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à débattre & décider

Land Use and Food Security in 2050: a Narrow Road

Agrimonde-Terra

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16. Lessons on Land Use and Food Security from the Scenarios

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Introduction

In this chapter we report the main insights that can be drawn from the qualitative and quantitative analysis of the five Agrimonde-Terra scenarios. We summarize these insights in five broad messages which constitute the following five sections of the chapter.

Ensuring world food availability in 2050 will involve expanding the world's agricultural land area...

Most Agrimonde-Terra scenarios lead to an expansion of the world's agricultural land area (Table 16.1). Hence, according to our quantitative hypotheses (Chapter 14), the land-using effects of increased world food consumption (following increased world population, either reinforced or alleviated by changing food diets) tend to exceed the land-saving effects of increased performance in world agricultural production (following increased crop yields and improved livestock feed-to-output ratios).

... But with major differences between scenarios

However, the extent of the expansion in world agricultural land varies widely across scenarios. It is particularly high for scenarios involving either a stagnation in crop yields and deterioration of livestock production performance (+2 billion ha or +41% for 'Communities with collapse') or a huge increase in animal product consumption (+1.3 billion ha or +27% for 'Metropolization with animal products'). It is far more limited, even close to zero, for scenarios involving either reduced calorie availability in food regimes (+142 million ha or +3% for 'Communities with agroecology') or a limited increase in consumption of animal products coupled with the substitution of ruminant meat with monogastric meat in meat consumption (+29 million ha or +0.6% for 'Healthy with agricultural technology C' and –54 million ha or –1% for 'Metropolization with ultra-processed products').

Table 16.1. Land-use change at the world level over 2010-2050 in the different scenarios (million ha and % with respect to base period levels).

	Total agricultural land area	Arable and permanent crops (cropland) area	Permanent meadows and pastures (pastureland) area
Metropolization			
Metropolization_Ultrap	–54 (–1%)	+243 (+16%)	–297 (–9%)
Metropolization_Animp	+1,318 (+27%)	+620 (+40%)	+698 (+21%)
Regionalization			
Regionalization_A	+249 (+5%)	+70 (+4.5%)	+179 (+5.5%)
Regionalization_B	+691 (+14%)	+174 (+11%)	+517 (+15.5%)
Healthy			
Healthy_C	+29 (+0.6)	–56 (–4%)	+85 (+2.5%)
Healthy_D	+269 (+5.5%)	+50 (+3%)	+219 (+6.5%)
Communities			
Communities_AE	+142 (+3%)	+277 (+18%)	–135 (–4%)
Communities_Collapse	+2,013 (+41%)	+555 (+36%)	+1,458 (+43.5%)

Note: Table 14.6 for the meaning of each variant.

In nearly all scenarios world cropland area increases

With our quantitative hypotheses, all Agrimonde-Terra scenarios, apart from 'Healthy with agricultural technology C' (Healthy_C, *i.e.* sustainable intensification for cropping systems and agroecological livestock systems), involve an enlarged cropland area at the world level (Table 16.1). The higher the share of animal products in food diets, the larger the expansion in the world's cropland area (+620 million ha or +40% for 'Metropolization with animal products', Metropolization_Animp). The lower the increase in crop yields or the improvement in livestock feed-to-output ratios, the stronger the need for cropland area at the world level (+555 million ha or +36% for 'Communities with collapse'). It is interesting to note that the 'Metropolization with ultra-processed products' scenario (Metropolization_Ultrap) induces a significant increase in the world's cropland area (+243 million ha or +16%). In practice, in this scenario we have assumed a steady process of substitution of ruminant meat with poultry meat in food diets. Hence world poultry meat production and consumption increase significantly (+201% in 2050 compared to 2010), requiring more feed and contributing to the rise in the world cropland area required. This

adjustment mechanism is particularly marked in regions such as India and ECS Africa and, to a lesser extent, West Africa, where the share of meat in food diets is particularly low in the initial situation, so that transition in diets even when based on ultra-processed products induces a significant increase in meat consumption (Chapter 14). On the contrary, it is also interesting to note the 'cropland saving' nature of the 'Healthy' scenario (from –56 million ha in the variant C to +50 million ha in the variant D, *i.e.* agroecology for both cropping and livestock systems). In this scenario, the increase in world production and consumption of meat and animal products more generally is limited because of both the decrease in the daily calories available per capita in most regions and the substitution of pulses for animal products in regions where the share of animal products in food diets is initially high (developed and emerging regions, see EU 27, for example, in Chapter 14).

