

Sustainable Food Systems: The Way Forward in the Indian Context

ABHISHEK CHAUDHARY

Department of Civil Engineering, Indian Institute of Technology (IIT), Kanpur, Uttar Pradesh.

Correspondence to: Dr Abhishek Chaudhary, Department of Civil Engineering, Indian Institute of Technology (IIT) Kanpur 208 016, Uttar Pradesh. abhishekc@iitk.ac.in2

Current Indian food system is not sustainable as it fails to fulfil its primary function of delivering adequate nutrition to its population while causing high environmental impacts along with widespread poverty among farmers. Here, we discuss how recent research has enabled quantification of a country's current food system sustainability through multiple indicators across nutrition, environmental, and economic dimensions. This data can be used by policy makers, farmers, businesses, consumers, and other stakeholders to make scientific evidence-based informed decisions regarding which diets and food items to promote or discourage in near future to make progress towards sustainability. While several government initiatives are underway to transform Indian agri-food sector, the need of the hour is multi-sectoral collaboration across ministries along with dietary behavior changes by consumers, and innovations in agri-tech and food formulations by businesses to make farm production more efficient and products more nutrient dense.

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Food system of a country includes activities related to producing primary crop and livestock products, their processing into secondary products, consumption of food by the population, its disposal and all transport, storage, retail, and other logistics activities involved in this cycle [1]. Like other countries, India's success in achieving the 17 Sustainable Development Goals (SDGs) by the year 2030 depends heavily on the performance of its food system in this decade [2,3]. Recent research has enabled quantification of a country's food system sustainability through multiple indicators across nutrition, environmental, and economic dimensions through which one can track its progress over time [1]. Within India, National Institution for Transforming India (NITI Aayog) has started to publish the annual report on progress of each of its 36 States and Union Territories towards 17 SDGs employing 65 indicators, each varying between 0 to 100 (<https://sdgindiaindex.niti.gov.in/>). At present, the Indian food system fails to fulfil its function across all three of these dimensions as evident from quantitative indicators summarized below.

CURRENT STATUS OF FOOD SYSTEMS SUSTAINABILITY

On the environment side, Indian food systems are responsible for huge impacts on every domain of the environment such air, water, land, biodiversity, climate, resources, human health etc. Almost 60% of the total country's land area is under cultivation often yielding multiple crops in a

year and utilizing around 90% of country's total freshwater consumption leading to soil degradation, salinization, and groundwater depletion in many places [4,5]. Agriculture is responsible for 18% of the total national greenhouse gas (GHG) emissions causing climate change, next only to energy sector, mainly due to a large livestock population, high fertilizer application rates, large area under rice cultivation, and widespread burning of crop residues [6]. It is thus a key sector where improvements are needed if India is to meet its GHG emission reduction commitments under Paris Climate agreement. Land use for agriculture production is the number one threat to the biodiversity in the country as it encroaches upon the natural habitat of numerous species and drives them to the brink of extinction [7]. The nitrogen, phosphorus and potassium fertilizer use per hectare has increased many times over past six decades costing the country foreign exchange due to their imports and their run-off has led to contamination of the land and water resources threatening human health along with both the terrestrial and aquatic species [8,9]. Another externality due to imbalanced use of fertilizers by farmers is that the soil has become deficient in micronutrients such as iron, zinc, and manganese, which are essential for human growth, especially in children.

The primary function of any country's food system is to fulfill the nutritional requirements of its population. Despite high environmental impact and high production volumes of cereals and other crops, around 30% of world's stunted and 45% of world's wasted children are in India

alone [10]. Despite rising incomes, a huge proportion of population still suffers from deficiency of one or more essential vitamins and minerals [5,11]. While inability to afford nutritious food is the main reason for this, even the households with sufficient income to afford healthy diets are deficient in micronutrients due to their everyday food choices and consumption behaviors. The malnutrition problem of India is even worse than many countries with even lower income levels than India such as its South Asian neighbors (e.g., Nepal) and many Sub-Saharan Africa countries. In parallel, overweight and obesity cases are on the rise leading to increasing number deaths due to non-communicable diseases such as diabetes, stroke, cancer, heart ailments etc. [12].

