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AGRIMONDE-TERRA

Land Use and Food security in 2050



Agrimonde-Terra foresight: Land use and food security in 2050

Scenarios of land use and food security in 2050

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Method for building land use and food security scenarios

The objective of this paper is to describe in details the scenarios of Land use and food security in 2050 that have been built for the Agrimonde-Terra foresight.

A foresight approach based on morphological analysis was used for building scenarios. This method was chosen to highlight systemic relations, and to explore alternative futures for land use and food security in 2050.

The first step consisted of analyzing the long-term dynamics of the ‘land use and food-security’ system, with a focus on the five dimensions of land use (agronomic potential, access to land, degree of intensity of land use, distribution of land between different uses and services provided by land). By identifying a range of variables influencing each driver of the system and its dynamic of change, hypotheses on how each driver might evolve in 2050 were elaborated (presented in a Technical Report of Agrimonde-Terra; Le Mouël et al, 2016).

In the second step, scenarios were built, in close collaboration with a Scenario Advisory Committee¹, by combining one or several hypotheses per driver, respecting causal relationships, seeking consistency of the hypotheses and plausibility of the scenario. Five contrasting scenarios of land use and food security by 2050 were developed. They are based on a morphological table presented below, with each line devoted to a driver. Within a line, each cell contains one of the hypotheses for the future of the concerned driver.

Figure 1: Drivers of land use and food security and alternative assumptions for 2050

Drivers		Alternative assumptions for 2050					
Global Context		Sustainable and cooperative world	Regionalization and energy transition	Economic and political fragmentation	Conventional development by market forces	Non-State actors	
	Climate Change	Stabilization of global warming		Moderate warming	Runaway climate change		
		Food Diets	Transition to diets based on ultra-processed products	Transition to diets based on animal products	Healthy diets based on food diversity	Regional diversity of diets and food systems	
Urban – Rural Relationships	Large metropolitan region		Multilocal and multi-active households in rural-urban archipelagos	Rural areas integrated within urban networks through value chains		Urban fragmentation and counter-urbanization	
	Farm Structures	Marginalized farms for a livelihood survival	Hit-and-run strategy for agro-investment	Independent farms but commercial dependency	Farms producing goods and services to surrounding community	Agricultural cooperatives emphasizing quality	Resilient farms embedded in urban processes
		Livestock Systems	Backyard livestock	Conventional intensive livestock with local resources	Conventional intensive livestock with imported resources	Agro-ecological live-stock on land in synergy with agriculture or urbanization	
	Cropping Systems		Collapse of cropping systems		Conventional intensification	Sustainable intensification	Agro-ecology

The scenarios are based on major trends, weak signals and potential breaks affecting the drivers of the system and explore their impacts on land use and food security. Each scenario is built as a specific combination of hypotheses.

¹ The Scenario Advisory Committee was composed by : A. Andersson Djurfeldt (LundUniversity), L. Ben Becher (Synagri), M. Elloumi (Inrat, Tunisia), A. Faye (IPAR), R. Guissou/Y. G. Bazie (Ministry of Agriculture and Food Security, Burkina Faso), H. Kray (World Bank), J. Lewis (Terra Global Capital), P. Meyfroidt (Louvain University), M. Mueller (FAO), S. Msangui (IFPRI), A. Onorati (International Planning Committee on Food Sovereignty), S. Parmentier (Oxfam), A. Retière (Cap 2100), R. Sonnino (Cardiff University), S. Treyer (IDDRI), D. van der Mensbrugge (Purdue University), J. Vervoort (Oxford University), H. Zehni (IFAD)

The first three scenarios are based on current trends identified in most regions of the world. The first (“Land use drive by metropolisation”) links the development of megacities at a global level with a nutrition transition led by global agri-food companies selling ultra-processed foods, in a global context of development through market force and rapid climate change, leading to the marginalizing of small farmers. The second (“Land use for regional food systems”) relates the increase of medium-size cities and their networking with rural areas to the emergence of regional food systems based on traditional foods, family farming and a set of regional agreements. The third scenario (“Land use for multi-active and mobile households”) links strong individual mobility between rural and urban areas and a development of non-farm employment to the emergence of hybrid diet based on traditional and modern value chains, in an globalized world where family farms and cooperatives are majors actors in land use. The last two scenarios involve potential breaks that could change the entire system. The fourth scenario (“Land use for food quality and healthy nutrition”) assume that due to the increasing cost of malnutrition, a radical move towards healthy diets occur fuelled by global cooperation and public policies, in a context of climate change stabilization, involving a re-configuration of agricultural systems backed by new alliances between stakeholders. The fifth scenario (“Land as commons for rural communities in a fragmented world”) assume that in a context of repeating multiple crises, development based on small towns and rural communities occurs, focusing on managing common property in agriculture in order to ensure food security.

The quantitative impacts of the scenarios in terms of land use, agricultural production and trade in the 14 regions under consideration and at the world level have been assessed through simulations conducted with the biomass balance model GlobAgri-AgT (presented in a Technical Report; Le Mouël et al, 2016).

The five scenarios of land use and food security in 2050 are fully described below through some keywords, an abstract, a combination of hypotheses, a narrative description of direct and external drivers and their impacts on the five dimension of land use and on the four dimension of the food and nutrition security (availability, access, utilization, stability).

Land use driven by metropolization

Key words: *metropolization, megacities, international trade, modern value chains, agri-food companies, spatial divide, animal-based and ultra-processed foods, diet-related non-communicable diseases, double burden, dual agriculture*

Overview

By 2050, two-thirds of the world's population live in cities and more than 15% of the urban population lives in megacities (over 10 million inhabitants)². Urbanization is part of global economic growth, which emerges out of conventional development. The world economy is built upon a network of "global cities" in which most of the activities and jobs are located. Value creation within these megacities is mainly based on the concentration of activities in services, industry, knowledge and finance. Urban growth is fuelled by high levels of internal migration from rural areas. While environmental concerns have taken a back seat with the emphasis on conventional development, climate change has significant effects, especially in agriculture.

Processing, retailing and wholesaling transnational corporations control the greater part of food markets in both urban and rural areas. They provide the connections between rural production sites and mainly urban consumption zones. Two dynamics in diet change are occurring: one driven by the expansion of globalized value chains providing low-price ultra-processed foods, and one supported by the major consumption of animal products, meat in particular, based on the increasing demand of an emerging middle class. Compared to 2010, diets in 2050 are higher in edible plant oils, refined cereals, sugars and sweeteners (through soft drinks), salt and animal products (including processed meat fats) and lower in coarse grains and pulses.

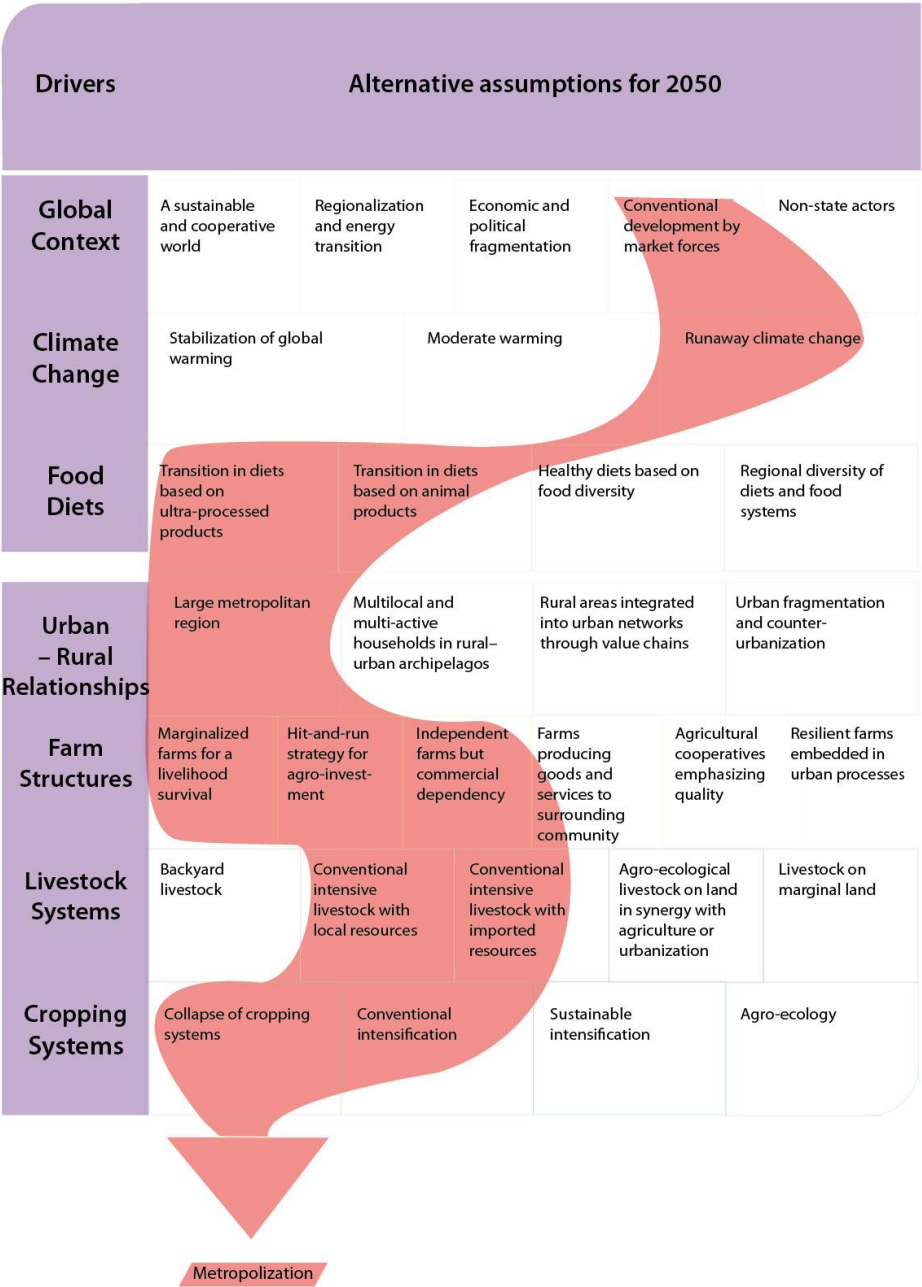
Intensive conventional agriculture based on a high level of inputs has developed via private capital from investment funds, companies, and the urban middle class. They invested in production areas tightly linked to urban food markets, in specific and specialized regions, which can be remote. Agricultural production only takes account of environmental issues after the fact (end-of-pipe), leading to severe soil degradation, entailing the displacement of agricultural areas (to select land best suited to this form of intensification) and greenhouse gas emissions. The emergence of global interlinked urban archipelagos has excluded vast expanses of the world from economic growth. In rural areas distant from large cities, which are difficult to access and isolated from global markets, poor farmers seek to carry on their farming practices in arduous economic and environmental conditions (degraded soil, unsecure access to land, poor access to water and to markets).

As a result of the evolution of the food system, unhealthy diets developed in lower and middle classes, leading to a dramatic increase in diet-related non-communicable diseases in developed and developing countries, while growing inequalities within urban areas and between urban and rural areas have led to problems of undernutrition. The dynamic of the global food system led to an international specialization in production with Brazil/Argentina and North America doubling or tripling their exports, and the Former Soviet Union and EU 27 increasing their exports, with the Rest of Asia increasing both exports and imports. Other regions became highly dependent with imports tripling in West Africa, East, Central and South Africa (ECS Africa), North Africa and the Near and Middle East, and even bigger increase in India. Both importing and exporting regions (except China) experience an increasing pressure on arable land and the most significant pressure on pasture arises in ECS Africa. Here, diet type is of major significance for land pressure as the ones based on animal products put much more pressure on land compared to diets based on ultra-processed food goods. Despite the increase in global trade and because of strong pressure on agricultural land, the considerable impact of climate change on

² United Nations (2015). *World Urbanization Prospects: The 2014 Revision*, (ST/ESA/SER.A/366).

agricultural production has made the food supply system more vulnerable, triggering occasional food crises, especially for low-income households.

Figure 2: Combination of assumptions describing the “Metropolization” scenario



Description of the scenario

In 2050, global urbanization has resulted in an overwhelming concentration of population and activities within large cities. These megacities and their regions have become highly attractive for rural and international migrants in search of employment. Most of these megacities have surged since 2015 in developing countries. This process of metropolization driven by the intensification and globalization of financial flows and also flows of products, information and people, coupled with the emergence of higher-level service-sector functions, has created a large middle class around the world. Metropolization has driven the spatial expansion of peri-urban areas resulting, in the case of the megacities, in the emergence of large urban regions, referred to as “mega-

regions”³. More generally, these urbanization processes have given rise to highly uneven spatial development and marked spatial divides, with many rural areas left out of development processes.

Speedy urbanization has deeply transformed lifestyles and diet behaviour patterns. Out-of-home consumption and snacking have risen. The food supply environment which is now in the hands of large-scale retailers was also transformed. A dominant middle class has driven rapid growth in consumption of animal-based and ultra-processed products⁴ which are also widely consumed by the most disadvantaged members of the population. Agri-food and retail multinationals have played a key role in this food transition fuelled by foreign direct investment, marketing and advertising, and supported by logistics infrastructures, distribution networks and digital platforms. By adapting their strategy to the economic context of developing countries, these companies have reshaped their food offering, distributing low-priced, ultra-processed products in place of more traditional foods. They source their raw materials in geographically remote agricultural production regions with which they are linked by highly efficient transport systems. Modernization of value chains, with investments in logistics and storage facilities, combined with raised technological level of agri-food activities, have brought efficiency gains in the supply-side chain, as well as cutting losses and waste, thanks to improved use of by-products and industrial and agricultural waste.