The change in the world's agricultural area is mostly driven by the change in the world's pastureland area

With our hypotheses, in most Agrimonde-Terra scenarios the change in the world's agricultural land area is mainly explained by the change in the world's pastureland area (Table 16.1). Once again, the lower the increase in crop yields or the improvement in livestock feed-to-output ratios, the larger the world pastureland area in 2050 (+1.46 billion ha or +43.5% for the 'Communities with collapse' scenario). The higher the share of animal products in food diets, the larger the world pastureland area required (+698 million ha or +21% for Metropolization_Animp). The 'pastureland using' nature of the 'Regionalization' scenario (+517 million ha or +15.5% for 'Regionalization with agricultural technology B', Regionalization_B, *i.e.*, agroecology for both cropping and livestock systems) partly relates to the higher share of small ruminant meat in food diets involved in this scenario. Because in Africa and the Near and Middle East, traditional diets are based on small ruminant meat, the 'Regionalization' scenario implies a significant increase in small ruminant meat consumption in these regions. Overall, the small ruminant sector is less efficient than monogastric sectors in transforming feed into meat, so the additional pastureland area required at the world level is significant.

No further expansion of agricultural land at the world level with 'Metropolization_Ultrap' and 'Healthy_C'

With our hypotheses, only the scenarios 'Metropolization with ultra-processed products' (Metropolization_Ultrap) and 'Healthy with agricultural technology C' (Healthy_C) are able to produce sufficient food for the expected growing population up to 2050 without further expansion in agricultural land and potential deforestation at the world scale. Under all the other scenarios, ensuring food availability in 2050 would require large additional agricultural land areas, which would likely be obtained through deforestation, at least partially. In some cases, world agricultural land expansion and then potential deforestation is so huge that the corresponding scenarios may be considered clearly unsustainable in 2050: both 'Communities_Collapse' and 'Metropolization_Animp' scenarios for example. Moreover, the 'Regionalization' scenario also induces a significant expansion in world agricultural land, whatever the variant. Although more limited, the agricultural land

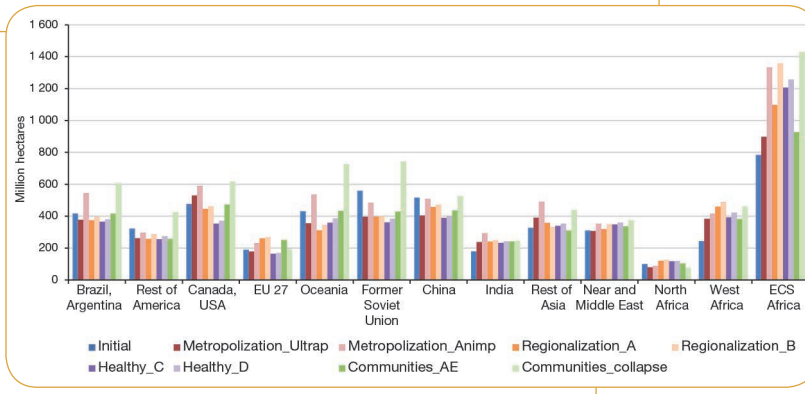
expansion and induced potential deforestation under the 'Healthy with agricultural technology D' (Healthy_D) scenario puts into question the consistency of this scenario, given that it involves strong mitigation objectives aimed at stabilizing climate change.

