Section 4: Eat Sustainable

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Chapter 18: Food Ecosystem and Sustainability

‘Sustainability’, often quoted across forums discussing development agenda, is a complex concept. What does sustainability really mean? With reference to ecology it means the avoidance of the depletion of natural resources in order to maintain a balance. The UN World Commission on Environment and Development defines sustainable development as ‘development that meets the needs of the present without compromising the ability of future generations to meet theirs’.

Simply put, think of a bucket with water pouring in and draining out at the same time. If the amount of water pouring in is equal to the amount draining out, the level of water in the bucket remains the same. However, if the rate at which water drains out is faster than the rate at which it gets into the bucket, the level of water in the bucket would gradually decrease. That’s essentially what we are observing in the world today. We are draining the resources faster than they can be replenished.

Typically, environment, economy and society form the three-pillars of sustainability. These three pillars converge on a singular goal of ensuring a bright future for the next generation. This brings us to a pertinent question, how does food become integral to the sustainability discussion?

The World’s population is expected to reach 9.8 billion by 2050. To feed this population, we would put extreme pressure on the earth’s climate, natural resources and ecosystems. At present some 11 percent (1.5 billion ha) of the globe’s land surface (13.4 billion ha) is used in crop production (arable land and land under permanent crops). This area represents slightly over a third (36 percent) of the land estimated to be to some degree suitable for crop production. This implies agriculture alone is the largest use of land on this planet. Yet, roughly one-third of the food (1.3 billion tonnes) produced globally gets wasted or lost. Food losses and waste amounts to roughly US$ 680 billion in industrialized countries and US$ 310 billion in developing countries. The situation becomes even more grim when we consider the rates of malnutrition globally. About 815 million people globally, regularly go to bed hungry. Children under five years of age face multiple burdens: 150.8 million are stunted, 50.5 million are wasted and 38.3 million are overweight. Many of these children would never reach their full physical and cognitive potential. Sustainable food production and responsible food consumption therefore become central to the risks related to human health as well as environmental sustainability. In fact, goal # 12 of the 2030 Agenda for Sustainable Development aims to ensure sustainable consumption and production patterns.

This chapter integrates the concept of food production, consumption and utilization (food ecosystem) with sustainability by studying the elements involved, both from a challenges and potential solutions perspective.

Understanding the Food Ecosystem and Sustainability Issues

A Food Chain describes how energy and nutrients move through an ecosystem. The length of food chain is determined either by the dynamical stability of food webs or by the availability of limiting food resources. The length of food chain also involves complex
relationships between food chain length and ecological processes like the history of community organization, resource availability, habitat stability and ecosystem size (Post, 2002). A **Food Web** is an important tool for understanding the ecological interactions that define energy flow, predator-prey and other relationships. It is particularly important to understand and study the food web in context to ecosystems as there are various concerns like climate change, habitat loss, changes in food production and consumption patterns, etc. (Pimm, 1984; Daily, 1997; Dunne, 2009)

**Food Ecosystem** refers to a community of living organisms existing in concurrence with physical non-living environment. These living and non-living components are linked to each other through nutrient transfer cycles and energy flows. In agriculture and food production systems, ecosystem services are provided by entities which can be incorporated into crop production systems enabling production increase, minimizing environmental impacts by modulating the use of fertilizers, pesticides, energy, and irrigation and soil management practices. Apart from soil and irrigation, the temperature also plays vital role in managing the various processes of food production ecosystem. It has been reported that minimal rise in temperature alters the food web structure and ecosystem by changing the ratio disproportionately between predators and herbivores resulting in changed distribution of organisms. Technically, these interactions between different biotic and abiotic entities of ecosystem are known as ‘Ecological intensification.’ This revolves around the concepts of optimization of resources and sustainability. Ecosystem size determines food-chain length.

A **sustainable food ecosystem** (SFS) 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, 2018)

The resource footprints could also be termed as ‘Ecological Footprint’ which are defined as an aggregated indicator of demand on nature and can be measured using a standardized area unit termed a ‘global hectare’ (gha). This is usually expressed on a per capita basis (gha/capita). The ecological footprint estimates the area of land required to support the resource consumption of a defined population, usually for one year (WWF, 2006). For example, the environmental impact of producing beef and veal generates a footprint figure of 0.0157 gha/kg (when consumed at home) as compared to fresh potatoes which has a footprint of 0.0003 gha/kg. This is because the production of beef and veal is more energy and resource intensive and requires larger areas of land. Thus, sustainable food consumption also becomes an important part of food ecology. The type of food and drink consumption pattern defines the food production resource utilization pattern in a community and marginal changes in diet patterns could significantly impact the ecological footprint and could make sustainable diet more achievable (Duchin, 2005; Leitzmann, 2005). Sustainable diet favouring ecological basis may be characterized by maintaining optimal nutritional supply on one side and maintaining lower ecological impact while producing per kilogram of food.

While discussing ecological footprint and ecological balance in food production and consumption ecosystem, it is also important to have an insight on ecological resilience. The concept of ecological resilience in the context of global change refers to stabilizing the ecosystem productivity by utilizing high plant diversity and through increasing resistance to climate extremes (Oliver et al. 2015; Isbell, 2015). In recent past, the extreme climate events
like heat waves, floods, droughts have adversely affected the food production and this may be addressed by enhancing the resilience of food production systems (i.e. maintaining production of sufficient and nutritious food) through diversification of agro-ecosystems (Reyer et al., 2015; Bullock et al., 2017). To achieve resilient food production systems, it would be required to merge the ecological and sociological approaches across multiple stakeholders from the farm to the global scale. This may start at farm gate with farmers making right choice of crop varieties in response to changing climatic conditions and diversification in livestock. At global scale, it would require coordinated implementation of adaptive strategies across farms, scientific and technical knowledge exchange to and among farmers (Weiner, 2017).

The studies on impacts of human nutrition on land use, nutrient balances and water consumption have shown that optimizing only one aspect of resources has potentially severe impacts on other resources. As the food supply is based on demand patterns, the changes in diet habits would impact resource consumption, resource footprints and ecological balance (Thaler et al., 2013).

Figure 1 presents an integrated flow chart of various entities (abiotic-biotic) and activities in a food system showing dynamic interactions which exist between the food production and consumption systems. These drivers also elaborate the concept of ecosystem services which link ecology and society. Ecosystem services can be defined as the processes of the ecosystem which benefit the human beings and can be broadly categorized as cultural, regulating and supporting services (Costanza et al., 1997; Bommarco et al., 2013). In our context food ecosystem services can include cultural services (modern, traditional and ethnic food systems), regulatory services (food safety, codex, SPS regulations, government policies) and supporting services (enabling infrastructure, technology, trained workforce).

Figure 1. Integration of drivers in a food system
(adapted from https://www.futureoffood.ox.ac.uk/what-food-system)
Challenges of the food ecosystem: The Indian perspective

The green revolution of 1960s has gradually transformed India from a food insecure country to a self-sufficient nation. In 2017-18, total food grain production was estimated at 275 million tonnes (MT). India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. India’s annual milk production was 165 MT (2017-18), making India the largest producer of milk and pulses, and has the world’s second-largest cattle population 190 million in 2012. It is the second-largest producer of rice, wheat, sugarcane and groundnuts, as well as the second-largest fruit and vegetable producer, accounting for 10.9% and 8.6% of the world fruit and vegetable production, respectively.

Despite the rapid development in agriculture sector, India continues to face multiple challenges. The economic progress has also led to a structural transformation wherein the economy has diversified to manufacturing (industry) and service sectors. Subsequently, agriculture’s contribution to Gross Domestic Product (GDP) has steadily declined from more than 50% in the 1950s to 17.1%.