Global food supply of plant-based products is mainly structured around four agricultural products: rice, corn, wheat and soya beans. They are the first link within a value chain in which they undergo multiple transformations (“cracking”) or are incorporated into ready-made dishes, being converted along the way into ultra-processed products. These developments generated narrow diets based on a small number of agricultural products and have driven worldwide production towards increasingly uniform commodities. Agriculture has become highly specialized within broad regions, although this specialization remains fragile on account of the considerable effects of climate change, and instability prevails on international markets (price volatility).

Livestock and cropping systems have become highly intensified, drawing on technical and genetic innovation. Livestock systems are now dominated by intensive farming of monogastrics, using animal feed from outside the production system. These activities are often located near cities (e.g. dairy farms) or ports. Cropping systems have been simplified. They are now intensive systems with standardized products and techniques. The specialization of production has often brought high yields per hectare, thanks to the use of agro-industrial inputs, improved seed and increased mechanization. The specialization of production areas, meanwhile, combined with the concentration of population in urban areas, has allowed an increase in farming structure sizes in developing countries, leading some regions to develop mechanization and achieve sustained growth in output per worker. Due to a reduction in cultivated biodiversity and the impacts of agricultural intensification on the environment, these systems are vulnerable and have low levels of resilience to climate change. Yields show high levels of variability in regions in which climate change is particularly pronounced and in those places where irrigation systems are not enough to offset drought problems.

The trend among farming structures is towards integration and contract farming with agri-food players on international markets. These agricultural projects are capital-intensive, with agricultural development brokers negotiating with investment funds or the urban bourgeoisie to get the resources to finance production, entering into contracts with landowners for the land they need, and calling in service providers to carry out the work. Many farmer organizations are reliant on their relations with an agri-food processing company or a go-between. These structures must therefore deal with a small number of major intermediation operators on agricultural markets.

Alongside these integrated systems, small-scale farming nevertheless persists, as isolated structures in remote rural areas with poor access to transportation infrastructure. They are generally capital-poor, family-run farms

³ McGee T. G. (2009). The Spatiality of Urbanization: The Policy Challenges of Mega-Urban and Desakota Regions of Southeast Asia, UNU-IAS Working Paper N°161, 40 p.

⁴ Monteiro C.A., Moubarac J.C., Cannon G., Ng S.W. and Popkin B. (2013). Ultra-processed products are becoming dominant in the global food system. *Obesity Review* 14 (Suppl. 2): 21–28.

that are not integrated into an economic fabric in which to market their products. They are also located on degraded, non-competitive land where mechanization is more difficult. They have low investment capacity and are excluded from development policies. In developing countries, production in these areas tends to be consumed by the farming household without however entirely meeting their dietary needs.

Agronomic potential of land

As a consequence of significant climate change since 2010 (+2°C), the potential cultivable land area has increased by about 600 Mha by 2100⁵ (+120 Mha for moderately suitable to very suitable lands by 2050). This increase is unevenly distributed, however. It mainly concerns Northern regions, while arable land has shrunk in tropical areas. Most of the additional cultivable area is made up of non-competitive land that is marginally suitable. As a result of this, the average quality of the potentially cultivable land has decreased significantly.

The combined effects of agricultural activities and climate change have accelerated degradation of farm land cultivated in 2015, both for arable land and pastures.⁶ The intensification of conventional agriculture has increased physical disruption of the soil through increasingly-frequent ploughing of larger surface areas, causing organic carbon losses. There are also some regions where rising temperatures have increased the speed of carbon mineralization in soils. The absence of policies to preserve soil organic matter as well as the conversion of wetlands into arable land, have resulted in severe soil degradation, particularly in arid and semi-arid areas. By 2030, soil degradation of agricultural area has affected 225 Mha⁷. Latin America and Sub-Saharan Africa have been hit particularly hard by land degradation, with almost 50% of the agricultural land in Latin America having been affected by desertification since 2015⁸.

Distribution of land between different uses

Land use trends have shown a marked increase in pasture and in crops areas.

Due to tight resources and the absence of regulation, the development of livestock farming has been a frequent source of tensions over land use. Among other things, it has led to considerable deforestation in favour of arable land (cereals and fodder) and pastures. Production of monogastrics has often been relocated in order to reduce the distance from large urban markets where their output is consumed.

The development of crop farming has also generated severe tensions over water between agricultural uses (irrigation) and domestic consumption by residents in the large cities.

Market developments and the contrasting impacts of climate change have led to significant relocations of certain crops, in particular perennial fruit trees (e.g. coffee in Sub-Saharan Africa) and certain field crops (e.g. soya beans in Latin America). These transfers have driven a redistribution of land uses within regions and between different regions around the world.

In parallel, urbanized areas have grown by 121 Mha by 2030⁹. 80% of this urban growth has been on existing farmland. It is in the developing countries that competition over land has been the most severe by 2050, due to the burgeoning growth of cities, with these countries representing 90% of the additional urbanized land area¹⁰. Half of this urban expansion has been in Asia, with China and India representing 55% of the regional total. In

⁵ Zabel F., Putzenlechner B., Mauser W. (2014). Global agricultural land resources – A high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. *PLoS ONE* 9(9): e107522.

⁶ 12 million hectares of land are lost each year; 1/3 of arable land has been lost in the space of 40 years (FAO, 2011).

⁷ Scherr S. (1999). Soil Degradation: A Threat to Developing-Country Food Security by 2020? *Food, Agriculture and the Environment Discussion Paper: 63*. International Food Policy Research Institute. Washington, D.C.

⁸ IFAD (2010). Desertification, Rome: International Fund for Agricultural Development.

⁹ Seto K.C., Güneralp B., Hutyra L.R., (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *PNAS* 109: 7687–7692.

¹⁰ FAO (2011). The state of the world's land and water resources for food and agriculture (SOLAW) - Managing systems at risk, Food and Agriculture Organization of the United Nations, Earthscan, Rome.

China, this expansion has taken place along a 1,800km coastal urban corridor stretching from Hangzhou to Shenyang, while it has been concentrated around the state capitals in India. Urban growth has been rapid in Africa, more particularly in the Nile Delta, West Africa (coastal areas) and the Gulf of Guinea, around the Great Lakes in Kenya, Uganda, Rwanda and Burundi, and also in Nigeria and Ethiopia.

Growth in energy biomass production has been weak, against a backdrop of market liberalization and near-absence of public policies. Out of a total of 60EJ produced worldwide, half comes from farming residues and the other half from lignocellulose fuel crops.

Access to land

Land tenure is secured by legislative systems but access to land does still vary among farmers. In most regions, land tenure systems have evolved towards land markets more liquid and open to investment. There is now little risk of expropriation, while the development of transport infrastructures has opened up the possibility of developing land that was inaccessible hitherto. In certain regions, entrepreneurial agriculture has developed, based on family-run structures and on external capital (lending). In parallel, it is now easy for international and urban investors (businesses and the urban middle classes) to buy and sell land in areas of high agricultural potential, moving from one region to another depending on the farming potential of the land and trends in demand. Such activities which were previously criticized as being land-grabbing, now constitute a profitable, low-risk investment. These actors have a mining-type relationship with agricultural land resources, however, and may engage in speculative investments.

For small farmers suffering from difficult market access and a lack of capital, it is difficult to stabilize their use of agricultural land. They are forced to seek refuge on cheap, isolated land that is often degraded and where they engage in subsistence agriculture in places that are particularly sensitive to climate change. In this way, a dual system has now taken shape with the coexistence of large farm structures on good-quality soils and small, family-run structures on non-competitive land.

In the urbanized mega-regions, however, urbanization processes create great instability in agricultural real estate and in farming land use.

Degree of intensity of land use

Under the effects of climate change, taking a world average and excluding the intensification of farming systems that has occurred over the period, the potential yields of crops have decreased since 2015, by 13% for wheat, 14% for corn, 16% for rice, 30% for soya beans and 21% for groundnuts¹¹. Extreme weather events (heatwaves, flooding, etc.) are also becoming more frequent, causing increased variability in crop yields from one year to the next.

Intensification and technical innovation processes have partly offset the fall that was once expected in yields. The marked intensification of agriculture, and the systematic use of inputs, enhanced seed, irrigation and precision technologies it has brought with it, has succeeded in boosting yields in places where technological intensification levels were previously low. It is therefore the countries where there was a wide yield gap in 2015 that have increased their yields sharply, while countries with a small yield gap have seen their yields level out. However, these intensification processes have not concerned those rural areas that are excluded from development on account of their isolation or their lack of connections with international markets.

Faced with the effects of climate change, a race has started to find new resources (new varieties, new molecules, etc.) and develop cropping systems that are adapted to these changes. The increasing frequency of extreme climatic events has also resulted in lower yields and input efficiency in some regions. In some

¹¹ Müller C., Robertson R.D. (2014). Projecting future crop productivity for global economic modeling. *Agricultural Economics* 45: 37–50.

intensively cultivated regions, cropping systems have collapsed under the effect of climate change, causing some areas to be abandoned while others have been put into cultivation.

Livestock systems have also become more intensive due to changes in animal feed and the improved genetics of breeds. For reasons of efficiency, it is mainly monogastric livestock systems (e.g. chicken) that have developed, using cereals and agricultural by-products (e.g. oil cake, spent grains....) from international markets as animal feed. Ruminant farms are divided between highly-intensive feedlots located near consumption markets on the one hand, and extensive systems making use of non-cultivable grasslands. However, outbreaks of diseases are more frequent due to climate change and sometimes destabilize these systems.

In those areas that are cut off from urban development, agricultural intensification remains weak in the absence of investment capital and due to difficult access to inputs and markets.

Services provided by the land

All the regulating services are affected by the rise in agricultural production and the expansion of urban areas. The main consequences of changes in land use and artificialization include local climate change (heat islands, lower rainfall, etc.), an increase in soil erosion and a reduction in soil water retention capacity, thus aggravating the effects of climate change. Increase arable land and grassland areas at the expense of natural areas and forests cause considerable organic carbon losses and emissions, as does the conversion of pastures into arable land.

Provisioning services are particularly affected by climate change. Agricultural over-exploitation also causes soil depletion, while generating pollution that affects drinking water resources. The specialization of agricultural production and the move towards more homogeneous practices are reducing the genetic diversity of plant, animal and fish species.

Cultural services are also significantly impacted. In a world dominated by economic concerns, natural and protected spaces are gradually shrinking, giving way to exploitation for agricultural or energy purposes. The rise in eco-tourism has slowed due to the low level of interest in environmental issues. Ecosystem diversity and amenities are being reduced due to uniformization, over-exploitation and the impacts of climate change.

The multifunctionality of land uses is not considered important. Landscapes are simplified and specialized. Vast areas are dedicated either to foodstuff and livestock feed production, or to nature conservation. There is a pronounced spatial segregation of functions, thereby reducing ecosystem resilience. Finally, agricultural land use contributes little to rural development, due to the decline in agricultural employment since 2015.

Food and nutrition security

There has been a general increase in food availability thanks to agricultural intensification and modern value chains. On average, developing countries have seen a rise in food availability thanks to highly efficient production sectors.

However, against a backdrop of severe climate change, low-resilience agricultural systems with poor biodiversity, high technical content and a great reliance on international markets are generating high variability in output in the different regions. Due to interdependency of the markets and the importance of world trade dominated by a small number of operators, there is high volatility in foodstuff prices, thereby making access to food unreliable for the most vulnerable populations (e.g. the consequences of drought in a region affect the whole of the system).

There are multiple effects of urbanization on food and nutrition security. They depend on the ability of large cities to generate jobs and boost incomes. On this point, the megacities are not all on an equal footing. On account of a series of cultural, social and institutional factors (education levels, infrastructure quality, integration into the world market, etc.), some regions are succeeding better than others in the transition of

their economy towards urbanized secondary and tertiary sectors. Intra-urban inequalities in food access are compounded by inter-urban inequalities in growth in non-farming sectors.

As a general rule, thanks to the rising incomes driven by urbanization, disadvantaged populations have seen an improvement in their access to food (thanks to cheap calories). However, the limited diversity of affordable food for low incomes leads to occasional phenomena of micronutrient deficiencies. With the fast pace of urbanization, food inequalities are also widening within cities: wealthier urban populations have access to a more diversified diet and are therefore seeing an improvement in the nutritional quality of their diet, while the more disadvantaged urban populations, especially in slums, have a tendency to consume cheap, energy-dense foods that have negative nutritional effects¹².

Changes in diet combined with levels of physical activity that are on average 10% lower among city-dwellers than among rural inhabitants, significantly impact public health. The development of non-communicable diet-related diseases is a consequence of the nutrition and diet transition in urban areas. A rapid rise in overweight and obesity rates in all the developed countries was followed, between 2015 and 2050, by an increase of non-communicable diet-related diseases, in the wake of changes in diet. On a worldwide basis, food is made up of 60% of processed and ultra-processed products and contains large quantities of “empty” calories, which is to say calories providing only a small amount of micro-nutrients. Changes in eating patterns have led to a sharp increase in obesity, type-2 diabetes, cardio-vascular diseases and cancers in particular in developing countries. In 2020, non-communicable diseases, mostly related to diet, represented two-thirds of the world morbidity burden¹³. By 2030, almost 59% of the world population was obese or overweight (against 33% in 2005)¹⁴.

Finally, the divide between large cities and rural areas has had significant effects on food and nutrition security. In disconnected rural areas, it has made access to food markets difficult and caused phenomena of poverty-related undernutrition. In addition to this, small farmers who often work non-competitive land are particularly exposed to climate risks, thereby increasing risks of undernutrition.

How did we get there?

