ORF ISSUE BRIEF
OCTOBER 2020
ISSUE NO. 407

Harnessing Agriculture for Achieving the SDGs on Poverty and Zero Hunger

RV Bhavani
Priya Rampal

ABSTRACT Agriculture remains the world's biggest employer and the most important source of food and raw material for various economic activities. The fulfillment of a number of the Sustainable Development Goals (SDGs) is anchored on the performance of the sector. This brief examines the most crucial negative consequences of how modern agriculture is practiced, and how these will make it difficult for the world to realise the SDGs. Drawing on examples from India, the brief outlines the nature of change required to transform agriculture, arrest the overexploitation of scarce resources, make agriculture climate-resilient and nutrition-sensitive, and nurture sustainability.

Attribution: RV Bhavani and Priya Rampal, "Harnessing Agriculture for Achieving the SDGs on Poverty and Zero Hunger and Zero Hunger," *ORF Issue Brief No. 407*, October 2020, Observer Research Foundation.

ISBN 978-81-948115-9-6

INTRODUCTION

Agriculture and its allied sectors are crucial to the achievement of the 17 Sustainable Development Goals (SDGs) adopted by 193 countries in 2015, setting targets for 2030 and referred to as Agenda 2030. Source of both food and raw material, agriculture—crops, livestock, aquaculture, fisheries and forests—traces its beginnings to the birth of human civilisation. It is the world's biggest employer and the main source of food and income, especially for the extreme poor.[1] A large majority of the population in developing countries across Asia, Africa and Latin America depend on agriculture for their livelihood.

The SDGs are interconnected in many contexts and a link with agriculture is clear for many of them. (See Table 1)

Table 1: Agriculture's link with SDGs

SDG	Link with Agriculture
SDG 1: End poverty in all its forms. Everywhere	As most of the poor in the developing world are dependent on agriculture, ending poverty is linked to increasing returns from agriculture. Major indicators are ownership and control over land and natural resources, both of which are essential endowments for practicing agriculture.
SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Directly related to sustainable agriculture
SDG3: Ensure healthy lives and promote well-being for all at all ages	Can only be achieved through nutritious food produced via agriculture and allied sectors
SDG5: Achieve Gender Equality and empower all women and girls	Women play an important but largely unrecognised role in agriculture; their empowerment, decision-making and time for care work are pathways in leveraging agriculture for nutrition
SDG 6: Ensure availability and sustainable management of water and sanitation for all	Increasing water use efficiency across sectors, integrated water resource management, and protection and restoration of water related ecosystems —all have a bearing on agriculture
SDG7: Ensure access to affordable, reliable, sustainable and modern energy for all	Reduction in agriculture's dependence on fossil fuels and consequent pollution
SDG8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Agriculture engages a large segment of the working population and consequently has a bearing on the realisation of decent work and economic growth
SDG10: Reduce inequality within and among countries	Disparity in asset ownership and wages in agriculture activities

SDG12: Ensure sustainable consumption and production patterns	Sustainable management of all natural resources, sustainable production patterns, and reducing food loss and waste
SDG13: Take urgent action to combat climate change and its impacts	Strengthening resilience and adaptive capacity of agriculture to the impacts of climate change, and lowering green-house gas emissions without affecting food production
SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.	Conservation and sustainable use of marine and coastal ecosystems, reduction of pollution, and sustainable fish harvest.
SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	All these are the feedstock for agriculture activities; indiscriminate agriculture expansion has led to decline of forest area and biodiversity loss and overexploitation of land, resulting in degradation.

Authors' own.

Agriculture as it is practiced today in most parts of the world, is facing multiple challenges: shrinking resource base; overexploitation of land and water resources; and climate change. Further, although agriculture and its allied activities are the most important source of food as well as livelihood for many, and the link of agriculture to nutrition and health is enshrined in the SDGs, the critical contribution of agriculture to nutrition is yet to receive sufficient attention.[2] It is increasingly being recognised that reforms in agriculture are crucial to harness its potential in helping realise the SDGs. Humankind in the anthropocene era finds itself in a situation where "...agriculture and food systems are characterized by a failure to deliver food security for all, as illustrated for example by the effects of the present price volatility, which is severely restricting access to food for the poor, while simultaneously placing an increased strain on the environment."[3] This brief draws on examples from India to examine aspects related to current practices of agriculture and their impact. It outlines the nature of change required, in order to transform agriculture into a key driver of fulfilling the SDGs.