The contrast in this development journey can be seen in the malnutrition indicators. India ranks 102 out of 117 countries on the Global Hunger Index. With a score of 30.3, India suffers from a level of hunger that is serious.

Land use for food and protection of biodiversity

Current practices of agricultural production are resource intensive, regionally biased and skewed towards carbohydrate-rich cereal crops such as rice and wheat. The increasing food production has led to an imbalance in soil nutrient levels, decline in water table and an overall depletion in the soil health. Soil health is considered good when it has at least 5 per cent organic matter. Unfortunately, the national average for organic matter in soil in India is 0.4 per cent.
Despite being one of the leading producers for many food grains and cash crops (figure 2), India struggles with agricultural productivity on account of many factors. A major proportion of land holdings are small or marginal which face problems with using advanced mechanization and irrigation facilities. Most of the small land holdings are fragments of larger land holdings which have been passed on within the family or leased to farmers by a large holder. In latter case, formal lease agreements are often missing thereby restricting the farmer’s access to formal credit, subsidies or crop insurance.

**Use of fertilizers and chemicals in farm operations**

Imbalanced application of different plant nutrients through fertilizers is a widespread problem in India. The major reasons are lack of adequate knowledge among farmers about the nutritional requirement of crops, poor access to proper guidelines on the right use of plant nutrients, inadequate policy support through government regulations, and distorted and poorly targeted subsidies.

*Figure 18.2: Percent Share of Area Under Major Crops in India*

http://agricoop.nic.in/sites/default/files/pocketbook_0.pdf
According to the 29th Parliamentary Standing Committee Report, about 292 districts account for consumption of 85 per cent of all of the country’s fertilisers. Besides, there are discrepancies in the use of fertilisers on the basis of chemical ratios. The current consumption ratio of nitrogen, phosphorus and potassium (NPK) is 6.7:2.4:1 against their desirable ratio of 4:2:1.

As noted by the Economic Survey of India (2015-16), use of pesticides without following proper guidelines, use of sub-standard pesticides and lack of awareness about pesticide use have led to an increase in pesticide residues in food products in India.

**Water for irrigation**

India is facing a major challenge on the water front. Its per capita water availability of 1544 cubic meters per year, as reported in 2011, has already fallen below the cut-off point of 1700 cubic meters, placing it among the water stressed nations of the planet. Of the total 140 million hectares of net sown area, only 48.8 per cent is under irrigation and rest is rain fed. Of the net irrigated area of 68.38 million hectares, about 60 per cent is irrigated through groundwater.

Estimates suggest that in the next three decades, the global food systems will need 40-50 per cent more freshwater than today. Municipal and industrial demand for water will increase by 50-70 per cent during this period, while demand for energy sector will increase by 85 per cent. Irrigation sector with almost 78 per cent share dominates the present and future water use scenario in India.

In addition to land and labour productivity, the concept of ‘water productivity’ has therefore become prominent in the recent times with the aim of ‘more crop per drop’. Various initiatives including crop diversification, rain-water harvesting, alternate cropping patterns, micro-irrigation, hydroponics and related technologies, knowledge and practices amongst farmers, subsidies etc. are under-way to address water productivity.

**Food loss and wastage**

After agricultural produce is harvested, it requires a robust storage infrastructure in order to minimise any losses due to adverse weather conditions or in the process of transportation. Food loss is understood to occur when the food produced for human consumption is discarded or suffers a reduction in quantity or is diverted for non-food purpose. The primary cause is lack of adequate handling, storage facilities and failure to connect produce to markets in a timely manner. Food waste, on the other hand, is understood as the waste that occurs in the hands of consumers, conscious or unconscious due to habitual excesses or other rejection factors.

Central Institute of Post-Harvest Engineering and Technology (CIPHET), Ludhiana an ICAR (Indian Council of Agricultural Research) Institute conducted a study on “Assessment of Quantitative Harvest and Post-Harvest Losses of Major Crops and Commodities in India” and submitted its final report in March 2015. The study estimated that annual value of harvest and post-harvest losses of major agricultural produces at
national level was of the order of Rs. 92,651 crores calculated using production data of 2012-13 at 2014 wholesale prices.

In order to arrest post-harvest losses of horticulture and non-horticulture produce and to provide integrated cold chain and preservation infrastructure facilities from the farm gate to the consumer or from the production site to the market, Ministry of Food Processing Industries (MoFPI) has been implementing the Central Sector Scheme of Cold Chain, Value Addition and Preservation Infrastructure since 2008-09.

It is estimated that saving one-fourth of the food currently lost or wasted globally would be enough to feed hungry people in the world, of which the highest number (about 194.6 million) are in India. An eye-opening revelation had been made by a report cited in CSR journal. It says, “Indians waste as much food as the whole of United Kingdom consumes”. It is worth mentioning that food that is lost and wasted, converts into greenhouse gases and has a direct impact on global warming, besides resulting in loss of water and other resources used during cultivation. Already the fourth largest economy, India is the world’s third largest greenhouse-gas-emitter.

Addressing food loss therefore can make significant contribution to addressing hunger as well as environmental sustainability.

**Potential solutions**

So, what are the potential solutions to the challenges which have been discussed in the above section? There are several lessons to learn from nations around the globe which can be applied in the local context. Let us examine some of these:

**Nutritious food and healthier food choices**

Nutritious food and healthier food choices are at the apex of food and land use reforms. Consumption patterns of 1.3 billion Indians and more than 9 billion people globally are critical factors which shape how food and land use evolves over a period of time. A significant body of evidence has emerged on environmental impacts of various diets, with many studies concluding that a plant-based diet with few animal source foods confers both improved health and environmental benefits.

Food and Agriculture Organization (FAO) defines ‘sustainable diets are those diets 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’.
As per figure 3, meat seems to be a low contributor to global food wastage in terms of volumes (less than 5% of total food wastage), however, it has a significant impact on climate change with more than 20% contribution towards carbon footprint. This is due to the methane emissions by ruminants, emissions related to animal feed production as well as emissions from manure management. All these emissions get added up to produce a kilogram of meat.

In order to achieve human and planetary health, our diets should balance the positive elements with the negative. Protective foods such as fruits, vegetables, whole grains, legumes and nuts should be included in daily meals. Whole grains should be preferred over refined. Unhealthy foods such as salt, sugar, saturated fats should be consumed with restriction. Red meat consumption should be in moderation.

In the above context, alternative proteins that can act as substitutes for traditional animal-based food are attracting considerable financial investment, research attention and interest in the media as a pathway to meeting the nutritional needs and food demands of a predicted mid-century population of 10 billion, in a healthy and sustainable manner.
Promoting sustainable and regenerative agricultural practices

Agriculture priorities need to be reoriented to not only produce sufficient calories to feed a growing population but also to encourage dietary diversification that nurtures human health and supports environmental sustainability. Wheat and Paddy (Rice) will face challenges as temperatures gradually increase on account of climate change. Climate resilient or climate ‘smart’ crops such as pulses and millets offer a potential solution while also adding more nutrition to the food basket of a household.

A significant reduction in yield gaps from current croplands is the need of the hour. Crop and water productivity should be dealt with in tandem. Cropping patterns should be realigned with water endowments of that state/geography. Judicious water use in agriculture may also be promoted by rationing irrigation water supplies. Farmers cultivating water guzzler crops like paddy and sugarcane can purchase extra requirement of water from farmers cultivating less water intensive crops.

