

100 ANSWERS

An
interview with
The Food Futurist
about the report
“100 Questions
of Importance
for the Future of
Global
Agriculture”



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Dear reader,

Following up on the recent publication of the report “[100 Questions of Importance for the future of Global Agriculture](#)” by a group of experts from all over the world under the lead of Jules Pretty of the University of Essex in the United Kingdom, I wanted to react candidly and spontaneously on every of these 100 questions.

Since giving extensive answers would represent several months, if not years of work for a single individual, I chose for the interview format. I gave myself just a couple of minutes to say what came to my mind.

The result is this document.

I hope it will be as enjoyable for you to read as it was for me to write. I hope that it will trigger reactions, as this is more a first attempt to initiate a forum discussion.

The questions were quite interesting. However, I missed a few elements that I believe to be quite important in the challenge of feeding a population of nine billion by 2050. The initial report did not raise enough questions about the issue of water. Water is essential to agriculture, and the challenge of accessing enough water is even more urgent and more critical than improving food availability. Similarly, the initial report did not reflect much on urban farming. Estimates of today's urban food production are of 15-20% of the total world food production. Considering that about 50% of the population lives in cities, this means that 30-40% of all the food consumed in cities is produced in urban centers. This is far from negligible. As the urban population is expected to double by 2050, urban farming will be an essential part of our food supply. I had also expected more attention to aquaculture, which is the fastest growing food production.

The initial report focuses more on production aspects and systems than it does focus on the human factor. Population increase, distribution and especially the quality of leadership will be crucial for the way food security strategies can be set up. As I mention in one of my answers, our future will be as bright as our leaders.

Writing this document, and reacting to questions asked by highly qualified experts, was a good way of assessing the book "[Future Harvests](#)" that I published in August 2010. I was quite happy to see that the book addresses all the concerns of the thinkers and policymakers.

I wish you happy reading,



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The Food Futurist

Founder & President of The Happy Future Group Consulting Ltd.

1. What are the predicted critical impacts of climate change (e.g. changes in temperature, wind speed, humidity and water availability, storm intensity, crop water requirements, snowmelt and seasonal runoff, pests, waterlogging, agroecosystem shifts, human migration) on agricultural yields, cropping practices, crop disease spread, disease resistance and irrigation development?

This is a very general question. To answer it with some effectiveness, it would be necessary to have every country/region answer it for their particular conditions, although the origin of the problem maybe outside their territory. For instance, Himalayan glaciers provide water for all the Asian large river systems, such as the Indus, the Brahmaputra, the Ganges, The Yellow River or the Mekong River. Environmental changes need to be predicted and analyzed locally. Some regions will be affected negatively, but others will benefit from improved climatic conditions. Once this is done, the scenarios can be compiled together for a coordinated approach and a mapping of future agricultural activities.

2. What would be the global cost of capping agricultural water withdrawals if environmental reserves were to be maintained?

Like the first question, this very general question needs to be looked at locally. Water availability varies greatly between regions. Every region must have a strategy to maintain drinking water reserves at a sufficient level to ensure the availability of drinking water for the generations to come.

Some regions have plenty of water and capping would not be relevant. However, practices that reduce waste and contamination of water must prevail.

Some regions have a physical water scarcity situation and they must manage water in such a way that there is always potable drinking water available. The use of water for agricultural, industrial and municipal use need to be reviewed critically. There are many new systems and techniques in development to use water more efficiently and eliminate wastage. These regions need to prioritize their needs and develop their water usage accordingly. When it comes to agriculture, irrigation systems may need to be adjusted; rainfall collection systems need to be developed. The choice of agricultural productions, both vegetal and animal, needs to be reviewed to optimize the production of calories and of protein for the local population. In these regions, food security is firstly a matter of water security. Imports will have to be part of the policies.

Other regions suffer from infrastructural shortages. The water is available, but the systems to extract it and use it are missing. The first priority for these regions is to develop the infrastructure. They may do this with their own financial resources, with the aid of other governments or from private funders. It does not matter much which financing solution they would choose. They must make it happen, and the world community must encourage and facilitate this. The efficient use of water and the measures to reduce wastage apply just the same as for the two previous groups.

3. What is the effect of increased rainwater harvesting on local hydrological fluxes, and how do local changes combine and alter water resource availability at larger geographic scales?

The answer to this question may vary between regions, depending on the level and the nature of agricultural activity, on the size of the population and on the geological nature of the region. However, the water that is collected from rainfall is water that will not have to be pumped out of the ground water reserves. Therefore, the variance of the water balance may not be affected too much. Another factor to take into account for this particular issue is to trace the natural flow of the rainwater, as what is collected in a location may affect negatively the ground water reserves of another region hundreds of

miles away or maybe even further away. Coordinated research and tracing of the complete water flow, possibly beyond borders, is necessary.

4. How can aquaculture and open water farming be developed so that impacts on wild fish stocks and coastal and aquatic habitats are minimized?

In many areas, aquaculture producers and local authorities are addressing this.

When it comes to the use of fish for the production of fishmeal and fish oil destined to the feed industry, the most sustainable approach is for the fisheries of these species to be carried out in a way that does not deplete stocks, and not harvest what the feed industry demands. If this means that fishmeal and fish oil become too expensive, let it be the aquaculture industry's problem. They will have to look for more competitive alternative and if they cannot, they will have to stop increasing production, because that would be the only sustainable thing to do. There are other ways to meet food production than increasing aquaculture production beyond the limits of sustainability.

About interaction of fish farms with the ocean ecosystem, all necessary preventive measures need to be taken to avoid any long-term negative impact on marine life. This can be achieved by adapting the location of farms to their environment. Another way is to use system that isolate or at list reduce interaction to a sustainable minimum. Aquaculture is still a rather young activity and many improvements will come if all issues are addressed and all stakeholders take appropriate action on a clearly determined schedule to eliminate risks.

5. What approaches (operational, agronomic, genetic, supplemental irrigation schemes, fertility management, winter rainfall storage) can be developed to increase water use efficiency in agriculture and what is the cost-effectiveness of these approaches?

The question contains its answer. All the areas indicated in the questions are indeed relevant for action towards improvement. Many techniques and systems have been developed and are being developed to achieve a more water-efficient agriculture. The cost effectiveness of the different solutions depends on many factors. Situations vary greatly between regions. The political, natural and economical environments can influence positively –or negatively- the feasibility of the different solutions. Financial incentives also can play a role. It is necessary to reward good behaviour and to deter unsustainable practices. This always pays off in the long term.

6. What combinations of forestry, agroforestry, grass cover, water-collecting systems and storage facilities, drought-resistant crops and water-saving technology are needed in arid and semi-arid areas to increase food production, and to what extent can they become cost-effective?

For this question, too, the answer depends very much on the local situation. The political, natural and economical environments influence which choice is best. Some regions would choose for only one of the alternatives mentioned in the question, while other regions would indeed look for a combination of several of these options. As far as the cost effectiveness is concern, see my comments under answer to question #5.

7. How can the allocation of water be optimized between irrigated agriculture and environmental functions, and what innovative policies and technologies can minimize trade-offs between irrigation and healthy functions of natural ecosystems?

