Food chains and the reasons behind rising food prices

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This article addresses the food crisis and its impacts on food chains. There are nine general causes of higher prices: use of grains and agricultural land for biofuels; population growth effects; strong income increase and distribution in emerging economies; urbanization of populations (mega-cities); local government income support programmes; high oil prices; production shortages; dollar devaluation; and investment funds speculation. To face this problem, 10 food chain solutions are proposed: sustainable horizontal expansion in food production using new available areas; vertical expansion increasing productivity; reduction in food taxes; investment in global logistics to reduce waste; use of the best sources for biofuels production; reduction in transaction costs; new generation of cheaper and innovative sources of fertilizers; sustainable supply contracts to farmers for more balanced margins allocation; spreading innovations (GMOs, nanotechnology); and, finally, consumer behaviour changes. The article ends by proposing a 14-point agenda for food chains in the future.

Keywords: food chains, food inflation, production, farms, food prices

To develop suitable food chain strategies, we should understand the macro-economic and environmental changes that are taking place. These changes are so dramatic that the world is nowadays a 'one surprise per day' world. Now food inflation is back. I discussed the food crisis using previous research and analysis in 2008 and 2009 (Neves, 2008, 2009) and it was not difficult to anticipate another food crisis, since global society is facing a new era in consumption. As an illustration, global consumption of wheat is increasing (using a 3 year average) by 10 million tons per year; corn (maize) by almost 30 million tons per year; and soybean by 20 million tons per year. Meat consumption grew by almost 20 per cent in 9 years (FAO website). In essence, people have increased access to food, and production is not responding as required: in 2010 there was a deficit of 50 million

People have increased access to food, and production is not responding as required

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tons of grains. Food commodity prices rose by almost 40 per cent in 2010, and non-food commodities by almost 94 per cent. These price increases are bringing back inflation, hunger and political disturbances in some developing countries, where the population spends 30–50 per cent or more of their income on food and the countries are net importers of oil (FAO website; Nielsen website; Hook and Cookson, 2010; Frangos et al., 2011).

In a speech in 2008 (FAO website) the UN Secretary-General, Ban Ki-moon, asked for food production to be doubled by 2030. According to the FAO, even with the reduction of hunger in the world (the proportion of starving people fell from 37 per cent to 15 per cent between 1969 and 2000), food prices in some countries were 80 per cent higher in 2009 than in 2007. As an average, food prices are 24 per cent higher than in 2006. The FAO also expects commodity prices to rise by 10–30 per cent in the next 10 years, claiming that food is not a priority in global politics and this should change.

Almost 1 billion people are likely to move into the middle classes in Asia

Asia is creating a huge population of higher income people, with a possibility of almost 1 billion people moving into the middle classes. All forecasts that were done 10 years ago, in terms of production, exports and imports in China/Asia, were incomplete and some were very wrong. For example, in 1995 China produced and consumed 14 million tons of soybeans. In 2010 it still produced 14 million tons, but imported 70 million tons (representing 80 per cent of its needs). The imports in 2010 were higher than those projected for 2030. If China is to be self-sufficient in soybeans today, over 35 million new hectares of land need to be dedicated to soybean cultivation. Where are these hectares? Probably in land that is being bought outside China, in Africa and South America. The situation will become even more complicated in the coming years because of the new 5-year strategic plan by China that will focus on improved income distribution and better working wages. So we can expect higher incomes for poor people, which will be reflected immediately in higher food consumption (Leung and Kennedy, 2011).

We can expect higher incomes for poor people in China, and higher food consumption

Importing soybeans into China also represents importing fresh water: over-exploitation of water resources is already creating problems in China and India. Additionally, half of the world's population is located in less than a third of the arable land, and this means a large food trade in the future, which will require bigger ships, bigger ports and more efficient logistics and transport systems.

The objectives of this article are to share views regarding this problem, and identify the major impacts for food industries, distributors and other participants in food chains, and what to do in the short and long term. The paper first describes how farms and farmland are under pressure to produce more and more 'renewable' resources of many types. It then discusses the major factors that are responsible

for food price increases and how these factors affect food processors and distributors. The next part shows how food chains should react to this situation, addressing a public–private agenda for development. Finally, the paper lists 14 points for the strategic planning of food chains by 2020.

