Indian Journal of Agricultural Economics
Volume 77, Number 1, January-March 2022

Agriculture and Allied Sectors in Nutritional Security*

K.R. Ashok†

I

INTRODUCTION

About 690 million people in the world (8. 9 per cent of the world population) are estimated to have been undernourished in 2019. Nearly half of the undernourished population of the world live in South Asia. Food insecurity remains high, with around 23 per cent of the population not having access to adequate calorie intake. Micronutrient deficiencies afflict more than two billion individuals, or one in three people, globally. Despite a growing number of global and regional initiatives to control undernourishment and micronutrient deficiencies, 'hidden hunger' remains a serious health threat, especially for pregnant women and children. The Global Hunger Index (GHI) computed with four indicators such as undernourished population with insufficient caloric intake, child wasting, child stunting and child mortality ranks India in the 101st position out of 116 countries in 2021. According to current estimates, in 2019, 21.3 per cent (144.0 million) of children under 5 years of age were stunted, 6.9 per cent (47.0 million) wasted and 5.6 per cent (38.3 million) overweight. The nutritional status of the most vulnerable population groups is likely to deteriorate further due to the health and socio-economic impacts of Covid-19 (FAO, IFAD, UNICEF, WFP and WHO, 2020). The findings in Phase I of the National Family Health Survey -5 (NFHS-5) for 22 States and Union Territories found that the childhood stunting rose in 13 States, high prevalence of anaemia among children and women and wasting was a serious concern in 12 States. The number of people going hungry in 2020 was 15 per cent higher than in 2019, owing to the Covid-19 pandemic and armed conflicts (FAO, 2021). The emergence of Covid-19 has highlighted the fragility of our food systems and calls for transformation of food systems – to make healthy diets available, accessible, attractive and safe (Development Initiatives Poverty Research, 2020).

The global food systems determine the access, affordability and diversity of foods available to consumers. In this context, leveraging agriculture for better

---

*Keynote paper presented at the 81st Annual Conference of the Indian Society of Agricultural Economics held under the auspices of Shri Mata Vaishno Devi (SMVD) University, Katra (Jammu & Kashmir) on December 1, 2021.

†Director, Centre for Agricultural and Rural Development Studies (CARDS), Tamil Nadu Agricultural University (TNAU), Coimbatore-641 003.

The author gratefully acknowledges the critical comments given by Madhura Swaminathan, R. Balasubramanian and D. Suresh Kumar, and the assistance rendered by A. Surendran, Research Associate, CARDS, TNAU.

nutritional outcomes has been one of the key approaches debated worldwide for achieving health and nutritional security. In low- and middle-income countries, promotion of more sustainable and nutritive crop production, urban agriculture, or implementation of programmes that directly provide healthy foods have been presented as ways to improve the nutritional status of population (UNSCN, 2019). Focus on crop preferences, technologies, institutions and policies are important for making nutritious food available and affordable. Also, agri-food systems impact public health through imparting immunity and preventing diseases leading to wholesome healthy lives. Low quality diets are the number one risk factor driving the global burden of disease (Global Panel on Agriculture and Food Systems for Nutrition, 2016). The UN Food Systems Summit in September 2021, among other things, called for revamping global food system and advocated that scientists need to identify optimal conditions and opportunities for investments to make healthy and nutritious foods more available, affordable and accessible. In this milieu, it is important that the synergies between agriculture, nutrition and health are harnessed to address the issues related to undernourishment and human health.

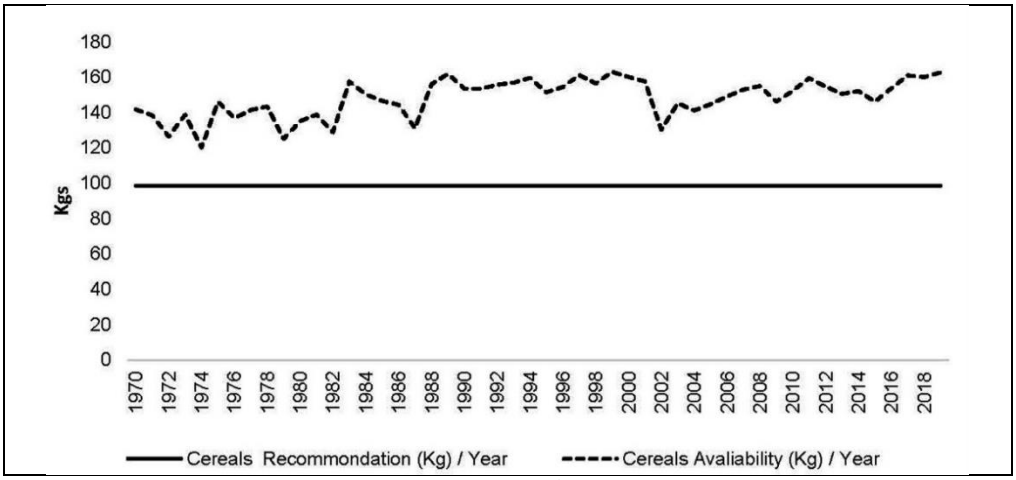
Food and Nutritional Security in India

Food security, as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. Food security exists ''when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life'' (Kennedy *et al*., 2011). FAO's report *The State of Food Insecurity in the World* presents a set of indicators describing the four dimensions of food security: availability, access (economic and physical), utilisation, and stability (vulnerability and shocks) over time and shows the issue's complexity. India has made remarkable progress in many of these indicators but still, a lot needs to be addressed. For example, though stunting in child below five years declined from 48 to 38 per cent during the period 2006 to 2016, 4 out of 10 children are not meeting their full human potential because of chronic undernutrition or stunting. With nearly 195 million undernourished people, India shares a quarter of the global hunger burden. (UN, 2021).

The cereal production in the country has registered impressive growth in the last fifty years due to the continued improvements in cereal varieties, better production technologies and policy support from the government. As a consequence, the per capita availability of cereals in the country has increased from 141.67 kgs/year in 1970 to 162.71 kgs per year in 2018 despite high population growth in the country. Compared to the recommended per capita quantity, the cereal availability in the country is higher at 84.68 kgs per year (Figure 1).

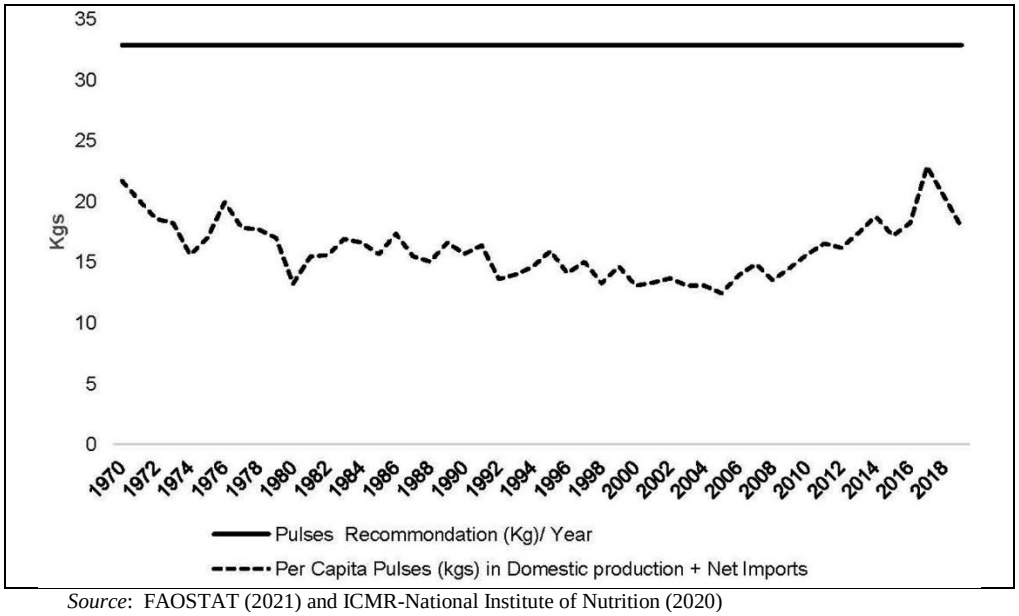
The per capita availability of pulses in the country is less than the recommended quantity of 45.62 kg per year. The per capita availability of pulses is stagnant or

declined as the growth in pulses production is very low compared to cereals. In 2018 there is a gap of 27.74 kg per year between the per capita recommended quantity and availability of pulses in the country (Figure 2).



Source: FAOSTAT (2021) and ICMR-National Institute of Nutrition (2020).

Figure 1. Cereals- Per capita Recommended Quantity and Availability.