The two scenarios which involve the largest expansion in agricultural land ('Metropolization' with the animal product variant and 'Communities' with the collapse variant) are also those where the political context leads to insecure access to land. In the first case, farm structures evolve towards 'hit-and-run agro-investments' or 'independent farms' contracting with agri-food companies. Land expansion will be stimulated by these farm structures, either by renting or grabbing the land of small farmers, who will then be displaced and may push the agricultural frontier further, or by expanding themselves. In the second case, farm structures evolve towards 'marginalized farms' that practice subsistence farming in a degraded environment with high competition for access to land as a consequence of the increased rural population. It will be these farm-type structures which contribute to land expansion and it will not have the same impact on the rural population as in the first case. In the other three scenarios, the political context favours security in access to land and land expansion is more limited.

Limiting agricultural land expansion will require increased performance of agriculture in some regions

GIVEN THE INITIAL SITUATION AND WITH OUR QUANTITATIVE HYPOTHESES, there are three regions where the agricultural land area expands significantly under all scenarios: India, West Africa and ECS Africa. This is not the case for other regions where agricultural land may expand or decrease according to the scenarios (Figure 16.1).

Figure 16.1. Regional agricultural land area in the initial 2010 situation and in 2050 in the various scenarios (million ha).



Source: GlobAgri-AgT model.

Beyond the historical social, economic and political differences between India as a continent-wide country and Africa as a 45 country-continent, the initial situation (initial food diets and initial agricultural performance), the Agrimonde-Terra hypotheses for food diets in 2050 (and their quantitative translation) and the UN projections adopted for population change largely explain this specific situation for India, West Africa and ECS Africa.

In India, West Africa and ECS Africa, hypotheses on dietary changes lead to increased consumption of animal products in all scenarios

India, West Africa and ECS Africa all show initial food diets where both the daily calorie availability per capita and the share of animal products (especially meat) are the lowest in the world: 2,390 kcal/cap/day including 6% of animal products and less than 1% of meat for India; 2,663 kcal/cap/day including 3% of animal products and 2% of meat for West Africa; 2,225 kcal/cap/day including 9% of animal products and 4% of meat for ECS Africa. Hence, as all our hypotheses about the future of food diets result in an increase to 2,500 or 3,000 daily kcal per capita in 2050 and an increase to 10% or 16% in the share of animal products for those regions which are below these levels in the initial situation, India, West Africa and ECS Africa all experience changes in diets which are little differentiated across the scenarios (except for the share of meat in 'Metropolization_Animp') and which induce a rather large increase in the share of animal products in diets (Chapter 14). However, in India, due to traditional vegetarian diets, meat consumption remains stable in all scenarios apart from 'Metropolization_Animp' which assumes a huge increase in meat consumption, notably poultry meat; in the 'Healthy' scenario, Indian consumption of animal products is replaced by consumption of pulses.

India, West Africa and ECS Africa are likely to experience a strong population increase from 2010 to 2050

West Africa and ECS Africa are the two regions where the population is expected to increase the most in the world: +192% and +155% respectively from 2010 to 2050. The expected population increase is lower in India (+45%) but remains very substantial in absolute numbers given the current size of the Indian population.

The combination of dietary change and increasing population implies huge consumption increases, notably for animal products, in the three regions in all scenarios. In this regard it is interesting to emphasize the contrasting positions of India and China regarding diet and population change on the one hand, and the resulting expansion in agricultural land on the other. In contrast to India, the Chinese population is expected to stop growing and remain stable from 2010 to 2050. Furthermore, in China, our hypotheses for the future of food diets result in stable or a decrease in daily calorie availability per capita as well as a fall in the share of animal products in diets in all scenarios except 'Metropolization_Animp'. Hence it is not so surprising that while both regions already use nearly all their cultivable area in the initial situation (Chapter 14), in most scenarios China experiences

a reduction in its agricultural land area while India expands its agricultural land area (Figure 16.1) and is increasingly constrained by its cultivable area.

In India, West Africa and ECS Africa the performance of agricultural production systems is rather weak in the initial situation

This third piece of the puzzle is particularly significant in the two African regions (Chapter 14) where the acceleration in the growth of crop yields and in the improvement of livestock feed-to-output ratios, which is assumed in most of our scenarios, closes only partially the initial gap observed with the average performance of developed and emerging regions.