In 2050, the population has continued to concentrate in major urban centres, in particular in coastal areas and in developing countries. This metropolization process has been driven by intensification of international trade, concentration of activities in megacities and strong technical innovation. Economic growth in the emerging countries continued at a fast pace over the period 2015-2030. Low-cost fossil fuels (oil and coal) allowed industry and services to develop, creating jobs in large numbers. To achieve these results, an alliance was formed gradually between a number of multinational companies and investment funds on the one hand, and the UN, Bretton Woods institutions and WTO on the other. The former, thanks to their influence and finances, gradually brought the principles and objectives of the international institutions into line with their own. They convinced them to lower trade barriers in order to foster international trade and favour foreign investment in the agricultural, mining and industrial sectors of countries in the southern hemisphere, as well as in cleaning up their environment. Worldwide agreements on international trade were introduced, backed by harmonization of product standards in line with criteria that were far from stringent. The prevailing free-market principles gradually weakened States which began to restrict the exercise of their functions to their powers of government, without seeking to build checks and balances vis-à-vis international institutions, corporations and emerging large cities. They have fostered growth in consumption and worldwide trade as a way of avoiding social tensions.

¹² Drewnowski A. (2009). Obesity, diets, and social inequalities. *Nutrition Review* 67(S1):36–39.

¹³ Chopra M, Galbraith S, Darnton-Hill I. (2002). A global response to a global problem: the epidemic of overnutrition. *Bulletin of the World Health Organization* 80:952-8.

¹⁴ Kelly TN, Yang W, Chen C-S, Reynolds K, He J. (2005). Global burden of obesity in 2005 and projections to 2030. *International journal of obesity* 32(9):1431-7.

Metropolization processes around the world have buoyed global economic growth and led, in spatial terms, to the emergence of heterogeneous urbanized areas, with a mosaic of urban centres and peri-urban areas where some agricultural spaces and neglected areas still remain. Due to the rapid pace of urbanization fed by rural and international migration, urban mega-regions have emerged in the developing nations. In these large regions, tensions over resources and competition for the use of land are high, while the constant extension of infrastructures, housing and enterprise areas is continually pushing agriculture further out onto the urban fringes. Although they are often cut off from the rural areas within their own national space, these megacities are sometimes connected by international trade to rural areas which are very remote, making the most of low transport costs. Agricultural activities are therefore located in specialized areas on an international scale, although some farming spaces do still survive within the large urban regions (high-value-added produce for city-dwellers). The general decline in agricultural employment in rural areas is mainly linked to migration from these areas towards the large urban areas, and to the increase in labour productivity in agricultural areas. The food strategies of urban and rural households are based on the purchase of foodstuffs via national or international markets. Everywhere, intense urbanization has generated greater uniformity in lifestyles dominated by the principles of consumption, while territorial and family solidarity are weakening.

The food transition has been driven jointly by urbanization-related lifestyle changes and improved income levels with the emergence of a middle class, as well as by a modification of food supply. We have seen a fast-moving convergence in diets around the world and a sharp rise in daily calorie intake. Urban lifestyles have led to the development of out-of-home catering (restaurants, snacking products, sodas) and a decline in the meals taken at home (development of ready meals). The agri-food, logistics and distribution multinationals established themselves quickly on food markets in the developing countries and they have dominated worldwide food supply since 2030. By reconfiguring the product offering, they have redefined the diet of individuals in both urban and rural areas. In the developing countries, thousands of family-run, small-scale companies continue to exist alongside these large corporations. This concentration among actors has also increased in the seed, chemical input and farm machinery sectors, thereby reshaping not only agriculture, but also the whole food system.

The world's economies remain highly reliant on fossil fuels, while a low level of concern for environmental issues prevails. Internationally, climate negotiations have not succeeded, due to the opposition of the countries that produce fossil fuels and a lack of determination on the part of the main greenhouse gas emitters. On the local, national and regional levels, grassroots initiatives are not enough to counterbalance the influence of the oil companies and mining conglomerates, and the belief that technical progress can mitigate the impacts of global changes (GMO, geo-engineering, etc.). Fossil fuel availability remains high, thanks to the exploitation of oil shale, fossil fuel reserves in the Arctic and Antarctic and deep-sea drilling. The energy mix has therefore remained focused on oil, gas and coal. In order to avoid disrupting economic growth, no efforts were made on carbon sequestration until the mid-2030s, except for a few injections of CO₂ into depleted oil or gas well, initiatives that were no more than symbolic but did attract wide media coverage. Emissions of CO₂ and other gases have continued to grow. Economic competition between States has prevented climate negotiations from establishing an effective carbon market.

In 2050, per capita GDP is \$24,000 (WEC - Jazz scenario¹⁵) and the resource-intensity of GDP is high. Total energy consumption stands at 879 EJ (against 546 EJ in 2010).

In the face of the local and global environmental issues generated by human activity, confidence in the ability of science to resolve and overcome the problems was previously high. Research focused on industrial efficiency, on decoupling production and resources by enhanced efficiency, on recycling and on a continuous reduction in the amount of waste that could not be re-used. The preference was given to technological innovations that could be privatized. Technological progress, meanwhile, made it possible to contain the

¹⁵ World Energy Council 2013, *World Energy Scenarios: Composing Energy Futures to 2050*, London.

increase in the cost of extracting fossil fuels. Generally speaking, technological progress led to intensive use of rare earth and high-tech metals. Convergence between various technologies did allow considerable progress, but at the price of a number of accidents with serious effects on health and the environment.

In the years just preceding 2050, however, there were increasing numbers of environmental, economic, health and social catastrophes. Energy prices rose sharply as conventional oil and then gas resources became increasingly rare. Tensions rose over water with urbanization, the extension of industrial uses and the increased frequency of extreme climate phenomena. Reserves of phosphate and rare metals with low extraction costs became depleted, meanwhile. Public health deteriorated sharply due to pollution and, most importantly, imbalanced diets with excessive intake of fat, sugar and animal proteins.

Land use for regional food systems

Keywords: *regionalization, supranational regional blocs, traditional and hybrid diets, food systems, food crops, food sovereignty and subsidiarity, regional association of production and consumption*

Overview

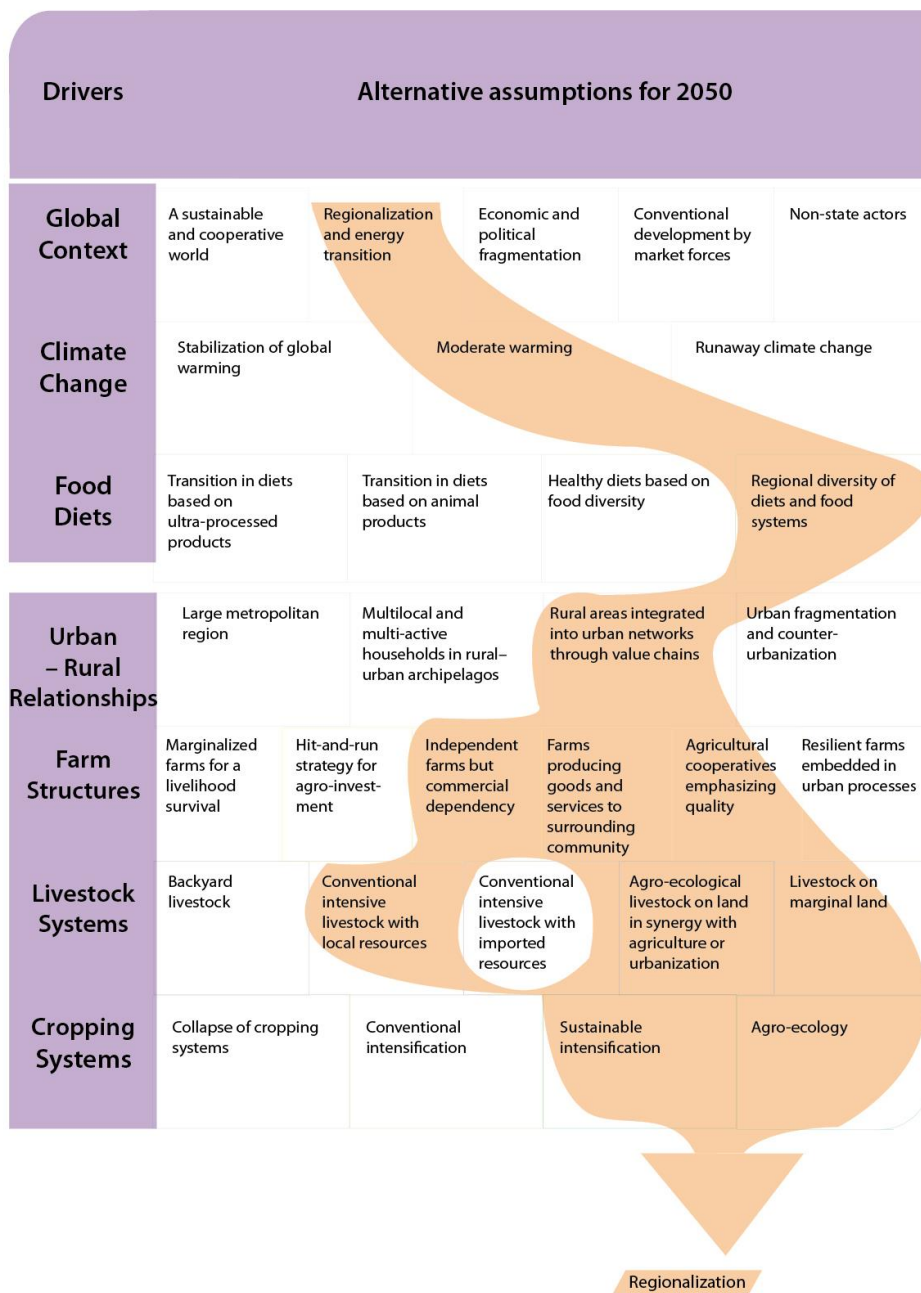
By 2050, States have joined to form supranational regional blocs. Political and economic governance in regional blocs arose as a way to address a series of issues such as financial crises, unemployment, pollution and high rates of diet-related non-communicable diseases. This led to a shift in urbanization from large cities to medium-size cities and small towns. The latter became part of the regional development process playing a significant role as intermediates between rural areas and larger cities. Within these blocs, States are managing energy transition and improving food diversity. They seek greater energy autonomy by increasing the production of renewable energy and by using regionally available fossil fuel resources.

Regional blocs shaped food systems by investing preferentially in traditional regional foods and by reconnecting the food industry to regional production. Regions applied the concept of “food sovereignty and subsidiarity”, wherein as much food as possible is produced within the region and recourse to imported products is only made when regional production is not sufficient (such as in North Africa and the Near and Middle East). This process involved major changes in land use in regions where agriculture had been largely shaped to supply international markets such as in the Brazil/Argentina region 40 years ago. Traditional diets have been promoted, thanks to a reconfiguration of supply chains and value chains at the regional level, with medium-size cities and small towns concentrating industrial and small-scale food processing. Each region has now broadened the range of foods on offer by supporting diverse food industries based on regional food cultures. The production and consumption of roots and tubers, coarse grains, pulses, fruit and vegetables has increased dramatically. Systems of agricultural cooperatives and contract agreements with downstream partners such as agri-food industries had a positive knock-on effect for agriculture and rural development. With the development of regional food value chains, nutrition transition towards the consumption of ultra-processed foods was limited together with its potential negative impact on public health, and food access for rural populations was improved.

In a context of moderate climate change, renewed diversity in production has transformed cropping and livestock systems. Diverse cropping and livestock systems co-exist, from conventional systems to sustainable intensification agriculture or agroecology. Diversification led to increased production of legume crops, thereby making cropping systems more agroecological, while also strengthening ties between cropping and livestock systems. Depending on the region, cropping systems evolved towards sustainable intensification agriculture or agroecology. Animal feed is expressly sourced from regional plant production, and trade in organic fertiliser between livestock and crop farms is organised at small and medium scales. In general, farmers have favoured the use of varieties suited to regional agri-climatic conditions.

These evolutions have generated either slight increases or decreases in arable land for both exporting regions such as North America, Brazil/Argentina, Oceania or the Former Soviet Union and importing regions such as the Rest of Asia or East, Central and South Africa (ECS). But four regions have experienced high pressure on agricultural land: EU 27 and India where arable land increased, West Africa where both arable land and pastureland grew strongly, and ECS Africa where pastureland expanded significantly. Globally the regionalization of diets and food systems has limited international trade which, nevertheless, remains a major concern for net importing regions such as the Near and Middle East, North Africa and West Africa.

Figure 2: Combination of assumptions describing the “Regionalization” scenario



Description of the scenario

In 2050, urbanization growth shifted from being concentrated in large cities to medium-size cities and small towns¹⁶. Migration towards medium-size cities and small towns has generated a multipolar urbanization process. This process, supported by national and regional policies, has generated a regional development with significant relationships between rural areas and cities. Networks of urban and rural areas emerged, developing synergies between agriculture, food processing and local markets. Rural development has been reconnected to urban food supply chains by promoting traditional diets in the region and by building synergy within the region between agriculture and food. Regionalisation, at a supranational level, in food systems relies on producing

¹⁶ Montgomery M. (2008). The demography of the urban transition: what we know and don't know. In G. Martine, G. McGranahan, M. Montgomery and R. Fernandez-Castilla (eds.), *The new global frontier*, Earthscan, London, pp. 17-36.

agricultural products suited to the region's agro-climatic conditions, on regional cuisines rooted in traditional food practices, and on key value-chain stakeholders. Rather than global convergence of dietary practices, diverse pathways for regional food systems emerged around the world.

