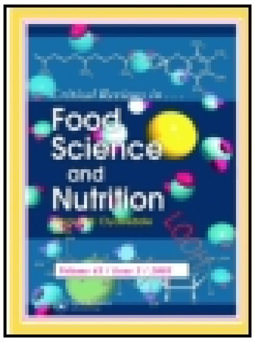

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Solutions for the sustainability of the food production and consumption system

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ABSTRACT
Due to the increasing population, there is high concern about whether the current food system will be able to provide enough healthy food for 10 billion people by 2050. The general opinion is that it is possible to feed this population, but the food system requires major transformations on behalf of promoting sustainability, reducing food waste and stimulating a change toward diets healthy for humans and also sustainable for the planet. This article will review some detected problems in food production and consumption. In food production, current problems like destruction of land ecosystems, overfishing or generation of high amounts of residues stand out. Some solutions have been described, such as implement the agroecology, improve productivity of aquaculture or re-valorization of by-products. In food consumption, the main problems are the food fraud and the unhealthy dietary patters, whose main solutions are the standardization along food chain and education on healthy lifestyles. Concluding, food system should change toward more sustainable practices and behaviors in other to ensure the subsistence of the present and the future generations.

KEYWORDS
Food production; consumption; sustainability; healthy diets; challenges

Highlights

The world population is expected to reach 10 billion people by 2050;

High concern whether the current food system can provide enough food;

Major transformations: sustainability, reduction of food waste and sustainable healthy diets;

Problems and solutions associated with food production and consumption;

Food system should change to ensure the subsistence.

1. Diagnosis of the food production and consumption system

During the last century, the scientific advancements and the innovations introduced in the production systems, provided by the Green Revolution, promoted rapid socioeconomic changes that favored human well-being and life expectancy. Consequently, these two factors led to the increase and aging of the population (FAO 2017a, 2017b, 2018a). In general, the world growth rate has decreased, especially in developed countries. However, the population of certain regions, such as Africa and Asia, will continue to grow. By 2050, the world population is expected to reach between 10 billion and 11 billion people by the end of the century. These estimations also indicate a rise in the population of cities and in the income per capita. All these factors will lead to a rise in the demand for food, thus it will be necessary to increase the production to meet global needs of safe and nutritious food (The Eat-Lancet Commission 2019; FAO 2017b). The key question is whether the required increase can be achieved, despite the fact that land and water resources are scarce, biodiversity is diminishing, and the negative impacts of climate change are increasing. Therefore, in order to achieve an adequate food system, increasing the production is not the only requirement: it is necessary to do it in a sustainable way, introducing best practices and reducing the adverse impact on the environment and greenhouse gas (GHG) emissions (FAO 2018a). The general opinion is that current systems can produce enough food for a growing population, but major transformations should be done. Also, it is necessary to implement policies to favor the transition to sustainable systems (FAO 2017a, 2018a). The international community has recognized the enormous challenges that the increase in food production implies, such as destruction of habitats, biodiversity loss, land degradation, pollution, etc. This preoccupation has been reflected in the 2030 Agenda for Sustainable Development and in the Paris Agreement of Climate Change, which demand profound transformations that will involve governments, society, and the science and business sectors. The future food system should meet the current food needs without compromising the food security of future generations and also join economic, social and environmental demands (Horton, Koh, and Shi Guang 2016; Lawrence et al. 2019).

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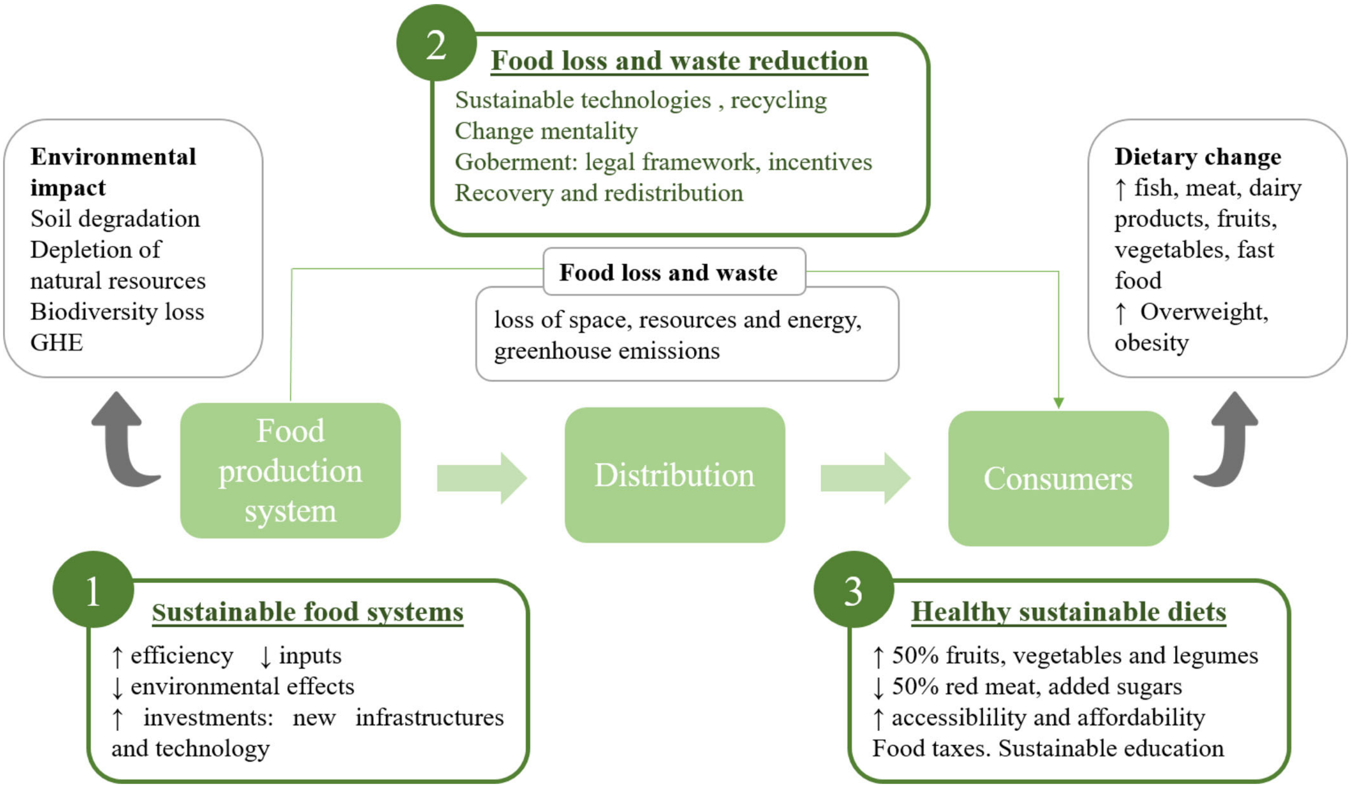

Figure 1. Global challenges to achieve a sustainable food systems.

Currently, among the different challenge of food systems, three main challenges may be described: 1) Improvement of food systems in a sustainable way, 2) Reduction of food loss and waste (FLW) and 3) Global diet change toward plant-based diets. Considering the opinion of several organizations, meeting these challenges would not be easy, but it could help to achieve productive systems without compromising sustainability. In the paragraphs below and in Figure 1, these challenges will be explained.

1.1. Development of sustainable food systems

According to Food and Agriculture Organization of the United Nations (FAO) estimates, global production will need to increase at least 50% to meet the future demands. Specifically, in the South Asia and Sub-Saharan regions, the production would have to double or more by 2050, while in the rest of the world, projections suggest that about one-third would be necessary to meet the rising demands (FAO 2017a; Horton, Koh, and Shi Guang 2016). The previous achievements suggest that the increase in production will not present major problems. Between 1950–60s and 2010s, the Green Revolution, (based on the increment of agricultural land, large-scale mechanization, use of pesticides and synthetic fertilizers, etc.) managed to triple the agricultural production in previous years. Livestock and aquaculture also presented an increase of their production in the last decades through the intensification of production methods. However, these food supply systems had several negative consequences for the environment such as decreased soil quality and fertility, depletion and contamination of natural resources and biodiversity loss (Béné et al. 2019). In the present scenario, these negative effects, along with climate change and low investments, made the search increment in food production very difficult (FAO 2017a; Horton, Koh, and Shi Guang 2016). To guarantee the sustainability of agriculture and livestock, some key factors have been described, as a more efficient use of land, conservation and restoration of natural resources, increase crops variety, efficient management of inputs (like water, fertilizers, energy, etc.) and reduction of waste and pollution (The Eat-Lancet Commission 2019; FAO 2018a). Regarding aquaculture, similar factors have been defined: improvement of oceans' management, responsible use of aquaculture species stocks, reduction of negative environmental impacts and sustainable expansion of global aquaculture (The Eat-Lancet Commission 2019). In addition, future food systems should become resilient to short term events, such as droughts and floods, and also to the long-term, as possible declines in crops' production may occur (Béné et al. 2019). Another needed action is to increase the investment in the food systems, both to developed new sustainable technologies and infrastructures and also to promote and implement the technical advances. For instance, numerous techniques have been developed to improve food conservation, such as high hydrostatic pressure, pulsed electric field and preservation with ozone, among others (Galanakis 2018). If implemented, these techniques would improve the efficiency of the food chain and reduce the residues generated. Thus, the central strategy for sustainability searches for the efficiency of production and not only increasing the amount of inputs. (FAO 2017a; Galanakis 2018).