On the economic side, more than half of Indian population is engaged in food sector but it contributes less than 20% to national annual gross domestic product, with majority of farmers living in poverty [13]. The current proportion of farm households with income below poverty line stands at 23% at the national level and as high as 45% in certain eastern states such as Jharkhand, Odisha, and Bihar. One of main reason for this is that around half (45%) of farmers in India are marginal and small land holders (i.e., owning less than one and two hectares of agriculture land, respectively) and just 10% are large land holders (i.e., owning >10 hectares). This proportion is as high as 80% in states such as West Bengal, Kerala, Bihar, and Tripura [13]. Moreover, due to lack of access to education, credit, infrastructure and technology, yield gaps (kg/ha) of major crops are high in India, leading to smaller profits for farmers. There also exist a large disparity in income of farmer and non-farm worker with the latter earning three times more than the former. Worse still, this disparity has not changed over the past 40-year period and the country has witnessed agrarian distress and widespread farmer suicides in recent decades [13]. In this background, the government set the goal of doubling the farmers' income by 2022 compared to 2015 levels but it did not achieve it.

In sum, meeting the nutritional needs of ever-growing population of children and adults in the face of looming water scarcity, cropland expansion constraints and climate change effects such as irregular rainfall and extreme events, is a major challenge for Indian food systems in coming years [14]. In the past, the focus in India was on simply producing enough food to feed the population with adequate calories (Green revolution period) followed by some calls for nutrition-sensitive agriculture [12] but at present, it is clear that the food systems in India needs a paradigm shift towards sustainability to improve its efficiency and tackle the triple challenge of producing adequate nutritious food for country's population without harming the environment,

while increasing the farmers income and contribution to the national gross domestic product.

THE WAY FORWARD FOR FOOD SYSTEMS SUSTAINABILITY

Recent advances in sustainability data analytics and development of multiple indicators of sustainability has enabled scientists to design region-specific sustainable and optimized diets that are nutritious, affordable, culturally acceptable, and whose footprints are within environmental planetary boundaries (e.g., EAT-Lancet reference diet [3]). For India, such optimization research has suggested the % by which the consumption of different food items in different states need to increase or decrease such that individual diets meet the nutritional needs as well as environmental planetary boundaries [11]. They found that on average, across the country, the daily per capita intake of vegetables, fruits, pulses, nuts, and coarse grains (e.g., millets, sorghum, barley, maize) need to increase by more than double the current intake amounts while the intake of sugar, rice, wheat, and oils needs to decrease substantially for meeting the national nutrition and environmental goals [11]. This also entails huge reductions in intake of junk food and discretionary items high in bad nutrients.

Many data resources are now available online that can inform individuals on the nutrient content of different food items, thus aiding in choosing one product over the other (e.g., <https://www.nutritionvalue.org/>). Individuals and government can also leverage the ongoing research on ranking, profiling and prioritizing food items that are nutrient dense and have lower impact on the environment than traditionally consumed items [11,15-18].

For example, a comparison of data on the environmental footprint, nutrient content, and price of one serving (30 grams) of five major cereals of India (rice, wheat, maize, millet, and sorghum) reveals that compared with currently popular cereals such as rice and wheat, one serving of millet is relatively cheaper, richer in protein, fiber, essential minerals (calcium, iron, magnesium, potassium, zinc, copper, selenium), and vitamins (B1, B2, E, K, choline) and has lesser water (irrigation) and fertilizer requirements (nitrogen and phosphorus) [5,11]. Similar inferences can be drawn for individual items within other food groups such as pulses, nuts, dairy, meat etc. based on relevant data. Such data-driven information can be used by consumers, businesses, and government to promote sustainable items and discourage unsustainable items from the country's food system.