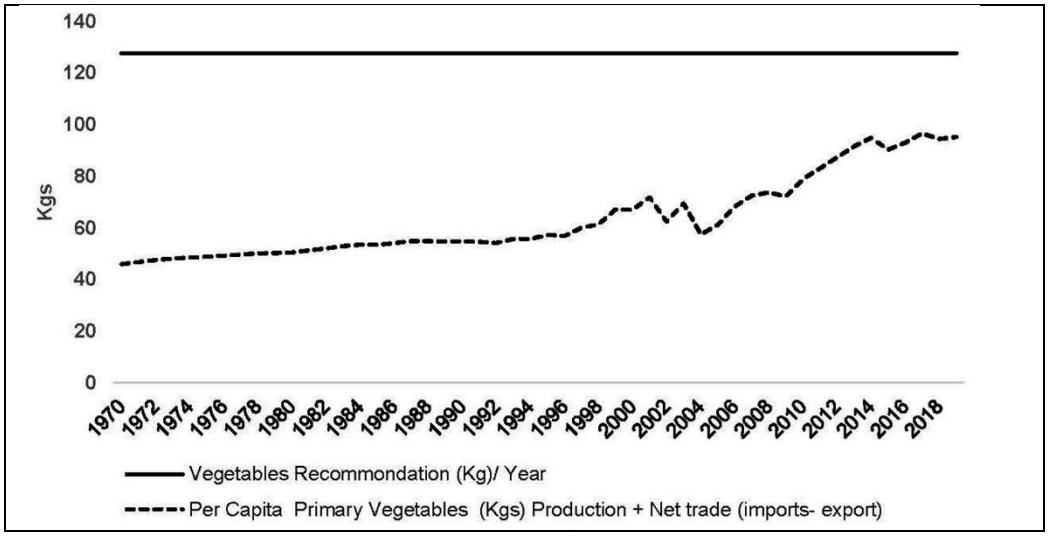
Source: FAOSTAT (2021) and ICMR-National Institute of Nutrition (2020)

Figure 2. Pulses - Per capita Recommended Quantity and Availability.

Fruits and vegetables are low in fat and calories and provide nutrients vital for health and maintenance of your body and it is a very important part of the healthy diet. The United Nations has declared 2021 as the International Year of Fruits and

Vegetables with the aim to raise awareness of the nutritional and health benefits of consuming more fruits and vegetables as part of a diversified, balanced and healthy diet. Insufficient intake of fruit and vegetables is estimated to cause around 14 per cent of deaths from gastro-intestinal cancer worldwide, about 11 per cent of those due to ischemic heart disease, and about 9 per cent of those caused by stroke (Afshin *et al.*, 2019).

Fruits and vegetables consumption is low among the poor due to production challenges, relatively high prices and problems in storage and transport. In India the net availability of vegetables was almost stagnant till the year 2000 and after that increased gradually and the current availability is 95.15 kg per year. But still the per capita availability of vegetables is less than the per capita recommended quantity of 128 kgs per year (Figure 3). But in the case of fruits, the per capita availability has surpassed the per capita recommended quantity of 73.00 kgs per year since late 2000s (Figure 4). Mission for Integrated Development of Horticulture' (MIDH), has played a significant role in increasing the area under horticulture crops in India. During the year 2019-20, the country recorded of 320.77 million tonnes of horticulture production from an area of 25.66 million hectares. Area has increased by nine per cent and production by 14 per cent between 2014-15 and 2019-20.

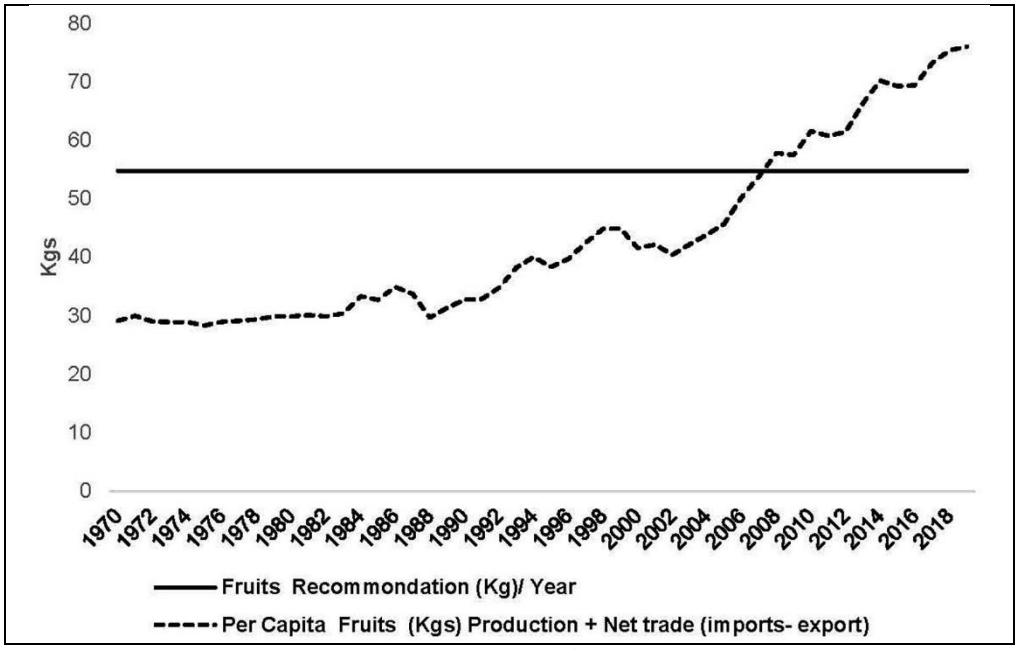


Source: FAOSTAT (2021) and ICMR-National Institute of Nutrition (2020).

Figure 3. Vegetables - Per capita Recommended Quantity and Availability.

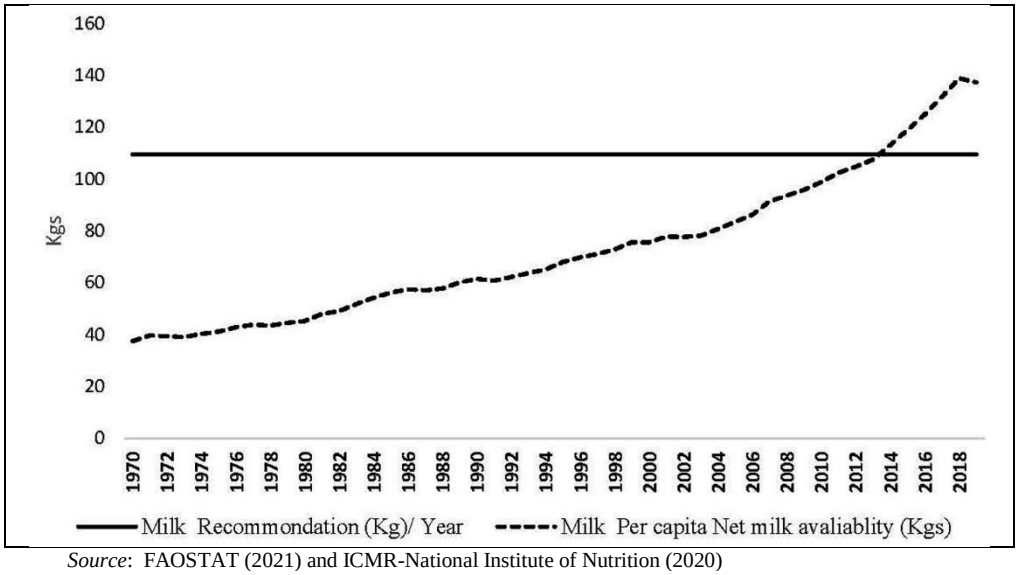
Milk and milk products play a key role in healthy human diet. India is the world's largest milk producer, with 22 per cent of global production. Milk is mainly produced by small and marginal farmers and it contributes to nutrition security and livelihood security to the poor. Milk and other livestock products have a high income-elasticity of demand at low income levels. With rising incomes and increased production, milk and dairy products are increasingly become an important part of the Indian diet. The

per capita net milk availability of 38 kgs per year during 1970s was below the recommended quantity of 110 kgs per year till 2013. Currently the milk availability has increased to 137 kgs per year (Figure 5).



Source: FAOSTAT (2021) and ICMR-National Institute of Nutrition (2020).

Figure 4. Fruits- Per capita Recommended Quantity and Availability



Source: FAOSTAT (2021) and ICMR-National Institute of Nutrition (2020)

Figure 5. Milk- Per capita Recommended Quantity and Availability.

Eggs are an inexpensive source of high-quality protein, essential vitamins, and minerals that are needed for a healthy life. The per capita availability of eggs is far below the availability of eggs in the country, though the availability has increased steadily over years (Figure 6). The per capita net availability of 10 eggs per year during 1970s was below the recommended quantity of 180 eggs per year. However, during late 2000s the eggs production gradually increased to the current availability of 84 eggs per year.

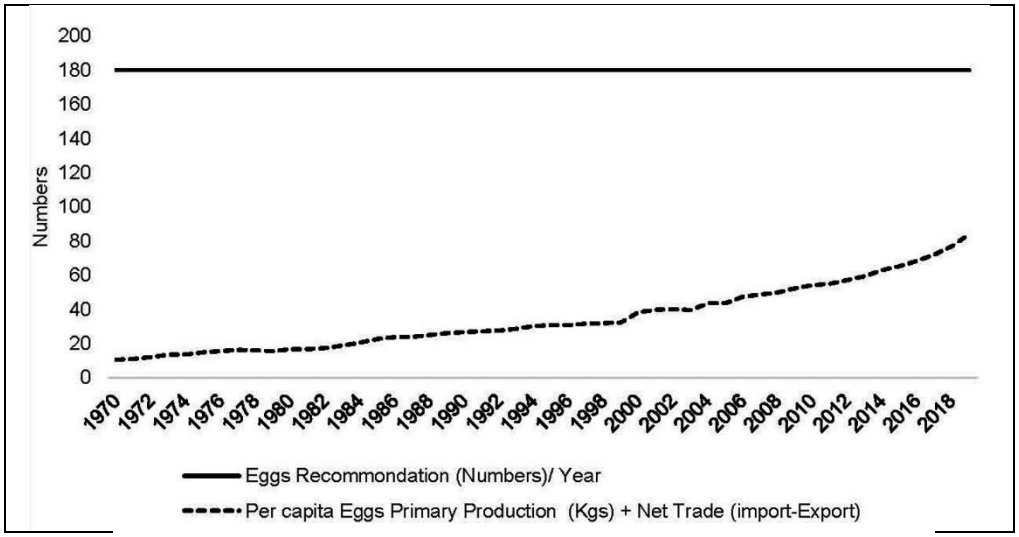


Figure 6. Eggs-Per capita Recommended Quantity and Availability.

