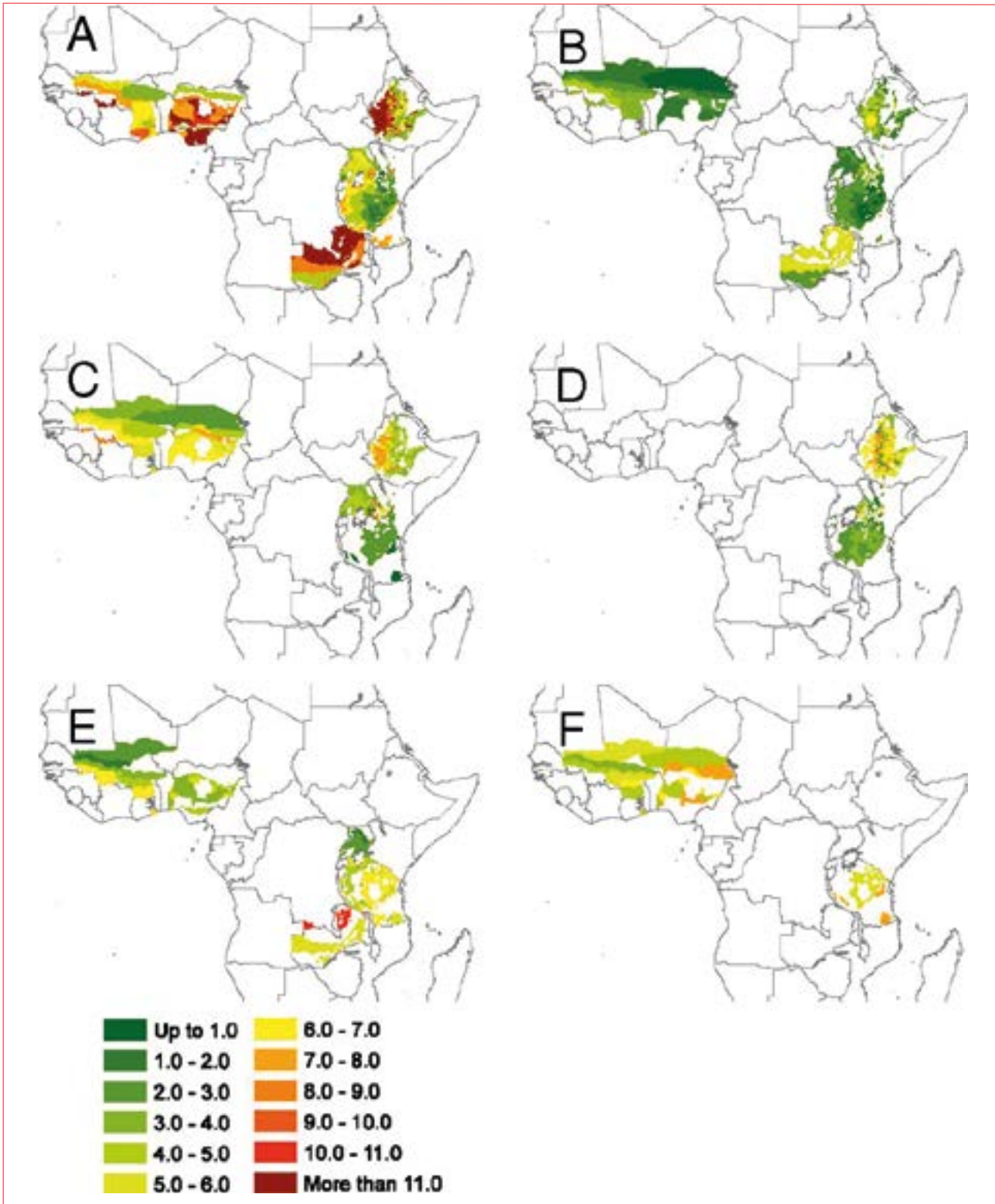


Figure 21: Yield gaps (yield potential minus actual yields, t/ha harvested area) in sub-Saharan Africa. Source: van Ittersum *et al.*, 2016.

Rainfed maize (A), rainfed millet (B), rainfed sorghum (C), rainfed wheat (D), rainfed rice (E), irrigated rice (F).

BOX 14

YIELD GAPS IN SUB-SAHARAN AFRICA

The yield gap (Yg) is the difference between potential yield (Yp, for irrigated crops) or water-limited yield (Yw, for rainfed crops) and actual yield (Ya), as found in farmers' fields. Yg is based on Yp or Yw that can be simulated with crop growth models using optimal agronomic management as inputs (i.e. cultivar maturity, sowing date and planting density).

A global yield gap analysis (Licker *et al.*, 2010) has shown that for many crops, especially maize and rice, yield gaps are at their largest in sub-Saharan Africa. For example, actual rainfed maize yields during the period 2003-2012 ranged from 1.2 to 2.2 t/ha, which represents 15 to 27 percent of the water-limited yield potential (van Ittersum *et al.*, 2016). For all rainfed crops, the largest gaps are found in the more favourable (higher rainfall) regions of the savannahs and cooler highlands of Ethiopia and the northern Zambia plain (cf. Figure 21). Increasing maize yields from the approximately 20 percent of yield potential in 2010 to 50 percent by 2050 would require a doubling of annual crop yield increases compared with past decades. Although it is possible to achieve accelerated yield gains with improved cultivars coupled with good agronomy, increased fertiliser use and modern pest management practices, it is generally agreed that this will require greater investment in research and development in order to tackle the socio-economic constraints (for example, access to capital, infrastructure and markets) that have prevented smallholders in sub-Saharan Africa from achieving higher yields.

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CHAPTER 5.2

RISKS OF HIGHER FOOD PRICES ON INTERNATIONAL MARKETS

Thierry Brunelle¹ and Patrice Dumas¹

SUMMARY

Agricultural commodity prices have increased since the early 2000s in response to a combination of causes on the demand side (demographic growth, increased animal product consumption in emerging countries and biofuel mandates) and on the supply side (the phasing out of agricultural policies subsidising food supply in the European Union and United States, lack of public investment in agriculture, reaching ceilings in cereal yields in already high-yield countries and an increase in energy prices). The succession of food crises between 2008 and 2012 has brought the agricultural price regime and its implications for food security back to the forefront. Even though the increase of average agricultural prices could profit some farmers, part of the price increase corresponds to increased costs and urban dwellers, as well as many food-insecure food producers, depend on the market for their supply. In addition, environmental policies concerning the protection of biodiversity, climate mitigation and pesticide reduction could make these issues even more acute.

Will high prices be the 'new normal'?

Following the food price peaks at the turn of the 2010s, debates have emerged on what the 'new normal' will be for the long-term trends in agricultural prices. An optimistic view has argued that the long-term trend in food prices should remain downward (Baldos and Hertel, 2016). This argument is based on an analysis of the main determinants of agricultural supply and demand: population, per capita income, diet, climate change, agricultural productivity and biofuel production among others. According to Baldos and Hertel (2016), the deceleration of population growth to 2050 and its concentration in developing countries, where per capita food consumption is relatively low, should more than offset the effect of global growth in per capita income. Moreover, growth in agricultural productivity should not necessarily weaken because substantial margins for growth remain in many countries around the world (Foley *et al.*, 2011), and the effects of climate change will be felt mainly after 2050 (Rosenzweig *et al.*, 2013). Finally, demand for biofuels, which has driven agricultural prices since 2000, is not expected to change significantly given the criticism of its environmental impact and the low price of fossil fuels.

However, there are several risk factors to consider that may temper this optimism. First, the UN's demographic projections have recently been revised upwards (*cf. Chapters 1.3 and 5.1*). Changes in animal product consumption could also outpace income-based projections. The uncertainties are important. Given current population levels, there is a potentially huge multiplicative effect of changes in diet per capita if the traditionally vegetarian population of South Asia, in particular India, adopt Western consumption patterns. There are also concerns about the potential for future productivity growth (*cf. Chapter 5.1*).

