

ZERO HUNGER INDIA

POLICIES AND PERSPECTIVES

KV PETER (EDITOR)



BRILLION Publishing

**ZERO HUNGER
IN
INDIA**
Policies and Perspectives

**ZERO HUNGER
IN
INDIA**
Policies and Perspectives

Professor K.V. Peter



Brillion Publishing

Taking Science Everywhere



Brillion Publishing

22 B/5 Ground Floor, Desh Bandhu Gupta Road,

Karol Bagh, New Delhi - 110005

Ph.: + 91 (11) 4155-8799

Email: info@brillionpublishing.com

brillionpublishing.com

© Publisher, 2018

ISBN: 978-93-87445-14-7

All Rights reserved under International Copyright Conventions. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior consent of the publisher or the copyright holders.

This book contains information obtained from authentic and highly regarded resources. Reasonable efforts have been made to publish reliable data and information, but the author/s editor/s and the publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The author/s editor/s and the publisher have attempted to trace and acknowledge the copyright holders of all materials reproduced in this publication and apologize to copyright holders if permission and acknowledgements to publish in this form have not been taken. If any copyright material has not been acknowledged please write and let us know so that we may rectify it, in subsequent prints.

Trademark Notice: Presentation, logos (the way they are written or presented) in this book are under the trademarks of the publisher and hence, if copied/resembled the copier will be prosecuted under the law.

Printed in India

Science is the Language of the Universe

Every book tells a story. From how the miniscule atoms make up vast galaxies, how a single cell transpires into millions of species, or how a single chemical helps us travel into the far universe, every book, even scientific, is telling a story. The story of how the universe speaks. At Brillion we believe science belongs to everybody and hence, we bring it at your disposal.

Our motivation each day lies in bringing our authors and readers closer to each other, in broadening the horizons of the wisdom and insight of the author, inspiring the minds of our readers and taking science everywhere.

We express our gratitude to the scientists who make the technology of tomorrow possible, helping us evolve without the biological tools. We understand their vision while writing a book, the vision of a better tomorrow. And we are here to help them spread this mission to all possible readers and scholars, waiting to be inspired. We hope to do justice to their beliefs by our efforts, and carry and sustain the torch of wisdom lit by their passion for science.

We want all our readers to read this book as if they know the author, with the capacity to question the work, of keeping the inquisitive spirit of science alive. We promise our readers to have their opinions and doubts heard by the author and return them answered whenever possible.

You can sign up at our website to have a chance to interact live with the authors about their work, opinions and everything science.

The Brillion Team



Brillion Publishing

Taking Science Everywhere



Professor M.S. Swaminathan

Dedication

"If agriculture goes wrong, nothing else will have a chance to go right in the country"
- Prof. Swaminathan.

Professor M.S. Swaminathan is a living legend and is the *Father of Green Revolution in India*. This academic work has been inspired by his actions and services over the years, and we as a nation are forever indebted to him for his role in lifting India from the shackles of poverty to the agricultural giant it is today. As the Chairman, Farmers Commission of India, his historical report calls for Minimum Support Price (150% of cost of cultivation) for a zero debt farmers economy. Hailed by farmers of India, the report is a beacon of hope to the Indian farmers to stick to the farming profession.

I am fortunate to join hands with my senior colleagues and honourable personalities like Dr. Manmohan Singh, Honourable Former Prime-Minister of India, Prof. K.V. Thomas, Member of Parliament and a key person behind the landmark National Food Security Act-2013, Dr. Trilochan Mohapatra Secretary (DARE) and Director General, ICAR; Prof. Panjab Singh, President of the National Academy of Agricultural Sciences, Dr R.B. Singh, Chancellor and Former President of NAAS, Dr. S. Ayyappan, Chancellor, Former President, National Academy of Agricultural Sciences; and DG ICAR, Dr. A.K.S. Srivastava, Chairman, ASRB and many more eminent scientists in wishing Prof. Swaminathan a long healthy life and service to the nation. The present book "Zero Hunger in India: Policies and Perspectives" is dedicated to Prof. M S Swaminathan as a mark of respect and near adulation to him.

We thank Professor for his services, now and always.

Prof. K.V. Peter

Contents

<i>Dedication</i>	vii
<i>Foreword</i>	xiii
<i>Extended Foreword</i>	xv
<i>Message: M. Ramachandran</i>	xxi
<i>Message : T. Mohapatra</i>	xxiii
<i>Message : Panjab Singh</i>	xxv
<i>Message : R.S. Paroda</i>	xxvii
<i>Message : V.L. Chopra</i>	xxix
<i>Message : Manju Sharma</i>	xxxii
<i>Acknowledgement</i>	xxxiii
<i>List of Contributors</i>	xxxv

Preamble

1. Role of International Years in meeting the Zero Hunger Challenge <i>Prof. M.S. Swaminathan</i>	1
2. A Life of Dignity for All: Accelerating Progress Towards the Millennium Development Goals and Advancing the United Nations Development Agenda Beyond 2015 <i>Ban Ki Moon</i>	5
3. Transforming Indian Agriculture: by Loving Some Agriculture Less and the Rest More <i>Arvind Subramanian, Chief Economic Adviser, Government of India</i>	29
4. Market Liberalization for Horticulture Revolution at Small Farms <i>Ramesh Chand</i>	39
5. Mismatch between Policies and Development Priorities in Agriculture <i>National Academy of Agricultural Sciences</i>	43
6. Strategy for Transformation of Indian Agriculture for Doubling Farm Income and Improving Farmers Welfare <i>National Academy of Agricultural Sciences</i>	55

Chapters

1. Zero Hunger India: The Challenge <i>R.B. Singh</i>	73
2. Hunger and Food Security in India <i>Binoo P Bonny, Sachana P.C, Sreejith Kumar, V. P. Sandra George and K.V. Peter</i>	115

3. Is Food Security an Answer to Hunger in India? 129
Praveen Kumar Jain
4. Knowledge Management Perspective of Zero Hunger Challenge Programme in India 143
A.T. Francis
5. Economics of Gender Initiatives for Hunger Free India 155
Indira Devi P and Judy Thomas
6. Nutrition Security and Women Empowerment 173
Jayasree Krishnankutty and K.V. Peter
7. Ever Green Revolution: Key to Improving Dietary Diversity and Nutritional Status of Indians 185
Prema Ramachandran
8. The Challenge of Hidden Hunger-micronutrient Deficiencies 205
K. Madhavan Nair and Mahtab S Bamji
9. Promotion of Horticulture for Nutritional Security 231
Narayan G. Hegde
10. New Age Herbals for Nutrition Security 243
Brahma Singh
11. Fruits and Hidden Hunger 259
S.K. Mitra and P. Rajendran
12. Nutrition Security Through Minor Fruits 277
Prakash Chandra Tripathi
13. Management of Hidden Hunger by Cashew Apple Products 311
A. Sobhana
14. Livelihood Security Through Coconut Palms– Experiences of Coconut Communities in India 331
V Rajagopal, C V Sairam, S. Arulraj, C Thamban and S J D Bosco
15. Science Led Vegetable Technologies to Aid Food Security 353
Hari Har Ram
16. Mitigating Food and Nutrition Insecurity of the Masses Through Vegetables in this Millennium 383
K.V. Peter, B. Singh and P.G. Sadhan Kumar
17. Microgreens for Food and Nutritional Security 421
Navya. K and K. D. Desai
18. Livelihood Opportunities in Floriculture 427
T. Janakiram and K.V. Prasad
19. Fish for Food and Nutritional Security 459
S. Ayyappan

20. Pisciculture for Nutritional Security <i>S Vincent</i>	477
21. Suggestions to Fishery Biologists and Government of India <i>T J Pandian</i>	499
22. Safety of Aquacultured Products: Emerging Issues and Immediate Challenges <i>Satyen Kumar Panda and C.N. Ravishankar</i>	509
23. Towards a Food Secure Zone through Farming Commercially Important Crustaceans <i>Dinesh Kaippilly</i>	519
24. Livestock for Enhancing Farmers' Income and Food & Nutritional Security <i>A.K. Srivastava and A. Kumaresan</i>	535
25. Millets in A Zero Hunger India <i>B Venkatesh Bhat, Vilas A Tonapi and H.S.Gupta</i>	565
26. Biotech-Innovations for Food and Nutrition Security <i>E.V. Sonia, Lakshmi Priya and Aswathy, U.</i>	587
27. Climate Change and Agriculture <i>G.S.L.H.V. Prasada Rao</i>	597
28. Dynamics of Water for Food and Nutrition <i>Ravinder Kaur</i>	621
29. More Crop Per Drop: Towards Food and Nutrition Security <i>E J Joseph</i>	633
30. Extension Service Delivery for Food Security demands reforms <i>R M Prasad</i>	657



Manmohan Singh
Member of Parliament
Rajya Sabha



सत्यमेव जयते

Foreword

“*Food for All*” is the cherished dream of our national leaders. Through foresighted political policies and support, use of science and technology-based agriculture, enlightened and hardworking farmers, an effective public distribution system and an ever-increasing demand for food grains, horticultural produces and milk, India could become a leading developing country from the ‘ship to mouth existence’ in 1950-1962 to the present scenario of ‘mountains of grains and surplus to export’. During 2018, food grain production reached 286 million tons and horticultural produces-fruits and vegetables - a record 307 million tons. Availability, Access and Absorption along with good drinking water are the keys to a “Zero Hunger India”. Despite availability of grains, pulses fruits and vegetables, India is home to 190.7 million chronically undernourished. It is harsh reality that in our country 38.4% of children are stunted while 51.4% of women suffer from anaemia.

As member of Rajya Sabha, Prof. M.S. Swaminathan impressed up on the then Government to include also pulses and millets in TPDS to ensure Nutrition Security. His efforts helped our nation bound by malnutrition and hunger to the agricultural giant we stand as today. Prof. Swaminathan received liberal political support and patronage from Smt. Indira Gandhi and Shri. C. Subramaniam to use science-based technologies in agriculture by importing dwarf wheat varieties from CIMMYT, Mexico. The hardworking farmers used seeds and technology and a targeted public distribution system (TPDS) to meet the increasing demand. The then leadership and vision of Prof. Swaminathan started what we know as the *Green Revolution in India*, and forever transformed the nation. His life’s work has been an inspiration to me and the entire country and I wish Prof. M.S. Swaminathan a long healthy life to serve India through science and technology.

India made a leap in 2013 by enacting the historic National Food Security Act-2013 making access to food including millets and pulses a right of people to be implemented by the States. In fact, majority of states has implemented the same. The cherished dreams of Gandhiji, Jawaharlal Nehru, Indira Gandhi and Lal Bahadur Shastri were thus materialised. Much headway remains for a “hunger free India”.

I extend my congratulations to the Editor, for encapsulating Prof. Swaminathan’s life’s work and vision of a hunger-free India in the form of this book on the occasion of his 93th birthday.

