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Climate change: an extra challenge for agriculture in Africa

2050 outlook for food security and agricultural productivity

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A study funded by the *Fondation pour l'agriculture et la ruralité dans le monde* (FARM - Foundation for World Agriculture and Rural Life) and conducted by the *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD - Centre for International Cooperation in Agronomic Research for Development) has raised serious questions on the ability of sub-Saharan Africa to meet the double challenge of feeding its future population - which everyone is agreed will rise sharply - and providing a proper income for its farmers. The perspective thus offered is already fairly pessimistic in nature and could be made even more gloomy by the forecasts commonly made on how climate change will affect agricultural production. All of this calls for an in-depth examination of potential anticipatory measures that could be taken and which are not primarily technical but concern instead agricultural policies, with the aim of reducing the risks borne by producers and of increasing their investments.

Summary

According to the CIRAD study, which is based on benchmark FAO projections, the predicted rise in demand for agricultural food products in sub-Saharan Africa (SSA) by 2050 is likely to be higher than in any other region in the world (2.6 times greater than 2006). Production is unlikely to be able to keep up with this sustained increase, although it is predicted to be higher here than in any other region for all product groups. Through the contribution of imports, per capita food availability would eventually be 3000 kcal/day, and therefore satisfactory, but at the cost of maintaining a dependency rate of 12%, measured in terms of the net imports/consumption ratio, due largely to the deficit in animal products of which SSA would be the second largest importing region.

While the food availability projections in the study are relatively favourable, this optimism should be tempered by successive population growth revisions, which would result, all other things being equal, in the daily availability calculation dropping to 2340 kcal in 2050 compared to the initial CIRAD estimate. This food availability figure is lower than that of 2006. Rises in working population numbers would also have an effect on resources as the surface area available per agricultural worker would drop to under 0.7 ha.

This threat is further increased by climate change and a potential deterioration in the production and living conditions of farmers. Using the assumption of an average reduction in agricultural production of 8% compared to the projected figures for 2050 in the CIRAD study, per capita food availability could plummet by 23% (again compared to the baseline scenario) given the simultaneous marked rise in the population, unless net imports fill the gap; they would then be equivalent to half of all production.

While sub-Saharan Africa should be the region benefiting from the highest increases in production by 2050 (+164% for plant products and +185% for animal products), increased yields relative to surface area would be lower than in other regions, this occurring against a backdrop of a significant rise in the working agricultural population, thus in all probability increasing the gap between SSA and the rest of the world in terms of productivity of agricultural labour. The differential would be a ratio of 1 to 372 with North America, for example. All potential ideas should therefore be explored which could loosen the constraints on agriculture. Halving the losses between harvest and consumption, leading to a potential increase in food availability of around 7.5%, would not be sufficient to offset the consumption deficit but would have a

significant impact on net agricultural imports in Africa, allowing them to be halved. Other avenues should therefore be explored in terms of land productivity since, despite catching up somewhat, the yield growth patterns projected in the study would be relatively modest compared to what occurred in East and South Asia or Europe during their green revolutions. If the yield increases experienced by these regions could be applied, labour productivity could increase by a factor of 2.7 compared with 1.4 in the CIRAD study, but without any assurance that this would make up the gap with other economic sectors and the rest of the world. What is, however, certain is that only increased investment efforts and economic policies strongly encouraging capital accumulation in agriculture, thus reducing the risks borne by producers, will make it possible to open new perspectives, something the long-term model cannot easily incorporate.

The Millennium Development Goal of halving extreme poverty in sub-Saharan Africa between 1990 and 2015 has not been met. Its eradication by 2030, as set out in the new sustainable development goals that have just been adopted, can only be achieved if considerable effort is made to improve the situation of rural communities which, in Africa, are the poorest group in society with highly uncertain prospects when it comes to improving income trends. Agriculture, from which 60% of the African population draws its income, lies at the heart of this challenge. Defining potential scenarios of how the production and productivity of agricultural activity is likely to develop, while taking account of environmental and demographic variables, is therefore essential to prevent food crises which could be long-lasting, and social crises which would undoubtedly generate massive underpayment and unemployment of a young and rapidly growing population.