Nowadays, several sustainable techniques and food systems have been designed. For example, evolutionary breeding and genomic-assisted breeding techniques have been reported to increase production without an increase in the amount of inputs. Evolutionary breeding consists on cultivating different genotypes of the same species. Natural crossing will lead to a progressive improvement in adaptation to the environment. This technique is used in crops such as barley, wheat, maize, tomato or rice, and producers have reported a high yield of production. In addition, low levels of diseases, weeds and damage caused by insects were observed, which reduced the use of antibiotics and pesticides (Dwivedi et al. 2017). Genomic-assisted breeding employs genetic advances to improve crops' resistance to stress factors and yield. This technique has been applied in different rice cultivars and chickpeas (Dwivedi et al. 2017; Galanakis 2018). For example, the cultivation of genetically modified rice resistant to fungi entailed less expense on antifungals (Galanakis 2018). Several sustainable systems have been proposed, like the mixed crop-livestock, which seeks both production and environmental benefits through the use of different practices, such as the utilization of manure to maintain soil fertility instead of chemical fertilizers or the rotation of forage crops to prevent erosion (FAO 2017a). A similar approach has been conducted with the aquaculture. The integrated multi-trophic aquaculture is based on the coculture of algae and/or filtering mollusks to mitigate the residues produced by other organisms, such as fish, mollusks or crustaceans (FAO 2018b). It has been described that sustainable production systems may not offer substantial increases in the short term, but they do in the long term, because the pressure on natural resources is reduced (FAO 2018a).

1.2. Reduction of FLW

As mentioned before, one of the main objectives to assure sustainable food systems is reducing the FLW. This reduction would diminish economic losses of producers and the needed increase of production. Firstly, loss and waste are different concepts. Food loss is considered as an accidental action caused, for example, by inexperience, inadequate harvest practices, insufficient technology for conservation during transport, inexistent packaging, etc. Food waste consists in the conscious discard of safe food for human consumption, for example, due to limited shelf life, esthetic standards or over-buy by consumers (this occurs mostly in high-income countries) (FAO 2019a; The Eat-Lancet Commission 2019). Current data about FLW is little. However, monitoring residues is expected to aid in the collection of accurate data. It has been estimated that about 1.3 billion tons of food produced for human consumption are lost or wasted along the food chain (FAO 2017a; Notarnicola et al. 2017). In general, food losses are higher for roots, tubers and oil-bearing crops, whose percentage of losses between post-harvest to distribution was estimated at 25% in 2016, followed by vegetables and fruits, with a percentage greater than 20%. In the case of food waste, it habitually happens at the consumer level and the most wasted products are animal products, fruits and vegetables. Regarding regions, the estimations ranged between 5–6% in Australia and New Zealand and 20–21% in Central and Southern Asia. Global food losses are estimated around 14%. In developing countries, food is lost between production and sale, whereas in developed counties, food is lost and wasted at the retail and consumer levels. (FAO 2019a; Chaudhary, Gustafson, and Mathys 2018). These food residues not only represent a loss of space, resources and energy, but they also produce millions of GHG emissions. According to FAO estimations, more than 3.3 gigatons of GHG emissions are produced by FLW (Notarnicola et al. 2017). Considering the aforementioned data, in the context of the 2030 Agenda for Sustainable Development, the international community has proposed to reduce the FLW by half. Among the different measures described to achieve the reduction, improving the efficiency of the food systems in a sustainable way stands out. Introducing sustainable technologies along the food chain and favoring the recycling of products are some steps that increase the efficiency of the production, benefiting both producers (who save money) and the environment (reduction of GHG emissions). Reducing food waste at the consumer level is also important, as they would save money. However, technological advances do not solve the problem by themselves. It is necessary to change the general consumption behavior and establish an efficient food pricing (FAO 2017a, 2018a). People involved in the food chain and consumers should be aware of the need to avoid FLW. For example, consumers should not buy in excess, to avoid throwing away products not consumed before the expiry date. Governments also play a fundamental role. They can establish a legal framework that indicates acceptable levels of FLW and incentives to reduce these residues. The recovery and redistribution of safe discarded food is also a good practice to reduce food waste (FAO 2017a). The strategies to reduce FLW may vary depending on the prevalence of food insecurity of a determinate country. In countries with severe food insecurity, usually low-income countries, reduction of FLW at the local producers' level may alleviate food scarcity. On the other hand, in high-income countries, most people have easy access to food. In this situation, the more adequate interventions are the food redistribution and social policies (FAO 2019a; Chaudhary, Gustafson, and Mathys 2018).

1.3. Global healthy diets

In the last decades, a migratory movement has been observed from the rural areas to the cities. By 2015, urban population reached a 49% of the total world population. This urbanization process has changed greatly the production food systems and also dietary patterns. It has been observed that products like fish, meat, dairy products, fruits, vegetables, and also processed and fast food (rich in salt, fat and added sugar) have increased in the demand, while the demand of cereals or roots has decreased (FAO 2017b, 2018a). This change in dietary patterns has caused alarm,

Table 1. Reference diet for human and planetary health proposed by the EAT-*Lancet* Commission (The Eat-Lancet Commission 2019).

		Macronutrient intake Grams/day (possible range)	Caloric intake Kcal/day
	Whole grains	232	811
	Tubers or starchy vegetables	50 (0–100)	39
	Vegetables	300 (200–600)	78
	Fruits	200 (100–300)	126
	Dairy foods	250 (0–500)	153
	Protein sources Beef, lamb and pork	14 (0–28)	30
	Poultry	29 (0–58)	62
	Eggs	13 (0–25)	19
	Fish	28 (0–100)	40
	Legumes	75(0–100)	284
	Nuts	50 (0–75)	291
	Added fats	40 (20–80)	354
	Unsaturated oils Saturated oils	11.8 (0–11.8)	96
	Added sugars	31 (0–31)	120

especially in developed countries, where the current data of obesity in children, adolescents and adults shows a worrying increase. Furthermore, this contrasts with the rates of hunger and malnutrition in developing countries (Béné et al. 2019). In this context, the challenges are to increase food production in a sustainable way, and also provide healthy and nutritious diets. In addition, future food system should make inequalities between developed and developing countries disappear. Several studies have concluded that a diet rich in plant foods and less consumption of animal foods could improve human health and reduce the risk of diet-related diseases as well as negative environmental effects (Chaudhary, Gustafson, and Mathys 2018; Béné et al. 2019). Therefore, reaching healthy and environmentally sustainable diets by 2050 will involve a global change in dietary patterns. The EAT-*Lancet* Commission, which brought together thirty-seven experts to develop a report about healthy diet for a sustainable future, advised that planetary health dishes should consist in a 50% of vegetables and fruits. The other 50% would correspond to whole grains, plant protein sources, unsaturated plant oils and low amounts of animal protein sources (Lawrence et al. 2019). In Table 1, the diet reference for human and planetary health proposed by the EAT-*Lancet* Commission is presented. This diet is flexible and may vary depending on personal preferences and needs, cultural differences, traditional eating, etc. According to the presented diet, global consumption of products such as fruits, vegetables and legumes should be doubled, whereas consumption of less healthy food like red meat or products with added sugars should be reduced more than 50%. A similar situation occurs in North America, where people are over-consuming animal foods, such as dairy products, eggs or red meat, and starchy vegetables. On the other hand, Sub Saharan Africa and South Asia over-consume starchy vegetables, while other products like vegetables, fruits and fish are present in low amounts in the diet (The Eat-Lancet Commission 2019). However, in developing countries, a gradual diversification of food, increasing the presence of processed foods, has been observed as incomes rise (FAO 2017b).