Manmohan Singh
(Manmohan Singh)



Prof. K.V. Thomas
Member of Parliament (Lok Sabha)
Ernakulam, Kerala



Extended Foreword

“There are people in the world so hungry that God cannot appear to them except in the form of bread” – Mahathma Gandhi stated while witnessing the infamous Bengal famine in 1943. Pandit Jawaharlal Nehru made the much quoted statement when the First five year plan was formulated. He advised Dr. P.C. Mahalanobis and Dr. C.R. Rao “Everything can wait but not agriculture”. After 23 years Indira Gandhi who provided the political leadership to Green Revolution stated in Parliament in 1966 – “We announced that there’d be no more starvation in India. And you responded impossible. You’ll never succeed!’ Instead we succeeded; today in India no one dies of hunger anymore; food production far exceeds consumption”. India’s self-sufficiency in food and many sectors of agriculture including dairying owes to the Green Revolution that Indira Gandhi mentored. Despite availability of food grains, pulses, fruits and vegetables, access to them was limited to people with adequate purchasing power. Dubbed as “game changer” the flagship measure of the UPA Government will legally entitle 67% of the population (including 75% of rural and 50% of the urban to get subsidized grains under the Targeted Public Distribution System (TDPS). Then Congress President Smt. Sonia Gandhi dubbed the legislative measure as “an employment revolution”. She described the measure as “a big measure” and as party’s promise to “wipe out hunger and malnutrition”. Dr. Manmohan Singh then Prime Minister was all out for wellness and welfare of “aam admi” in respect of availability of food, access to food and absorption of nutritious food. The subsidy for food to “aam admi” is quite below that given to petroleum products. His defense of the NFS Bill 2013 is marked with economic conviction and science based facts and figures.

Indian achievements in attaining food grain self-sufficiency have been much heralded for long in the name of green revolution worldwide. But the availability of food grains could not ensure food security which involve economic accessibility and nutritional security to the millions in the country. FAO (2002) defined food security as a situation that exists when all

people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life, As per USDA food insecure people are defined as those consuming less than the nutritional target of roughly 2,100 calories per day per person. India with 246 million food insecure people is the frontrunner and accounts for close to 30% of the total food insecure people in developing countries. This is more evident from the reports of rampant poverty and malnutrition among the vulnerable sections of Indian population. Statistics suggest that around one third of the population live below poverty line as per World Bank definition of US \$1.25/day. Estimates on Global Hunger Index by IFPRI indicate that over 33% of Indian women in the age group of 15-49 have body mass index below normal and 78.9% of children below 3 years of age are anaemic. All these estimates point to the existence of food insecurity at the micro-level in terms of either lack of economic access to food or lack of absorption of food for a healthy life. This paradox of poverty in the midst of plenty has long been a formidable challenge for India. It also substantiates the fact that growth alone, though essential, may not be sufficient at least in the short run to ensure food security for the poor and vulnerable, who spend almost 60% of their expenditure on food. These people need a safety net targeting economic access to food and its absorption.

National Food Security Bill (NFSB) is one of most ambitious legislations of the United Progressive Alliance (UPA) government of India that attempts to fight hunger by providing subsidized food. It is aimed at transforming the lives of the food insecure millions through legal entitlement to subsidized food grains and marks a paradigm shift from welfare approach to rights based approach. This would be one of the greatest experiments in the world to distribute subsidized food grains to achieve food and nutritional security (Gulati *et al*, 2012). The NFSB was introduced in the Winter Session of Parliament in December 2010 and has been under consideration for over three years. The basic framework of the Bill (NFSB) was proposed by the National Advisory Council (NAC) on October 27, 2010 to ensure food security to all below the poverty line (BPL). However, the Ministry of Rural Development made a recommendation to replace BPL survey with socio-economic census by Register General and Census Commissioner of India to focus. All these were considered by the expert Committee with C. Rangarajan as Chairman and its suggestions were finally sent to a Parliament Standing Committee for its recommendations. The committee submitted its report and introduced the revised bill in Parliament in the budget session, 2013 for enactment. The spirit of the Bill is to make the Right to Food a legal right. No other country gives the right. What is also important is that this Bill recognizes the mother as the head of the family.

The long delayed bill originally sought to limit entitlements to a maximum of 75 per cent of rural and 50 percent urban population is designated as priority households. It is indicated that, 62-63 million tons of grain will have to be distributed at Rs. 3/kg for rice

and Rs.2/kg for wheat. However, the Parliamentary Standing Committee of Food has made some new recommendations that in effect lower the coverage to 67 per cent of the total population and reduces the entitlement to five kilograms of food grains per person. In that classification of including 67% of the population, the proposal is to protect the 25.2 million families under Antyodaya Anna Yojana (a scheme to provide food grains to the poorest) who currently get 35kg per month and the states' current allocation under the targeted public distribution system (TPDS) scheme. But many States have raised concerns about the exclusion ratios and suggested that it should not be decided in a uniform manner across states as the poorer states would stand to lose.

The provisions under the bill imply a massive procurement of food grains and a very large distribution network. The gigantic task of handling the procurement, storage, transportation and delivery of about 64 million tons of food grains each year, needed to provide subsidized food for 167.5 million households in 2013 involve huge financial expenditure. The quantum of food grains required will increase inexorably until at least 2035 when the population is expected to stabilize at 1.6 billion. The total subsidy for food grains alone under the food security Bill at the current rates will be around Rs.1,25,000 crore. In addition funds would be needed for investment in infrastructure for transportation of grains, putting up stocking facilities and other logistics. Still the Government is committed to get the Bill enacted and other legal rights on women and children and other Special Groups such as destitute, homeless, disaster and emergency affected persons and persons living in starvation, to receive meals free of charge or at an affordable price.

Major challenges in the execution of the privileges under the Bill will be the strengthening of the Targeted Public Distribution System (TPDS) and improving the efficiency of the Food Corporation of India (FCI). Estimates indicate that about 40 percent of the grain that is distributed through the TPDS does not reach the target groups. Therefore, expanding the coverage of the Targeted Public Distribution System (TPDS) under the Bill calls for plugging the loop holes, which cause diversions. Another issue will be enhancing the storage capacity under the FCI by a whopping 40 per cent against the current capacity of 75 million tons. Attempts are also made to reduce the wastage of food grains in storage through an operation called "clean FCI" (to clean the entire warehouse). Construction of ware houses will remain the responsibility of the State governments. Central funds, that is already available under schemes like Rural Godown Scheme of the National Bank for Agriculture and Rural Development (NABARD) and Rashtriya Krishi Vikas Yojana can be made use for this.

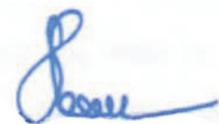
The understanding that malnutrition and related food insecurity problems are multidimensional and needs more effective strategies like conditional cash transfer (CCT) rather than physical distribution of subsidized food calls for considering income policy

instrument in the place of price policy. This suggests that there exist some mismatch between objectives and instruments in the proposed bill. The fact that there are poor people who need to be helped by augmenting their income seems neglected. The best instrument for this would be to use a policy which gives them direct income support and lets them choose what sort of food they want. Any misappropriation in the use of funds from spending on food can be overcome by giving the money to the female head in the family. This suggests that for every 1 kg of rice, Rs.20 will be paid in the account of beneficiary and he can add Rs.3 from his pocket and purchase from the fair price shop (FPS). Since the system will be computerized, it can be ascertained that the beneficiary has purchased rice from the FPS, and that will get adjusted in the quota. If the beneficiary does not purchase food grain with that money, after two months he will stop getting the cash. In order to affect this, integration with Aadhaar through IT has been suggested. Technology through Aadhaar can help to plug the huge diversion that takes place from the PDS and cut down to the subsidies. However, this can be affected only when at least 90% of the beneficiaries have bank accounts and there is end-to-end computerization, which can be achieved in another two years' time.

Moreover, achievement of food security on sustainable basis warrants for a holistic approach to the entire system of food production and distribution. Ensuring adequate availability of food grains calls for a vibrant and resilient agriculture system that demands investments in research and infrastructure. It also includes helping small and marginal farmers and become a bigger part of the solution to food security. This needs to go hand-in-hand with helping them to farm in a way that is more sustainable in its use of the natural resource base, and more resilient to the ever-growing impacts of climate change. It's a challenge that is given added urgency by the need to feed a global population that will likely exceed 9 billion by the year 2050. The only alternative remains continued hunger, mass migration and a threat to the social stability. The success of Indian Agriculture leading to record production of food grains (275.7 million tones in 2016-17) and horticultural crops-fruits, vegetables, spices and plantation crops-303 million tons in 2017-18) is the ever green revolution from policies and political leadership, use of science and technology, hardworking farmers, minimum support prices and marketing. Prof. Swaminathan prevailed upon the political leadership for nutrition security and got millets and pulses included in the public distribution system.

As Minister of Consumer Affairs, Food and Public Distribution Government of India, I was assigned to get the Food Security Bill-2013 placed and debated in the Lok Sabha. The bill was introduced on 22nd December, 2011, promulgated as a Presidential ordinance on 5th July 2013, debated and passed in Lok Sabha on Monday midnight, August 26, 2013 and enacted into law on 12 September, 2013. The Odisha Government implemented the act in 14 districts from 17 November 2015 followed by Government of Assam on 24 December 2015. Other state Governments followed soon.

Prof. M.S. Swaminathan a Former Member of Rajya Sabha is the voice of farmers and his contributions in the enactment of the food security Bill-2013 are legion. It is appropriate a book “Zero Hunger in India: Policies and Perspectives” is being dedicated to him on the eve of his 93rd Birth Day on 7th August 2018. I am all the more happy that the dedicated book is edited by my brother Prof. K.V. Peter, Former Vice-Chancellor Kerala Agricultural University and a student of Prof. Swaminathan. I conclude with the best of wishes to Prof. M.S. Swaminathan.



K.V. Thomas



Mullappally Ramachandran
Member of Parliament (Lok Sabha)



Message

The infamous Bengal famine of 1943 brought scepticism regarding a self sufficient and self feeding India. Even the democratic form of Governance was questioned under the “ship to mouth existence”. Indira Gandhi replied to foreign media ‘. How is it possible for democracy to work with an illiterate people who are dying of hunger?’ But with that people we made democracy to work.” To quote Mahathma Gandhi” There can be no rule of God in the present state of iniquitous inequalities in which a few roll in riches and the masses do not get enough to eat”. The concerns expressed by national leaders were aptly reflected by the statement of India first Prime Minister Jawaharlal Nehru ”Everything can wait, but not agriculture.”

Transformation of India from the state of ”ship to mouth” existence to a food surplus and exporting country is a historic event lauded all over. Political will and farming friendly policy, use of science and technology, risk taking farmers of Punjab, Haryana, Western U.P., West Bengal and Odisha; public distribution system and above all vast demand for food grains led to the much acclaimed Green Revolution. Indira Gandhi and C. Subramaniam extended the fullest political support and policy initiatives even for importing high yielding wheat seeds from Mexico-thanks to Nobel Laureate Dr. Norman Borlaug. Prof. M.S. Swaminathan and his team of dedicated scientists transferred technologies for high production to enterprising farmers. Mechanization in sowing, weeding, spraying, harvesting and post harvest processing came to existence. The grain markets in India had high demand and as such the economic principle of “demand and supply” worked in favour of producer farmers numbering 65% of Indias population. There was criticism regarding extension services and linkage between farm scientists and producer farmers. Realising the urgent need to bridge the gap between science based farming and unsustainable farming Krishi Vijyan Kendras were established in all the Districts of India. As the then Minister of State (Agriculture) I could facilitate establishment of Krishi Vijyan Kendras and Agricultural Technology Information Centres (ATIC). Agricultural technology Management Agency (ATMA) with participation of farmers came into existence. The historic legislation National Food Security Act - 2013 reflected the resolve of the UPA Government to make access to food a right to its citizens. The Targeted Public Distribution System envisages access to food at free or affordable prices. I participated in the debates at Indias Parliament, the sole objective being a hunger free India envisaged by Mahatma Gandhiji. Much more has to be done in the area of hidden hunger due to deficiency of Minerals and vitamins. India houses the largest number of men, women and children anaemic, stunted, wasted and susceptible to diseases. Post harvest losses need to be brought down. Horticulture-fruits, vegetables, tubers, spices etc. (303 million tones in 2017) has exceeded grain production (286 million tones) and is a good sign for nutritional security.