A study funded by FARM and conducted by the CIRAD[1] has evaluated key trends in agricultural production, demand, availability and productivity, its focus being sub-Saharan Africa (SSA). The results of this prospective analysis are based on projections made by the FAO which are used as a benchmark[2]. They relate to the volumes produced by countries which, for the purposes of the study, are aggregated into product groups and regions, one of which is sub-Saharan Africa. Most of the projected agricultural data is the result of estimates made by experts. Balances between production and use are ensured through the foreign trade of regional groups.

This note presents the principal results of these projections on production, coverage of food consumption, and land and labour productivity in sub -Saharan Africa; it then further examines them through a discussion of key areas of uncertainty, namely climate change and variations in population growth forecasts. The last part of the note suggests avenues for exploration which would reduce the projected food deficit by reducing post-harvest losses and further increasing yields. The conclusion points out that not all options have been retained in the long -term model and that the door is therefore open to more promising public interventions than the projections imply .

■ Positive production growth but insufficient to meet demand

The demographic projection used by the FAO estimates that in 2050 the population of SSA will be double what it was in 2007, making it the region with the highest growth over the period. This population increase is likely to take place against a backdrop of economic growth in sub-Saharan Africa similar to the global growth figure (around 4% per year) which means a relative loss of position in terms of GDP per capita, when Africa was already at the bottom of the list. In other words, the per capita income disparity between Africans and the rest of the world will increase to a ratio greater than 1 to 50. A first consequence of this would be the risk of seeing a high percentage of Africans south of the Sahara remaining under the poverty line in 2050, as the estimated average income would only be $4.8 per inhabitant per day, and that only a big reduction in inequality would prevent a large proportion of the population living under the threshold of $1.25[3].

Under these conditions, it is even more important to closely examine the food availability projections for each region in order to compare them with demand, which is itself constrained by the average income of populations. SSA appears to be the region in which the increase in demand is likely to be highest for all products, falling between 2% per year (for roots and tubers) and 3.1% (for eggs). With an average annual increase in demand of 2.2% for crop products and 2.7% for livestock products, demand is likely to

1. Dorin B. (2015)

2. Alexandratos et al. (2012)

3. We mention the reference figure of $1.25 and not $1.9 which became the new poverty threshold in October 2015, as it was established for a purchasing power parity in 2005 in an economic context similar to that used for the FAO projections.

increase by a factor of 2.5 to 3 between 2006 and 2050. However, sub-Saharan Africa would still consume less than 7% of the worldwide volume of livestock products in 2050, while its population would represent almost a fifth of humanity. This is a reflection of continuing weakness in purchasing power.

However, production could only partially meet this growth in demand. It is true that Africa would be the region with the highest production growth rates for all products by 2050 (always greater than 2% a year, leading to a doubling by 2040 at the latest) but this is starting from a very low point, making catching up to a satisfactory level difficult.

Of course, this growth in production should be set against the strong rise in demand linked to population growth, leading to a widening of the gap which increasing imports would have to fill. Converted into equivalent plant-based dietary calories, the deficit could increase by a factor of 2.3 by 2050. The region would then become the second largest net importer of livestock products in terms of volume while, as we have seen, the consumption level of these products should remain low, especially in comparison with developed countries. The continent would not be self-sufficient in any group of products except tubers. Only the balances of trade for fruit, fibres and other tropical products[4] would be positive. The relative deficit, in terms of consumption percentage, would be practically the same as it was 45 years earlier (with self-sufficiency of 80% for cereals, for example). The only difference would be the origin of the foods purchased on the global market, as Latin America should gain ground in providing cereals, oilseeds, meats and milk, mainly at the expense of Europe.