CONTEMPORARY AGRICULTURE: KEY CHALLENGES

Agriculture is seen as central to the challenges facing humankind in the anthropocene era, in terms of being a key driver of global environmental change. Agriculture and food production has impacts on land degradation, deforestation, loss of habitat and biodiversity, depletion of natural resources, and contamination of air, soil and water.[4,5] Improvements in technology and productivity have led to increased production of food for a burgeoning population. However, this has come with a huge cost as shrinking traditional agriculture vis-à-vis intensive commercial farming, and expanding industrial production have led to the exploitation of available limited natural resources. The progress has

often come with social and environmental costs which include land degradation, decreasing water tables, loss in biodiversity, and high emissions of greenhouse gas (GHG). The productive potential of the world's natural resources base has been compromised, affecting the future fertility of the planet.[6] Indeed, globally, production patterns supporting prevalent dietary patterns are responsible for anywhere from 21–37 percent of total GHG emissions.[7]

The use of synthetic fertilisers and pesticides in agriculture causes chemical pollution of the ecosystem—such contamination may in turn lead to health consequences.[8,9] These practices, compounded by the growing competition for land, water and energy, affect the capacity for future sustainable healthy food production.[10,11,12] In India, for instance, 147 million hectares (Mha) of a total land area of 329 Mha has degraded soil or has water-related issues such as dwindling surface water and unregulated groundwater extraction. Deteriorating air quality has also emerged as a major threat to human life.[13] With declining agricultural land, growing populations, increasing pressure on water and energy resources, and soaring climate variability, South Asia and other parts of the world, are facing the challenge of producing food for an increasing population —food that is both nutritious and environmentally sustainable, given the same or less resources.

Apart from the decreasing water table, farmers are directly affected by floods, droughts, rising temperatures, unpredictable rainfall, crop diseases and pests such as locusts. As a consequence of climate change, sea levels have risen and low-lying coastal areas are being swamped with saltwater that increases soil salinity. These salts can be dissipated by rainfall, but climate change is also increasing the frequency and severity of extreme weather events, including droughts and heat waves, leading to higher use of groundwater for drinking and irrigation. This further depletes the water table and allows even more salt to seep into soil.[14]

A large, multi-site global analysis in 2014 tested the effects of rising carbon dioxide ($CO_{2)}$ on zinc, iron, and protein levels in staple crops, viz. rice, wheat, maize, soybeans, field peas, and sorghum. It was found that increases in CO_2 were associated with a decrease in the range of 3 to 17 percent in protein, iron and zinc in the tested crops.[15] Researchers then examined the effect of reduced nutrient level in staple crops on human nutrition and found that projected increases in CO_2 levels could cause 175 million people (1.9 percent) to become deficient in zinc, and an additional 122 million people (1.3 percent) to become deficient in protein. With regard to iron, 1.4 billion women of child-bearing age and young children (representing 57 percent of these groups) would be at high risk for iron deficiency. This is a matter of serious concern and calls for future research to focus on breeding CO_2 tolerant crop strains, biofortification and supplementation to address nutrition deficiencies.[16]

Loss of biodiversity is another threat to agriculture, globally. Currently, only 30 crops provide 95 percent of human food-energy needs. Of these, only five– rice, wheat, maize, millet and sorghum—account for about 60 percent. Five animal species – cattle, sheep,

goats, pigs and chicken –account for about one-third of average daily protein consumed. This narrowing down of the food basket increases the vulnerability of agriculture and food systems and puts food security and nutrition at risk, as the natural resource base and ecosystem services are the foundation of food and agricultural systems.[17]Genetic diversity helps species adapt to changing environment conditions and confers resistance against various stress conditions. The loss of this diversity reduces the feedstock for coping with environmental challenges like increasing salinisation of soil and extreme weather conditions like drought and floods. In his commentary, Swaminathan links the Irish potato famine in the 1840s to the loss of genetic diversity and emphasises the need to "promote genetic heterogeneity." [18]

In India, researchers are calling attention to the consequences of food "increasingly being produced in intensive industrial settings."[19] This includes (mis)use of antibiotics in animals and birds grown for consumption, to promote faster growth and prevent disease. The gut bacteria in the animal or bird becomes resistant and spreads through food, contact and waste, besides antibiotic residues in food and unmetabolised antibiotics in faeces. Further, increasing monoculture and loss of genetic diversity may be help viruses amplify and attain higher virulence, and lead to infectious zoonotic diseases in humans.[20]