Therefore, it is not surprising that all three regions are among the largest contributors to the expansion of the world's agricultural land area in all Agrimonde-Terra scenarios, either through an expansion of the cropland area (India and West Africa) or through the expansion of pastureland area (ECS Africa). As a direct consequence, these three regions are likely to experience significant deforestation in most Agrimonde-Terra scenarios. Hence, it is clear from Figure 16.1 that under our quantitative hypotheses, all of our Agrimonde-Terra scenarios are unsustainable for West Africa, ECS Africa and, to a lesser extent, India, which would all experience a dramatic expansion in their agricultural land area, seriously threatening their forest area.

Limiting agricultural land expansion in India, West Africa and ECS Africa will require improvements to the performance of their agriculture

In other words, given the hypothesis of population increase in West Africa, ECS Africa and, to a lesser extent, India, and given the hypotheses about food diet evolution in these regions, especially the increasing consumption of animal products, ensuring world food availability in 2050 without major deforestation around the world would certainly require limiting the expansion of the agricultural land area in these regions either by increasing imports or through improving the performance of their agricultural production systems, especially livestock production systems. Increasing Indian, West African and ECS Africa imports would make it possible to save some agricultural land area, avoiding some of the potential deforestation in these regions. Such an adjustment would not induce more potential deforestation at the world level provided that the available agricultural land in other regions is sufficient for producing these additional imports. But it would also mean that these three regions have the means to buy food abroad.

Increasing the performance of Indian, West African and ECS African agricultural production systems, particularly livestock systems, would also be a land-saving lever, making it possible to reduce the threat to forest areas. Our hypotheses on the future of cropping and livestock systems result in a sharp improvement in performance of the agricultural production systems

in the three regions, especially in the African ones, in most scenarios. There is, however, uncertainty regarding the potential for increased performance in all three regions.

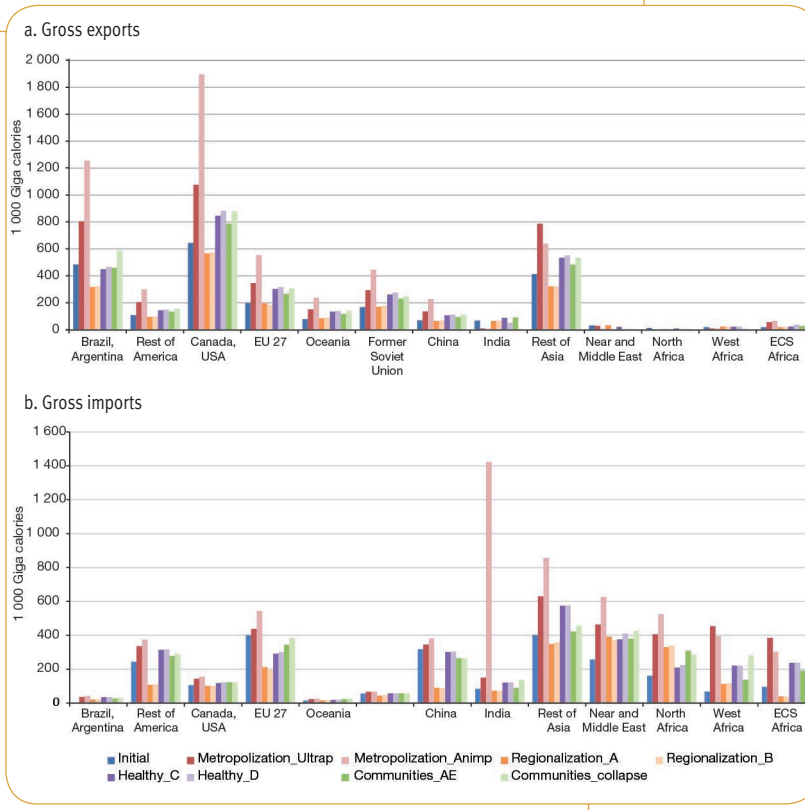
Let us underline at this stage that West Africa and ECS Africa are the two world regions exhibiting the lowest initial performance in terms of livestock feed-to-output ratios, especially in ruminants. For instance, in the initial situation, the feed-to-output ratios of the mixed systems in the dairy sector and in the beef sector in the two African regions are five (dairy sector in ECS Africa) to 15 (beef sector in West Africa) times higher than those of the EU 27 (one of the world's best performers in dairy and beef meat production). This means that producing 1 tonne of milk or of bovine meat in ECS Africa or West Africa requires five to 15 times more dry matter feed than in the EU. Of course, there are great uncertainties regarding the initial livestock feed-to-output ratio data, notably in West Africa and ECS Africa. In this regard it is worth noting the roles of livestock in West and ECS Africa (and in India) where mixed crop-livestock systems and pastoralism are very common and livestock not only provide nutrient-rich food products but also draught power, organic manure and domestic fuel; livestock also serve as a source of income, as a means for capital accumulation and insurance against income shocks, generate employment and play a role in the security of territories. Despite huge uncertainties, one may assume however, notably on the basis of literature and experience, that room for manoeuvre exists for improving livestock feed-to-output ratios in all three regions.