The first step is to determine how much water is available in the region considered. Then, deciders must look at the need for different activities requiring the use of water. They must take into account the evolution of the population and future economic development to assess how much water is usable. The bottom line is that there has to be enough water left for a sustainable ongoing human activity. There will be new water-efficient systems required for all activities, not only agriculture. Even if agriculture is the main user of water, action must be on all fronts. Water management will require a critical look at agricultural productions. In regions where water is scarce, the preference should go to the most water efficient production first, although this may need to be adjusted to the need for more strategic food sources as well. Food security is not just about producing enough volume, but it is about being secure in the supply of all essential agricultural products.

8. What benefits can sustainable soil management deliver for both agricultural production and delivery of other ecosystem services?

Sustainable soil management is essential. If it is not sustainable, soil will disappear, and agriculture with it. The question is more about a proper definition of sustainability. This depends on climatic conditions, the nature of the soil, the hydrographical situation and the current agricultural practices. After assessing the situation locally, it is more effective to set up the action plans and ensure soil sustainability.

9. What are the best uses of organic amendments by subsistence farmers in cropping systems to improve soil nutrients and water-holding capacities and thereby assist in restoring agroecosystems?

Organic amendments are always an improvement. There is no such thing as too much organic matter in soils. Too little organic matter is always a problem. The problem for subsistence farmers would be more about having access to have enough organic matter to enrich their soils, especially under a tropical climate. In these regions, the enrichment or even the conservation of soils depends greatly on climatic conditions, especially erosion and oxidation of minerals, which create sterile red crusts. Another important factor for these farmers is to have access to technical support and financial support to take proper actions and ensure the future of their farms. There are successful examples of effective action in the Sahel region.

10. What are the most practical and economic methods for managing soil fertility in paddy soils and upland production systems in the tropics?

The type of crop rotation, the management of organic matter, the control of salinity, methods that do not cause soil erosion, will have the preference. Those issues have been identified and there have been several reports published on this subject.

11. *What guidelines can be established for poor small-scale farmers to ensure that nitrogen fertilization is managed in a way that results in net accretion of soil organic carbon rather than net mineralization?*

The answer to this question is rather similar to the one for question #9. Technical extension services play an important role to achieve positive results.

12. *How can salinization be prevented and remedied?*

The main cause of salinization is irrigation. This process is the most sensitive in arid and semi arid regions where agricultural production requires irrigation. These regions need irrigation, just better systems than the most common one of flooding fields, which also wastes a lot of water. The development of more efficient irrigation systems, such as the drop-per-drop approach is necessary to prevent excessive salinization and waste of water. Such systems are expensive in comparison with the traditional system, but one can wonder what the cost of losing large areas of soil for food production would be in comparison. There will be a trade-off, but I would support the development of efficient irrigation. The cost probably needs to be supported by governments, as it is in the interest of the taxpayers, eventually.

The process of salinization is very difficult to reverse and preventive measures will always be more economical on the long run.

13. *How can native soil organisms be exploited to maximize food productivity and minimize environmental impacts?*

Soil organisms certainly contribute to the quality of the soil and its level of fertility. The challenge is have a balanced approach between a strictly organic system and the necessities of intensive large-scale farming. The destruction of soil organisms by chemicals is detrimental in the long run, and it must be avoided. This is really a matter of farm management. Managing the ecosystem is not simple, but ecosystem thinking is the most optimal approach. It is important to determine the externalities of the current intensive methods, and realize that they are not sustainable in their current form. Massive use of herbicides and pesticides will have to be curbed. A field is much more than just a monoculture and no other life form in between. Such a production method is actually much more outdoors hydroponics than anything else. We will not beat nature, as it adapts continuously, and it will become more and more difficult to find technological solutions to the problems we create. Remember the saying that goes "If you cannot beat them, join them!"

14. *What are the world's mobilizable stocks and reserves of phosphate, and are they sufficient to support adequate levels of food production globally for the next century?*

There is a theory of peak phosphate (similar to the peak oil theory). Whether this theory is true or not is difficult to say. Nonetheless, the situation around phosphate is similar to oil. We use more and more, and stocks are depleting. Some estimates indicate that minable phosphate reserves might run out within 20 years. Large quantities of phosphates are transported between continents inside agricultural commodities and the phosphate ends up largely in manure through animal feed, and in human feces as a by-product of food. Regions with intensive animal husbandry produce an excess of phosphate in the manure. Phosphates stock up in soils, threatening their fertility, and in waterways causing algae growth and toxic river environment for fish. More than just pondering whether we have enough mineral phosphates to extract, we need to further work on a sustainable phosphate strategy that includes higher

feed efficiency for farm animals, and systems to recuperate and recycle the phosphate that accumulate at the end of the food chain.

15. What is the relationship between productivity and biodiversity (and/or other ecosystem services) and how does this vary between agricultural systems and as a function of the spatial scale at which land is devoted mostly to food production?

This very general question can be answered only by analyzing local situations. Every food production has its specific impact on biodiversity. Similarly, the size of farms, the types of agricultural techniques, climatic conditions, topography, overall ecological conditions, as well as other non-agricultural human activities play a role in the quality of biodiversity. To bring an answer effectively, specific cases need to be studied. These cases would have to be as representative as possible to allow some level of reliable extrapolation.

16. How should the options of intensification, extensification, habitat restoration or the status quo be chosen and how can we best combine measures of economic, environmental and social benefit to make the choice?

Each region needs to figure this out for itself. Because the environment for agriculture and food production varies greatly between countries, and even within a country, the need for intensification will differ, too. An assessment of this question must be done a local level.

17. What are the environmental consequences of drought-resistant crops in different locations?

Again, this would vary locally. Intuitively, one could think that the consequences depend on the type of plant produced, its water consumption, and the overall water availability in the production region.

18. What are the consequences for biodiversity conservation and delivery of other ecosystem services if crop and livestock management is driven by the objectives of greenhouse gas emission reduction?

The production of green house gases by livestock production depends on the production system, the type of feed used, the level of intensification, the production and handling of manure, as well as by all the fuel used for transportation of inputs as well as of finished products to the consumer markets. This is a broad topic that includes many factors that can be influenced by many different production and marketing strategies. It would be possible to answer this question only for specific cases and situations. Moreover, this is not only a production problem, but also at least as much a matter of consumption. The more meat we consume, the more difficult this problem is to solve. Changing behaviours is part of the solution.

19. In intensive production systems, are agrienvironment measures best deployed to buffer protected areas and areas of pristine or seminatural habitat, or to 'soften the matrix' between patches of these habitats?

Different situations will bring different answers and strategies for improvement. This has to be studied from the production point of view and from the natural environment point of view. A habitat-rich region will have different requirements than a habitat-poor one. Proper action plans would depend greatly on the natural situation.

20. *Where would natural habitat restoration provide the greatest food and environmental benefits to society?*

It would be necessary to define “natural habitat restoration” first. Is it at all possible to restore something that has been altered, or is the attempt to restore, only a correction towards what used to be the natural habitat? One can wonder if trying at all cost to restore the lost habitat is the best strategy. Maybe it would be as effective to simply work toward developing a balanced situation between human activities and environment. The result may not be the original situation, but could very well offer a satisfactory, and sustainable, solution.