It is equally important to highlight the important correlation between agricultural prices and energy prices. Optimism about the evolution of agricultural prices is largely based on the assumption of moderate growth in energy prices. If energy prices were to increase, in particular because of the increased scarcity of fossil fuels, there is a risk of a spill-over effect through the price of inputs, particularly fertilisers whose production process is energy intensive (Brunelle *et al.*, 2015), or through the demand for biofuels. Climate policies in line with the Paris agreement objectives could also lead to increased energy prices as some relatively cheaper conventional and unconventional fossil fuel sources would be left untouched in order to avoid climate change.

In recent years, international trade has played an important role in moderating agricultural prices, in particular in responding to isolated shocks in production (for example, France in 2016).

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However, increased trade flows tend to polarise situations with some regions taking an increasing share of the world market, particularly South America, while others are increasingly dependent on imports, such as Africa and China (Kastner, Erb and Haberl, 2014). The geo-political context will be a key determinant of how countries cooperate to ensure the global food balance. The hypothesis of regional fragmentation leading to trade wars, as is currently the case with the soybean trade between the US and China, could profoundly change the long-term dynamics of agricultural prices.

Food prices under scenarios of stringent climate change mitigation and environmental preservation

Over the past few decades, low-cost food and plentiful production have been the main outcomes expected from food systems. If environmental issues now become a higher priority, there is a risk that food prices will rise on international markets in the coming decades.

The most ambitious climate change mitigation scenarios are largely based on the agriculture, forest and other land-use sector (AFOLU), because the mitigation potential, whether through reduced emissions or carbon sequestration, is large and the costs of abatement are low compared to other sectors (Krey *et al.*, 2014). Such a mitigation strategy may have major implications for our food future as research shows that the introduction of a carbon tax on the AFOLU sectors could have greater consequences for food security than the impact of climate change itself by 2050 (Hasegawa *et al.*, 2018). However, it is important to note that these conclusions are based on assumptions that are not favourable for food security since in most models carbon tax revenues are not properly redistributed to the people affected in the modelling framework.

In most scenarios, ambitious mitigation targets cannot be reached without negative emissions (Rogelj *et al.*, 2018). Given the lack of known alternatives, land-based mitigation options are the preferred choice to remove carbon dioxide, emitted in particular by non-agricultural sectors: bioenergy with carbon capture and sequestration (BECCS), biochar, afforestation/reforestation and carbon storage in soils. The land footprint of such techniques can be large and contribute to a profound change in global food balances. According to the Intergovernmental Panel on Climate Change Special Report on global warming of 1.5°C (Rogelj *et al.*, 2018), trajectories to maintain the average temperature increase well below 2°C (1.9 W/m²) would require between 100 Mha and 700 Mha of additional energy crop areas by 2050 and up to nearly 1,000 Mha of additional

forest areas. These changes would be at the expense mainly of pastureland (up to -800 Mha) and cropland (up to -450 Mha), with consequent significant impacts on food production and on agricultural commodity prices, with increases from 50 percent to 100 percent in 2050 and 140 percent to 340 percent in 2100. To this day, the assessment of the effects on agricultural production and prices remains difficult. It depends on assumptions about the potential for productivity increases in the livestock and crop sectors, whose realism is difficult to assess. In any case, given the scale of land-use changes, such scenarios will imply major changes for food security and in production processes, with intensification trajectories that may be a risk or an opportunity for smallholder agriculture.

Changes in agricultural production systems in line with objectives for environmental protection would lead to sparing natural land for biodiversity (*cf. Conclusion of Section 3*), avoiding monocultures and diversifying land use, reducing pesticide use and avoiding nutrient leaching.

A move towards healthier diets could have substantial co-benefits on food supply. For example, the processes involved in the production of vegetable proteins are much less land-intensive than those of animal proteins and therefore put less pressure on food systems (Hallström, Carlsson-Kanyama and Börjesson, 2015). Concerns about pollution, health and nutritional quality could lead to a reduction in mineral fertiliser use, an increase in nutrient recycling, a decrease in pesticide use and more diversified plant production. Currently, organic agriculture is the main system with reduced pesticide use that is developed enough to be analysed quantitatively, though it requires more land (Muller *et al.*, 2017) and is more expensive than conventional systems (Seufert and Ramankutty, 2017). The major increase in demand for organic agricultural products in developed countries is an obvious reflection of these concerns, but food quality is also a growing concern in developing countries (Ndungu, 2013).

Caught between reduced land use for food production as more land will be needed for nature preservation or bioenergy production, and adverse impacts on yields for various reasons (climatic, economic and progressive withdrawal from conventional agriculture), long-term agricultural prices could return to an upward trend, creating major issues of access to food for various populations. ●

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CHAPTER 5.3

WHY FOOD PRICES ARE LIKELY TO BECOME MORE UNSTABLE

Franck Galtier¹

SUMMARY

Extreme food price volatility is extremely damaging to food and nutrition security. It is likely to increase in the future because: (i) food markets will probably become more vulnerable to shocks; (ii) supply shocks can be expected to increase because of climate change, emerging diseases and armed conflicts that could affect production and trade; (iii) demand shocks are predicted to rise due to the growing links between the food, energy and financial markets.

Many food prices are already unstable, both on international and national markets. Since food products account for a large share of household expenditure in many low-income countries, especially the poorest ones, sharp price increases have a very negative impact on food and nutrition security. Some households need to reduce their food consumption level or diversity, causing possible calorie or nutrient deficiencies, with possibly irreversible effects, especially for young children (Glewwe, Jacoby and King, 2001). Equally, price collapses affect food production and investment: as farmers are facing a huge market risk, they are not willing to invest and banks or microfinance institutions are not willing to lend them money. Food price volatility is likely to increase in the future for the reasons explained below.

Increased vulnerability to shocks

Food markets are already highly vulnerable to shocks. This is because there is no mechanism to guarantee that stock levels are adequate to absorb significant shocks in supply or demand. Stocks usually have a stabilising effect on prices because storers usually buy when prices are low (thereby reducing the quantity available on the market and exerting an upward pressure on the price) and sell when prices are high (thereby releasing quantities on the market and exerting a downward pressure on the price). This mechanism applies to both private storers and the food reserve agencies that manage public stocks. However, if stock levels are sometimes sufficient (after successive good harvests), they are sometimes too low, allowing for sharp price increases, as illustrated by the international grain markets (European Commission, 2018).

The trends analysed in Chapter 5.2 are likely to increase the vulnerability of food markets. Some world regions, especially Africa, will become more dependent on food imports and therefore more vulnerable to trade shocks. We note here that WTO disciplines on export restrictions are extremely weak and export bans were enforced by many exporting countries during the 2008 crisis, thereby penalising countries which import rice and wheat.

Increased supply shocks

Climate change

Although climate change impact studies have mainly focused on changes in mean climate, IPCC (2012) acknowledges the fact that “a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and

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climate extremes, and can result in unprecedented extremes.” Changes in extreme events have been observed since 1950. Further changes may occur in the future, although there is no certainty about this in the IPCC projections. Current knowledge on the impacts of increased climate variability and extreme events have been reviewed by Thornton *et al.* (2014). Temperature extremes are expected to reduce yields: “rice yields [would be] reduced by 90% with night temperatures of 32°C compared to 27°C,” [whereas] “in maize, each degree day spent above 30°C can reduce yield by 1.7% under drought conditions.” “High temperature extremes during grain filling can affect the protein content of wheat grain” (Thornton *et al.*, 2014). Changes in rainfall variability or seasonal patterns (both droughts and floods) are the principal cause of inter-annual yield variability (cf. Section 2). The probable increase in the frequency of extreme climate events is likely to render food production more unstable, at least in some parts of the world, thereby increasing price instability on national and international markets.