The current imperative is to find means of producing enough and enabling everyone to have access to healthy diets without overexploiting the earth's resources. "Therefore in the Anthropocene, humanity faces the imperative question of how to transform agriculture that feeds the world, contributes to eradicate poverty, and contributes to a stable planet."[21]

RECOMMENDATIONS

At one level, humankind is still trying to grasp the severity of impact of overexploitation of natural resources in order to produce more. It is clear that prevalent high-input and resource-intensive farming systems which have led to exploitation and degradation of natural resources cannot lead to sustainability of the food systems.[22]

There is evidence, however, in pockets across the globe of various initiatives and innovations that demonstrate how things can be done differently to address or avoid these problems. According to the Food and Agriculture Organisation of the UN (FAO), sustainable food and agriculture practices if adopted and practiced in the right manner, have the potential to help achieve the SDGs.[23] The following paragraphs highlight a few of the plausible innovations for reforming agriculture.

Some of the most commonly proffered recommendations for building climate resilience in agriculture include water and energy-saving irrigation, conservation agriculture, controlled environment farming, livestock grazing management, energy-efficient cold storage, and biogas production.[24] In the context of rising sea levels, in particular, India has demonstrated the potential of Joint Mangrove Management (JMM) for widespread adoption and replication (See Box 1).

Box 1: Joint Mangrove Management and sustainable fish farming

The Integrated Mangrove Restoration Programme along the Coromandel coast of India led by the M S Swaminathan Research Foundation (MSSRF) has restored over 1,500 ha of degraded mangrove wetlands over the period 1999 to 2002. Further, the Joint Mangrove Management (JMM) programme has brought together about 10,000 mangrove user families covering almost 20,000 ha of mangrove forests for restoration. The programme proved crucial especially in the aftermath of the massive Indian Ocean tsunami in 2004, because mangroves serve as a buffer against such extreme events. The JMM had a two-fold objective: to restore the mangrove forests, and to ensure the participation of the local communities. The National Mangrove Action Plan of the Ministry of Environment, Forests and Climate Change, Government of India, has cited the JMM as the best available model for mangrove management. It can be adapted widely to help overcome the challenges of sea level rise and other climate change-induced disaster events.

The MSSRF also promotes Integrated Mangrove Fishery Farming System (IMFFS) in Tamil Nadu and Andhra Pradesh, under which mangrove plantation and aquaculture are combined. Here, the promotion of traditional canal fishing in the midst of mangrove plantation, has resulted in healthy and high harvest of fish with low external inputs. This model has demonstrated the successful culturing of sea bass, milk fish, mullet, crab and prawn, and provides a tangible option of coastal aquaculture as a source of sustainable livelihood. The pilot model covering an approximate area of 20 hectares has shown potential of generating income between INR 15,000 to 30,000 from the fish ponds within four months of operation. The set-up requires limited energy to operate, and does not use artificial feed—these result in reduced input cost and less environmental pollution.

Source: MSSRF[25,26]

There are production processes that are more efficient in promoting sustainability and should be encouraged. For instance, crop rotation where short variety leguminous crops are planted after harvest, increase the nitrogen content of the soil and make it more productive; crop waste or animal waste can be used as manure and has the potential to improve soil health; collection of rainwater via channeling and use of renewable sources of energy encourages resource-use efficiency. There are also technological innovations like hydroponic (plants grown in nutrient-rich solutions), aquaponic (using water and fish waste), and aeroponic (nutrient-rich water is sprayed onto—in air—dangling roots) techniques, for growing crops without soil.[27]

In northwest India, which was the heartland of the green revolution of the 1960s and 1970s, groundwater has been overexploited due to the extensive use of the rice-wheat cropping system. A study observed that improved technologies which do not

require deep drainage are being adopted.[28] The benefits associated with this include less energy consumption to pump groundwater, less nutrient loss by leaching, and no groundwater pollution. Laser land leveling, alternate wetting and drying water management in rice, delayed rice transplanting, shorter duration rice varieties, zero till wheat, raised beds, and replacing rice with other crops are other practices that can help in efficient water use. Another study suggests replacing subsidy for inputs like electricity to operate tubewells, with support for output (i.e. increase in procurement price or bonus on agricultural marketable produce), would encourage farmers to use irrigation water more efficiently.[29] This is because large-scale cultivation of rice and its early transplantation in June, before the monsoon, facilitated by regular subsidised supply of electric power to tubewells may be key to the fall of Punjab's water table.