21. *What type and specific combinations of improved technologies, farming practices, institutions and policies will result in the maintenance of ecosystem services, including soil fertility, in agricultural systems undergoing intensification in developing countries, in particular in sub-Saharan Africa?*

The key for this is the human factor. Success –or failure- will depend on the quality of the leadership to develop education, training and extension services to introduce all the required techniques to farmers. The leadership must also be in a position to enforce all of the above so that all of the above can be implemented properly. In many of the countries the question refers to, this will require a lot of time, work and patience.

22. *Can payments for ecosystem services (e.g. carbon sequestration, green water credits, biodiversity enrichment) lead to adoption of recommended land-use and management practices by resource-poor farmers in developing countries?*

Money incentives always work. However, the devil is in the details, and the incentives must be set up in such a way that excesses and even fraud are not possible. Too often, financial incentives fail because they carry some unforeseen side effects. There, too, a hands-on education, training and control are necessary for the proper implementations of the measures and the prevention of deviations.

23. *What are the best options for agriculture increasing food production while simultaneously reducing its contribution to greenhouse gas emissions?*

There are many options. I would start by addressing food waste issues. Currently, about 40% of all food produced never is eaten. That food has already been produced, using all the inputs, in particular energy. By making sure that the food that is currently wasted and spoiled is effectively consumed, this would already increase the amount of food available for a minimal increase of what generates greenhouse gases. Similarly, there is a huge loss of nitrogen in the fields. The estimate is that half the nitrogen fertilizers are loss due to leaching. The production of nitrogen fertilizers consumes about 5% of all the natural gas produced in the world. More efficient nitrogen use would certainly reduce the amount of greenhouse gases emissions. In questions #18, we already addressed the situation of livestock, which produces a large amount of gas emissions. Rice is also a large contributor of methane, and better production systems should improve the situation.

24. What will be the risk of mass migration arising from adverse climate change, and how will this impact on agricultural systems?

This risk depends on what climatic events take place. Migrations will not happen immediately, as it will take a succession of recurrent events to convince populations to move. At first, migrations will be limited in distance. After that, it really is a matter of the extent of the problem.

I do not see migrations being the cause of changes in agricultural systems, but they both will be a consequence of the climatic events. For instance, if the sea level rises and land is submerged, then of course agriculture will be possible. Similarly, if the climate was to turn dry, the type of production and the yields would be affected, but the migration would be caused by the lack of sufficient quantities of drinking water.

If climate change can affect negatively some regions, it also could affect positively others. For instance, in cold countries like Canada or Russia, large areas are not put in agricultural production, or the yields are poor because of cold temperatures. If temperatures were to rise, which is a possible scenario, yields would increase and acreage available for agriculture could increase substantially.

When it comes to migrations, an important aspect to consider is the readiness of countries to accept the arrival of new inhabitants. Some countries are rather empty, while they have ample food production. This is the case in particular in the US, Brazil, Argentina and Uruguay. Population densities in Asia are so high, and climate in Arab country is so dry that these regions are unlikely to be able to accommodate the arrival of new people.

25. Given the high current direct and indirect energy inputs into agriculture, how can food production be made carbon neutral to allow emission targets to be met over the next 40 years?

Part of the answer is in the question. Agriculture uses large amount of fossil fuels. In question #23, I addressed the high amount of waste in food and agriculture. My answer also gives some direction about what could be done for this question.

Further, about this question, I wonder whether it is an absolute necessity to try at all cost to make agriculture carbon neutral. The greenhouse gas issue needs to be resolved for all our activities and not for all activities as such. Other human activities and industries will also change in the next 40 years. Our energy sources will also change and many new technologies will come, too. The key will be to encourage and help research and development of new systems as a basic policy, a part of which agriculture will be.

26. How would different market mechanisms of payment for greenhouse gas reduction and carbon storage in agriculture affect farming and how could these best be implemented?

As I mentioned in my answer to question #22, money incentives always work. Therefore, any system that would include rewards or penalties depending on the greenhouse gas performance of agriculture will generate corrective action from farmers and the all food production and distribution chain as a whole.

The implementation will have to consider two main things. First, realistic targets must be set and a clear schedule for completion must be decided. The second thing to keep in mind is that food demand will increase, and it is necessary that while working on reducing the environmental impact of agriculture, we keep our ability to feed the world.

This is why we also will have to start addressing our eating habits, and put mechanisms in place to entice consumers to eat better. By comparing, and ranking the causes of environmental damage, we will prioritize the sectors within agriculture that need reforming the most.

27. How can competing demands on land for production of food and energy best be balanced to ensure the provision of ecosystem services while maintaining adequate yields and prices?

This depends on what biological material is used to produce energy. A serious look must be taken at ethanol production subsidies that tend to divert production towards fuel production instead of food. Markets will always react to supply and demand, and volatility and increase of agricultural commodities prices will be an indication that we do something wrong. In the previous questions, I was addressing the need to realize that we must change some of our eating habits. Similarly, we need to take a serious look at our energy consumption habits. It is clear that we cannot have the same reckless lifestyle and waste natural resources in the coming four decades, as we have in the past six decades. Our survival really depends on our behaviour. It does not depend on Nature or the planet. Supposedly, we are an intelligent species. It is high time that we start demonstrating this, instead of self-indulging ourselves into extinction. Our leadership will have to show us the way.

28. How can the resilience of agricultural systems be improved to both gradual climate change and increased climatic variability and extremes?

This is a very general question, for which there is no one simple answer. Every region has its specific characteristics of soil, climate, social structures, and agricultural systems. Every region must define the possible scenarios of climate change that will affect them and develop a response to this. The causes, as well as the consequences, will vary. Therefore, so will the solutions.

29. What is the appropriate mix of intensification and extensification required to deliver increased production, greenhouse gas reduction and increased ecosystem services?

General question again, that cannot be answered generally. Every region needs to find the answer to this. However, if we want to look at it from a global point of view, we must think in terms of rebuilding the cycles of organic matter and of minerals, as global trade of agricultural commodities has caused a rupture of the direct return of organic matter and minerals on the same field. This causes the use, and the depletion of large amounts of energy and minerals, especially phosphates. Having a global management of manure will become a necessity. It is likely that farms will become mixed again, but in a more modern system than we had in the 19th century.

30. How can crop breeding, new technologies, the use of traditional crops and improved agronomic practice be balanced to increase food production and enhance resilience to future climate change?

We will achieve this mostly by using our common sense and our scientific knowledge. There is nothing wrong with common sense, although this has seemed to be left behind in the past decades, and that explains why we are in so much trouble. Proper leadership is also essential to ensure that we will do the right thing, and not just think in terms of short-term profit. Sustainability will be essential. Therefore, proper regulations will be necessary.

31. *How can the transition from a hydrocarbon-based economy to a carbohydrate-based economy best be made using biorefineries to process agricultural products to provide high-value products, biomaterials, energy and soil improvers, in addition to the food products currently produced?*

This is such a general question. It would have to be broken down into much more specific items. WE need to set targets and see how much and how fast we can achieve. The main principal here is to produce food sustainably. There is nothing wrong with carbohydrate if we use them in quantities that do not put our environment in jeopardy.

32. *How can long-term carbon sinks best be created on farms (e.g. by soil management practices, perennial crops, trees, ponds, biochar)?*

The question brings its answer. Soil management, in particular its organic matter management and tillage strategy, perennial crops, trees, ponds, biochar, are all possibilities. Which techniques is the most valuable, will depend on the local situation.