Dietary change would have different beneficial effects, depending on the region. In developing countries, the amount and quality of nutrients would be improved, whereas in developed countries, the reduction of animal foods will imply a reduction in consuming inadequate nutrients, such as saturated fats and cholesterol. Adopting healthy diets, with less consumption of animal foods, would reduce global food related GHG, carbon footprints and the use of water. In fact, a reduction of around 12% of GHG emissions related to food production has been estimated (Chaudhary, Gustafson, and Mathys 2018). Regarding measures to achieve the dietary change, several approaches have been considered. Currently, unhealthy foods, rich in calories, salt, added sugar and fats, but not in nutrients are cheaper than the recommended foods that are rich in nutrients, so it is necessary to make healthy products more accessible and affordable, especially for low-income sectors. Improving nutritional information and food marketing could also help to make the consumer aware of the need to choose healthy products. Some measures that can be taken by governments include creating food taxes on less healthy products, investing in public health to provide reliable information and

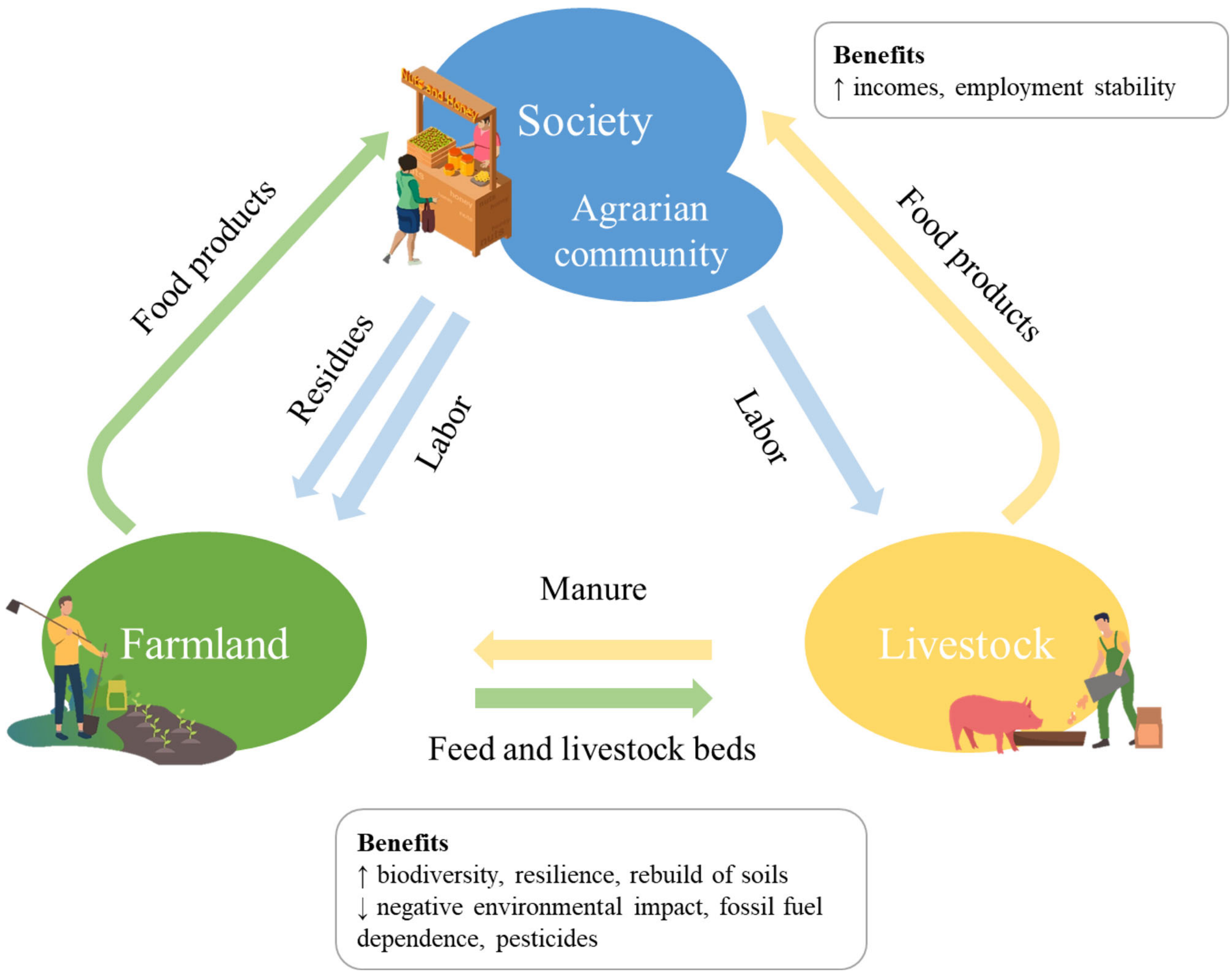

Figure 2. Schematic representation of the actors of agroecology approach and their relationships.

creating healthy eating guides or encourage sustainable education in schools (The Eat-Lancet Commission 2019; FAO 2017b).

2. Detected problems and potential solutions in food production

As mentioned above, one of the major challenges of the current food system is increment food production for a growing population without increasing pressure on natural resources, including land, water and biodiversity. In the following paragraphs, several problems that threat food production and several solutions proposed to solve them have been reviewed.

2.1. Destruction of land ecosystems

During human history, population growth has led to the degradation of the environment, to create habitable areas and obtain needed resources. Unlike the rest of the species, whose populations reach the carrying capacity of their respective ecosystems, humans have developed new technologies that allow them to continue increasing their population. As a result, not only other species have been displaced, but natural habitats were destroyed or overexploited. Land degradation is defined as the decrease or loss of biological or economic productivity, which leads to the subsequent reduction of yield, incomes, food security, and the loss of vital ecosystem services (Barbut and Alexander 2016). This process is happening at a shocking pace and drives to a dramatic decline in the productivity of land worldwide (D'Odorico and Ravi 2016). According to the United Nations (UN) data, natural ecosystems have been reduced by 47% on average and land degradation has reduced productivity by 23% in all land areas. Biodiversity data is worrying. Agricultural and livestock biodiversity has declined in recent decades, while wild mammals have been reduced by 82%; and an average of about 25% of animals and plants are currently threatened (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 2019). Considering that agriculture is the main driver of diversity loss, a new term has emerged to try to reduce this deterioration: agroecology.

2.1.1. Agroecology

Agroecology is defined as the science of the relationships of organisms in an environment transformed by man for crop or livestock production (Martin and Sauerborn 2012). This term can be applied to different fields such as science, agriculture, politics and economics. Agroecology was first used in the thirties by a Russian economist in reference to ecological methods of production. The term is also related to agriculture practice and as a movement in the seventies (Martin and Sauerborn 2012). The scale of the application of agroecology has evolved from the field, to an agro-ecosystem, to finally food systems (Gallardo-López et al. 2018). In Figure 2, a schematic representation of the actors of agroecology and their relations is presented.

The development of agroecology is strongly important, due to the interest of producing food through sustainable and regenerative systems, using resources more effectively and minimizing negative environmental impacts. The objective of this science is to reduce dependency on external inputs and increase the productive capacity of biotic and abiotic system components. Agricultural practices seek to imitate natural processes, creating beneficial biological interactions and synergies among the components of the systems and valorizing ecologic processes (Migliorini and Wezel 2017). Some examples of agricultural practices are the biological fixation of nitrogen, low use of pesticides, crops rotation, minimal tillage and soil erosion control, or the use of compost and organic matter from livestock as fertilizers. Different studies have proved that agroecological systems have different environmental advantages such as keeping carbon in the ground, supporting biodiversity, rebuild soils, increasing resilience (D'Annolfo et al. 2017; Garbach et al. 2017; Lefèvre et al. 2020). In addition, agroecology reduces dependence on fossil fuels and favors the implementation of renewable energy sources (Aguilera et al. 2020). Regarding economic and social advantages, several agroecologic systems conducted in Europe have reported to provide higher and more stable incomes and employment, compared with industrialized systems (van der Ploeg et al. 2019). Thus, agroecology is considered a possible solution to the current food systems, promoting local food systems with rural-urban links and sustainable livelihoods (D'Annolfo et al. 2017; Migliorini and Wezel 2017).