Yet another study in India, using a process-based crop water model and data on food production and nutrient content to understand whether various crop shifting scenarios had any impact on consumptive water demand and nutrient production, found that historical growth in wheat production during the rabi (non-monsoon) season was the main driver of the country's increased consumptive irrigation water demand and that rice is the least water-efficient cereal for the production of some of the key nutrients—iron, zinc, and fiber.[30] By replacing rice areas in each district with alternative cereals (maize, finger millet, pearl millet, sorghum) with the lowest irrigation (blue) water footprint, it will be possible to reduce irrigation or water demand by 33 percent and improve the production of protein (+1%), iron (+27%), and zinc (+13%) with only a modest reduction in calories. There is also evidence of pulses and millets being climate-smart crops, i.e., they can be grown in regions without proper irrigation.[31] They are also more nutrient-dense crops, when compared to rice.

Speaking of leveraging agriculture for nutrition, it was only towards the end of the last century that the role of agriculture in promoting better nutrition outcomes and health started getting discussed in international discourse.[32] Agriculture and its linkages to nutrition are crucial to realise SDG1 to end poverty, and SDG2 which focuses on sustainable agriculture, achieving zero hunger, and ending malnutrition in all its forms. Focus is required at different levels: increasing awareness in the population on the importance of producing and consuming nutrient-rich crops; providing support and incentives to produce nutrient-rich crops such as millets and pulses; and promoting self-consumption by growing vegetables and fruits in home gardens and on common land, whose produce can be used for consumption. There is evidence from various studies that agriculture and production diversity promotes dietary diversity, and efforts that encourage farmers to diversify their crop portfolios will help in improving diet quality.[33,34,35]

The imperative is for agriculture policies and programmes to move beyond its traditional focus on production and productivity, and instead mainstream the nutrition dimension. M S Swaminathan advocates an approach called 'farming system for nutrition' (FSN), defined as: "The

introduction of agricultural remedies to the nutritional maladies prevailing in an area through mainstreaming nutritional criteria in the selection of the components of a farming system involving crops, farm animals and wherever feasible, fish."[36] The FSN approach comprises a combination of location-specific measures including advanced crop production practices, bio-fortification, and promotion of kitchen (nutrition) gardens of fruits and vegetables, livestock and poultry development, setting up of small-scale fisheries, combined with nutrition awareness. It is an inclusive location-specific approach based on the resource endowments to address the nutritional needs of smallholder farm families, who constitute the majority of farmers. (See Box 2)

Box 2: A Farming System for Nutrition Approach

MSSRF led a study from 2013 to 2017 to examine the feasibility of a Farming System for Nutrition (FSN) approach to address undernutrition, in a cluster of villages in Koraput, Odisha and Wardha, Maharashtra, under a research programme on Leveraging Agriculture for Nutrition in South Asia (LANSA). Both regions are characterised by small and marginal land holdings and rain-fed farming. Baseline survey revealed high levels of undernutrition and lack of dietary diversity.[37] The FSN design developed in discussion with the community focused on increasing the production and availability of nutrient-dense crops like millets and pulses; promoting nutrition gardens of fruits and all three groups of vegetables based on a seasonal calendar, at household level, on common land; and setting up demonstrations in schools, increasing access to animal foods (fishery in Koraput and poultry in Wardha) and nutrition awareness across the board. The viability of recommended crops, varieties and practices in terms of economic returns was demonstrated through on-farm trials, along the lines discussed for the case of finger millet.[38]

Nutrition awareness was integral to the approach and an important aspect of this was building the capacity of members of the community to be community nutrition champions or 'community hunger fighters (CHF)'. Using participatory action research methods, selected community representatives, both men and women, were facilitated through a process of action and reflection to help them identify, prioritise and take action to address the issues related to the importance of balanced diet and dietary diversity, food availability and sourcing of food, good dietary practices, food, nutrition and care during different stages in the life cycle.

An endline survey in late 2017 revealed increase in availability and consumption of finger millet, pulses and vegetables by households, a greater proportion of households consuming more than 70 percent of recommended allowance of all food groups, and an improvement in household dietary diversity. [39][40]

CONCLUSION

It is increasingly become clear that a 'business as usual' approach is no longer an option if the targets set by the 2030 Agenda for Sustainable Development are to be met, specifically those related to food and agriculture.