Emerging diseases

Emerging infectious diseases are diseases whose incidence has increased in the past 20 years and could increase in the near future (cf. Chapter 2.4). Climate warming may contribute to boosting their development (for more details on this, see FAO 2018). Emerging diseases can affect plants, animals and humans. They could lead to more unstable food prices by affecting production and trade. For example, it is estimated that by generating labour shortages, the Ebola virus disease outbreak that affected West Africa in 2014 led to reductions in rice production of 11.6 percent in Liberia, 8 percent in Sierra Leone and 3.7 percent in Guinea (FAO, 2016). In addition, it disrupted the local rice trade both within and between countries because of traders’ fears of harvesting rice in affected areas and government decisions to close markets and borders. This resulted in worse connections between surplus and deficit areas, leading to both increases and decreases in prices.

Conflicts

Armed conflicts are already a huge problem in some regions of the world, including the Sahel. The probability of future conflicts is likely to increase with the growth of climate-driven migration and rising pressure on resources such as land and water. Analysis of existing conflicts shows that they can affect food supply by reducing production, disrupting trade or causing stock theft or destruction (as occurred with jihadist movements in northern Mali). The way in which Boko Haram’s attacks affect agricultural market activity has been studied in 112 markets located in northern Nigeria and in 2,429 reported conflicts for the period July 2009 to November 2016 (Van Den

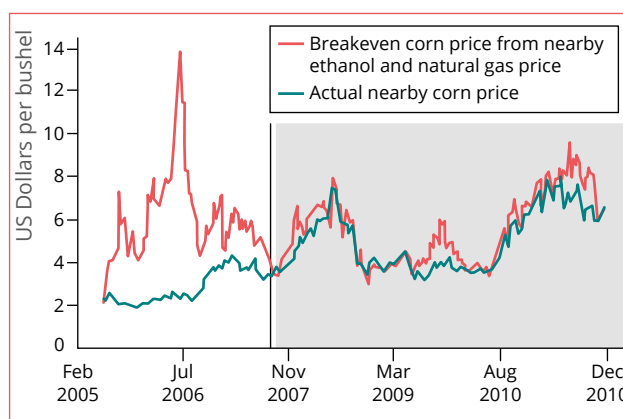


Figure 22: Biofuel production capacities (since 2007) resulted in a strong relationship between maize prices and energy prices. Source: HLPE, 2013.

Hoek, 2017). Conflicts have been found to reduce market activity even though less than 2 percent of them occurred at or near markets.

Increased demand shocks

As food markets will be increasingly linked to energy and financial markets, food prices will increasingly be affected by the shocks that occur on these markets.

Growing links between energy and food markets

Because of methodological challenges, the many econometrical studies carried out show diverging results regarding whether the instability of energy prices is transmitted to food prices (for a review, see HLPE, 2013). However, the more comprehensive and reliable approach (based on estimating the ‘break-even point’ for a given food product, i.e. the price level below which using it to produce biofuel is profitable) clearly shows that the price of maize is driven by its break-even point, which in turn depends on the dynamics of ethanol and natural gas prices (cf. Figure 22 and HLPE, 2013). This is not the case for vegetable oils because their price is higher than their break-even point. In the future, the role of energy prices as drivers for food prices is likely to increase because of the on-going development of biofuel production in many emerging countries (HLPE, 2013) and the likely increase in energy prices (cf. Chapter 5.2). The price of food products not directly used to produce biofuels may also become more unstable because when there are sharp increases in energy prices, land and scarce inputs are likely to be diverted from food products to energy feedstock crops.

Within a few decades, the phenomenon may go beyond energy. To solve the problems related to increasing pollution and emerging scarcity of resources, biomass will probably be increasingly used for materials, as had been the case since the beginning of human history until the industrial

revolution of the nineteenth century (Daviron, forthcoming). This return to a 'solar economy' (an economy based mainly on renewable energies) is likely to link food prices to the prices of all their non-food substitutes.

Growing links between financial and food markets

Food markets are being progressively linked to financial markets because agricultural futures markets are increasingly used by speculators following market deregulation at the end of the

twentieth century. Indeed, the proportion of contracts held by speculators jumped from 23 percent in 1998 to 69 percent in 2008 (Masters and White, 2008). Although the responsibility of excessive speculation in the 2008 food price boom is controversial (Masters and White, 2008; Sanders *et al.*, 2008), the growing nexus between financial and food markets is likely to foster an increasing transmission of the instability of financial markets to food prices. ●

BOX 15

GRAIN PRICE INSTABILITY IN THE SAHEL REGION: AN EXTREME CASE?

Grain prices are already highly volatile in the Sahel region, causing huge food crises. In Sahel countries, poor households mainly consume coarse grains (millet, sorghum and local maize varieties), whose production is highly sensitive to natural hazards (mainly droughts and locust attacks). It is difficult to offset deficits with imports because these grains are not available on international markets and the grains available (rice and wheat) are much more expensive. Therefore, coarse grain prices spike when harvests are bad (they increased by 150 percent in 2005 and 80 percent in 2012), provoking food crises and famines.

Grain price volatility is expected to increase still further in the future for two reasons. The first is related to climate change. Over the past decade, "the Sahelian rainfall regime [has been] characterized by a lasting deficit of the number of rainy days, while at the same time the extreme rainfall occurrence is on the rise" (Panthou *et al.*, 2014). This more extreme climate is likely to increase the instability of food production. In addition, the seasonal pattern of rainfall has evolved: peak rainfall has shifted from late August (before the 1970s) to mid-August, therefore increasing the risk of water stress at the end of the millet production cycle. Projections for the late twenty-first century "reveal an extension of torrid climates throughout West Africa. In addition, the Sahel, predominantly semi-arid in present-day conditions, is projected to face moderately persistent future arid climate. [...] Consequently,

West Africa evolves towards increasingly torrid, arid and semi-arid regimes with the recession of moist and wet zones mostly because of the temperature forcing, although precipitation can be locally an important factor. [...] Such changes point towards an increased risk of water stress for managed and unmanaged ecosystems" (Sylla *et al.*, 2016). These developments may have a very strong impact as Sahelian countries are often ranked among the countries most vulnerable to climate change. For example, Chad had the world's highest Climate Change Vulnerability Index in 2016 and Niger the third highest.

Another source of increased food price instability is the expected increase in the frequency and magnitude of conflicts. Armed conflicts are already a problem in the region, with the insecurity generated by jihadist or separatist movements disrupting production, trade and income (Van Den Hoek, 2017). The situation may worsen in the future because the likelihood of conflicts will rise with climate-driven migration. This kind of migration is already a reality (more than 500,000 people were displaced in Niger because of floods in 2012) and is likely to increase in the future (in terms of both people and distance). Another source of concern is related to the increasing pressure on land and water. This is a worldwide issue, but is likely to be particularly acute in the Sahel region due to the significant population growth that will occur over the coming decades.

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CHAPTER 5.4

NUTRITIONAL RISKS OF UNHEALTHY DIETS

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SUMMARY

Currently, one in three people in the world is affected by at least one type of malnutrition and, if no action is rapidly taken, this could become one in two by 2025. Different types of malnutrition coexist in almost every country, causing severe consequences in terms of human health and economic losses: 45 percent of the mortality in under-five children is linked to undernutrition and globally malnutrition in all its forms costs US\$ 3.5 trillion per year. Inadequate diets are a major cause of malnutrition and access to healthy diets for all would save 11 million lives per year.