It is important to encourage research and development of such techniques and practices, as soil organic matter is of the highest importance for food production. Remove the organic matter, and the result is soil erosion, desertification and no fertility anymore.

33. *How can the inclusion of agriculture in carbon markets provide significant benefits for farmers?*

That is a matter of how the markets are structured, and how the financial incentives look like for the farmers. If the farmers make less money because of it, it will not work.

34. *What are the benefits and risks of embracing the different types of agricultural biotechnology (environmental impacts; sensitivity/resistance to environmental stressors such as heat, drought, salinity; dependence on/independence from inputs; risks of accelerated resistance; food safety, human health and nutrition; economic, social and cultural impacts)?*

This very general question needs to be broken down to one-item questions. The answer will depend on local situations and strategies will vary. If we want to succeed in meeting future demand, we will have to realize that there is not one fix-it all solution, but that we will have to use the best solutions for a given local situation. We will meet food production by optimizing locally, not by trying to find a universal model.

35. *What are the advantages and disadvantages of organic production systems in terms of biodiversity, ecosystem services, yield and human health, particularly in resource-poor developing countries?*

Organic production systems as such are excellent. The main limiting factor is in the production cost, although tremendous progress is being made. If organic foods can be produced at the same cost as industrial systems, they would take over the market in little time.

36. What practical measures are needed to lower the ideological barriers between organic and GM, and thus fully exploit the combined potential of both GM crops and organic modes of production in order to achieve agroecological management practices compatible with the sustainable intensification of food production?

Although ideology plays a role in the resistance to modern technology, it must not be overstated. “Ideological” opponents are a minority. However, the large majority of consumers do not feel too much for GM foods. This is not for ideological reason, but because they are concerned about long-term consequences. GM foods producers are the ones to prove what they claim, and so far, they are not very successful at it. Actually, resistance seems to be growing. Obviously, GM producers are not convincing the public. More and more studies are showing up demonstrating that GM genes have escaped fields and that we have already lost control.

I believe that the best practical measure would be to have GM technology that does not result in making a field nothing less than outdoors quasi-hydroponic operations. GM producers have to take clear actions to ensure biodiversity and to show actual environment management. They also need to demonstrate beyond doubt that they care for the environment and to mankind, instead of this perception that they play politics behind the screen for no other purpose than profits and power. Lack of empathy is not conducive for popularity. It does not matter if this perception is true or not. It is the perception, and therefore it becomes the truth.

Further, the idea of patenting life is an impediment. This will have to be reviewed at some point in time. In addition, it would be quite useful to engage in open debate through the whole society about how people feel and why. Today, there is no real communication, just media PR, which nobody believes.

37. What is the long-term capacity of fossil fuels and nitrogen, phosphorus and potassium fertilizer stocks to support intensive production systems globally?

Somebody would have to find out about this indeed. In the mean time, we must practice the three R's: reuse, recycle, and reduce.

38. How can food production systems that reduce dependence on externally derived nitrogen, phosphorus and potassium resources be designed?

Think manure. Specializing farms and especially removing farm animal to engage in monoculture, is one of the main reasons why we need so much mineral fertilizers. Farms will be mixed again.

39. How can we develop agreed metrics to monitor progress towards sustainability in different agricultural systems that are appropriate for, and acceptable to, different agroecological, social, economic and political contexts?

By defining sustainability, and setting environmental regulations accordingly. Here too, local situations will vary and local solutions need to be developed.

40. *What part can reclamation, restoration and rehabilitation of degraded land play in increasing global food production?*

Every bit of land that can be more productive in a sustainable manner will be welcome. Depending on the cause of land degradation, different strategies will apply. This very general question needs to be broken down into specific cases.

41. *What are the best integrated cropping and mixed system options (including fallow rotations and other indigenous cropping systems for cereals, tubers and other staples, agroforestry, crop-livestock and crop-aquaculture systems) for different agroecological and socioeconomic situations, taking account of climate and market risk, farm household assets and farmers' circumstances?*

The question contains its elements of answer. Solutions need to be developed locally, as situations vary between regions.

42. *What are the gains in resource use efficiency that could be achieved by crop genetic improvement for resistance to abiotic and biotic stresses?*

This question needs to be more specific, because the answer will be. They should have indicated which stresses they are referring to.

43. *What improvements to crop varieties can be made to ensure that emissions of greenhouse gases from agriculture and horticulture are significantly reduced?*

Each crop should be assessed on its greenhouse gases emission, and on what the causes of these emissions are. The question is too general to be answered as such.

44. *What is the comparative effectiveness of different genetic approaches to the development of crops with tolerance of abiotic stresses such as frost, heat, drought, waterlogging, acid infertility and salinity?*

Some progress has been made. In Australia, trials on salt-tolerant wheat have shown a yield increase of 25%. There are many programs to develop drought-resistant wheat and corn. Programs to develop flood-tolerant rice, as well as drought-tolerant rice are also carried out. It is a bit early to make hard absolute statements about the effectiveness of these programs, but results are encouraging.

45. *What is the efficiency of different ways to genetically improve the nutrient-use efficiency of crops and simultaneously increase yield?*

The yield will depend, partly, on the availability of nutrients to the plant. This as such is independent of whether there is nutrient waste or not. One of the main nutrient problems is with nitrogen. As I have mentioned before, half the nitrogen spread on fields is lost through leaching. Potassium is less mobile and is less of a problem. The mobility of phosphorus in the soil is limited and there would be a problem of accumulation before there would be one of loss.

The amount of organic matter influence the level of retention of nutrients in the soil, and this is one of the most important functions of organic matter.

There have been attempts to develop plants that could fix nitrogen, but so far, only legumes have this natural ability through the symbiotic relationship with the bacteria in their roots. A way of improving nitrogen retention is by having combination and/or rotation of crops together with legumes. Research on rice focuses on a different element to improve yields. Researchers are looking at ways of developing varieties that have higher photosynthesis efficiency (so-called C4) so that the plants would be able to turn more of the CO₂ into starch, thus increasing yields.

46. What impact can crop genetic improvement have on levels of micronutrients available to humans, livestock and fish?

I guess it is possible to have genetic programs on anything we want, but I am not sure that the micronutrient level in crops is the most important objective. First, we need to produce enough of affordable food. Hunger and malnutrition do not depend on the nutritional quality of the food we produce, but on the lack of money of those suffering of hunger. We must also realize that 70% of the world's hungry people are small farmers, who often cannot afford to buy good quality seeds. How would they be able to afford these genetically improved plants? For the people who can afford a diversified diet, such genetic programs may not be all that relevant. This would need more research. About livestock and fish, the issues about micronutrients, and nutrients as well, is a matter of which ones end up in the manure and are they ways of reducing the loss of minerals through manure. The actions are more about the use of enzyme in animal feed to increase the absorption of minerals, phosphorus mainly, so that less ends up in the environment, and to reduce the use of mineral phosphorus used as an additive in animal feed.

47. What evidence exists to indicate that climate change will change pest and disease incidence?

There is no evidence, as this is a prediction exercise. Quite a few scenarios are being developed, but how accurate are they?