The above analysis shows that the per capita availability of cereals, fruits and milk is more than the recommended quantity for healthy diets while the availability of pulses, vegetables and eggs needs to be increased. Availability is only the first step towards the provision of healthy diets to the population. Targeted interventions, institutions and policies are important to make the available food, affordable and accessible to all sections of the society. It is ironic that despite being a net exporter and food surplus country at the aggregate level, India has a 50 per cent higher prevalence of under nutrition compared to the world average though the share of the under nourished population declined from 21.6 per cent during 2004-06 to 15.4 per cent during 2018-20 (Parajuli and Chand, 2021).

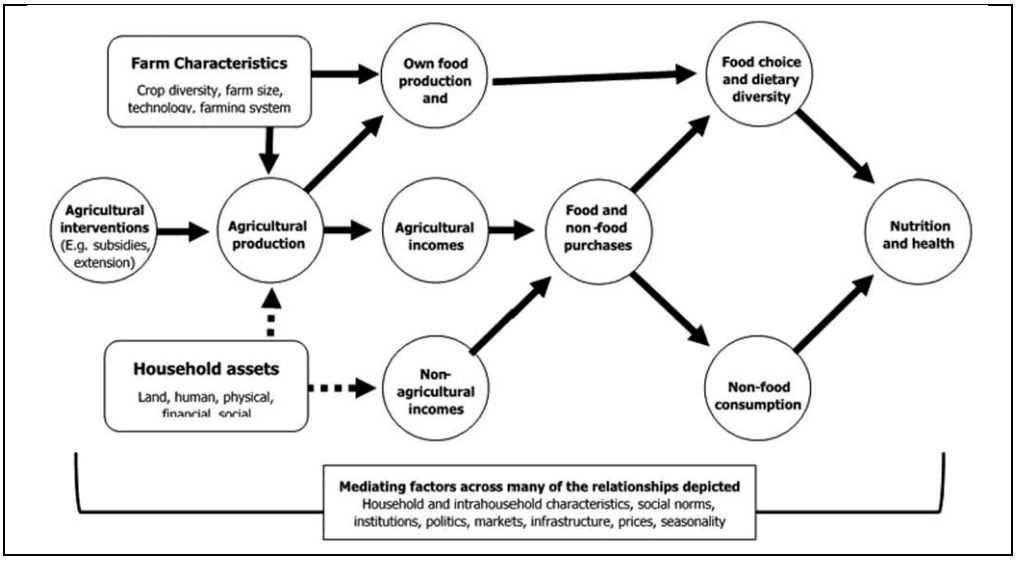
II

AGRICULTURE - NUTRITION PATHWAYS

Impact Pathways

Agricultural development has historically focused on food security and poverty reduction, but the role of agriculture for better nutritional outcomes has been

increasingly recognised in the past decade (Nagarajan *et al.*, 2014). But improvements in food production do not necessarily lead to improvements in nutrition and health outcomes. Agriculture has the potential to improve nutrition through several pathways, it is a source of food, of income for food and non-food expenditure (Jaideep and Richard, 2019). The impact pathways from agricultural interventions to nutritional outcomes describes the linkages between the sequences of steps from interventions to outcomes with the causal assumptions. It is important to understand these pathways to design effective and efficient agricultural interventions for nutritional and health outcomes. Many reviews have analysed the evidences on the pathways from agriculture to nutritional outcomes. The results of these reviews bring out different dimensions and complexities of agricultural-nutrition linkages. Figure 7 presents a conceptual framework of the relationships between agricultural interventions, market participation, food consumption, dietary diversity, and nutrition and health outcomes.



Source: Mirriam *et al*, 2021 as adapted from Bellon *et al.* (2016) and Kumar *et al.* (2015)

Figure 7**.** Conceptual Framework Linking Agriculture, Nutrition and Health.

Researchers have produced more evidence that describes the conceptual links between agriculture and nutrition. While there is some evidence of the impact of agricultural interventions on intermediary nutrition outcomes such as health and nutrition knowledge, production, consumption, and expenditure indicators, there is little evidence on the impact of agricultural interventions on final nutrition outcomes such as stunting, wasting, or micronutrient status, and very little evidence on the

"pathways of impact" (Webb and Block, 2011, Berti *et al*., 2004, Leroy *et al*., 2008, Ruel and Alderman, 2013, van den Bold *et al*., 2013).

Agriculture can play three interlinked roles to improve nutrition outcomes by providing nutritious food, being a source of income for people to buy nutritious food and health care, and empowering women, if agriculture interventions are undertaken in a gender sensitive fashion (Hoddinott, 2016). Kadiyala *et al*. (2014) summarise six major pathways that link agriculture and nutrition in India. These pathways include as a source of food, as a source for expenditure on nutrition-enhancing goods and services, as a determinant of relative prices of food, its influence on the empowerment of women and household decision-making in nutrition-relevant resources, through its impact on workload in agriculture for females and child care and the hazardous conditions of agricultural labour on maternal nutritional status. A systematic review by Pandey *et al*., (2016) in the South Asian region highlighted evidence that interventions such as home gardens, introduction of livestock, poultry and aquaculture may improve production diversity, animal ownership and women's empowerment, leading to beneficial effects on intermediate nutritional outcomes such dietary diversity and consumption of nutrient-rich crops. Homestead food production of vegetables, legumes, dairy, poultry, fish and fruit are important to provide greater access to healthy diets in poor rural settings. MSSRF promotes the Farming System for Nutrition (FSN) as a pathway for addressing malnutrition in India. The FSN approach comprises a combination of measures including advanced crop production practices, biofortification, promotion of kitchen gardens of fruits and vegetables, livestock and poultry development, and setting up of small-scale fisheries, combined with nutrition awareness (MSSRF, 2018). The findings from South Asia and elsewhere consistently show that there is a potential for agricultural interventions to improve intermediate nutritional outcomes (such as dietary diversity and the consumption of animal-source foods) at least during the life-time of the intervention. (Bird *et al*., 2019). In spite of differences in the methods and nutrition indicators most reviews found evidence that agricultural development programs that promoted production diversity, micronutrient-rich crops, dairy, or small animal rearing could improve the production and consumption of targeted commodities, and some evidence that such improvements led to increases in dietary diversity at the household and sometimes at the maternal and child level (Ruel 2021).

Agricultural change can influence what people eat through income and price effects, but also influence nutrition through the disease environment via crops (for example, moulds that spawn mycotoxins), livestock (for example, zoonotic diseases, fecal contamination of the environment), and exposure to hazardous chemicals (for example, pesticides) (Headey and Masters, 2021). Brainerd and Menon (2014) looked at the long standing concern that excessive and inappropriate use of chemical inputs, particularly pesticides and herbicides, has harmful effects on health and nutrition. They found significant evidence of adverse impacts on maternal and child health, including birth weight. Food recalls alone are estimated to cost the economy between

$60 and $70 billion annually in America, along with the countless unnecessary deaths and illnesses that result from eating contaminated food. The fundamental reason why America has become so unhealthy is because we have lost our connection between agriculture, health and nutrition (Patrick Johnson, 2011). Reviews of that literature focus on how each household's nutritional outcomes relate to their own farm production, in contrast to systems-level research that tries to understand the nutritional impacts of larger-scale agricultural growth and transformation processes (Pinstrup-Andersen 2013).

Agricultural Diversity and Commercialisation

Dietary diversity is a cost-effective, affordable and sustainable means of eradicating hunger and malnutrition. Diversification is an effective means of closing the production and nutrition gaps. Agricultural diversity is the most important factor in providing the spectrum of micronutrients essential for human health. Biodiverse crops will ensure sustainable diets that are environment healthy, strengthen local food systems by producing traditional/indigenous crops, and provide fodder for livestock (Yesudas, 2021). Promoting production diversity was found to be much more important for ensuring household access to diverse diets in areas where households had limited access to markets (and were unable to sell and purchase products) than in areas where farmers had greater access to markets (Sibhatu *et al*., 2015). The primary focus of the existing agriculture systems was on staple cereals like rice, wheat and maize. Over a period of time the diversity of agricultural production systems has declined due to several reasons. But large scale diversification of agricultural systems into healthy foods like fruits and vegetables are essential from the perspective of nutrition. Intensification of agricultural systems due to mono-cropping of major staple grains and cash crops has led to a substantial reduction in the genetic diversity of domesticated plants and animals in agricultural systems (Khoury *et al*., 2014; Herrero *et al*., 2017). FAO (2010) estimates that of the approximate 300,000 plant species that exist in the world, 10,000 plant species have been used for human food since the origin of agriculture. Out of these, only 150–200 species have been commercially cultivated, with four – rice, wheat, maize and potatoes – supplying 50 per cent of the world's energy needs and 30 crops providing 90 per cent of the world's calorie intake. Yet the implications of this loss for the biodiversity and quality of the global food supply is scarcely understood or measured from an economic or nutritional perspective.