Traditional techniques such as crop rotation, controlled livestock grazing etc. should be encouraged alongside new advanced practices of bio-based fertilizers and pesticides. Zero tillage, raised bed planting, direct seeded rice, crop residue management and cropping diversification (horticulture, bee keeping, mushroom cultivation, etc) seed/fodder banks, ICT-based weather advisories and knowledge sharing are also critical factors while moving towards sustainable production.

Farmers continuously experiment to get better results and are a powerhouse of knowledge. This wealth of knowledge and best practices should be consolidated and made available to all the farmers across the country via an easy-to-understand and convenient platform. This is of particular interest to small and marginal farmers who need improved extension services and could benefit from examples from other states.

In a bid to tackle malnutrition, the government is working on a POSHAN (Partnerships and Opportunities to Strengthen and Harmonize Actions for Nutrition) atlas that will map the crops and food grains grown in different regions of the country because the solution to tackling malnutrition lies in promoting regional cropping patterns and embracing local food rich in protein and micronutrients.

Protecting and restoring forests and other natural ecosystems

Protecting and restoring global forests could reduce annual net greenhouse gas emissions by more than eight gigatons carbon dioxide equivalent (GtCO2 e) by 2050, which is consistent with limiting global heating to 1.5-degrees Celsius.

India is ranked 10th in the world, with 24.4% of land area under forest and tree cover, even
though it accounts for 2.4% of the world surface area and sustains the needs of 17% of
human and 18% livestock population.

Strong and coordinated governance of land and oceans implies feeding humanity on
existing agricultural lands. Between protecting nature and expanding agriculture, there is a
real trade-off. However, a zero-expansion policy is imperative so as to avoid encroachment
of new agricultural lands into natural ecosystems such as forests. A ‘Half-earth’ strategy is
therefore recommended for biodiversity conservation i.e. conserve at least 80% of
biodiversity by protecting 50% of Earth as intact ecosystems.

This approach also lends itself to management of oceans to ensure fisheries and
aquaculture do not negatively impact ecosystems. The ocean could sustainably supply 80
to 90 million metric tonnes of seafood protein a year (versus around 50 to 60 million tonnes
unsustainably sourced today), reducing demand for land to supply protein and improving
human health at the same time.

India contributes to about 6.3 per cent of the global fish production. However, as one of the
sustainable development goals is to aim for a better aquatic balance, India has a long way to
go to become a country which uses 100 per cent sustainable fishing practices. The onus is
not only on the supply side, but also demand, where the consumers too should be
accountable for the fish they purchase and know how it is sourced.

**Investing in a more diversified protein supply**

Over the years, India has seen a steady increase in meat consumption. This trend has
obvious repercussions with respect to greenhouse gas emissions, carbon footprint and
ecosystem preservation as discussed earlier.

Recently alternate protein sources have emerged such as plant-based proteins, lab-
cultured meat, insects and aquatic based proteins which have the potential to provide
consumers with sustainable, reliable, healthier and ethical (in some cases) protein sources.

India has a wealth of natural biodiversity and several indigenous crops like millets, pulses
happen to be ideal ingredients for plant-based proteins. Industrial animal agriculture
contributes significantly to climate change, pollutes our air and water and uses a
tremendous amount of land, water and other precious natural resources. For instance,
raising chickens releases 40 times more carbon dioxide per calorie of protein than lentils.
About 70% of India’s antibiotics are given to farm animals. The World Health Organisation
has said that antibiotic resistance is one of the biggest threats to global health, food
security, and development today. Animal protein supply is often threatened by zoonotic
diseases and could also pose public health challenges on account of the same.

It will, however, be important to develop suitable regulatory frameworks for some of the
novel products such as lab-cultured meats or insect proteins. Collaboration with scientific
experts, research and development institutions and other stakeholders would be crucial to
support innovation and at the same time ensure public health, safety and appropriate
labelling for such products.

Animal protein will continue to play an important role: certain vulnerable groups, such as
women of childbearing age and young children in low-income countries will indeed need to
increase their animal protein consumption to improve their health. More sustainable production of meat, dairy and eggs is therefore also essential.

Reducing food loss and waste

Substantial reduction in food losses (supply side) and food waste (consumption level) is essential for the global food system to ensure planetary health. Tangible steps in this direction could include improvement in post-harvest infrastructure, improved food transport, packaging and processing, increased collaboration across the supply chain, training and education of all stakeholders across the value chain.

Reduction of 25 percent in food loss and waste by 2050 would significantly reduce both demands for land and greenhouse gas emissions (Ranganathan et al., 2018).

United Nations Sustainable Development Goal 12 (SDG 12) on “Ensuring sustainable consumption and production patterns” includes a specific food waste reduction target: “by 2030, to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses”.

Preventive solutions at upstream level include resource efficient and regenerative agricultural practices, access to low-cost handling and storage facilities. Post-harvest solutions at intermediate level include increased processing of perishables (e.g. food parks), active and intelligent packaging solutions and use of technology to trace and communicate balance shelf life. Recovery solutions at downstream level include surplus food recovery through food banks, redistribution of close to shelf-life but safe food items through social supermarkets at discounted prices.

Building Food smart cities, digitalization and stronger rural livelihoods

Innovative high-tech horticulture e.g. hydroponics, vertical farming and low-tech circular economy models e.g. composting of organic matter are experiencing a rise in the urban and peri-urban areas. There are many advantages to urban farming. The land requirement is quite low, water consumption is 80 percent less, the water is recycled and saved, it is pesticide-free and in cases of high-tech farms there is no real dependency on the weather.

Other ways to strengthen local food economies is to have better urban planning, public procurement and new digital platforms to efficiently connect producers with consumers. Technologies such as automation, decision support system and agriculture robots are being widely adopted in the sector globally. Farmers are using the Internet of Things and smart sensors to get access to valuable information like soil moisture, nutrient levels, temperature of produce in storage and status of farming equipment. The sector is also ripe for the use of big data analytics and artificial intelligence, technologies that have been deployed successfully in various sectors across the globe.
Digitization is expected to be beneficial for small farmers, independent producers and consumers enabling them to make informed choices.

Agriculture employs more than half of the total workforce of the country. The share of population depending on agriculture for its livelihood consists of landowners, tenant farmers who cultivate a piece of land, and agricultural labourers who are employed on these farms. In India, as cities have grown in size and economic opportunities have increased in allied sectors, a gradual rural to urban migration has occurred in response.

Meanwhile, there is a major challenge in attracting young entrepreneurs to rural areas and keeping them there, whether for farming (increasingly knowledge-based and digital agriculture), for other nature-based activities (such as natural forest protection and restoration) or for non-agricultural businesses.

The gap between rural and urban incomes are growing and this warrants serious efforts. Key actions identified to enable an equitable transition include investment in rural infrastructure and value addition, training and capacity building, supporting the rights of women and indigenous communities.

Women can be powerful ‘change agents’ thanks to their central role in agriculture and decision making related to nutrition, health and family-planning. Promotion of gender equality should be executed in such a way to improve access of women to land, labour, water, credit and other resources.

Demographic transition is typically used to explain how population growth and economic development of a country are connected while it goes through a change from non-industrial to industrial. A salient feature of this transition is switch from a regime of high birth rates-mortality rates to low birth rates-mortality rates.

As India undergoes demographic transition, it is important to invest in education for girls and women, maternal and child health and auxiliary health systems. Life expectancy in India has undergone a significant change from 49.7 yrs (1970-75) to 69 (2013-17). Sustaining quality of life therefore becomes paramount. Unchecked urbanization and migration might become a barrier for last mile connectivity of health services. In such circumstances, women are often the first to get affected. Therefore, a gender equality lens must be applied to address demographic transition as well.
Summary

• Sustainability requires direct action to conserve, protect and enhance natural resources. It's time that we all should start looking at the choices we make and understand how the food we eat can impact our climate.