Regionalisation of food systems resulted in a reconfiguration of food supply chains and value chains at the regional level. Logistics, agrifood, and retail distribution companies came together in networks organised around rural production sites, harvesting activities, local processing in intermediate urban centres, and diverse distribution systems at both urban and rural levels. Well-structured industries developed, making use of transport networks and storage infrastructure, and of cooperatives that put producers in contact with consumers. Small- and medium-sized cities now act as intermediaries between rural areas and urban centres. The growth of agrifood industries and small scale food processing has had a positive knock-on effect for agriculture and for rural development in general.

The nutrition transition towards the consumption of ultra-processed foods, which had begun in full force in the 2000s, was limited, as were its potential effects on public health (notably the increase of non-communicable diet-related diseases). Regional measures protected national food markets from the influx of low-cost and heavily processed foods, and national policy measures promoted the production of food products traditional to local diets.

Regions do not, however, seek autarchy. They have instead pursued the idea of "food sovereignty and subsidiarity": when regional production is not sufficient, products are imported from outside the region. Food supply chains are thus also external and interregional, regulated by bilateral agreements between regions, particularly in cases where regional food resources are not sufficient.

In 2050, each macro-region has broadened the range of foods on offer by supporting diverse food industries that are based on local food cultures. As a result, certain regions have specifically increased their production of tuber and root crops (e.g. West Africa), while others have focused on coarse grains and pulses (e.g. India, ECS Africa), and others on fruits and vegetables, and have developed the attendant supply chains for these products. Production became more diversified as a result of agricultural policy measures emphasising food diversity rather than staple foods and contract agreements with value chain partners.

Collectively organised farms participate in regional agrifood industries, and produce quality-certified regional products. These farms may be family operated with contract agreements to agribusinesses or may be groups of farms organised into cooperatives. Some farms and cooperatives, benefitting from the shift to regionalism, manage goods and services for their local communities. This trend continues to reinforce urban–rural ties.

Diverse cropping and livestock systems, ranging from conventional systems, sustainable intensification, and agroecology are all used to produce food. Increased product diversity is significant in both cropping and livestock systems. Diversification led to increased production of legume crops, thereby making cropping systems more agroecological, while also strengthening ties between cropping and livestock systems. Animal feed is expressly sourced from regional plant production, and trade in organic fertiliser between livestock and crop farms is organised at small and medium scales.

In general, farmers favour the use of varieties suited to their regional agro-climatic contexts. Accordingly, small ruminant production in semiarid areas increased, using land with low agricultural potential. Small ruminant production is based on pasture feeding in almost wholly grass-based extensive or pastoral systems with low stocking rates. These livestock systems were developed on marginal or on uncompetitive land. Increased herd mobility freed up resources both over time and in terms of space.

Agronomic potential of land

In 2050, moderate levels of climate change (+1°C in 2050) affected agriculture (median projected impact), particularly in tropical areas and in the Northern Hemisphere. The amount of suitable cropland worldwide

increased by 100-200 million hectares (+60 Mha for moderately suitable to very suitable lands for agriculture by 2050), although increases were distributed very unevenly. The amount of suitable arable land increased in higher latitudes but decreased in tropical areas, thereby fostering interdependence among world regions.

In some regions where the impact of climate change on suitability of cropland was substantial, soil conservation and soil quality remediation became important policy issues. In areas where the impact was not as strongly felt, regional policy focused on limiting soil degradation.

Distribution of land between different uses

Between 2015 and 2050, food, feed, and livestock production gradually fell back into sync with regional dietary habits. Cultivated varieties are once again grown in proximity to areas of consumption within the region. The production of crops for export has declined sharply and has been replaced by the production of plant and animal products for consumption within the region.

The production of vegetable oils, which had previously been a mainstay of global trade, declined worldwide, as did the amount of land used for their production.

The production of animal feed crops also declined markedly since 2015. Livestock systems were restructured to make use of regionally available feed crops. Certain regions, such as the European Union, replaced soybean imports with the production of legume crops for animal feed.

In regions where there was contention over the production of biofuel versus food crops, priority was given to food crops. These regions pursued other renewable energy sources, such as solar and wind, and the large-scale production of biomass. The growth of biofuel was particularly visible in regions that had few fossil fuel resources. Countries with available cropland produce biomass specifically for energy production. Countries with extensive forest area make maximal use of forestry and crop residues and improve their forestry management practices. In some regions, forests are planted while in others there is deforestation to convert land to agricultural use. In all countries, the use of agroforestry practices is on the rise.

Access to land

Land use planning policies progressively introduced regulations to manage the use of land. The policies served to protect agricultural land from encroaching urbanisation and encourage the relocation of production systems.

Land tenure was strengthened, which increased stability for small family farms and improved land tenure rights for women and young people. Intermediaries such as collective land holdings, agricultural cooperatives, producer associations, agribusiness, or municipalities, who favour certain types of agriculture and products and organise market access, also determine access to land.

Degree of intensity of land use

Between 2010 and 2050, climate change had an adverse effect on potential yields: a 6% decrease for wheat, -7% for maize, -8% for rice, -15% for soybean, and -10% for groundnuts. Production declines were felt more sharply in tropical regions than in the Northern Hemisphere. The increasing frequency of extreme weather events such as droughts, floods, and hurricanes also exacerbated year-to-year variability in production.

A variety of methods are used for agricultural intensification, ranging from conventional intensification to intensive agroecology. A region's access to energy resources is a deciding factor in shaping its agricultural production systems. In regions with accessible fossil fuel resources, agricultural systems continue to evolve conventionally towards intensification. Regions with few fossil fuel resources have systems centred around energy autonomy (biomass energy, anaerobic digestion) and low dependence on industrial inputs (mineral

fertilisers, pesticides, seed). The most autonomous and resilient systems, which draw on organic production regulations, required specially adapted mechanisation technology or high levels of human labour.

A second factor affecting intensification was the amount of available arable land in a region. This was particularly the case in intertropical areas where climate change affected arable land in increasingly adverse ways. Agricultural intensification is strongest in areas with limited land resources. Here, agroforestry systems are popular as they are able to meet food and energy needs at the same time.

It was possible to limit yield losses through the use of species and varieties adapted to local soil and climate conditions and by reintroducing coarse grains, legumes, roots, and tubers to diversify the range of crops produced.

Services provided by the land

Social services associated with land use, rural development in particular, are significant. Growing ties between farmers and food value chains created agricultural jobs and generated agricultural revenue in rural areas.

In certain regions, land use has contributed to increases in environmental services. In regions where agricultural and food issues are crucial, fragile land is particularly protected against degradation. Cropping systems that protect against soil salinization, erosion, and flooding are developed and expanded.

Food and nutrition security

The availability of food products varies considerably from region to region, but has improved in terms of caloric intake in those regions where it was lowest.

The regionalisation of trade made it possible to protect farmers in developing countries against competition from areas with higher agricultural productivity. In terms of food access, the development of regional food value chains increased revenues for rural farmers, thereby boosting their purchasing power. It also improved physical access to food in both rural and urban areas.

The growth of regional food value chains lessened the impact of ultra-processed foods on diets. This meant that the quality of local diets, particularly in developing countries, did not decline. In many cases, creating food systems aligned with traditional diets and based on diverse plant crops actually improved the nutritional quality of local diets. Nutritional deficiencies were offset by an increase in the consumption of animal products in regions where the daily intake of such products was very low (less than 10% of total calorie intake).

How did we get there?

In the face of recurrent crises (price volatility, pandemics, local pollution, obesity, and increase of diet-related non-communicable diseases) caused by climate, social, and economic change, States joined to form large, supranational regional blocs. Between 2020 and 2035, European countries were finally able to reach agreements on strict financial management systems and to implement structural reforms to lower debt loads, to restore economic growth, favour investment and employment, and institute comprehensive policies on climate change adaptation, energy, the environment, food, and the fight against poverty. Between 2030 and 2050, the European Union, North Africa, and sub-Saharan Africa were able to develop economically, politically, and socially, while each preserved their own unique cultural specificities. Regional integration in Asia is centred around Japan, ASEAN countries, and Australia, with India close to this bloc, while China and Russia build closer ties with each other. For China, Russia is appealing in terms of security, and the Chinese market, particularly for oil and gas, is attractive for Russia. In Latin America, the Latin American Integration Association (LAIA) contributes to regional integration through trade. A degree of competition among regions does, however, take place.

Small- and medium-sized businesses, numerous civil-society organisations, and governments all understood that institutions needed to be strengthened, regional cooperation encouraged, and intraregional trade

expanded. These were necessary to successfully manage the energy transition, to strengthen the labour market, to promote social cohesion, to improve food diversity with particular focus on local dietary habits, to sustainably manage natural resources, and to support democracy. These measures would also prevent political fragmentation, avoid international governance by market forces, and avert a loss of identity.

To reduce food dependency, regions introduced strategies to make the best use of regional agricultural resources to supply the population with their needs. These measures also address important health issues, namely obesity and non-communicable diet-related diseases. Accordingly, regions promote the production of certain food products associated with traditional local diets. Food supply is now at the centre of a wide range of policy objectives and is the force driving many comprehensive policy measures that jointly address agriculture, food and energy. The measures affect investments in food production, processing, storage, and distribution. They are designed to strengthen links among the various businesses along the value chain. The resulting food supply chain resembles a tapestry of large regional companies and small businesses. Through their support for this network of food systems to meet urban food needs, regional organisations also address rural development and food and nutrition security concerns for rural households. National rural development policies are therefore in line with efforts to develop regional food value chains. Private land ownership is increasingly regulated across all regions as a way of safeguarding the land resources necessary for food production.

Investment in research varies according to region. Countries with more limited financial resources concentrate on social innovation and on modernising organisations. This allows them to remain competitive in a digital world. Within each region, countries work together to improve education and investment in research in an effort to be more competitive in a world where the knowledge economy takes increasing precedence over resources.

In each region, holistic and integrated food and energy policy measures are gradually introduced. They promote efficiency and reduce losses and waste, which in turn cut carbon emissions. In Africa, substantial levels of investment are made in the production of local, renewable energy sources (solar, biomass) and in the electrification of urban and rural areas in order to limit fossil fuel imports and to encourage economic development based on local resources for regional markets.

In 2050, per capita GDP is \$20,000. The use of biomass energy has increased. Energy from biomass sources has reached 150 exajoules (EJ), but there is strong variation among regions, and particularly among countries, by virtue of their available mineral and land resources. Globally, 60 EJ comes from agricultural residues, 30 EJ from better-managed forest resources, and 60 EJ from energy crops (second-generation biofuels and bioelectricity from very-short-rotation coppice). Regional carbon-trading schemes have developed in the absence of international agreements on climate change, which encourages regional energy autonomy. Prices are higher in regions without fossil fuel resources to hasten the transition to renewable energy.

Land use for multi-active and mobile households

Key words: *non-State actor, networks, mobility, households, multi-activity, multi-local, non-farm jobs, transport, information technologies*

Overview

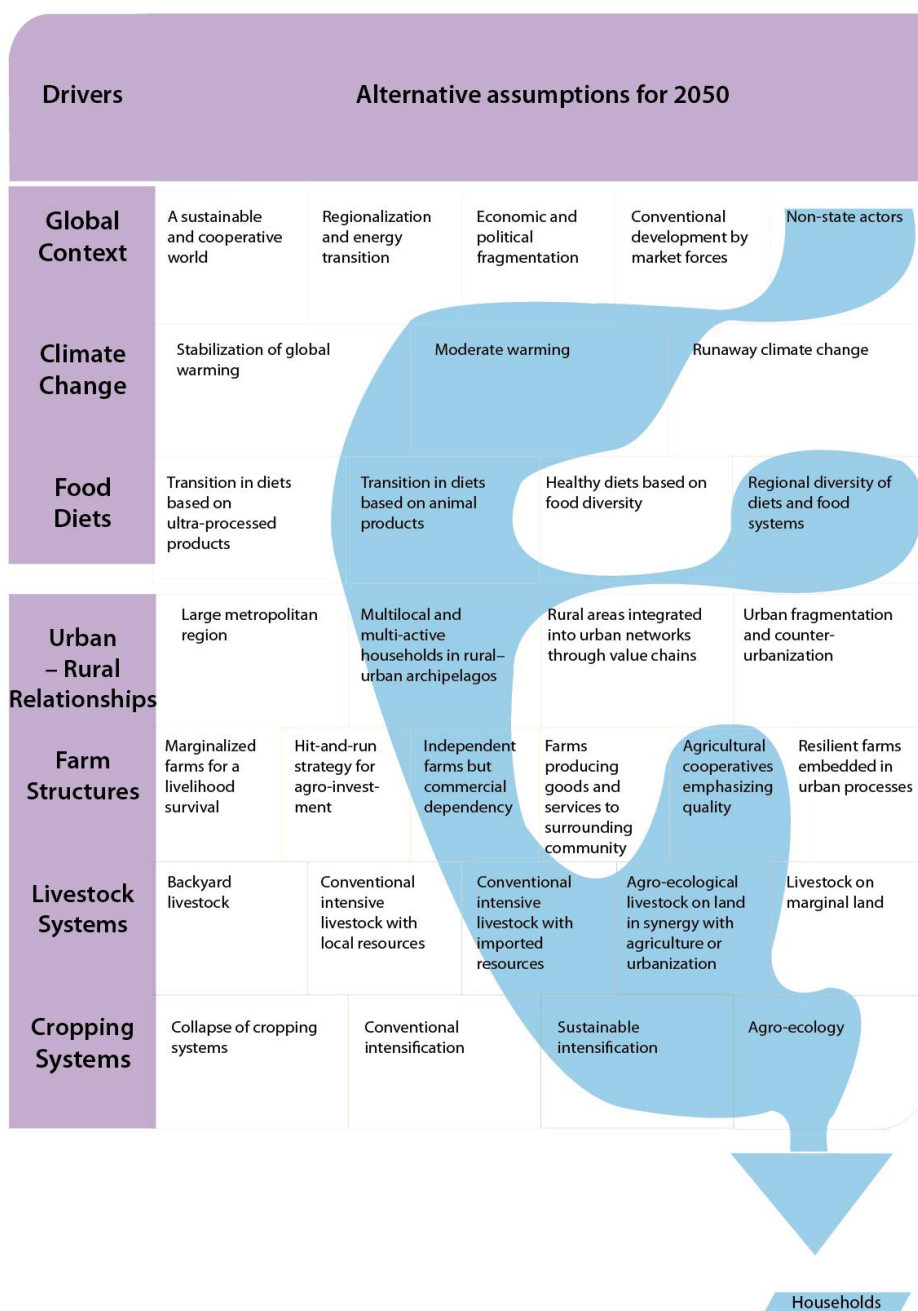
In a highly globalized, mobile and hybrid world, non-State actors including civil society groups, international NGOs, local authorities, multinational companies, academic institutions, foundations and cities drove social, economic and geopolitical transformation processes. They have organized themselves to form *ad hoc* networks that play a key role in trade and are gradually superseding sovereign governments. These networks are fuelled by public debates and steered by concerned groups structuring both consumption and production through new forms of disintermediation of food value chains. Their strategies are jointly defined with citizens, consumers, residents and other relevant groups who express their concerns regarding health, biodiversity, the environment and climate change. In this dynamic but unstable economic context, households have improved and diversified their incomes by being much more mobile. Reversible, temporary, short- or long-distance mobility have driven social networks and economic strategies. Circular migration between rural and urban areas is now a normal way to gain access to employment.