Malnutrition in all its forms: current situation is alarming

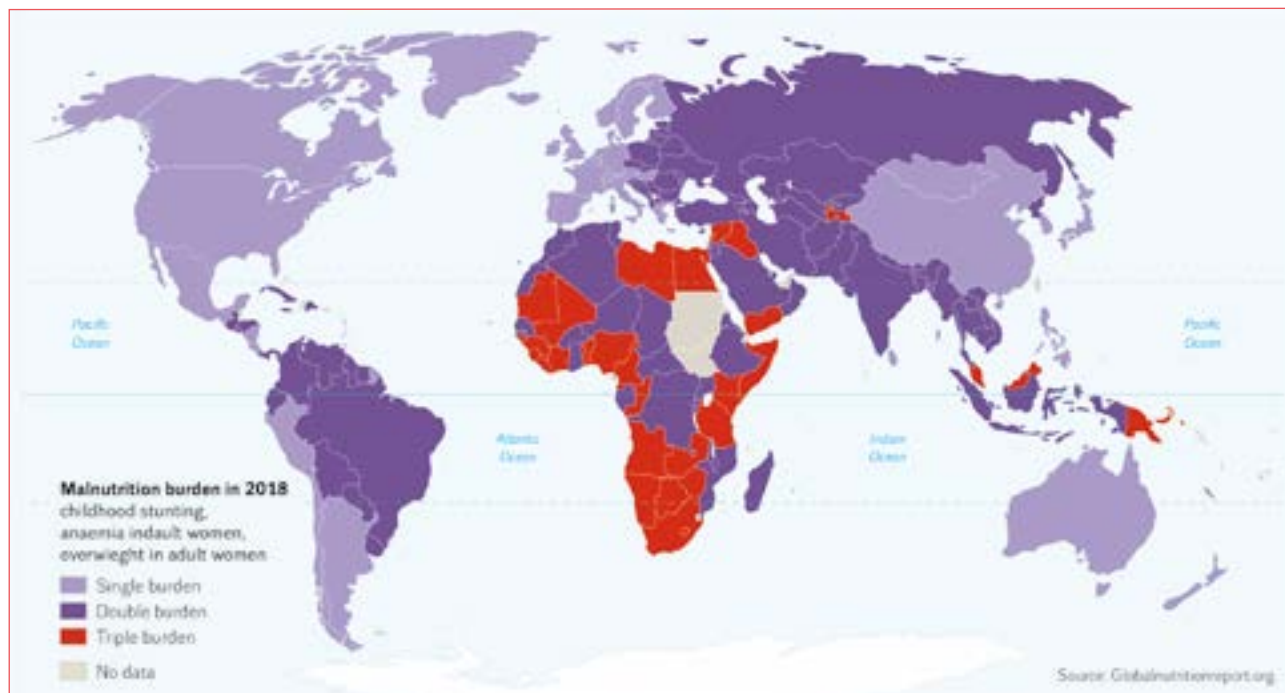
Currently, one in three people in the world is affected by at least one type of malnutrition and, if no action is rapidly taken, this could become one in two by 2025 (Glopan, 2016). Malnutrition is a multifaceted, truly universal problem. The number of undernourished people has again been growing since 2015 and has now reached 820 million people (FAO *et al.*, 2018). There are also 151 million under-five children whose stunted growth compromises the achievement of their full physical, intellectual and health potential and 51 million whose life is threatened by wasting. Anaemia in women is on the increase at the global scale (FAO *et al.*, 2018); more than 500 million women of reproductive age suffered with anaemia in 2011 (Stevens *et al.*, 2013). In addition, around 2 billion people suffer from micronutrient deficiencies. Simultaneously, around 2 billion adults are overweight, among which 670 million are obese. The world obesity epidemic continues to grow and to date no country has reversed this trend (Roberto *et al.*, 2015). Overweight even starts at a young age as 38 million under-five children are overweight. This category of malnutrition contributes to the rise in non-communicable diseases (NCD) such as type 2 diabetes, hypertension, heart disease, strokes and some cancers.

While every country in the world faces at least one serious form of malnutrition, most countries face several nutritional challenges. The coexistence of persisting undernutrition and growing obesity and diet-related chronic diseases is a consequence of a rapid nutrition transition occurring in Low-Income (LI) and Lower Middle-Income (LMI) countries, leading to a double burden that is a complex issue to tackle for under-equipped national health systems. There is even a triple burden in many countries, with deficiencies in some essential micronutrients added to the mix (*cf. Map 11*). Of the 141 countries with consistent data on three forms of malnutrition - childhood stunting, anaemia in women of reproductive age and overweight among women - 88 percent experience a high level of at least two types of malnutrition, with 29 percent experiencing high levels of all three. Most of these countries are in Africa. Coexisting burdens bear down on millions of children, with 16 million children affected by both wasting and stunting, which increases the risk of child mortality, and 8 million children are affected by stunting and overweight (Development Initiatives, 2018).

There has been some progress in reducing malnutrition, but it has been too slow and not spread across all its forms meaning that projections for the next 20 years are threatening. The prevalence of overweight, obesity and diet-related NCD such as diabetes are increasing in all regions and most rapidly in LI and

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Map 11: Malnutrition burden across countries.
Data source: Development Initiative, 2018 GlobalNutritionreport.org.

LMI countries. For example, for sub-Saharan African men, the growth rate of overweight and obesity now exceeds that for underweight and projections of these indicators suggest the situation is going to get much worse by 2030 (NCD-RisC, 2016). In 2017, there were 425 million adults with diabetes in the world, four in five living in LI and LMI countries. The projection is that 630 million adults in the world will be affected by diabetes by 2045 (IDF, 2017). Obesity contributes to an increase in chronic NCD, including diabetes and hypertension, which is why the World Health Organization is calling on countries to phase out artificial trans fats by 2023³.

Consequences of malnutrition are huge

The consequences of undernutrition are severe as it is linked to 45 percent of the mortality in children under the age of five (Black *et al.*, 2013). In addition to affecting survival, undernutrition in childhood affects growth, development, health and educational and economic outcomes. It has lasting effects on following generations, hampering the human capital of countries and is a risk factor for overweight and NCD in later life (Branca *et al.*, 2019).

NCD were responsible for 41 million deaths (71 percent of all deaths) in 2016 (Branca *et al.*, 2019). Approximately 4 million people aged between 20 and

79 died from diabetes in 2017. Diabetes accounted for 11 percent of the global all-cause mortality among people in this age group. This is higher than the combined number of deaths from infectious diseases. In Africa, 77 percent of all deaths due to diabetes occurred before the age of 60 (IDF, 2017).

The economic consequences of undernutrition represent losses in gross domestic product (GDP) ranging from 3 percent to 16 percent in various African countries. Conversely, investment in stunting reduction would generate a benefit-cost ratio of 16:1 across 40 LI and LMI countries (Hoddinott, 2016). Estimates of the economic consequences of nutrition-related NCD are also large. Globally, in 2014 the total economic impact of obesity was about US \$2 trillion (Dobbs *et al.*, 2014).

Inadequate diets are the major drivers of all forms of malnutrition

All forms of malnutrition have several drivers, including non-food related causes, but inadequate diets are common to all of them. The last global study estimated that a change towards healthy diets would save 11 million deaths per year (Willett *et al.*, 2019).

Food production has benefitted from massive progress and change over the past century. Hunger (insufficient caloric intake) and undernutrition are no

3. *The New York Times*. Page A20 of the New York edition with the headline: Making Trans Fats History. May 14, 2014

longer a problem of supply but a question of uneven distribution at the global or local levels. The average global food supply reached 2,904 kcal/cap/day in 2015-17, compared to 2,196 kcal/cap/day in 1961. Despite this steady rise, progress in universal access to food is still too low: today there are still 820 million people who lack access to the minimum caloric intake needed to maintain a productive life. Most people suffering from undernourishment are the rural poor and live in South-East Asia, although the prevalence of undernourishment remains highest in sub-Saharan Africa.

Simultaneous to progress in food production, LI and LMI countries have witnessed an unprecedented demographic transition, which was at the origin of the speedy nutritional transition in the global South (Popkin, 2006). Economic development, globalisation of trade and urbanisation, along with a decrease in the relative price of many foods, first helped improve access to higher quantities and diversity of food. However, today increased production of processed food, aggressive marketing and changing lifestyles have led to a shift in dietary patterns.

With urbanisation and economic development, demand is growing for more processed and convenient food, street food and fast food. Many people in LI and LMI countries have access to cheap and empty calories, particularly in the form of ultra-processed food, while the availability and affordability of nutrient-rich food is too low. Many processed products contain high levels of added sugar, salt, fat

and other additives that could lead to NCD and death if consumed in large quantities. Taken together, the consumption of both healthy and unhealthy food items increased between 1990 and 2010, but the latter outpaced the former in most regions (Imamura *et al.*, 2015).