Prof. K.V. Peter Former Vice-Chancellor Kerala Agricultural University has compiled and edited 6 preambles and 30 chapters from eminent men as a commemorative book on the eve of 93rd birthday of Prof. M.S. Swaminathan-“Father of Green Revolution in India”. My appreciation to him and the Publisher, Brillion Publishing.

Mullappally Ramachandran



TRILOCHAN MOHAPATRA
Ph.D., FNA, FNASc, FNAAS
Secretary and Director General



सत्यमेव जयते

Message

A hunger free India is eluding despite mountains of grains and record production of horticultural crops. “In a word of plenty, no one, not a single person, should go hungry. But almost one billion still do not have enough to eat. I want to see an end to hunger everywhere within my life time says Ban Ki-Moon. Former United Nations Secretary General citing global deprivation of food. Green Revolution in 1962 onwards saw transformation of India from “begging bowl” existence to “food surplus graneries overflowing” grain exporting country. Science and technology based agricultural policies and programmes made this historic change to be proud to all of us. The Indian Council of Agricultural Research with 5 Deemed Universities, 64 Research Institutions, 13 Directorates/Project Directorates, 5 National Bureaux, 15 National Research Centres, 60 All India co-ordinated Research Projects with comes all over the country, 19 Net Work Projects and 10 other projects and 3 Central Agricultural centres provided and continue to provide science based knowledge inputs to the policy makers, farmers, processors, trade and consumers. The National Agricultural Research System (NARS) consisting ICAR and State Agricultural Universities (64 till date) along with 681 Krishi Vijyan Kendras, minimum one in each district under 11 Agricultural Technology Application Research Institutes (ATARI) link science and scientists with farmers. The NARS is the largest science led organization in the world catering to the farmers to produce more from less inputs keeping wastage at minimum” and produce “a crop from a drop”. The year 2018 witnessed the highest production of food grains at 279 million tones and horticultural crops 303 million tones. Despite availability of food grains, access is limited due to lower purchasing power and vagaries of weather. Post harvest losses and wastes at tables of people of upper and middle classes are colossal. The ICAR holds continued consultation on food losses and keep the people aware about hunger, poverty and social responsibility. “If agriculture goes wrong, nothing else will have a chance in go right in the country” the much repeated quote of Prof. M.S. Swaminathan speaks volumes on agriculture and India’s economy. Access to food is legislated as a right of Indian citizen by the historic National Food Security Act-2013 now implemented in majority of states and subsidised food grains are distributed to eligible ration card holders headed by the women member. Much headway has to be made to make food and nutrition security insulated from vagaries of weather, climate change, natural disasters, decreasing availability of farm land, water and energy. Indias population is expected surpassing the Chinese population by 2020 and newer scientific initiatives to be taken up to meet the emerging challenges.

I am happy Professor K.V. Peter Former Vice-Chancellor Kerala Agricultural University is editing “Zero Hunger in India: Policies and Perspectives” dedicated to Prof.M. S. Swaminathan who is 93 on 7th August 2018. I appreciate all the contributors for informative inputs and the publisher Brillion Publishing for error free printing.

T. MOHAPATRA



PROF. PANJAB SINGH
President



National Academy of Agricultural Sciences

Message

A hunger free India is the cherished dream of our national leaders. Indian granary is now overflowing with food grains and production of horticultural crops has reached a record of 303 million tones in 2018. But in spite of availability of grains, fruits and vegetables, India is ranked 100th among the galaxy of nations in Global Hunger Index by IFPRI (2017). Access to food is limited only to 55-60% of Indian population and hidden hunger causes anaemia, stunting, and high child mortality due to inadequate nutritious diet. The Government of India enacted National Food Security Act-2013 making access to food a legal right to less privileged and unreached people especially in rural and peri-urban areas. “You will eat not to satisfy your palate but your hunger. A self-indulgent man lives to eat; a self restrained man eats to live”- Gandhiji had said. Subsidising food to poor is criticized by many without being aware of the extent of subsidy given by the government to petroleum products. The Government of India has taken up a national programme of : Doubling Farmers Income by 2022” during 75th year of India's Independence.

Prices farm produce are oscillating and producer-farmer has no control on prices. Recently Government of India enlarged the scope of Minimum Support Prices to kharif crops. Horticultural crops-fruits, vegetables, tubers, plantation crops, mushrooms-are outside the scope of MSP. In 2016, the national Academy of Agricultural Sciences issued a strategy paper on ‘Transformation of Indian Agriculture for Doubling Farm Income and Improving Farmers Welfare’ and the Government of India has established a separate Department of Doubling Farmers Income. Many discussions were held and macro-economic decisions have been taken in this issue.

The present book “Zero Hunger India: Policies and Perspectives” dedicated to Prof. M.S. Swaminathan on his 93rd birthday is a tribute from the scientists and his students for his well recognized contributions for progress towards a hunger free India. It is stated that more than 80% of income of 65% of people is spent on food alone, leaving a little for health, education and social security.

I appreciate Prof. K.V. Peter’ efforts, a Fellow of NAAS, New Delhi for editing the book that should prove useful to diverse stakeholders in agricultural sector.

(Panjab Singh)



Trust for Advancement of Agricultural Sciences

Avenue-II, Indian Agricultural Research Institute, New Delhi - 110 012
Phone: 011-65437870 Telefax: 011-25843243
E-mail: taasiari@gmail.com Website: www.taas.in



DR. R.S. PARODA

Chairman, TAAS

Former Director General,

ICAR and Secretary,

DARE, Govt. of India

Message

Experiencing hunger and poverty in Bengal in 1943-47, Mahatma Gandhi stated “there can be no rule of God in the present state of iniquitous inequalities in which a few roll in riches and the masses do not get enough to eat”. Albert Einstein also stated “an empty stomach is not a good political advisor”. It is well known that hunger even leads to violence and hatred. The comparison of development in India during 1947-50 with that in 2017-18 amply reveal the success of science and technology, farmers hard work, effective public distribution system and above all the increasing purchasing power. Food grain production has touched all time record of 279 million tones and horticultural crops 303 million tones. Percentage of people depending on agriculture has started coming down and exportable surplus going up. The minimum support prices for *rabi* and *kharif* crops are insulating farmers from fluctuations in sale prices. The criticism of subsidy for inputs to farming has been countered by the higher subsidy now being given for petroleum products. Satisfaction of the farmer is the best guarantee against social unrest and violence. The Food Security Act-2013 enacted by Indian Parliament later ratified by State Legislatures is termed as the most notable revolutionary legislation for making available food to all the people especially people below poverty line (BPL). However much headway has still to be made to sustain crop productivity under the changing scenario of climate change, globalization of trade (Free Trade Agreement), food safety standards, strengthening rural farm infrastructure, creating awareness on modern tools of crop improvement like genetic engineering, transport and storage in the context of loss (20-40%) in fruits and vegetables and changing needs of food and catering industry.

The book “Zero Hunger in India: Policies and Perspectives” edited by Prof. K.V. Peter, Former Vice-Chancellor, Kerala Agricultural University embraces chapters authored by the eminent experts in agriculture and allied disciplines. I congratulate Prof K V Peter for his sincere efforts and hard work in bringing out this important publication. I am happy that the book has been rightly dedicated to Prof. M.S. Swaminathan on his 93rd birthday falling 7th August 2018. The whole nation is grateful to Prof Swaminathan for his outstanding contribution as father of Green Revolution to make India not only self-sufficient in grain production but a food surplus country. I also acknowledge the political leadership of the time, committed farmers and the public distribution system which made India a proud nation among the galaxy of nations. However, a lot more still needs to be done to transform India into a zero hunger and hidden hunger free country for which all out efforts need to be made at all levels on priority.

I am sure, this book will be immensely useful, to policy planners, researches, educationist, extension workers, farmers, students and other stakeholders.

(R.S. Paroda)



V.L. CHOPRA

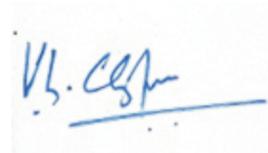
**Former Member, Planning Commission
Yojana Bhawan, New Delhi – 110 001**

Message

The need of ensuring that basic, wholesome food is available to all has been emphatically articulated by all hues of leadership. Gandhiji stated “There can be no rule of God in the present state of iniquitous inequalities in which a few roll in riches and the masses do not get enough to eat”. And, according to Kofi Annan, Former Secretary General of the United Nations ‘Hunger is one of the worst violations of human dignity. In a world of plenty, ending hunger is within our grasp. Failure to reach this goal should fill every one with shame. A hunger free India is the cherished goal of national leaders, because hunger leads to violence, hatred and deprivation. The long journey from the days of Bengal famine in 1943 to the present surplus production of 279 million tons of food grain and 303 million tons of horticultural crops-fruits and vegetables-is the result of an effective symphony among political and policy decisions, use of science led agriculture, progressive and risk taking farmers and an effective targeted public distribution system. Indian granaries are full and overflowing. The paradox existence of hunger among mountains of grains. Also hidden hunger is manifested among 65% of India’s women and children. Access to available food grains is limited to only 40-45% of people. Government of India enacted the National Food Security Act -2013, a historic legislation that makes access to food a legal right. Subsidised food grains are supplied through ration shops at prices much below the cost of their production. State Governments in Odisha, Assam, Tamil Nadu and Madhya Pradesh implemented the act soon after its legislation. In fact Chattisgarh has an operative model public distribution system. The success story of horticultural crops has led to per capita availability of fruits at 200g/capita/day and vegetables at 400g/capita/day. Despite this availability, incidence of hidden hunger in India is a matter of serious concern. Hidden hunger leads to stunting, low body weight at birth and anaemia leading to loss in working hours and susceptibility to physiological disorders. Prof. M S Swaminathan, therefore suggested nutrition security along with food security for a healthy India and got millets and pulses included in the public distribution system.

Trade and marketing are still weak links in Indian Agriculture. Harvest and post-harvest losses are abysmally high. Climate change, free trade agreements with producing countries, degradation of natural resources of soil, water and rhyzosphere and booming population are throwing new challenges to Indian agriculture.

I am happy that Prof. K V Peter, Former Vice-Chancellor Kerala Agricultural University has edited the present book “Zero Hunger in India: Policies and Perspectives” and dedicated it to Prof. M S Swaminathan on his 93rd birth day falling on 7th August 2018. I appreciate the efforts of the publisher, Brillion Publishing, for this timely publication.

A handwritten signature in blue ink, appearing to read 'V.L. Chopra', is written over a horizontal line.

(V.L. CHOPRA)

Indian Institute of Advanced Research, Gandhinagar, Gujarat



Dr. Manju Sharma
Padma Bhushan awardee

Message

Transformation of India from a food deficient country to a grain surplus and exporting country is a saga of proper use of science and technology for the benefit of humankind.” Green Revolution” resulting from appropriate policy support, use of science and technology, hardworking farmers, high demand for food grains and effective public distribution system since 1965 made India self sufficient in food. New Technologies especially Biotechnology since then have played a pivotal role in sustaining our food production.

It became possible to grow crops throughout the year in areas where these crops are not commonly grown. Vegetables, fruits and spices are still not in the public distribution system. Biofortification through biotechnological tools is carried to enrich tomatoes with high foliate and amaranths with high vitamins and minerals. Harvest and post harvest losses are 20-40% in horticultural crops. Many slow ripening genes and ripening inhibitor genes are identified.