48. How can insecticide application in agriculture be modified to lessen the evolution of pesticide resistance in mosquitoes and other major vectors of human disease?

The best way to prevent pesticide resistance is by rotating different products to avoid the creation of a new stable environment. The rotation of pesticides makes it more difficult for a mutated gene to survive, as the chances of having resistance to several pesticides are much lower.

49. How can landscape-level interventions help pest management and which approaches are the most economically and socially sustainable?

This is really a local issue. There is no general answer to this question. What is the pest? What is the landscape? What is the problem?

50. How can perennial-based farming systems include cover crops as a pest management method and what are the economic and noneconomic costs and benefits?

Similar answer as for question #49.

51. *How can intensive livestock systems be designed to minimize the spread of infectious diseases among animals and the risk of the emergence of new diseases infecting humans?*

The question should be more about how intensive can animal husbandry be if we want to offer animal products and protect animals and humans from diseases. High densities of animals and of humans increase the risk of disease transmission. This is even higher when animals and humans are both in high densities in the same regions. The status of disease-free, for a particular disease, has been used regularly as a protectionist weapon to limit imports of animal products and protect the domestic farmers. Some epizooties could have been prevented by using vaccination, because the vaccine existed. For trade reasons, it was decided not to vaccinate in order to have the possibility to export. This thinking may have to be challenged, as it causes two problems. First, it makes it easier for a disease to spread. Secondly, it has a huge economic cost as the massive culling of animals has to be paid by taxpayers. Another side effect of this is the huge amount of high value food that is wasted, as it is not consumed. The model of specialization may have to be challenged, too, because it creates very intensive farms with huge numbers of animals, and it creates regions with too many intensive animal farms. The risk is about not only diseases, but also manure surpluses and environmental problems are another unsustainable consequence of this model. This is another reason that makes me think that mixed farms will return.

52. *How can increasing both crop and non-crop biodiversity help in pest and disease management?*

I am not sure increasing biodiversity helps pest and disease management as such. Farmers must manage the ecosystems that their farms are. The quality of the biodiversity is much more relevant than the quantity of it.

53. *How can middle and small-scale animal production be made suitable for developing countries in terms of environmental impact, economic return and human food supply and what should be the key government policies to ensure that a balance between the two is implemented?*

Have animal husbandry market-oriented: produce what you can sell for a profit, instead of pushing at a loss something that does not meet market demand. Have proper environmental regulations and policies to ensure environmental and social sustainability. Reward good behaviour and deter bad behaviour! All of this is actually not specific for developing countries. It applies for developed nations just as well.

54. *What are the priority efficiency targets for livestock production systems (e.g. the appropriate mix of activities in different systems, the optimal numbers and types of animals) that would enable these systems to meet the demand for livestock products in an environmentally sound, economically sustainable and socially responsible way?*

This very broad question would have different answers depending on the region of production. This covers the origin and the quality of the feed, feed conversion efficiency, manure production, availability of land to spread the manure, water efficiency of the considered animal production, skill level of the farmer and many other production items.

One must also ask which animal production we should have. Feed efficiency and water efficiency varied greatly between the types of production. This is an important factor to take into account when developing a global strategy of animal protein.

What should not be forgotten here is the market end, in particular the consumer eating habits and the pricing of animal products. If they were not subsidized so much, they would be more expensive, farmers and processors would make more money, people would consume less, yet enough to meet their nutritional need (in countries with reasonable economic development level), and production would be less. Everyone and everything would benefit.

55. What are the effective and efficient policies and other interventions to reduce the demand for animal products in societies with high consumption levels and how will they affect global trade in livestock products and the competitiveness of smallholder livestock production systems in poor countries?

Cut the subsidies on animal products and for their inputs. Accessorily, forbid all “unnatural” practices that lower the cost price, such as the use of hormones.

56. In addition to livestock production, how can inland and coastal fish farming contribute to a more sustainable mode of animal protein production in developing countries?

Fish farming may be more sustainable than land-based production if the latter are not sustainable, (which then should be changed as soon as possible). Sustainability of aquaculture depends on very similar criteria as sustainability of land animal production: level of intensification, origin of feed, management of feces, environmental regulations, etc...

57. What are the best means to encourage the economic growth of regional livestock markets, while limiting the effects of global climate change, and what can industrialized countries do to improve the carbon footprint of its livestock sector?

Make local products cheaper than the products coming from far away. This is often not the case, because local sells at a premium. That is marketing, working against the environment. Reducing the carbon footprint starts by identifying the main causes of a high carbon footprint. Prioritize the actions and work on it. It is also useful to see how financial incentives have shaped the carbon footprint the way it currently is.

58. What are the environmental impacts of different kinds of livestock-rearing and aquaculture systems?

This has been already well established, as these productions have been around for a long time. There are always new systems coming on the market that bring better answers for future requirements and regulations. Some affect energy, others are about feed efficiency, others about manure handling or treatment. It is all out there, but just too long to detail here.

59. As agriculture is highly knowledge intensive and institutionally determined, what is the effectiveness of different novel extension strategies and how best can they be set up to facilitate institutional change and technical innovation with the aim of ensuring that the widest number of farmers are reached and engaged?

Extension services must work in close contact with the education system and research institutes. This is critical to transfer the proper knowledge diligently to farmers. Extension services must also look at farming from a market perspective. Producing without a market is useless. Only by knowing the market

requirements, and especially the product specifications, can farmers develop a strategy that is successful both technically and financially.

Next to face-to-face contact, which is still the most effective way of convincing farmers of changing their way of working, the modern tools of communications such as laptops, and smart phones can speed up the implementation of change and action tremendously. The penetration rate of cell phones is high in all parts of the world. Even small farmers in Asia and Africa are getting online nowadays.

60. How much can agricultural education, extension, farmer mobilization and empowerment be achieved by the new opportunities afforded by mobile phone and web-based technologies?

See my previous answer.

61. Which models and mechanisms for private sector funding or co-financing of extension advisory systems have most successfully reached farmers otherwise excluded from public sector extension services?

There are examples of successful extension services from companies. For instance, in my book *Future Harvests*, I mention the example of McCain Foods in India. The company has helped farmers produce the kind of potatoes that was required by the market, but the company pays these farmers more money than market and these farmers are making more money and are able to expand their operations.

The key for success is to have a market-oriented approach of agriculture. I will not get tired of repeating it because it is crucial if we want to feed nine billion people.

62. What are the most effective approaches for retaining women in research and extension systems and ensuring that they are fully involved in the design of research and extension systems to meet both gender-specific and wider needs?

The best approach is probably by offering job and career opportunities that attract women. There are more and more females involved in agriculture and agricultural services. The trend is already there. However, there are differences between countries, and we must not ignore the fact that in some cultures, this evolution will take longer than in others.

63. What are the best social learning and multistakeholder models (e.g. farmers field schools) to bring together farmers, researchers, advisors, commercial enterprises, policy makers and other key actors to develop better technologies and institutions, for a more equitable, sustainable and innovative agriculture?

The most successful model has to be market driven and must help farmers make more money. If they do not, they will not listen. The format is less important than the significance for the farmer's livelihood. Some cultures will prefer to have group approach, and others will prefer a one-on-one approach. What is important is to have all the stakeholders aligned on the same final goals, which is an economically viable, environmentally sustainable and socially rewarding agriculture.