The transition from subsistence to commercial agriculture by exploiting comparative advantages is key for economic growth. Commercialisation leads to monoculture which may lead to reduced crop diversity especially among the small and marginal farmers. But it may also result in higher incomes and enable people to purchase diversified foods from markets. Numerous studies have shown that cash-crop schemes generally increased smallholder incomes. Nadjia and Amy (2021)

found that the agricultural specialisation seems to have mixed effects on dietary diversity –decreases in the number of food groups consumed from 'own production' and a gain in diversity as a result of increases in food groups consumed from market purchases enabled by higher incomes. But the increase in food group consumption from the use of markets did not compensate for the decline in food group consumption from 'own production'. The diversity of food through markets may work well at micro levels/at local or regional scales such as districts, states and countries, etc. The markets/supply chains can provide diversity in food only if there is overall diversity in crop production at macro level.

Biofortification is a process of increasing the density of vitamins and minerals in a crop, especially in staple crops through conventional plant breeding, transgenic techniques, or agronomic practices. Initial research has indicated that selection of lines with diverse vitamin and mineral profiles could be exploited for genetic improvement (Saltzman *et al*., 2013). Genetic transformation is an alternative method to incorporate specific genes that express nutritional density. Parallel to crop improvement, nutrition research measures retention and bioavailability of micronutrients in the target crop under typical processing, storage, and cooking practices (Bouis *et al.*, 2021). By the end of 2017, more than 290 varieties of 12 biofortified crops had been officially released in over 30 countries, and hundreds of varieties of 13 biofortified crops were being tested in over 30 more. Released biofortified crops include vitamin A orange sweet potato (OSP), vitamin A yellow cassava, vitamin A orange maize, vitamin A banana/plantain, iron beans, iron pearl millet, zinc maize, zinc rice, zinc wheat, iron and zinc cowpea, iron and zinc sorghum, and iron and zinc lentils. Additional biofortified crops being tested are iron and zinc Irish potato, iron and zinc sorghum, and vitamin A squash (Bouis *et al*., 2021). The African Biofortified Sorghum (ABS) project has produced transgenic sorghum with improved protein profile [lysine (30–120 per cent), tryptophan (10–20 per cent), threonine (30–40 per cent)], elevated levels of pro-vitamin A (5.7–21.0 μg/g beta-carotene) and reduced phytate (35–65 per cent) (Okwuonu Ihuoma *et al*., 2021)

The World Bank considers biofortification as a low-cost, high-impact and scalable solution. World Bank (1993) suggested that interventions costing less than US$150 per disability adjusted life year (DALY) averted (approximately US$261 in 2018 dollars) are highly cost-effective. Ex post results on the cost-effectiveness of biofortification are currently limited to OSP in Uganda. These results show biofortification to cost US$15–20 per DALY saved (Harvest Plus, 2010), while for the same country the cost of vitamin A sugar fortification is US$56 per DALY saved (Fiedler and Macdonald, 2009) and the cost of vitamin A supplementation is US$52 per DALY saved (WHO, 2018). Even in countries where relatively few DALYs are lost due to micronutrient deficiency, biofortification is expected to have an advantageous benefit– cost ratio (Lividini *et al.*, 2017). However biofortification is not a 'silver bullet' for the elimination of micronutrient deficiencies, but presents an

opportunity for increasing micronutrient intakes of rural households in developing countries (Bouis *et al.*, 2021). There is much unfinished business in scaling up and mainstreaming biofortification. In 2018, Harvest Plus entered its fourth 5-year phase and is implementing its new strategic plan, which is designed to lay the groundwork for biofortification to benefit 1 billion consumers globally by 2030 (Bouis *et al.*, 2021).

Gender Role in Agriculture-Nutrition Linkage

There is now better understanding of the gender dynamics in agriculture and its role in achieving nutritional and health outcomes. Malnutrition adversely impacts women's physical and mental capacity to perform their work. Also there is a strong positive association between rural women's empowerment and good child nutrition. Targeting nutrition to women and mothers is perhaps the most common approach used in nutrition-sensitive agricultural development programs. (Malapit, 2021). Participation in agriculture may give women increased access to and decision-making power over resources, such as income, and agricultural assets such as land and livestock, which in turn can increase their social status and empowerment to allocate food, health, and care within their households (Kadiyala *et al*., 2014, Jaideep and Richard, 2019). Gender- and nutrition- sensitive agricultural programmes converge around strategies that attempt to increase women's access to resources and information by targeting women or women's groups, but it is not clear whether any gender impacts are achieved and to what extent these gendered mechanisms contribute to the observed changes in nutrition outcomes (Malapit, 2021). Nutrition-sensitive agricultural programmes can improve a variety of nutrition outcomes in both mothers and children, especially when they include nutrition behaviour change communication (BCC) and carefully designed interventions to empower women, including interpersonal counselling and social mobilisation (Ruel, 2021).

Gender approaches used to measure the relationship between women's empowerment and nutrition include use of nationally-representative data on women's status and malnutrition (Smith *et al.*, 2003); proxy measures of bargaining power such as income, assets, and education (Thomas, 1994); and direct measures of empowerment such as mobility, decision making, and attitudes toward verbal and physical abuse (Bhagowalia *et al.*, 2012). The pathways linking women's work in agriculture to nutrition are complex and lack of quality evidence has often been posed as a barrier. This is partly from the methodological challenges, given that the drivers of undernutrition are multiple, and agriculture nutrition pathways interconnected, which makes it difficult to both generate evidence, and to delineate direct relationships between gendered agrarian systems and nutrition outcomes (Nitya *et al.*, 2019). The findings of the research consortium Leveraging Agriculture for Nutrition in South Asia (LANSA) concluded that the evidence base in South Asia was scant,

especially lacking data on the role of women in agriculture and nutrition (Gillespie and van den Bold, 2017).

Behaviour Change for Better Nutrition Outcomes

The inclusion of a strong behaviour change communication (BCC) intervention to promote optimal diets and child feeding practices, and a focus on improving women's status and empowerment through agriculture, were consistently reported as key to enhancing the potential impacts of agriculture on diets and other nutrition outcomes (Ruel, 2021). Nutrition behaviour change communication (BCC) comprises a range of interpersonal, group and mass-media channels and methods that provide program participants with relevant information to encourage and support the adoption of optimal nutrition and child feeding practices and behaviours (McNulty, 2013). Nutrition-targeted taxes have become a popular measure in the recent past, due to their comparative effectiveness in influencing consumption behaviour (Mazzocchi, 2017). Various kinds of food tax modelling studies can be found in the literature. Most of these studies focus on the effects on nutrition and health {Nnoaham *et al.* (2009), Springmann *et al.* (2018), Veerman *et al.* (2016)}. The success of nutrition interventions ultimately hinges on people - consumers' behaviour as influenced by their physiological and nutritional needs, their socio-demographic contexts, their hedonic motivations, and their attitude and beliefs towards food (Cuevas *et al.,* 2021; Haddad, 2020; Shepherd, 1999). In the end, the relationship between health and agriculture comes down to personal preferences and choices. While there are actions the government, producers, marketers and food retailers can and should take to increase availability of healthy foods and encourage good eating habits, the decision to be healthy will remain yours (Patrick Johnson, 2011).

Role of Markets in Agriculture-Nutrition Linkage

One of the key contextual factors found to modify or mediate the impacts of agricultural interventions on nutrition is market functionality and access (Ruel *et al.* (2018). Recent empirical studies have highlighted the relative importance of markets for farm household dietary diversity and reported that markets are critical for dietary diversity than subsistence production (Qaim and Sibhatu, 2018). The food purchased from the market contributed more to household nutrition than self-produced food (Luckett *et al.*, 2015). Sibhatu *et al.* (2015) found access to agricultural markets positively affects household dietary diversity, even more so than production diversity. A systematic review by Nandi *et al.* (2021) reported a consistent positive association between access to markets and dietary diversity, and few studies reported positive or negative association. Households located farther from markets had lower overall diversity and accessed relatively more of their diversity from home production than did households located closer to markets (Luckett *et al.*, 2015). Studies show a positive relationship between various proxies for market participation and dietary

diversity, either through agricultural output sales or through food purchases. Comparing own food production with purchases, they show stronger income effects on dietary diversity, with incomes enabling households to have a wider choice, subject to availability in food varieties (Mirriam *et al.*, 2021).

Studies also investigated the limitations of markets in providing dietary diversity. Markets might fail to provide an adequate supply of all foods because of the perishability of certain foods – particularly eggs, fresh milk and many fruits and vegetables – and because local demand for these products is quite limited in low-income and low-density rural populations (Headey and Masters, 2019). Micro-econometric evidence also sheds light on the importance of incomplete markets. Overall, these results strongly suggest that there are high degrees of market failure in developing countries, leading to a high degree of dependence on local agricultural systems and vulnerability to local shocks (Headey and Masters, 2019). Poorly developed markets and market infrastructure and the presence of large number of smallholders results in high transaction costs.