The Farmers Commission Report by the team led by Prof. M S Swaminathan is a historical pro-farmer document debated much in the media. Agriculture being initiated and nurtured by women, Prof. M S Swaminathan established Centres of Gender Concerns in Universities and empowerment of women with knowledge and legal rights. It is befitting that a book “Zero Hunger in India: Policies and Perspectives” is being devoted to him on the occasion of his 93rd birthday.

I have four decades of association with the Professor and I have been mentored and guided by him throughout this period. His contributions in agriculture, environment and ecology and gender issues specially favoring the women are monumental and have resulted in a robust system to nurture future generation towards sustainable development. I wish him continued service to the nation and I also wish him good health and happiness. The best gift we can give Professor is to continue working with dedication and commitment for the country. The scientific community would always remain grateful to him for his most valuable guidance, encouragement and support.

Manju Sharma

(Manju Sharma)

Acknowledgement

I acknowledge National Academy of Agricultural Sciences, The Niti Aayog and the Office of U.N. Secretary General for their thought provoking blogs and publications which appear as Preambles forming the philisophical foundation of the edited book.

Words are inadequate to express gratitude to Honourable Former Prime Minister of India, Dr. Manmohan Singh, who himself has deep bond with academia, for extending his kind words as the Foreword. I also thank Prof. K.V. Thomas, M.P., who played a significant role in legislating the historical bill and the act, NFSA-2013, and for his words forming the Extended Foreword for this book. Mr. Mullappally Ramachandran, M.P. was much pleased to write a message of support and appreciation, and I am grateful for his contribution.

I acknowledge all the 6 eminent men and women who have conveyed their messages and support to the publication and the 50 authors who worked day and night to contribute to this book. My never-ending gratitude goes to the scientists, academicians, and all the people who dedicate their life to science and help make our lives easier. My special mention goes out to Mahtab S. Bamji, who authored the chapter “The Challenge of Hidden Hunger-Micronutrient Deficiencies” sitting on her bed after an injury, such is her dedication to science which I am inspired and awed by.

I also thank my colleagues at Central Library Kerala Agricultural University and Bioinformatic Centre who provided me with great technical and physical support in correspondence, compilation and editing of the work.

Brillion Publishing is thanked for their efforts to taking on this project and publish this work in the way it has come out. I acknowledge Mr. Vardhan Gupta for carefully orchestrating the editing, production and designing of this work.

I am grateful to my family for the constant emotional and moral support – my wife Vimala, my sons Anvar and Ajay, my daughters-in-law Anu and Cynara, and my grandchildren Antony, Anna and Annie for with their joyful presence.

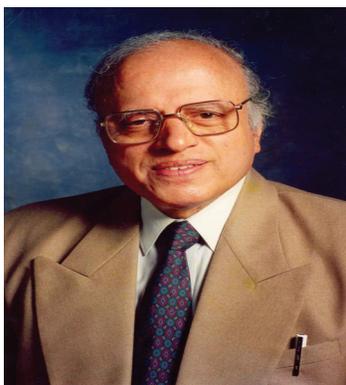
Lastly, I thank everybody in joining me and extending this small token of gratitude to the giant man who helped our nation out of a dark age of poverty and laid the foundation for the golden days ahead, Prof. M.S. Swaminathan.

Prof K V Peter

List of Contributors

- A. Kumaresan**, *Principal Scientist (Animal Reproduction)*, Southern Regional Station, ICAR-NDRI, Bengaluru-560030
- A. Sobhana**, *Professor, Cashew Research Station, KAU, Madakkathara, Thrissur-680651*
- A.K. Srivastava**, *Chairman, Agricultural Service Recruitment Board, New Delhi-12 and Former Vice-Chancellor ICAR-NDRI, Karnal-132001*
- A.T. Francis**, *University Librarian, Kerala Agricultural University, P O KAU Thrissur-680656*
- B Venkatesh Bhat**, *Principal Scientist, ICAR-Indian Institute of Millets Research, Hyderabad-560030*
- B. Singh**, *Director, ICAR-IIVR, Varanasi-221305*
- Bamji, Mahtab S.**, *INSA Emeritus Scientist, Dangoria Charitable Trust, Hyderabad-500020*
- Binoo P. Bonney**, *College of Horticulture, Kerala Agricultural University, P O KAU Thrissur-680656*
- Brahma Singh**, *Former Director, Life Sciences, DRDO, New Delhi, Former Officer on Special Duty, Rashtrapathy Bhawan, Pocket E-713, Mayur Vihar, Phase II, Delhi-110091*
- C. Thamban**, *ICAR-Central Plantation Crops Research Institute, Kasaragod-671124 Kerala*
- C.N. Ravishankar**, *ICAR-Central Institute of Fisheries Technology, CIFT Junction, P O Matsyapuri-682029 Cochin, Kerala*
- C.V. Sairam**, *ICAR-Central Plantation Crops Research Institute, Kasaragod-671124 Kerala*
- Dinesh Kaippilly**, *Associate Professor and Head, Kerala University of Fisheries and Ocean Studies (KUFOS), P O Panangad Kochi-682506*
- E J Joseph**, *Former Director, Centre for Water Resources Development and Management, Kozhikode-673571, Kerala*
- E.V. Soniya**, *Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram-695014*
- G.S.L.H.V. Prasada Rao**, *Academy of Climate Change Education and Research, Kerala Agricultural University, P O KAU 680656 Kerala*
- H.S. Gupta**, *Former Director and Vice-Chancellor, ICAR-IARI, Pusa Campus New Delhi-110012*
- Hari Har Ram**, *Former Professor, Vegetable Sciences, G.B.Pant University of Agriculture and Technology, Pantnagar-263145, Uttarakhand*
- Jayasree Krishnan Kutty**, *Kerala Agricultural University, P O KAU Thrissur-680656*
- Judy Thomas**, *Kerala Agricultural University, P O KAU Thrissur-680656*
- K V Peter**, *Former Vice-Chancellor, Kerala Agricultural University P O Mannuthy-680651 and Director ICAR-IISR, Calicut-673012*
- K. Madhavan Nair**, *ICMR-National Institute of Nutrition, Hyderabad-500062*
- K. Navya**, *Aspee College of Horticulture and Forestry, Navasari Agricultural University, Navasari, Gujarat-396454*
- K.D. Desai**, *Aspee College of Horticulture and Forestry, Navasari Agricultural University, Navasari, Gujarat-396454*

- K.V. Prasad, *Director, ICAR Directorate of Floricultural Research*, Pune-411015 Maharashtra
Lakshmi Priya, *Rajiv Gandhi Centre for Biotechnology*, Thiruvananthapuram-695014, Kerala
Narayan G. Hegde, *Trustee and Principal Advisor, BAIF Development Research Foundation*, Pune-411058 Maharashtra
P. Indira Devi, *Kerala Agricultural University*, P O KAU Thrissur-680656
P. Rajendran, *Associate Director, RARS Ambalavayal, Kerala Agricultural University*, Wayanad-673593
P.C. Sachana, *College of Horticulture, Kerala Agricultural University*, P O KAU Thrissur-680656
P.G. Sadhan Kumar, *Kerala Agricultural University*, P O KAU-680656 Thrissur
Prakash Chandra Tripathi, *Principal Scientist, ICAR-IIHR*, P O Hessarghatta Lake, Bengaluru-560089
Praveen Kumar Jain, *School of Agriculture, IGNOU*, New Delhi
Prema Ramachandran, *Director, Nutrition Foundation of India*, New Delhi-110016
R.M. Prasad, *Former Professor and Director of Extension, Kerala Agricultural University*, PO Mannuthy-680651, Kerala
Ram Badan Singh, *Chancellor, Central Agri. University, Imphal, Former President, National Academy of Agricultural Sciences*, NAS Complex, New Delhi-110012
Ravinder Kaur, *Principal Scientist and Former Project Director, Water Technology Centre, IARI*, New Delhi-110012
S J D Bosco, *ICAR-Central Plantation Crops Research Institute*, Kasaragod-671124 Kerala
S. Vincent, *Dean of Research, Loyola College (Autonomous)*, Chennai-34
S.Arulraj, *ICAR-Central Plantation Crops Research Institute*, Kasaragod-671124 Kerala
S.Ayyappan, *Former Secretary (DARE) and Director General ICAR, NABARD Chair Professor*, NDRI Regional Station, Adugodi-560030, Bengaluru
S.K. Mitra, *Chairman, Section: Tropical and Subtropical Fruits, ISHS*, B-12/48, Kalyani-741235
Sandra George, *College of Horticulture, Kerala Agricultural University*, P O KAU Thrissur-680656, Kerala
Satyen Kumar Panda, *ICAR-Central Institute of Fisheries Technology*, CIFT Junction, P O Matsyapuri-682029 Cochin Kerala
T. Janakiram, *Assistant Director General (Horticultural Sciences), ICAR, KAB-II*, P O Pusa New Delhi-110012
T.J. Pandian, *Former National Professor ICAR*, 9, Old Natham Road, Madurai-625014 Tamil Nadu
U. Aswathy, *Rajiv Gandhi Centre for Biotechnology*, Thiruvananthapuram-695014, Kerala
V. Rajagopal, *ICAR-Central Plantation Crops Research Institute*, Kasaragod-671124 Kerala
V.P. Sreejith Kumar, *College of Horticulture Kerala Agricultural University*, P O KAU, Thrissur-680656
Vilas A Tonapi, *Director, ICAR-Indian Institute of Millets Research, Rajendra Nagar, Hyderabad*-5000030



Preamble I

Role of International Years in meeting the Zero Hunger Challenge*

Prof. M.S. Swaminathan

The UN Secretary-General, Ban Ki-Moon, launched, in 2012, the Zero Hunger Challenge Programme designed to achieve a hunger-free world, with the following words: 'In a world of plenty, no one – not a single person-should be hungry. I invite you all to join me in working for a future without hunger'. At a later meeting of governments, it was decided that 2025 should be the target year for winning the Zero Hunger Challenge.

The concept of zero hunger was introduced in Brazil in 2003, by the then President, Lula da Silva, who took steps to address, in an integrated manner, the three major dimensions of food insecurity, namely availability, access and absorption of food in the body. Availability of adequate food depends on both production and imports, while access is conditioned by purchasing power, and absorption by known – food factors such as clean drinking water, sanitation, primary health care and nutrition education.

Brazil achieved, in a short period of time, a substantial reduction in poverty and hunger, due to the Zero Hunger programme. Encouraged by the performance of Brazil, the UN Secretary – General has suggested coordinated action in five areas to achieve freedom from hunger by 2025. These are : Zero stunted children less than two years, 100% access to adequate food all year round, promotion of sustainable food production systems, 100% increase in smallholder productivity, and zero loss or waste of food.

India has been described in the past as a country where mountains of grains and hungry millions often co-existed, thus emphasizing that food production alone is meaningless unless

*Guest Editorial, Current Science Vol.107(1) : 7-8.

backed up by equity in access. Such a situation may not prevail in the future with the historic passage of India's Food Security Act in 2013, which makes access to the minimum quantity of food required by a person a legal right. The transition from a 'ship –to – mouth' existence to right to food with home – grown food marks a proud moment for every Indian.

There is, however, no time to relax since there are several serious threats to sustainable food security, such as loss of prime farm land to non-farm uses, water scarcity, climate change and lack of interest among youth to take to farming as a profession. It is in this context that agriculture – centric *international years* assume importance in generating the necessary political action and public interest in fostering an ever –green revolution in agriculture, which can help increase productivity in perpetuity, without associated environmental or social harm.