Diverse demands have drawn public attention to farm practices and farmer groups. Farming households are driving organizational and technical innovations in food value chains, networking with each other via numeric platforms that disintermediate and shorten traditional supply chains. Access to these platforms and their modes of regulation have become central to food governance in urban and rural areas. As these networks diversified, ranging from local, regional or national scales to international, they became the basis for the development of agriculture and contributed to a relative improvement in farm incomes.

Regarding these changes, households played a key role as places in which work, exchanges and solidarity were organized, and which are enmeshed within various networks of production, consumption and social activities. Thanks to resources generated by mobility, households increased and diversified their incomes by being located in both rural and urban areas and by carrying out farming and non-farming activities in the food trading and processing sectors, in industry, in the building sector or in services.

Farm structures within these food networks are diverse, ranging from small farms with family labour to large, highly-capitalized farms. But, in general, multi-activity systems contribute to ensuring food and nutrition security for rural and urban households by diversifying their income and guaranteeing direct access to foodstuffs. Pressure on land in this scenario is similar but lower than in the "Regionalization" scenario due to more active international markets that ease specific regional pressure on agricultural land.

Figure 3: Combination of assumptions describing the “Households” scenario



Description of the scenario

In 2050, migration to cities is temporary and mobility evolves according to employment and income opportunities in urban and rural areas. Circular migrants find employment either in cities or other rural areas, in the sectors of industry, services, food trade and agriculture (cash crops). Farming remains a core activity within rural households, but the share of non-farm activities in the incomes of rural households increases as mobility intensifies¹⁷.

¹⁷ Rigg J, Salamanca A, Parnwell M (2012). Joining the dots of agrarian change in Asia: A 25 year view from Thailand. *World Development* 40(7): 1469–1481.

Farming households are generally multi-active engaging in multi-local, farming and non-farming and rural and urban activities. The various household members also belong to diverse network organizations. Many formal and informal networks have emerged. They are composed of non-State actors playing both economic and non-economic functions ranging from processing, sales of products, and finance through foundations, crowdfunding platforms and local investments. These networks are built at different scales and provide links between producers and consumers, and between people living in rural and in urban areas, on a regional or transnational scale. As these networks have become international, they have come to serve as the basis for the development of agriculture and a relative improvement in farm incomes over the following decades. In a dynamic but somewhat unstable economic context, reversible, temporary, short- or long-distance types of mobility represent a valuable strategy for rural households. Through circular migration between urban and rural areas, and also seasonal or transnational mobility, they improve and diversify their incomes while maintaining their local roots.

Food diets have become increasingly mixed, keeping some of the features of traditional local diets while also including some of the features of global diets. Mobility between urban and rural areas has brought with it cultural mixing and changes in diet between the two: certain rural practices have developed in urban areas, while practices related to modern value chains have spread into rural areas. The value and supply chains that shape these diets are extremely diversified, ranging from highly-centralized large-scale retail systems to systems based on direct relations between producers and consumers, along with all the possible intermediate variants. An important feature of the changes that have taken place in supply chains is disintermediation between producers and processors or distributors. Intermediaries have gradually disappeared as digital management and logistics platforms emerged. A second feature of these value chains is their prominence in public debates on product properties taking place within an opinion-driven regime. Non-profit “interest groups” that include citizens, consumers, residents, and any group with demands in terms of health, biodiversity, the environment, or the fight against climate change, operate in close connection with these new value chains. These relations have focused public attention on groups of farmers in the organization of markets and foodstuffs.

Agricultural activities serve as a buffer in household strategies, depending on the context and access to urban or rural non-farming jobs¹⁸. Farming activity contributes to balancing the books of the household. Household organization largely allows for a number of different activities, combining farming and non-farming activities and turning to multi-local strategies. Each household member develops their activity depending on their location, the opportunities that arise and their ability to find their place in existing networks or to construct new ones. All these income sources, both farming and non-farming, contribute to the economy of the household. The organization of the activities of household members shows a high level of plasticity depending on the social and economic environment, with the respective weight of agriculture within household income varying according to the ratio between farming income and income from activities in other sectors. This continuing diversity of activities is part of a household resilience strategy, with the aim being primarily to maintain overall income. These multi-activity systems contribute to ensuring household food and nutrition security, by diversifying income and guaranteeing direct access to foodstuffs.

For households, agriculture is therefore a stable activity among a number of other, more transient activities. Within farming structures, family labour adapts to on-farm and off-farm income opportunities, including seasonal labour. Younger workers leave for the city and then return, and older relatives work on the farm on a more permanent basis, while women operate either as farm managers or go look for employment in the city. Due to the mobility of active individuals, however, farming skills are not always reinforced. In parallel, large farms have developed links with international processing and mass retailing.

¹⁸ Haggblade S., Hazell P., Reardon T. (2010). The rural non-farm economy: Prospects for growth and poverty reduction. *World Development* 38(10):1429–1441.

More generally, the intensification of production systems (increased output per hectare) varies according to the availability of labour, the networks in which agriculture plays a part and the available financial resources. The organization of labour within the household is transforming cropping and livestock systems. Women and the elderly in particular take on a large part of the agricultural work. Labour-intensive systems are developing in places where labour supply is still plentiful, and when this is not the case, systems are intensified by increased use of technologies and the purchase of machinery and inputs. Within the household, monetary flows from non-farming activities to agriculture (e.g. remittances) have played an important role in intensification processes, as have investments or borrowing from the networks to which these farmers belong. Above all else, however, it is the marketing and distribution networks that determine the types of production and farming practices. For example, high-value-added products such as fruit and vegetables or backyard livestock products are marketed in cities via ad hoc networks based on groups of urban consumers or on extended solidarity groups or non-market trading. Systems that are labour intensive but require little land such as vegetable gardening and backyard livestock systems are therefore developing. There are also food staples that are recognized for their quality (e.g. Thai rice) which are marketed at a larger scale via hybrid networks combining public actors, large cities, private companies and consumer groups. Individual farmers now belong to specific networks of actors that determine the type of production and intensification, depending on the interests of those actors. The intensification of cropping and livestock systems varies from highly technical systems with low environmental impact based on sustainable intensification agriculture to agro-ecology systems making use of the labour and know-how of farmers. As a general rule, farming practices are negotiated with the interest groups concerned.

Agronomic potential of land

Cultivated land areas are stable on account of the moderate level of urban growth (due to reversible migration) and levelling out in demand for animal products. Private standards emerging from public debate limits over-exploitation of land by farming and soil degradation.

Distribution of land between different uses

The area of land cultivated for high-value-added or high-quality products is increasing, as is the area cultivated for animal feed.

Due to conventional intensification of livestock farming, there is a limited increase in pasture land which is being given over to cultivation or reforestation.

Access to land

In these systems in which individuals are highly mobile, access to land is secure, in particular for women in charge of farming structures.

This type of household strategy aims for resilience of farming structures, with the objective of maintaining productive capital for future generations of the family, notably thanks to the support of the multi-actor networks (consumers, foundations, local authorities, industry) that are involved in agriculture. Farming activity is therefore being adapted within households and is maintained as a core activity.

Degree of intensity of land use

There is considerable intensification of production systems (production per hectare), driven by significant innovations in such systems. These innovations consist either in making greater use of cutting-edge technologies (information technologies), or in turning to innovative techniques relying on a plentiful supply of labour (e.g. agro-ecology) in response to public demand. The networks of public and private actors who organize marketing and sale of the products define the goals of agricultural activities and also play a role in redefining farming practices and types of intensification, giving priority either to cutting CO₂ emission, to reducing environmental impacts (agro-ecology), to improving nutrition, or to addressing social issues of rural

poverty or inequalities in access to food. Due to the high public profile of farmers and farming, agricultural practices and forms of intensification are constantly being challenged and redefined in interaction with interest groups. Thus, most farmers evolve towards sustainable intensification agriculture or agro-ecology.

As far as small farms are concerned, monetary flows (from non-agricultural activities to agriculture) have favoured the intensification process. These flows are made up of remittances (non-farming income sent by members of the household), financing from foundations or NGOs, or private investments of urban origin. In addition to this, the reversible mobility of household members has generally made it possible to limit the breaking up of farms, by limiting growth in the agricultural population, in particular in those regions which were previously at risk of experiencing sharp growth in their rural and farming populations (like Sub-Saharan Africa, North Africa, Central Asia, Oceania).

Concerning large farms enjoying access capital thanks to their ties with multinational firms, they have turned to sustainable intensification by using new technologies and practices (significant mechanization and use of external inputs).

Services provided by the land

Regarding social services, agriculture contributes to the resilience of rural households and provides a fixed basic income as part of the overall revenues of farming households.

In certain regions where interest groups are active, agriculture plays a role in the production of environmental services (water quality, biodiversity, etc.).

Food and nutrition security

Food availability remains stable, as small and medium-sized structures have maintained or intensified their production per hectare, alongside the growth of a highly-capitalized agricultural sector.

Access to food is buoyed by growth in the overall (farming and non-farming) incomes of households with an agricultural activity.

Agricultural output contributes to the food and nutrition security of the extended household, either via local consumption (e.g. milpa in Latin America) or via formal and informal food trading networks between the village and people living in the city but who were born in the village (e.g. in Sub-Saharan Africa or in Asia).

There can be risks of instability in food supply availability when conflicts arise between interest groups, causing a sudden shift in stakeholder networks and alliances.

How did we get there?

In an ultra-globalized, hybrid world, non-State players dominate in social, economic and geopolitical change processes. International NGOs, local non-profit organizations, multinational firms, academic institution, foundations and local authorities such as members of city government, form *ad hoc* networks that are driving forces in devising responses to local and global challenges. These network groups gradually supersede the power of national governments. These trends emerged after the failure, in the 2020s and 2030s, of sovereign States to take up the challenges of climate change and poverty, while non-State actors were multiplying their initiatives. The weight of NGOs therefore increased, in particular in public opinion, as a counterweight to the power of transnational corporations. World development has become an uneven patchwork in which membership of an individual or a collective to networks, or their ability to mobilize their forces to create new networks, determines success and the level of their wealth.

Rather than uniting around a national government, the public has tended to join groups of actors that share common interests, thereby creating powerful currents of opinion. Consensus within public opinion regarding the main challenges, fed by the affirmation and growth of the middle classes, provides the foundation on which

the power of these non-State interest groups is based. Urbanization and the spread of information technologies facilitate the development of these multiple, labile coalitions that are independent of national governments.

The themes they address range from reducing poverty to the environment, climate change and the fight against corruption. Agricultural activity and production methods adapt to the interactions and negotiations between the various groups concerned by the services that are provided by farming activity, such as biodiversity, drinking water quality, landscape, health, climate change and even local identity linked to food products. The role of charities and philanthropic foundations is gradually overtaking that of international aid. Solutions are being found to specific global problems through the coalitions of networks of international actors.

National governments do not disappear entirely. They tend to perceive their role as being organizers and coordinators of “hybrid” coalitions of State and non-State actors that evolve according to the challenges of concern. Authoritarian governments struggle to maintain a foothold in this new context. In contrast, smaller, more “agile”, decentralized governments allowing and facilitating the development of dynamic coalitions play a central role in this system of governance by network and interest group. Emerging countries benefit from these changes, in the absence of existing and established networks, by relying massively on new technologies. Sovereign governments are finding it difficult to develop public policies in this new context in which the importance of the State is declining. Transnational interest groups that no longer rely on just a single State now have the ability to bypass national governments seeking to regulate their activities. They challenge traditional jurisdictions and regulations. The power of these networks and ad hoc coalitions raise security issues and generate geopolitical uncertainty, although such changes also bring greater global wealth.

Decentralized energy systems are created, bringing together residents, renewable energy producers and various energy consumers (industry, services, etc.) via smart networks. Faced with the erosion of national power, diseconomies of scale linked to new technologies, an increase in the cost of capital and of energy and the decentralization of energy sources have given small and medium-scale farming with family labour a competitive edge.