2.1.2. Genetic edition for the improvement of resilience

Resilience is the system's capacity to absorb disturbances without altering the characteristics of structure and functionality; being able to return to its original state once the disturbance has ended (Tendall et al. 2015). Some examples of these disturbances include pest, diseases, extreme conditions and climatic change. These factors can reduce food production with the consequent change in product prices, affecting both producers and consumers. Therefore, the development of food products with resilience is very important as they are crucial to sustainable development (Tomich et al. 2011). There are several emerging strategies for enhancing sustainable crop production and resilience. Among them, genetic edition stands out as an useful tool to increase protection against diseases, resilience to abiotic stress, such as drought, salinity or extreme temperatures and also to improve metabolic conditions (Bailey-Serres et al. 2019). In this context, numerous studies have evaluated diverse genetic modifications to improve the resilience of crops. Plant immune receptors, responsible of the detection of pathogens, are a promising objective of genetic engineering to develop crops more resistant to pathogens (Monteiro and Nishimura 2018). For example, the resistance of the legume *Medicago truncatula* against the bacterial pathogen *Ralstonia solanacearum* was enhanced by transferring a specific receptor from *Arabidopsis thaliana,* which recognizes a proteic structure of the bacteria. This genetic modification had a significant positive impact on disease resistance against the pathogen (Pfeilmeier et al. 2019). The transference of the *Pm3e* resistance gene against powdery mildew from a resistant wheat variety to a susceptible variety produced an effective protection (Bailey-Serres et al. 2019). Modifications against abiotic stresses, such as flooding, droughts salinity or extreme temperatures have been studied. For instance, the stoma guard cell Bca of *Arabidopsis thaliana* was overexpressed to improve water use efficiency, especially important in extreme temperatures. This modification lead to a 44% increase in water use efficiency, without any changes in photosynthetic assimilation rates (Hu et al. 2010). Another important factor in the resilience of a species is the nutrition. In this context, the efficient use of nitrogen is very important and several modifications have been investigated to improve it (Cormier et al. 2016). For instance, a greater growth regulating factor 4 abundance allowed to improve the nitrogen assimilation in rice (Li et al. 2018).

2.2. Overfishing

The negative effects on the environment caused by humans are also palpable in aquatic ecosystems, especially in marine. The increase in world population and the fish demand has driven to the overexploitation of marine resources, reducing the population of marine species, like *Thunnus thynnus,* whose population diminished a 96.4%. Aquaculture and putting fishing limits in open water might be the solutions of this problem (Bardey 2020).

2.2.1. Implementing catch shares and community-based fisheries management systems

The National Oceanic and Atmospheric Administration (NOAA) defined catch shares as any fishery management strategies that assign a specific portion of the total acceptable fishery catch to individuals, cooperatives, communities, or other entities. Each recipient of a catch share is directly responsible to stop fishing when its limited amount of captures is reached (Morrison 2017). The aim of the catch shares is to favor the sustainable exploitation of fish stocks, helping to stabilize the fisheries, and also the economic development. Several studies have been carried in the past decades, which showed that this approach is efficient to manage fish population and also stabilizes landings and catch limits (Essington 2010). In addition, catch shared also lead to a reduction of the discards and a greater profitability (Branch 2009; Newell, Sanchirico, and Kerr 2005). An example of efficient management is the catch-share program

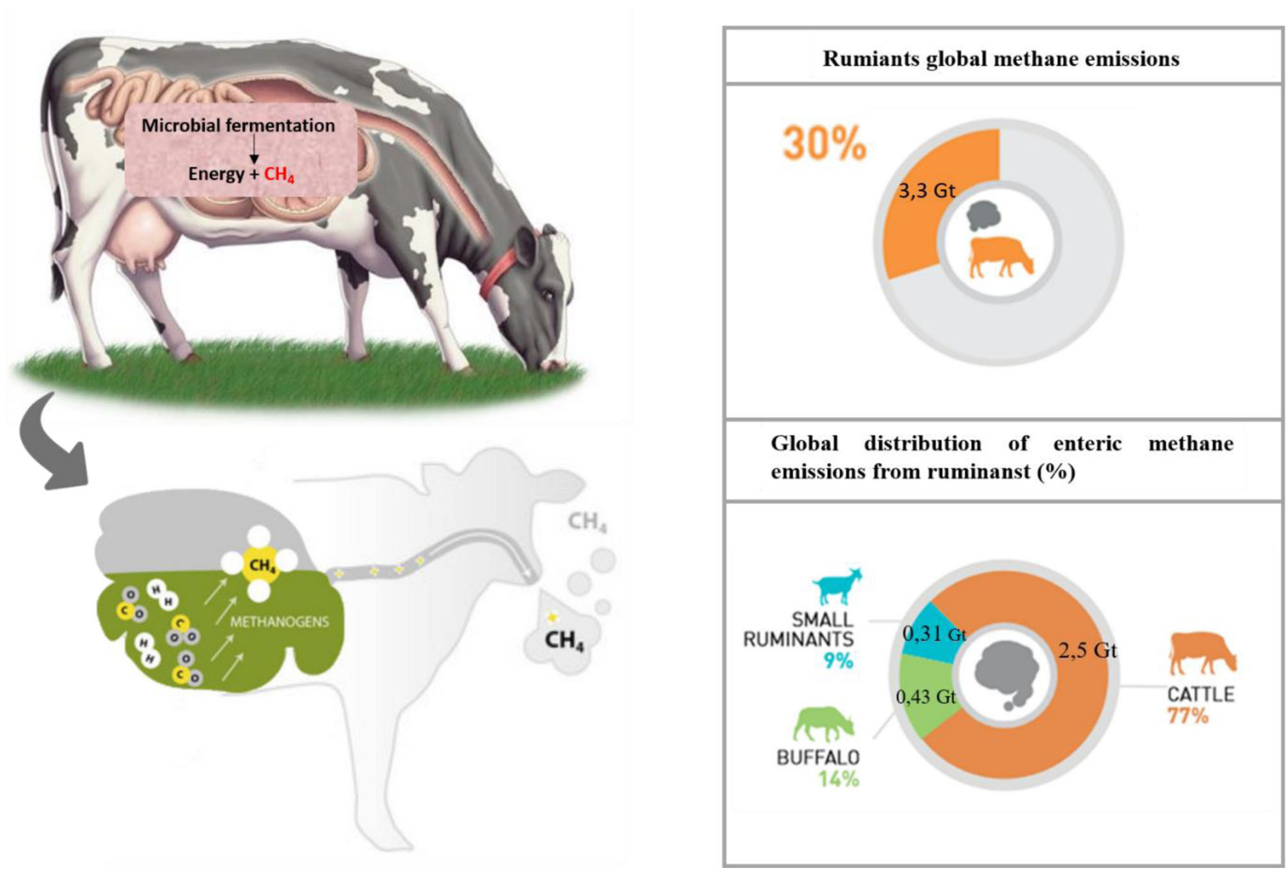

Figure 3. Production of M due to enteric fermentation.

for catches of bottom fish. This program includes an equitable allocation and offers opportunities for new participating, which directly benefits coastal communities and small businesses that support anglers. Catch shares result in better environmental management, economic improvements, changes in social performance and diminution of discarded fish (Grimm et al. 2012). However, this technique is not enough to ensure the sustainability of the medium and long term, since, if fishing is centralized in a certain area, this location may be exhausted (Emery et al. 2012). The principal disadvantages of the implementing catch shares include high costs of monitoring and enforcement, and also unexpected costly economic and safety consequences of command-and-control solutions that achieve fairness.

2.2.2. Improve productivity of aquaculture

In 2016, FAO estimates showed that about 171 million tons were caught between capture and aquaculture stages, increasing this supply at a rate of 3.2% every year since 2005. Fish caught in recent decades has remained relatively constant, but its future under threat due to resource depletion. In this context, aquaculture is gaining more attention as the first step to achieve a sustainable fish supply and allow stocks to recover by reducing catching wild fish. In recent years, stocks continued to decline, with an estimated 64% of the stocks evaluated as having greater production after a reconstruction process. The global recovery of fisheries would simultaneously create increases in abundance (56%) and fishing yields (up to 40%) (Costello et al. 2012). As stated above, to increase productivity in a sustainable way, aquaculture should improve the management of land, water, feed, energy, and the control of diseases and minimize water pollution. In addition, it is necessary to increase the investment in technological innovation, such as in genetic modification or feed formulation, establish incentives to reward improvements in productivity and environmental management and shift fish consumption toward low-trophic farmed species. All these parameters are essential for achieving a better productivity with better environmental performance in order to develop a sustainable food future (Munguti, Kim, and Ogello 2014).