The year 2013 was designated by the United Nations as the International Year of Quinoa (*Chenopodium quinoa*). Rich in protein, Quinoa has played an important role in food and nutrition security among the Andean people. Thanks to the 'Quinoa Year', there is now greater interest in under-utilized crops and dying wisdom related to nutrition. The Quinoa Year has also helped simulate interest in agricultural remedies to nutritional maladies in different farming systems. The diversification of dietary components has become urgent since recent reports suggest that climate change may result in crops like wheat and rice becoming less nutritive, with particular reference to iron and zinc.

Fortunately, the Indian Food Security Act provides for enlargement of the food basket under the Public Distribution System (PDS) by including a wide range of millets like *ragi*, as well as maize, sorghum, pearl millet (*bajra*) etc. If such a provision is supported by a nutrition literacy programme, agriculture can become the means for both food and nutrition security.

The year 2014 is the International year of Family Farming. If the year is used for the revitalization of family farming traditions, with particular emphasis on the empowerment of women and young people, we can help improve small farm productivity and profitability, on the one hand, and nutrition – sensitive agriculture on the other. Family farming, as a way of life, and the means to sustainable livelihood, helps promote both job-led economic growth and conservation of biodiversity, thus protecting the ecological and economic foundations of sustainable agriculture. An estimated 500 million family farms are playing a vital role both in preserving our agricultural heritage and in combating hunger. Family farms can play a catalytic role in achieving a shift from food to nutrition security, since nutritional criteria can be integrated in the choice of crops cultivated by family farmers, particularly women. In contrast, corporate farming will tend to be based on mono-cropping.

The year 2015, dedicated to the conservation and enhancement of soil health, has been named the International Year of Soils. Most of the food we eat today comes from the soil. Land and water-use decisions have a feedback relationship. A major threat to food security in the future may be climate change-induced inadequate and uncertain rainfall. There should be integrated attention to soil and water conservation and sustainable use during the Year of Soils, particularly in regions like South Asia and sub-Saharan Africa, where the adverse impact of higher mean temperature is expected to be high and where climate change adaptation and mitigation measures are as yet inadequate. A soil health care movement should be launched during the Year.

Finally, the year 2016 has been selected to highlight the role of pulses (grain legumes) in improving both human nutrition and soil health (through biological nitrogen fixation). Pulses occupy a central place in nutrition sensitive agriculture, and every effort should be made during the Pulses Year to increase the production and consumption of protein-rich grain legumes, particularly among vegetarians.

Meeting the Zero Hunger Challenge should include attention to hidden hunger, caused by the deficiency of micronutrients like iron, zinc, iodine, vitamin A and vitamin B12. Naturally bio-fortified plants like moringa, sweet potato, breadfruit, and a wide range of fruits and vegetables should find a place in all family farms. Varieties of wheat, rice and pearl millet, rich in iron, zinc and other vital micronutrients, developed through conventional plant breeding are now available.

It would be appropriate to designate one year during this decade as the International Year of Bio-fortification and Under-utilized Crops. This will help promote nutrition-sensitive farming practices, and at the same time enable concurrent attention to ending all the three forms of hunger, namely calorie deprivation or under nutrition, protein hunger and hidden hunger. This would also help move from food to nutrition security and thereby address the Zero Hunger Challenge in its totality.

Agenda for 2014

Some of the initiatives which could be undertaken for commemorating the International Year of Family Farming are the following:

Soil health monitoring and amelioration centres – Soil is the stomach of the plant and its importance to sustainable food security will be evident from the fact that UN has declared 2015 as the International Year of Soil. I suggest that starting from this year and extending up to the next five years, we may set up in every block of the country a Soil Health Monitoring and Amelioration Centre. There are excellent and effective new technologies of

soil health monitoring which are now available. Such centres can also help farmers in the effective utilization of nutrient based subsidies.

Water Security – This is fundamental to both food security and ecological security. Our aim to ensure irrigation water for all can be realized only if rainwater harvesting, conservation and efficient use become mandatory. Ultimately, every farm should harvest both rain and solar energy.

Conservation of genetic resources – Reasonably satisfactory work is in progress in the area of conservation of biodiversity of plants. However, work on the conservation of indigenous farm animal breeds is poor. I suggest that in every state farm about 100 ha may be made available for the conservation of local breeds of cows, buffaloes, sheep and goat. We have already lost precious animal genetic resources, for example, the Badavari breed of buffalo found in Bundelkhand. This breed is reported to have 8-10% butter fat content.

Avoiding food losses

Our performance in the post-harvest technology sector has been poor. There is mismatch between production and post-harvest technologies. We should end this mismatch by establishing a National Grid of Ultra-modern Grain Storage Structures. Preventing food losses is an exceedingly important and urgent need.

Finally, the Ministry of Agriculture both at the Central and State levels should be redesignated as Ministry of Agriculture and Farmers' Welfare in order to stress that the ultimate purpose of such government departments is for ensuring the income and livelihood security of the farming community, which constitutes over 60% of our population. The monsoon and the market are the two major determinants of the well-being of farmers. The Ministry of Agriculture and Farmers' Welfare should give priority to promoting climate smart agriculture and to minimizing price volatility in the market.

The foregoing agenda will help make the International Year of Family a meaningful one, both for producers and consumers.

REFERENCES

- Myers, S. S. *et al.*, 2014 Nature, published online on 7 May 2014; doi: 10.1038/nature 13179.
Swaminathan, M.S. 2012 Science, 2012, 338(1009)

A Life of Dignity for All: Accelerating Progress Towards the Millennium Development Goals and Advancing the United Nations Development Agenda Beyond 2015*



Report of Dr Ban Ki Moon, the Secretary-General, United Nations to the 68th session of General Assembly.

Summary

The present report is submitted pursuant to General Assembly resolution 65/1, in which the Assembly requested the Secretary-General to report annually on progress in the implementation of the Millennium Development Goals until 2015 and to make recommendations for further steps to advance the United Nations development agenda beyond 2015.

Renewed efforts are essential for achieving the Millennium Development Goals by the end of 2015. While providing an assessment of progress to date, the report also identifies policies and programmes that have driven success in the achievement of the Goals and can contribute to accelerating it. These include emphasizing inclusive growth, decent employment and social protection; allocating more resources for essential services and ensuring access for all; strengthening political will and improving the international policy environment; and harnessing the power of multi-stakeholder partnerships.

A new post-2015 era demands a new vision and a responsive framework. Sustainable development — enabled by the integration of economic growth, social justice and environmental stewardship — must become our global guiding principle and operational standard. This is a universal agenda that requires profound economic transformations and a new global partnership. It also requires that the international community, including the

*Acknowledge the Office of Secretary General, United Nations for reproducing the address.

United Nations, embrace a more coherent and effective response to support the agenda. As we make the transition to this new era, we need to continue the work begun with the Millennium Development Goals and ensure that extreme poverty is ended within a generation. In keeping with United Nations principles, this post-2015 framework can bring together the full range of human aspirations and needs to ensure a life of dignity for all.

I. Introduction

1. The world's quest for dignity, peace, prosperity, justice, sustainability and an end to poverty has reached an unprecedented moment of urgency.
2. In 2000, the States Members of the United Nations agreed on a bold vision for the future that reaffirmed the fundamental values of freedom, equality, solidarity, tolerance, respect for the planet and shared responsibility.
3. That vision, enshrined in the Millennium Declaration (General Assembly resolution 55/2) and rooted in the Charter of the United Nations, recognized the need to pool efforts as never before and to advance on three fronts simultaneously: development, peace and security, and human rights. Global challenges, local solutions; shared burden, shared gain: this remains the credo of international action for our collective well-being.
4. Among the promises made in the Millennium Declaration was a compelling pledge to spare no effort to free all women, men, girls and boys from the abject and dehumanizing conditions of poverty. The call itself was not new; the commitment to better standards of living is part of the purposes and principles of the United Nations. But what was new was the sense of possibility — the conviction that through a combination of targets, tangible investments, genuine action and political will, countries and people working together could end poverty in all its forms.
5. The Millennium Development Goals gave expression to this resolve. Since their adoption, Governments, partners and an inspiring constellation of groups and individuals around the world have mobilized to tackle the many dimensions of poverty. Those efforts have generated unprecedented advances in human development.
6. There has been substantial progress in achieving the Millennium Development Goals and several successes in reaching specific targets globally and in individual countries. However, the prospects for achieving all of the Goals differ sharply across and within countries and regions. More than a billion people still live in extreme poverty. Far too many people face serious deprivation in health and education, with progress hampered by significant inequality related to income, gender, ethnicity, disability, age and location. The prolonged global economic downturn and violent conflicts in recent years have

- exacerbated poverty, inequality and exclusion. Biodiversity loss, the degradation of water, drylands and forests and the intensifying risks of climate change threaten to reverse our achievements to date and undermine any future gains.
7. We must do everything we can to achieve the Millennium Development Goals by the end of 2015. That work is unfinished and must continue in order to secure the well-being, dignity and rights of those still on the margins today, as well as of future generations. By meeting our existing commitments, we will be in the best possible position from which to agree upon and implement a universal agenda for sustainable development after 2015.
 8. At the same time, the world has changed radically since the turn of the millennium. New economic powers have emerged, new technologies are reshaping our societies and new patterns of human settlement and activity are heightening the pressures on our planet. Inequality is rising in rich and poor countries alike.
 9. A new era demands a new vision and a responsive framework. Sustainable development, enabled by the integration of economic growth, social justice and environmental stewardship, must become our global guiding principle and operational standard. This framework can bring together the full range of human aspirations and needs. It offers a template for mutually reinforcing approaches to global challenges. Sustainable development is, in short, the pathway to the future.
 10. So the challenge remains, even as it has taken on new complexity and increased in scale: we must fulfil our promises and meet the aspirations of the world's peoples, and we must summon the unity to realize the dream of the Charter and the Millennium Declaration. Ours is the first generation with the resources and know-how to end extreme poverty and put our planet on a sustainable course before it is too late.
 11. The transition to sustainable development must not mean any diminishment whatsoever in the commitment to ending poverty. As underscored in the outcome document of the United Nations Conference on Sustainable Development, held in Rio de Janeiro, Brazil, in 2012 (General Assembly resolution 66/288), poverty eradication is an indispensable requirement for sustainable development. This is a matter of basic justice and human rights. It is also a historic opportunity. If ours is the generation that can end poverty, there should be no deferring this essential mission, no shrinking away from the task. In a world of great wealth and technological advances, no person anywhere should be left behind. No person should go hungry, lack shelter or clean water and sanitation, face social and economic exclusion or live without access to basic health services and education. These are human rights, and form the foundations for a decent life.

