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Food Sustainability Challenges in the Developing World

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SUMMARY

This chapter highlights some of the current issues and topics of concern facing the agriculture and food sustainability sectors. Special emphasis is placed on the various challenges facing low- and medium-income countries. Some of the major obstacles to sustainability and the factors affecting it are examined, as are novel approaches to the management strategies employed for various issues in agriculture (e.g. biodiversity, agricultural development, pests/rodents, organic farming, livestock, poultry and aquaculture) and food security (e.g. poverty, hidden hunger and diseases, stability of food supply and access to safe, high-quality food, food diversification, dietary health supplements, food wastage, food safety and challenges in the food industry).

1.1 Introduction

In a global context, 'sustainability' has been defined as '*the ability to accomplish the needs of our present generation by ensuring that the desires of the future generation remain uncompromised*'. According to Asheim (1994), sustainability is expressed as a requirement of the present generation to manage its resources in such a way that the current average quality of life can potentially be enjoyed by all future generations. Sustainability is from the Latin (*sustinere*) and means to 'hold up', 'support' or 'maintain.' However, according to Phillis and Andriantiatsaholiniaina (2001), sustainability is very difficult to define or to be measured as it is an ambiguous and complex concept about which there is no consensus as to its definition or on how it is to be measured. And so Phillis and Andriantiatsaholiniaina developed the Sustainability Assessment by Fuzzy Evaluation model, which provided a reliable mechanism to measure sustainability development that considers both ecological and human inputs.

Before we look at sustainability issues in any depth and the various challenges the world is facing now, a few basic questions need to be answered. For example: Why sustainability? Does sustainability matter? If it does matter, then to whom? Why do we

need to be concerned about the agrofood sector? Well, the answer to all these questions is simple: *there is only one earth where rich biodiversity and life exists, and hence sustainability matters!* The majority of the world's population, it seems, including expert researchers, believes that sustainability is just about ecology and going green. However, technically, sustainability goes beyond this. Indeed, what does 'agriculture sustainability' and 'food sustainability' mean precisely? Are there any appropriate definitions available? What is the link between these two concepts? This chapter focuses on current sustainability issues and the trends and challenges facing the agrofood sector, especially in the developing regions of the world.

1.2 Agriculture and the Food Sustainability Sector

According to the Food and Agriculture Organization of the United Nations (FAO), '*Sustainable agriculture needs to nurture healthy ecosystems and support the sustainable management of land, water and natural resources, while ensuring world food security.*' Besides, it has been clearly stated (FAO 2015a) that sustainable agriculture should encompass a global governance system which can respond to the various issues of food security (e.g. trade regime, trade policies and agricultural policies) in order to promote agricultural marketing locally and regionally. When agriculture is of concern, sustainability is referred to as a complete system involved in producing high-quality and safe agrofood products that also takes care of the social and economic conditions of farmers, as well as that of the surrounding environment.

Theoretically, sustainable agriculture symbolizes a system that integrates socio-economic equity with that of economic success and environmental health. The concept of agricultural sustainability is presented effectively by Corwin *et al.* (1999), who stated that this is about finding the elusive balance between maximizing crop productivity while minimizing destructive effects on the environment and sustaining the economic stability of the whole system. Several novel methods have been proposed and reviewed with regard to agricultural sustainability, all of which concentrate on sustainability indicators, including considering socio-economic and environmental issues (Binder *et al.* 2010; Rao and Rogers 2006; Roy and Chan 2012; Speelman *et al.* 2006). And yet an agricultural system that aims at sustainability can also have a negative impact. In many developing countries, the inappropriate sharing of knowledge on technological innovations and engineering, and mistimed practical applications of the new techniques, have had a devastating effect on the natural flora and fauna of the agriculture region. Today's modern agricultural practices have added to global warming (e.g. deforestation to grow crops as well as to raise livestock), climatic changes, increased greenhouse gases (e.g. methane released from agriculture farms and nitrous oxide from fertilizers) and polluted water and soil (e.g. run-off water from fields nourished with fertilizers and organic manure). The scarcity of natural water resources and the depletion of ground-water resources have tremendously increased in recent years, owing to human intervention (Hoekstra 2015; Pfeiffer 2006). In fact, stress has been laid on the importance of rain-dependent agriculture in order to improve global food security and assure environmental sustainability (Bastos *et al.* 2013; Yang *et al.* 2006). Approximately 85% of the natural water resource in developing countries is used for irrigation (IAASTD 2008). The importance and threats of cultural eutrophication, acidification of fresh water,

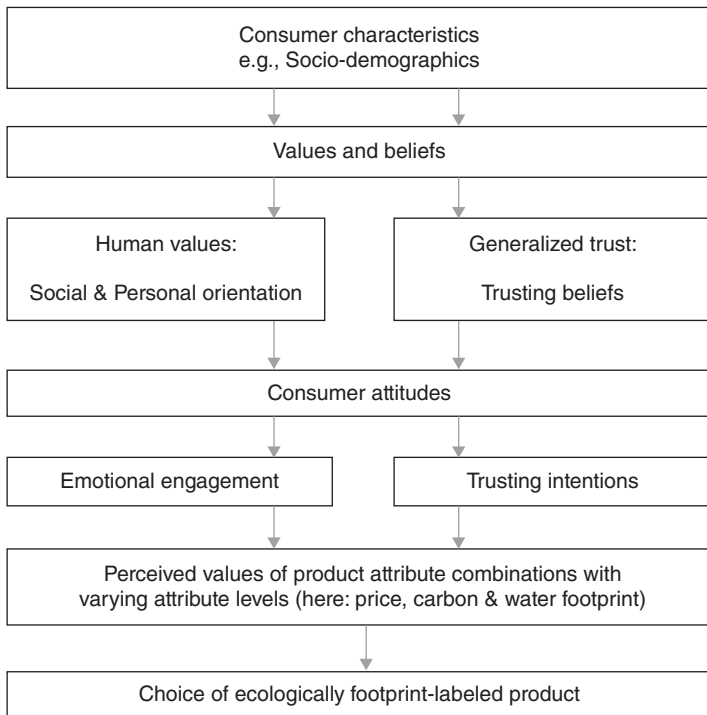


Figure 1.1 Conceptual model. *Source:* Grebitus *et al.* 2015. Reproduced with permission of Elsevier.

depletion of natural resources or biodiversity and emerging respiratory diseases (owing to elevated levels of nitrate concentrations in the water as well as in the air) have been identified by the European Nitrogen Assessment forum (Sutton *et al.* 2011). Added to this, natural disasters can have serious implications for the agriculture system as a whole. According to Misselhorn *et al.* (2012), almost one billion people experience famine or suffer from malnutrition in the world today. Developing an ecological and agriculture/food footprint as well as a water footprint for an individual region/country is very important to overcome recurring issues. In Figure 1.1, a conceptual model based on the concepts of ecological footprints, trust and human values is depicted.

Further, when it comes to food sustainability, can ‘food sustainability’ or ‘sustainable foods’ be segregated from ‘agriculture sustainability’ or are they interdependent concepts? From a broader perspective, food sustainability encompasses a wide array of multidisciplinary themes, which can have an extensive paradigm (development and implementation of novel concepts, hypotheses, policies, theories and ideas, etc.) relevant to the socio-economic state of affairs of the agro-ecological food sector. Food sustainability is linked to ensuring food security (quality and safety, overcoming hidden hunger, population explosion and poverty, food loss/wastage, food governance and food crisis, food trade, etc.) as well as attaining successful sustainable food production. Food sustainability relies on ensuring nutritional security without foregoing the long-term health of the surrounding ecosystem and the vital cultural scenario providing the basic food needs. Further, according to the FAO, and as outlined by the Panel of Experts on

food security and nutrition ‘a sustainable food system is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised’ (FAO 2016). Hence, ultimately, is it ‘sustainable foods’, ‘sustaining the foods’ or ‘sustainable food production’ that we need to refer to?