Eventually, because these deficits would grow at the same pace as production, the overall degree of dependency, measured by the net imports/ consumption ratio, would be identical to that of 2006, i.e. around 12%. This assumption, which may appear to temper the pessimism of the deficit projections in terms of absolute value, should, however, be considered from a dual perspective: Africa's loss of food self-sufficiency - which it had achieved in the 1960s - and a probable worsening of the deficit caused by the confirmed delay in demographic transition.

On the basis of the population and production projections in the FAO study, and through the contribution of imports, the CIRAD study estimates that food availability[5] could reach 3000 kcal/capita/ day in 2050. Africans south of the Sahara would consume on average as many plant products as Europeans, or the equivalent of just over 2700 kcal/ day. In contrast, consumption of livestock products would stay low, representing the equivalent of 190 kcal/day, a long way behind the 600 kcal/capita/day calculated worldwide.

For Africa, this would mean an overall ability to satisfy the food needs of its population, even if it has to be said that at this stage the cost of this is impossible to calculate, particularly regarding its actual ability to pay the import bill on food products. Finally, it should be noted that in 2050, the total calorie equivalent of edible products in Africa would only represent 13% of all calories consumed worldwide, while its population will account for 19% of the global total. In some sense, the "footprint" of Africans in terms of agricultural resources should remain modest compared to their position in the world, even if the land under cultivation on the continent increases by 20% by 2050.

Atypical patterns of productivity growth

The calorie accounting in the CIRAD study, the principle of which is developed in its Agribiom model, is used to aggregate all agricultural products and therefore to simulate global trends for Africa by avoiding the uncertainties linked to variations in prices and exchange rates. The study confirms the growth of food production expected in sub-Saharan Africa by 2050, with growth of 164% for plant products and 185% for livestock products[6], making SSA the region with the highest increase. But it also highlights the limitations of the growth pattern. SSA is at the same time the region where the contribution of yields to growth of production would be lowest (+81%) after Latin America, the rest (19%) of the increase coming from an expansion in land under cultivation. This would occur despite a higher increase in yields than in the previous period (+120% compared with +105% over a similar period of 45 years), which implies that relative to other regions, the expansion in land under cultivation would be sustained, as it should also be in Latin America. Eventually, the result in terms of increasing yields

4. The aggregate includes rubber, coffee, tea and cocoa.

5. The CIRAD study is unusual in that it converts product volumes, including those of animal origin, into a common energy unit, and focuses on the biomasses actually used for human food. Food availability is then estimated in terms of production and the imports minus exports balance compared to the population.

6. In both cases, the calculation is made in consumable kilocalories.

would be fairly similar to that of Asia after a period of 90 years. But because it is starting from a lower level, it would still not be possible to catch up.

Yields would certainly increase at higher rates than those of other regions for all products, but despite this, would continue to be relatively modest; we will return to this point later. Irrigation - which could be a strong lever for increasing land productivity - in sub-Saharan Africa in 2050 would only account for 3% of the total land irrigated, despite a strong growth rate (+0.7% per year) whereas Asia would represent 62% of the world's irrigated land.

The other factor affecting growth of production and productivity, namely the availability of land, could be exploited to increase the amount of land put to crops. This would occur in the highest numbers in sub-Saharan Africa with 51 million additional ha according to the FAO, which would represent around half of all increases in land, given that elsewhere certain regions such as Europe, Central Asia and North America would see a drop in the amount of land under cultivation. This expansion in cultivated areas would however still be less than the land surfaces considered to be potentially cultivable without causing environmental damage (see Roudart, 2011; World Bank, 2009).

However, we must also consider the African exception, namely the growth of its working agricultural population. Sub-Saharan Africa will undoubtedly make the biggest contribution to the growth of the world's population by 2050, even if the exact figures are debatable. On the basis of the estimates made in 2008, this figure would be 39%. However, the latest UN projections[7] suggest that its contribution to population growth could even be as high as 44%. Africa would then become the second most populated region in the world behind Asia but with a very different population trend profile. In fact, Africa would be completely atypical, with the continuation of a very significant rise in its agricultural working population. While Asia would see its agricultural workforce drop by 24% and Latin America by 42%, that of sub-Saharan Africa would grow by 81% so that in 2050, 30% of the world's agricultural workers would be Africans south of the Sahara.