12. Nor can progress be achieved or sustained amid armed conflict, violence, insecurity and injustice. These ills often have roots in social and economic deprivation and inequality. In the same vein, poverty can be a precursor and breeding ground of instability. We know that upholding human rights and freeing people from fear and want are inseparable; it is imperative that we do more to act on this basic truth.
13. The present report is intended to galvanize greater efforts to end poverty and achieve sustainable and inclusive growth. We will need enlightened and courageous leadership in the halls of government and the engagement of responsible businesses and civil society the world over. I have drawn considerable inspiration from a dynamic United Nations-led process — a global conversation launched in 2012 on the priorities of a new development agenda that would build on the Millennium Development Goals. In a series of global, regional and national consultations in nearly 100 countries and through a social media platform, more than a million people have shared their views on “the world they want”. I am profoundly grateful to all who expressed their hopes and expectations and offered ideas and constructive criticism. The United Nations is strongly committed not just to listening to those voices, but also to amplifying and acting on what we have heard and learned.
14. In defining a new agenda, Member States can also benefit from the insights of a set of illuminating reports. My High-level Panel of Eminent Persons on the Post-2015 Development Agenda, co-chaired by Susilo Bambang Yudhoyono, President of Indonesia, Ellen Johnson-Sirleaf, President of Liberia, and David Cameron, Prime Minister of the United Kingdom of Great Britain and Northern Ireland, called for major transformative economic and institutional shifts: a new accountability.
15. Reports by the Sustainable Development Solutions Network, the Global Compact Office, the United Nations System Task Team on the Post-2015 United Nations Development Agenda, the regional commissions and our partners in civil society and academia have also provided important inputs and recommendations for the formulation and content of the processes ahead.
16. The common ground in these contributions far outweighs any differences. Indeed, it is possible to see the emerging outlines of a new sustainable development agenda: universal in nature yet responsive to the complexities, needs and capacities of individual countries and regions; bold in ambition but simple in design; combining the economic, social and environmental dimensions while putting the highest priority on ending poverty and reducing inequality; protective of the planet, its biodiversity, water and land; rights-based, with particular emphasis on women, young people and marginalized groups; eager for new and innovative partnerships; and supported by pioneering

- approaches to data and rigorous accountability mechanisms. Guided by this far-reaching vision, a limited set of goals with sustainable development at the core, as called for at the United Nations Conference on Sustainable Development, could be constructed to encapsulate current challenges and the priorities of the new agenda and to guide the transformation we need.
17. In the present report we take stock of where we are and where we need to go — first, in the time that remains until the end of 2015, and second, in the period beyond that. As a contribution to the discussions and negotiations of Member States, I offer my sense of the lessons we have derived from the Millennium Development Goals and set out a number of possible elements for consideration in charting a way forward. I look forward to a rich process of consultation and debate as the crucial year of 2015 draws near.
 18. We are all aware of the vulnerabilities and perils that define daily life across the world. But there is also simultaneously a sense of wondrous potential made possible in part by science and technology but even more by our own hard work and devotion to common progress. Based on everything I have seen and heard during my six and a half years as Secretary-General, I am convinced that, collectively, we have the leadership, conviction and courage to address short-term uncertainties while seizing the opportunity for long-term change. In that spirit of hope and resolve, I offer the present report to the membership of the *United Nations*.

II. Achieving the Millennium Development Goals and accelerating progress

19. The Millennium Development Goals are our promise to the world's poorest and most vulnerable. They have succeeded in placing people at the centre of the development agenda.
20. We have made remarkable progress. Many countries — including some of the poorest — have aligned their policies and resources with the Goals to make unparalleled gains. Several critical targets have already been met or will be met by the end of 2015, both at the aggregate level and in individual countries. Sizable gains have occurred in even the poorest countries.
21. However, progress has been insufficient and highly uneven. Rural areas and marginalized groups continue to lag behind on virtually all goals and targets. Countries in or emerging from conflict, disaster or instability face significant challenges. In addition, the economic and financial crisis has complicated efforts, including by putting pressure on official development assistance.

22. Yet progress continues. In the *Millennium Development Goals Report 2013*, it is stressed that despite challenges and gaps, the agenda embodied by the Goals retains great power in engendering collective action for faster results.

A. Where do we stand on the Goals?

23. At the global level, poverty and hunger have been reduced significantly. In developing regions, the proportion of people living on less than \$1.25 a day fell by more than half, from 47 per cent in 1990 to 22 per cent in 2010, with the majority living in rural areas. Much of this progress, however, has been made in a few large countries, primarily China and India. Moreover, even if the poverty target has been met, 1.2 billion people are still living in extreme poverty. For example, despite recent strong economic growth and declining poverty rates in sub-Saharan Africa, the number of people living in poverty is rising, and the region is still vulnerable to shocks that can rapidly erode gains.
24. The target of halving the percentage of people suffering from hunger by 2015 is within reach. The proportion of undernourished people in developing regions fell from 23.2 per cent in the period from 1990 to 1992 to 14.9 per cent in 2010-2012. However, one in eight people remain chronically undernourished, and one in four children suffers from stunted growth because of malnutrition.
25. We risk failing to keep our promise to enable all children to go to school. The number of children out of primary school declined from 102 million to 57 million between 2000 and 2011. But progress has slowed significantly over the past five years. Without renewed efforts, the target of universal primary education by 2015 seems beyond reach, particularly in conflict-affected countries. Half the world's out-of-school children live in sub-Saharan Africa, with the gap largest for children and adolescents from the poorest households. Much stronger efforts are needed to improve the quality of education and provide lifelong learning opportunities, especially for girls and women, those belonging to ethnic minorities, persons with disabilities and children living in conflict-affected areas, rural areas or urban slums.
26. Women and girls are major drivers of development. Yet challenges to achieving gender equality and women's rights remain significant. In many developing countries, girls are denied their right to primary education. Women have been gaining employment in non-agricultural sectors, but often in less secure jobs with fewer social benefits than those held by men. In both the public and private spheres, women continue to be denied opportunities to influence decisions that affect their lives.

- Gender-based violence contravenes women's and girls' rights, undermines development and is an affront to our common humanity.
27. Despite significant progress globally and in many countries, a renewed commitment is needed to improve the health and life prospects of mothers and children. The mortality rate for children under 5 dropped by 41 per cent between 1990 and 2011 — a significant achievement, yet far short of the target of a two-thirds reduction. The maternal mortality rate fell by 47 per cent over the past two decades — again, important progress, but still far from the target of 75 per cent. Intensified efforts are needed to reach the most vulnerable women and children and ensure their sexual and reproductive health and reproductive rights, including full access to basic health services and sexual and reproductive education.
 28. New HIV infections declined by 21 per cent globally over the past decade, and close to 10 million people living with HIV are receiving lifesaving antiretroviral treatment. Expanded treatment and prevention yielded a 25 per cent reduction in AIDS-related deaths between 2005 and 2011. Yet 2.5 million new infections still occur each year and in many parts of the globe, millions lack access to treatment. The last decade saw a 25 per cent fall in mortality rates from malaria globally, sparing the lives of an estimated 1.1 million people. Between 1995 and 2011, 51 million tuberculosis patients were treated successfully, saving 20 million lives.
 29. Some of the targets for ensuring environmental sustainability have been achieved: the target for improved water sources was met ahead of schedule, and over the past decade over 200 million slum dwellers — double the target — benefited from improved water and sanitation facilities, durable housing or sufficient living space. Furthermore, from 1990 to 2011, 1.9 billion people gained access to a latrine, flush toilet or other improved sanitation facility. With rapid urbanization and population growth, however, the number of slum dwellers is on the rise. Two and a half billion people lack access to improved sanitation, while a billion practise open defecation, a continued source of illness.
 30. In all countries, the achievement of Goal 7, on ensuring environmental sustainability, remains at significant risk because of the profound and urgent challenges posed by climate change. Carbon dioxide emissions are more than 46 per cent higher than in 1990. The atmospheric concentration of carbon dioxide has exceeded 400 parts per million, a level not seen in millions of years and threatening the existence of the planet.

31. Biodiversity loss continues at a rapid pace. Freshwater resources are being depleted and fish stocks are overexploited. Land degradation and desertification, ocean acidification and the loss of species and forests continue at an alarming rate.
32. As shown in the forthcoming MDG Gap Task Force Report 2013, progress towards a global partnership for development has fallen short of expectations. Following an encouraging rise in official development assistance since 2000, over the past two years aid flows have declined. Despite significant debt relief for many countries, the debt-servicing burden of some low-income countries remains intolerably high. Progress in improving market access for many developing countries has been slow, and “aid for trade” has not escaped the impact of reduced official development assistance. Despite welcome gains in connectivity, a substantial digital divide remains between developed and developing regions.

B. Which policies and programmes have best driven progress?

33. It is crucial to know what works and what does not. More than a decade of experience has painted a revealing picture. Strong national ownership and well-managed policies, supported coherently by partners at all levels, has underpinned progress in achieving the Millennium Development Goals. Policies that foster robust and inclusive economic growth, accompanied by measures to improve the access of poor and excluded people to quality basic services, have produced gains in many countries. Much has been learned by formulating and implementing those policies. Applying these lessons will be important for making more rapid progress in the time that remains. Emphasizing inclusive growth, decent employment and social protection
34. Inclusive economic growth with decent employment and decent wages has proven to be a prerequisite for achieving the Millennium Development Goals, particularly Goal 1, on eradicating extreme poverty and hunger. Progress in East Asia has been strong, and several countries in Latin America and Africa have successfully combined economic growth and redistributive policies.
35. Targeted investments in public health systems, fighting disease, education, infrastructure and agricultural productivity have all played important roles in achieving the Goals and promoting economic growth. These interventions work in a synergistic way and are therefore highly effective in integrated development programmes. Cash transfers targeting poor and marginalized families have also bolstered progress.
36. In East Asia, reforms in the agricultural sector have lifted hundreds of millions of people out of extreme poverty. Many Governments in the region have also adopted policies that increase social spending, expand social protection and raise the minimum wage.

37. Policies promoting rural employment have proved to have positive results in terms of poverty reduction, food consumption, household spending on education and health, debt reduction and asset creation.
38. In addition, programmes in Latin America and South-East Asia that have combined increased food production and distribution with skills training, microfinance, land distribution and nutrition education programmes have had positive impacts on child mortality and maternal health.

Allocating more resources for essential services and ensuring access for all

39. To accelerate progress on education, some countries have eliminated school fees and reduced the indirect costs of schooling. In Africa and the Middle East, policies have targeted orphans and other vulnerable children with vouchers for uniforms and books. In Asia, countries have scaled up stipend programmes and introduced financial support mechanisms for ethnic minority students.
40. In West Africa, complementing investments in infrastructure with female literacy campaigns to overcome resistance to girls' education in rural areas led to a significant increase in the rate of enrolment of girls in primary schools.
41. Some countries have expanded access to primary education while tackling gender disparities at the same time. Achieving the parity target by 2015 is within reach if entrenched gender disadvantages can be overcome, particularly in countries where early marriage remains pervasive.
42. Countries in Sub-Saharan Africa have launched nationwide midwifery schemes to train and deploy tens of thousands of front-line health workers to accelerate progress in preventing maternal and child mortality.
43. Improved national strategies supported by additional financial resources have contributed to faster progress on the Millennium Development Goals in the area of health in many countries. The Global Fund to Fight AIDS, Tuberculosis and Malaria, the GAVI Alliance and the United States President's Emergency Plan for AIDS Relief have played a major role, complementing national efforts.
44. Investments in human and physical infrastructure for the public health-care sector are paying off in South Asia, where services have been provided free of charge in facilities close to patients.
45. Policies supporting free universal access to quality primary health care for women and children have reduced child mortality in some countries in Sub-Saharan Africa,

- especially when special attention is given to reducing deaths from malaria, pneumonia, diarrhoea and measles and to rapidly scaling up the provision of insecticide-treated bednets, measles vaccine and vitamin A supplements.
46. National initiatives have proven to be effective in achieving water and sanitation targets. In South-East Asia, partnerships between local governments, builders and community leaders have been launched to meet the need for drinking water and sanitation. Access to latrines has increased significantly, driven by community empowerment activities, strengthened institutions and a community hygiene campaign.