2.3. GHG associated with meat and milk from ruminants

Another important problem in the food chain that contributes significantly to climate change are the anthropogenic emissions produced by ruminant livestock (Figure 3). During the digestion of their food, ruminants carry out an enteric fermentation in which food is fermented and decomposed in the digestive tract by the action of microorganisms with the consequent release of methane (CH_4) into the environment. Between 2–12% of a ruminant's energy intake is lost as CH_4, one of the main GHG that contribute to climate change. Livestock production will probably grow to meet the future the demands, and consequently, the CH_4 emissions will increase. In this context, following the Paris Agreement, more than 100 countries have committed to reduce GHG associated with food production (Doyle et al. 2019).

2.3.1. Reduction of enteric fermentation

Different investigations have been carried out to reduce CH_4 production without having to give up meat and dairy consumption, since ruminants provide globally 51% of all protein from the livestock sector, of which 67% is from milk and 33% is from meat. Reduction of enteric fermentation may be achieved mainly by varying the type and amount of food consumed and using feed supplements that inhibit the methanogenesis (the formation of CH_4 in the rumen of livestock by the rumen methanogenic archaea). Several studies have reported that diets rich in legume fiber produced less CH_4 than grass fiber, attributed to the lower digestibility of legumes (Wattiaux et al. 2019). Regarding feed supplements, several studies have demonstrated their efficacy. For instance, supplementation with natural herbal or algae with methanogenesis inhibitors in ruminants' diet reduced the amount of CH_4 generated and improve rumen fermentation with the consequent increase in productivity (Zoupanidou 2019). Other supplements have been tested in different ruminants, including essential oils, tannins, nitrates and saponins. The results showed that these compounds alter the rumen microbial population, conducing to a diminution of CH_4 emissions (Patra and Yu 2013; Jafari et al. 2019). Chemical inhibitors or enzymes target to essential function of archae have been also administered to ruminants (Chellapandi et al. 2018). Another proposed strategies are the biologic control (for example, using latic acid bacteria to modulate the rumen microbiota to reduce the emission of CH_4) and anti-methanogenic vaccines (Doyle et al. 2019; Chellapandi et al. 2018). Veterinary vaccination is a relative new strategy, consisting in the acquire immunization against particular methanogenic archaea (Chellapandi et al. 2018). Breeding selection of the animals that require less to produce the same amount of food, meaning the most productive, is also a possible solution to reduce methane emissions and also production costs. However, more research is needed in this topic (Wattiaux et al. 2019).

2.3.2. New alternative protein sources

As mentioned before, the consumption of meat should be reduced to achieve healthier diets and maintain planetary health, dropping the levels of CH_4 emissions. Other protein sources have been described, such as vegetables, algae, insects and even protein synthetized in laboratory. Most people require approximately 58 grams of protein per day for an adult weighing 160 pounds, and this amount needs to be increased by about 10–20% in vegetarians and vegans due to the lower digestibility of the plants protein (Petrusán et al. 2016; Berrazaga et al. 2019). Currently, the major source of vegetal proteins is soybean. Further sources of historical consumption and sustainable production proteins are grains (wheat, rice, millets, sorghum), seeds (chia, hemp), nuts (almond, walnut), pulses (beans, lentils, peas, lupins) and leaves (moringa, duckweed) (Nadathur, Wanasundara, and Scanlin 2017). These products also have interesting advantages when compared to animal proteins. Plant proteins are produced more efficiently, require less water, land, nitrogen, and fossil energy to produce the same amount, and fewer natural resources are necessary to produce food for human consumption. In addition, they contain phytonutrients, vitamins, minerals or fiber, which have been demonstrated to have beneficial effects on consumer's health (Lonnie et al. 2018).

Novel protein sources (like insects, algae, duckweed, and rapeseed) are projected to appear in the European feed and food market as substitutes for animal derived proteins. However, to introduce these kinds of products in the market, it is necessary to adjust and clarify European legislation as well as study safety aspects (van der Spiegel, Noordam, and van der Fels-Klerx 2013). Insects are a good source of protein, their industrialization being a relatively recent process. Some available products are crickets, locusts, grasshoppers, caterpillars or beetles. The commercialization of this products must be careful as they may be allergenic or contain toxins and contaminants (Loveday 2019). Regarding proteins synthetized, cultured meat was put into practice in 2013 when a research group produced a burger patty formed by bovine cells grown in a laboratory. The process of production consists on isolate skeletal muscle stem cells from an animal, inducing cells to proliferate and differentiate in culture medium and engineering tissue structures. More research is needed to be able to bring these products to the market (Loveday 2019).

2.4. Reduction of FLW

2.4.1. Improving food storage/preservation and rationalization of expiration labels

Consistent with the second challenge, several options to reduce FLW have been proposed, starting with the development of preserving and elaborating techniques to guarantee the safety of the products and increase their shelf life. Food preservation is essential to maintain the quality and obtain maximum nutritional benefits. Several techniques have been developed that allow us to overcome the inconveniences of improper planning in agriculture, have food available year-round or produce value-added products. Time, globalization and growing demands increased interest in preservation techniques, such as high pressures or electrical pulses, which impede food spoilage and yield longer shelf life (Amit et al. 2017). Another way to preserve food is by adding additives. Nowadays, the use of natural additives is gradually replacing synthetic ones, due to their poor image and the controversy they generate. In this respect, in the last decade, there have been great advances in the extraction of interesting compounds from plants, for example. Carotenoids, phenolic acids, anthocyanins and betalains have been proven to be effective natural additives for foods, due to their antioxidant properties (Roriz et al. 2017; Pinela et al. 2016).

Nevertheless, many safe foods are still discarded, due to the misinformation of the labels or the restrictive dates that must be included. This confusion also generates a rejection

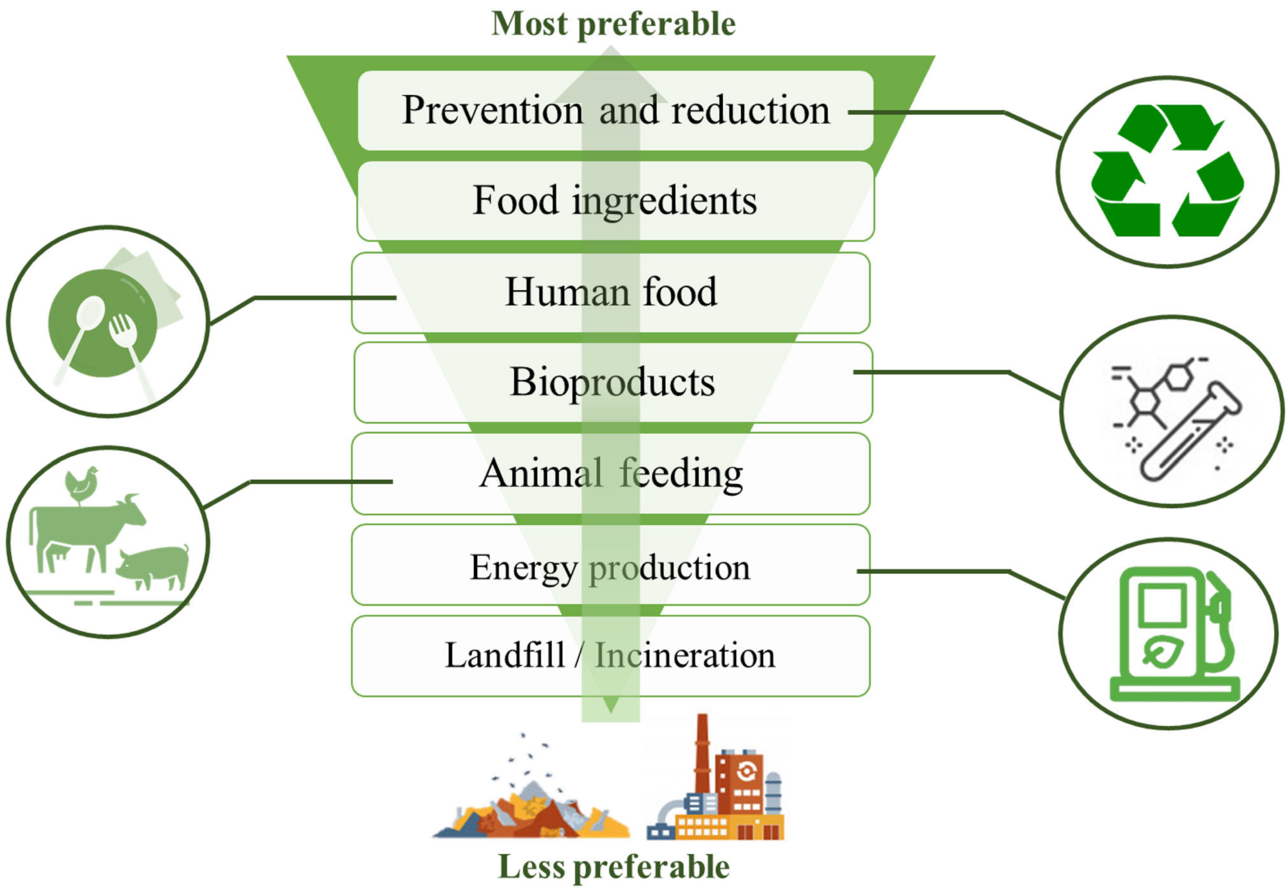

Figure 4. Re-utilization and re-valorization of subproducts following a hierarchy waste model.