The continuous presence of a plentiful working agricultural population is likely to hamper the growth of labour productivity which, although its rate will practically double compared to the previous period, will continue to be modest; in fact, it will be lower here than in any other region in the world at a rate of 0.86% per year. The gap with the most productive regions would then widen. The average productivity of agricultural labour would be 372 times higher in North America than in sub-Saharan Africa. In the latter, farmland per agricultural worker would fall from 1.2 ha to around 0.8 ha/agricultural worker, in contrast to all other regions, including Asia, where, because of the drop in the number of agricultural workers, the average land area per agricultural worker would increase from 0.45 to 0.6 ha.

If productivity is broken down into yields on the one hand and land per worker on the other, it shows that the positive contribution of 211% of the first is counteracted by the negative contribution of the second in a proportion of -109%. Indeed, while land under cultivation would increase by 20% in Africa, the surface area that each farmer could exploit would drop by an average 34%.

Dorin then calculates what would be necessary in terms of growth of crop area or yields[8] or of the number of agricultural workers, all other things being equal, for sub-Saharan Africa to reach the agricultural labour productivity levels of Asia in 2050. He arrives at the conclusion that either the crop area would have to increase by 82% (instead of the 20% in the baseline scenario), which is equivalent to an increase of 175 million ha, corresponding to one and a half times the crop area in the European Union, or the average yield would have to more than triple (and not only double as projected in the baseline scenario), or the number of agricultural workers would have to increase by only a fifth (instead of growing by 81%). These performances may appear to be out of reach. We will see below that in fact they are perhaps not so utopian after all.

On the other hand, it is clear that these figures are worth what hypotheses are worth as are the different projections on which they are based. We have therefore attempted to evaluate the variation in results caused by considering the uncertainties commonly cited regarding the growth of the African population, which is suspected of being underestimated, and the effect of climate change.

7. 2015 revision

8. More specifically, this concerns the productivity of the land, which takes account of multiple crops grown on the same plot over a year.

■ The threat of African population growth on food balance

The initial CIRAD estimates suggested that the outlook for meeting food needs in sub-Saharan Africa were favourable, with predicted food availability per person of 3000 kcal per day in 2050. However, the latest demographic trend projections published by the United Nations could tarnish this view. Firstly, the Dorin study mentions that the FAO calculations were based on United Nations population forecasts from 2008, which underestimated the 2050 projections for sub-Saharan Africa by 395 million inhabitants compared with the 2012 revision. The 2015 revision of population data further accentuates the trend as it would eventually be necessary to add 451 million people to the projections used by the FAO.

Any adjustment should automatically lead to a revision in per capita food availability, even if reaction assumptions related to production or trade for each population increase are introduced. We calculate that if there is no change in production or trade structure, per capita food availability in SSA per day would be reduced to around 2340 kcal, i.e. less than the availability of 2006, if the latest population projections are introduced. In order to maintain the consumption level initially calculated, i.e. 3000 kcal per day and per inhabitant, imports of plant-based food calories would have to more than triple, making sub-Saharan Africa the world's largest net importer region.

The adjustment of population projections on agricultural labour productivity trends also has a very significant impact. With an upward revision of more than 2 billion inhabitants instead of the initially forecast 1.7 billion, the working population engaged in agriculture in sub-Saharan Africa, and therefore the pressure on land, would increase significantly. According to our calculations, using the Dorin data and assuming that the working agricultural population increases in the same proportions as the total population, all other things being equal, the land area per agricultural worker would decrease even further than initially projected, falling from 1.17 ha in 2006 to 0.62 ha in 2050 (instead of the 0.77 ha estimated in the CIRAD study). The productivity of agricultural labour would therefore plummet by 20% compared to the CIRAD baseline scenario if no additional effort to increase yields is made. If the amount of land under cultivation remains constant, labour productivity parity with Asian farmers could only be achieved at the cost of quadrupling yields from the 2006 level or almost halving the agricultural workforce compared to what is projected for sub-Saharan Africa[9].