Land use for food quality and healthy nutrition

Keywords: *healthy diet, malnutrition, GHG emissions, integrated public policy on nutrition, food diversification, meat and ultra-processed food consumption, cropping system diversification, crop–livestock integration, soil carbon storage*

Overview

In the 2020s, as healthcare systems were saddled with the considerable costs associated with diet-related non-communicable diseases and, more generally, as the consequences of malnutrition on public health were increasingly felt, most States were compelled to implement a raft of policy measures aimed at shifting consumption patterns towards healthier diets. These policies were aligned with international measures to fight climate change. They focus on energy, transport, construction, food systems and carbon storage. In this context, synergy across multiple scales (national, regional and international) on food, agriculture, and climate policy was sought so that agricultural and food policies simultaneously generated widespread, positive impacts on both diets and climate change at the global level. Global soil improvement policies have also led to the rehabilitation of degraded land¹⁹ for agricultural use and carbon storage. National states and urban authorities shaped more inclusive development processes linking rural to metropolitan areas, improving transport and communication infrastructures, land planning and favouring efficient food value chains.

To meet nutrition targets, food chains have been reshaped to give access to diverse and high-quality products such as fruits and vegetables, coarse grains and pulses, and improving the quality of industrial processing in order to preserve micronutrients and fibres. Compared to 2010, the diets of 2050 in emerging and developed countries are lower in animal products, fats, ultra-processed foods, sugars and sweeteners. In specific developing countries, as a response to the continued incidence of undernutrition, the share of animal products in diets has increased. Access to fresh food in urban and rural areas has improved with the development of a large range of distribution channels such as outdoor markets, small retailers and large supermarkets. To meet the challenges posed by under- and overnutrition, both crops and cropping systems have diversified, incorporating techniques from agroecology, while livestock systems are now re-associated with crop production in order to improve mineral cycles. Depending on the availability of capital and the situation in the agricultural labour force, cropping systems have evolved towards sustainable intensification or agroecology. These changes contributed to both limiting agricultural greenhouse gas (GHG) emissions and increasing carbon storage in soil, raising per-hectare yields in instances where yield potential was previously far from being reached. Organized in cooperatives, farmers are part of healthy food chains, producing quality foods based on standards and contracts with agri-food industries, or selling high value fresh products to urbanites. Better-organised food systems have also reduced food losses and waste, in particular by improving the food storage and preservation capacities of countries in the Southern hemisphere.

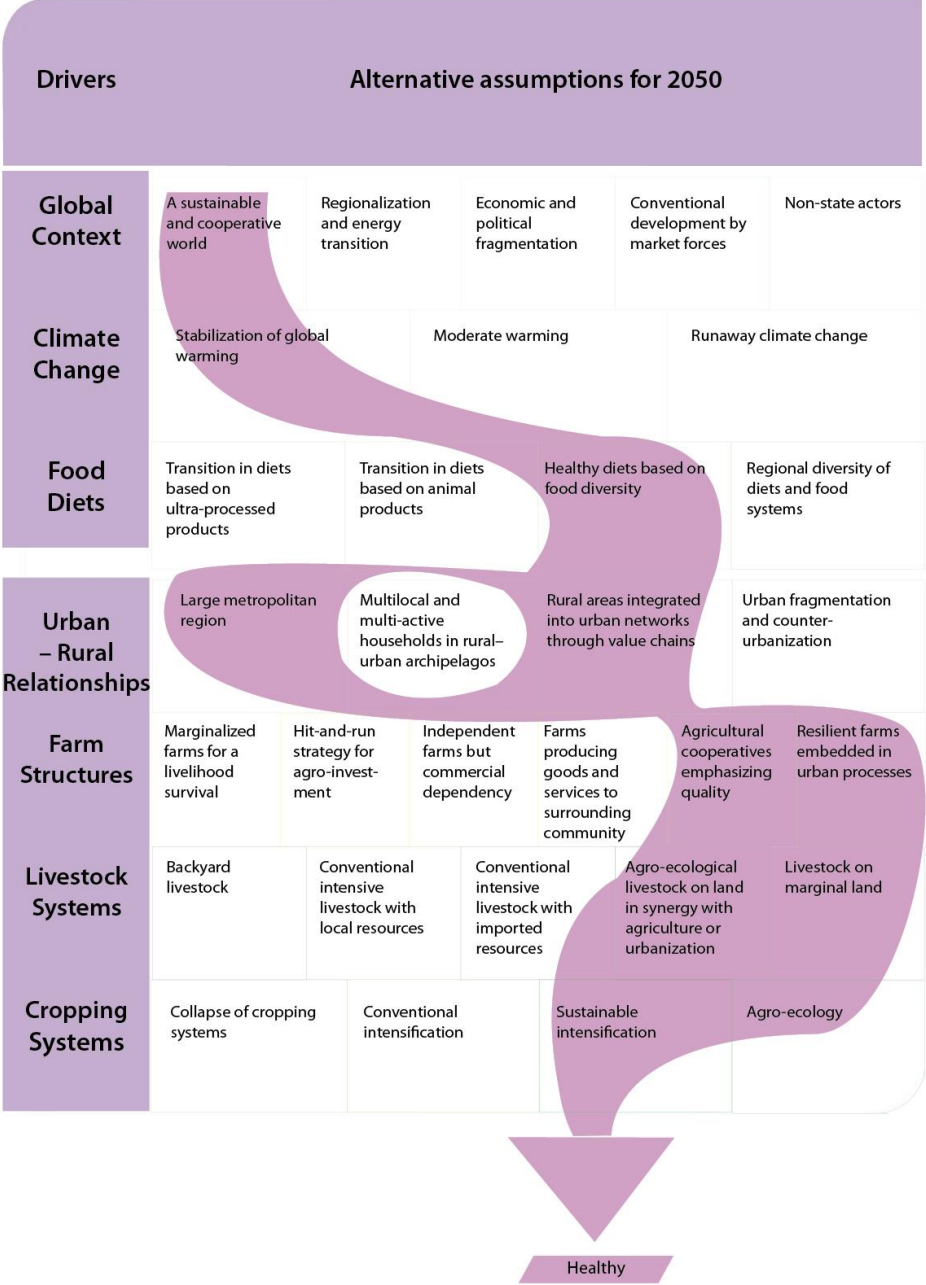
Worldwide shifts in land use reflect this crop diversification, limiting globally the expansion of the agricultural area. Most regions have seen a decrease or a stabilisation in their arable land area. But three regions, where in the past consumption levels of animal products were inadequate, have experienced an expansion of agricultural land with an increase in arable land in West Africa and India, and a major increase in the pastureland area of East, Central and South Africa (ECS Africa).

As a result of the mixed cross-sectoral policies reshaping food markets and agriculture, global diet is much healthier than 40 years ago. The increase in unhealthy food consumption has been halted, and undernutrition has decreased due to food diversification and better resilience of farm systems. International trade has

¹⁹ 25% of the global soils and 38% of the agricultural lands were degraded around 2000 (Scherr 1999).

remained significant and has strengthened in importing regions such as the Near and Middle East and North Africa, Sub-Saharan Africa and the Rest of Asia, with products coming from exporting regions such as North America and to a lesser extent the EU 27 and Former Soviet Union.

Figure 4: Combination of assumptions describing the “Healthy” scenario



Description of the scenario

Strong public food and agriculture policies and consumer mobilisation against unhealthy foods triggered major changes in the food system. The proportion of ultra-processed foods and soft drinks in diets declined in favour of fibre and high-value nutrients such as pulses, coarse grains, and fresh foods – fruits and vegetables in particular. Access to nutritious products was improved possible by reconfiguring existing value chains. Fresh products and certified agroecological products were subsidised through a reallocation of agricultural subsidies by the State during a transition period. A range of sales distribution channels, such as open-air markets that make fresh products more accessible, were supported and modernised in developing countries. Governments

also introduced public food markets with mandatory nutritional-quality standards, particularly for the restaurant and catering industries. Agribusinesses and major retailers are now fully involved in the production and distribution of healthy products that meet nutrition standards or that are certified. To these ends and following the implementation of restrictive measures on ultra-processed foods, innovation in the agrifood industry has shifted. At the start of the twenty-first century, policy encouraged industries to do their best; now, policy is centred on results-based accountability. Innovation and industrial processes must prove their positive nutritional and environmental impact. Agribusiness processing companies changed their innovation strategies. They aligned themselves with farmers, retailers, input suppliers, and shippers to both improve the nutritional quality of their food products and to reduce their impact on climate. In particular, changes to industrial food processing such as limiting heavy processing to preserve dietary fibre and micronutrients, made it possible to improve the nutritional quality of their processed foods. Close links between rural and urban areas, made possible in large part by efficient transportation infrastructure, is organised around a range of value chains. These ensure that all areas have access to nutrient-rich food. Consumption of animal products has decreased in developed countries. In certain developing countries, consumption of animal products has increased to meet nutritional needs, although it remains within the limits of recommended healthy eating guidelines.

To meet these new food needs, farms and farmers have reorganised. They entered into contracts with agribusiness and major retailers. They benefitted from government schemes to improve food supply and to define food standards. And they built direct relationships with consumers. Agricultural cooperatives were formed or expanded to produce high-quality products. Commercial farming adjusted its practices to meet nutritional needs. Farmers also built relationships among themselves to supply certified products to food processors, or directly to retailers, across a variety of both short and long distribution chains. An assortment of agricultural practices developed in periurban areas, specialising in supplying fresh products with high added value.

Cropping and livestock systems diversify and are re-associated with one another. Farmland used for the production of protein crops increases everywhere. The number of market gardens and fruit orchard is on the rise, and organic household waste is put to use in local, small-scale livestock farms. Both traditional know-how and scientific knowledge of agroecology practices are used to diversify. They concern crop associations, mosaic crop planting to limit pest development, and agroforestry (trees, including fruit trees, provide shaded areas and habitat for pollinators in annual crop fields and pastures). Through a range of measures – including reduced soil tillage, permanent soil cover (cover crops, mulch), and more diversified, longer crop rotations – farming systems improve both soil quality and the storage of organic carbon therein²⁰. These changes serve to improve soil structure, increase water availability for plants, enhance the retention and effectiveness of soil nutrients, and intensify soil microbial activity, which, in turn, restores soil quality in degraded areas and increased soil fertility. Livestock systems focused efforts to limit nitrogen cycle losses by improving the management of animal manure, and to avoid overgrazing by improving the management of pastures, through the introduction of a diversity of grass and legumes species.

Together, these trends and shifts affected land use directly in various ways.

Agronomic potential of land

Owing to the range of measures adopted, global temperature change by 2050 was kept well below the +1°C threshold, and changes in rainfall patterns were limited. Consequently, climate change did not have a substantial effect on the agricultural suitability of land at a global level.

At the same time, measures taken by many countries to restore soil fertility and to increase organic matter in

²⁰ Bindraban P.S., Van der Velde M., Ye L., Van den Berg M., Materechera S., Kiba D.I., Tamene L., Ragnarsdóttir K.V., Jongschaap R., Hoogmoed M., Hoogmoed W., Van Beek C., Van Lynden G. (2012). Assessing the impact of soil degradation on food production. *Current Opinion in Environmental Sustainability* 4: 478–88.

soils served to curtail soil degradation. Farmland yield potential increased while the yield potential for degraded land was restored. Consequently, cropland acreage remained constant and the agricultural output potential of soils rose. The increase in organic carbon storage in soils also led to higher yield potentials, with impacts varying by region.

Distribution of land between different uses

The proportion of land used for animal feed crops and pastures *per capita* shrunk, while at the same time, the proportion of land devoted to producing crops for direct human consumption *per capita* increased. This farmland grows a diverse range of crops: cereals, coarse grains, pulses, fruits, and vegetables.

Whereas production systems in the past were focused on specialised production areas, systems now are based on planting different crops in succession, creating spatial diversity. Cropping systems now include more varied, longer crop rotations that incorporate diverse grain crops, protein crops, and vegetable crops. Agroforestry systems also have become more prominent, allowing for a wider distribution of crops across landscapes by incorporating both perennial and annual crops and combining energy and food crops within a single system. Livestock systems were redesigned to reconnect them with cropping systems.

Government land-use planning policies limited the loss of farmland to urbanisation.

Since 2010, marginal land and heavily degraded land unsuited to agriculture has been reforested. Forests now represent an important source of biomass for energy production.

Access to land

The reorganisation of food systems to favour nutritional quality led consumers to change their perception of agriculture, and increased its esteem. Farmers are guaranteed access to land in rural and periurban areas as a part of long-term investment strategies in favour of improving soil potential and carbon storage. While there are no measures to oppose large-scale production, there is support given to a large number and wide range of farms and farming organisations. Support is provided through a variety of land tenure systems that formalise customary land ownership and use via the creation of specialised institutions or the allocation of land titles. Whereas land-use and access issues were major sources of instability to 2020, regions that made reconfiguring food systems a priority were able to safeguard access to land. Government land-use management policies limit the loss of agricultural land to urbanisation, particularly in periurban areas. In 2050, privileged access to land is granted to farmers in support of nutritional needs, food security, and carbon storage.

Degree of intensity of land use

In 2050, the primary methods to improve soil fertility include increasing carbon storage in the soil, reduced soil tillage, the use of cover crops, and more varied, longer crop rotation cycles. These soil-quality remediation measures may impose limits on the export of residues for energy generation or other uses depending on the type of soil, its initial soil carbon content, the local climate, and its uses²¹.

The reassociation of crops and livestock has created systems that rely less on agroindustrial inputs and that are better at managing the nitrogen and phosphorus cycles. This reduces dependence on mineral resources and the need to buy mineral fertilisers. Agroecology practices are used instead to increase per-hectare productivity (agroforestry, crop associations), and increase the diversity of products per hectare.

