Chapter 18: Food Ecosystem and Sustainability

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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).

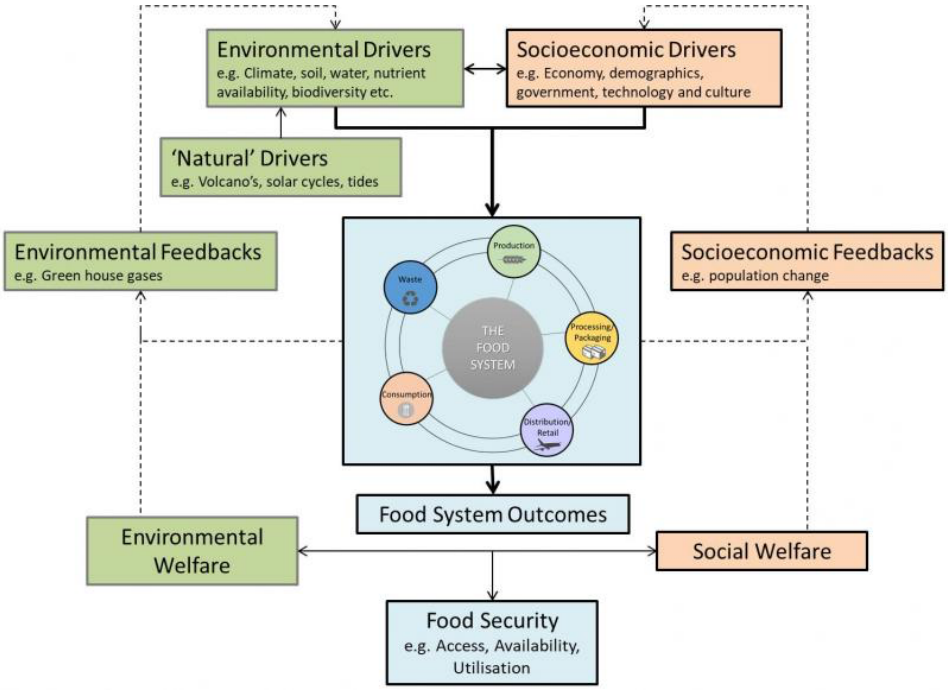

Figure 18. 1: Integration of drivers in a food system

(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.