The success of sustainability in any region or country depends directly on the linkages between food, energy and water (Bhat 2015). Hence, it is vital to assure these three components go hand-in-hand. Moreover, population increase, food scarcity, scarcity of fertile agricultural land, recurring environmental issues (mainly climate change) and high levels of economic instability can be the major challenges to be overcome in low- or medium-income countries. For the majority of developing countries (or rather low- and medium-income groups of countries), sustainable production and the sustainable consumption of food is vital to fulfil the ever-growing demands of local populations without depleting natural resources or causing any ill effects on human health (Bhat 2015; Pretty 2008; Verain *et al.* 2015).

Further, when a ‘sustainable agrofood system’ is referred to, it indicates a consolidation of crops and livestock production and effective land use, and includes the overall well-being of farmers, animals, consumers and environmental health. Van Wijk (2014) has developed an excellent overview of land use and food production on a global basis (Figure 1.2).

Today, the major emerging challenging themes in the agrofood sustainability sector are global climatic changes, global loss in biodiversity, global food security issues, global food health and global water crisis, trailed by the issues of desertification and the depletion of marine flora and fauna. In addition, disaster risk management and mitigation and issues related to trade, human rights and labour are of highest concern. Recently witnessed disasters in the environment include natural disasters, namely floods or famine (in some Asian countries), haze and burning of crop waste in agricultural fields

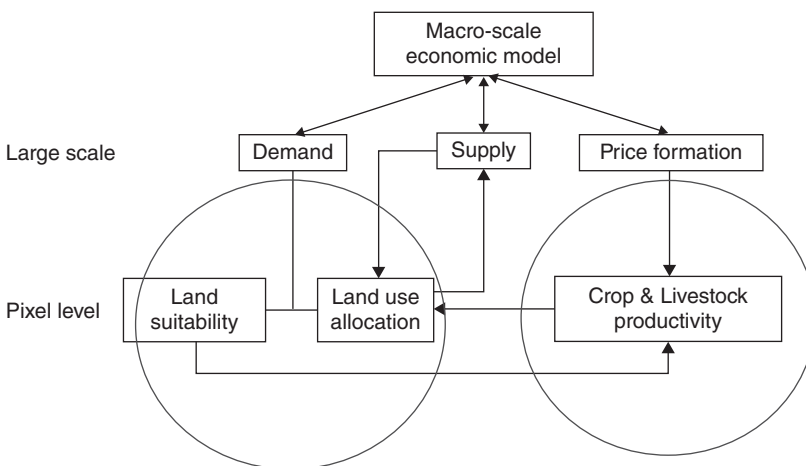


Figure 1.2 Generic structure of large-scale economic impact assessment tools. The circles indicate the entry points where incorporating information from small-scale, bottom-up approaches can improve model reliability. *Source:* van Wijk, M. T. (2014). Reproduced with permission of Elsevier.

(e.g. those recently witnessed in the oil palm plantations of Indonesia/Malaysia), nuclear leaks in Japan and snow disasters in Mongolia, to name just a few. Besides these, changes to traditional farming methods, new plant diseases and resistant pathogens and new field vectors are also causing problems in the agrofood sector. In the majority of low- and medium-income countries, the rise in unemployment, changing economic policies, globalization and/or trade liberalization, a lack of appropriate marketing strategies for farmers coupled with unstable governance have become the major contributing factors to instability. Also, movement of family-based farmers from rural to urban regions is on the rise, especially in developing countries (Bhat 2015). So how can we overcome these incurring problems? The international task force set up for managing these crises includes experts coming from leading organizations such as the FAO, the World Health Organization (WHO) and other local governmental and non-governmental organizations, who all have played a pivotal role. However, it is imperative that local populations also play a role in identifying the richness of their region and how sustainability principles can be applied to benefit them. Further, encouraging family farms, buying local produce or foods (and preferably seasonal foods) can all help to achieve self-sufficiency and ensure sustainability (Bhat 2015; Graeub *et al.* 2015; Medina *et al.* 2015; van Vliet *et al.* 2015).

1.2.1 Biodiversity and Agriculture

Irrespective of the region and agricultural practices involved, there is an interdependent link between an agriculture system, biodiversity and agro-ecosystem services (a system which imparts direct or indirect benefits to humans). This linkage is of immense help to predict changes in weather conditions and the surrounding environment (Altieri 1999; Bårberi *et al.* 2010; Bengtsson 1998; Power 2010). When it comes to minimizing the damage done to biodiversity, it has been opined that limiting various human necessities from land use as well as integrating the conservation ideas and policies affecting a food system will be the vital factors in restricting the impact on biodiversity, and thus enhancing global food production (Phalan *et al.* 2011). However, globally, certain recurring sustainability challenges in the agriculture sector include environmental change (pollution, climatic changes, water scarcity, etc.), lack of space, decline in the profit or the margin gained in growing traditional food crops, overdependence on landraces (local variety/local crop cultivars), genetic or hybrid varieties, monoculture production and gaps in identifying potential drivers of productive crop diversification. In some developing countries, the monoculture system of farming remains popular. Nevertheless, how far this system can be productive and how new approaches can be adopted for improvement needs to be evaluated.

In the US alone, it has been reported that some ecosystem services – such as pollination, pest control and water storage practices – have contributed tremendously to the increase in crop production resilience (Daily 1997; Losey and Vaughan 2006; Lovell 2010). Besides, urban agriculture (including domestic gardening that cultivates spice plants, vegetables or fruit-yielding trees and involves the domestication of poultry, cow or goat rearing, etc.) is also expected to gain importance and be profitable in the coming years (Lovell 2010). In fact, in a majority of countries, rainwater harvesting, afforestation and mixed cropping systems have all yielded good results and have contributed substantially to the success of agrofood sustainability. In certain cases, in some of the

tropical regions, increases in agricultural biodiversity (e.g. the use of non-timber forest products) have been recommended as a way of minimizing natural resource degradation as well as an effective way of tackling poverty in rural areas (Vadez *et al.* 2004). Agro-forestry and the practice of apiculture (beekeeping) for producing highly prized honey in plantations (e.g. in coffee or tea plantations) have also been a success in the majority of developing countries. It has been opined that various strategies put forth towards bio-diversification in a region should first target staple food production, followed by the implementation of various marketing policies to enhance food security (Delgado 1995). So how about new genetically modified (GM) food crops, which have been suggested as an answer for the 'green revolution'? The challenges to the acceptability of biotechnology still remain in the majority of countries. Will the 'gene revolution' be an answer to the 'green revolution'? Only time will tell.

In contrast, in the majority of the developing regions (low- or middle-income countries), there is a lack of dissemination of up-to-date information among the local communities or the farmers involved in agriculture practices, which can be a hindrance to achieving sustainability. Nevertheless, disseminating knowledge of crop diversity among community leaders and heads of households in rural areas has led to a growth of crop diversity in those regions (Bottazzi *et al.* 2014). Also, designing appropriate commodity-based crop development programmes (e.g. growing crops for food sovereignty) in rural regions can also be of immense benefit.

1.2.2 Agricultural Development

Some of the challenges facing the agricultural development sector include increasing crop productivity, encouraging green farming, overcoming competition from local market unions, strengthening links with other sectors and designing and maintaining a timeline for the implementation of new policies (both locally and regionally). Further, when it comes to sustainable energy, it is vital that a holistic approach be adopted for the efficient tapping of bio-energy for land rehabilitation and for the effective utilization of biomass or agro-wastes for generating energy. And climate change mitigation also has to be kept in mind. Use of renewable energy technologies – such as hydropower, solar power (solar energy) or wind power (wind energy) in agriculture fields – can reap enormous benefits for farmers (Baruah 1995; Frey and Linke 2002; Resch *et al.* 2008; Omer 2008). Application of biofuel systems in small-scale organic farms is reported to positively affect food production (Johansson *et al.* 2014).