The new pressure on land

The traditional function of a farm is producing food, but advances in technology have made farms a multi-product and service supplier. At least 13 industries whose products come from farms (Figure 1) are putting pressure on land, production and productivity. Land prices are increasing and this pressure moves along the food chain to food processors and distributors.

These industries are as follows:

- *Food and beverages*. This is the best-known function of a farm, to produce food (including grains, fruits, eggs, vegetables, milk, meat, fibres) for a growing, richer population that demands higher

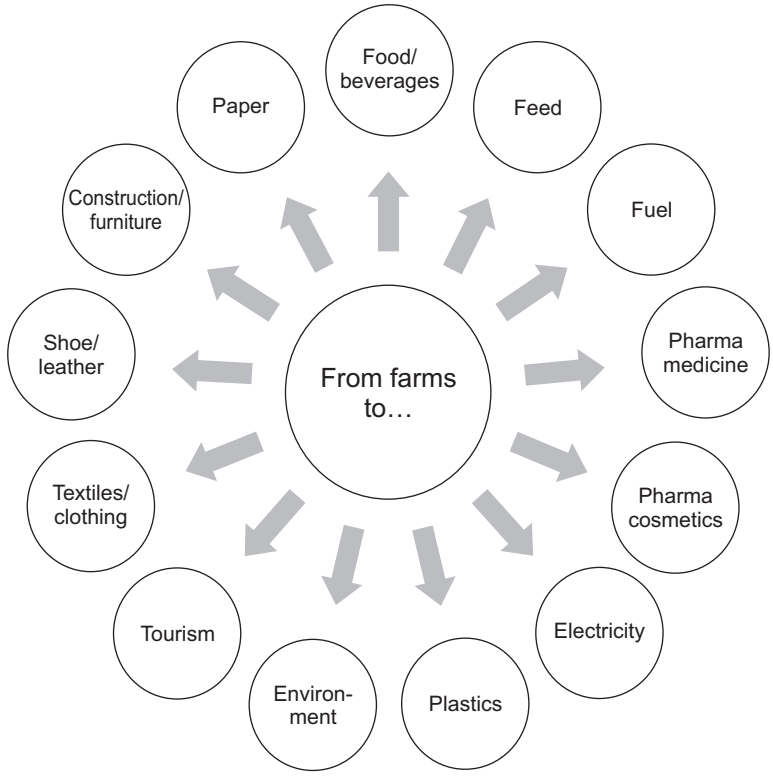

Figure 1. Industries that source materials from farms

quantities, quality, conservation, environmental protection and animal welfare.

- *Animal feed*. A traditional industry that benefits from farms by supplying feeds for larger domesticated animals, poultry and for pets.
- *Fuel*. Several countries have started biofuel blending programmes, using maize, wheat, sugar cane or beet, grasses and agricultural residues.
- *Pharma-medicine*. This is a growing food market segment of 'nutra-ceuticals' (food having additional health benefits such as fruit juice with added calcium or lycopene).
- *Pharma-cosmetics*. A market segment named 'nutri-cosmetics' containing products from food/farms that have benefits in terms of beauty, skin, tanning, and other characteristics desired by consumers.
- *Electricity*. Several farm products are used as a renewable source of electricity, including burning biomass such as bagasse from sugar cane in boilers and generating heat that is then transformed into electricity and sold to the electricity network.
- *Plastics*. Several companies are planning to substitute plastics from oil with renewable plastics from farm materials (e.g. Coca-Cola recently launched its plant-derived drinks bottle from sugar cane (Neves et al., 2011).
- *Environment*. Farms are being used in the battle against global warming, recovering forests, creeks, rivers, and even benefiting from participation in carbon credit markets.
- *Entertainment/tourism*. In recent years there has been enormous growth in some countries in the use of farms for tourism, as a weekend rest for urban families, for festivals, for schoolchildren's education, and other benefits for urban people.
- *Textiles and clothing industry*. The supply of natural fibres used to produce textiles, clothes and hats.
- *Shoe and leather industry*. Leather from cattle and other animals comes from farms to supply the shoe and leather industries.
- *Construction and furniture*. The majority of wood for walls, roofs and furniture nowadays comes from planted farms.
- *Paper*. Farmed wood pulp is transformed into paper.