This major uncertainty is accompanied by another variable which could further threaten the food security outlook: climate change.

■ The threat of climate change on production and therefore food availability

According to the IPCC, "*climate change is very likely to have an overall negative effect on yields of major cereal crops across Africa, though with strong regional variability in the degree of loss*"[10]. A major difficulty then is to assess the impact on agricultural production, knowing that climate change will of course lead to average changes in yield potential but above all to variability of results and that these changes could be very different from one African region to another. For example, according to one study[11], while the estimated climate-change-induced annual losses for maize are likely to rise in Malawi, conversely, they should fall in Kenya and Niger using the same climate change model. Moreover, modellers produce scenarios for climate change and a range of agronomic responses such as fertilisation with carbon dioxide which lead to very different results[12]. Finally, threshold and substitution effects are also very important. We are likely to see disruption in production trends, either because as yields drop in certain areas, crops could be abandoned through lack of profitability, or because the land is no longer physically suitable for certain crops, unless massive investment is made to artificially change the environment (irrigation, protection from the sun, intercropping, etc.). Conversely, areas of land could be gained for crops that were previously judged "unsuitable".

Given the above, it is clear that reasoning based only on changes in yield without taking account of crop substitution and modification of management techniques is highly simplistic. Nevertheless, we have conducted such an exercise to illustrate an initial approximation of the possible impact.

9. Instead of a reduction of only one third in the scenario based on the initial (2008) demographic projections of the United Nations.

10. IPCC 2014, p.1218

11. Jayanthi H, 2014, Assessing the agricultural drought risks for principal rainfed crops due to changing climate scenarios using satellite estimated rainfall in Africa; UNISDR

12. Consultation of meta-reviews will give an idea of projection variety: Rosenzweig C. et al. (2014).

Moreover, this approach has been used by different authors in publications from which some meta-reviews have been produced[13]. Authors agree that the depth of the phenomenon could see yields fall by as much as 40% in certain cases even if some studies report a probable increase in yields, most notably for maize in East, West (and North) Africa. An 8% reduction in cereal crop average yields in 2050 is often cited[14] although in West Africa some authors suggest reductions of 25% for maize and millet and up to 50% for sorghum[15]. We will use this figure of -8% for all the crops in our simulations, whether they result from a reduction in yields or in land under cultivation.

Again to simplify matters, we have assumed that a reduction in agricultural production will automatically lead to a reduction in animal production of similar proportions, based on the assumption that the parameters for transforming plant calories into animal calories remain constant. If we set aside the consequences of lower production on income and the resulting effects on demand, we can roughly estimate the impact of an 8% drop in food production on consumption (compared with the 2050 baseline projection)[16]. On the basis of the population forecasts used by the FAO, the impact on per capita kcal consumption (direct and indirect via the consumption of animal products) would be a reduction of 7% in 2050 compared to the baseline projection. But if the revised population projections are incorporated, we estimate that this reduction could be as much as 23%. This would then take us back below the 2006 level.

If, on the other hand, we analyse foreign purchases at constant consumption, the effect of climate change, as we have calculated it, could lead to an increase in the deficit by 2050, rising from 12% of consumption in the baseline scenario to 22% (using the 2008 population growth projections). But this deficit could be equivalent to half of all production if the most recent forecasts on population growth are incorporated. In other words, far from stagnating, Africa's food dependency would only increase.

As a result, the productivity of agricultural labour, assumed to increase by 46% in the CIRAD study, would remain practically stagnant (+9 % in 44 years).

These evaluations are of course very approximate but they show that the impact of climate change will probably be a combination of two types of phenomena, unless production systems are radically adapted: restrictions on the consumption of Africans if imports become too costly, and growth of the agri-food deficit. In every case, it means that the food security of sub-Saharan Africa will be eroded, whether examined individually or from a political and economic angle.