Further, when development in the agriculture sector is concerned, it is worth considering the effects on human health (maternal and child health), wherein modern agricultural practices are reported to contribute to poor health conditions and the occurrence of infectious and chronic diseases, mainly caused by the extensive use of pesticides (e.g. various risks associated with occupational health), human and livestock diseases, etc. (Kataki and Babu 2002; Lipton and de Kadt 1988; Nugent 2004). Additionally, success of agricultural development relies on encouraging agricultural practices with less dependence on rain, adopting rainwater harvesting, limiting the degradation of natural water resources, using drought-resistant crop varieties, soil conservation, rotational grazing, enhancing agriculture productivity by employing modern technologically versatile irrigation facilities, etc. Reports are available on the importance of virtual water trade and water scarcity linked with food security. These reports have highlighted some of the

challenges faced when developing international policies to deal with sustainability and food security (Hoekstra and Hung 2005; Oki and Kanae 2004; Yang *et al.* 2003, 2006). Besides, recurring problems of microbial pathogens affecting food crops during pre-harvest (agriculture fields) or post-harvest stages, as well as pests and vectors problems, need to be managed effectively for agricultural development.

Apart from the above-mentioned norms, appropriate care should be taken to understand and work towards some of the trade-related issues and policies, for example trade agreements proposed by the North American Free Trade Agreement (NAFTA), the European Union (EU), the ASEAN Economic Community (AEC) and that between Canada and the EU (CETA), etc. Above all, human rights and labour-related issues, child labour, farmer suicide owing to debts (e.g. in some states in India) need to be sorted out regionally with the help of local governments, NGOs and other reliable international organizations.

The way ahead rests mainly on freezing the agriculture footprint, which can be achieved by avoiding deforestation, preventing the conversion of agriculture lands for urban development, enhancing farm productivity through using natural resources, more competent use of natural fertilizers and adopting organic farming, etc. Above all, the promotion and development of a sustainable agriculture system should focus on individual regional conditions based on the adaptation and cultivation system which can establish and syndicate productivity with sustainability. For this, some of the facts that need to be carefully considered include: inter-cropping systems, replacing the mono-crop culture system, crop rotation, cover crops and the use of local organic manures, using disease- and pest-resistant plant stocks, employing various bio-fumigation techniques and adopting all available farmer-friendly techniques.

1.2.3 Agriculture: Pests and Rodents

Pests and rodents have been a part of the agriculture system in the majority of the world's agricultural fields. In fact, the damage caused by rodents in the agricultural field (e.g. mice, rats and voles) is substantial and can greatly risk food security in a region. Moreover, on a global scale, it has been stated that damages incurred during pre-harvest (on structural damage to plants) and post-harvest stages (during storage) can contribute significantly to malnourishment and reduced food security (Belmain *et al.* 2015; Brown *et al.* 2008, 2013; Meerburg *et al.* 2009; Oerke 2006). Besides, individuals working in the farming sector can also get infected, as rodents in the fields can be carriers of human pathogens and this can lead to various disease transmissions (such as arena viruses, murine typhus, leptospirosis, etc.) (Bausch and Mills 2014; Meerburg *et al.* 2009). Here, sustainability could get a severe setback, especially in those regions/counties whose economies are wholly agrarian-based. Hence, proposing appropriate measures for rodent control using biological methods, using safer rodenticides, employing an integrated approach to designing appropriate trapping systems, planting trap crops, understanding the life history and damaging seasons can all be of practical help. However, use of chemical fertilizers needs to be limited. In addition, monitoring crop harvest loss incurred by rodents is a necessity for food security. Around the world, researchers are exploring various mechanisms for developing host plants' and crops' resistance to pests. The use of biocontrol agents and the adoption of integrated pest

management (IPM) strategies have been success stories (Brunner 2014; Kloosterman and Mager 2014; Lazarovits *et al.* 2014; Trematerra 2013).

Apart from the rodents, plant parasitic nematodes can also have huge economic losses and can affect agrofood security (Auwal Hassan *et al.* 2013; Becker 2014; Sasser and Freckman 1987). Hence, overcoming this problem shouldn't be neglected.

1.2.4 Agriculture and Organic Farming

Many people associate or confuse the term 'organic agriculture system' with 'sustainable agriculture system.' Even some researchers suggest organic farming to be comparable with green farming or as a sustainable agriculture system (Henning *et al.* 1991; York 1991).

So why is there a need for organic farming? Today, there is much criticism and public concern about the extensive use of chemical fertilizers and the presence of their residues, which has led to a focus on organic farming. Various types of chemicals used in farms not only are expensive but also have wide implications for the environment, animal and human health and food quality and safety when they enter the food chain (Altieri 1999; Dorne and Fink-Gremmels 2013). Organic agriculture influences the impact of the nitrogen cycle, as chemical fertilizers are not used. Further, organic farming can provide the required control strategies for the certification process along the entire production chain (Castellini *et al.* 2006). Moreover, it is a well-accepted fact that crop rotation using leguminous cover crops can be highly effective and can fix adequate amounts of nitrogen in the soil from the atmosphere. An overview of an organic and a conventional production system is provided by Nakajima and Ortega (2015). It highlights various components involved in the system (Figure 1.3 and Figure 1.4). Researchers

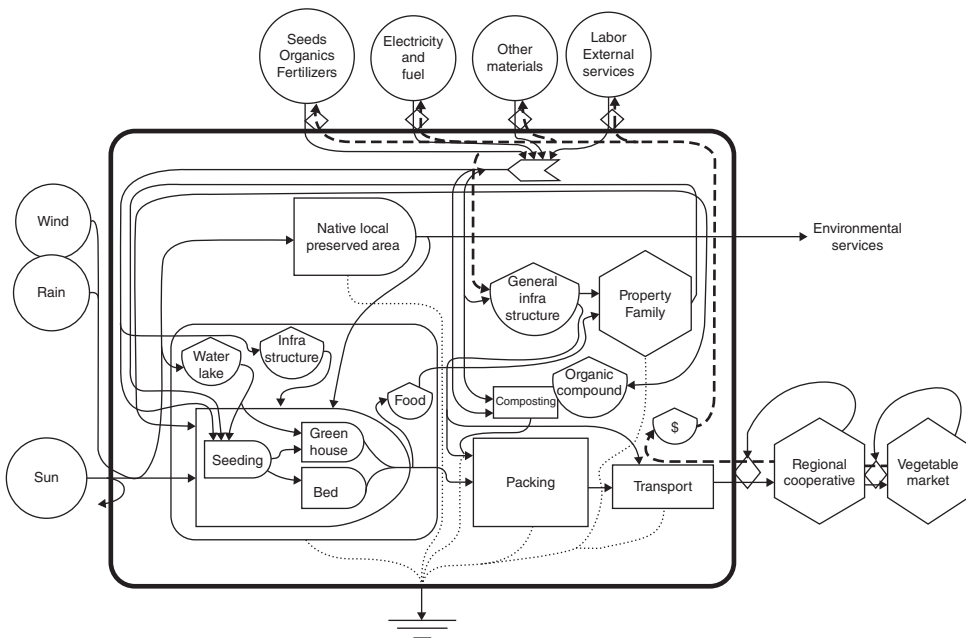


Figure 1.3 Organic production diagram. *Source:* Nakajima, E. S. and Ortega, E. 2015. Reproduced with permission of Elsevier.