Several farm products are used as a renewable source of electricity

There is, therefore, more pressure on farms and farmland in most parts of the world, and this is a huge change that operators in food chains need to understand and adapt to. Prices of land are increasing, putting pressure on margins and creating a new equilibrium of forces.

There is now more pressure on farms and farmland in most parts of the world

Next, the main factors that have caused this disequilibrium in food chains are addressed. They are not new, but some of these factors are

changing dramatically and should be closely followed by food chain strategists.

The major macro-environmental factors causing food chain disequilibrium and price increases

There are nine major factors that have changed rapidly in the last 10 years and these are bringing pressure on the capacity to supply food to the world. Some of them, such as income distribution, urbanization and development in fast growing emerging economies, are not being adequately measured, since local data are poor. Countries that never appeared in food import statistics have started importing huge amounts of grains and protein-rich foods, and this was not predicted.

The nine major macro-environmental factors for food price increases are:

1. the increase in areas dedicated to growing crops for biofuels;
2. the growth of the world population;
3. economic development and income distribution in highly populated countries;
4. stronger governmental programmes for aid and food consumption;
5. migration and urbanization of society bringing mega-cities, increasing food consumption and changing consumption habits;
6. oil price increases, affecting production and transport costs;
7. the dollar devaluation;
8. production shortages in food supply;
9. investment funds operating in futures markets and other agribusiness markets.

The urbanization of society has resulted in changing consumption habits

The first of the nine factors is the increase in areas dedicated to growing crops for biofuels. Several countries are starting production of biofuels, which, in some of them, is taking land used for food production. Now the fuel tank of the car is a competitor of the stomach: both want food. With higher oil prices, the estimates are that, in 2011, 40 per cent of the corn produced in the USA (the major world supplier with 55 per cent of the share) will be used for ethanol. It is interesting to see that several analysts blamed biofuels usage as having a major responsibility for the food prices increase. However, many studies are only linking biofuels to food inflation because they ignore several other factors, some of which have been known for a long time. Biofuels are not the major problem: there are very positive results in areas where biofuels are being produced together with an increase in food production.

In 2011, 40 per cent of corn produced in the USA is expected to be used for ethanol production

For example, biofuels production in Brazil takes place more than 1,500 miles away from the Amazon region, and is therefore not threatening the rainforest. Several significant research studies (see Neves et al., 2011) have been published over the decades validating positive experiences and solutions to the sustainability of biofuels. Since the debate is becoming ever bigger, one must scrutinize studies published in developed world journals, newspapers and magazines, using sometimes obscure methodologies and dangerously generalizing the results. Biofuels cannot be put into the same category because significant differences exist between ethanol sources and their energy-yield efficiency. Brazil produces its sugar cane-based ethanol without subsidies, for less than half the cost per litre and with more than twice the yield per hectare compared with the US product. South-central Brazil produces around 7,500 litres per hectare, compared with the sugar beet ethanol produced in Europe with ethanol yields of around 5,500 l/ha and US corn ethanol with yields of around 3,800 l/ha. Additionally, because of the need for crop rotation, 15–20 per cent of the areas used for growing sugar cane are also producing food (usually soybeans, peanuts or beans). This has contributed to Brazil's record food production year after year, despite increasing biofuel production (Neves et al., 2011).

Brazil produces its sugar cane-based ethanol for less than half the cost per litre compared to the US product

The second factor is the growth of the world population, expected to reach 9 billion people in 2050. This is not a new factor, but it contributes to the need for greater food production. Projections of future demand are impressive: for grains it will rise from 2.2 billion tons in 2009 to 3.3 billion tons in 2025; for milk a rise from 3.4 billion tons in 2009 to 5 billion tons in 2017; and for meat from 220 million tons in 2000 to 315 million tons in 2020. As an example, the MENA (Middle East and North African) countries have a population of around 380 million today, and are expected to have 510 million people in 2025 (World Bank website; Goldman Sachs website; International Monetary Fund website).