Whatever the scenario, international trade will play a key role for ensuring world food availability in 2050

World trade increases in all scenarios, apart from 'Regionalization' (Figure 16.2). Unsurprisingly, 'Metropolization' is the scenario inducing the highest increase in world trade (from 2010 to 2050, world exports in kcal would increase by +151% under the 'Animal products' variant and by +71% under the 'Ultra-processed products' variant), while the 'Healthy' and 'Communities' scenarios result in far smaller rises (from +20% to +30% according to the scenario and variant). In contrast, the regionalization of food systems involved in the 'Regionalization' scenario logically leads to a reduction in world trade (–15% in both variants).

Beyond these global figures, the Agrimonde-Terra scenarios lead to far different world trade configurations and positioning of regions in international trade (Figure 16.2). 'Metropolization' relies on international trade and specialization. Hence in this scenario, world agricultural production concentrates both on a few products and in a few of the most competitive regions. Regions with lower comparative advantages become more dependent on imports. In such a situation, ensuring world and regional food availability requires increased trade flows between exporting and importing regions. In 'Metropolization', agricultural production and exports are clearly concentrated in Brazil/Argentina and Canada/USA, two regions benefiting from large areas of available

Figure 16.2. Agricultural trade in the initial 2010 situation and in 2050 in the various scenarios (1,000 Giga calories).



Source: GlobAgri-AgT model.

cultivable land. In contrast, North Africa, the Near and Middle East, India, West Africa and ECS Africa experience dramatic rises in their agricultural imports, increasing their dependence on world markets to ensure their food availability. This raises questions about access at the regional level and probably at the household level too. Interestingly, we note that concerning exports, the concentration process is more marked in the 'Animal products' variant than in the 'Ultra-processed products' one. In the 'Animal products' variant, Brazil/Argentina and Canada/USA share the leadership on world agricultural export markets because they are the both largest exporters of animal products and feed ingredients. In the 'Ultra-processed' variant, both regions share the leadership on world agricultural export markets with the Rest of Asia due to the significance of

this region in palm oil exports and the central role of vegetal oils in the diet based on ultra-processed products.

World trade also increases under the 'Healthy' scenario, but to a significantly lesser extent and without the concentration process specific to 'Metropolization'. 'Healthy' is one scenario allowing net importing regions to alleviate the increasing trend in their food import dependence, and in addition with higher quality standards for products on international markets. Reducing the dependence on international trade is part of the spirit of 'Regionalization' but world trade would be far from finished and would continue to play a key role regarding food availability.

According to our hypotheses, some regions are likely to become highly dependent on imports for their food whatever the scenario. This is clearly the case for North Africa as well as the Near and Middle East, with both regions initially strongly dependent on imports, a situation which worsens in all scenarios. This also seems to be the case for West Africa and to a lesser extent for India. These four regions experience strong population growth, pushing up food demand, but are either constrained or almost constrained by their cultivable land area, which limits the potential for an increase in domestic production in most scenarios. In this regard, the almost 80% net import dependence that North Africa reaches in the 'Metropolization' scenario (meaning that in 2050, 80% of North African food needs are covered by imports) is due, at least partly, to the loss of half its cultivable area induced by the strong climate change hypothesis involved in this scenario.