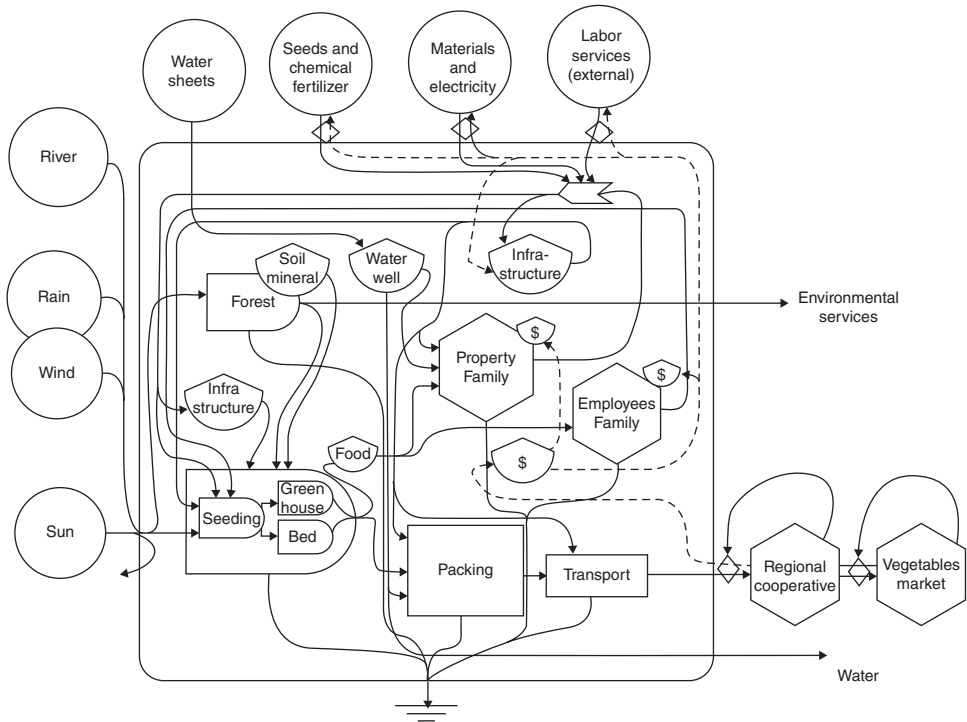


Figure 1.4 Conventional production diagram. *Source:* Nakajima, E. S. and Ortega. E. 2015. Reproduced with permission of Elsevier.

have evaluated the cost-effectiveness of organically grown products and have concluded that the price of organic food products is much higher than their normal market value (Cavigelli *et al.* 2009; Pimentel *et al.* 2005). Besides, studies of the environmental impacts of conventional farming versus organic farming have shown that energy-related emissions as well as greenhouse gas emissions are comparatively much higher in organic farms (Bos *et al.* 2014; Wood *et al.* 2006). Today, with the economic success of the organic farming sector, there is also an enhanced risk of conventionalization of various practices involved in organic food production (Darnhofer *et al.* 2010). However, an overall evaluation concerning agricultural sustainability and food security versus organic food production needs to visualize whether the final yield obtained/produced via organic farming can fulfil the needs of the world's population.

Overall, for organic farming to become a successful sustainable method, appropriate care should be taken to control microbial diseases, pests, vectors and weeds in farms, as no chemicals are used. So developing an effective evaluation method (or protocols) to maintain the production costs when compared to conventional production costs is also a prerequisite for the organic farming sector.

1.2.5 Livestock, Poultry and Aquaculture

Livestock (ruminants) have played a pivotal role in human life. Since time immemorial, domestic animals have been used in a sustainable way: they were used to graze on

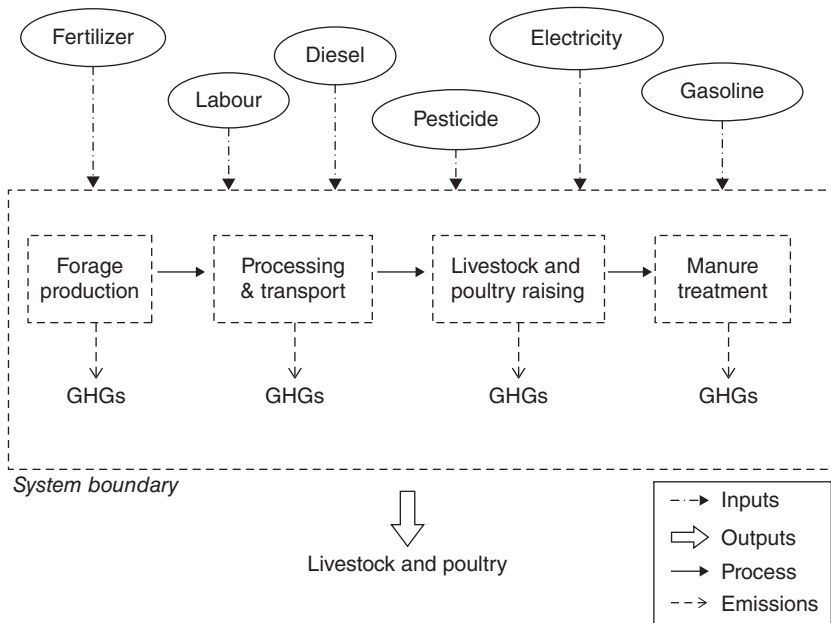


Figure 1.5 Schematic of livestock and poultry production showing major inputs and outputs relevant to greenhouse gas (GHG) emissions. *Source:* Luo *et al.* 2015. Reproduced with permission of Elsevier.

wasteland, their dung (waste) being used as natural organic manure as well as for the production of biogas, and their milk and meat being used for consumption. The importance and the role of livestock for achieving sustainability and ensuring food security is discussed in many excellent reports (Baudron *et al.* 2015; Franzluebbers *et al.* 2014; Gerber *et al.* 2014; McKune *et al.* 2015; Nardone *et al.* 2010; Schiere *et al.* 2002; Scholten *et al.* 2013). On the other hand, many reports are also available on ensuring sustainability along the poultry chain (e.g. such as those of producing electricity from poultry manure, using the emergy approach, egg production, etc.) (Billen *et al.* 2015; Castellini *et al.* 2006, 2012; Van Asselt *et al.* 2015). Luo *et al.* (2015) provide a schematic representation of the livestock and poultry production chain highlighting significant contributions (input and output) pertinent to the emission of greenhouse gases (Figure 1.5).

Further, reports are also available on sustainable aquaculture (from environmental issues to the agrofood sector) (Beveridge *et al.* 1997; Chopin *et al.* 2001; Huntington and Hasan 2009; Iizuka and Katz 2015; Robinson and Lovatelli 2015; Sfez *et al.* 2015). However, for achieving a successful sustainability forum, there are still plenty of issues to be sorted out. Some of these include: the need to overcome diseases of concern (e.g. foot and mouth disease, Newcastle disease, avian influenza, other viral diseases), antibiotic abuse and resistant microbes, the never-ending competition for food/feed, issues of water pollution, contaminant and residues in feed, adulteration and other safety issues... the list goes on.

1.3 Food Security and the Developing World

Agriculture has been a mainstream economic backbone in the majority of countries since the beginning of human civilization. On the whole, agriculture includes the cultivation of food crops for human consumption and for livestock feed. Besides this, water management, agro-forestry, horticulture, the rearing of animals for useful products and fisheries can also form a part of the agriculture system. Agriculture can be designated as an age-old industry that contributes almost 7% to global GDP. Each region or country has its own biodiversity (flora and fauna), diverse climates and diversified farming practices. Besides, agriculture and farming methods adopted can also be a reflection of a rich regional history, heritage and culture.

Food insecurity is an indication of failure to gain access to good quality or adequate amounts of food in a household, in a socially acceptable manner (Caraher and Coveney 2004; Dowler 2001). Overcoming the challenges of population explosion, feeding poor people, reducing poverty, finding a final irreversible solution for malnutrition and 'hidden hunger' issues and adopting tailored marketing strategies can all be a part of dealing with the issue of food security. Food security can directly influence sustainable food production – and is technically defined as achieving self-sufficiency as well as having free access to food to satisfy the needs of the common man (Risku-Norja and Muukka 2013). Conversely, household food security is more about availability, affordability and access to quality foods (Maxwell 1996). Food security signifies a situation wherein a population has access at all times to safer, wholesome and high-quality food that meets their daily dietary needs (Riches 2002). According to Siamwalla and Valdes (1994), food security can be termed the capacity of an individual household, region or country to meet the levels of its projected food consumption.

Further, the prerequisite to adapt to rapid climatic changes emphasizes the need for the cultivation of natural plant breeding and disease-resistant food crops (rather than exploring alternatives for GM crops). On the whole, food security depends on the competence of food supply in terms of nutrition, wholesomeness, safety, quality and cultural concerns. Finding appropriate solutions to produce foods which are not dependent on fossil fuels is essential. As such, it is opined that to ensure food security it is vital that a food system be resilient and must not be a burden to the changes in the environment in a global context. Hence, the effect of agriculture on carbon and nitrogen cycles should be minimal (Johansson *et al.* 2013). Indeed, extensive degradation of soil has been observed, which is caused by rigorous farming/cultivation, over-grazing and widespread deforestation and this also affects food security (Gao and Liu 2010). In fact, the success of sustainability in an agrofood system depends on its carbon footprint (Gelaw *et al.* 2014).