Beyond this threatening global picture, local diets and trends vary considerably across countries. For example, the consumption of sugar-sweetened beverages exceeds 400 g/cap/day in Latin America, followed closely by North America. This is in contrast to East Asia, where intakes are ten-fold lower (~40 g/cap/day). In America and Europe, consumption of red meat is excessive in terms of both the health and environmental impact. It is associated with increased risk of type 2 diabetes and coronary heart diseases. At the same time, sub-Saharan African consumers do not eat enough animal-sourced foods (Willett *et al.*, 2019).

These contrasting dietary and malnutrition patterns make it complicated to design simple and universal policies, especially when considering countries that have recently struggled to combat hunger and undernutrition and whose food systems are transitioning. However, there is a renewed and solid consensus for promoting multi-sectoral integrated approaches for transforming food systems, targeting the promotion of healthy food environments, including physical and economic access to healthy food items. ●

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CHAPTER 5.5

FOOD SAFETY RISKS

Muriel Figuié¹

SUMMARY

Foodborne diseases are responsible for 420,000 deaths each year, one-third of them in Africa. Food safety issues are usually attributed to traditional food systems, but the development of modern food systems in low-income (LI) and lower middle-income (LMI) countries brings with it new risks. The setting of private standards can counterbalance the poor capacity of States to enforce safety regulations, but can also contribute to a dual system that concentrates the flow of unsafe products on the most vulnerable section of the population. Unsafe food not only poses significant public health risks but also contributes to large food losses and insecurity, and creates barriers to trade. Dealing with it requires a multi-sectoral approach.

The heavy burden of food safety

Food safety is a major issue for LI and LMI countries. Unsafe food can be defined as food containing harmful microorganisms (bacteria, viruses, parasites etc.) or harmful amounts or combinations of substances (cyanide, aflatoxin, melamine etc.). It causes diseases ranging from diarrhoea to various cancers. It is a major issue in Africa and more broadly in LI and LMI countries (*cf. Map 12*). According to the WHO (2015), an estimated 91 million people fall ill every year in Africa after eating contaminated food (600 million worldwide), and 137,000 people die (420,000 worldwide). In Africa, this death toll is mostly related to bacterial contamination and mainly affects children under the age of five.

Data is lacking to track the trend of this burden in LI and LMI countries. We have known about some of these risks for decades, such as aflatoxin contamination (26,000 people living south of the Sahara die annually of liver cancer associated with aflatoxin exposure), but remain a major challenge (Unnevehr and Grace, 2013). Most likely, the burden of many of these risks will increase in the future. First, because exposure to food-related risks might rise. Foodborne outbreaks are mainly related to the consumption of animal products and fresh fruit and vegetables, the consumption of which is increasing as part of the dynamics of food transitions in urban settings, and simultaneously supply chains are getting longer. Furthermore, the uncontrolled industrialisation of food systems could increase the number and scale of the risk of contamination with potentially toxic substances (agrochemicals, food additives etc.). Second, vulnerability to foodborne diseases could increase with the development of antimicrobial resistance, whose impact is expected to be greatest in Africa (O'Neil, 2014).

Moreover, as shown with the problem of mycotoxins, unsafe food not only poses significant public health risks, but also contributes to major food losses (and consequently impacts food insecurity) and creates barriers to trade in agricultural commodities.

Managing food safety requires the involvement of all actors in the food chain

While a large proportion of this burden is related to general hygiene issues, including at the domestic level, other food system segments also have a large degree of responsibility. Different surveys quoted by Grace (2015) show that in LI and LMI countries a large amount of marketed foods do not meet the standards for common hazards. For example, only 6 percent of pork samples tested in Nagaland state (India) complied with standards.

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Similarly, only 2 percent of meat samples in the city of Ibadan (Nigeria) complied with standards and none of the milk samples in Assam state (India) did so. However, these hazards do not necessarily translate into risk because consumers in LI and LMI countries often use domestic risk mitigation practices that can be sufficient to deal with microbiological risks, such as boiling milk (Roesel *et al.*, 2015). However, with the development of processed foods and consumption outside the home, consumers' mitigation capacities lose efficacy (Bricas, Tchamda and Mouton, 2016) and are not adapted to the new kinds of 'industrial' risks that they have to face (for example, hormone residues in meat). The management of these new risks requires governmental control, oversight and enforcement.

However, public authorities in most LI and LMI countries have little capacity to set up and enforce safety standards. This context encourages the lack of compliance with food standards among stakeholders in food systems. The capacity to implement surveillance of foodborne outbreaks is also limited. As an example, the assessment by the World Organisation for Animal Health (OIE) of the performance of national veterinary services (based on the Performance of Veterinary Services Pathway (PVS) tool) indicates a lack of capacity in enforcing legislation in most LI and LMI².

The lack of efficient public food safety authorities in many LI and LMI countries is an opportunity for the development of private guarantees aimed at high-income populations. These guarantees rely on brands (often in relation with Western imported products) and/or a distributor, such as supermarkets. Market incentives, through export value chains and high-income consumers, contribute to a duality in safety standards. While these private initiatives can contribute to the development of safe supply chains, they may also contribute to a concentration of the flow of unsafe products to the most vulnerable section of the population, one that cannot access high value-added chains and has less access to hygiene and health services. This development signals the difficulty of many LI and LMIC countries in assuming one of the sovereign functions of the State: ensuring the safety of its population.

Improving food safety as a public health issue requires the involvement and coordination of a large range of stakeholders. Commonly, food chain stakeholders are insufficiently trained and organised to contribute to the implementation of the collective action required to improve food safety (for example, the adoption of

good practice guidelines). Consumers' associations are also too weak to protect consumers' rights to safe food and mainly focus their efforts on food prices.

Industrialisation and the lengthening of food chains pose new challenges in a context of weak regulatory authorities

As mentioned above, industrialisation and the lengthening of food chains multiplies the intermediaries and can contribute to an increase in fraud and contamination. For example, fresh milk contamination tends to increase from farms to retail shops, as shown by Yobouet *et al.* (2015) in the Republic of Côte d'Ivoire. The industrialisation of food systems, from production to distribution, brings 'new' risks such as chemical hazards related to the growing and often uncontrolled use of pesticides, veterinary drugs and food additives, whose full impact on public health may only be visible and measured in the long term (Figué *et al.*, 2019). Moreover, industrial food systems generate large amounts of waste and food packaging that contributes to environmental pollution and impacts public health. Additionally, the weak capacity for controlling food safety at the national level in LI and LMI countries encourages imports of low-quality industrialised products from the international market.