• The avoidance of the depletion of natural resources in order to maintain an ecological balance is termed as Sustainability.

• Typically, environment, economy and society form the three-pillars of sustainability. A sustainable food ecosystem would cater to all safe and wholesome food without impacting the society, economy and environment.

• The sustainability challenges in food ecosystem are lack of adequate advanced mechanisation and irrigation facilities, imbalanced application of different plant nutrients through fertilizers, resource intensive agricultural practices, lack of adequate handling and storage facilities for produce leading to food loss which ultimately converts into greenhouse gases and has a direct impact on global warming and thus affecting environment.

• Agricultural system can be made sustainable and regenerative by encouraging traditional techniques such as crop rotation, controlled livestock grazing etc., use of new advanced practices of bio-based fertilizers and pesticides and by sharing knowledge and best practices among farmers.

• A plant-based diet with few animal source foods confers both improved health and environmental benefits since meat has a significant impact on climate change with more than 20% contribution towards carbon footprint.

• Eating foods that are grown locally improves the economy in our community and also helps in maintaining sustainable ecosystem.

• More sustainable production of meat, dairy and eggs could be achieved by investing in a more diversified protein supply.

• Environment could be saved by protecting and restoring global forests. A ‘Half-earth’ strategy is recommended for biodiversity conservation i.e. conserve at least 80% of biodiversity by protecting 50% of Earth as intact ecosystems.

• Substantial reduction in food losses (supply side) and food waste (consumption level) is also essential for the global food system to ensure planetary health. Tangible steps in this direction could include improvement in post-harvest infrastructure, improved food transport, packaging & processing, increased collaboration across the supply chain, training and education of all stakeholders across the value chain.

• Investment in rural infrastructure and value addition, digitization, training and capacity building, supporting the rights of women and indigenous communities would help delivering stronger rural livelihoods.
Key Words

**Artificial intelligence** – computer systems which can handle tasks normally requiring human intelligence

**Biodiversity** – the variety of plant and animal life in a habitat

**Carbon footprint** - the amount of carbon dioxide released into the atmosphere as a result of an activity

**Cold chain** – a temperature-controlled supply chain

**Data analytics** – science of analysing raw data to make conclusions about information

**Ecosystem** – refers to the living and physical components of an area and how they are linked to each other

**Global warming** - a gradual increase in the overall temperature of the earth's atmosphere

**Greenhouse gases** - a gas that contributes to the greenhouse effect by absorbing infrared radiation. Carbon dioxide and chlorofluorocarbons are examples of greenhouse gases.

Exercises

1. Briefly explain the need for sustainability of food ecosystems.
2. Discuss the challenges faced and possible solutions for the following:
   i. Chemicals used in agriculture
   ii. Water for irrigation
3. What can be done to reduce food loss and waste in the country?
4. Why is it better to eat plant-based, local and seasonal food?
5. Write a short note on sustainable agricultural practices.
6. How can the protein supply be diversified? Discuss giving relevant examples.
7. How can rural livelihoods be protected? Why is it important to do so?

References


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Chapter 19: Approaches to a Sustainable Food System

- Reducing Food Loss and Waste
  - Occurrence of food losses and waste in Food Supply Chain
  - Trends in food loss and waste
  - Strategies to reduce food loss and waste

- Sustainable and Safer Packaging
  - Need and different types of packaging
  - Problems with different packaging materials
  - Recent safe and sustainable packaging technologies

- Reducing Water Usage in Food System
  - Importance of reducing water usage
  - Ways for minimizing water use in food industries

- Sustainable Food systems
  - Rural and urban food system
  - Inadequacies of Rural and Urban Food System:
  - Approaches for making healthy and sustainable urban food system
Chapter 19: Approaches to a Sustainable Food System

With the world’s population predicted to pass nine billion by 2050, the additional food required to feed future generations will put enormous pressure on our land and water resources. Today the world is facing a complex challenge; population growth, urbanization and rapidly developing economies are driving consumer demand for food. An expanding middle class leads to more people choosing western-style diets. These diets are high in protein, sugar and fat, all of which are expensive in terms of water for food production. At the same time there are more than two billion people living on less than US$2 per day. It is also estimated that 33% of the total food produced is lost and wasted every year (Gustavsson et al., 2011). So, there is an urgent need for switching towards sustainable food system which not only ensure the judicious use of the resources for the production of food but also ensure food for all. Keeping all these in view, this chapter aims to provide an overview to the students about the importance of reducing food loss and waste, safer and sustainable packaging, reduced water use in food processing and healthy and sustainable urban food system.

Reducing Food Loss and Waste

The Food and Agricultural Organization (FAO) reported that approximately one-third of all produced foods (1.3 billion tons of edible food) for human consumption is lost and wasted every year across the entire supply chain. The monetary value of this amount of Food Loss Waste (FLW) is estimated at about USD $936 billion, which does not include the social and environmental costs of the wastage that are paid by society as a whole. The amount of FLW is sufficient to alleviate one-eighth of the world’s population from undernourishment and address the global challenge to satisfy the increased food demand, which could reach about 150–170% of current demand by 2050 (FAO, 2018). Food loss and waste have many negative economic and environmental impacts. Economically, they represent a wasted investment that can reduce farmers’ incomes and increase consumers’ expenses. Environmentally, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished natural ecosystems and the services they provide.

According to FAO “Food loss and waste” refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people. In particular, “Food Loss” refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging, or marketing.

“Food waste” refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded either before or after it spoils. Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain and is the result of negligence or a conscious decision to throw food away.
Occurrence of Food losses and waste in Food Supply Chain

Food loss and waste apply to food products in the value chain starting from the moment that:

- Crops are ripe in the field, plantation, or orchard
- Animals are on the farm in the field, sty, pen, shed, or ready for slaughter
- Milk has been drawn from the udder
- Aquaculture fish are mature in the pond
- Wild fish have been caught in the net.

The value chain ends at the moment food products are consumed by people, discarded, or otherwise removed from the food chain intended for direct human consumption. Therefore, food that was originally meant for human consumption but is removed from the food chain is considered food loss or waste, even if it is then used as animal feed or bioenergy.

Food loss and waste can occur at each stage of the food value chain (figure 1). These stages are as follow:

Figure 19. 1: Schematic representation of Food Loss and Waste at different stages of food chain.
Some examples of how they can occur at each stage are:

- During production or harvest in the form of grain left behind by poor harvesting equipment, discarded fish, and fruit not harvested or discarded because they fail to meet quality standards or are uneconomical to harvest.
- During handling and storage in the form of food degraded by pests, fungus, and disease.
- During processing and packaging in the form of spilled milk, damaged fish, and fruit unsuitable for processing. Processed foods may be lost or wasted because of poor order forecasting and inefficient factory processes.
- During distribution and marketing in the form of edible food discarded because it is non-compliant with aesthetic quality standards or is not sold before “best before” and “use-by” dates.
- During consumption in the form of food purchased by consumers, restaurants, and caterers but not eaten