when buying products close to the dates indicated on the package, leading to associated problems, such as buying only the freshest products, leaving some in perfect condition to be discarded (Hall-Phillips and Shah 2017). This situation is especially worrying in USA, where it has been estimated that the 43% of the waste occurs in homes, since consumers throw away food without understanding the meaning of the food date labels, being a 25% of this waste still safe for consumption. All these residues cost $29 billion per year. Standardized labeling has been proposed to be a possible tool to solve the problem of food waste (Thomson 2017).

2.4.2. Re-valorization and re-utilization of subproducts and reduction of wastes

A global average of 14% of the total generated food is lost along the production (including post-harvest) and supply chains, which means that this value is even higher in some regions such as central and southern Asia or northern America and Europe where the percentages are 16 and 21%, respectively. In a FAO study published in 2013, it was estimated that due to FLW, the global carbon footprint was 3.3 gigatons of carbon dioxide equivalents and represents a waste of two main natural resources: around 250 km^3 of water and 1.4 billion hectares of agriculture land (FAO 2013; Kummu et al. 2012; FAO 2011). In Europe, the previously mentioned percentages mean that an estimation of 88 million tons of food are wasted annually, which have an associated cost of around €143 billion (Stenmarck et al. 2016). In the transition to sustainability of food systems, the optimization of industrial processes that trigger the reduction of FLW is fundamental (Springmann et al. 2018; FAO 2019b). European Commission have published different directives, regulations and communications, in order to provide a legal framework for waste management (Commission of the European Communities 2005a, 2005b; European Parliament and Council 2006, 2008, 2009). Nowadays, many different industrial and academic approaches of sustainable production have been designed based on economical and legal interests. The most used model is the "circular economy," in which the term "end-of-life" is replaced by reducing, reusing, recycling and recovering materials that allows the re-valorization of the subproducts and minimize the environmental impact (Kirchherr, Reike, and Hekkert 2017). To maximize the throughput of the system, a hierarchy management waste model shall be applied to the subproducts (Figure 4). The first approach is to prevent the waste production, followed by the re-introduction of the recovered ingredients as part of the human nutrition, bio-products or food aimed for animals, later different industrial applications are incorporated such as energy production, and lastly, and the least recommended step, landfill or incineration.

Currently, many works have been published presenting solutions for accomplishing the reduction of food waste. A study reflected the importance of reducing food waste at school canteens by planning the demand based on the cultural diversity present in the school and the meal acceptance by students, as well as by optimizing the portion sizes. Another alternative suggested by these authors is the inclusion of a green garden to provide a composting facility at schools (Derqui, Fernandez, and Fayos 2018). In terms of re-utilization and re-valorization of subproducts, the most relevant ones are those aimed to reduce the waste from the most productive industries, the one of roots, tubers and oil-bearing crops and the one of fruits and vegetables. These two food categories have a high content in antioxidants, such as in the case of onions, carrots, or olive oil. For example, onions have been demonstrated to have a high concentration of two classes of flavonoids, flavanols, being quercetin-4′-glucoside and quercetin-3-4′-diglucoside the most abundant ones accounting up to a 95%, and anthocyanins in red onions may reach a 50%, cyaniding glycosides being the main ones (Rodrigues et al. 2017). Carrot discards have shown to have 68% made up of carbohydrates and 23% made up of fiber, and carotenoid yields may range from 65 up to 94% in equivalents of α-and β-carotenes (Clementz et al. 2019). The consumption of olive oil has been reported to provide human health benefits; indeed, the European Food Safety Authority (EFSA) considers that extra virgin olive oil is a functional food. The bioactivities present in olive oil are due to the high content of phenolic acids, flavonoids or monounsaturated fatty acids. In olive oil subproducts, such as the olive mill wastewater residue, phenolic acids have also been detected. The phenolic acids that were especially relevant are hydroxytyrosol, tyrosol, verbascoside, oleuropein, oleacin or oleocanthal for their anti-oxidant and cytoprotective activities (Lafka et al. 2011; Fabiani et al. 2008). In the case of fruits, different subproducts have been described to possess high percentages of carbohydrates some examples are the mango seed kernel (around 33%), pineapple pomace (43%), banana peel (59%) or grape pomace (60–70%). Fiber is another important component of tomato peel (86%), grape pomace (76%), mango peel (ranging from 51 to 78%) or pineapple pomace (45%) (Torres-León et al. 2018). Therefore, recovered biomolecules from subproducts may be further re-utilized as food ingredients destined to human consumption in different presentations, such as fortifying other food matrixes (see section 3.2.2. Functional food) in order to provide functional properties to them.

3. Detected problems and potential solutions in food consumption

3.1. Food fraud

A simple definition of food fraud is that it is an illegal deception for using food. It includes the alteration (substitution, dilution, concealment, etc.) of the composition of the product or ingredients or the misdescription of the way they have been obtained and/or prepared. The economical motivated adulteration of food in Europe has been estimated to have a repercussion of about € 8 to 12 billion per year (Spink, Elliott, et al. 2019; Spink, Bedard, et al. 2019; Grace 2019). The most cited categories in terms of food alteration are milk and dairy products, meat and its derivatives, fish and seafood, oils and fats, fruit juice, coffee and tea, alcoholic beverages, spices and extracts, sweeteners (such as honey), cereals and pulses, and organic foods (Hong et al. 2017; Bouzembrak et al. 2018).

3.1.1. Standards for food chain integrity

During the last decades, a few food frauds cases have drawn worldwide attention for their huge impact on human health. The most representative are the rapeseed oil (1981), which caused the death of more than 350 people in Spain; the presence in food of a dioxin (1999) in Belgium; the melamine-adulterated milk from which more than 50,000 babies were intoxicated and six died (2008); the methanol spike of spirits in Czech and Poland caused 59 casualties, similarly a liquor adulteration killed nine people and poisoned 51 between 2002 and 2004 in Norway; in 2013, beef products were found to contain horse meat throughout diverse European countries and finally, in 2017, fipronil was detected in eggs (Bouzembrak et al. 2018). In order to detect food fraud, different techniques may be applied depending on the use of targeted or non-targeted analyses. The first one has a narrower field of detection since a countable number of markers are considered. The second one allows the comparison of the suspected sample against a library, which contains the profile of historical samples. The detection of the fraudulent samples can be performed through different methodologies such as chromatography, mass spectrometry (MS), electrophoresis, spectroscopy or immunoassays. Nowadays, the most utilized ones are MS-based, including methods such as the nuclear magnetic resonance (NMR), liquid or gas chromatography (LC or GC, respectively); followed by DNA-based analyses, being the polymerase chain reaction (PCR) the main one (Ellis et al. 2016; Hong et al. 2017). However, the development of these analytical assays has evolved over the last two decades to become massive molecular-based tools. Currently, these modern omic techniques (genomic, proteomic, metabolomic, or isotopolomic) are applied individually or in combination, and the performance of different approaches to the data permit an accurate way to determine the authenticity of the sample to be achieved (Creydt and Fischer 2018).