World population is expected to reach 9 billion people by 2050

The third factor is economic development and income distribution in highly populated countries such as India, Brazil, Eastern Europe, China, Indonesia, Thailand, South Africa, Argentina, Arabian countries and African countries, which are bringing millions of new food consumers to the market. Several African economies have grown by more than 5 per cent per year in the last 5–10 years. Experts in food consumption expect in the next 10 years an increase of 50 per cent in food expenditure in China, 78 per cent in India, and 40 per cent in developing Asia, Middle East and North Africa (Global Demographics website). From a current proportion of 60:40 per cent consumption in developed and emerging economies, in 10 years' time, food markets will be 50:50 per cent. Comparing China's population with

its participation in world trade, it is still less than 50 per cent – there is a lot more to come.

The fourth impact factor is stronger governmental programmes for aid and food consumption, such as one in Brazil that reached 10 million families (or 40 million people), all new consumers coming into the food market. As an example, the market for sausages in Brazil grew from US$0.5 bn in 2003 to $1 bn in 2007 (Nielsen website). These are just some examples of what is happening in several parts of the world. There are many other indicators that are not being captured in an adequate way by major economists.

The fifth factor is migration and urbanization of society, bringing mega-cities, increasing food consumption and changing consumption habits towards eating less grain and more protein (although more grain is used as feed in animal production). Consumption is becoming more individually based, more sophisticated and more energy consuming. This has a potentially huge impact, considering that in several countries, 50 per cent of the population still in rural areas is moving to cities. There is an estimate that around 350 million people in China will move to cities by 2025, and they will require 5 million new buildings (equivalent to 10 cities the size of New York), demand computers, TVs and air conditioning, and bring new food consumption habits (Xinlian, 2009; Aston, 2009).

Consumption is becoming more individually based, more sophisticated and more energy consuming

The sixth factor is oil prices that increased from $35 to $140 in five years, affecting production and transport costs. Prices are rising again, and oil is not only used for transportation: it is also used in several other industries, including plastics, which have also seen an increase in consumption. Increases in oil prices produce economic incentives for biofuels, further increasing pressure for land to grow corn and other grains. China had 65 million cars in 2008 and it is expected to have 150 million by 2020, consuming 250 million tons of fuel per year (Xinlian, 2009; Aston, 2009).

The seventh factor is the dollar devaluation that has happened in the last few years, which has also contributed to higher commodity prices that are fixed in dollars. Factor number eight is probably the most impressive: production shortages in the food supply have been caused by lower margins, climate changes, droughts and diseases and are a major concern. Additionally, there are major concerns about the availability and cost of water, and also the unknown impacts of global climate changes on crop productivity in the future.

Funds investing in food commodities have brought higher prices and fluctuations

Finally, the last factor is related to investment funds operating in futures markets and other agribusiness markets. These funds have increased their participation with lower interest rates in several countries. It is known that some of these have been replaced by strategic investors with conservative financing mechanisms, but there is still a movement of funds towards investing in food commodities,

bringing higher prices and fluctuations. This is also increasing consolidation of farmland, food industries and other chain participants (Ruitenberg, 2011).

The degree to which each of these nine factors is responsible for the problem is an avenue of further research by academics and strategic thinking by food chain specialists, but it is most important to monitor these factors and see how they are changing.

Food chain reactions: The pathway to address food demand growth and food inflation

Participants in food chains and governments have two ways to solve the coming food demand/inflation problem: one is to go backwards to increased protectionism, stimulating non-competitive areas to produce an 'economically artificial environment' and returning policies of 'self sufficiency'; the other is to move forward toward growth, global trade and inclusion. The following 10-point agenda is offered to governments and international organizations as a contribution to the upcoming debate on the problem of food demand and inflation. This could be the right avenue to follow, in providing long-term results, peace, income distribution and inclusion.

The two options are to move towards increased protectionism or towards increased global trade

The 10 integrated chain solutions for food inflation are:

1. sustainable horizontal expansion to new production areas;
2. vertical expansion with more technology;
3. reduction in food taxes and other protection;
4. investments in international logistics platforms;
5. reduction in transaction costs in food chains;
6. use the best crop sources for biofuel production;
7. new generation fertilizers;
8. sustainable supply contracts to farmers;
9. innovations (genetics and others);
10. consumption behaviour for lower energy use.