Besides, various food scandals (e.g. plastic rice, chemical-based 'eggs', melamine in milk, using horsemeat as beef, worldwide recall of dairy products, etc.) have become an emerging issue of concern, especially in the developing world. It is widely believed that issues of food security are of major concern only in the developing or underdeveloped regions of the world. However, in the developed regions also there may be instances where the local population or consumers still feel they are food insecure and malnutrition prevails. According to Astier Dumas (2003), malnutrition in developing countries is characterized by micro- and macronutrient deficiencies (e.g. a lack of essential

vitamins and minerals). Whereas, malnutrition in developed countries is characterized by over-nutrition, which has led to neurodegenerative diseases including those of diabetes, obesity and cardiovascular disease, mainly linked to the consumption of fatty (oily/fried) and sugary foods.

As of today, globally, 'hidden hunger' is still rampant, while poverty has been assumed to have greatly decreased. The 'hidden hunger' of micronutrient deficiency affects nearly two billion people and is often overlooked. More details on this issue and the concerns raised are discussed in International Food Policy Research Institute (2014).

Of late, food security has become a global issue. It is estimated that several million people are still starving. A hunger database has been regularly updated by the FAO. Recent information indicates that nearly 805 million people are suffering from chronic undernourishment (2012–2014). The majority of hungry people (791 million) live in developing countries, with nearly 11 million people being undernourished in developed countries (FAO 2014). A majority of low- and middle-income countries exist in a state of 'food emergency'. Overdependence on starchy foods, rapid changes in the environment, competition for human food from livestock along with a population explosion have resulted in food scarcity (Bhat and Karim 2009). The FAO maintains that by the year 2050 total agricultural production needs to be doubled to meet the global demand for food. Besides, global food demands are forecasted to rise by 70% by 2050 with the world's population being predicted to rise by 2.3 billion people between 2009 and 2050 (FAO 2009). Most affected are children in developing countries (approximately 100 million), who are underweight or are stunted in growth, with the number of annual cases of malnutrition-related death being as high as 3.1 million.

According to Alexandratos (1999), a total dependence on agriculture has been the main arena for survival of poor and food-insecure people in the majority of the countries facing acute food-security problems. Collapse of economic growth accounts for the perseverance of poverty as well as food insecurity. Additionally, farming communities in developing countries (those countries excluding Europe and North America) during the latter part of the twentieth century were able to augment harvest production in conjunction with increased population rate as well as enhance the per capita status of food energy. Further, there is a pressing need to reform agriculture to meet future global food demands. Around the world, countries have put forward their own economic reforms and policies to overcome food security issues.

Many people are of the opinion that an inadequate food supply system has led to food insecurity. However, the issues pertaining to food insecurity cannot be inevitably related to supply failure (Chen 2015; Drèze and Sen 1991; Gorton *et al.* 2006). Food security issues can directly have an influence on the economy of a region. Hence, to overcome food security issues, creating an interdependent framework that generates desired levels of sustainable food production is vital. Competition for common food-stuffs between humans and livestock is growing, owing to various geopolitical and environmental factors. For example: demand for protein-rich legumes and cereals is on the rise, which needs to fulfil the demands of both humans and livestock, especially in developing countries (Bhat and Karim 2009). Recent years have seen rapid changes throughout the food chain from farm to table (including innovations in food processing, preservation and transportation). So also, interest among consumers has been aimed at encouraging and searching for a better option to replace conventional food markets (Wilkins 2005).

To recap, the major challenges of food security in developing regions of the world are directly related to overpopulation, social instability (hunger, malnutrition and poverty), economic instability (lack of access to capital and markets), the depletion of natural resources, instability in access to food supply, food wastage and basic facilities required from farm to table level (handling and processing, storage, transportation, marketing, adoption of safety standards, etc.). In some developing (low- and middle-income) countries, though, traditional farmers contribute substantially to local food security. They often tend to work on smaller, more productive plots with minimal capital investment and scant access to novel food processing or farming technologies (Devendra 2007; Goma *et al.* 2001; Van Keulen 2005). Also, as indicated earlier, the problems of pests, diseases and inadequate storage and transportation facilities can all be a threat to food security.

1.3.1 Poverty, Hidden Hunger and Diseases

All over the world, but mainly in developing countries, food insecurity is estimated to have been reduced substantially, and the major reason for this reduction is the new policies set up by international communities. However, malnutrition and hidden hunger are still prevalent in the majority of developing regions. The magnitude and estimated rate of global poverty can significantly differ each year. Poverty is linked to monetary status and the household income of a general population, and this can affect overall food security (Omonona and Agoi 2007). In fact, many experts have related household poverty with food security. Poverty can include a lack of food and other daily essential resources and the inability to contribute substantially to the overall development of a society. According to Townsend and Gordon (2002), poverty can be considered a '*social exclusion*'. The word 'poverty' can be defined in various ways. What we need to know is whether poverty can be estimated by the lifestyle of a person or a family (economic conditions) or whether it owes more to social respect gained in a society. According to Sen (1992), poverty is not related to the '*low well-being*', but it is the helplessness to pursue a '*higher well-being*', mainly owing to a lack of good socio-economic conditions. Deteriorating health, stunted growth, reduced mental growth/function and low energy levels are expected to reduce an individual's capability to work, judge and ascertain the facts, and this can lead to increased hunger (Victora *et al.* 2008). The importance of 'food sovereignty' is excellently described by Patel (2009).

In 1990, the World Bank introduced a US dollar-a-day poverty line based on an average of purchasing power parity exchange rates between fifteen purchasing power parity countries (World Bank 1990). This was subsequently disparaged by many experts, who believed that the theory did not consider the actual requirements of the overall well-being of humans (Klasen 2009; Ravallion *et al.* 2009; Reddy and Pogge 2010). Later on, alternative purchasing power parity rates were proposed by Deaton and Dupriez (2011) which took into consideration various patterns of expenditure by the poor populations.

Besides, unemployment has also increased in a majority of developing countries. Changes in agro-economic policies and the influence of globalization in developing regions, a low demand for labour thanks to technological advances, the movement of people from rural to urban areas and other factors have contributed significantly to unemployment (Brown *et al.* 1994; de Melo and Robinson 1980; Dupraz and Latruffe 2015; Huffman 2014; Khadka 1989). Further, a structural transformation of higher

agricultural productivity coupled with a dynamic non-agricultural economy can be a reliable answer for achieving a *sustainable* pathway to overcome poverty. Provisional stores marketing reasonably priced healthy foods have also been suggested to be an important element for an anti-poverty strategy (Reisig and Hobbiss 2000). Free foods or a midday meal provided for school-going children have been a success story in India and in other regions of Asia. Several novel strategies have been put forth by leading global organizations to reduce poverty via organizing various programmes, developing effective institutional infrastructures, providing funding, ensuring a better distribution of funds, removing policies with an urban bias, enhancing the income of poor or poverty-stricken people, etc. Various initiatives relevant to ‘farm to school’ programmes and taking care of the overall welfare of farmer families have helped tremendously to enhance the health of young people (nutritional quality of life and managing childhood obesity) and farming communities (Ehlert *et al.* 2014; Levy *et al.* 2015; Thompson *et al.* 2014). However, there is a lack of supporting evidence to prove and establish a direct link between agriculture and poverty. In fact, it is a universally accepted fact that the world’s food supply is sufficient to feed and fulfil growing demand, excluding the fact that distribution and consumption are unevenly distributed.

1.3.2 Emerging Diseases

Over the past few decades, changing lifestyles (socio-economic status) and dietary habits coupled to significant global climatic change have led to an increase of communicable and non-communicable diseases around the world.