It is clear that reforms are required in the practice of agriculture. Drawing on examples from India, this brief has outlined some of the practices that have been demonstrated as means to transform the sector, arrest the overexploitation of scarce resources, and nurture sustainability.

The crisis triggered by the COVID-19 pandemic has led to a food emergency and the number of people who are food and nutrition insecure is expected to further rise in the coming years.[41] Indeed, the pandemic has exposed the fragility of current global interconnections. Given existing gaps in the health sector of the economy, supply-side issues, and prevailing inequalities, the pandemic has led to an immediate failure of desired goals under SDGs 1, 2 and 3, for millions of people who were already food-insecure, to begin with, or were rendered jobless and therefore without means to take care of their health and nutrition. In India, the breakdown of the supply chain during the initial period of the lockdown caused massive wastage of perishable foods that could have fed many.[42] Further, there were numerous lay-offs, pay cuts apart from lack of work with a complete freezing of construction activities leading to job losses for workers in the informal sector. Not only did many migrants have to walk back to their hometowns, there was no assurance of their next meal at this time. COVID-19 has aggravated the situation of large populations who were already vulnerable before the pandemic; their numbers have increased.[43,44]

While the 2030 Agenda was already difficult to achieve even before the outbreak of the COVID-19 pandemic—with many nations like India falling behind targets—the health crisis has exacerbated the situation.

Drawing on available evidence and examples from across the world, the FAO has listed 20 integrated and interconnected actions knitting together the many dimensions of agriculture and rural development, that may be seen as comprehensively laying the foundation for resilient and sustainable societies and achieving the SDGs.[45] (See Box 3)

Box 3. FAO Recommendations for Agriculture and Rural Development

1. Facilitate access to productive resources, finance and services;
2. Connect smallholders to markets
3. Encourage diversification of production and income;
4. Build producers' knowledge and develop their capacities;
5. Enhance soil health and restore land;
6. Protect water and manage scarcity;

7. Mainstream biodiversity conservation and protect ecosystem functions;
8. Reduce losses, encourage reuse and recycle, and promote sustainable consumption;
9. Empower people and fight inequalities;
10. Promote secure tenure rights;
11. Use social protection tools to enhance productivity and income;
12. Improve nutrition and promote balanced diets;
13. Prevent and protect against shocks: enhance resilience;
14. Prepare for and respond to shocks;
15. Address and adapt to climate change;
16. Strengthen ecosystem resilience;
17. Enhance policy dialogue and coordination;
18. Strengthen innovation systems;
19. Adapt and improve investment and finance;
20. Strengthen the enabling environment and reform the institutional framework.

Going forward, the Food Systems Summit to be convened by the United Nations in 2021 will be an opportune time for participating member nations from across the globe to commit to the required reforms in agriculture. The period leading to it must be used by nations to rethink strategies and initiate measures to change and work for the building of resilient and sustainable communities, beginning with the transitions required in agriculture. Replicating and upscaling sustainable agriculture practices and models from across the globe will be a good first step.

ABOUT THE AUTHORS

RV Bhavani is Director, Agriculture Nutrition Health Programme at the M S Swaminathan Research Foundation.

Priya Rampal is an Assistant Professor at the Economics and International Business Department in the School of Business Studies at Sharda University.

ENDNOTES

1. FAO "Sustainable Food Systems – Concepts and Framework" Food and Agriculture Organisation of the United Nations, Rome.(2018a) http://www.fao.org/3/ca2079en/CA2079EN.pdf.

2. Shenggen Fan et al. "Seizing the Momentum to Reshape Agriculture for Nutrition." Ch.1, pp.1-15 in Agriculture for Improved Nutrition: Seizing the Momentum. Fan, S., Yosef, S. and Pandya-Lorch, R. Wallingford, UK, International Food Policy Research Institute (IFPRI) and CABI.