Each point in the list above is addressed in sequence as follows:

Promote horizontal expansion in production into new areas, with environmental sustainability

Expansion could take place into millions of hectares of land that today are poorly used

This expansion could take place using millions of hectares of land that today are poorly used in several countries on all continents (for example, South America uses only 25 per cent of its land capacity). In Brazil, several studies by recognized institutions confirm the existence of more than 100 million hectares that can be utilized for food and biofuel production, mostly on degraded pastures without touching fragile ecosystems (Embrapa website).

If stimulated by sustainable contracts, these expansions of production and land use will bring inclusion in farming, new entrepreneurs, job creation in less-developed nations, income redistribution and economic development, even having a positive impact on democracy. Land costs are increasing because pension funds are looking for security and buying land: for example, recently a fund of $800 m in Arabian countries was dedicated to land buying and food security, with South American and African countries as targets (*Financial Times*, 2009a). China and other countries are moving to build supply chains abroad. This is a perfect match of investments and need for development. To promote more food production in new agricultural areas is a strategy without losers, bringing benefits to world society.

Promote vertical expansion, or more production in areas that are already being utilized

Large areas in developing countries could produce more food if there were more technology and investment

Large areas of South America, Africa, Asia, and even developed nations could produce more food if there were more technology and investment. We still have large areas that produce low amounts of food, and could increase with some support. The amount of corn produced by a US farmer (in tons per acre) is two or even three times higher than the average production in Brazil and other countries. With irrigation, some farms in the tropics can generate three crops per year. Major research and investment should be dedicated to these improvements. We also need:

- Crop and land use decisions to maintain sustainability and resource conservation while, on the other hand, making the maximum possible use of the land. Some areas of the world allow three different crops per year.
- Equipment that allows better usage of land, which helps increase yield.
- Development and application of technologies that reduce consumption of water per area.
- Animal welfare techniques.
- Better governance structures, allowing equipment to be shared between neighbours, and exploiting the assets of the property, in order to be as efficient as possible.

Better governance structures could allow equipment to be shared between neighbours

Reduce food import taxes, internal taxes and other import barriers and protection

Food prices in some countries are artificially inflated by import taxes and other types of consumer tax that can be reduced. Protectionism also damages international trade, markets and growth, keeping high

Beef in the European Union costs three to four times as much as the same quality beef in an Argentinean store of the same European retailer

local market prices. As an example, beef in the European Union costs three to four times the same quality beef in an Argentinean or Brazilian store of the same European retailer (Neves et al., 2011). The argument mostly used is that lowering protection will damage the local agriculture. It must be assumed now that the new and higher level of commodity prices may allow local agriculture to be competitive. Several other internal taxes on food can also be reduced by national governments, so reducing consumer prices.

Investment in international logistics to reduce food costs

Some grain and other food producing countries have extremely poor logistics and infrastructure to bring this production from farms to markets. Governments should invest, and society should work harder, to change institutions in order to facilitate public–private partnerships to privatize ports, roads, and other food distribution and logistics to make the production flows faster, with lower energy consumption, working to reduce losses of food due to poor transport. A lot of waste could be reduced with better logistics.

Reduce transaction costs

There are many inefficiencies in major international food chains

Transaction costs are the costs involved in the selling and buying processes. Since food is perishable and has several other specificities, transaction costs tend to be high. There are many deficiencies in major international food chains: they are badly coordinated; they have several redundant activities; poor use of assets; corruption; opportunism and other inefficiencies, sometimes brought by intermediaries that don't add any value and remove margins from the chains. These are largely responsible for losses, increased costs, and continuation of companies, agents or others that do not add value, so affecting food prices (Williamson, 1985; Besanko et al., 2000).

Institutional reforms as proposed by North (1994) are a solution here. Also, more efficient cooperatives, producer groups and other collective actions should gain force to reduce redundancies and increase producer organization and bargaining power.