Strengthening political will and improving the international policy environment

47. The global nature of many current challenges requires coordinated global action. I am very concerned by any developments or trends that threaten the global partnership for development, a core part of the Millennium Development Goal framework. There is an urgent need to stop and reverse the two-year contraction of official development assistance and aid for trade, especially for the least developed countries. Stakeholders should strengthen coordination and follow through on commitments to and for effective aid delivery, as well as cracking down on illicit capital flows, returning stolen assets and stemming tax avoidance and evasion.
48. I urge the members of the World Trade Organization to redouble their efforts to reach a development-oriented conclusion of the Doha Round of trade negotiations and improve duty-free, quota-free market access for products of least developed countries. Further efforts are needed to ensure timely debt relief for critically indebted developing countries, thus improving their chances of achieving the Millennium Development Goals.
49. A stronger partnership is also needed among governments, pharmaceutical companies, research facilities and philanthropic organizations to make essential medicines more affordable and available in public health facilities, including using the provisions available to developing countries in the Agreement on Trade-Related Aspects of Intellectual Property Rights.
50. Limiting and reversing the increase in the average global temperature to 2 degrees Celsius above pre-industrial levels in line with international agreements demands bold, coordinated national and international action. The United Nations Framework Convention on Climate Change contains commitments and guidance, most notably the agreement of Governments to negotiate an ambitious, legally binding global agreement by 2015 that will cover all countries of the world in a fair way. The situation calls for full and urgent adherence to what was agreed.

51. Bolder measures are equally urgent on other environmental sustainability targets, including those related to biodiversity, water, land use and forests. Where commitments already exist, we need faster implementation of the corresponding multilateral environmental agreements.
52. With support from the international community, developing countries should accelerate efforts to improve the transfer of and access to information and communications technology, as well as to lower its cost, especially in key service-delivery areas. In order for technology transfers to countries embracing deep structural economic transformations to be successful, the institutional and human capacity gaps will need to be addressed at the local level.
53. The multi-stakeholder partnership model has emerged as a promising way to share burdens, catalyse action and bring all relevant actors to bear in addressing specific problems. We need to mobilize more action to deliver on commitments and exploit the full potential of the partnership approach.

C. Accelerating progress towards the Goals to 2015

54. Fulfilling our existing commitments and promises on the Millennium Development Goals must remain our foremost priority. Member States, with the continued support of development agencies, civil society and the private sector, should and can take bolder action to accelerate progress.
55. Together, we need to focus on those Goals that are most off-track and on countries that face particular development challenges, including the least developed countries, landlocked developing countries, small island developing States and countries affected by or recovering from conflicts or disasters. In so doing, we must pay particular attention to the needs and rights of the most vulnerable and excluded, such as women, children, the elderly, indigenous people, refugees and displaced families, as well as people with disabilities and those living in poor rural areas and urban slums.
56. The preceding section highlighted some successful strategies for achieving the Millennium Development Goals. They show that accelerating progress requires national ownership and international commitment, with the right policies backed by reliable, timely financial resources and people-centred multi-stakeholder partnerships. Countries should make every effort to mobilize domestic resources. At the same time, these resources should be supplemented by external support where necessary.
57. In April I launched the campaign “MDG Momentum — 1,000 Days of Action” as a spur to achieve the gains we need by 2015. My appeal seeks to give additional impetus to several key initiatives that were already under way in response to the call

- for acceleration made at the 2010 high-level plenary meeting of the General Assembly on the Millennium Development Goals.
58. The Millennium Development Goals Acceleration Framework, a coordinated effort by the United Nations Development Group, is firmly rooted in national ownership and supports the systematic identification of bottlenecks and local solutions. Acceleration plans are being implemented in more than 46 countries across all regions, covering a range of goals and targets and bringing together a full spectrum of actors. Those efforts are assessed by the United Nations system in collaboration with the World Bank under the umbrella of the United Nations System Chief Executives Board for Coordination.
 59. In one sub-Saharan African country, an acceleration plan on maternal health is being implemented through the revised national reproductive health policy and protocol. This is backed by a multi-pronged strategy that includes the use of mobile telephones for diagnosis and referrals and partnerships with local road transport associations to facilitate the travel of women in labour.
 60. When implemented at the subnational level, the Acceleration Framework can also help to address disparity and inequality, as well as underlying causes such as discrimination and sociocultural exclusion. In one South American country, provinces and municipalities are implementing acceleration plans to address local priorities, such as poverty reduction and the economic empowerment of women, where progress lags behind the national level.
 61. The 1 billion Millennium Development Goals initiative of the European Union has been supporting countries in the African, Caribbean and Pacific regions to accelerate progress on the Goals that are the most off-track: eradicating hunger, improving maternal health, curbing child mortality and improving access to water and sanitation. Nearly 50 have been supported to date.
 62. Regional initiatives are an increasingly important part of the picture. In 2012, the African Union Commission adopted a road map on shared responsibility and global solidarity to accelerate progress in the response to HIV, tuberculosis and malaria. The actions in the road map are organized around three strategic pillars: diversified financing, access to medicines and enhanced health governance. Similarly, in 2012, the Association of Southeast Asian Nations adopted a road map for the attainment of the Millennium Development Goals focusing on five key areas: advocacy and linkages, knowledge, resources, expertise, and regional cooperation and public goods.

63. Every Woman Every Child, a multi-stakeholder partnership launched in 2010, seeks to save the lives of 16 million women and children by 2015. The United Nations secured commitments of \$20 billion from more than 250 partners, including governments, multilateral organizations, the private sector and civil society. A new partnership between governments and United Nations agencies, “Committing to child survival: a promise renewed”, was launched to reduce the under-5 mortality rate to fewer than 20 deaths per 1,000 live births in all countries by 2035.
64. The Sustainable Energy for All initiative, launched in 2011, aims to provide universal access to modern energy, double the global rate of improvement in energy efficiency and double the share of renewables in the global energy mix, all by 2030. Over \$50 billion has been committed from all sectors to make this a reality, and more than 70 countries have signed up.
65. The Global Agriculture and Food Security Programme mobilizes resources to scale up agricultural assistance to low-income countries. The Zero Hunger Challenge, launched at the United Nations Conference on Sustainable Development, calls for universal access to adequate food year-round, steps to prevent childhood stunting, a sustainable transformation of food systems, a doubling of productivity and incomes among smallholder farmers and drastic reductions in food losses and waste. Through the “Scaling Up Nutrition” movement, a partnership effort involving governments, civil society, the United Nations system, business and researchers, more than 100 partners are supporting 40 countries in their efforts to reduce malnutrition and child stunting.
66. The Global Education First Initiative, launched in September 2012, aims to raise the political profile of education and seeks to ensure access, improve the quality of learning and foster global citizenship.
67. The Call to Action on Sanitation, initiated in March, has provided new momentum on an area that has received inadequate attention. The campaign for universal access to bednets by the end of 2010 made important inroads in tackling malaria. The One Million Community Health Workers campaign in Sub-Saharan Africa is expected to be critical in generating gains across the health-related Millennium Development Goals.
68. The replenishment of the Global Fund in the third quarter of 2013 will be of decisive significance for continued progress against AIDS, tuberculosis and malaria. I call upon all donors, public and private, to do their part to support the Fund at this moment of utmost urgency as well as opportunity.

69. Multi-stakeholder arrangements have proven successful because they expand on traditional partnerships by significantly increasing available resources, improving the effectiveness of their use and increasing policy and operational coherence. To build on those advantages, I have put forward a proposal to Member States for a new United Nations Partnership Facility, which would aim to enhance the Organization's ability to facilitate delivery at scale at both the global and country levels.

D. Making the transition to a new sustainable development agenda that builds on the Goals

70. The adoption of the Millennium Development Goals represented a major shift in galvanizing global political will for poverty eradication. The Goals focused the world's attention on halving extreme poverty and promoting human development by setting priorities, goals and targets. Yet the Goals represent only the halfway mark towards the aim of tackling poverty in all its forms. United Nations projections for 2015 indicate that almost 1.3 billion people will still live in extreme poverty, mothers will continue to die needlessly in childbirth and children will suffer and die from hunger, malnutrition, preventable diseases and a lack of clean water and sanitation.
71. The job we started with the Millennium Development Goals therefore needs to be finished. Careful attention will be needed as we make the transition to an agenda that embraces the three dimensions of sustainable development yet ensures that poverty eradication is its highest priority and that extreme poverty is ended within a generation.
72. Since the Millennium Development Goals were devised, major new challenges have emerged, while existing ones have been exacerbated. Inequality has deepened. Environmental degradation has increased, threatening our common future. People across the world are demanding more responsive governments and better governance and rights at all levels. Migration challenges have grown, and young people in many countries face poor prospects for decent jobs or livelihoods. Conflicts and instability have halted or reversed progress in many countries, affecting primarily women and children. Organized crime, including trafficking in people and drugs, violates human rights and undermines development. The deepening ways in which the lives of people and countries are linked demand a universal agenda addressing the world's most pressing challenges and seizing the opportunities of a new era.

III. Advancing the United Nations development agenda beyond 2015

A. Vision and transformative actions of the agenda

73. The articulation of a post-2015 development agenda provides an opportunity to place sustainable development where it should be: at the core of humankind's pursuit of shared progress. With a new sustainable development agenda, the world can make

- many historic achievements: eradicating extreme poverty by 2030, protecting the environment and promoting social inclusion and economic opportunities for all. Ultimately, the aspiration of the development agenda beyond 2015 is to create a just and prosperous world where all people realize their rights and live with dignity and hope.
74. As agreed at the United Nations Conference on Sustainable Development, the framework for sustainable development reflects our commitment to three interconnected objectives: economic development, social inclusion and environmental sustainability. Each of these dimensions contributes to the others and all are necessary for the well-being of individuals and societies. Together, they are meant to enable people to fulfil their potential within the finite resources of our planet.
 75. For such a sustainable development agenda to take root, four building blocks need to be agreed upon: (a) a far-reaching vision of the future firmly anchored in human rights and universally accepted values and principles, including those encapsulated in the Charter, the Universal Declaration of Human Rights and the Millennium Declaration; (b) a set of concise goals and targets aimed at realizing the priorities of the agenda; (c) a global partnership for development to mobilize means of implementation; and (d) a participatory monitoring framework for tracking progress and mutual accountability mechanisms for all stakeholders.
 76. Decisions on the shape of the next agenda rest with Member States. To support their deliberations, I put in motion an inclusive and transparent process to hear from all stakeholders. Through the efforts of the United Nations Development Group and others, I sought the views of people around the world through consultations in nearly 100 countries, global thematic consultations on 11 issue areas and a global online conversation and “My World” survey. These efforts have reached more than a million people. A large number of civil society organizations and academic institutions worldwide have also actively participated in the discussions.
 77. In addition, my High-level Panel of Eminent Persons on the Post-2015 Development Agenda provided critical proposals (see A/67/890, annex). I have made the report available to all Member States and recommend it as an important contribution to this process.
 78. I also benefited from the expertise of the science and technology community through the Sustainable Development Solutions Network. The contributions of the private sector around the world were conveyed through the Global Compact. The United Nations System Task Team, comprising more than 60 agencies and international organizations, conveyed the knowledge and experience of the Organization, while regional perspectives were provided by the regional commissions.