Cost of Food and Affordability

Cost of food determines the affordability of food. Even the most conservative cost estimate of a healthy diet is unaffordable for more than 3 billion people in the world. The cost of the diet increases incrementally as the diet quality increases and this is true across all regions and country income groups. One of the main constraints to the achievement of nutrition related Sustainable Development Goals globally is the high cost of healthy diets (FAO, 2020). The cost of a healthy diet is 60 per cent higher than the cost of the nutrient adequate diet, and almost 5 times the cost of the energy sufficient diet (FAO, IFAD, UNICEF, WFP and WHO, 2020). Gupta *et al.* (2021) estimated that the cost of the EAT Lancet dietary recommendations for rural India ranges between $3.00- $5.00 per person per day. In contrast, actual dietary intake at present is valued at around $1.00 per person per day. In order to get to the EAT Lancet recommendations individuals will have to spend nearly $1.00 per person per day more on each of meat, fish, poultry, dairy foods and fruits. The important drivers of the cost of healthy diet are low productivity, insufficient diversification, low levels of technology adoption, post-harvest losses, pests and diseases and climatic risk factors. There is a need for stronger policies towards more nutrition-sensitive value chains. Investments in improved storage, processing, improving the road network, transport and market infrastructure, can go a long way to ensuring greater affordability of healthy diets.

III

EVIDENCE-BASED DECISION MAKING

A common strand of thought among the number of reviews on this topic is that the current evidence-base on the impact of agricultural interventions on nutrition

outcomes is weak due to the absence of sufficient good-quality research. An evidence-based decision making framework can shape policies, investments and actions that are necessary for leveraging the agriculture-nutrition linkages. A good analysis requires robust study designs, appropriate metrics and credible evidence supported by data and information. Also a sound statistical system is essential to generate reliable data, make it available and accessible in a timely manner.

Study Designs: Overall, the quality of impact evaluation designs and analyses improved in the newly published studies, with more studies using cluster randomised controlled trials or quasi-experimental approaches. More studies than before used baseline and endline surveys and valid comparison groups (through either randomisation or matching) to document impacts (Ruel, 2021). The study designs employed in agriculture-nutrition study linkages include Randomised Controlled Trials (Miller *et al.,* 2014, 2016, Darrouzet-Nardi *et al.,* 2016, Osei *et al.,* 2017); before and after studies (Birdi and Shah, 2015, Murty *et al.,* 2016, Pant *et al.,* 2014); and quasi-experimental designs with a non-randomised comparison group and long-term follow-up (Schreinemachers *et al.,* 2014; 2016). Economy wide simulation models were run to understand how different agricultural policies can influence both household income and dietary measures such as household calorie supply (Pauw and Thurlow, 2010), dietary diversity, or disease burden associated with inadequate diets (Springmann *et al.* 2016). To evaluate the implications of the Covid 19 impact channels on food security, Nechifor *et al.* (2021) used an economy-wide computable general equilibrium (CGE) model integrated with a Food Security and Nutrition (FS&N) microsimulation module. Nadjia and Amy (2021) used poisson fixed effects model to analyse the association between dietary diversity and production diversity and market access of the households over time. They found positive and statistically significant association between household dietary diversity and production diversity, increasing production diversity by one food group is associated with a change in household dietary diversity between 4.9 per cent and 5.8 per cent depending on the market access variables and other co-variates included in the model. But there was an overall decline in dietary diversity over time in the same households as their production diversity has declined.

Melba and Ashok (2021) analysed household dietary diversity (HDD) among the marginal farmers through a Poisson regression model wherein the HDD is the dependent variable and crop production diversity and socio-economic variables as determinant variables. Crop production diversity, measured in crop species count, farm income and education had significant positive impact HDD while distance to markets, and age had significant negative impact on HDD (Table 1).

The researchers have pointed out some of the limitations of these models. Growing body of research linking farm production indicators to household consumption or individual nutrition outcomes is empirical and essentially describes associations that may or may not be causal (Jones, 2017; Sibhatu and Qaim, 2018). Experimental trials of various nutrition-sensitive agricultural interventions have been

TABLE 1. DETERMINANTS OF HOUSEHOLD DIETARY DIVERSITY (HDD)

Particulars (1)	Marginal farmers (2)
Production Diversity (Crop Species Count)	0.112** (0.037)
Market Distance (Km)	-0.355*** (0.046)
Gender (Male=1, Female= 0)	0.081 (0.086)
Age (Years)	-0.030*** (0.004)
Family Size (Numbers)	-0.022 (0.043)
Education (Illiterate-0, Primary-1, secondary-2 and Higher secondary and above -3)	0.212*** (0.042)
Cultivable Land (ha)	-0.001 (0.001)
Farm Income (Rs./ month)	0.006*** (0.000)
Constant	1.661** (0.754)
Log Likelihood	-216.27
Chi^2	68.88***
Prob > chi^2	0.0000

Note: *** and ** denote significance at 1 and 5 per cent respectively.

widely critiqued in the literature for their limitations, including small projects and sample sizes lacking statistical power (Headey and Masters, 2021). Many nutrition-sensitive agricultural interventions do not take into account that production and consumption decisions within households are often separate, and that, except for income, farming households' production decisions may not directly affect their consumption (Fan *et al*. 2019).

*Metrics for Agriculture-Nutrition Linkages***:** Studies employed different metrics for establishing the linkage between agriculture and nutritional outcomes. The metrics for intermediate nutritional outcomes included household dietary diversity, household dietary intake, food variety scores, weighted food consumption scores, frequency of individual food items and food groups consumed and child feeding index and nutrition-related knowledge and behaviour. The final nutritional outcomes included anthropometric measurements and biochemical indicators like body mass index, child height-for-age, weight-for-age, weight-for-height and mid-upper-arm circumference. Dietary Diversity Index for a household includes indicators for production diversity, dietary diversity, calorie and nutrient consumption and food security. Household dietary diversity Score (HDDS) is a qualitative measure of food consumption that measures the household's access to a variety of foods. HDDS is validated as a proxy of nutrition quality (Swindale and Bilinsky, 2006; Jones *et al*., 2014). Food Purchases Diversity Score (FPDS) measures market participation through food purchases diversity, using the same food groups to collect data on diversity of household food purchases as well as household dietary diversity (Mirriam *et al.*, 2021). The Determinants of Nutrition and Eating (DONE) framework provides an interdisciplinary perspective on drivers of food choice across the multiple interrelated levels from biology through policy (Stok *et al.*, 2017) and a starting point to establish priorities for intervention in developed countries (Blake *et al.*, 2021). DALYs (Disability Adjusted Life Years) capture "person-years lost in a population owing to disability and shortened life" (Stein, 2014) as a consequence of adverse health outcomes associated with the burden of hunger. The DALY framework has

been widely applied by the World Bank and the World Health Organization (WHO) to measure the health gap in developing countries. This method describes both mortality and disability-weighted morbidity of a health condition in a single index, expressed in terms of the number of DALYs lost.

Production diversity is measured through crop species diversity, crop varietal diversity, livestock species diversity, crop and livestock species diversity, food groups produced, nutritional function diversity, crop species richness and crop species evenness. Nutritional Functional Diversity (NFD) is a metric that assesses plant species composition on farms as well as the nutritional composition of those plants, thus capturing the diversity of nutrients on farm landscapes (Remans *et al*., 2011). Jones (2017) used Crop Species Richness (CSR), to assess the relationship between on-farm diversity and diets.

Data Gaps: A study design is robust as much as the metrics employed and, metrics are as good as the quality of data used for the estimation of metrics. Data required for many key variables used in different metrics in nutritional studies are scant in the regular statistical systems. In a country like India where nutritional inequity is pervasive data need to be generated at disaggregate level with multiple dimensions like income, sex, age, food sourcing and costs, migration status, disability, geographic location and other relevant characteristics. For India one of the biggest data gaps at present relates to the unavailability of recent consumption expenditure data. The publicly available NSSO data on consumption expenditure at present dates back to 2011-12 (Gupta, *et al*. 2021).

IV

POLICY ISSUES AND GLOBAL NUTRITIONAL INITIATIVES

It is evident that leveraging agriculture for nutritional outcomes needs a system approach that encompass crop improvement, crop diversification, well-functioning markets including market infrastructure, behavioural changes and policy interventions. Nutritious foods are the product of policies, distribution networks, infrastructure for storage, research and technology, information and awareness, and consumer preferences. A number of research studies have noted the failure of these systems to ensure access to nutritious foods due to lack of nutrition awareness, adequate infrastructure or functioning markets (Maestre *et al*., 2017). Agricultural programmes or policies that aim to improve nutritional status often require complementary initiatives designed specifically to improve nutrition, including, for example, targeting increased consumption of nutritious food (Ruel *et al*., 2013; Pandey *et al*., 2016).

Many agricultural policies in low-income countries were originally designed to address undernourishment, in terms of energy intake, and food security during the early stage of development characterised by food shortages and famines. The continuance of such policies may affect the relative price in favour of staples with

considerable effect on the nutritional intake. Policy and institutional support for staple crops relative to other crops, as illustrated by PDS, has crowded out traditional micronutrient-rich food crops, such as coarse grains and pulses. India's disproportionate price and marketing incentives to major cereals have made diversification to pulses and coarse grains difficult (Pingali and Abraham, 2021). Most nutrients are also income elastic, therefore, a rise in income also increases nutritional intake (Pingali and Rao, 2017) especially among the lower income groups.

Trade policies, mainly protectionary trade measures and input subsidy programmes, tend to protect and incentivise the domestic production of staple foods, such as rice and maize, often at the detriment of nutritious foods, like fruits and vegetables. Non-tariff trade measures can help improve food safety, quality standards and the nutritional value of food, but they can also drive up the costs of trade and hence food prices, negatively affecting affordability of healthy diets (FAO, IFAD, UNICEF, WFP and WHO. 2020).