Use the best sources for biofuels in a totally sustainable way

The example of biofuel production in Brazil from sugar cane could be replicated.This value chain enables Brazil to supply all the internal market with sugar and, with its surplus, to export to the world market, achieving 53 per cent of global market share. Cane generates not only sugar, but also ethanol and bioelectricity. Of the total fuel consumed in the country, ethanol already accounts for 52 per cent, against 48 per cent from gasoline. Since Brazil is selling more than 3 million new

Cars in Brazil are soon likely to use 80% ethanol and 20% gasoline

cars per year, and of these, 90 per cent are flex fuel vehicles (using either gasoline or ethanol), it is expected that by 2015, this ratio of consumption will be 80 per cent from ethanol and 20 per cent from gasoline. This cane production takes place on only 9 million hectares, from the available 350 million hectares for agriculture development in Brazil (i.e. less than 3 per cent of the area) (Neves et al., 2011).

After crushing the sugar cane, about a third of its weight is bagasse. This bagasse is burned in boilers inside the industrial units, cogenerating electricity, partially used to run the mill, and part sold to electricity companies, representing a third source of income. Brazil estimates that by 2020, 15 per cent of its electricity supply will come from sugar cane (in 2010 it is 3 per cent) (Neves et al., 2011).

The efficiency benefits of ethanol are passed on to consumers. Most mills have a production cost of about $0.40/litre, and the retail price is an average of around $0.80/litre (55–60 per cent of the price of gasoline). At gas stations, consumers in Brazil can choose either what is called the E100 (100 per cent hydrated ethanol) or, at the other pump, normal gasoline, which for more than 10 years has been mixed with 25 per cent anhydrous ethanol, with no damage to gasoline engines.

Companies are extracting several other products from sugar cane, and probably the most promising markets are bio-plastic and diesel. There is a lot to come from sugar cane in the near future. The first GMOs (genetically modified organisms) are expected to be developed by 2014. Hydrolysis is a new technology that will increase the yields of ethanol from sugar cane and allow production to go from 8,000 litres of ethanol per hectare to 12,000–15,000 (Neves et al., 2011).

Invest in a new generation of fertilizers

It is important to produce fertilizers from alternative sources

Fertilizers are among the most important and expensive inputs for agriculture, and at a time in which yields must be improved, their importance is growing. It is important to produce fertilizers from alternative sources, using plants that can absorb more of the energy from the sun, and to recycle more by-products as sources of fertilizers to mitigate their huge risk and cost in the future. This is a major concern for society: how to produce more and renewable sources of fertilizers.

Work towards more sustainable supply contracts for farmers, with integrated investments and projects

It is of fundamental importance that margins and income should be better distributed in food chains, reaching farmers all over the world. Price stimulus is the best economic incentive for growth in production.

It is well known that concentration in food industries and retailing produces margins that could be better distributed to farmers to increase economic development in many regions. Methods integrating projects with sustainable development could be used (Neves and Castro, 2009). This type of method has four dimensions. The first dimension is *project management*. All projects must have strong criteria in terms of viability and attractiveness. First there must be a rigorous analysis of the technical feasibility of the activity which one intends to attract to a specific region. For instance, food processing requires different models for estimating agricultural and industrial investments and costs. It is also extremely important to analyse the market condition of the product to be produced. Investing in products that have many competitors and no clear regional competitive advantage is clearly a mistake. It is important to understand demand behaviour, quantitatively and qualitatively. All investments today must have very strong, world class project analysis, particularly if they are supported by federal or local governments.

Investing in products that have many competitors and no clear regional competitive advantage is clearly a mistake

The second dimension needed to bring about sustainable regional development is *integration*. Many investments fail because of the lack of a holistic view that considers chain coordination and integration aspects. A firm must buy from suppliers and sell to distributors and final consumers competitively. The way the firm will govern the relationships with these agents is fundamental for its development. This may range from vertical integration, contractual arrangements to spot markets.

All food chain agents should be able to generate profits above their capital costs

The third important dimension is the *business dimension*. It has to be clear that all the agents have to generate profits above their capital cost. Regarding smallholders, their income must be high enough to keep them motivated and committed to the activity. This is the basis for the long-term orientation of the producing chain and economic sustainability. It is important to mention the need for innovation and quality improvements in any chain, and this could be achieved by linkages with local research centres, universities and technical consultants. The whole integrated chain must have a long-term perspective.