In all scenarios, apart from 'Regionalization', India and West Africa would experience a significant increase in their import dependency, which is often double or even four times greater than in the initial situation. Both these regions have small reserves of cultivable land for meeting the increase in domestic consumption. Hence they start to increase their imports. The case of India under 'Metropolization', whereby food diets change towards an increased share of animal products, is particularly striking: facing the upper limit of cultivable land, India starts to import both feed ingredients and monogastric meat.

Over-reliance on food imports can increase the risk of disruption to supply and access caused by global fluctuations in production and price volatility, as well as trade wars. Over-reliance on food imports also places a significant burden on State budgets.

Increasing food and nutritional diversity in 2050 will require greater diversification in cropping and livestock systems

Among Agrimonde-Terra scenarios, two involve increased food and nutritional diversity in 2050: the 'Healthy' scenario and, to a lesser extent depending on traditional regional

diets, the 'Regionalization' scenario.[73] According to our hypotheses, both these scenarios lead to an expansion in agricultural land, thus potential further deforestation, at the world level, but to a very different extent depending on the scenarios and the variants within each scenario.

First of all, increasing food and nutritional diversity through the 'Healthy' scenario would use significantly less land than increasing food and nutritional diversity through the 'Regionalization' scenario (Table 16.1 and Figure 16.1). In addition to the differences between the 'Healthy' and the 'Regional' food diets, implying differentiated changes in regional food consumption of various products, the decrease in inter-regional trade in the 'Regionalization' scenario also contributes to greater land use. By favouring the substitution of imported products with local ones, the 'Regionalization' scenario also leads to increased production in regions which are less productive, resulting in a greater requirement for agricultural land at the world level. All in all, the land-use changes induced by both scenarios exhibit significant discrepancies, the 'Regionalization' scenario achieving increased food and nutritional diversity at a far greater cost in terms of the global expansion of the agricultural land area than the 'Healthy' scenario: +249 million ha agricultural land (+70 million ha cropland and +179 million ha pastureland) under 'Regionalization_A' and +29 million ha agricultural land (–56 million ha cropland and +85 million ha pastureland) under 'Healthy_C' for instance.

Secondly, among the possible development paths for cropping and livestock systems, the A and C variants would demand significantly less land than the B and D variants, whatever the scenario. This is not surprising and is closely related to the quantitative hypotheses adopted, which make changes in crop yields up to 2050 more favourable in the variants 'Regionalization_A' and 'Healthy_C' than in the variants 'Regionalization_B' and 'Healthy_D'. The same thing is observed for average livestock feed-to-output ratios, but only in the 'Regionalization' scenario (Chapter 14, Table 14.5). Beyond the quantitative hypotheses, which may be questioned given the lack of empirical evidence on the input-to-output performance of crops and animals in agroecological systems compared to conventional systems, both scenarios suggest the unavoidable need for the appropriate diversification of cropping and livestock systems (mainly regarding the composition of animal rations) together with an increase in food and nutritional diversity if we wish to limit the expansion of agricultural land and, therefore, deforestation around the world.

An illuminating illustration is the situation of Brazil/Argentina in both scenarios. In Brazil/Argentina, the increased food and nutritional diversity involved in both the 'Healthy' and the 'Regionalization' scenarios (as well as the reduced inter-regional trade in the latter) contradicts the development path the region had previously adopted, at least for

73. The 'Communities' scenario also increases food and nutritional diversity in 2050 since it shares the same food diet pathway as the 'Regionalization' scenario. But in this case, because of the context of crises and low economic growth, the increased diversity is compensated by a decrease in available energy per capita and per day (Chapter 14).