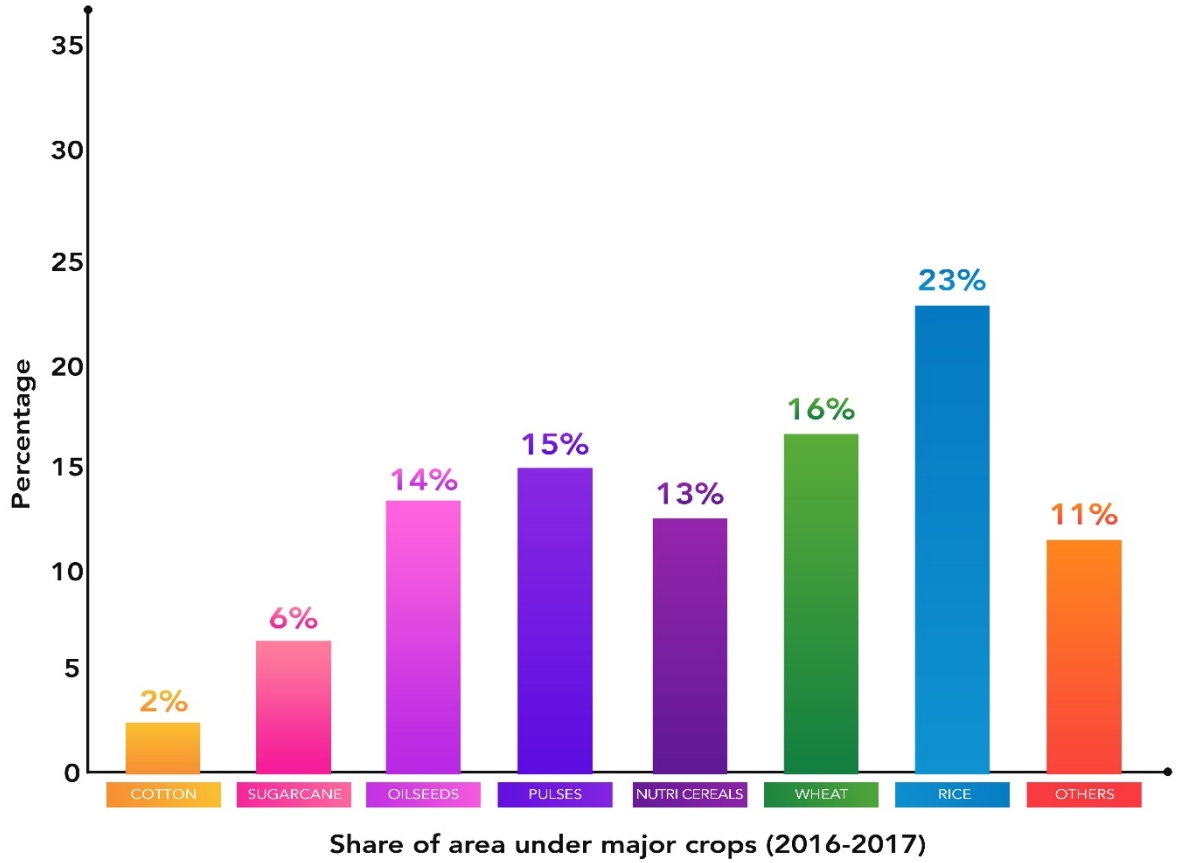

Figure 18. 2: Percent Share of Area Under Major Crops in India

Source: Directorate of Economics & Statistics, Ministry of Agriculture and Farmer's Welfare, GOI (2017)
http://agricoop.nic.in/sites/default/files/pocketbook_0.pdf

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.

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'.

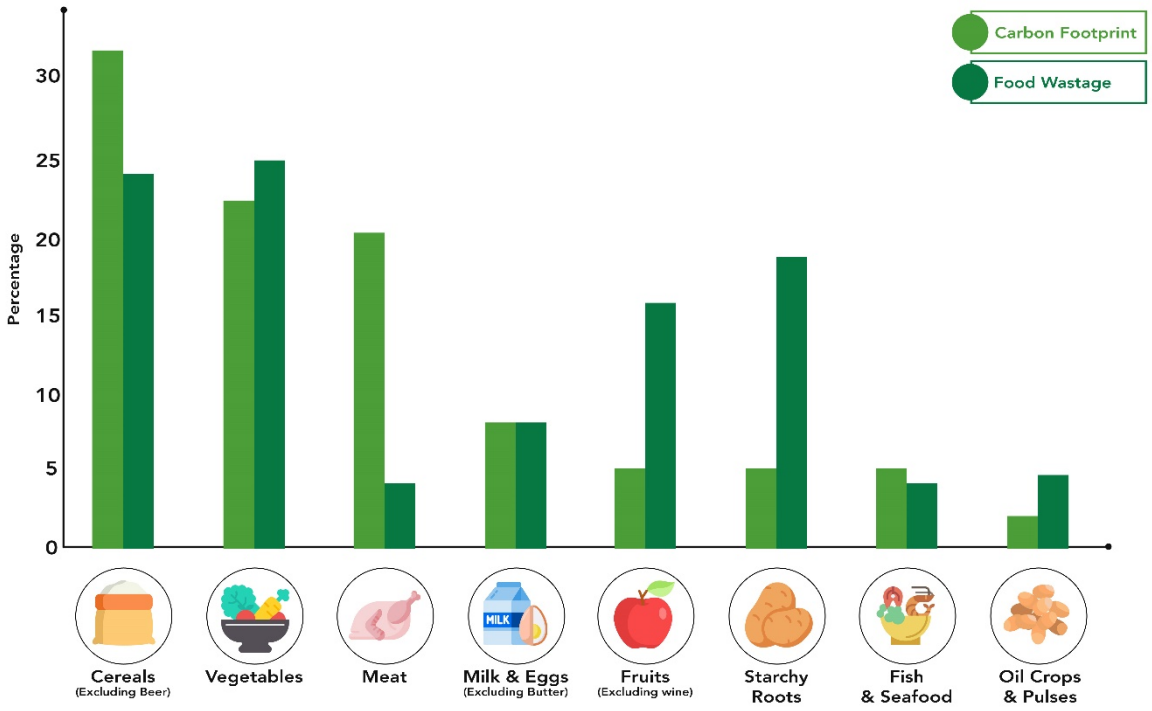

Figure 18. 3: Global contribution of food commodities to carbon footprint and wastage

Source: FAO. Food Wastage Footprint and Climate Change
http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/FWF_and_climate_change.pdf

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.

> Uzhavan app, Ag mobile, CCMobile app, IFFCO Kisan are some of the applications developed keeping in mind the need of the hour requirements in farming. Several notable initiatives like e-choupal, Agri market, Kisan Suvidha and the more recent e-NAM had long been trying to place agriculture as the forerunner.

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, digitization 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?

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