3.1.1.1. Genomic. This group of DNA-based techniques consists of the analysis of the genome and allows the study of undesired adulterations at low concentrations. Classical methods such as PCR (in its wide varieties: real time PCR, multiplex-PCR, restriction fragment length polymorphisms-PCR (RFLP-PCR), microarray PCR, etc.) have been employed for the identification of different species, varieties, and geographical origin. Such as in the case of different milk producer species (cow, sheep, goat and buffalo). In fish products, diverse species were detected using PCR methods. Different kinds of meat such as processed, minced, and foie gras, among others, were analyzed by PCR-based techniques. These techniques were able to differentiate a huge number of species (beef, pork, chicken, turkey, duck, goose, pheasant, ostrich, lamb, horse, goat, dog, deer, rabbit, cat, kangaroo, deer pig, dog, cattle, goat, sheep, horse, chicken, deer, buffalo, turkey, etc.) and their geographical origins (Black, Chevallier, and Elliott 2016; Böhme et al. 2019; Hong et al. 2017; Ellis et al. 2016). However, further advances in this methodology has permitted the development of more specific, sensitive and efficient techniques such as next-generation sequencing (NGS), high resolution melting (HRM), droplet digital PCR (ddPCR), loop mediated isothermal amplification (LAMP) and DNA-barcoding. Following the trend of the application classical PCRs, the novel DNA-based technologies allow the determination of food fraud in meat, milk and dairy products, seafood, plants origin, oils, genetic modified organisms (GMOs), wines, etc. (Ellis et al. 2016; Böhme et al. 2019; Creydt and Fischer 2018).

3.1.1.2. Proteomic. The analysis of the proteins, peptides and their post-translational modifications is a very useful tool for the evaluation of the quality and authentication of food products. Different approaches and technologies are used for this purpose: two-dimensional gel electrophoresis (2-DE), matrix-assisted laser desorption/ionization time of flight (MALDI-TOF)-MS, LC–MS and high-resolution tandem MS (MS/MS) (Ellis et al. 2016; Böhme et al. 2019). Proteins may be analyzed as a whole unit, but they are usually treated with different enzymes to be reduced into peptides and further evaluated using MS or MS/MS that allow them to be sequenced, identified and quantified. The quantification of proteins or the peptide mass fingerprint (PMF) obtained after the enzymatic digestion of proteins allows the establishment of targeting ones that provide an identification tool for determining species or genera. Thus, proteomic techniques are commonly applied for the evaluation of food fraud in matrices such as fish, shellfish, meat, milk, and cheese (Cajka et al. 2016; Böhme et al. 2019; Hong et al. 2017).

3.1.1.3. Metabolomic. This technique represents the systematic study of low molecular weight compounds involved in the biological metabolism of living beings (Fraga-Corral et al. 2020). The identification and quantification of the metabolites may provide a full fingerprint of the organism or a profile of a specific group of metabolites or metabolic pathways. The complete evaluation of a metabolome requires the utilization of different techniques. The preferred options are GC/LC–MS and NMR. The most common techniques for obtaining metabolic fingerprinting profiles are Fourier transform infrared (FT-IR) and Raman spectroscopies. Independent of the selected approach, metabolomic assays generate huge amounts of data that need to be studied with bioinformatic chemometric tools (Ellis et al. 2016). Metabolomic analysis have been used for determining the country of origin of coffee, fish, shellfish or seafood; the presence of adulterants in herbs, spices, meat; the identification of melamine contamination in milk or the authentication in diverse products such as the Sicilian lemon variety, wine varieties, fruit juice composition, honey content or fish, shellfish and seafood (Cajka et al. 2016; Black, Chevallier, and Elliott 2016; Ellis et al. 2016; Hong et al. 2017).

3.1.1.4. Isotopolomic. This field analyzes the submolecular composition of food, it means it provides elements or isotopic profiles (isotopolome) that allow the geographical and organic origin of the products to be established. The elemental composition of vegetal and animal tissues permits the study of rare earth elements that are critical for determining their geographical origin. These analyses can be performed with inductively coupled plasma (ICP)-MS, ICP-atomic emission spectroscopy (AES), or multi-element and multi-isotope-ratio analysis with isotope-ratio mass spectrometry (IRMS) that detect elements and isotope ratios such as that of C, N, O, S and Sr which may result to be very useful for origin studies. The origin of milk and cheese, beef, sesame oil, tea, rise, wheat, etc. or the adulteration of different products such as wine, honey, fruit juice, maple sirup and organic products have been detected and identified with these methods (Creydt and Fischer 2018; Hong et al. 2017).

A drawback of these non-targeted techniques is that the information contained in databases is not always enough. They are standardized or the results are dependent of the instrument, and some specific conditions cannot always be replicated. However, in the case of MS where this issue is common, it is possible to develop an *in-silica* fragmentation which usually covers this gap (Creydt and Fischer 2018). In fact, these methods are mostly used for screening purposes, which reduces the number of samples to be tested by confirmatory ones (McGrath et al. 2018).

3.1.2. The potential of blockchain together with sensors in food traceability

A blockchain is a distributed ledger conformed of small dataset, named blocks that consist of encrypted and protected data and records of all transactions. These blocks can be shared with all the users involved which can be verified and, at the same time, protect its content and the privacy of the parties involved. To ensure this protection and privacy level, a computational intensive mathematical problem that is presented to the network requires a minimal number of miners connected to provide and verify the solution (Galvez, Mejuto, and Simal-Gandara 2018; Creydt and Fischer 2018). The application of the blockchain systems to the food systems field is a very useful tool since it permits the multiple and complex processes involved in the chain food from the producer to the consumer to be recorded. In order to track the origin and the pathway that food products follow, it is required to store data from different stages. In general terms, these stages comprise the production (agricultural activities developed at the farm and farmer work protocols, such as fertilizers classes), processing (transformation of the primary product and if it applies, the packaging step also), storage, distribution (delivery conditions), retailing, administration requirements (such as at routine inspections at border ports) and consumption (consumer can provide feedback or require all the traceable information) (Kamilaris, Fonts, and Prenafeta-Boldύ 2019; Galvez, Mejuto, and Simal-Gandara 2018). The most widely used blockchain devices used in food sectors are barcodes, such as quick response (QR) codes, associated to different identification and wireless systems such as radio frequency identification

(RFID), near field communication (NFC) or Bluetooth (Azzi, Chamoun, and Sokhn 2019; Creydt and Fischer 2019; Kamilaris, Fonts, and Prenafeta-Boldύ 2019).

The Ambrosus network tracks the products along the full cycle using different tags, tracers and sensors that send notifications to the blockchain when necessary. The variability of tracking components is based on the diverse nature of the products. For example, the cycle life of fish products requires the application of a smart gel to the fish skin that detects fraudulent manipulations; the container is sealed with a sensor that ensures its integrity. Another two sensors control the temperature and the geoposition, and it can be completed with a charge-coupled device camera. The data collected by all the sensors are linked to a QR code that by using RFID, can send data to the microcontroller directly connected to the blockchain where the data gets verified and saved. After this complex process, the customer can have access to the data of the full life cycle of the product by an application programming interface (Azzi, Chamoun, and Sokhn 2019).

In the Modum network, shipment control is established by an application, a SensorTag and a NFC plate. Standard criteria are determined and registered in the web/mobile app. The SensorTag measures the environmental conditions, mostly temperature and humidity, along the shipment and share the data with the application. This sensor is associated with a unique QR code which allows the access to the information of the cold chain from the departure to the destination of the product (Azzi, Chamoun, and Sokhn 2019).

3.2. Unbalance and unsustainable diets

Nowadays, more than 820 million people do not have access to sufficient food amounts while an uncountable number of people have diet habits characterized by micronutrient deficiencies that are related to the increase of nutritional pathologies such as obesity, coronary heart disease, stroke or diabetes. Low-quality diets have been described to induce more risk of morbidity and mortality than unsafe sex, or the combined consumption of alcohol, drug and tobacco. Besides, the current diet models are negatively pressing terrestrial, aerial and aquatic ecosystems and are expected to become stronger with the estimated rise of population up to 10 billion people. Therefore, it is required to globally remodel the dietary patterns and the nutrition education in order to improve and protect human health and environment (Willett et al. 2019).

3.2.1. Education on healthy and sustainable food habits

The World Health Organization (WHO) has established that a healthy diet protects against all malnutrition diseases, and it recognizes the importance of practicing it from very early life stages starting with breastfeeding. The current nutrition model is characterized by the excessive consumption of processed and high energy foods for their elevated content in fat, sugar and salt. In general terms, the WHO has established that energy expenditure and energy intake must be balanced. Besides, the energetic profile should be characterized for containing less than a 10% of free sugar (even though less than 5% is suggested to provide additional health benefits), less than 5 g/day of salt, and less than a 30% of fat from which saturated ones should represent less than 10% , and industrially-produced trans-fats less than 1%. Instead, at least 400 g of fruits, vegetables, legumes, nuts and whole grains (starchy roots such as potatoes being excluded from this list) should be daily consumed avoiding the excessive intake of animal proteins, especially red meats and refined products. The definition of sustainable diet has been provided by FAO as "those with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (WHO 2019).