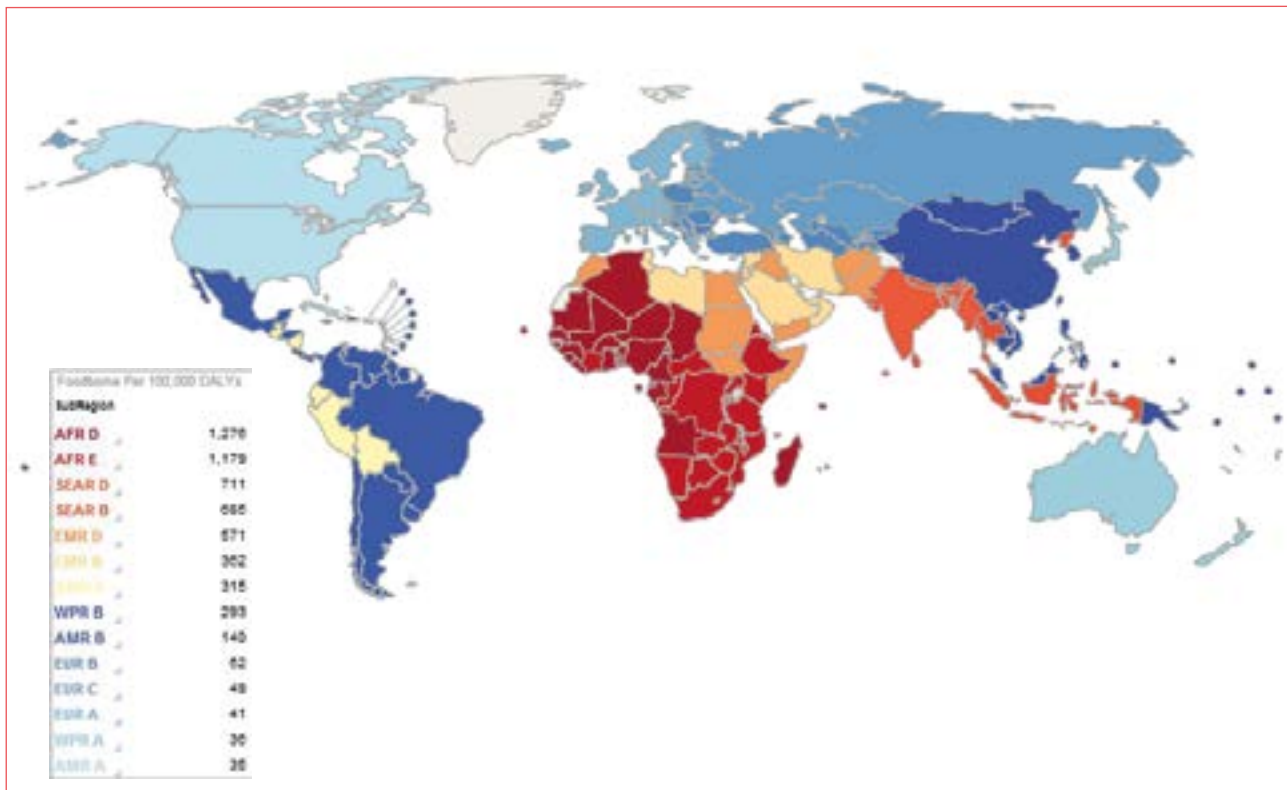
Because of the growing speed and range of food distribution, hazards and their related risks can provoke large-scale outbreaks. For example, in 2018 processed meat from a South African food factory was the source of more than 1,050 illnesses and in excess of 200 deaths, with possible spread in neighbouring countries³.

Large-scale food safety crises can also result in systemic crises, since they generate distrust towards actors in the entire food supply chain and, more broadly, towards authorities, with potentially important political and economic consequences. For example, the 2008 milk scandal in China revealed broad and fraudulent use of a harmful additive, melamine, in the milk industry. The incident was not only a major event in terms of health, with more than 300,000 victims in China, but it also revealed the corruption of many politicians and damaged the reputation of China's food exports.

This background of distrust is a breeding ground for rumours, such as the one related to fake Chinese rice

2. <http://www.oie.int/en/solidarity/pvs-pathway/>

3. <https://www.foodpoisonjournal.com/?s=africa>



Map 12: WHO estimates of the global burden of foodborne diseases.

Source: World Health Organization Map Production: Foodborne Disease Burden Epidemiology Reference Group (FERG), World Health Organization, 2015.

Hazards include diarrheal disease agents and invasive infectious disease agents (viruses, bacteria, protozoa), Helminths (cestodes, nematodes, trematodes), chemicals and toxins (cassava cyanide, dioxin, aflatoxin).

(FAO and WHO, 2018) in Africa. In December 2016, it was reported in the Nigerian media that customs officials had seized 2.5 tonnes of plastic rice. Such 'revelations' continue to make regular headlines even though no instances of 'fake' or 'plastic' rice have been substantiated by national authorities' investigations.

Conclusion

Stakeholders in food chains in many LI and LMI countries face constraints in matching the ongoing transformations in food systems with their associated risks. Most projects to improve food safety focus on supporting high-quality value chains (for example, targeting export markets or high-income consumers) (Alonso, 2019). The development of some specific high-quality and high-value chains may have a ripple effect on the quality of the whole market chain. However, it can also have a competitive effect, concentrating the distribution of poor-quality products to the poorest; the results are highly dependent on the economic context and commodities (Moustier, Anh and Figuié, 2003). But, as health is a public good and food safety

is not only a quality attribute, supporting the capacity of States to ensure the food safety quality of low-cost food available to the poorest must be a priority. Obsolete, ineffective or simply missing food safety standards, combined with a lack of enforcement, are key to this issue. And as value chains need time to adapt, establishing modern food safety standards and their enforcement needs to be done in a gradual and measured way in order to avoid an immediate food security issue. As with other challenging global health issues (for example, transboundary infectious diseases, antimicrobial resistance, environmental contamination etc.), dealing with food safety requires an inclusive and adaptive approach, which is multidisciplinary and trans-sectoral (health, agriculture, environment and trade), as suggested by the One Health approach. ●

BOX 16**FOOD SAFETY AND CONSUMER ANXIETY IN VIETNAM¹**

The improvement in agricultural production observed in Vietnam over the past 20 years has relied on an intensification of production, particularly through the increased use of chemical inputs (fertilisers, pesticides etc.). Food processing has also been industrialised, alongside the retail sector (through the development of supermarkets).

Food security has greatly improved but new food safety issues are emerging. The modernisation process in the Vietnamese food system operates in a context where authorities lack the capacity to properly monitor the sector. Checks are scarce and when they exist there is a low level of trust given the frequency of misleading information. Due to the lack of official monitoring and information, the media are the main source of information for consumers.

Indeed, local media regularly reports cases of mass poisoning. Examples of fraud, such as reconstituted powdered milk sold as fresh milk and, more dramatically, imported milk from China adulterated with melamine in 2008, are numerous. Moreover, social media is developing thanks to increased internet access and contributes not only to providing information to consumers

but also acts as an amplifier of crises and contributes to the spread of rumours (for example, artificial eggs from China sold on the markets).

This context contributes to a growing food anxiety among consumers, mainly related to the presence of chemical residues: pesticides in vegetables, hormones in meat, preservatives in processed food etc. The safety of apples has been a recent topic of concern to Vietnamese consumers. In 2012, the media reported that Chinese farmers from Yantai had coated bags for apples with prohibited toxic pesticides (Tuzet and Asomate) and arsenical fungicide. China is the principal source of apple imports in Vietnam and Vietnamese consumption of Chinese apples has been deeply affected by this revelation. Media headlined the issue of 'toxic apples' and 'toxic Chinese fruits'. Despite the problem being localised to one Chinese province, it affected trust in all apples, all fruit and then all products imported from China. This distrust remained even after the announcement that the company which had disseminated the toxic bags had been sanctioned. Consequently, Vietnamese imports of Chinese apples halved between 2009 and 2013.

1. Based on Figuié et al., 2019

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CONCLUSION OF SECTION 5

THE ELUSIVE AND UNSTABLE LINKAGES BETWEEN FOOD CONSUMPTION AND FOOD PRODUCTION

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and Hélène David-Benz¹

There is a contrast in food and nutrition security issues between the global and local levels. At a global level, production of most food products has increased faster than population growth and now exceeds the nutritional caloric average requirements. Today, the average consumption of animal products, sugar, fat products and ultra-processed foods are far too high, leading to several global pandemics (obesity, diabetes, cancers etc.) (cf. Chapter 5.4). At the same time, important food shortage threats exist at local levels, especially in Africa, and many new food safety problems have emerged in LI and LMI countries due to the rapid industrialisation of food systems, increasing consumption of animal products and poor regulation capacity (cf. Chapter 5.5).

No single and simple solution exists, and the contributions in this section shed light on the complexity of possible answers, especially with regards to production and marketing.

Solutions based mostly on trade are not desirable since relying on the international market to import food on a regular basis or during specific events will become increasingly risky. On the one hand, increasing climatic shocks, together with erratic national decisions (do not forget the numerous export bans during the 2008 crisis), are likely to make international staple food markets more unstable (cf. Chapter 5.3). On the other, there is a serious possibility that international food price trends will rise compared to their level before the 2008 food price crises (cf. Chapter 5.2).