To improve the accuracy and reliability of such estimates of sustainable diets and food items, more invest-

ments are needed in near future to increase data collection efforts on environmental footprints, nutrition content of individual food items and dietary intake values of population at finer spatial scale such as households, village, and district level and other parameters. This is summarized in **Box I**. For example, there is a huge gap in our understanding of environmental footprints of food items produced in India and their nutrient contents after processing. Private retail supermarket companies in several foreign countries have already commissioned scientific studies on profiling the food items sold by them through nutrition and environmental footprints data [19]. This data is then used by them to improve the sustainability profile of their products along their supply chain. Indian retailers need to follow suit and aim to include more sustainable items in their product portfolio. The government and funding agencies need to invest more in data collection, research, and development to fill the above mentioned gaps.

Government can also use such data on multiple indicators of sustainability to increase the minimum support price (MSP) of crops such as millet to encourage farmers to grow them in place of rice and wheat without incurring financial loss. One such initiative based on scientific data is Indian government's declaration of 2018 as the Year of Millets to achieve a win-win scenario for nutrition and environmental outcomes [20]. More such efforts offering financial incentives for farmers are needed to make a shift towards producing sustainable food items and ensuring these items are affordable to public. Such items should be promoted through education campaigns and included in schemes such as public distribution system (PDS). These efforts need to be complemented with food and bio fortification programs [21]. Investments to improve logistics and cold storage infrastructure are also need of the hour to avoid current loss of around 30% of food from farm to consumer.

Several government initiatives are underway to trans-

form Indian Agri-Food sector [2]. On the production side, this includes initiatives such as National Mission on Sustainable Agriculture for improving water and nutrient efficiency and soil health, PM-KISAN scheme for income support to farmers, MGNREGA scheme for mitigating water scarcity in rural areas, establishment of Agri-Infrastucture Fund, crop insurance schemes (PMBFY), scheme for improving food processing and supply chain efficiency (PM-SAMPADA), scheme for promoting solar energy use at farms (PM-KUSUM), programs to improve crop seed varieties, schemes for improving livestock and fisheries production efficiency and so on [2]. On the consumption side, government runs Targeted Public Distribution System (TPDS) for adults and Mid-Day Meal (MDM) schemes for school children under the National Food Security Act (NFSA). In addition to central government, several agri-sustainability initiatives have also been undertaken by individual states of India [2].

However, the success of these government efforts will depend upon the cooperation from food producers, consumers, and businesses. Farmers need to leverage incentives offered by above schemes to diversify their crop production and improve farm efficiency given India has one of the highest yield gaps in the world. Learning from the government's education campaigns and programs, the individual consumers need to make changes to their current dietary behaviors to adopt sustainable food items.

Complementing efforts by government and individual consumers, businesses have a big role in maintaining a trend towards producing and consuming sustainable food items. On the production side, advances in Agri-Tech are needed to fill the yield gaps, increase farm, and supply chain efficiency [22]. On the consumption side, businesses need to come up with innovative product formulations such that snacks, bread, noodles, and other items popular with consumers contain healthier and sustainable

Box I Data Analytics to Inform Food System Sustainability: Improvements Needed and the Way Forward

- Improved data on current dietary behaviors including high-resolution food intake, representing variety of demographics and geographic regions of the country.
- Improved data on nutrient content (vitamins, minerals, macronutrients) of raw and processed food items and their digestibility, bioavailability.
- Improved data on location-specific environmental footprints (impacts on air, water, land, biodiversity, human health) or individual food items calculated using life cycle assessment (ICA) methodology.
- Improved data on location-specific cost of producing food items by farmers, their market prices, farmer's profit per food item, value addition along supply chain.
- Improved data on what foods are culturally acceptable for consumption in different regions and what barriers exist for farmers to diversify crop production.
- Development of easy to use apps and web interfaces that takes above quantitative data as inputs and allows user to evaluate consequences of alternative policies, behaviour change and scenarios.

ingredients like millet or lentil flour in place of refined wheat (maida) or rice without compromising the price and taste [23].

Overall, there is no silver bullet or a single actor that can trigger the paradigm shift of Indian food systems towards sustainability. The need of the hour is breaking the silos and multi-sectoral collaboration across ministries and stakeholders such that each actor in food system contributes their bit towards it.

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