The goal for the next following years is to perform a change in dietary behaviors by shifting them into healthy ones which is expected to avoid around 11 million deaths yearly. In order to reach this global change, many studies have been performed to understand what are the key factors that intervene in the widely spread exacerbated consume of high energy diets. Mostly, the socioeconomic status (SES) seems to be related with the quality of the diet. Generally, groups with low socio-economic status have been described to have a poorer diet mainly due to the high cost of health products (and cheaper processed ones) and scarcity of nutritional knowledge. In fact, it has been demonstrated that the cost of the products has a stronger effect on shifting choices than the logo and/or label (Hoek et al. 2017). A low SES is usually associated with diets rich in fat, sugar, and salt and a lower intake of fruits and vegetables. Contrary, those with higher SES, they have been estimated to have an additional intake of fruit of nearly 29 g/person/day and about 15 g/person/day for vegetables (de Ridder et al. 2017; Irala-Estévez et al. 2000; Michels et al. 2018; Desbouys et al. 2020; Yannakoulia et al. 2016; Prebil 1983; Pinket et al. 2016). Other factors such as the culture and culinary traditions have a strong influence on the diet design. A study has demonstrated that migrants in high-income countries have plant-based diets that imply a greater consumption of fruits and vegetables even though they also have high rates of sugary sweetened beverages and energy-dense foods consumption (Desbouys et al. 2020). Significant differences can be observed in the diet pattern of different nationalities, for example in Indonesia, Mexico, India, China, and West Africa. They eat very little amounts of red meat, and some of them traditionally consume legumes, some have low consumption levels of dairy products, while others consume about 100 g/day of nuts such as in Niger or around 46 g/day of soy foods in Taiwan (Willett et al. 2019). Therefore, it is important to know the culture of origin in order to apply effective shifts in food behaviors (Carrus, Pirchio, and Mastandrea 2018; Willett et al. 2019; Desbouys et al. 2020). Besides, family influences, educational programs such as school meals, or eating environment seem to have an important role in the future diet pattern of children and adolescents (Benedetti, Laureti, and Secondi 2018; Oostindjer et al. 2017). Based on the impact that these factors have on the diet education of the different age ranges they can be modulated to remodel their behaviors and promote the selection of a healthy diet. In the same way, this healthy model should imply a sustainable pattern in order to meet the goal established for 2050 to reduce, recycle and improve the efficiency of fertilizes, to maximize the use of natural resources, to minimize the emission of GHG, to implement the circular economy in agricultural systems and to shift production priorities. Therefore, the complexity of this scheme requires the effort of multiple actors: stakeholders, individual consumers, policy makers, etc. (Willett et al. 2019).

3.2.2. Functional foods

Functional foods are defined as those that besides having nutritional properties and consumed in normal rates, they may have a potential positive effect on health by contributing to restore it, enhancing some function and/or reducing the risk of appearance of non-communicable diseases. In the recent years, the growing interest for functional foods in academia has been shown by the increasing number of scientific books, chapters and articles (Granato, Sávio Nunes, and Barba 2017; Doyon and Labrecque 2008). Many studies have been focused on recovering biomolecules from very different origins such as micro- and macroalgae, plants, herbs, nuts, mushrooms, animal tissues, and, even from food industry by-products (Arya, Salve, and Chauhan 2016; Lafarga and Hayes 2014; Giavasis 2014; Wells et al. 2017; Bharat Helkar and Sahoo 2016; Granato, Sávio Nunes, and Barba 2017). The bioactivities of the extracted molecules are usually well-characterized, such as in the case of some polyunsaturated fatty acids (PUFAs) like the omega-3 ones (Nigam, Yadav, and Tiwari 2018). However, some other compounds belonging to very extensive families, such as the polyphenols, which requires to be chemically identified and, even, biologically evaluated as it happens with the phlorotannins (Murray et al. 2018). Once the function of the biomolecules has been fully studied, these recovered compounds may be added to a food matrix in order to fortify it and provide it functional properties. In fact, nowadays many products present in the market and classified as functional are fortified foods such as infant formula, which contains additional ingredients to provide all the required nutrients, milk enriched with vitamin D or PUFAs among others, yogurts with proteins or phenols, fruit juices differently enriched, etc. (Betoret et al. 2011; Doyon and Labrecque 2008). In order to fortify products, different techniques may be applied, such as vacuum impregnation or microencapsulation, which allows isolating molecules or even cells in a capsule and avoids the biochemical degradation (oxidation, hydrolysis, etc.) that they would suffer in its absence (Betoret et al. 2011).

3.2.3. 3D printing to produce new food with subproducts

3D printing, also called additive manufacturing, is an emerging technology with great potential to fabricate 3D constructs with complex geometries, elaborated textures and custom-made characteristics (Godoi, Prakash, and Bhandari 2016). 3D printing allows to customize food, including shape, color, flavor, texture, and even nutritional values. Food products can be designed and fabricated to meet individual needs through controlling the amount of printing material and nutrition content. The food materials such as sugar, chocolate and cheese are used to create designed shape based on layer-by-layer (Sun et al. 2015). Food designs, personalized nutrition, sweet products, military and space food are several applications of this technology (Liu et al. 2017).

The main challenges of this technique are precision and accuracy of printing, process productivity and production of colorful products, multiple flavors and multiple structures (Liu et al. 2017). The structures obtained so far are simple and repetitive, which has allowed the elaboration of personalized chocolates or simple homogenous snacks, those of which need more development (Sun et al. 2015). Increasing numbers of novel food formulations with intricate and attractive shapes are being developed (Yang, Zhang, and Bhandari 2017). These printers may be a useful tool to achieve sustainable food systems, due to their capacity to elaborate new ingredients, prepare food to order and even collaborate with doctors to develop healthier diets (Sun et al. 2015).

4. Conclusions

In this article, a diagnosis of the challenges and problems facing the current food system to ensure the subsistence of a growing world population has been performed. The first challenge is to increase production and at the same time, to introduce major transformations to obtain a sustainable food system, whose central strategy is to improve the efficiency of resource use. Parallel, it is necessary to reduce the global FLW. Finally, global diets should evolve to healthier and sustainable diets. Regarding the problems associated with the current food production and consumption, numerous solutions have been described, which would involve economic, social and environmental changes. Destruction of land ecosystems, GHG emissions or overfishing are just a few examples of problems that threat food production, against which solutions such as agroecology, genetic engineering or improvement of aquaculture production have been proposed. In general, several studies have reported that these solutions present positive effects and could be suitable strategies to try to achieve more sustainable food systems. However, the application of these solutions must be accompanied by policies and more investment, to achieve realistic results. On the other hand, food fraud and unbalance and unsustainable diets are the major problems of food consumption, whose solution will entail the development of traceability technologies and favor a global dietary change. Although this change involves great difficulty, it is estimated that it could considerably reduce environmental degradation. In conclusions, the solutions proposed would have a positive effect on the food chain, but it is important to point out that these measures should be accompanied by greater investments for technological development and legislative measures.

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No potential conflict of interest was reported by the authors.

Abbreviations Generic

EC	European Commission
EFSA	European Food Safety Authority
FAO	Food and Agricultural Organization of United Nations
FLW	Food loss and waste
GHG	Greenhouse gasses
NOAA	National Oceanic and Atmospheric Administration
SES	Socioeconomic status
UN	United Nations

Compounds

CH_4	Methane
PUFAs	Polyunsaturated fatty acids

Analytical techniques & Technologies

2-DE	Two-dimensional gel electrophoresis
AES	Atomic emission spectroscopy
ddPCR	Droplet digital PCR
FT-IR	Fourier transform infrared
GC	Gas chromatography
GMOs	Genetic modified organisms
HRM	High resolution melting
ICP	Inductively coupled plasma
IRMS	Isotope-ratio mass spectrometry
LAMP	Loop mediated isothermal amplification
LC	Liquid chromatography
MALDI-TOF	Matrix-assisted laser desorption/ionization time of flight
MS	Mass spectrometry
MS/MS	Tandem mass spectrometry
NFC	Near field communication
NGS	Next-generation sequencing
NMR	Nuclear magnetic resonance
PCR	Polymerase chain reaction
QR	Quick response
RFID	Radio frequency identification
RFLP-PCR	Restriction fragment length polymorphisms-PCR

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