3. Uno Svedin "Global conditions for the future of agriculture in the Anthropocene". In: Jacquet, P., Pachauri, P.J.R, Tubiana L. (eds.) Towards Agricultural Change? (2012) The Energy and Resources Institute, New Delhi, 107-116

4. Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) "Thematic assessment report on land degradation and restoration" IPBES (2018) Bonn. https://ipbes.net/assessment-reports/ldr

5. Sarah Whitmee et al. "Safeguarding human health in the anthropocene epoch" Report of The Rockefeller Foundation-Lancet Commission on Planetary Health. Lancet 386 (2015):1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1

6. FAO "The future of food and agriculture – Alternative pathways to 2050."Food and Agriculture Organisation of the United Nations, Rome (2018b). http://www.fao.org/3/CA1552EN/ca1552en.pdf

7. FAO, IFAD, UNICEF, WFP and WHO "The State of Food Security and Nutrition in the World 2020.Transforming food systems for affordable healthy diets." Food and Agriculture Organisation of the United Nations, Rome (2020) https://doi.org/10.4060/ca9692en

8. Simonetta Corsolini et al. "Persistent organic pollutants in edible fish: a human and environmental health problem". Microchemical Journal 79 (2017):115–123. https://doi.org/10.1016/j.microc.2004.10.006

9. Philip J Landrigan et al. "The Lancet commission on pollution and health." Lancet 10119 no. 391 (2017) P462-512. https://doi.org/10.1016/S0140-6736(17)32345-0

10. Tara Garnett "Changing what we eat: a call for research and action on widespread adoption of sustainable healthy eating". University of Oxford, Food Climate Research Network (2014) Oxford.https://www.fcrn.org.uk/sites/default/files/fcrn_wellcome_gfs_changing_consumption_report_final.pdf

11. Whitmee et al. "Safeguarding human health in the anthropocene epoch"

12. H. Charles J. Godfray et al. "Food security: the challenge of feeding 9 billion people" Science 327(2010): 812–818. https://doi.org/10.1126/science.1185383

13. Government of India - GoI "Draft National Resource Efficiency Policy 2019" Office Memorandum, International Cooperation Division, Ministry of Environment, Forest and

Climate Change (2020) New Delhi. http://moef.gov.in/wpcontent/uploads/2019/07/Draft-National-Resourc.pdf

14. Joyce J. Chen and Valerie Mueller "Climate change is making soils saltier, forcing many farmers to find new livelihoods" (2018) https://theconversation.com/climate-change-is-making-soils-saltier-forcing-many-farmers-to-find-new-livelihoods-106048 (accessed 10 July 2020)

15. Matthew R Smith and Samuel S Myers "Impact of anthropogenic CO2 emissions on global human nutrition." Nature Climate Change 8 (2018): 834–839. https://doi.org/10.1038/s41558-018-0253-3

16. Smith and Myers "Myers "Impact of anthropogenic CO2 emissions on global human nutrition."

17. FAO "Transforming Food and Agriculture to achieve the SDGs: 20 interconnected actions to guide decision-makers" Food and Agriculture Organisation of the United Nations, Rome (2018c). http://www.fao.org/3/I9900EN/i9900en.pdf

18. M.S. Swaminathan (as told to Nitya Rao) [Commentary] "Covid-19 and food security: Lessons for Indian Agriculture" https://india.mongabay.com/2020/04/commentary-covid-19-and-food-security-lessons-for-indian-agriculture/ (accessed on 11 August 2020)

19. Centre for Science and Environment (CSE) "Body Burden – Antibiotic Resistance: The State of India's Health" CSE (2020). New Delhi

20. CSE "Body Burden-Antibiotic Resistance"

21. Johan Rockström et al. "Sustainable intensification of agriculture for human prosperity and global sustainability". Ambio 46 (2017) 4–17. https://doi.org/10.1007/s13280-016-0793-6

22. FAO "The future of food and agriculture – Alternative pathways to 2050"

23. FAO "The future of food and agriculture – Alternative pathways to 2050"

24. UN Policy brief: "The impact of COVID-19 on Food Security and Nutrition" (2020) https://reliefweb.int/report/world/policy-brief-impact-covid-19-food-security-and-nutrition-june2020#:~:text=Meat%20processing%20plants%20and%20food,disruption%20and%20falling%20consumer%20demand

25. M.S. Swaminathan Research Foundation (MSSRF) "Journey of MSSRF: Harnessing Science for Sustainable Development: Innovations and Impacts"(2019a) MSSRF/OP/19/9 http://59.160.153.188/library/sites/default/files/30-years-journey-of-MSSRF.pdf

26. MSSRF "Restoring mangroves, rebuilding livelihoods"(2019b) M S Swaminathan Research Foundation, Chennai. https://www.mssrf.org/mssrfthirtyyearsnew/restoring-mangroves-rebuilding-livelihoods/

27. Nicholas Clinton et al. "A global geospatial ecosystem services estimate of Urban agriculture" Earth's Future 6 (2017): 40–60. https://doi.org/10.1002/2017EF000536

28. E Humphreys et al. "Halting the Groundwater Decline in North-West India—Which Crop

Technologies will be Winners?" Advances in Agronomy 109 (2010): 155-217. 10.1016/B978-0-12-385040-9.00005-0.