Instabilities in food supply and food prices are also locally driven. They have serious consequences for poor consumers for whom food accounts for a large share of total household expenditure. To smooth food supplies and reduce price variations, more investments could be steered towards physical investments in LI and LMI countries, such as transport and storage infrastructure, and market regulation policies.

In LI countries, and more specifically in Africa, there is an obvious need to reduce the yield gap and improve the productivity of cropland. But health, natural resources and climate issues mean conventional intensification is questionable. Agroecological intensification is therefore considered as a possible pathway (cf. Chapter 5.1). However, the issue is controversial since the productivity of agroecological agriculture is deemed to be low and may lead to an expansion of cultivated land at the expense of tropical forests (cf. Chapter 5.2).

Technology may contribute to meeting the growing demand in an increasingly risky context if it is able to reduce production sensitivity to natural hazards (climate shocks, pests and diseases), lags in production, and transport and storage costs. Research can help the required technologies to emerge, but a significant level of investment would also be necessary. In both cases, supportive policies will be required.

However, tailoring food supply to meet the needs of a highly diverse and changing demand is only one side of the coin. On the other are public policies, which will need to contribute to driving consumption towards more sustainable and healthy diets.

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GENERAL CONCLUSION

The background is a light blue-grey color with a stylized illustration. In the center, there is a globe of the Earth. To the left of the globe is a syringe. Below the globe, there are several human figures in various poses, some appearing to be in a crowd or interacting. The overall style is flat and graphic. On the right side of the page, there is a vertical bar with segments of teal, green, yellow, and red.

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GENERAL CONCLUSION

N. Bricas¹, P. Bendjebbar¹, E. Hainzelin², S. Dury¹ and T. Giordano³

● FOOD SYSTEMS' ROLES: FROM FOOD PRODUCTION TO MULTI-PURPOSE

Until recently, food systems have been evaluated based on their capacity to ensure sufficient safe food to meet consumer food demand. At first, the main challenge for agriculture and food policy was to feed a growing population. This meant the priority was to increase agricultural production. The environmental, health and social equity effects of production, processing, trade and consumption patterns were considered externalities, side effects that were not included in performance measurement. In fact, over the past century and until now, food production has grown strongly almost everywhere in the world. Food availability has even outpaced the growth in the world's population. Food has diversified, product quality has improved and 'caloric' food insecurity has decreased, though it can still be considered too high. The planet now produces more than its nutritional needs. These findings could suggest that these ongoing trends will help to eliminate what has been known as "the world's hunger" since the 1950s.

When other food systems outcomes are considered, alongside the risks threatening these systems, three phenomena are challenging this highly optimistic projection:

- First, the future of food production is threatened by both overexploitation or depletion of resources, environmental degradation, climate change and the poverty which is still found in many rural areas. Not all of these threats are exogenous to food systems. Some development models generate or increase these threats. In contrast, other models contribute or can contribute to maintaining biodiversity, capturing carbon and managing resources more sustainably. Environmental effects can no longer be considered as an externality of food systems but have become one of its purposes.
- The second phenomenon is longstanding and was first revealed by Amartya Sen: food insecurity is more a question of access than availability. The challenge of food security is therefore not only to produce enough food but to make it accessible to all, which means combatting poverty and inequality. Again, food systems can make a significant contribution to this objective through price and income stability where stocks (savings and capital, food reserves and seed banks) can play an important role. They can also contribute through income creation. In countries where the rural population is predominant and continues to grow, these systems can play a significant role in facilitating access to food. To this end, development models for food systems should focus on job creation. They must not only create added value but, crucially, ensure it is redistributed more equitably among value chain actors, and governance models must enable the most vulnerable to better defend their interests. And it is on these economic and social functions that food system interventions must be designed and evaluated.
- The third phenomenon is nutritional transition. Although far from being eliminated, nutritional deficiencies are now coupled with excessive malnutrition and new safety risks. Again, depending on the development model, which may or may not promote sustainable, diversified and healthy diets, food systems can contribute to worsening or reducing their effects on nutrition, health and well-being and therefore a country's economic situation.

So, beyond their initial purpose of qualitative food production, food systems must also be assessed on their role in creating jobs, stabilising livelihoods, reducing inequality between stakeholders and between territories, and preserving and improving environmental integrity. The challenge is not only to reduce threats to the future of food production. The challenge is to contribute more broadly to the Sustainable Development Goals, including goals that do not directly address the issue of food security. It is about contributing more broadly to building a sustainable planet in the longer term. Assigning this plurality of purposes to food systems, as has been done with the concept of multifunctional agriculture, leads to a complete rethinking of them, a better understanding of the interconnections between their outcomes and an assessment of them across a plurality of criteria and not only their productive capacity. The way their performance and efficiency are measured must be completely revised.

● A COMBINATION OF RISKS

The steady reduction in undernutrition observed since the 1960s seems to have stalled or even gone into reverse since 2015. The number of undernourished people is increasing, both in quantity and in proportion to the world's population. Is this recent evolution accidental or does it mark the beginning of a new era? It is a difficult question to answer, but a number of findings presented in this report are worrying. They reveal that some regions of the world are now subject to a combination of risks of different kinds resulting from climate change, land degradation, collapse in biodiversity, pollution, resource depletion, epidemics, non-communicable diseases driven by unhealthy diets, new health risks, conflicts and civil insecurity, etc. Trend predictions and their consequences for food systems demonstrate a superposition and multiplication of risks in certain parts of the world, especially in LI and LMI countries. These combinations of risks are relatively new.

Some authors emphasise the relationships between droughts, climate change, displacement and conflict (Raleigh, Choi and Kniveton, 2015; Burrows and Kinney, 2016). Others underline the common causes of these risks (Mason and Lang, 2017). Such accumulations of risks bring the world into an unknown period, with levels of uncertainty that raise fears of new food crises. They invite us to go beyond sectorial approaches to risk (climate, demographics, pollution, resources, etc.). Risks cannot be analysed and addressed in isolation. Rather, a systemic approach (cf. Figure 23) is urgently needed. This may explore the effects of interactions between risks, particularly their synergistic effects, and take into account feedback effects, spillovers, tipping points and the irreversibility of vicious circles.

On the one hand, such an approach should seek to avoid crises, for example, by reducing the pace of negative drivers or by stabilising the environment. On the other hand, it should lead to developing resilience trajectories that make it possible to resist and recover from unavoidable

Dealing with risk: the need for a better assessment of resilience factors

While this study has focused on risks, further work is needed on the resilience factors in food systems, in all their components and functionalities. All societies, organisations and human communities have a greater or lesser ability to cope with unexpected events, to adapt and to transform. They have human, social, economic and diversified resources (knowledge and skills, stocks and capital, etc.) that can be mobilised to deal with shocks. People can more or less easily change their production methods or consumption patterns, migrate and share risk through solidarity systems, etc. Depending on the way they produce, exchange and consume, food systems themselves can more or less adapt to situations of instability or crisis. Assessing the risks in each situation is not enough. It is also necessary to be able to assess the resilience factors in societies and their food systems. However, paying more attention to resilience does not mean giving up on ways of mitigating risks. In its most comprehensive sense, resilience also includes the ability of societies to mitigate risks.

Assessing risks and resilience factors on a case-by-case basis

In some cases, a territorial scale analysis may be relevant. Within large countries, the risk mix can vary significantly from one region to another and between rural and urban areas. Moreover, it is at the territorial level that risk management practices and innovations implemented by stakeholders to change food systems can be identified. Recognising these capacities, evaluating their performance, identifying the obstacles to their wider implementation and supporting the development of these capacities requires a break in the way food risks are managed. To take into account the specific combinations of risk factors particular to each territory, universal solutions for a single purpose are of little interest. Such solutions are often promoted by a few large powerful actors with an economic or political vested interest. These actors tend to marginalise local actors, to neglect the capacities of the latter to mobilise their resources and invent their own solutions, often combining solutions from other territories and adapting them to local contexts. One of the ways to manage risks in food systems is therefore to also reconsider their governance. The challenge is to reconfigure the balance of power, giving more weight to those who suffer most from food insecurity and not to those who seek to benefit from it.