Attaining sustainability will be a tough task if the pressing issue of antibiotic-resistant microbes including multidrug-resistant bacteria (in both humans and livestock) or newly emerging viruses (e.g. SARS, Middle East Respiratory Syndrome coronavirus, MERS-CoV, human infection with avian influenza A or H7N9, Ebola virus) is not sorted out. In fact, low immunity and resistance in humans to diseases and microbial infections, coupled with changing lifestyles and food habits, are some of the major contributing factors to the occurrence of diseases and, in the worst case, death. Recently, the World Health Organization (WHO 2015) proposed the ‘Global Action Plan for the prevention and control of non-communicable diseases 2013–2020’. It focuses on achieving various obligations of the UN’s political declaration on non-communicable diseases.

Owing to technological interventions and free trade policies, there has been a free movement (sometimes non-quarantined) of food among various importing and exporting countries. Quality and safety, in many cases, and especially in those of low- or middle-income countries, remain compromised. Of course, there is a growing awareness that disruptions in natural ecosystems, depletion of natural resources and undermining biodiversity can adversely affect human health (Epstein 1995; Grifo and Rosenthal 1997). Frenk *et al.* (1997) proposed that connecting different regions of the world would inevitably have an influence on human health. As detailed earlier, cardiovascular disease, obesity, diabetes, cancer and other diseases are on the rise, especially in urban areas and low- or middle-income countries (FAO 2012; Lopez 2004; White 2007; Wilson 1995; Yach *et al.* 2006). The most alarming fact is that, globally, 1.9 billion adults (i.e. those above 18 years of age) are overweight, with 600 million being obese, and this contributes significantly to the death of a majority of people who live in countries where overweight and obesity compared to underweight is a major problem (WHO 2015).

Also, foodborne illness has been a major issue and is a global threat in today's world. Extensive usage (rather, abuse) of antibiotics has led to antibiotic-resistant microbes (e.g. *Campylobacter*, *Escherichia coli*, *Salmonella*, *Shigella* species, *Vibrio* species, methicillin-resistant *Staphylococcus aureus*, etc.) (Economou and Gousia 2015; Koluman and Dikici 2013; Tauxe 2002). In fact, environment and healthy food habits can play a major role in achieving sustainability in health care in a majority of the regions of the world.

Furthermore, there are reports of the low consumption of fresh fruits and vegetables in many low- and middle-income countries. For example, in Southeast Asia, it is reported that more than 80% of the population consumes fewer than five servings of fresh fruit or vegetables a day (Peltzer and Pengpid 2012). Above all, in this part of the world, younger generations consider fast foods to be easily accessible and, because these foods are from multinational companies, they usually think they are of good quality and are healthy. Moreover, in developing and underdeveloped countries, there are plenty of inexpensive processed foods available on the market which are high in saturated fats, salt and sugars that significantly contribute to an unhealthy diet. Above all, the younger generations' taste for junk food has become a problem in a majority of countries. In a society, food practice or a consumer's dietary choice may vary. For example: expensive foods can be bought by rich consumers, while low-cost foods are affordable for poor consumers, and these issues are scarcely part of the discourse informing any one country's food or health policy (Beaulac *et al.* 2009; Dowler *et al.* 2007; Lobstein 2009; White 2007). Furthermore, it is widely recognized that food habits are resulting in emerging health problems, especially in low-income population groups (Hawkes 2008; Lang *et al.* 2009).

1.3.3 Stability of Food Supply and Access to Safe, High-quality Foods

As highlighted earlier in this chapter, stable food production depends on various factors, ranging from climatic changes and environmental stability (e.g. community-based resource management) to social stability (e.g. community-based and government-run social security schemes), economic policies (e.g. income distribution, marketing strategies) and production levels including those of conditions relevant to food harvest, handling, storage, transport and processing. Encouraging farmers' cooperatives supported by various agricultural policies and local governments to popularize local foods (food marketed directly by the producer or which has travelled a shorter distance from the farm or the production place) can have good results. In fact, it was observed that there is a commendable shift among the majority of consumers towards local food (Watts *et al.* 2005). Further, in one of the studies reported by Monzote *et al.* (2012), from Cuba, local stakeholders – comprising farmers, scientists as well as representatives from the Ministry of Agriculture – were able to identify and propose surrogate strategy models to support sustainable farming systems for agriculture wherein 'best practice of mixed farming systems management' had a positive impact on land productivity and improved socio-economic performance and food self-sufficiency. Besides, a study performed in the Philippines has indicated that the active participation of stakeholders is necessary for introducing sustainable and new agricultural systems (Vilei 2011). Also, in developing countries challenges posed by invasive pests as well as diseases (microbial or physiological) can affect food security and the production of safe, high-quality food. Updating the

information on changes in the climate, proposing appropriate steps for disaster risk management/mitigation, promoting self-sufficiency and green farming are all important factors to be considered. In fact, producing healthy food crops, improving the export market, supporting farmers' organizations and training on a regular (weekly or monthly) basis can all be of immense benefit. But enhancing the quality and safety of a harvest along the food chain can also depend on adopting good agricultural practices, good handling practices and good manufacturing practices along with appropriate certification and a hazard analysis and critical control points (HACCP) approach.

1.3.4 Food Diversification

Food diversification is a concept wherein diets and the cooking style of a local population of a particular region can influence sustaining household food security. Food diversity can be down to either plant or animal sources, or both, which are established in providing substantial nutritional security in a local population. Various aspects – such as supporting mixed cropping, integrated farming systems, introducing new food crops, promoting the use of traditional foods, value addition for traditionally produced agricultural products, encouraging diminutive livestock raising, fisheries, utilizing local forest products for common household consumption and enhancing smallholder productivity – are all taken into consideration. Besides, food diversification includes various aspects of post-harvest technologies involving improvements in the preservation of the fresh harvest (e.g. grains, fruits and vegetables), waste reduction, novel approaches to income generation, strengthening small-scale agro-processing and agrofood industries, education relevant to food nutrition, recommending regular intake of a wholesome diet, which are all to be considered (FAO 1997; Ojiewo *et al.* 2013; Yang and Keding 2009).

Food diversity can influence public health and food policy. Understanding the concept of food diversity can be of immense help when ageing populations are considered wherein dietary habits and the required nutritional components vary (Wahlqvist 2003, 2005). At a local level, food diversification can involve introducing a wide range of new healthy and tastier foodstuffs to a community. However, owing to commercialization, changing food habits and marketing, there is an ever-increasing challenge for the successful accomplishment of sustainability when food diversification is considered. For example, in several countries, the popularity of local traditional foods is being diminished. The most popular foods are those which can be prepared easily, like porridge, noodles and soups.

In some instances, using the same basic raw materials to produce varieties of foodstuffs can also signify food diversity, for example using breakfast cereals to prepare baked goods (Wahlqvist 2005). Besides, there is a lack of knowledge among a majority of consumers on healthy and nutritious food consumption patterns. Also, in some developing regions, there is a high level of dependency on imported commodities. Considering the trend, there is an urgent need to support local farming communities, creating employment and keeping local farmers in business.

The other important aspect to consider is the purchasing behaviour of consumers regarding fresh produce, wherein consumers are ready to pay higher prices for good-quality foods and those of local origin (Bhat *et al.* 2015; Costanigro *et al.* 2014; Gracia *et al.* 2014; Zepeda and Deal 2009). In a globalized food trade scenario, the reduction of

food miles depends on consumer demand and attitude, for example buying local produce, eating seasonal foods, supporting the local farming community or reducing transport costs. Several research reports highlight the benefits of supporting local food supply chains (Cowell and Parkinson 2003; Morris and Buller 2003; Murdoch *et al.* 2000; Winter 2003, 2005). In addition, the emotional engagement of consumers with the issue of climate change can heighten their understanding and choice of footprint-labelled products (Greibitus *et al.* 2015; Roeser 2012).