The whole integrated chain must have a long-term perspective

The fourth important dimension for regional development is *sustainability*. Sustainability covers three different components: the environment, economic development and equal wealth distribution for participants. It is important to involve national and international environmental certification processes because they help prepare the firm and the region to meet environmental criteria and later on to compete on open markets. Companies should invest in market segments such as organics and fair trade, and promote social inclusion in poor communities.

Stimulate research and investment in innovation from all possible sources, but mostly in genetics, in order to find new solutions for food and biofuel production and consumption

In trying to solve the sustainability equation, the shortage of seeds is a problem. Public investments in agricultural research and development have decreased considerably in the last two decades, resulting in a slowdown in yield growth, disabling production and the ability to keep up with rising consumption. Since trust in biotechnology is increasing in society, bringing a new era of acceptance, research in this area should receive more attention.

We also need innovation in the following areas:

More economic, fuel-saving machinery is needed

- There is a need to develop renewable production inputs that replace non-renewable ones, such as today's fertilizers. Fertilizer shortages will become a threat for humanity, and we should come up with something new.
- The reuse of resources and the use of by-products in order to reduce pollution.
- Innovation that reduces costs for farmers, saving some operations and improving their margins.
- New technologies that lead to reduced residual effects of chemical products used in agriculture.
- Better, more efficient and more economic machinery that saves fuel.
- Genetically modified varieties in order to increase yields.
- Better grain-to-protein (animal) and sun-to-energy (plant) conversion.
- Biotechnology and natural control in order to use fewer chemical products.
- Innovation that reduces losses on input transport and application.
- Genetically modified plants more adapted to droughts and water restrictions.
- More efficient feeding technologies for animals.
- Innovation towards use of more resistant plants.
- Innovation on breeding that leads to precocity, which would reduce life cycles and therefore enhance production.

Slowly work to change consumption habits in both food and fuel

There are insufficient resources to allow 9 billion people to live at standards that are common in developed nations

There should be increased recognition that there are insufficient resources on the planet to allow 9 billion people to live at the standards that are common in developed nations. Behaviour should gradually be changed towards greater sustainability. Food is over-consumed in several parts of the world, bringing with it obesity – a major health concern. Another area of inefficient consumption is fuel, and investment is needed in resource-efficient public transportation.

These 10 suggestions are not new, and some are already being implemented with good results. But there is a turning point: one can either go back to increasing protectionism, less-efficient ventures in self-sufficiency, a ban on biofuels, introduction of food export taxes or even threaten to turn private companies into public companies; or society can move forward, with this positive agenda, which is the correct avenue for global sustainability.

Planning food chains for the future (2020)

The points presented below are gaining importance and should be included in discussions on how to prepare food chains for the 2020 environment. The 13 points shown in Table 1 can be useful for food chain companies, governments and academics in terms of the future development of food chains, emerging topics and suggestions for policies and regulations. They are intended to contribute to a more

Table 1. The food chain strategic agenda

Chain design, governance and performance	Adequate governance Contracts that can add value Profit generation and distribution Reduce costs
Chain waste	Management and reduction/re-usage Integrated inventory management and collaborative logistics
Food risks and chain integrated	Integrated approach to all the increasing risks in food chains (e.g. contamination, financial risks and others) Food security should be improved and the costs shared with all agents
Sustainable chains and certification	Land use, resource conservation, nature and biodiversity Certification processes, value and costs
Chain and networks impacts and adaptation	Know how growing impacts from an unstable environment affect food chains and networks
Chain and networks legislation and regulation	Deal with different governments and laws Deal with different institutional environments
Food and health communication	Know the restrictions that chains are starting to face: marketing communications, over-consumption, obesity and marketing for children
Climate change and chain adaptation	How to reduce the lower production and harvests and loss of land and water
Chain information management	To develop information management systems and decision support models
Biomass-based chains	Competition for resources Growth in the use of biomass and grains to produce energy and fuel
Metropolitan agriculture chains	Growth of food production in metropolitan spaces
Chain and network intermediaries	Start a process of mapping and redesigning chains Add value
Chain inclusion and social innovation	To promote the inclusion of smallholders

efficient sustainable food production system, in a new era of scarce resources.