Services provided by the land

Stabilising anthropogenic GHG emissions required massive efforts to sequester carbon in plants and in the soil as well as to reduce actual emission levels. In agriculture, this happened through the use of mixed systems that were able to improve the range of services provided by soils by addressing the issues of food production,

²¹ Warren Raffa D., Bogdanski A., Tiftonell P. (2015) How does crop residue removal affect soil organic carbon and yield? A hierarchical analysis of management and environmental factors. *Biomass and Bioenergy* 81: 345-55.

carbon storage, and control of GHG emissions:

- storing carbon in the soil through the use of appropriate agricultural practices, as well as planting forests on marginal land;
- cutting GHG emissions by curtailing the use of mineral nitrogen fertilisers: (1) less nitrous oxide associated with mineral fertilisers; (2) less fossil fuel used for fertiliser production; (3) substituting mineral fertilisers for organic ones.

Food and nutrition security

Daily calorie intake decreases slightly in developed countries and increases moderately in developing countries. In developed and emerging countries, consumption of animal products experiences a plateau, then decreases slightly; in developing countries, diets become more balanced and diversified through the inclusion of more fruits and vegetables, the consumption of more varied pulses and coarse grains, and a moderate intake of animal products (milk, eggs, meat). As a consequence, non-communicable diet-related diseases have decreased significantly.

Improving accessibility to a variety of foods can also address the challenges of under-nutrition, particularly those associated with child stunting. For rural households, diversification in cropping systems increases food security at farm-household level.

How did we get there?

Discussions during the 2015 United Nations Climate Change Conference (COP 21) on the financing of climate, energy, environmental, and agricultural policies were an important step. The commitment to ambitious objectives with regard to change in worldwide temperatures sent a clear signal to business and industry, which then began to prepare for a shift to the green economy. In the 2020s, the increasing social cost of diet-related chronic diseases, dietary deficiencies and under- and over-nutrition, pollution, and their impact on work and productivity, led most governments to implement new, stringent food and environmental policy measures affecting agriculture, the agrifood industry, and food retailers.

Since 2020, the rising healthcare costs of diet-related chronic disease (cardiovascular diseases, type 2 diabetes and cancer) jeopardised public healthcare systems. Faced with these mounting needs, an ever-increasing set of stakeholders and policymakers publicly decried the decline of healthcare services and the rationale driving a medical system based solely on prescriptive cures rather than proactive approaches, and the privatisation or liberalisation of healthcare systems on State-funded life support. Healthcare system reform began in a number of large, emerging countries, such as Brazil and Mexico, and then spread widely. The aim was to move focus onto the prevention of diet-related diseases. The number of public awareness and education campaigns about healthy eating grew. At the same time, there was international recognition of the need to control the evolution of food systems. Efforts to that end focused on the effects of global changes on food systems. The rapid development of ultra-processed had gone hand-in-hand with the expansion of transnational business into food markets in emerging and developing countries. These were identified as the vector for the excessive consumption of calories, fats, oils, sugars, and salt, and the reduced intake of the nutrients and dietary fibre that are more prevalent in unprocessed food.

In the 2020s, many governments introduced food policy measures to shift consumption patterns towards healthy eating habits. The move began in emerging countries most heavily affected by the increase in diet-related chronic disease, then later spread to developed and developing countries. Led by emerging countries such as Brazil and Mexico, most governments came together to regulate the nutritional quality of products in the food market. They introduced regulation of ingredients and nutritional guidelines through the Codex Alimentarius and the World Health Organization, as well as trade regulations on non-healthy products and conditional investment through the World Trade Organization. Over the subsequent decades, energy, climate,

logistics, and food policies converged. These now support the reduction of GHG emissions, prioritise the use of biomass for food production, place limits on transport, improve carbon sequestration, advocate for consumer restraint, and are more people-centred. The fight against poverty is now multifaceted; it includes efforts to redistribute capital, to reduce energy insecurity through energy transition, to reduce inequality, and to find new production methods that make farm households more resilient.

Agrifood companies followed the example set by other industries that had to adapt following the introduction of limits on their GHG emissions. Agrifood companies, cognisant also of their role in mal- and over-nutrition, committed to improving the nutritional quality of their food products and to reducing the impact of their industry on the climate. They spent a portion of their profits on increased research, the results of which came to fruition some ten years later. Diversification of food products better met consumer needs and could allow better adaptation of crops to local resources. This reduced losses and waste, increased product shelf-lives, and improved consumer and environmental health.

Cooperation among States, businesses, civil society organisations, and international institutions – carried out in a period of lessening inequality and moderate economic growth (in 2050, per capita GDP is \$20,000) – was vital to this transformation of our economic and social models. Integrated food policies including the banning of advertisement for products with negative health impacts were implemented. They aimed at promoting nutrition education and regulating the food industry- and establishing-specific measures for key components of the food system by supporting products with positive health impacts. Land reform was carried out by a number of States to provide vulnerable populations with access to land and to limit internal or international migration. Social and environmental regulations were set to control production. Gradually, land and water became collective property, managed through intergovernmental and national framework agreements. A climate of collaboration precipitated the development of technological, social, and organisational innovations. From the start of the 2030s, developing countries were able to benefit from this new order. Businesses and cooperatives grew by using their local, natural and human resources to best meet the needs of local markets. With the help of technology transfer, technical assistance, and financial resources, developing countries were able to establish efficient energy production systems that generate little pollution and operate on small scales.

These changes naturally led to decreases in energy consumption and a shift in its sources, with less reliance on fossil fuels. In 2050, worldwide energy consumption is 696 exajoules (EJ) (WEC – Symphony²²). Of that figure, 102 EJ is produced from biomass: 30 EJ from residues and wastes, 30 EJ from dedicated biofuel plantations (*miscanthus*, *eucalypts*), 30 EJ from managed forests (resides, clearings, etc.), and 12 EJ from microalgae. Crop residues are comprehensively managed, but do not usually contribute to biofuel as it is used first for soil regeneration. Third-generation biofuels (microalgae) came to prominence in 2035 as their per-hectare yield is higher than yields from land biomass. The use of fossil fuels, coal in particular, is sharply reduced through the promotion of low carbon technologies and efforts in greater sobriety. Information and communications technologies including smart grids allow networks to maximise energy distribution. Carbon taxes or cap-and-trade systems are now widespread in liberal economies. Restrictive limits on CO₂ emissions were put in place in countries whose economies are largely planned. Carbon has become the cornerstone of the energy market: implementation of policies to reduce GHG emissions associated with tropical deforestation and forest degradation; reforestation policies (REDD+); nationally appropriate mitigation actions.

²² World Energy Council 2013, *World Energy Scenarios: Composing Energy Futures to 2050*, London.

Land as commons for rural communities in a fragmented world

Key words: *fragmentation, international governance, economic, energy and ecological crisis, international trade, communities, territories, commons, agro-ecology*

Overview

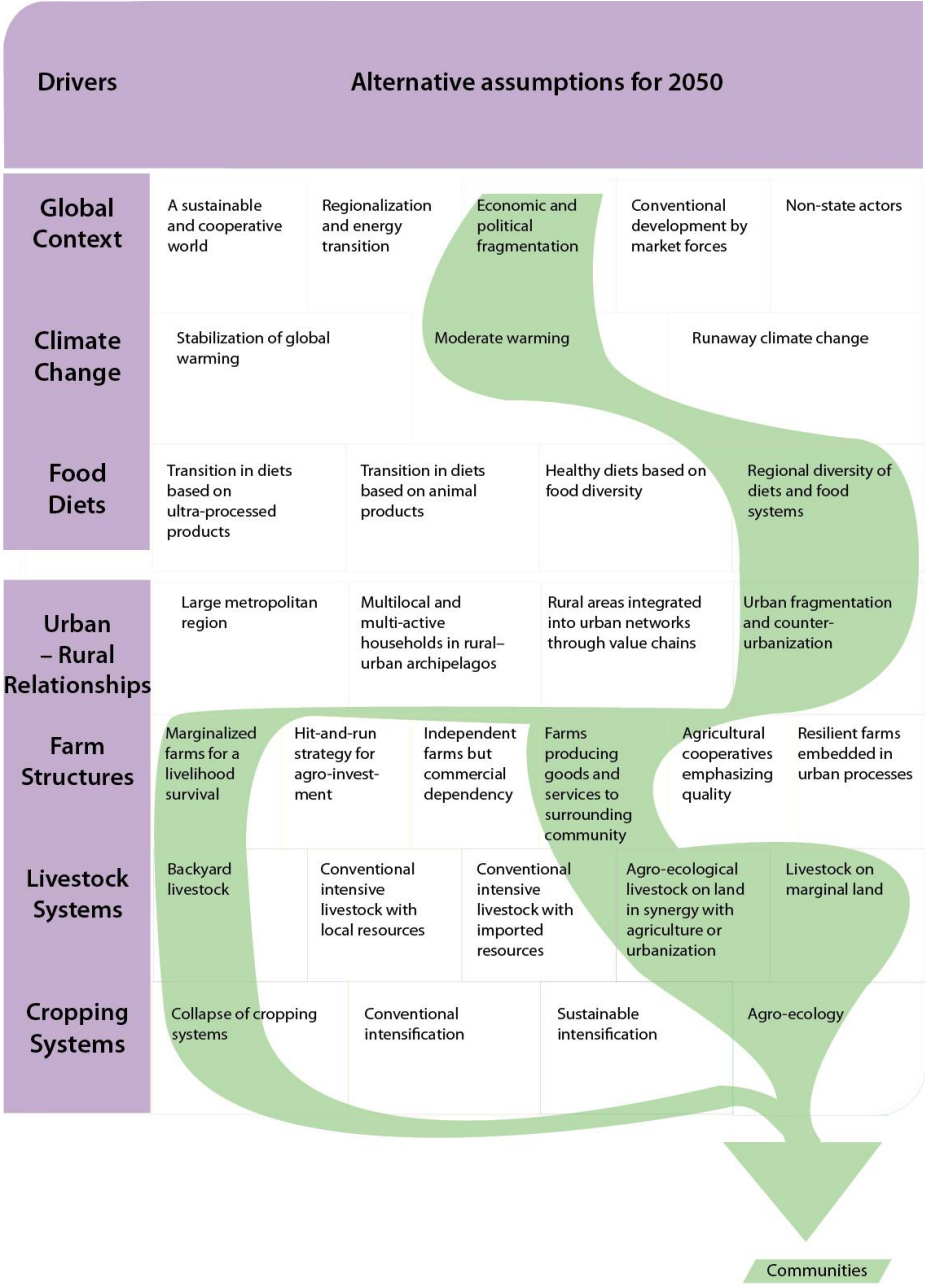
In 2050, simultaneous financial, energy, ecological and geopolitical crises have shaped a world situation that is fragmented not only politically, but also economically. States have reduced public expenditure to basic functions. Unemployment increased thereby impeding metropolitan growth. This process slowed down population and economic concentration in large urban areas, generating an urban de-concentration. Reduced migration from rural to metropolitan areas has led to the growth of smaller towns and fragmented urban development. Rural populations have increased in South Asia, Sub-Saharan Africa and Oceania where birth rates remain high. By 2050, food supply chains in urban areas are based on formal and informal markets providing staple foods and on networks between urban communities and rural ones. Urban and peri-urban agriculture provides incomes and food for poorer urban households, especially women active in markets. Faced with this situation, two evolutions have prevailed.

In order to cope with the multiple crises, in some places farmers have succeeded in organizing themselves within their community to develop agro-ecological farms. Cooperation and collective management have served to co-construct and manage common land to provide sustainable production of foodstuffs, energy and environmental services. Agro-ecological agriculture is regarded as both an agricultural system based on biological self-regulation and a central element of the food system and of social organization, ensuring the food sovereignty of rural and urban communities. Synergies between communities have been developed to relink livestock and cropping systems and therefore to improve soil fertility management and ensure self-sufficiency in animal feed.

In other places, where farmers failed to organize themselves, subsistence farming has developed against a backdrop of declining farm sizes resulting from the growing rural and farming population and the absence of economic development in urban areas. The process of conventional intensification in cropping systems encountered two types of pitfall, depending on the region and access to inputs: over-exploitation of the soil and over-intensification of small-scale farming generating strong adverse impacts on the environment. These processes have generated collapse and stagnation in cropping yields.

By 2050, changes in land use are highly diversified from one region to another, according to the different challenges they face (energy, climate, soils and water) and the collective ability of farmers to bring about a transition to agro-ecology in their community. These changes have increased the pressure on agricultural land especially when the collapse pathway prevails. In this case, North America, Brazil/Argentina and Oceania have expanded strongly both their arable land and pastureland, as well as the Rest of Asia, West Africa, East, Central and South Africa (ECS Africa) and India. But the levels of trade dependency in the regions have been maintained. The consequences for food and nutrition security vary. But undernutrition is still significant, especially in regions with low calories availability remains such as India and ECS Africa. Through self-governing institutions and local food systems, local communities ensure a certain level of food and nutrition security in an extremely negative global context by turning to agro-ecological practices. Conversely, due to the vulnerability of technical systems and the lack of a resource management strategy, regions with subsistence farming face repeated instances of food insecurity and have contributed to deforestation.

Figure 5: Combination of assumptions describing the “Communities” scenario



Description of the scenario

By 2050, economic and energy crises have stemmed urban growth, triggering a process of de-concentration of the urban population. Populations are no longer growing in large cities, unlike in secondary, medium-sized and small cities²³. The new urban map is the result of this differential growth in favour of historic locations and, in certain regions, of counter-urbanization phenomena. The slowdown in migration from rural areas to large cities is a consequence of growing unemployment, pollution and congestion problems, and difficulties in access to

²³ Satterthwaite D., McGranahan G., Tacoli C. (2010). Urbanization and its implications for food and farming. *Philosophical Transactions of the Royal Society B* 365(1554):2809-20.

housing and basic services²⁴. Reduced rural migration towards cities engenders phenomena of urban fragmentation and sprawl, as well as an increase in rural populations in Sub-Saharan Africa and Asia where birth rates remain high. Food supply to cities is provided partly by the informal sector, via community or family networks, and partly by a private sector that provides staple products such as wheat, rice, corn, root and vegetables which are processed within households.