Similarly, as agriculture develops and transform into a commercial activity, focus will be on monocropping and specialisation. As people are growing fewer fruits, vegetables, and legumes, they are also eating less of these nutrient-rich foods, conversely, as people's incomes are rising they are increasingly purchasing dairy, eggs, and meat. Thus there appear to be nutritional gains and losses. The policy challenge is how to maintain the improvements in dietary quality that accompany increased specialisation and rising incomes, while doing something to minimise the dietary 'losses' that seem to arise from declining production diversity (Nadjia and Amy, 2021).

Public expenditures need to be increased to enable many of the policy decisions and investments needed to raise productivity, encourage diversification in food production and ensure that nutritious foods are made available abundantly. Countries will need a rebalancing of agricultural policies and incentives towards more nutrition sensitive investment and policy actions all along the food supply chain to reduce food losses and enhance efficiencies at all stages. (FAO, IFAD, UNICEF, WFP and WHO. 2020). Globally, there has been a growing interest among governments and development institutions in using nutrition-sensitive value chains as a means to improve nutrition (Fanzo *et al*., 2017).

Major Nutritional Initiatives

Nutrition is central to the SDGs, with 12 of the 17 SDGs containing indicators relevant to nutrition. Agriculture features prominently in the SDGs as a driver of poverty reduction, equity, food and nutrition security. SDG 2 aims to "end hunger, improve food security and improved nutrition, and promote sustainable agriculture" with one of its main targets (2.2) stating: "By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of

adolescent girls, pregnant and lactating women and older persons". Decade of Action on Nutrition (2016 to 2025) was proclaimed by the United Nations in 2016, following the recommendation of the International Conference on Nutrition (ICN2). Decade of Action on Nutrition is a commitment of Member States to eradicate malnutrition in all its forms in all countries and one of the areas of focus is Sustainable, resilient food systems for healthy diets. The focus of the 2020 Global Nutrition Report on "Action on equity to end malnutrition" highlights dramatic inequities in the burden of stunting, wasting, obesity, micronutrient deficiencies, and diet-related non-communicable diseases.

The International Conference on Nutrition 2 (ICN2) in 2014, culminated in the release of the Rome Declaration on Nutrition, which recognised that food systems, inclusive of agriculture, need to contribute to nutritious, diverse, and balanced diets. IFPRI held a global policy consultation on 'Leveraging Agriculture for Improving Nutrition and Health' which gave momentum to launch the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), a large programme which undertakes work on healthy food systems, biofortification, food safety, supportive policies and programs, and human health (Fan *et al*. 2019). The Leveraging Agriculture for Nutrition in South Asia (LANSA), an international research partnership (2012–2018), led by the M.S. Swaminathan Research Foundation (MSSRF) worked together to discover how agriculture and food-related interventions can be better designed to improve nutrition, particularly for children and adolescent girls in South Asia (specifically in India, Bangladesh, Pakistan and Afghanistan). LANSA research programme consortium has had a particular focus on the design of nutrition-sensitive interventions in agriculture. Bird *et al*. (2019) systematically reviewed LANSA programme and found its potential to influence and improve intermediate outcomes such as dietary diversity, and the consumption of animal-sourced foods.

V

CONCLUSIONS

Harnessing agriculture for nutritional and health outcomes gained importance in recent years and several policies have been initiated at national and global levels. The research so far in the subject highlights that the pathways and linkages connecting agriculture and nutrition is complex. Such linkages can only be leveraged through multi-sectoral nutrition-sensitive interventions that can, diversify towards nutrient rich crops like legumes and fruits and vegetables, increase the income of the poor, improve the access to markets, cause changes towards nutrition sensitive behaviours, ensure gender equality and can make an enabling policy environment. Policy actions are required to incentivise production of nutritious crops and to remove the distortions against producing and consuming nutritious foods. It is also important to make considerable investment in data systems and support research and development

of nutritious foods. In India the health and nutritional parameters like stunting, anaemia, and underweight in children showed favourable improvement but wasting among children and obesity both among men and women were on the rise between 2005–06 (NFHS-3) and 2015–16 (NFHS-4). One of the key strategies to achieve these challenges is improving nutrition through agriculture and contribute to achieve the sustainable development goals on nutrition. As social scientists and economists we need to bring in new evidences through robust designs, relevant metrics and good quality data.

REFERENCES

Afshin A.; P.J. Sur, K.A. Fay, L. Cornaby, G. Ferrara and a further 127 GBD 2017 Diet Collaborators (2019), "Health Effects of Dietary Risks in 195 Countries, 1990-2017: A Systematic Analysis for the Global Burden of Disease Study 2017", *Lancet*, Vol.393(10184), pp.1958-1972. doi: 10.1016/S0140-6736(19)30041-8. Epub 2019 Apr 4.

Bellon, M.; G. Ntandou-Bouzitou and F. Caracciolo (2016), On-Farm Diversity and Market Participation Are Positively Associated with Dietary Diversity of Rural Mothers in Southern Benin, West Africa. PloS One 9, e0162535.

Berti, P.R.; J. Krasevec and S. Fitzgerald (2004), "A Review of the Effectiveness of Agriculture Interventions in Improving Nutrition Outcomes", *Publ. Health Nutr.* Vol.7, pp.599–609.

Bhagowalia, P.; P. Menon, A.R. Quisumbing and V. Soundararajan (2012), What Dimensions of Women's Empowerment Matter Most for Child Nutrition? Evidence Using Nationally Representative Data from Bangladesh, IFPRI Discussion Paper 01192. International Food Policy Research Institute, Washington, D.C., U.S.A.

Bird, Frances A.; Aliza Pradhanb, R.V. Bhavani and Alan D. Dangour (2019), Interventions in Agriculture for Nutrition Outcomes: A Systematic Review Focused on South Asia, *Food Policy*, Vol.82, pp.39–49.

Birdi, T.J. and S.U. Shah (2015), "Implementing Perennial Kitchen Garden Model to Improve Diet Diversity in Melghat", *India. Glob. J. Health Sci.* Vol.8, pp.10–21.

Blake Christine E.; Edward A. Frongillo, Andrea M. Warren, Shilpa V. Constantinides, Krystal K. Rampalli, Shiva Bhandari (2021), "Elaborating the Science of Food Choice for Rapidly Changing Food Systems in Low- and Middle-Income Countries", *Global Food Security*, Vol.28 (2021) 100503.

Bouis Howarth E.; Amy Saltzman and Ekin Birol (2021), Improving Nutrition Through Biofortification in Agriculture for Improved Nutrition: Seizing the Momentum, in Shenggen Fan, Sivan Yosef *and* Rajul Pandya-Lorch, (Eds*)* (2021), IFPRI, CAB International, Boston, MA 02111.

Brainerd, E. and N. Menon (2014), "Seasonal Effects of Water Quality: The Hidden costs of the Green Revolution to Infant and Child Health in India". *Journal of Development Economics*, Vol.107, pp.49–64.

Cuevas, R.P.; M.C. Custodio, J. Ynion, A. Samaddar and M. Demont (2021), Gastronomic Systems Research, in Galanakis, C.M., Wang, E. (Eds.) (2021), Gastronomy and Food Science. Elsevier, Amsterdam, The Netherlands, pp. 55–74.

Darrouzet-Nardi, A.F.; L.C. Miller, N. Joshi, S. Mahato, M. Lohani and B.L. Rogers (2016); "Child Dietary Quality in Rural Nepal: Effectiveness of A Community-Level Development Intervention", *Food Policy*, Vol.61, pp.185–197.

Fan, S.; Sivan Yosef and Rajul Pandya-Lorch (2019), Seizing the Momentum to Reshape Agriculture for Nutrition in Agriculture for Improved Nutrition: Seizing the Momentum, in Shenggen Fan, Sivan Yosef *and* Rajul Pandya-Lorch, (Eds.) (2019), IFPRI, CAB International, Boston, MA 02111.

Fanzo, J.C.; S. Downs, Q.E. Marshall S. de Pee and M.W. Bloem (2017), Value Chain Focus On Food And Nutrition Security, in S. de Pee, D. Taren and M. Bloem, (Eds.) (2017), Nutrition and Health in a Developing World, pp.753–770. Cham, Springer International Publishing, Switzerland.

FAO (2010), "An International Consultation on Integrated Crop–Livestock Systems for Development. The Way Forward for Sustainable Production Intensification", *Integrated Crop Management*, Vol.13, Food and Agriculture Organization of the UN, Rome.

FAO (2020), The State of Food Security and Nutrition in the World 2020: Transforming Food Systems for Affordable, Healthy Diets. FAO, IFAD, UNICEF, WFP and WHO. https://doi.org/10.4060/ca9692en

FAO (2021), International Fund for Agricultural Development, UNICEF, World Food Programme and World Health Organization, The State of Food Security and Nutrition in the World 2021.

FAO, IFAD, UNICEF, WFP and WHO. (2020). The State of Food Security and Nutrition in the World (2020), Transforming Food Systems for Affordable Healthy Diets, FAO, Rome. https://doi.org/10.4060/ca9692en

FAOSTAT (2021), http://www.fao.org/faostat/en/#data

Fiedler, J. and B. Macdonald (2009), "A strategic approach to the unfinished fortification agenda: feasibility, costs, and cost-effectiveness analysis of fortification programs in 48 countries", *Food and Nutrition Bulletin*, Vol.30, No.40, pp.283–416.