Adequate governance and contracts can lead to better performance and profit generation

1. *Chain design, governance and performance*. Since chains compete in a global arena, and against each other, adequate governance and contracts can lead to better performance in adding value, profit generation and distribution, reduced costs, processes and other measures.
2. *Chain waste*. An integrated food chain generates waste at almost all stages in addition to wastage of final products, estimated at up to 40 per cent. Waste management and reduction/re-use is of fundamental importance in an environment that is pressured by society demanding sustainability. Integrated inventories management and collaborative logistics are among the most important developments to reduce waste and depletion of fossil resources.
3. *Food risks and integrated risk management in chains*. There is a need for an integrated approach to deal with all increasing risks in food chains, including contamination, financial risks and others. Food security should be improved and the costs of this improvement shared with all agents.
4. *Sustainable chains and certification*. Certification processes, their value and costs is a source of debate when considering land use, resource preservation, nature and biodiversity.

There needs to be consideration of growing impacts of an unstable environment on food chains

5. *Chain and networks impacts and adaptation*. There needs to be consideration of how the growing impacts of an unstable environment are affecting food chains and networks.
6. *Chain and networks legislation and regulation*. Chains are transnational and deal with different governments and laws, different institutional environments, bringing complexity to their management.
7. *Food and health communication*. This point is linked to the previous one, but gains importance because of restrictions that chains are starting to face in terms of marketing and communications, due to over-consumption, obesity and marketing aimed at children.
8. *Climate change and chain adaptation*. Higher incidences of droughts and climate unpredictability may lead to a situation of lower production and harvests, loss of land and water, and possible future population migration.
9. *Chain information management*. Information transparency and sharing has a positive impact on chain activities, bringing better management and performance. This also involves the design of information management systems and decision support models.

10. *Biomass-based chains*. Growth in the use of biomass and grains to produce energy and fuel causes pressure on existing resources in some countries, bringing a mixture of chains and competition for resources.
11. *Metropolitan agriculture chains*. There is a growth in food production in metropolitan areas and its integration with modern supply chains.
12. *Chain and network intermediaries*. In a process of mapping and redesigning chains, there is no more space in a world of giant companies and lower margins for intermediaries that do not add value. These agents and companies are facing rapid exclusion.
13. *Chain inclusion and social innovation*. An important topic is the capacity of chains to promote inclusion of smallholders.

How can we promote the inclusion of smallholders in food chains?

Conclusions

Interventions such as high export taxes may have an immediate positive result on controlling inflation in local markets, but they produce damage in the medium term, since they reduce farmers' incentives to increase production and productivity. Food chains lose out with these strategies. It is now time to make changes, to redesign food chains. Farmers worldwide, but mostly in emerging nations and Africa, need price incentives, technology, credit and buying contracts for market access in order to invest and grow production to a level that will be able to meet the increasing food demand in the next 10–20 years, and solve the food crisis.

Taxes on food should be reduced immediately and lower income people should even be supplemented with temporary governmental support to move towards the 10 points of development proposed above. Food production will need to double in 10 years, and the world has land area, technology, water and farmers to do it. Food chains should move in the right direction: incentives for sustainable growth in global farm production and trade, generating welfare, inclusion and peace.

Redesigning food chains is a task that involves the public and private sector

Redefining or redesigning food chains is a task that involves the public and private sector, and it is a task made much more difficult because the food system has changed and merged to form a much more sophisticated system, from commodity companies to consumer companies. Food is culture, economic development and a new integrated partnership system. Health insurance companies are now working with food companies (Goldberg, 2010), since food is the most important element of health.

There is a thin line between private companies, public companies and NGOs, which is making people sit together to plan chains

strategically and even to avoid conflicts of interest. In order to know that we are doing the right thing, third party evaluators will become the fastest growing industry in the food business.

Food production, health, nutrition, environment and climate change are not isolated public policy issues

For those involved with education, the need is to create managers who can look at the totality of these decisions, since food production, health, nutrition, environment and climate change are not isolated public policy issues. We must follow the 14 point list, generating research, ideas and solutions.

We have to teach in a multidisciplinary way and not treat multifaceted problems in isolation. We are navigating a new world of multidisciplinary approaches which are very complex and fast moving. This article has attempted to contribute to the debate, raising points and lists for further development of knowledge on food chains.

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