The potential severity of the combinations of risk to which LIC and LMIC food systems are exposed requires a change in their transformation pattern. It is not a question of replacing one model with another but rather of envisioning, with all the actors in the territories, a diversity of transformation trajectories built on new performance criteria that integrate concerns about food security, environmental integrity, job and income generation and the reduction of inequalities.

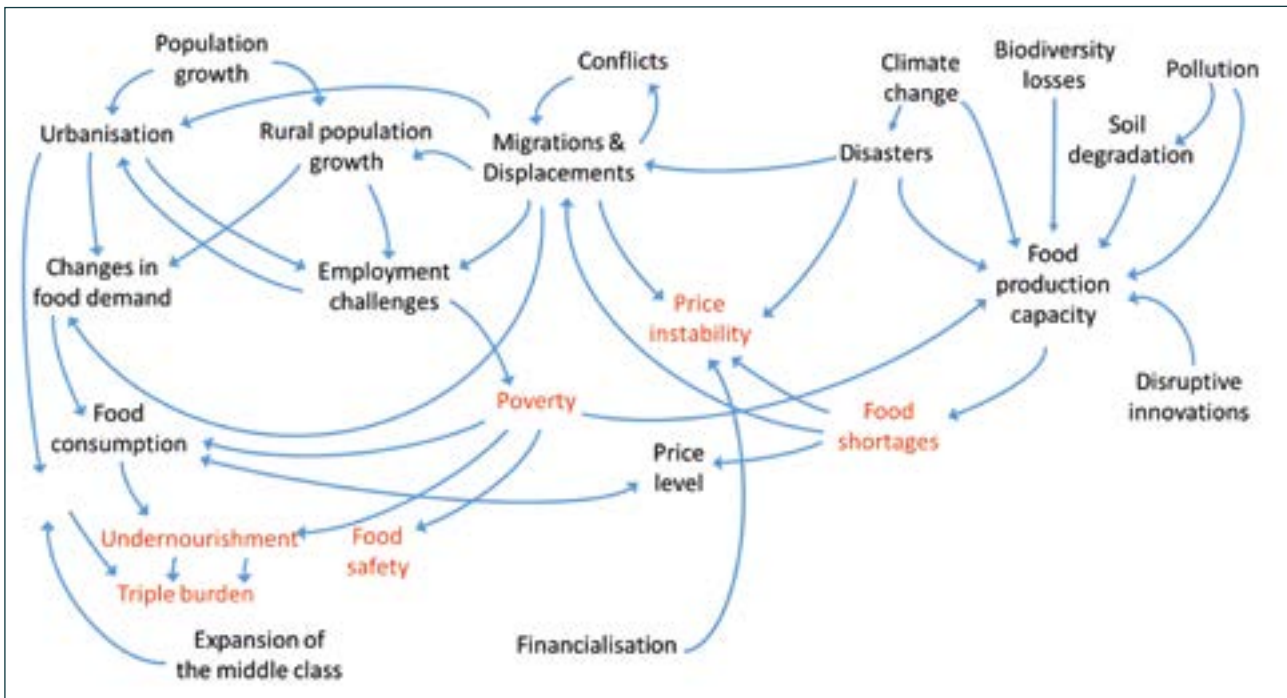
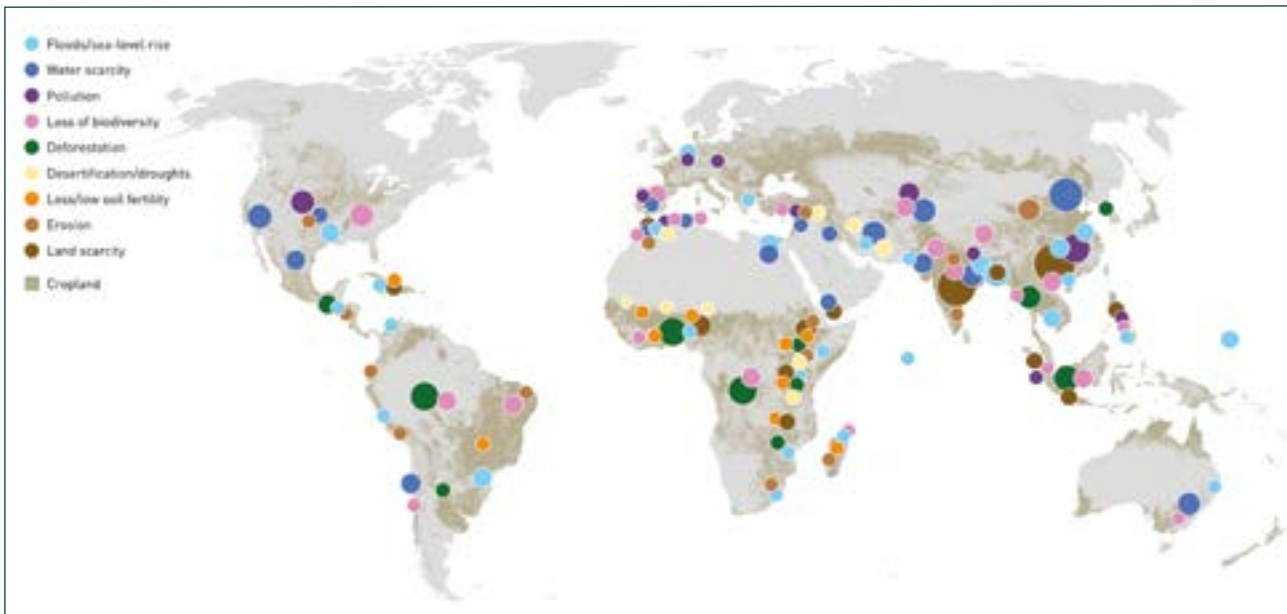


Figure 23: Food system drivers combine and generate cumulative risks.
Source: Authors.



Map 13: Schematic overview of risks associated with main agricultural production systems.
Source FAO, Fisheries and Aquaculture Department (fishery and aquaculture statistics).

● TOWARDS A COMPREHENSIVE FRAMEWORK FOR ASSESSING AND TRANSFORMING LOCAL FOOD SYSTEMS

Just as food systems face locally specific combinations of risks, they also have to meet locally specific objectives of food security and nutrition, decent job creation and inequality reduction, as well as environmental integrity. Faced with high level of uncertainties, food system actors have to anticipate. First and above all, this calls for the cooperation of key political, economic, and social actors to be fully invested in the codesign of the assessment

and future options. This calls also for the development of operational and forward-looking methods for diagnosing food systems, which fully integrate food systems' long-term contribution to environmental and socio-economic outcomes. Based on this analysis, this food system diagnosis framework must meet a set of indispensable requirements: it must be systemic (and not value chain centred) to embrace the locally specific features and combination of risks food systems face; applicable at different scales depending on inner features of food systems; dynamic to unravel past evolutions and imagine future scenarios and their main drivers; and operational to identify the potential policies, projects and programmes – and the critical stakeholders – which could radically transform food systems in the future. Such a diagnosis framework does not yet exist, but is urgently needed.

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FOOD SYSTEMS AT RISK

NEW TRENDS AND CHALLENGES

The way food systems have evolved over past decades means that they now face major risks, which in turn threaten the future of food systems themselves.

Food systems have seriously contributed to climate change, environmental destruction, overexploitation of natural resources and pollution of air, water and soils. Despite the global average improvement in calorie production and major development of the food and agricultural product markets, huge inequalities in food access and repartition of the added value have emerged, leading to new serious nutritional and social problems.

Based on a review of the most recent scientific knowledge, this report paints a gloomy picture with an emphasis on Low-Income and Lower Middle-Income countries where the population faces greater challenges than elsewhere. Different threats are adding up and there are few options to adapt or mitigate these combinations of risks.

This is a call for all those - businesses, policy makers, consumers, funding agencies - who are engaged in food systems transformations to bear in mind their systemic aspects and their multiple outcomes and risks in order to be able to fashion more sustainable and equitable food systems.

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