an important chunk of its agriculture: openness on international markets, simplification of production systems and specialization in products at the heart of the nutritional transition (vegetable oils, sugar and poultry meat). Hence these scenarios would lead to tremendous changes for Brazil/Argentina's agriculture, which would experience a decrease in agricultural land area (from –5 to –12% according to the variant and scenario) following the –25% ('Healthy') or –50% ('Regionalization') decrease in domestic soyabean production, the –10% decrease ('Healthy') or quasi-stagnation ('Regionalization') in domestic production of sugar plants and products and the quasi-stagnation in the production of animal products in both scenarios. Of course, given the assumptions in the scenarios, the production of some diversified products would increase substantially (nearly a +350% increase in fruit and vegetable production in the 'Healthy' scenario and nearly a +150% increase in roots and tuber production in the 'Regionalization' one) and, according to our quantitative hypotheses, their yields per hectare as well. This faster increase in per-hectare yields of diversified products (resulting from induced technical change) avoids an expansion in agricultural land in Brazil/Argentina in both scenarios. Hence, these results suggest that for some regions, such as Brazil/Argentina, increasing food and nutritional diversity all over the world would imply huge changes in their production systems and a total redesign and adaptation of production systems aimed at diversity. This could take some time and in the meanwhile it is likely that following increased food and nutrition diversity, agricultural land would expand in these regions.

Only the 'Healthy' scenario is likely to be able to ensure world food and nutrition security in 2050

Among the Agrimonde-Terra scenarios, at least two are clearly not able to ensure sustainable world food and nutrition security in 2050: the 'Metropolization' (both variants) and the 'Communities' scenarios, notably under the 'Collapse' variant. Furthermore, two have ambiguous results: the 'Regionalization' and the 'Households' scenarios. Only the 'Healthy' scenario seems likely to be able to meet the objective of world food and nutrition security in 2050.

'Healthy': Reduction in over and undernutrition with limited agricultural area expansion

'Healthy' is the scenario which contributes most to reducing not only overnutrition and its related diseases, but also undernutrition. This is also the one scenario allowing world food availability to be achieved at the cost of a rather limited expansion in the agricultural land area at the world level. There are some regions, however, where promoting healthier diets induces an increased consumption of animal products, such as India, West Africa and ECS Africa. In these regions, even the 'Healthy' scenario is likely to induce an expansion in the agricultural land area and potentially significant deforestation. As the 'Healthy' scenario

also involves a strong commitment from governments, corporations and international institutions to mitigating climate change, requiring the production of renewable energy and the maintenance of world forest cover as far as possible, there are potential tensions between the objectives of food security and climate change stabilization, resulting in increased competition for land between agricultural and forestry uses. Agroforestry and farming practices that contribute to improved soil quality and the storage of organic carbon in soils (thus yield potentials) could be very interesting options in this case, since they simultaneously work towards the objectives of food security and climate change stabilization.

'Metropolization': Unsustainable from both the public health and resource preservation perspectives

'Metropolization' is the scenario which contributes most to the expansion of overweight, obesity and diet-related non-communicable diseases all over the world, with considerable impacts on public health and economic activities. In setting up a kind of race between changing food systems, increasing yields, deteriorating natural resources and propagating diet-related non-communicable diseases, 'Metropolization' induces a series of effects which work against food and nutrition security at various levels. Firstly, as far as food availability is concerned, previous analysis has clearly shown that the propagation all over the world of animal rich food diets is unsustainable both at the world level and for some regions. However, the expansion of agricultural land area and related potential deforestation could be significantly reduced if transition in diets was based on ultra-processed products all over the world. Secondly, 'Metropolization' relies on crop and livestock systems which are sensitive to climate change and contribute to natural resource degradation (notably soil and water). This throws into question the future performances of such systems and therefore world food availability in the longer term. Thirdly, this uncertainty, combined with the international specialization process involved in the 'Metropolization' scenario, is likely to result in increased price instability on world agricultural markets, which is likely to put into question the stability dimension of world and regional food security. Fourthly, as 'Metropolization' involves increased spatial and economic inequalities, a large section of the rural and urban population is marginalized with poor access to food due to low incomes.