64. *What is the impact of agricultural subsidies in Organisation for Economic Co-operation and Development countries on the welfare of farmers in developing countries?*

This is one of the controversial topics, and I could not give an absolute answer. There are certainly many subsidies in OECD countries that may benefit and protect their farmers while being detrimental to farmers of developing countries. However, agricultural subsidies are only one of the many tools that countries use to support their farmers. To address this issue, all support mechanisms should be reviewed, including trade regulations, import tariffs, barriers, and all other hidden protectionist measures.

It would be good if developing countries could have the possibility to provide for their markets first, instead of trying to play in the global arena at all costs. Developing countries' markets are the ones who might need the most protection.

65. *What systematic approaches can be used to identify and adapt technical options for increasing land and water productivity of rainfed crop and livestock systems so that they contribute to poverty reduction in different agroecological and socioeconomic situations?*

The systematic approach is called a plan. Every country or region must determine agricultural policies that meet these requirements. Agricultural development is not enough. It fits in the larger economic development strategy.

66. *What are the society-wide trade-offs among efficiency, social equity and environmental outcomes for agricultural development in societies with large rural and smallholder populations?*

That would depend on what agricultural productions these societies want to develop, and to what level they want to develop them. It also depends on the local environmental and socio-economic characteristics.

67. *What are the best options to improve the sustainable intensification of agriculture?*

By understanding that intensification is not the same as efficiency. We need an efficient food production. It does not need to be ever increasingly intensive. Actually intensive agriculture has already hit its limits. Environmental damage is the proof of that. As I state in *Future Harvests*, the next agricultural revolution will be about the way we think. Mindset and paradigm are our most serious impediments now.

68. *How can the transition from today's smallholder-based agriculture to sustainable agricultural intensification occur in ways that maintain livelihoods for smallholder farmers?*

A look at the history of agricultural development in developed nations gives some ideas about what to expect. Intensifying agriculture requires capital, and the result has been a decrease of the number of farms, as the farms become bigger. Always bigger is not necessarily always better, but too small is not viable either. As 70% of the world's hungry are small farmers, there clearly is a minimum farm size necessary. The optimal size of a farm depends on many economic, environmental, political, socio-economic, cultural factors, as well on the type of production.

What is essential is what alternatives the farmers have when they leave agriculture. Economic development must help create jobs for those who will no longer be farmers. There is little point in creating poverty in cities, either. That does not solve anybody's problem. For the farmers who stay on the land, only profitable farms can maintain their livelihoods.

69. What are the long-term impacts of international donors and aid enterprises on target beneficiaries in terms of food security, environmental sustainability, local economies and social inclusion?

That depends very much on the donors, the way the donations are organized and how the financial aid is executed, if that ever happens, on the field. There are successful projects and there are legions of failed aid projects.

70. How can interdisciplinary frameworks integrating scientific innovation and multi-stakeholder perspectives be designed and effectively applied to farming systems within developing countries?

I already shared some views about this when answering questions about extension services. This is very similar when it comes to the design of implementing innovation.

71. Under what environmental and institutional conditions will increasing agrobiodiversity at farm and landscape scales result in increased livelihood opportunities and income?

This would depend on what "increasing agro biodiversity" really means. The question would have to be more specific. Livelihoods would depend on the economic value that this increasing agro biodiversity has.

72. Who will be farming in 2050, and what will be their land relationships (farm ownership, rental or management)?

The world population will be concentrating in cities. In 2050, the urban population will double from the 2010 number. However, in the same time, the rural population is expected to decrease by 25%. Fewer farmers means fewer farms, this means that on average, farms will be larger. That is not a surprise. Depending on the region, different scenarios are possible. In industrialized countries, the population is aging. This is even truer for the rural population. There will be a shortage of farmers. Either farmers will buy more land and increase the size of their farms, or there will be the development of corporate farms where the people farming the land are employees. In Africa and Asia, where China, India and Arab countries are buying land to produce food for their own peoples, such farms will develop further.

There still will be small farmers of course. Some for subsistence, still. Some will be farming for specific niches. The farm will not be large, but revenues will be sufficient. There will be various types of farms because there are many different situations.

We will also see the development of urban farming.

I developed all of this in Future Harvests.

73. *What will be the consequences to low-income countries of the increased political roles of countries with growing economic and purchasing power (e.g. Brazil, China, India, Indonesia) in global food systems?*

They will pull these countries up in their economic development. China is already an active investor in Africa. Africa is still fragile, but there are already signs that something good is happening. If done well, Africa could very well follow a similar path as China as followed with the relocation of manufacturing from Western countries to China.

There will be consequences for the BRIC countries as well, especially as the standard of living will increase. China will not be able to provide all the manufactured goods at the low prices that they used too. Moreover, with the development of an 850-million people middle class, China will be more focused on meeting its own needs than to provide Western markets. Manufacturing activities will shift somewhere else. Western countries on the other hand will not see much wage increase, and it probably will make sense in the future, to relocate manufacturing activities back in Western countries.

74. *What is the effectiveness of various aid delivery models for multi- and bilateral donors for increasing the well-being and productivity of smallholder farmers in poorer developing countries?*

See my answer to question #69.

75. *Under what circumstances do investments in smallholder agriculture compared with larger and more mechanized farms achieve the greatest societal and environmental good?*

This works best if 1) there is a solid plan, 2) the local population supports the project and 3) the return on investment is not based only on financials, but also on social and environmental performance. Profitable value chains will create employment, and that is the basis for societal good.

76. *What are the consequences of different mixes of public to private investment in irrigation infrastructure?*

That will depend very much on the specific situation. In any project, the human factor is at least as important as the financial resources. Proper execution is essential. The people involved and, especially when there is a mix of public and private interests, the interests of all parties need to be listed before starting. Nothing must leave any room for infighting and "turf wars". The preparation phase is critical, and it will determine the consequences.

77. *What are the consequences of different choices of investments in the resilience of agricultural systems to address the multifaceted adverse effects of climate change?*

The consequence of the choice in investment will depend largely on the relevance of that investment. The systems that answer the best the future challenges will be effective. The others will not deliver.

78. *What steps need to be taken to encourage young people to study agricultural science?*

One cannot love what he/she does not know. The first step is to provide the youth with exposure to agriculture. Some will like it, others will not, but at least, it will create callings. This will become even more important as the population will concentrate further in urban centers, and have very little

exposure to farming. Agricultural science without farmers is rather useful. I would put the emphasis on farming.

79. How might a unified sustainable food standard be developed and implemented across trading blocs, such as European Union or North American Free Trade Agreement, to serve environmental, health (nutrition), food quality and social values, and how could this be effectively communicated to shape food purchasing behaviour?

This would have to start with a unified definition of sustainability. Foods come from very different places that have very different natural conditions. The impact of farming on the direct environment will not be the same between countries and between productions. There should be a sustainability index of some sort for every food value chain. The best way to have such a system be communicated to the public would be by having the sustainability performance indicated on labels. It could be a number although, just like for nutritional labelling, consumers might not know how to read them. I would prefer a coloured label that indicates the level of sustainability. Green would be for sustainable, red for not unsustainable, and amber for borderline. Clearly, “red” products should have a sales tax, and producers of these products would have only a limited period to make the proper changes and get at least in the amber category. Once the forgiveness period has expired, the red products would not be allowed for sale anymore.