Gillespie, S. and M. van den Bold (2017), Agriculture, Food Systems and Nutrition: Meeting The Challenge, Global Challenges; 1:1600002. doi: 10.1002/gch2.201600002.

Development Initiatives Poverty Research (2020), *Global Nutrition Report: Action on Equity to End Malnutrition (2020)*, Development Initiatives Poverty Research Ltd, Bristol, UK.

Global Panel on Agriculture and Food Systems for Nutrition (2016), Food Systems and Diets: Facing the Challenges of the 21st Century. London, UK.

Gupta Soumya; Vidya Vemireddy, Dhiraj K. Singh and Prabhu Pingali (2021), "Ground Truthing the Cost of Achieving the EAT Lancet Recommended Diets: Evidence from Rural India", *Global Food Security*, Vol.28, 100498.

Haddad, L.J. (2020), "Viewpoint: A View on The Key Research Issues that the CGIAR Should Lead on 2020–2030", *Food Policy*, Vol.91, 101824.

Harvest Plus (2010), Disseminating Orange-fleshed Sweet Potato: Findings from a HarvestPlus Project in Mozambique and Uganda. HarvestPlus, Washington, D.C. U.S.A.

Headey Derek and William A. Masters (2019), Agriculture for Nutrition: Direct and Indirect Effects in Agriculture for Improved Nutrition: Seizing the Momentum, in Shenggen Fan, Sivan Yosef *and* Rajul Pandya-Lorch, (Eds.) (2019) IFPRI, CAB International, Boston, MA 02111.

Headey, Derek and William A. Masters (2021), Agriculture and Undernutrition, in Agricultural Development: New Perspectives in a Changing World, in Keijiro Otsuka and Shenggen Fan, (Eds.) (2021), International Food Policy Research Institute Washington, D.C., U.S.A.

Herrero, M.; P.K. Thornton, B. Power, J.R. Bogard, R. Remans *et al*. (2017), "Farming and the Geography of Nutrient Production for Human Use: A Transdisciplinary Analysis", *The Lancet Planetary Health*, Vol.1, No.1, pp.e33–e42.

Hoddinott, J. (2016), The Economics of Reducing Malnutrition in sub-Saharan Africa. Global Panel Working Paper, Global Panel on Agriculture and Food Systems for Nutrition, London.

ICMR-National Institute of Nutrition (2020), My Plate for the Day, Department of Health Research, Ministry of Health and Family Welfare, Government of India.

Jaideep, G. and L. Richard (2019), "How Do the State's Organisational Capacities at the Micro- and Macro-Levels Influence Agriculture-Nutrition Linkages in Fragile Contexts?", *Food Policy*, Vol.82, pp.74–83.

Jones, A.D.; A. Shrinivas and R. Bezner-Kerr (2014), "Farm Production Diversity is Associated with Greater Household Dietary Diversity in Malawi: Findings from Nationally Representative Data, *Food Policy*, Vol. 46, pp.1-12, ISSN 0306-9192, https://doi.org/10.1016/j.foodpol.2014.02.001.

Jones, A.D. (2017); "On-Farm Crop Species Richness is Associated with Household Diet Diversity and Quality in Subsistence-and Market-Oriented Farming Households in Malawi", *Journal of Nutrition*, Vol.147, No.1, pp.86–96.

Kadiyala, S.; J. Harris, D. Headey, S. Yosef and S. Gillespie (2014), "Agriculture and Nutrition in India: Mapping Evidence To Pathways", *Ann. N. Y. Acad. Sci*., Vol.1331, No.1, pp.43–56.

Kennedy, G.; T. Ballard and M. Dop, (2011), Guidelines for Measuring Household and Individual Dietary Diversity. Rome, Nutrition and Consumer Protection Division. Food and Agriculture Organization of the United Nations.

Khoury, C.K.; A.D. Bjorkman, H. Dempewolf, J. Ramirez-Villegas, L. Guarino, *et al*. (2014), "Increasing Homogeneity in Global Food Supplies and the Implications for Food Security", *Proceedings of the National Academy of Sciences of the United States of America*, Vol.111, No.11, pp.4001–4006.

Kumar, N.; J. Harris and R. Rawat (2015), "If They Grow It, Will They Eat and Grow? Evidence from Zambia on Agricultural Diversity and Child Undernutrition", *J. Dev. Stud*., Vol.51, No.8, pp.1060–1077.

Leroy, J.; M. Ruel and D. Olney, (2008). The Micronutrient Impact of Multisectoral Programs Focusing on Nutrition: Examples from Conditional Cash Transfer, Microcredit with Education, and Agricultural Programs (1–91), Innocenti. Review 5.

Lividini, K.; J.L. Fiedler, F.F. De Moura, M. Moursi and M. Zeller (2017), "Biofortification: A Review of Ex-Ante Models", *Global Food Security*, Vol.17, pp.186–195.

Luckett, B.G.; F.A. DeClerck, J. Fanzo, A.R. Mundorf and D. Rose (2015), "Application of the Nutrition Functional Diversity Indicator to Assess Food System Contributions to Dietary Diversity and Sustainable Diets of Malawian Households", *Public Health Nutrition*, Vol.18, pp.2479–2487.

Maestre, M.; N. Poole and S. Henson (2017), "Assessing Food Value Chain Pathways, Linkages and Impacts for Better Nutrition of Vulnerable Groups", *Food Policy*, Vol.68, pp.31–39.

Malapit, Hazel (2021), "Women in Agriculture and the Implications for Nutrition in Agriculture for Improved Nutrition: Seizing the Momentum", in Shenggen Fan, Sivan Yosef and Rajul Pandya-Lorch, (Eds.) (2021) IFPRI, CAB International, Boston, MA 02111.

Mazzocchi, M., (2017), Ex-Post Evidence on the Effectiveness of Policies Targeted at Promoting Healthier Diets. Trade Policy Technical Notes, Trade and Food Security (No. 19), Food and Agriculture Organization of the United Nations.

McNulty, J. (2013), *Challenges and Issues in Nutrition Education*, Background paper for the International Conference on Nutrition (ICN2), Rome. Available at: http://www.fao.org/docrep/017/i3234e/i3234e.pdf.

Melba, Y. and K.R. Ashok (2021), Agricultural Interventions for Better Nutritional Outcomes - An Economic Analysis of Agriculture-Nutritional Linkages (Unpublished doctoral dissertation). Tamil Nadu Agricultural University, Coimbatore, India.

Miller, L.C.; N. Joshi, M. Lohani, B. Rogers, M. Kershaw, R. Houser, S. Ghosh, J.K. Griffiths, S. Mahato and P. Webb (2016), "Duration of Programme Exposure is Associated with Improved Outcomes in Nutrition and Health: The Case for Longer Project Cycles from Intervention Experience in Rural Nepal", *J. Dev. Eff*., Vol.9, pp.101–119.

Miller, L.C.; N. Joshi, M. Lohani, B. Rogers, M. Loraditch, R. Houser, P. Singh and S. Mahato (2014), "Community Development and Livestock Promotion in Rural Nepal: Effects on Child Growth and Health", *Food Nutr. Bull*., Vol.35, pp.312–326.

Mirriam Matita; Ephraim W. Chirwa, Deborah Johnston, Jacob Mazalale, Richard Smith and Helen Walls (2021), "Does Household Participation in Food Markets Increase Dietary Diversity? Evidence from Rural Malawi", *Global Food Security* Vol.28, 100486.

MSSRF (2018), Farming System for Nutrition: A Pathway for Addressing Malnutrition in India, M.S. Swaminathan Research Foundation, Chennai.

Murty, P.V.V.S.; M.V. Rao and M.S. Bamji (2016), Impact of Enriching the Diet of Women and Children through Health and Nutrition Education, Introduction of Homestead Gardens and Backyard Poultry in Rural India", *Agric. Res.*, Vol.5, pp.210–217.

Nadjia Mehraban and Amy Ickowitz (2021), "Dietary Diversity of Rural Indonesian Households Declines Over Time with Agricultural Production Diversity Even as Incomes Rise", *Global Food Security* Vol.28, 100502.

Nagarajan, S.; R.V. Bhavani and M.S. Swaminathan, (2014), "Operationalizing the Concept of Farming System for Nutrition through the Promotion of Nutrition-Sensitive Agriculture", *Current Science*, pp.959-964.

Nandi Ravi; S. Nedumaran and P. Ravula (2021), "The Interplay Between Food Market Access and Farm Household Dietary Diversity in Low and Middle Income Countries: A Systematic Review of Literature", *Global Food Security*, Vol.28,100484.

Nechifor, Victor; Maria Priscila Ramos, Emanuele Ferrari, Joshua Laichena, Evelyne Kihiu, Daniel Omanyo, Rodgers Musamali and Benson Kiriga (2021), "Food Security and Welfare Changes under COVID-19 in Sub-Saharan Africa: Impacts and Responses in Kenya", *Global Food Security*, Vol.28, 100514.

Nitya R.; G. Haris, C. Devanshi and L. Marium (2019). "Women's Agricultural Work and Nutrition in South Asia: From Pathways to A Cross-Disciplinary, Grounded Analytical Framework", *Food Policy*, Vol.82, pp.50–62.

Nnoaham, K.E.; G. Sacks, M. Rayner, O. Mytton and A. Gray (2009), "Modelling Income Group Differences In The Health And Economic Impacts Of Targeted Food Taxes And Subsidies", *Int. J. Epidemiol*, Vol.38, pp.1324–1333. https://doi.org/10.1093/ije/dyp214.