1.3.5 Health (dietary) Supplements

Another challenge for sustainability is the increase in the use of health (dietary) supplements as additions to or replacements of the intake of conventional food. In today's world, the majority of people in urban areas believe that health supplements are better than eating fresh food. Consumers in many instances rely on the marketing of a product and become a victim of false claims. In fact, the wellness and botanicals (nutraceuticals) market is generating enormous income because of this trend. These supplements may be minerals, vitamins, herbs or other plant-based products. In the marketplace, supplements include ready pills which can control weight, anti-ageing, memory enhancers, immunity enhancers, etc. In many instances, especially in countries where stringent rules are not imposed, the safety and quality of products can be highly compromised, thus undermining the sustainability agenda. A wealth of literature is available on the risks associated with health supplements (Raschi and De Ponti 2015; Reid *et al.* 2015; Wallace 2015; Willers *et al.* 2014). In fact, a set of regulations on dietary supplements has been proposed by the US Food and Drug Administration (2015), which should be of immense practical help.

1.3.6 Food Wastage

Food loss and wastage can be viewed as one and the same where sustainability is concerned. Loss, or wastage, can be categorized into many types, for example, along the food chain, pre-harvest loss in the farm due to vector problems or insect infestation or microbial spoilage; post-harvest loss due to improper storage or processing conditions, handling, microbial contamination, etc.

Further, 'on the table' waste by consumers can also be considered a major issue in today's world, especially in highly developed countries or at lavish family functions/ ceremonies in some developing countries. Food wastage, which can have socio-economic and environmental impacts, can vary among various categories of commodities and can happen at any stage between harvest to consumption (Göbel *et al.* 2015; Griffin *et al.* 2009; Parfitt *et al.* 2010). Food wastage or loss can have a high impact on regional food security, especially in low-income countries. Further, the loss incurred can be agriculture commodity based or livestock based. According to the FAO, globally, nearly one-third of the world's food production is lost or wasted, amounting to nearly 1.3 billion tons a year. This waste estimated can be all along the food supply chain, starting from agricultural production up to domestic consumption levels (FAO 2015b).

As the economy of a country, and particularly those of low-income countries, can be influenced by food waste or loss, detailed studies still need to be made on the level and volumes of food waste generated along the food chain in every country in the world. This would be of practical help when looking to propose a model and develop strategies

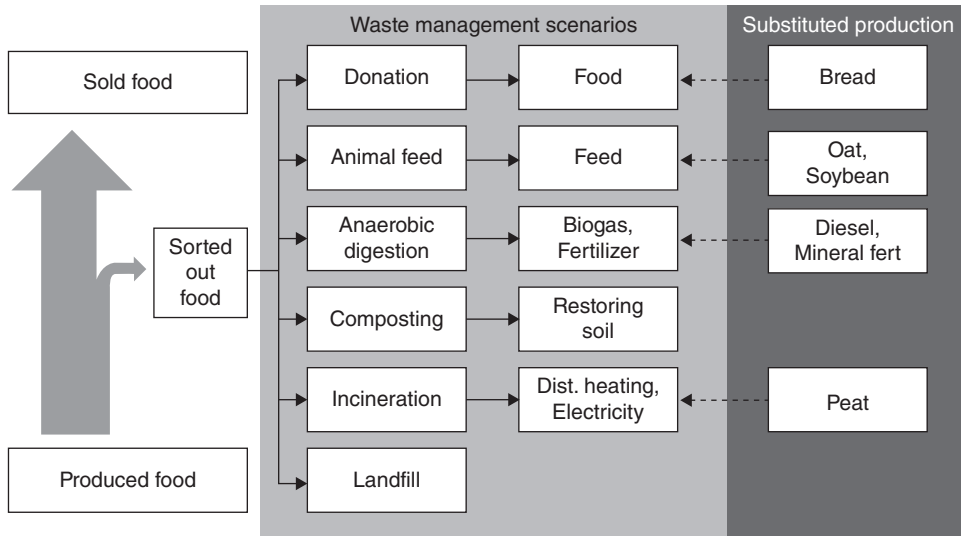


Figure 1.6 Schematic diagram of the six waste management scenarios, their outcome and what each scenario replaced. *Source:* Eriksson *et al.* 2015. Reproduced with permission of Elsevier.

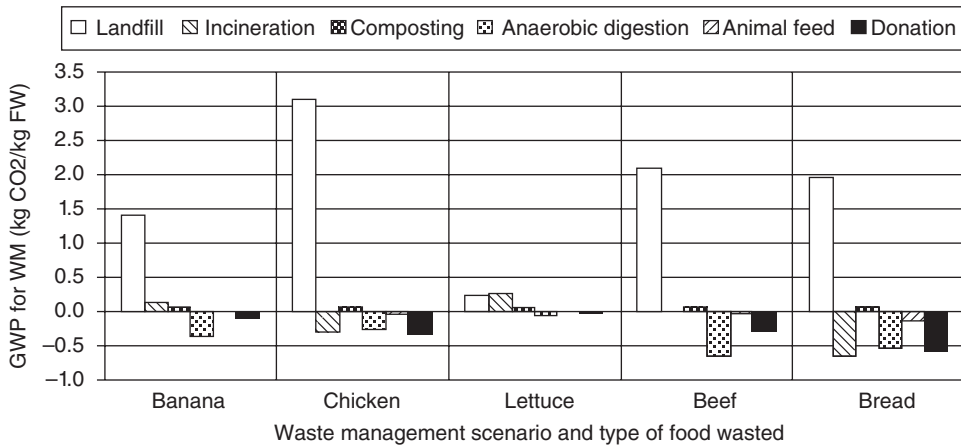


Figure 1.7 Global warming potential of each waste management scenario and food product. *Source:* Eriksson *et al.* 2015. Reproduced with permission of Elsevier.

to overcome the problems associated with food waste. Eriksson *et al.* (2015), working on the carbon footprint related to the management of food wastes (waste hierarchy from Sweden), propose a noteworthy schematic representation that considers six waste-management scenarios and highlights the outcome of each. Further, these researchers, taking into consideration the six scenarios, report a decreasing trend of global warming potential along the food waste hierarchy (Figure 1.6 and Figure 1.7).

When considering the current situation and sustainability challenges in a global context, it is easy to conclude that there is a pressing need to propose novel strategies to reduce, or at least manage the growth of, the agricultural footprint and help local farming communities to improve their overall productivity and reduce waste. As per FAO directives, creating awareness of the consequences, coordinating global initiatives, developing new policies and strategies on food loss and waste reduction as well as supporting and investing in various programmes and projects executed by both private and public sectors are all prerequisites for achieving success (FAO 2015b). Globally, nearly 40% of all produced foods are lost or wasted along the food supply chain, with fresh fruits and vegetables being the highest contributors of wastage in retail food waste (Gustavsson and Stage 2011).

In developed countries, food loss can occur because of cultural, socio-economic decisions furnished by the producers or the consumers at the far end of the food supply chain, while in developing countries the loss can occur at the earlier stages of food supply and can be attributed to a lack of financial support or technology (Dorward 2012). Further, the widening gap between farmers and the market, owing to poor facilities (storage and transportation), can contribute tremendously to loss/wastage of fresh produce, especially in low-income countries. Identifying the sources of wastage and developing a food wastage footprint for each of the cultivated cash crops can have long-term benefits.

1.3.7 Food Safety

Recent years have witnessed several challenges caused by food contaminants. In food commodities (both plant and animal based), contaminants can come in various forms. They can be chemical based (e.g. heavy metals, pesticide residues, dioxins), physical (e.g. broken glass, pieces of plastic, nails, insects) or of microbial origin (e.g. mycotoxins) (Benford 2013; Bhat *et al.* 2010; Cano-Sancho *et al.* 2015; Clarke *et al.* 2015; Crossley and Baines 2014; Muncke 2014). These contaminants may not be intentionally introduced to a commodity, but they can have serious health effects. However, certain instances of melamine contamination in milk can be considered as being intentionally added (Hong *et al.* 2014). Food safety is of paramount importance to improve the overall quality of human life and animal welfare. Various strategies relevant to educating and training consumers on food safety issues as well as the significance of the presence of anti-nutrients, pesticide residues, mycotoxins, radionuclides and other interrelated details are discussed by various authors in Bhat and Gómez-López (2014). So how about recent reports on plastic rice or the false or chemical eggs, which were marketed in some regions of Asia? There are several challenges that must be overcome regarding ensuring food quality and sustainable food production. Indeed, as indicated earlier and as discussed in the forthcoming text, adhering strictly to local and international food trade policies can be of great benefit to all countries where safety is concerned.