80. Where is food waste greatest in food chains in industrialized and developing countries and what measures can be taken significantly to reduce these levels of food waste?

In rich countries, food waste occurs mostly at the end of the chain, at retail, foodservice and household level. In developing countries, waste occurs mostly post-harvest. Food is lost because of spoilage due to the lack of proper infrastructure and storage facilities.

The issue in rich countries is really more one of selfish behaviour and of morals. Education and fines would have to be implemented. In developing countries, the solution is to develop the proper infrastructure to ensure that the foods can be delivered to market in good condition. This is a matter of policies and of making the necessary funds available. Local governments may lack the funds, but this is of global importance, and there is enough money to fix this. Political will is lacking, and this is the main problem. The amount of money required to fix this is insignificant in comparison of the amounts that have been made available to bail the big banks and the American carmakers, but apparently, these were more important than feeding the poor.

81. What is the best way to make food chains more resilient to exogenous trends (e.g. the upward price of hydrocarbons) and shocks (e.g. disruption to air freight)?

The simplistic answer would be to produce locally, but the food miles are not an exact indicator of the carbon footprint of foods. Every product needs to be assessed on its “vulnerability” to the exogenous trends. Local production and consumption is definitely part of the answer, especially for perishables that require fast transport to markets, usually by trucks, and by plane.

On the production side, the amount of fossil fuels used to grow the food needs to be looked at. Systems that are more efficient will have to replace our current ones. As oil price increase, the economics of farming will change, and options that do not seem economically viable today may well be very competitive in the future. In this area, research and development are necessary to make our food production more fuel efficient and cleaner.

82. *What is the potential contribution of localized food production to the overall sustainability of food systems?*

See my previous answer. The impact would be greatest with perishables. We should produce as locally as possible, but not be rigid to the point that urban centers could run short of food supplies. Urban farming is developing and that will contribute to improve the situation. Every progress is very useful. Pragmatism is necessary, though. This issue is about continuous improvement, not about ideology.

83. *How might appropriate limits be established on national per capita levels of meat consumption, while recognizing projected demographic and economic growth, given the aggregate impact of global livestock numbers particularly in relation to feed requirements and waste streams?*

This should start with education. As long as meat will be cheap, and especially thanks to subsidies, meat consumption will increase when people have more disposable income. Setting limits would have negative side effects such as black market and fraud. This would require policing the system, and that seems neither practical, nor desirable. We should have the market do its work and as prices of meat will increase, consumption will be curbed. It would have the advantage of creating a clear differential between different meats. Considering the respective feed efficiencies between poultry, pigs and cattle, the market would also favour the type of products that are the most efficient to produce, from a biological point of view. This would also have the advantage of improve the sustainability of meat production.

Of course, such a market approach puts the poor in a difficult situation, as they would not be able to buy meat. Then it is a matter for government to figure how important meat really is in the diet, and what other animal protein can replace it, partially or totally. Eggs, dairy and fish may be better options. There is also the possibility of having a system of food stamps for the most vulnerable in society to have the minimum of protein to feed their families.

84. *What are the best indicators that could be used to define agricultural sustainability thresholds (e.g. soil condition, biodiversity, nutrient cycling, energy use, key biological processes such as pollination) and how might these be communicated through the food chain?*

There should be indicators at every stage of the food value chain. Of course, some links of the chain would have a lesser performance than others have, simply because the differences are inherent to the type of activity. Therefore, indicators alone are not sufficient. Limits must be imposed on the impact of these activities on the sustainability of the production. Such standards would have to be defined locally as soil, climates, water reserves, and ecological environment differ from place to place. Biodiversity as such is a good indicator, but it would have to be used practically to identify which ecological factors are the best indicators of the performance of food production. This is complex, but quite possible to implement.

85. *What are the best institutional mechanisms to manage food stocks, storage, distribution and entitlement systems to ensure continued and sustainable supplies of food?*

I am not sure that the current mechanisms are that poor. This is really a matter of management. We need to measure and act as soon as something deviates from what is sustainable. Leadership and competence are even more important than the systems. I would focus on making people accountable for

the proper management of food supplies. The lack of accountability may very well be the main weakness of our current system.

86. How can we expand the range and commercial development of food plants (given calorie dependence on the seven key crops of wheat, rice, maize, potatoes, soya, sugar cane and sugar beet) in order to enhance resilience in food chains while retaining genetic diversity in crops and their wild relatives?

There are already many programs to preserve genetic diversity of plants, and animal breeds. Usually, the problem is about the funding of such programs. Our political leaders must be aware of what is at stake and impose a balanced approach between further development of agricultural production and preservation programs. This is possible to achieve. It is also a matter of political will and of resilience to the attempts of lobbies that have nothing else than short-term mercantile agendas. Some countries know how to keep the lobbyists on leash, but others have already given them the keys to the castle. We need strong leaders that will balance the short-term and the long-term interests. Our future is only as bright as our leaders.

87. How much land in agricultural regions should be left as natural habitats to provide ecosystem services and mitigate climate change threats?

This is something that needs to be determined at the local level. There is no global answer. Many bits of information to address this have been mentioned in previous answers.

88. What priority investments are needed to develop effective input and output markets in the poorest developing countries (especially sub-Saharan Africa)?

We must start with the beginning. Farmers need good quality seeds, which is not the case currently. Then they need the proper tools and inputs to work the land and help express the genetic potential of those good-quality seeds. Then they need access to financing to be able to run their farms. They need proper education, training and technical support to improve both the technical and financial performance of their farms. Infrastructure to bring the products to markets needs to be improved. This is much about time and money, but also proper leadership is required. The lack of good leadership, or even of leadership at all, has contributed greatly to the past situation.

89. As energy prices rise, how can agriculture increase its efficiency and use fewer inputs and fertilizers to become economically sustainable and environmentally sensitive, yet still feed a growing population?

It would be an illusion to think that feed prices could remain stable if the cost of inputs increases. There will be some inflation. It can be high or reasonable, depending on our ability to make the right decision timely. Once again, leadership and management are among the most critical aspects of the future of food and farming. How to increase efficiency and sustainability has already been addressed in previous questions.

90. *What mechanisms can be devised to buffer against growing market volatility and subsequent risk for farmers and under which conditions do different mechanisms work best?*

We must first look at the cause of market volatility. A much stricter regulation of futures market is essential. Today, many players influence the price of agricultural commodities while they have absolutely no physical function in either the production, the trading and the purchase and distribution of these commodities. They must be eliminated from futures contracts trading. This would already stabilize the markets a lot.

91. *How can market-based food supply systems be developed that offer economically sustainable levels of financial reward to all participants in the food chain (i.e. farmers, processors and retailers) while simultaneously providing safe, nutritious, natural resource-stewarding and affordable food to consumers?*

The money that the different participants in a value chain make is always based on their bargaining power. This is why there has been an ongoing consolidation of retail and industry. As I explain in *Future Harvests*, the strongest links of the food value chain are the two extremes: the providers of genetics and the marketers. Farmers, unless they sell directly to consumers, are in the middle and do not have a strong bargaining power. Fair trade is a difficult concept. It is rather easy to describe unfair, but it is more difficult to determine what fair is. Fairness is in the eye of the beholder. Usually, people do not get what they deserve, but only what they negotiate.