The gap with the rest of the world, in terms of the competitiveness and profitability of agricultural activity, would only deepen, making it harder to improve the economic situation of farmers. If significant efforts are not made to help small farmers adapt to climate change (Montpellier Panel, 2015), we are likely to see the agricultural economy weaken further, the instability of rural populations increase and, consequently, an increase in the imbalances internal to individual countries and across their borders.

It is clear that only a combination of adjustments can overcome the challenges facing African agriculture and which will only get worse with the latest population growth forecasts. The issue at stake will therefore be to support a larger proportion of the agricultural population to exit the sector, and to enable an increase in land productivity, in the most effective economical and politically sustainable way possible, unless massive social transfers of the rural African population are envisaged. But could it be that the production growth and food availability assumptions used are too pessimistic?

■ The issue of post-harvest losses

The issue of losses, and of food waste generally, has become a recent area of debate and campaigning[17]. The model used by Dorin estimates that in Africa, losses will represent 23% of total worldwide losses of plant-based food calories, while the continent's share of global calorie consumption will be only 13%. The results of the simulations are influenced by certain assumptions that have to be made given the lack of accurate data on some phenomena, in particular post-

13. Knox J, Hess T Daccache A, Wheeler T; 2012; Climate change impacts on crop productivity in Africa and South Asia.

14. Cf. Knox et al. for figures on cereal crops and Leclere D. et al. for a set of crops. Global impact simulations of climate change conducted by Wiebe K. (2015) use a yield drop of 6.9% as the baseline assumption. In 2009, the IFPRI established yield variations for 2050, with an average of -8.2% if wheat is excluded from the calculation. Fischer, for example, cites a potential drop in yield of 7% for rainfed cereal crops without taking into account fertilisation by CO_2 or adaptation of the varieties cultivated, based on a common scenario of the Hadley Centre climate change model. A huge variety of hypotheses exists in the literature.

15. Cf. Akumaga U et al (2014).

16. It is also assumed that the level of foreign trade remains unchanged.

17. See for example the campaign http://www.thinkeatsave.org/

harvest losses. We have attempted to examine this issue more deeply.

Using the CIRAD projections on the losses calculated from the food balance sheets of the FAO[18], we can estimate that worldwide losses would amount to almost 600 terakilocalories in 2050, of which 140 occurring in sub-Saharan Africa, or the equivalent of 5 to 6% of its food consumption. These values are no doubt a low estimate of what the literature considers to be of a whole other order[19].

Using another calculation method based on the average values of losses as a percentage of production in SSA[20], we estimate that these losses would represent around 15% of food availability in 2050. Even if it was possible to halve losses and waste, the residual loss figure would be similar to that inferred from the projections of the Dorin/FAO model, this being equal to 7.5% of actual consumption.

A reduction of losses in the order of 50%, which appears to be realistic[21], would represent a potential increase in food availability of between 185 and 230 kcal per day and per African living south of the Sahara depending on the population projection used. The same approach, applied to the whole world, also reveals relatively limited room for manoeuvre from the point of view of food availability, in the order of 185-200 kcal/day and per inhabitant. It would therefore appear that ultimately it is not here that the principal challenge for food in Africa lies, even if food losses and waste constitute an offence to reason[22]. No doubt the waste generated from harvest to food preparation accounts for very large volumes in terms of the natural resources involved, but it should not automatically be associated with lack of food in Africa.

On the other hand, one impact of these losses is the reduction in food availability, which translates directly into the need for higher imports. The losses calculated in kcal are slightly higher than the projected net imports of sub-Saharan Africa's food calories for 2050. If they were halved, one could envisage halving net imports. In an indirect sense, control of these losses therefore becomes an important issue as it offers great potential for reducing food dependency; it is from this perspective that it could be used as a strategy to improve food security in SSA.

■ What are the options for stimulating production?