Okwuonu Ihuoma C.; Narayanan N. Narayanan, Chiedozie N. Egesi and Nigel J. Taylor (2021), "Opportunities and Challenges for Biofortification of Cassava to Address Iron and Zinc Deficiency in Nigeria", *Global Food Security* Vol.28, 100478.

Osei, A.K.; P. Pandey, J. Nielsen, A. Pries, D. Spiro, D. Davis, V. Quinn and N. Haselow (2017), "Combining Home Garden, Poultry, and Nutrition Education Program Targeted to Families with Young Children Improved Anemia among Children and Anemia and Underweight Among Nonpregnant Women in Nepal", *Food Nutr. Bull*. Vol.38, No.1, pp.49–64.

Pandey, V.L.; P. Mahendra Dev and U. Jayachandran (2016), "Impact of Agricultural Interventions on the Nutritional Status in South Asia: A Review", *Food Policy* Vol.62, pp.28–40.

Pant, J.; B.K. Barman, K. Murshed-E-Jahan, B. Belton and M. Beveridge (2014), "Can Aquaculture Benefit the Extreme Poor? A Case Study of Landless and Socially Marginalized Adivasi (Ethnic) Communities in Bangladesh", *Aquaculture*, pp.418–419.

Parajuli, B. and R. Chand, R. (2021), "Reimagining Food Systems with Lessons from India", *The Hindu*, 4th October.

Patrick Johnson, D. (2011), Cornucopia: Leveraging Agriculture to Improve Health and Nutrition, Hamilton Books ISBN: 0761855963, 9780761855965.

Pauw, K. and J. Thurlow (2010), Agricultural Growth, Poverty, and Nutrition in Tanzania, 2010 AAAE Third Conference/AEASA 48th Conference. Cape Town: African Association of Agricultural Economists (AAAE); Agricultural Economics Association of South Africa (AEASA).

Pingali, P. and M. Abraham (2021), Unraveling India's Malnutrition Dilemma – A Path Toward Nutrition-Sensitive Agriculture in Agriculture for Improved Nutrition: Seizing the Momentum, in Shenggen Fan, Sivan Yosef *and* Rajul Pandya-Lorch, (Eds.) (2021), IFPRI, CAB International, Boston, MA 02111.

Pingali, P. and T. Rao (2017), Understanding the Multidimensional Nature of the Malnutrition Problem in India, in: Pingali, P. and Feder, G. (Eds.) (2017), *Agriculture and Rural Development in a Globalizing World*. Routledge, New York.

Pinstrup-Andersen, P. (2013). "Nutrition-Sensitive Food Systems: From Rhetoric to Action". *Lancet*, Vol. 382, pp.375–376.

Qaim, M. and K.T. Sibhatu (2018), On the Link Between Production Diversity and Dietary Quality in Smallholder Farm Households, in Hidden Hunger: Strategies to Improve Nutrition Quality, Vol.118. Karger Publishers, pp.102–111. https://doi.org/ 10.1159/000484510.

Remans, R.; D. Flynn, F. DeClerck, W. Diru, J. Fanzo *et al*. (2011), "Assessing Nutritional Diversity of Cropping Systems in African Villages", *PLOS ONE* Vol.6, No.6, pp.e21235.

Ruel, M.T.; H. Alderman and Maternal and Child Nutrition Study Group (2013), "Nutrition-Sensitive Interventions and Programmes: How Can They Help to Accelerate Progress in Improving Maternal and Child Nutrition?", *The Lancet*, Vol.382(9891), pp.536–551.

Ruel, M.T. and H. Alderman (2013), "Nutrition-Sensitive Interventions and Programmes: How Can They Help to Accelerate Progress in Improving Maternal and Child Nutrition?", *The Lancet*, Vol.6736, No.13, pp.1–16. https://doi.org/10.1016/S0140-6736(13)60843-0.

Ruel, M.T.; A.R. Quisumbing and M. Balagamwala (2018), "Nutrition-Sensitive Agriculture: What Have We Learned So Far?", *Global Food Security*, Vol.17, pp.128–153. doi: 10.1016/j.gfs.2018.01.002.

Ruel, Marie T. (2021). New Evidence on Nutrition-Sensitive Agricultural Programs in Agriculture for Improved Nutrition: Seizing the Momentum, in Shenggen Fan, Sivan Yosef and Rajul Pandya-Lorch, (Eds.) (2021) IFPRI, CAB International, Boston, MA 02111.

Saltzman, A.; E. Birol, H.F. Bouis, E. Boy, F.F. De Moura, Y. Islam and W.H. Pfeiffer, (2013), "Biofortification: Progress Toward a More Nourishing Future", Global *Food Security*, Vol.2, No.1, pp.9–17.

Schreinemachers, P.; M.A. Patalagsa, M.R. Islam, M.N. Uddin, S. Ahmad, S.C. Biswas, M.T. Ahmed, R.Y. Yang, P. Hanson, S. Begum and C. Takagi (2014), "The Effect of Women's Home Gardens on Vegetable Production and Consumption in Bangladesh", *Food Security*, Vol.7, pp.97–107.

Schreinemachers, P.; M.A. Patalagsa and N. Uddin (2016); "Impact and Cost-Effectiveness of Women's Training in Home Gardening and Nutrition" in *Bangladesh. J. Dev. Eff.*, Vol.8, pp.473–488.

Shepherd, R. (1999), "Social Determinants of Food Choice", *Proc. Nutr. Soc*., Vol.58 pp.807-812, 10.1017/s0029665199001093.

Sibhatu, K.T. and M. Qaim (2018), "Review: Meta-Analysis of the Association Between Production Diversity, Diets, and Nutrition in Smallholder Farm Households", *Food Policy*. Vol.77, pp.1-18.

Sibhatu, K.T.; V.V. Krishna and M. Qaim (2015), "Production Diversity and Dietary Diversity in Farm Households". Proceedings of the National Academy of Sciences, Vol.112, No.34, pp.10657-10662.

Smith, L.C.; U. Ramakrishnan, A. Ndiaye, L.J. Haddad and R. Martorell (2003), The Importance of Women's Status for Child Nutrition in Developing Countries. IFPRI Research Report No. 131. International Food Policy Research Institute, Washington, D.C., U.S.A.

Springmann, M.; D. Mason-D'Croz and S. Robinson *et al*. (2016), "Global and Regional Health Effects of Future Food Production under Climate Change: A Modelling Study." *Lancet* V387, pp.1937–1946.

Springmann, M.; D. Mason-D'Croz, S. Robinson, K. Wiebe, H.C.J. Godfray, M. Rayner and P. Scarborough, (2018), Health-Motivated Taxes on Red and Processed Meat: A Modelling Study on Optimal Tax Levels and Associated Health Impacts, PloS One 13. https://doi.org/10.1371/journal.pone.0204139 e0204139.

Stein, A.J., (2014), "Rethinking the Measurement of Undernutrition in a Broader Health Context: Should We Look at Possible Causes or Actual Effects?", *Glob. Food Secur.* Vol.3, No.3, pp.193–199.

Stok, F.M.; S. Hoffmann, D. Volkert, H. Boeing, R. Ensenauer, M. Stelmach-Mardas, E. Kiesswetter, A. Weber, H. Rohm, N. Lien, J. Brug, M. Holdsworth and B. Renner (2017), The DONE Framework: Creation, Evaluation, and Updating of an Interdisciplinary, Dynamic Framework 2.0 of Determinants of Nutrition and Eating, PloS One 12, e0171077. https://doi.org/10.1371/journal.pone.0171077.

Swindale, A. and P. Bilinsky (2006), Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide (v.2). FHI 360/FANTA, Washington, D.C., U.S.A.

Thomas, D. (1994), "Like Father like Son: Like Mother like Daughter: Parental Resources and Child Health", *J. Human Res*., Vol.29, No. 4, pp. 950-988.

UN (2021), United Nations in India, Nutrition and Food Security, https://in.one.un.org/un-priority-areas-in-india/nutrition-and-food-security/

UNSCN, (2019), UNSCN Nutrition 44: Food Environments: where People Meet the Food System. UNSCN, Geneva.

Van den Bold, M.; A.R. Quisumbing and S. Gillespie (2013). Women's Empowerment and Nutrition: An Evidence Review. (No. 01294). International Food Policy Research Institute, Washington, D.C., U.S.A. Retrieved from http://www.ifpri.org/sites/default/files/publications/ifpridp01294.pdf.

Veerman, J.L.; G. Sacks, N, Antonopoulos and J. Martin (2016), The Impact of a Tax on Sugar-Sweetened Beverages on Health and Health Care Costs: A Modelling Study. PloS One 11. https://doi.org/10.1371/journal.pone.0151460 e0151460.

Webb, P. and S. Block (2011), Support for Agriculture During Economic Transformation: Impacts on Poverty and Undernutrition, Proceedings Natl. Acad. Sci., Vol. 109, pp. 12309–12314.

WHO (2018), Choosing Interventions that are Cost Effective (WHO-CHOICE). World Health Organization, Geneva. Available at: http://www.who.int/choice/en/.

World Bank (1993), World Development Report, The World Bank, Washington, D.C., U.S.A.

Yesudas, Salome (2021), Food-Based Strategies for Nutritional, AESA Blog-159 https://www.aesanetwork.org/wp-content/uploads/2021/09/AESA-BLOG-159.pdf