**Trends in food loss and waste**

In less-developed countries like India, FLW occurs mainly in the post-harvest and processing stage, which accounts for approximately 44% of global FLW. This is caused by poor practices, technical and technological limitations, labour and financial restrictions, and lack of proper infrastructure for transportation and storage. The developed countries, including European, North American, and Oceanian countries, and the industrialized nations of Japan, South Korea, and China produce 56% of the world FLW as shown in below table. Of this, 40% of FLW in developed countries occurs in the consumption stage, which is driven mostly by consumer behaviour, values, and attitudes. A large portion of the food waste occurs after preparation, cooking, or serving, as well as from not consuming before the expiration date as a result of over-shopping, which might be associated with poor planning and bulk purchasing. Table 1 compares the food loss and waste in developing and developed countries.
### Table 19.1: Comparison of Food Loss and Waste in Developing vs. Developed Countries

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Food Supply Chain</th>
<th>Developing country</th>
<th>Developed country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Loss (%)</td>
<td>Production</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Handling and Storage</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Processing and Packaging</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Food Waste (%)</td>
<td>Distribution and market</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Consumption</td>
<td>6</td>
<td>29</td>
</tr>
<tr>
<td>Total Food Loss and Waste (%)</td>
<td></td>
<td>44</td>
<td>56</td>
</tr>
</tbody>
</table>

*Source:* WRI analysis based on FAO. (Gustavsson et al., 2011). Global food losses and food waste—extent, causes and prevention. Rome: UN FAO.

India achieved a record food grain and horticultural production of 281 and 315 million metric tonnes (MMT), respectively in 2018-19. In addition, India produces large quantities of pulses, oilseeds, sugarcane, milk, poultry, meat and fish. According to the FAO estimates, nearly 40% of the food produced in India is lost or wasted. Food Loss and Waste (FLW) is not confined to India alone, as the FAO studies have shown that yearly global FLW is nearly 30% of cereals, 40 to 50% of horticultural crops, 20% of oilseeds, meat and dairy products, and 35% of fish (NAAS, 2019).

Other sources, such as the Food Corporation of India, report a share of losses ranging from 10 to 15 percent of the total production. The Ministry of Food Processing Industries (MFPI) estimate losses of 23 million tons of grains, 12 million tons of fruits and 21 million tons of vegetables for a total approximate value of about 4.4 billion USD while total value of food loss and waste generated is supposedly 10.6 billion USD in 2014 (Segre et al., 2014). Table 2 presents the food losses in India in the different sectors.
Table 19. 2: Food Losses in India in different food sectors

<table>
<thead>
<tr>
<th>Food Commodity</th>
<th>Losses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains (Cereals)</td>
<td>4.6-6</td>
</tr>
<tr>
<td>Fruits and Vegetables</td>
<td>4.6-15.9</td>
</tr>
<tr>
<td>Dairy</td>
<td>0.9</td>
</tr>
<tr>
<td>Meat</td>
<td>2.7</td>
</tr>
<tr>
<td>Fish</td>
<td>5.2 (Inland)</td>
</tr>
<tr>
<td></td>
<td>10.5 (Marine)</td>
</tr>
<tr>
<td>Poultry</td>
<td>7.2 (Egg)</td>
</tr>
<tr>
<td></td>
<td>6.7 (Poultry meat)</td>
</tr>
</tbody>
</table>

Annual losses in percentage of agricultural produce, milk, meat, marine and poultry products as reported by ICAR-Central Institute of Post-Harvest Engineering and Technology (CIPHET) study conducted in 2014

Strategies to Reduce Food Loss and Waste

Strategies to reduce the Food Loss and Waste depend upon integrated efforts for providing adequate infrastructure, technical support and creating public awareness for the critical loss points along the food chain from harvest to consumption. These include, harvesting/field drying, threshing/shelling, winnowing, farm storage, packaging, cold chain, transportation to market, market storage, avoiding wastage at the retailer and checking wastage in consumption. Possible strategies to prevent the Food Loss Waste at different stages in food chain are summarized in table 3.

Table 19. 3: Food Loss and Waste at Different Stages in the Food Chain

<table>
<thead>
<tr>
<th>Stage</th>
<th>Strategy</th>
</tr>
</thead>
</table>
| Production Stage            | • Government investments in infrastructure  
• Improve harvesting techniques  
• Improve market access  
• Organize extension services and educate farmers  
• Increase tax incentives for donating unsellable edible foods. |
| Handling and Storage Stage  | • Improve transportation facilities  
• Provide access to cheap handling and storage technologies  
• Invest in storage facilities (warehouses, cold storage, etc.)  
• Improve the ability and knowledge of workers to employ safe food handling practice  
• Use of appropriate and clean containers for the products. |
| Processing and Packaging Stage | • Improve capacity of process line  
• Improve packaging to keep food fresher for longer |
<table>
<thead>
<tr>
<th>Stage</th>
<th>Strategy</th>
</tr>
</thead>
</table>
| Distribution and Marketing Stage    | • Improve inventory systems  
• Establish online marketplaces to facilitate sale (donation) of perishable products  
• Change food date labeling practices and in-store promotions  
• Improve transportation vehicles  
• Provide guidance on storage and preparation of food to consumers  
• Improve the knowledge and ability of workers  
• Improve market places (storage, covered areas)  
• Interlink with research institutions to predict consumer demand changes. |
| Consumption Stage                   | • Facilitate increased donation of unsold foods from cafeterias and restaurants  
• Implement consumer education and campaigns, both nationally and regionally  
• Reduce portion sizes  
• Provide education about home economics in education institutions and communities  
• Involve women in food safe campaigns  
• Effective use of leftovers  
• Training for restaurant, cafeteria, and supermarket management to forecast customer demand and reflect demand in food purchasing to avoid bulk purchases  
• Implement good storage practices  
• Correctly interpret label dates; Distribution of excess food to charitable groups |

**Sustainable and Safer Packaging**

Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale and use. Packaging also refers to the process of design, evaluation, and production of packages. Packaging of foods is perhaps one of the most challenging industrial activities, since safety of the foods we eat is dependent upon it. Packaging is heavily integrated into our daily lives, we see it all around us, on everyday items such as chocolate bars and potato chip (crisp) packets. As explained below, the main use for packaging is protection of the goods inside, but packaging also provides us with a
recognizable logo and information, so that we instantly know what goods are inside.

Packaging can be defined as a tool that protects and contains our goods with the aim of minimizing the environmental impact of our consumption. Ideal packaging can be compared with that of a banana, orange peel, coconut and eggshell- the packaging provided by Mother Nature.

**Need and different types of packaging**

Packaging is an important tool for making a product wholesome and safe for the consumption. Packaging is a form of food preservation which not only protects the product from the external factors- air, moisture etc. but also helps in creating a perception of a product quality to the consumers. So packaging is important as it helps in maintaining the freshness and nutrition of the product (figure 2).

![Figure 19. 2: Schematic diagram showing the need of packaging.](image)

There are different types of packaging:

**Individual packaging**: This means the packaging of individual items of goods and includes the technique of application of appropriate materials and containers, etc. to protect each individual item of goods, or to increase the merchandise value as well as the conditions of the goods to which those techniques are applied. This could also be called as ‘Primary Packaging’.
**Inner packaging:** This means the inner packaging of packaged goods, the techniques of application of the appropriate materials or container, etc., with consideration of the protection of goods against water vapour, light, heat, impact, etc. as well as the condition of the goods to which these techniques have been applied. This could also be called as ‘Secondary Packaging’.

**External packaging:** This indicates the outer packaging of packed goods, in other words, the techniques of placing the goods in a box, bag or other container such as a barrel or can, etc., or bundling without the use of a container, and adding markings to identify the goods as cargo; as well as the conditions of application of these procedures. This could also be called as ‘Tertiary Packaging’. In case of food packaging, the word ‘goods’ can be substituted by ‘food’.