1.3.8 Sustainability Challenges in the Food Industry

The food industry forms a major part of revenue generation in many countries around the world. Today's consumers are more choosy, well informed and critically evaluate any new food product that comes onto the market. They prefer to know the origin of raw materials, about the processing undertaken, the overall nutritional quality (labelling

information) and about how safe the food is to eat (especially with regard to allergic components) (Hobbs and Goddard 2015; Kemp *et al.* 2010; Resano *et al.* 2012; Varela *et al.* 2013; Waldman and Kerr 2015). In certain instances, consumers also consider food miles and carbon footprints when choosing foodstuffs. Hence, the food industry is under continuous pressure to provide high-quality foods and to be more transparent in its approach (Hooghiemstra 2000).

Ensuring a successful implementation of a secured food production is a prerequisite, especially for those countries whose agricultural exports contribute massively to their GDP. In the food industry, for successfully achieving sustainability, some of the key areas should revolve around adopting novel strategies for an eco-friendly approach to reduce solid wastes, minimize water use or to recycle waste water, lessen energy consumption and try to tap energy from natural resources (e.g. solar energy or bio-energy) (Afton *et al.* 2014; Bordewijk 2006; El Mekawy *et al.* 2015; Garrone *et al.* 2014; Kim *et al.* 2015; Martinez *et al.* 2009; Paraman *et al.* 2015).

When it comes to the food supply chain, life cycle assessment (LCA) has been universally recognized as a key factor for analysing the influence of things such as farming techniques, slaughtering processes (in a humane manner; halal requirements in Islam, etc.) and extraction processes adopted with regard to basic raw materials, etc. (Bloemhof-Ruwaard *et al.* 1995; Thomassen *et al.* 2008). Further, use of biodegradable, bio-packaging materials (e.g. utilize agro-wastes as filler materials) can also be a better replacement for non-degradable plastics used for packaging purposes in the food industry (Bhat *et al.* 2013; Bhat and Karim 2014; Russell 2014). Additionally, new low-cost technologies of processing and preservation should be adopted along the supply chain, especially in low- and middle-income countries, along with ensuring proper food labelling based on the requirements of consumers. Appropriate standard operating procedures (SOPs) and sanitation standard operating procedures (SSOPs) should be maintained to ensure food is of a high standard. Adopting good hygienic and handling practices and educating employees about sustainability can yield fruitful results.

1.4 Conclusions and Future Outlook

Available literature and databases highlight the ever-growing desire among consumers and policy makers to understand the significance of sustainable farming and the production of sustainable foods. The future of sustainability relies on overcoming various challenges pertaining to the food–energy–water nexus. Besides, in the food sector, future sustainability must focus on overcoming the persistent barriers of establishing a global food production and distribution system which not only avoids food wastes but also aims to produce good-quality food for the economic benefit of producers and to the nutritional and cultural requirements of consumers. A common vision of agrofood sustainability with a focus on low- and middle-income countries needs to be created. Education, networking and enhancing the institutional linkages are of paramount importance for achieving agrofood sustainability and in which all members of a society (including farmers, academics, research scientists, consumers, industry personnel, students and others) need to be involved. Employing smart agricultural practices, being prepared to deal with natural disasters and developing and monitoring appropriate action plans with regards to carbon and agricultural footprints must be a priority in

every volatile region of the world. Besides, novel technologies need to be developed for ensuring low-carbon agriculture and for the overall sustainable development in the volatile regions of the world. New theories, practical implications and evidence relevant to regional-based food production and consumption patterns need to be revised and reviewed from time to time. Encouragement needs to be provided for educating teachers and students to involve themselves in interdisciplinary topics relevant to agrofood sustainability issues and to help them identify gaps in research from both a natural and a social science perspective. Global food security drivers and challenges – some of which include empowering individual governments policies; the intensification of sustainable agrofood production systems; food supply value chains, including those of production and biodiversity; sharing of knowledge relevant to technological breakthroughs, especially those aimed at reducing food wastage; consumerism, including nutrition, diet and health links – need to be approached in a more practical way. Promoting the consumption of traditional foods and advocating agrofood tourism may also improve the local economy of a region.

As an example, 'home stay' is becoming widely popular in the majority of the rural villages in India (identified to be a part of sustainable food tourism). Tourists prefer to visit those rural regions/villages, which have retained not only their natural scenic beauty but also their rich tradition, heritage and culture. This can be in relation to sustainable farming and agricultural practices, food processing practices and food preparation/gastronomy, marketing strategies adopted for local produce, food consumption patterns and experience, environmental/biodiversity concerns (e.g. less dependence on pesticides and use of organic manure, managing food wastage). Home stay has become highly popular in many parts of India (mainly in the regions of Western Ghats and Malnad), where tourists go to enjoy the natural beauty of the scenery as well as to relish traditionally prepared foods. In the villages of India, local people use a Sanskrit term, *Atithi devo bhava*, meaning that the guests at their house are treated as if they were God. The unique experience of these home stays includes understanding the culture, rich traditional values and food habits of the local community. Figure 1.8 depicts a typical rural scene in the Malnad region, showing how basic culinary requirements (such as vegetables or herbs) are naturally collected from organic farms by the local community (Figure 1.8a, b); the normal way of heating and cooking traditional recipes using wood or wood energy (naturally fallen dried twigs or branches of tress are selected that give out a minimal amount of smoke) (Figure 1.8c, d); making an offering of freshly prepared food to the gods before serving guests and house members (Figure 1.8e); and finally serving the food in a traditional way: on banana leaves (Figure 1.8f).

Further, to promote agriculture, it is essential that a 'one stop' agriculture based food business centre be established which can help farmers (providing up-to-date information on the weather, disease- and pest-resistant and high-yielding crops; and incentives to farmers, e.g. insurance schemes) and food industry personnel (on quality and safety measures) to meet the needs and demands of consumers. International funding and supporting farmers' cooperatives can be of immense help, too, especially in developing regions. Further, local authorities can help to deal with the challenges facing the food industry, for example with meeting production targets, implementing international standards along the agrofood supply chain, effectively managing natural resources and using by-products, proposing a feasible and simple regulatory framework, etc.

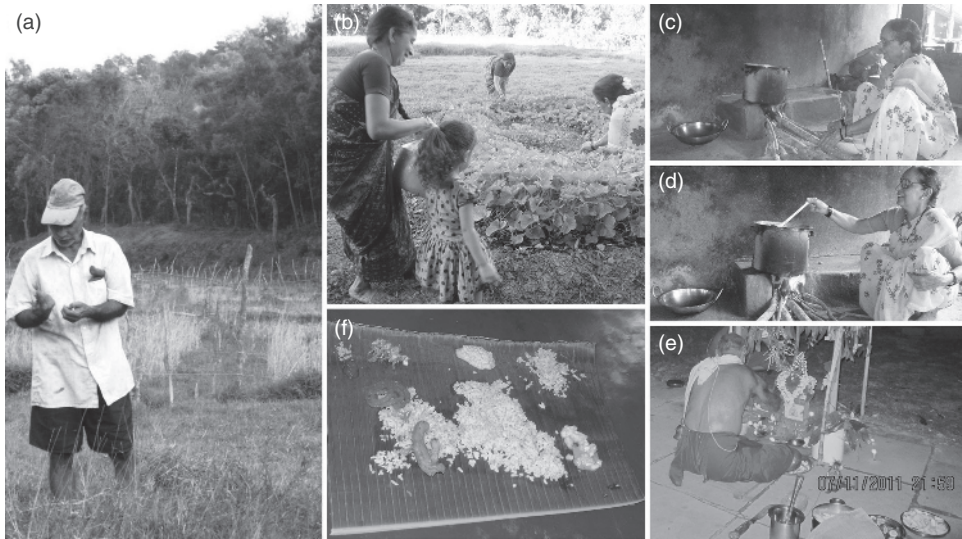


Figure 1.8 Examples of food tourism in India.

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