The yield growth assumptions formulated by the FAO and which the CIRAD calculations are based on are fairly pessimistic. A comparison of the yields projected for Africa with average yields worldwide in 2050 reveals a discrepancy ranging from a factor of 1 to almost 2 for cereals, legumes, textile plants and a gap of around a third for fruits, oilseeds and crops such as coffee, cocoa or tea, again to the detriment of Africa. The discrepancy is just under 20% for sugar. It is only root and tuber yields where Africa would be at the top end of the list.

The late introduction of irrigation infrastructure can certainly not be remedied in less than 40 years, which will undoubtedly penalise Africa, but it may be that the gap in yields could be largely overcome, provided that bold and determined voluntary measures are implemented to increase land productivity via the improvement of fertility, use of improved seed and adoption of more intensive cultivation methods. Improving access to inputs is no doubt the most effective option given the emergency situation in which Africa finds itself. The African yields

18. Our calculation of losses is based on FAO usage data which we converted into kcal using the kg/kcal coefficients inferred by the food balance sheets, then aggregated for sub-Saharan Africa and the world, and by making assumptions on animal losses which are converted into equivalent plant-based kcal using the fodder conversion rates in animal production. The 2050 projections are derived from the 2006 values by applying the growth rates calculated by the Dorin/FAO model to them.

19. See for example HLPE (2014) or Gustavsson (2011) or Kummu (2012).

20. Losses are usually calculated for each processing stage of the product but the HLPE has produced a coefficient applicable to production. To calculate its consumption equivalent, we have to apply the production loss coefficients in proportion to the human consumption of plant-based products as a percentage of total use of plant-based products. We have done the same thing for animal products. Only post-harvest, processing, distribution and consumption losses are applied to the production value. For imports, also considered in the same proportions, only processing, distribution and consumption losses are applied. We therefore apply a loss rate (identical for 2006 and 2050) which corresponds to production uses that will not be found in the stomach of the consumer. To calculate the net gain in relation to the simulation in the Dorin study and to avoid duplicate counting, we have subtracted from the "potential gain" thus calculated the volumes already deducted by him to arrive at the food availability figure.

21. Rutten (2013) restricts impact simulations to a 40% reduction in losses.

22. The definition of losses in the FAO statistics eliminates pre-harvest losses. It only includes what occurs when a harvest is transported, stored and processed and up to the end user. What happens during the preparation of meals, in or outside the home, or in the retailing process is not taken into account. The quality of the data is subject to debate as it results primarily from a calculation using a factor which is occasionally corrected in the countries and applied to the value of availability i.e. production plus imports and stock disposal.

projected for 2050 are similar to those seen in the rest of the world before the change of millennium for most products, including cereals, or those which are observed elsewhere and today for fruits, oilseeds, coffee, cocoa and tea.

History shows, however, that long-term growth in yields is possible at rates that are significantly higher than the maximum 2% projected by the FAO for sub-Saharan Africa. At the height of the Green Revolution, in the period from 1961 to 1980, both Western Europe and Southeast Asia experienced spectacular increases in yields: 4 and 5% per year respectively for maize, 3.5 and 6% for wheat, 4 and 3.7% for oilseeds, more than 2.4% for fruits in Europe, and more than 2.8% and 3% for rice and tubers in Southeast Asia. Application of more productive techniques in a region which is already starting from a low point in terms of yields, should make it possible to achieve yield growth rates higher than those anticipated in the study.

A simulation based on the best annual average yields obtained in East or Southeast Asia for the period 1961-1981, applied to different crops in sub-Saharan Africa, shows that the increase in the regional calorie supply, instead of being 160%, i.e. more than doubling, could be increased sixfold by 2050. Using these assumptions and taking the demand estimates calculated by the CIRAD, and revised with the latest United Nations population projections in 2015, coverage of demand from food production in SSA could be as high as 170%. Productivity of agricultural labour, in the low population growth assumption, could then be increased by a factor of 3.4. Even in the high population growth assumption using the 2015 revision, labour productivity would still be increased by a factor of 2.7 compared with 1.4 in the Dorin study. The outlook for reducing the poverty burden would therefore be more optimistic than that of the CIRAD study, even if income differentials with the rest of the economy would not necessarily be eliminated[23].