When it comes to safety, nutritional quality and environmental friendliness of food, some criteria need to be established by law, but even if we produce perfect foods, a balanced diet depends always on a combination of foods. This is in the hand of the consumers, and consumer choices are anything but rational. Certain tastes are acquired in the early years, and often food choices are unconscious. Education is the best solution. It is also important to reward good behaviour and penalize products that are obviously not made to be part of the fundament of a balanced diet. These foods and providers of foods are rather easy to identify.

There again, leadership is quite important to encourage the behaviour of the followers. Retailers seem to have taken over this leadership role from government agencies, and many of their initiatives are going in the right direction. Retail is the only powerful part of society that can counter industry lobbies.

92. *What mechanisms will provide incentives for further investment in sustainable, high-yielding agriculture that also maintains ecosystem services?*

It will be all about the money. Reward farmers for doing the right thing and they will do just that. Financial incentives, and there are many of those, even in countries that claim to have little or no agricultural subsidies, are the most powerful driver of behaviour, together with fear. There is nothing wrong by giving financial incentives when these incentives are leading us in the right direction.

93. *What mechanisms for institutional capacity can be used to create an efficient and equitable global marketing system so that food is produced in an economic and ecologically efficient manner and traded appropriately to achieve food security?*

This question is a bit redundant from several that have been asked previously. If we want things to evolve in the right direction, we need to give the proper incentives. It is all about leadership and rewarding people for doing the right thing. If we achieve this everywhere in the world, then we have solved the global problem.

Things are not that smooth, though. So many corrupt governments, so many bureaucrats that delay action, and so many interest groups that work hard to undermine anything that does not serve their short-term interests that this will be a difficult exercise. Money and power do not rest in the hands of utopians. That is a big part of the challenge to feed nine billion people.

And unfortunately, it takes a lot to have the people starting a revolution. The people's passivity is an impediment as well.

94. How can national food security policies be designed to be more compatible with worldwide open market food policies while securing the interests of local farmers and equitable access to food?

There are countries and regions that have good food security policies, and they achieve food security. This is not only the case in rich countries, but some developing nations have achieved great progress. To answer the question, I would recommend having a look at the success stories, and I would show them as examples to the ones who are less fortunate. All the success stories have one thing in common, though. These countries have, or had, strong leaders with the proper vision and the determination to succeed. Policies are only a reflection of the quality of the leaders.

95. How will predicted changes in meat consumption across different countries affect demand for the range of agricultural produce?

It will accelerate the increase of the demand for feed ingredients, therefore agricultural commodities. Since it takes more than one kg (almost 2 for poultry, about 3 for pigs, and even more for beef) to produce 1 kg of meat, a higher meat demand will reflect that factor.

Meat will become much more expensive and this will curb demand. We reviewed this in question #83.

96. What information is most useful to consumers wishing to make informed decisions about the environmental and social impacts of their food choices and can intervention methods be developed that encourage and provide incentives to all consumers to eat healthy diets?

A recent study in the US showed that most consumer do not pay much attention to nutrition facts on the label. This is not very encouraging. One can wonder if we should let the decisions to consumers. When we are dealing with issues such as health and environment, especially the sustainability of our species, we might have to reconsider the offering of foods to the public. Some products are good and others simply do not add anything, not to say some are simply harmful when consumed in excess.

Labelling alone will not achieve much. Only a minority of concerned consumers will pay attention. The majority will not care. The price will always be the primary factor to buy food, simply because their budget is limited.

I believe that we need a multilevel approach. Education is paramount. If people do not understand what a balanced diet is, and how to compose it, all the rest is wasted time.

Further, our leaders in government and industry must show more courage and act like good parents. Certain eating habits are bad and the message to the consumer should be "No!" Of course, this may mean that there are less business opportunities on the short-term, but from a societal point of view, having national budgets running deficits on health care because of leniency about food education is not a smart approach. Consumers have been used to have all they want available, and even more than that. This is convenient and quite pleasant, but one can wonder if it is responsible. If we want to overcome the food challenges of the next 40 years, we need to act responsibly, instead of looking for instant gratification. We will have to change our eating habits. We can choose to do it voluntarily by making the

right decision and acting responsibly, or we will be forced to change by Nature and economic forces, when our consumption society model cannot cope with shortages of goods.

97. Under which conditions can governmental health policy successfully affect consumers' diets by promoting good food as preventative medicine?

Instead of talking about "good food", I would prefer "good habits". We cannot change only one of our many reckless habits. We need to change radically the way we think. Good food is not preventative medicine. A proper hygiene of life is. Health problems are not caused by food only, but by lifestyle and pollution of many other industries that provide the goods that entertain our lack of responsible behaviour.

Governments can influence behaviour by passing appropriate laws, by making people more accountable for their actions, and by rewarding good behaviour and punishing bad behaviour. Bad foods should be taxed to death and that money should in part help subsidize good foods. Some type of products, although delicious and enjoyable, might very well be banned. I believe that social control also can play a role. For instance, a few decades ago, it was considered socially positive to smoke, and it looked cool, too. I still do not understand how some people, in fact the majority, could think that way. Nowadays, things have changed, and smokers are more considered like "losers" than like role model. Things can change, but something needs to trigger that change, and that is beyond the government alone. It is a society matter.

98. What programmes (or combinations) are most effective in promoting broad-based access to healthy food across different socioeconomic groups?

More than programs, the leadership of some people or organization is what we need. As examples, I would mention Growing Power from Milwaukee, WI in the US. They have developed urban farming for the local economically disadvantaged community. These people did not have access to healthy food. The Growing Power farm provides them with greens and fish. This program has attracted interest from the Clinton Global Initiative Foundation, and they develop similar systems in other US cities, but also in Asia, Africa and South America. Recently, Wal-Mart has launched its initiative to sell healthier food for a more affordable price. What we need are initiatives like those. Waiting for structured programs from government will not deliver much in comparison.

99. How effective are experiential learning programmes (e.g. garden-based learning, wilderness therapy, forest schools, outdoor learning) in promoting child nutrition, healthy child development, and prevention of obesity and diabetes?

I am sure that such programs are useful, but the key for success is the full involvement and commitment of the parents. Only good parenting will have the children get the right habits. The best of programs will not deliver much if parents at home send a different message. The whole society needs to focus on the same goals and values. All the other aspects of leadership, responsibility and personal accountability that I indicated in previous answers are also necessary to succeed.

100. *What is the effectiveness of different systems aimed at enabling informed consumer choice to directly reward farmers and thereby encouraging the spread of positive environmental attributes in food production (e.g. direct distribution networks organized by farmers, labelling schemes on food, information on farm websites)?*

Farmers markets are good, but the prices they charge tend to make them affordable mostly for the well off, thus excluding the poor from access to their foods. In a previous question, I mentioned that the financial performance of the various link of the food value chain depends on their bargaining power. This bargaining power is directly linked to their marketing strategy. We will solve very little by keeping good sustainable practices for a niche market. The right models need to be developed for the whole world population, although there always will be economic equality. One of the challenges is to manage ideals and necessity.