To cope with a situation of multiple crises, farmers engage at community level, in collective actions designed to reinforce ecosystems and make more effective use of the services they provide in local territories. Local communities of farmers and users of rural area in a large number of countries work together to share and manage use of resources, notably land and water, in order to feed the population and provide jobs, while reconciling natural resource management and agricultural production. These collectives have structured their territories made up of small towns and rural spaces to construct food sectors based on management of commons and also to organize recycling of material flows between these spaces. Other collectives of country-dwellers and farmers have been set up in rural spaces that have little in the way of connections with the cities. Each local community has worked collectively to organize its rules and standards for the use of resources. Governance has been structured around local forums in charge of managing common property. They define the use of resources (soils, water, biodiversity) for the production of food, energy and environmental services. These territorial forums have played a central role in the introduction of agro-ecology. Agro-ecology is considered not only as a farming system based on endogenous biological regulation, but also as a central component of the food system and social organization which confers food sovereignty to rural and urban communities. Exchange and barter mechanisms have developed based on territorial solidarity, with exchange of labour, products and skills, as well as recycling of organic waste. Through these territorial institutions, local communities have ensured a certain level of food and nutrition security in what is an extremely unfavourable global context.

These systems of activity are coherent on the scale of the local territory and community. Territorial organizations provide a means of coordinating landscape-level management to preserve water resources, establish connection between livestock and crops, and create ecological infrastructures such as hedgerows and woods. There is relocation of agricultural activities. Agriculture provides a basket of goods for the local community through ecological intensification of land use and diversification of production.

Farming structures are now based on powerful collective or community regulations: contracts and formal or informal arrangements have been established between producers and beneficiaries or clients. Common goods are recognized and these commons are managed collectively. Farmers share the resources of the territory and thanks to the introduction of territorial forums, governance is shared with other stakeholders outside the agricultural sector. Farmer income is diversified thanks to payments for the non-production services they provide. These changes are linked to the rise of a functional economy (in where payments are made for services rendered, rather than for the acquisition of goods. They have brought about many technical and organizational innovations. Communities, public authorities and private bodies organize mediation and networking between the stakeholders that are active in the physical area of concern.

In the absence of external inputs, agro-ecology systems have been developed by collective farmer organizations. They make use of the biological regulation processes inherent to the system, seeking to close the nitrogen and phosphorus cycles and increasing the amount of agricultural work, thanks to a plentiful supply of labour for lack of opportunities to work outside farming. These changes have required the development of ecosystem-specific collective knowledge and know-how, using, capitalizing on and furthering existing knowledge. In this way, cropping systems have become autonomous and boosted their economic and ecological resilience. Their reliance on energy and other industrial inputs such as fertilizer, pesticides and seed is very limited, although they do remain reliant on plentiful farm labour and appropriate mechanization. Agroforestry, which

²⁴ Potts, D. (2013). Rural–urban and urban–rural migration flows as indicators of economic opportunity in Sub-Saharan Africa: What do the data tell us? *Migrating out of poverty research programme working paper*.

simultaneously provides energy, building material and foodstuffs has grown significantly and is often linked to livestock husbandry.

Territorial synergies across farms and communities have been developed based on linking livestock and cropping systems, not only to enhance soil fertility via improved cycling of products and wastes, but also to ensure self-sufficiency in animal feed. Thanks to agro-ecological livestock farming, closer links have been established with local land uses, limiting inputs and negative externalities, and securing incomes for farmers. It is often based on producing robust breeds and boosting their capacity to adapt, notably with regard to reliance on local feed, reduce antibiotic and drug consumption, mixed species, and ensuring food and protein self-sufficiency in the context of extreme climatic events.

Subsistence farming has developed as the size of farms has declined, driven by a growing rural and farming population and the absence of urban economic development. In order to offset this reduction in farm sizes, farmers have turned to more intense conventional cropping methods, giving rise to two kinds of pitfalls. In regions where access to inputs has become difficult on account of their high prices, intensification has led to overexploitation of soils, generating soil degradation by rapid exportation of nitrogen and other nutrients and by reducing soil organic matter. In China, India and those regions where access to inputs is facilitated by their low costs, over-intensification of small-scale farming generates significant environmental, including water pollution and erosion. These cropping systems sometimes come to a technical and environmental dead-end caused by declining fertility, soil erosion and drought. Unpredictable yields and costly inputs reduce economic viability of small farms. As a result, certain areas with small farmers face recurrent food insecurity.

Agronomic potential of land

In 2050, moderate climate change (+1°C by 2050) has had effects (median impact) on agriculture, in particular in tropical areas and in the northern hemisphere. The land areas potentially available for agricultural production have increased worldwide by 100-200Mha (+60 Mha for moderately suitable to very suitable lands), mainly on non-competitive land and in a highly unequal manner. Arable land areas have increased in higher latitudes, but have decreased in the tropics, reinforcing interdependency between the regions of the world.

The various cropping systems have had widely varying impacts on the agronomic potential of the soils, causing acceleration in soil degradation in certain regions driven by conventional intensification or over-exploitation of the soil, and improvements in soil quality in others due to agro-ecology techniques.

Distribution of land between different uses

Between 2010 and 2050, production has been diversified in order to meet demand for food supply for rural and urban populations. Agricultural activities have been relocated to supply food to nearby communities. The quantities of crops grown for export have been drastically cut, due to the decline in international trade. As trade in plant products for animal feed has decreased sharply, livestock systems have been redefined in line with the locally available plant resources. Additionally, mixed cropping and livestock systems have been developed.

In areas where management of commons was adopted, spatial planning is conducted at the landscape level. Preference is given to closely interwoven land uses to produce a diversity of products and services. Such planning is driven by the action of local forums and has shaped mosaic landscapes, while boosting the ecological infrastructures of the territory.

Use of forest biomass for energy in the form of heat, electricity and biofuels, and materials as well as use of crop residues, have increased significantly in certain regions. By 2050, 150 EJ are produced from biomass, although only in countries that are without fossil fuel resources and are unable to develop solar or wind energy: 60 EJ from residues, 70 EJ from more effective exploitation of forests and 20 EJ from dedicated energy crops such as miscanthus and eucalyptus.

Deforestation is being driven by the reduction in average agricultural yields. However, in some region, if agroecology develops, these effects could be offset by the fall in demand for agricultural produce like in China or in Former Soviet Union. Forest surface areas are slightly decreasing in the world as a whole, only if agroecology is being generalized.

Access to land

Land access conditions vary greatly from one region to another, depending on whether they are governed by formal rules or by informal rules backed by community institutions. Land management is therefore either collective or private, and is rarely public.

In general, use of land has come to prevail over ownership, subject to management rules that are defined collectively. The idea of goods that are non-appropriable has come to be established, enabling access to land and natural resources to be renegotiated. While ownership continues to exist, collective rules restrict its scope. Ownership is thus regulated with a view to covering the widest possible range of services. Recycling and re-use are encouraged. Access to land is governed in certain regions by an economy of functionality.

In regions where land availability is low and farming populations are increasing, farmers are in competition with each other for access to land. In a context in which it is difficult to find work outside agriculture, the question of access to land generates conflicts between different groups seeking control of what land there is. These conflicts are amplified by soil degradation processes linked to intensification and over-exploitation of the soil. In these areas, there is great instability surrounding land usage rights.

Degree of intensity of land use

Climate change worldwide has reduced potential yields of wheat by 6%, corn by 7%, rice by 8% soya beans by 15% and groundnuts by 10%. These potential yield losses are greater in tropical regions than in the northern hemisphere. The greater frequency of extreme weather events has increased annual variability in yields.

Between 2010 and 2050, land use intensity varied greatly between regions, depending on their ability to implement effective collective action. Difficult access to mineral fertilizers and high input prices drove a territorial transition towards systems that were less reliant on the world market and based on ecosystem regulation.

The introduction of agro-ecology systems in local territories has reduced the impact of extreme weather events in some regions also in terms of damage and yield variability. Perennial fruit trees and legumes have reached yields nearly equivalent to those of conventional agriculture, while cereals, vegetables and, to a lesser extent, oil crops have suffered significant reductions in yields. However, they tend to improve over the medium to long term thanks to improved soil fertility and farmers knowledge.

On account of the absence of collective organizations, however, some of the world's regions are subject to over-intensification in farming practices, resulting in over-exploitation of resources. This type of intensification generates soil degradation and, over the long term, a decrease in yields. Some of these systems have also arrived at an agro-ecological dead end due to drought or erosion.

Services provided by the land

Collective land management has allowed an increase in the services land provides. The focus has been placed on the multifunctional nature of the territory, with land contributing to supplying residues and wood and agricultural biomass for energy, animal feed and materials, and foodstuffs. This multifunctionality is based on a reinforcement of the biodiversity of the territory. The regulating and cultural services of the ecosystem, which are of benefit to the whole of the community, have been enhanced (e.g. regulating water, protecting against flooding).

When there is no collective management, intensive or over-exploitative agriculture reduce the services provided by the ecosystem: soil degradation, reduced biodiversity, pollution and water shortages. Forests have also suffered from intensive use of wood for energy.

Agriculture and agricultural employment are central factors in rural development.

Food and nutrition security

Between 2010 and 2050, available food resources worldwide have fallen, in particular in those regions with land shortages.

Access to food is also very unevenly distributed. In urban areas, the weak rise in income and the decline in low-priced imported products have made access to food products is more difficult. In rural areas, population growth and decline in agricultural output per active person have made access to agricultural land more difficult. However, the foodstuff exchange systems that have emerged within informal family or support networks do facilitate access to food for some social groups. In areas where community organization does exist, the general increase in agricultural work and in farming-related services boosts farmer incomes and access to food. Backyard livestock systems play an essential role in the food security of households, especially among low-income households.

The effects of this scenario on food diet quality are mixed. On the one hand, low incomes in urban areas have cut consumption of animal products and therefore diet diversity. On the other, the diversification of production in agro-ecology systems has driven increased diversity of foodstuffs. Nutritional quality is in decline, however, in those areas with survival agriculture where production tends to be of staple products by priority.

Finally, access to food is generally unstable. Food is sensitive to weather events affecting agriculture, and all the more so as in this context where external markets can only offset any such problems to a small extent.

How did we get there?

In 2050, multiple economic, energy, geopolitical and ecological crises occurring at the same time and sometimes amplifying each other have led to fragmentation of the political and economic situation around the world. The situation has become chaotic in the wake of monetary and financial crises, the difficulties of States to cope with their debt, unemployment and social instability, and the inability of international and regional institutions to roll out coherent policies to help governments out of their political and economic difficulties. This crisis situation has triggered severe geostrategic tensions, hitting international fossil energy markets particularly hard (volatile prices) and reducing access to energy in some regions. The economic crisis has slowed down urbanization processes, especially in the largest metropolises where growth can no longer fully absorb migration from rural areas. The rural population has therefore grown, in particular in Sub-Saharan Africa and in Asia.

In and around the 2020s, it was Europe that was hit by crisis in the form of sovereign debt and the departure of a number of countries from the Eurozone. In North America, meanwhile, the shale gas industry failed to generate the expected economic growth, while crises in other regions around the world had serious repercussions for companies and government budgets. Crises in the developed countries, meanwhile, triggered more crises in emerging nations, and the absence of external economic drivers slowed down Indian and Chinese growth durably, especially as widening inequalities in both countries prevented the emergence of stronger domestic markets. These difficulties were also compounded by the impacts of extreme climate events, such as flooding of densely-populated urban areas, wildfires, drought and pollution, led to famines and increased poverty in both rural and urban areas. Economic difficulties were also aggravated by political instability, leading to internal conflicts in some countries.

From the 2020s onwards, these crises caused companies to turn their focus to privatizing their resources or even

seizing resources in other countries, particularly when States did not have the will and the legal means to prevent them from doing so. Many other companies have gone bankrupt, triggering unemployment and economic and social hardships. Trade is limited to those countries that are immediate neighbours, or to countries with which bilateral agreements have been signed. In many countries, the poor situation of public finances has resulted in budget cuts in education, healthcare and research, without that shortfall compensated by private funds. In 2050, per capita GDP stands at \$18,000, but with between-countries differences larger than in any of the other scenarios, and with a highly developed informal economy.

Social and economic upheaval and environmental degradations have reached such levels that in the 2030s to 2040s, local communities of farmers and users of spaces gradually started to organize themselves to share and manage use of resources. These communities had come to consider social organization, collaboration and sharing as an effective strategy. Teaching has developed in an informal yet efficient way, through exchange and sharing of experience, and healthcare is set to follow a similar trend. Groups of researchers and other interested stakeholders are organizing themselves to set up joint research and innovation projects supported by crowdfunding platforms and run by volunteer activists.

Due to these successive crises and the difficulties of access to energy, some regions where fossil fuel resources are scarce have been forced into the energy transition, making use on the one hand of those fossil fuel resources that are available in their regions, and on renewable energies on the other. 150 EJ are produced by biomass: 60EJ from residues, 20 EJ from plants dedicated to bioenergy production (miscanthus, eucalyptus) and 70 EJ from managed forests (residues, thinning operations, etc.). In those regions where energy has become costly, sparing use of energy has become an obligation for industry, transport and housing, although the scale of this forced reduction in energy consumption is not sufficient to halt the increase in CO₂ emissions.