**Status of Packaging Industry in India**

The packaging industry in India is very dynamic and influences all other industries directly or indirectly. The packaging industry, which stood at $32 billion in 2015, had grown at a compound annualized growth rate (CAGR) of 15 percent for the last five years, and is expected to continue growing at a CAGR of 13 to 15 percent in the coming years. According to the Packaging Industry Association of India, the Indian packaging industry was the fifth largest in the world in 2016.

The Indian packaging industry constitutes about 4 percent of the global packaging industry. The industry is underpenetrated, and thus offers significant business opportunities, since India’s per capita packaging consumption is only 10.5 kg per year, as compared to 109 kg in the U.S., 65 kg in Europe, 45 kg in China and 32 kg in Brazil.

Different kinds of packaging material are depicted in figure 3.

| Flexible Packaging | • Paper  
|                    | • Paper Board  
|                    | • Aluminum Foil  
|                    | • Plastic  
| Rigid Packaging:  | • Glass Container  
|                    | • Metal container  
|                    | • Plastic container  
| Semi-Rigid Packaging: | • Folding Carton  
|                     | • Lined Carton  
|                     | • Aseptic Carton  

*Figure 19. 3: Different kinds of packaging materials*
Problems with different packaging materials

Out of all types of packaging material plastic is widely used for packaging of food. It is estimated that worldwide production of plastics was approximately 322 million tons in 2015 which is a 3.5% increase as compared to 2014. In 2014–15, India produced 8.3 million tons of plastics and about 43% of annually produced synthetic polymers are utilized by packaging industry, which is more than the world average of 39%. According to statistics at present, about 99% of all plastic materials are manufactured by the petrochemical industries, i.e., they are produced from petroleum based (non-renewable) resources. Production and processing of plastics are energy exhaustive processes; those lead to increased emissions of greenhouse gases (GHGs) of enormous magnitude contributing to global warming. Moreover, plastics on burning release venomous emissions such as carbon monoxide, chlorine, hydrochloric acid, dioxin, furans, amines, nitrides, styrene, benzene, 1, 3-butadiene, and acetaldehyde which pose threat to environment as well as to public health. Apart from degrading air quality, plastics generate lots of waste after use that has adverse effects on environment (leaching of chemical in aquifers, soil pollution). Waste generated from the plastics has been a pressing problem for many years because of their resistance to degradation (Yadav et al., 2018).

This marine and soil litter of plastic first degrades into micro and then into nano-sized particles that could thus easily penetrate into living organisms such as fish and then be fed up the food chain, all the way to humans with dramatic deleterious long-term adverse effects. Researchers have estimated that if production and use continue within the current linear framework, and if nothing is done by 2050 there may be more plastic than fish in the ocean, by weight (World Economic Forum, 2016).

To tackle issues related to oil-based packaging, a lot of attention has been paid to raw materials to replace non-renewable oil resources. However, currently marketed bio-sourced bioplastic (such as Bio-PE, PLA, and more) use food resources such as corn or cane sugar. They contribute to increased food security concerns and pressure on agricultural land. Moreover, most of these bio-sourced bio-plastics are not biodegradable nor home-compostable (bio-PE, bio-PET) or are fit only for industrial composting (PLA) which contributes to complicating the waste management: separate collecting and sorting of these materials are thus needed (Endah, 2018).

Therefore, there is an urgent need of an innovative safer and sustainable packaging which aims to address food waste and loss reduction by preserving food quality, as well as food safety issues by preventing food-borne diseases and food chemical contamination. Moreover, it must address the long-term crucial issue of environmentally persistent plastic waste accumulation as well as the saving of oil and food material resources.

Recent safe and sustainable packaging technologies

Sustainable packaging is packaging which:

1. Is beneficial, safe and healthy for individuals and communities throughout its life cycle;
2. Meets market criteria for performance and cost;
3. Is sourced, manufactured, transported, and recycled using renewable energy;
4. Maximizes the use of renewable or recycled source materials;
5. Is manufactured using clean production technologies and best practices;
6. Is made from materials healthy in all probable end-of-life scenarios;
7. Is physically designed to optimize materials and energy; and
8. Is effectively recovered and utilized in biological and/or industrial cradle-to-cradle cycles.

### Principle of sustainable Packaging

The Australian-based SPA has developed four principles for sustainable packaging (SPA, 2005):

1. **Effective: social and economic benefit.** The packaging system adds real value to society by effectively containing and protecting products as they move through the supply chain and by supporting informed and responsible consumption.

2. **Efficient: doing more with less.** The packaging system is designed to use materials and energy efficiently throughout the product life cycle. Efficiency can be defined through reference to world’s best practice at each stage of the packaging life cycle.

3. **Cyclic: optimising recovery.** Packaging materials used in the system are cycled continuously through natural or industrial systems, with minimal material degradation. Recovery rates should be optimised to ensure that they achieve energy and greenhouse gas savings.

4. **Safe: non-polluting and non-toxic.** Packaging components used in the system, including materials, finishes, inks, pigments and other additives, do not pose any risks to humans or ecosystems. When in doubt the precautionary principle applies.

Figure 4 outlines the principles of sustainable packaging.
Some recent safer and sustainable packaging technologies are:

**Bio-degradable Plastic:** Biopolymers or bioplastics are intrinsically biodegradable and their use would reduce the damage inflicted to the environment by petrochemical plastics due to their extended lifetime in the environment. They are polymers utilized by bacteria as carbon and energy reserve material and accumulated by them when other essential nutrients are depleted from the medium. Plant derived starches has been used to produce biodegradable plastic articles viz. pharmaceutical capsule by blow molding process. Further sources of biodegradable materials are poly lactic acid, poly malic acid, or poly (ε-caprolactones), which are synthesized chemically. In contrast, poly B-hydroxy alkanoates (PHAs) are produced microbially from renewable, plant-derived feedstock. It can be processed by traditional techniques used in the plastic industry viz. injection moulding, PHA has the potential to become an important source material for biodegradable plastics. It has been estimated that in the year 2002 only 3% of the estimated annual 15 million tonnes of plastic-packaging waste were biodegradable.

Sources of biodegradable plastic are:
- Biopol polymers: produced by fermentation of carbohydrate by the bacterium *Alcaligenes eutrophus*.
- Poly (L-lactide): derived directly or indirectly from starch or sucrose.
- Starch based materials: incorporation of starch into traditional plastics.
- Cellulose-based: microbial cellulose is mixed with chitin, chitosan, CM-cellulose guar gum, collagen, dextran and gelatin.
- Pectin-based: Reaction of pectin with polyol like glycerol, sorbitol propylene glycol and ethylene glycol.

- Pullulan: Microbial polysaccharide is synthesized by the fungus *Aureobasidium pullulans*.

- Poly hydroxyalkanoate (PHA): bacterial polyesters.

**Edible Packaging:** Edible films and coatings are based on proteins, polysaccharides and/or lipids have much potential for increasing food quality and reducing food-packaging requirements. Edible films formed as coating or placed between food components provide possibilities for improving the quality of heterogeneous foods by limiting the migration of moisture, lipids, flavour/aromas, and colours between food components. Edible coatings also have the potential for maintaining the quality of foods even after the packaging is opened. In addition, edible films formed as coatings on foods could have an impact on overall packaging requirements. Edible coatings also have the potential for carrying food ingredients and improving the mechanical integrity or handling characteristics of the food.

Materials for Edible Films are shown in figure 5.