In other words, a successful increase in yields to the level which enabled the Green Revolution in Europe or East Asia would in large part free sub-Saharan Africa agriculture from its current crisis. This fact should recreate additional motivation for action and re-legitimise political investment to promote agriculture in Africa.

■ Conclusion: opening perspectives by including political economy in long-range planning

Without going into the productivity differentials between sectors within the continent, the fact that the productivity of agricultural labour in Africa is growing too slowly represents a major challenge which polarises debate on public intervention. The question often asked is which methods and resources should be implemented to meet the rise in regional food demand (how far trade should be opened up, regional specialisations in an integrated continental context, the quest for self-sufficiency, etc.), against a backdrop of a loss of competitiveness which the growth of the African agricultural population, still continuing apace and which nothing appears able to stop, makes seemingly inevitable.

Climate change is an aggravating factor on top of the challenges that Africa must already meet to get its rural population out of poverty, ensure a stable food supply for all of its population and create decent jobs for its young people. If we believe that Africa has the possibility, through its agriculture, of overcoming a good part of these problems, we must do everything we can to come up with ways of creating agricultural growth. In this regard, it is a cause for concern that climate discussions focus largely on questions of mitigation and that proposals aimed at adapting to climate change get the least attention. Is this not a defeatist attitude and one which implicitly increases Africa's food dependency in relation to the global market? An in-depth discussion on adaptation would also be a way of reopening the debate on the place of agricultural intensification.

The prospective study conducted by the CIRAD, based on FAO projections, helps us measure the extent of the challenges involved but could overwhelm us with pessimism. In fact, it rests on a principle which could have a significant influence on the results obtained and that it makes the production and food demand projections depending not only on population and global growth projections but also on yield and crop area growth assumptions conducted primarily by experts. They are therefore largely formulated on the assessment of current and future agri-ecological conditions, no doubt based on average expectations of technical progress and investment.

23. This issue will be dealt with in a future FARM note. It would in fact seem, based on the reasoning of Dorin, that the growth in productivity of agricultural labour, measured in kcal/worker, continues to be lower than the growth of productivity per worker across the whole economy when evaluated with the most recent projections.

We know that these methods favouring consensus between experts leave hardly any room for the unexpected or audacity. Under these conditions, one might wonder how highly proactive agricultural policy interventions which, in the past, have boosted agricultural growth, in particular during the green revolutions seen in other regions, might be taken into account and modelled. What would happen if there was a real change in the capital accumulation regime in Africa, resulting from increased public or private investment, for example in research or in infrastructure, and incentives for farmers to invest in their agricultural holdings?

We have shown that the application of historic yield growth rates - admittedly achieved under specific but nevertheless real conditions - open new more optimistic perspectives for designing public intervention strategies to promote African agriculture. The agricultural policies which led to spectacular (exponential) growth of land and labour productivity were based on clear assumptions regarding the adoption of innovations founded on policies to support income and manage risk, either indirectly through regulation affecting the prices of products and inputs, or more directly through mechanisms to support income. Structural policies, often criticised because of their economic inefficiency in a context of lacking economies of scale, also often made it possible to manage the controlled exit of rural populations from the agricultural sector. In contrast, when these policies were not implemented in a timely manner, social disasters ensued.

Pricing or income support policies could therefore certainly play a determining role in the creation of a new agricultural dynamic. These factors are not easily incorporated in the FAO model, while we have seen that in the past they have had a direct impact on productivity growth. While this assumption is something not included in the spontaneous philosophy of experts and the options offered by the model, we believe we are justified in reintroducing it for the future.

It is therefore not all over for the agricultural sector in sub-Saharan Africa and the possibility of disruptions is likely, which could change the perspective. The future is not yet written and it is quite possible that by modifying the approach to international trade, commercial dealings with non-agricultural sectors and relations between stakeholders in the agri-food system, the potential for adopting innovations may be greatly enhanced. We therefore have to find a way of including political economy in prospective scenarios and successfully learning the lessons of history. ♦

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