'Communities': Multiple crises and reduction of food availability at the world and regional level

'Communities' is a multi-crisis scenario in which the deterioration in agricultural production performance would create a reduction in food availability at the world and regional level. Because every region needs more land to meet its food needs, there is a struggle for resources, with very serious tensions over land and a degradation of natural resources, including soils. Long-term world food availability is put into question. World food availability and accessibility can be ensured only if communities are able to re-build collectively

local food systems based on agroecological cropping and livestock systems. But even if this is the case, the smaller expansion in agricultural land area corresponds to a –10% decrease in daily calorie availability per capita in most regions. In developed countries, this reduction in food availability could contribute to reducing overnutrition and related diseases. In developing countries, however, it could cause increased undernutrition, affecting women and children. In addition, as the 'Communities' scenario involves sluggish economic growth all over the world, households are likely to see their incomes stagnate or even decrease and therefore they could face difficulties in accessing food, mainly in urban areas. On the other hand, re-built local food systems could facilitate food access for rural populations as well as contributing to increased food and nutritional diversity through the crop diversification involved in agroecological cropping systems.

'Regionalization': Ambiguous results

The 'Regionalization' scenario induces a series of changes that work in favour of world and regional food and nutrition security, but at the same time leads to ambiguous results regarding world food availability. 'Regionalization' is a scenario opposing the global convergence of diets towards a few standardized products through the promotion of traditional diets and products. It therefore favours food and nutritional diversity and contributes to limiting the development of diet-related non-communicable diseases in world and regional populations, mostly by reducing the global diffusion of ultra-processed foods. This scenario also involves the development of agri-food industries in small and medium-sized cities acting as intermediaries between rural areas and urban centres. These industries positively affect rural development, rural employment and rural incomes for men and women. Hence 'Regionalization' may improve access to food for rural populations. However, 'Regionalization' is only able to ensure world and regional food availability at the cost of a significant expansion of the agricultural land area and a considerable threat to forest area at the world level. Land area expansion and potential deforestation by farmers may even be dramatic in regions poorly endowed with land and sometimes poor in other natural resources (water, for instance) such as North Africa, the Near and Middle East, India and West Africa, or better endowed with land but exhibiting poor agricultural productivity such as ECS Africa. In such regions, the 'Regionalization' scenario appears rather unsustainable.

'Households': An intermediate scenario with reduced undernutrition but increased overnutrition

Finally, 'Households' appears as an intermediate scenario, contributing to a decrease in undernutrition but with the opposite effects on overnutrition. Changes are induced by a wide variety of actors (groups of citizens, associations, NGOs, enterprises etc.). Regarding food and nutrition security, 'Households' is an intermediate scenario which has common elements with three other scenarios. It shares with 'Healthy' a major public interest in

nutrition, but State regulation is not involved. It shares with 'Regionalization' the idea that local food systems could respond to demands from consumer groups; the food diversification implied could have a positive impact on overnutrition. However, the main question raised by such a scenario is the extent to which changes in demand towards healthier foods from various consumer groups are able to induce the transformation of food systems without a regulatory framework. It therefore seems plausible that ultra-processed foods would retain non-negligible shares in both food diets and food systems in the 'Households' scenario, contributing to an increase in overnutrition. Finally, 'Households' is a scenario in which households use mobility to diversify their sources of incomes, accessing non-farm jobs in urban or rural areas. This income diversification is likely to improve food access and result in reduced undernutrition.

Conclusion

Agrimonde-Terra's scenarios identify a diversity of pathways of change for agricultural land use and food security in 2050. They highlight the fact that we are entering a period of great uncertainty and instability, which finds its origin in the dynamics and the interconnectedness between trend factors (demography, urbanization, climate change etc.), uncertainty and risk factors (economic growth, employment, eating patterns, climate change mitigation etc.), private actions and public policies at local, national and international levels.

Agrimonde-Terra's scenarios also suggest that ensuring world and regional food and nutrition security in a context of climate change is a difficult, long and narrow path. Public policies are likely to have a key role in guiding current agricultural and food systems towards this path.