![Materials for making Edible films](image)

**Figure 19. 5: Materials for making Edible films**

**Requirements of Edible Films and Coatings**

These edible films and coatings should:

- prevent product dehydration.
- control transmission of gases, vapour and solutes.
- provide mechanical protection to foods.
- restrict microbial invasion.
- have good mechanical properties.
• serve as a carrier for additives, viz. antioxidants, antimicrobial agents, flavours, colouring, nutrients, etc.

• conform in composition to the regulations those apply to the food product concerned.

Reducing Water Usage in Food System

We often consider the carbon footprint of our food, but most of us don’t consider the water footprint. Water scarcity is increasing; in a climate-changed world, water stress is becoming more widespread. Rainfall and water availability are likely to become more uncertain, with significant consequences for food production.

Importance of reducing water usage

Food production is reliant on water, with an estimated 70% of all extracted freshwater used for agriculture alone. A further 20% is used in the production and processing industries, leaving just 10% for domestic use e.g. drinking water (IChemE).

An estimated 97% of water is stored in our oceans as saltwater; just 3% of all water on earth is fresh water and the majority of it is found in glaciers and ice caps (figure 6). Reliance on freshwater for the maintenance of life places strains on this limited resource. Population growth will require 60% more food by 2050 and thus a 19% increase in agricultural water use. The water consumed in the production of an agricultural or industrial product is termed ‘virtual water’.

Studies have shown that these pressures on freshwater will continue to increase due to a combination of climate change, increasing population and socioeconomic demands. At present 7% of the world’s population live in water scarce areas. With population expansion, it is anticipated that 67% will live in water scarce areas by 2050 (McKinsey, 2009). Future increases in food production will be required to feed the population and increased production will need larger water supplies. It is estimated that global water withdrawal will grow from 4,500 billion m3/year to 6,900 billion m3/year by 20305; a 53% increase in water extraction (WRAP UK, 2014).
Ways for minimizing water use in food industries

Water is important to the food-processing industry for many reasons. In most foods, water is the primary ingredient or constituent. Water is extensively used in most food plants as a processing aid and for clean-up and sanitizing. Conservation and reuse of water saves money and reduces a food company’s exposure to rising water costs and potential shortages.

Determining Water Usage

One of the first steps in a water use reduction program is to develop an understanding of how water is currently being used in a food-processing facility. A water balance, or audit, may be conducted to track the input and output of water used throughout a facility. The balance should be comprehensive and may include the following areas or uses:

- Process operations such as cooling, cooking, size reduction, evaporation and cleaning
- Utilities, such as steam and condensate losses

Source: Institution of Chemical Engineers (IChemE), Green Paper
• Leaks
• Sanitary use
• Waste streams
• Laundry
• Minimizing Water Use

Four main areas in food-processing facilities should be considered for minimizing water use (figure 7):

Figure 19. 7: Areas where water use can be minimized in a food industry

**Sustainable Food Systems**

Food systems include all the interconnected activities of agriculture, forestry or fisheries involved in the production, aggregation, processing, distribution, consumption and disposal of food products (FAO, 2018). Food system does include a single system, but it is composed of various sub system (e.g. farming system, waste management system etc.). Sustainable Food System is a food system which ensures nutritious food for all without compromising the food needs of future generations. SFS is comprising of three pillars which are as follow:
• **Economic Sustainability**: Generate jobs/incomes and profits

• **Social sustainability**: Nutritious and healthy food for all population

• **Environmental sustainability**: Reduction in carbon footprint, water footprint and food losses, improvement in soil and plant health

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**Rural and urban food system**

Let us examine the rural and urban food systems and see how they differ.

**Rural Food System**

The global rural population is now close to 3.4 billion and is expected to rise slightly and then decline to 3.1 billion by 2050. Africa and Asia are home to nearly 90% of the world’s rural population in 2018. According to UN (2018), India has the largest rural population (893 million), followed by China (578 million). Rural Food System consist of diverse local food systems that provide the foundations of rural people’s nutrition, incomes, economies and culture. In rural India local food system is predominately food production system (farming) where farmers are growing food that is locally acceptable by utilizing the local available resources. Much of grown food is consumed at the household level and small surpluses sold in the local markets. In this way each link in the food chain offers economic niches for many more people such as millers, carpenters, iron workers and mechanics, local milk processors, bakers, small shopkeepers etc. The livelihoods and incomes of a huge number of rural dwellers are thus dependent on the local manufacture of farm inputs and on the local storage, processing, distribution, sale and preparation of food (Pimbert, 2005).

**Urban Food System**

The world is experiencing unprecedented urban growth. Today, over half of the global population is urban and by 2050 an additional 2.5 billion people are expected to live in urban areas. According to census 2011, Level of urbanization increased from 27.81% in 2001 Census to 31.16% in 2011 Census. Indian urban population was estimated at 37.7 crores in 2011.

An urban food system can be conceptualized as “a set of activities ranging from production through to consumption. These activities include production, processing and packaging and distribution, retailing and consumption. Distribution and retailing are particularly important parts of urban food systems; they include “all activities involved in moving the food from one place to another and marketing it”. It is important to note that food in urban areas is overwhelmingly purchased rather than produced by households. The final set of activities in urban food systems relate to the consumption of food, which includes “everything from deciding what to select through to preparing, eating and digesting food”.

A well-functioning urban food system can be regarded as one that ensures a high level of food security to residents, while simultaneously contributing to sustainable social and economic development. Food security can be defined as being when “all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO, 2009: 1). Food
Safety and Standards authority of India (FSSAI) is the statutory body under Central Government which ensures food safety in India.

Poor urban dwellers face unique nutritional challenges around accessing nutritious food, adequate employment, social protection, and adequate water, sanitation, and hygiene facilities, all of which affect food security and nutrition. With rapid urbanization and globalization, people’s daily diets are changing:

- Urban populations tend to consume **more calories**, yet a lower proportion of these calories comes from cereals or carbohydrates and more comes from fat.
- Urban populations consume more meat and other protein, or consume different animal protein sources than rural counterparts, but **less dairy**.
- They also consume **more fruits and vegetables** overall, though consumption of these food groups differs between richer and poorer urban populations.
- Urban dwellers consume more non-basic foods, including **sugary snacks** among children, food away from home, and **processed foods**.

IFPRI report, found that 66% of households consume packaged snacks high in fat, with two-thirds consuming these daily. With more people adopting ‘urban diets’, there have been some changes in the food supply chain also. For instance, the move away from staples such as rice and wheat to vegetables, fruits, dairy, meat and fish requires more infrastructure such as cold storage, etc. There is also a growing preference for retail supermarkets over traditional markets among urban consumers.

**Inadequacies of Rural and Urban Food System**

Rural food system is characterized by food production system, but in today’s time farming is losing its charm and is no longer a family pursuit. It has become more and more dependent on external inputs like seeds, water, pesticides etc. Excessive use of pesticides and ground water for increasing crop yield resulted in degradation of environment and depletion of water resources. It is estimated that agriculture alone accounts for roughly 70 percent of global freshwater withdrawals and causes water pollution. Food Production system is also a major contributor of greenhouse gases (GHG) emissions. According to FAO report, at present food systems are responsible for a significant share (20-35 percent) of greenhouse gas emissions.

Urban food system in India is now facing with the twin-burden of under- and over nutrition. Comprehensive National Nutrition Survey (CNNS), a cross-sectional, household survey covering more than 1,10,000 children and adolescents (0-19 years) in both urban and rural areas across all 30 states of India showed that 35% of children under the age of five are stunted (low height-for-age) and 17% are wasted (low weight-for-height), whereas in school going children (5-9 years) 22% are stunted and 4% were overweight or obese. In India, rapid increase in urbanization led to changes in the dietary patterns. Now people in cities are moving from plant-based diets to diets with a higher proportion of energy from...
animal-source foods, added sugars and fats which is a major cause of diet related non-communicable diseases (NCDs) such as diabetes and cardiovascular diseases. CNNS report (2019) revealed that around 10% of children in the age group of 5 to 9 years and adolescents in the age group 10 to 19 years are pre-diabetic and 5% suffered from blood pressure.