29. G.S. Hira "Water Management in Northern States and the Food Security of India, Journal of Crop Improvement" 23 (2009):2, 136-157. https://doi.org/10.1080/15427520802645432

30. Kyle Davis et al. "Alternative cereals can improve water use and nutrient supply in India" Science Advances 4(2018) eaao1108. 10.1126/sciadv.aao1108.

31. Priya Rampal "Situational Analysis of Pulse Production and Consumption in India" LANSA Working Paper (2017) No 20 M S Swaminathan Research Foundation, Chennai. http://59.160.153.188/library/sites/default/files/LANSA%20Working%20paper%2020.pdf

32. R.V. Bhavani and Priya Rampal "Agriculture Nutrition linkages in South Asia: A Systematic Review" CAB reviews no 13 (2018) 046

33. RaghavGaiha et al. "Dietary Shift and Diet Quality in India: An Analysis Based on 50th, 61st and 66th Rounds of NSS". ASARC Working Paper.(2012): 17. https://crawford.anu.edu.au/acde/asarc/pdf/papers/2012/WP2012_17.pdf.

34. Jef L Leroy et al. "Measuring the Impact of Agriculture Programs on Diets and Nutrition." Strategic brief CGIAR Programme on Agriculture for Nutrition and Health, International Food Policy Research Institute. Washington D.C. (2020), https://a4nh.cgiar.org/files/2020/08/StrategicBrief_2020_A4NH_DietsNutrition_web.pdf

35. Bhavani and Rampal "Agriculture Nutrition linkages in South Asia: A Systematic Review"

36. S. Nagarajan et al. "Operationalizing the concept of farming system for nutrition through the promotion of nutrition-sensitive agriculture." Current Science, 107(2014),6: 959–964.

37. Vijay Bhaskar et al., "Establishing integrated agriculture-nutrition programmes to diversify household food and diets in rural India" Food Security: The Science, Sociology and Economics of Food Production and Access to Food no 5 (2017): 981-999.

38. AlizaPradhan et al. "Finger millet in tribal farming systems contributes to increased availability of nutritious food at household level: Insights from India" Agricultural Research8 (2019): 540–547. https://doi.org/10.1007/s40003-018-0395-6.

39. MSSRF "India Impact brief: Evidence from Farming System for Nutrition Study". LANSA India Impact Brief (2019c). M S Swaminathan Research Foundation, Chennai. http://59.160.153.188/library/sites/default/files/IndiaImpact%20brief%20NSA-4pg-online.pdf.

40. MSSRF "India Impact brief: Nutrition Awareness under Farming System for Nutrition Study" LANSA India Impact Brief.(2019d) M S Swaminathan Research Foundation, Chennai. http://59.160.153.187/sites/default/files/IndiaImpact%20brief%20NA-2pg-online.pdf

41. UN Policy brief: "The impact of COVID-19 on Food Security and Nutrition"

42. MSSRF. "On Farmers and Farming in Tamil Nadu, Puducherry, Kerala, Odisha and Assam" Covid

19 impact Policy Brief (2020) M S Swaminathan Research Foundation, Chennai. https://www.mssrf.org/sites/default/files/04%20On%20Farmers%20and%20Farming.pdf

43. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) "COVID-19 and South Asia: National Strategies and Subregional Cooperation for accelerating inclusive, sustainable and resilient recovery" (2020) https://www.unescap.org/resources/covid-19-and-south-asia-national-strategies-and-subregional-cooperation-accelerating

44. FAO, IFAD, UNICEF, WFP and WHO "The State of Food Security and Nutrition in the World 2020.Transforming food systems for affordable healthy diets."

45. FAO "Transforming Food and Agriculture to achieve the SDGs"

ORF OBSERVER RESEARCH FOUNDATION
Ideas • Forums • Leadership • Impact

20, Rouse Avenue Institutional Area, New Delhi - 110 002, INDIA
Ph. : +91-11-35332000 Fax : +91-11-35332005
E-mail: contactus@orfonline.org
Website: www.orfonline.org