Approaches for Making Healthy and Sustainable Urban Food System

Government has an important role to play in creating healthy public policies and supportive environments to facilitate access to safe, affordable, nutritious food. Urgent and coordinated action is required to support government to make food systems more efficient, inclusive and resilient to price volatility, weather shocks and climate change in times of rapid urbanization. In order to tackle the menace like malnutrition and other nutrient related diseases Government of India has started various national schemes including rural and urban development which are listed below:

- **Targeted public distribution system (TPDS)**- Food distribution system providing subsidized ration to people belonging in BPL category both in rural and urban areas.

- **Mid-day meal scheme (MDM)**- Established to provide hot cooked meal to primary school children in schools run by various government bodies to ensure both nutrition of children and attendance in school.

- **ICDS**- Started in 1975 under Ministry of Women and Child Development, it provides supplementary food, vaccination, primary education, health facilities to children below 6 years and pregnant, lactating women and adolescent girls. Anganwadi centres are established to provide education, supplementary food to its beneficiaries in both rural and urban areas.

- **Poshan Abhiyaan**- Poshan Abhiyaan is India’s flagship programme to improve nutritional outcome for children and other beneficiaries by leveraging technology, a targeted approach and convergence.

- **'Eat Right India’,** started by FSSAI, built on three broad pillars of ‘Eat Healthy,’ ‘Eat Safe’ and ‘Eat Sustainable’, aims to engage, excite and enable citizens to improve their health and wellbeing. It is a collective effort to make both the demand and supply-side interventions through the engagement of key stakeholders. The movement provides citizens with information like their nutrient requirements, what to eat, when to eat, and how to lower the intake of sugar, salt and fat.

- **FSSAI established a Food Fortification Resource Centre (FFRC),** as a 'resource hub' to promote fortification of food as part of its mandate to assure "safe and wholesome food" to all.

In order to make Rural Food System more sustainable Government of India is taking various steps such as:
- Improving **connectivity and marketing** infrastructure in rural areas.
- Linking farms to markets through **contract farming**.
- **Diversification** out of staple grains towards high-value agriculture (fruits, vegetables, livestock)
- Increasing access to technology adoption for sustainable intensification
- Making agriculture production systems **climate-smart**

Apart from Government policies and schemes an individual can also contribute for maintaining the sustainability of food system by adopting a sustainable healthy diet. According to FAO/WHO (2019) **Sustainable Healthy Diets** are dietary patterns that promote all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, affordable, safe and equitable; and are culturally acceptable. A healthy diet is very effective in preventing malnutrition, diet related NCDs and promote over all well-being. Some tips for a healthy diet are listed below:

- Eating whole grains, legumes and a handful of nuts.
- Daily intake of at least one seasonal fruit.
- Reduction in intake of highly processed food and drinks (rich in fat, sugar, salt).
- Drinking safe and clean water
- Avoiding/Restricting oily and fried food in a diet.

Despite the big increase in world food production, there are still more than 800 million people who are chronically malnourished, 33% of the total food is lost and wasted, and there is a need of 6,900 billion m3/year water by 2030. Added to that, this growth in production has been accompanied by growing pressure on the environment. Understanding of the fact that the present food system is unsustainable is gradually increasing among scientists, institutions, businesses, policy makers, and citizens. Therefore, developing appropriate strategies to reduce food loss and waste, need for safer and sustainable packaging, reduced water use in food processing and healthy and sustainable urban food system are some of the most important issues related to sustainable development. A judicious use of resources can help find solutions that will provide the world's growing population with a sufficient supply of healthy food within the environmental limits.
Summary

This chapter covered the different approaches to sustainable food system in terms of reducing food loss and waste, safer and sustainable packaging, reduced water use in food processing and healthy and sustainable urban food system which can be summarized as below:

- The Food and Agricultural Organization (FAO) reported that approximately 1.3 billion tons of edible food for human consumption is lost and wasted every year across the entire supply chain.

- Food loss and waste occurs at different stage of the food value chain such as production stage, handling and storage stage, processing and packaging stage, distribution and marketing stage, consumption stage.

- Strategies to reduce the Food Loss and Waste depend upon integrated efforts for providing adequate infrastructure, technical support and creating public awareness for the critical loss points along the food chain from harvest to consumption.

- Packaging is utmost important in preserving and extending the shelf life of the food products. Plastic is widely used in packaging of food products but it poses threat to environment as well as to public health because of their resistance to degradation.

- To make food packaging safer and sustainable people are working on innovative techniques of food packaging such as biodegradable and edible packaging.

- Apart from packaging, water is also an integral part of food processing industries. With depleting water resources, it is imperative to save and conserve water usage for processing of food.

- In food-processing industries for effective and efficient water usage various points need to be considered such as process of manufacturing food, equipment used, facility and personnel training for proper water use.

- Food system plays an important role for overall development of human beings. In India we can find both rural and urban food system. Various surveys such as Comprehensive National Nutrition Survey (CNNS) show that India’s rural and urban food system is now facing the twin-burden of under and over nutrition. To combat this Government of India has started various national schemes such as Mid-day meal scheme, Poshan Abhiyaan etc.
Key Words

**Bio-degradable Plastic**: Plastic that can be decomposed by the action of microorganisms.

**Comprehensive National Nutrition Survey (CNNS)**: It is a survey carried out by Ministry of Health and Family Welfare to assess the malnutrition burden amongst children and adolescents in India.

**Edible Packaging**: It is a king of packaging which can be eaten along with the food product.

**FAO**: Food and Agriculture Organization is a specialized agency of United Nations that leads international efforts to defeat hunger.

**Food Loss**: Food loss refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer.

**Food Waste**: Food waste refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded either before or after it spoils.

**Green House Gases (GHGs)**: Gases such as carbon dioxide, methane, nitrous oxide, water vapour etc. that causes greenhouse effect.

**Packaging**: Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale and use.

**Sustainable Food System**: It is a food system which ensures nutritious food for all without compromising the food needs of future generations.

**Urbanization**: It refers to the increasing number of people that live in urban areas.

**Water Footprint**: It is the amount of the water utilized in the production or supply of goods and services used by a particular person or group.

Exercises

1. What do you mean by the terms - Food loss and Food Waste? Describe in brief about food loss and waste in the Indian context?

2. Discuss the food losses and waste in different steps of food chain with suitable examples.

3. What are the strategies for reducing food loss and waste?

4. Describe in brief about the need for packaging of food.

5. Define the sustainable packaging and list the four principles of sustainable packaging.

6. Write a short note on edible and biodegradable packaging?
7. Describe giving details of the areas in food-processing facilities for minimizing water use.

8. List the three pillars of a sustainable food system?

9. Discuss the short comings of Indian rural and urban food system with the help of CNNS data?

10. Write a short note on various national schemes and steps taken by Government of India for making rural and urban food system more sustainable?

Activity:

1. Visit United Nation, FAO, and UNICEF official website and read their latest reports on sustainable development goals, sustainable food system, global food losses and waste and malnutrition.
2. Visit a food industry and look at the usage of water during processing of food. Observe how water is recycled in a food industry.

Reference


Useful Weblinks