79. Reflecting on many of these inputs, the Open Working Group on Sustainable Development Goals is conducting a series of discussions aimed at formulating goals for sustainable development to be proposed to the General Assembly at its sixtyeighth session.
80. The common ground in the findings of these processes is encouraging. Discussions point to the importance of arriving at a single and coherent development agenda centred on sustainable development, applicable to all countries while taking into account regional, national and local circumstances and priorities.
81. The key elements of the emerging vision for the development agenda beyond 2015 include: (a) universality, to mobilize all developed and developing countries and leave no one behind; (b) sustainable development, to tackle the interlinked challenges facing the world, including a clear focus on ending extreme poverty in all its forms; (c) inclusive economic transformations ensuring decent jobs, backed by sustainable technologies, to shift to sustainable patterns of consumption and production; (d) peace and governance, as key outcomes and enablers of development; (e) a new global partnership, recognizing shared interests, different needs and mutual responsibilities, to ensure commitment to and means of implementing the new vision; and (f) being “fit for purpose”, to ensure that the international community is equipped with the right institutions and tools for addressing the challenges of implementing the sustainable development agenda at the national level.
82. Bringing this vision to life will require a number of transformative and mutually reinforcing actions that apply to all countries.
83. **Eradicate poverty in all its forms.** Poverty has many manifestations and is aggravated by discrimination, insecurity, inequality and environmental and disaster risks. Therefore, the eradication of poverty calls for a multifaceted approach, encapsulated in the concept of sustainable development, focusing on both immediate and underlying causes.
84. **Tackle exclusion and inequality.** In order to leave no one behind and bring everyone forward, actions are needed to promote equality of opportunity. This implies inclusive economies in which men and women have access to decent employment, legal identification, financial services, infrastructure and social protection, as well as societies where all people can contribute and participate in national and local governance.
85. **Empower women and girls.** The new agenda must ensure the equal rights of women and girls, their full participation in the political, economic and public spheres and zero tolerance for violence against or exploitation of women and girls. The practice of child marriage must be ended everywhere. Women and girls must have equal

- access to financial services, infrastructure, the full range of health services, including in the area of sexual and reproductive health and reproductive rights, and water and sanitation; the right to own land and other assets; a safe environment in which to learn and apply their knowledge and skills; and an end to discrimination so they can receive equal pay for equal work and have an equal voice in decision-making.
86. **Provide quality education and lifelong learning.** Young people should be able to receive high-quality education and learning, from early childhood development to post-primary schooling, including not only formal schooling but also life skills and vocational education and training.
 87. **Improve health.** Address universal health-care coverage, access and affordability; end preventable maternal and child deaths; realize women's reproductive health and rights; increase immunization coverage; eradicate malaria and realize the vision of a future free of AIDS and tuberculosis; reduce the burden of non-communicable diseases, including mental illness, and road accidents; and promote healthy behaviours, including those related to water, sanitation and hygiene.
 88. **Address climate change.** The international community must reconcile the challenges of mitigating and adapting to climate change while supporting the growth of developing countries. While the worst effects of climate change can still be averted by building the resilience of and investing in those communities and nations most vulnerable to disasters risk, those efforts will require a greatly stepped-up response, in keeping with the principle of common but differentiated responsibilities and respective capabilities. A successful outcome to the intergovernmental climate change negotiations is critical. Every effort must be made to arrive at a legally binding agreement by the end of 2015, as decided in Durban, South Africa, in 2011.
 89. **Address environmental challenges.** Environmental change has compounded problems worldwide, especially in vulnerable countries, reducing their capacity to cope and limiting their options for addressing development challenges. Managing the natural resources base — fisheries, forests, freshwater resources, oceans, soil — is essential for sustainable development. So too is building the resilience of and investing in those communities and nations most vulnerable to disasters, especially in the least developed countries and small island developing States.
 90. **Promote inclusive and sustainable growth and decent employment.** This can be achieved by economic diversification, financial inclusion, efficient infrastructure, productivity gains, trade, sustainable energy, relevant education and skills training. Labour market policies should focus in particular on young people, women and people with disabilities.

91. **End hunger and malnutrition.** Addressing hunger, malnutrition, stunting and food insecurity in a world experiencing rapid population growth will require a combination of stable and adequate incomes for all, improvements in agricultural productivity and sustainability, child and maternal care and strengthened social protection for vulnerable populations.
92. **Address demographic challenges.** While the population of developed countries is projected to remain unchanged at around 1.3 billion, the population of developing countries is projected to increase from 5.9 billion in 2013 to 8.2 billion in 2050. Countries with a high rate of population growth are generally on a path of falling fertility, especially as education for girls and sexual and reproductive health services become more widely available. Progress in these areas would enable many households to slow fertility rates, with consequent benefits for health, education, sustainability and the demographic dividend for economic growth. Countries with a high proportion of young people need to offer education and opportunities for decent work. Countries with an ageing population need policy responses to support the elderly so as to remove barriers to their full participation in society while protecting their rights and dignity.
93. **Enhance the positive contribution of migrants.** More than a billion people rely on international and domestic migration to improve the income, health and education of their families, escape poverty and conflict and adapt to environmental and economic shocks. Countries receiving migrants can also benefit significantly. Yet many barriers limit the positive effects of migration, including possible large economic and social gains. Discrimination is widespread and the human rights of migrants are often denied at different points in the migration process. The scourge of human trafficking, an unacceptable dimension of migration, must be ended.
94. **Meet the challenges of urbanization.** Some 70 per cent of the world's population will live in cities by 2050. Urbanization poses the challenge of providing city dwellers with employment, food, income, housing, transportation, clean water and sanitation, social services and cultural amenities. At the same time, living in cities creates opportunities for the more efficient delivery and use of physical facilities and amenities. Rural prosperity, land management and secure ecosystem services should form an integral part of sustainable urbanization and economic transformation.
95. **Build peace and effective governance based on the rule of law and sound institutions.** Peace and stability, human rights and effective governance based on the rule of law and transparent institutions are outcomes and enablers of development. There can be no peace without development and no development without peace. Lasting peace

- and sustainable development cannot be fully realized without respect for human rights and the rule of law. Transparency and accountability are powerful tools for ensuring citizens' involvement in policymaking and their oversight of the use of public resources, including to prevent waste and corruption. Legal empowerment, access to justice and an independent judiciary and universal legal identification can also be critical for gaining access to public services.
96. **Foster a renewed global partnership.** The Millennium Development Goals, in particular Goal 8, on the global partnership for development, speak to the importance of our common humanity and the values of equity, solidarity and human rights. The post-2015 development agenda will need to be supported by a renewed global partnership grounded on such values. As noted in the report of my High-level Panel, “the partnership should capture, and will depend on, a spirit of mutual respect and mutual benefit”.
 97. The global partnership should finish the job started with Goal 8, including meeting the assistance objective of 0.7 per cent of gross national income, as well as other existing and future intergovernmental agreements, such as the Millennium Declaration, the Monterrey Consensus of the International Conference on Financing for Development, the Principles set out in the Rio Declaration on Environment and Development, the Johannesburg Plan of Implementation and the Istanbul Programme of Action, as well as the outcome of the Ad Hoc Working Group of the Durban Platform for Enhanced Action. All partners should deliver on past commitments, particularly those on official development assistance, climate finance and domestic resource mobilization.
 98. The transformative actions of the post-2015 development agenda should be supported by multi-stakeholder partnerships that respond to the sustainable development agenda. These should include not only governments but also businesses, private philanthropic foundations, international organizations, civil society, volunteer groups, local authorities, parliaments, trade unions, research institutes and academia. Such partnerships can channel commitments and actions from a wider set of actors, and their success depends on assigning roles, responsibilities and clear accountability.
 99. Official development assistance will remain crucial, including for leveraging other finance, particularly for the least developed countries, landlocked developing countries and small island developing States, many countries in Africa and countries emerging from conflict and disasters. In addition to delivering on past commitments, it will be critical for donors to establish a timetable for meeting official development assistance targets and enhancing development effectiveness, including through the principles and actions set out in the Busan Partnership for Effective Development Cooperation.

- The impact of official development assistance can be magnified by other sources of finance, including innovative sources.
100. A universal development agenda beyond 2015 will require a robust framework for sustainable development finance including both private and public funding. International efforts are needed to create an environment conducive to business and thus channel capital flows and portfolio investments to the sustainable development agenda, to eliminate illicit financial flows, to enhance the regulation of secrecy jurisdictions and to promote asset recovery. Multilateral development banks have an important role to play in identifying novel sources of sustainable development financing.
 101. At the same time, the financing framework for the post-2015 period will require the mobilization of domestic resources, including by broadening the tax base and improving tax administration, including in developing countries, and improving corporate and public governance of extractive industries in resource-rich countries. In addition, the financing framework will require commitment by the public and private scientific and research communities to develop new and transformative technologies. Harnessing science, technology and innovative methods will be central in areas ranging from information and communications technology to transportation, the environment and life-saving medicines.
 102. South-South and triangular cooperation will also play a key role. This has increased significantly in recent years and has taken various forms, including infrastructure investment, technical cooperation, joint research and investment and information-sharing.
 103. I welcome the Intergovernmental Committee of Experts on Sustainable Development Financing, which will propose options on a strategy to facilitate the mobilization of resources and their effective use. The biennial high-level Development Cooperation Forum and the follow-up to the International Conference on Financing for Development also provide important opportunities for charting a way forward.
 104. **Strengthen the international development cooperation framework.** In order to respond to the challenges of funding and implementing a sustainable development agenda, both national and international institutions need to be strengthened to overcome the institutional and operational separation between economic, social and environmental responsibilities. I particularly welcome, in that regard, General Assembly resolution 67/290, in which the mandate, organizational structure and the working methods of the high-level political forum on sustainable development were defined. There is broad agreement that the forum should bring political support at the highest level

to the coordination, coherence, implementation and monitoring of the commitments in a universal sustainable development agenda.

B. Comprehensive monitoring framework and robust accountability mechanisms

105. Strong monitoring and accountability will be crucial for the implementation of the post-2015 development agenda. Governments, especially parliaments, will play a central role. The monitoring and accountability framework can be strengthened through the direct engagement of citizens and responsible businesses making use of new technologies to expand coverage, to disaggregate data and to reduce costs.
106. The availability of information has improved during the implementation of the Millennium Development Goals. Still, there is an urgent need to further improve data collection, dissemination and analysis. Better baseline data and statistics are needed, especially because the post-2015 development agenda will involve measuring a broader range of indicators, requiring new and disaggregated data to capture gaps within and between population groups. Assessing the quality of outcomes should also feature more prominently in a results-based framework. As suggested by my High-level Panel, targets will be considered to have been achieved only if they are met for all relevant income and social groups.
107. In this context, the advances in information technology over the past decade provide an opportunity for a “data revolution”, which should enable countries to strengthen existing data sources and develop new and participatory sources of information. Many developing countries will require technical and financial support to build solid statistical systems and capacity so as to take advantage of these new opportunities.

C. Setting goals for the agenda

108. Experience with the Millennium Development Goals shows us that goals can be a powerful way of mobilizing common action. To be effective, they need to be limited in number, measurable, easy to communicate and adaptable to both global and local settings.
109. At the United Nations Conference on Sustainable Development, Member States agreed that the sustainable development goals “should be coherent with and integrated into the United Nations development agenda beyond 2015”. The many consultations and reports suggest that a single, balanced and comprehensive set of goals, universal to all nations, which aims to eradicate all forms of poverty and integrate sustainable development in all its dimensions, should form the core of the agenda.

110. The framing of the set of goals for sustainable development will inevitably need to be broader than that of the Millennium Development Goals in order to reflect new challenges. Illustrative goals and targets have been proposed in a range of reports, including those of the High-level Panel, the Sustainable Development Solutions Network and the Global Compact, and in several initiatives from the research community.
111. Goals and targets should take into account cross-cutting issues such as gender, disability, age and other factors leading to inequality, human rights, demographics, migration and partnerships. The new goals should embrace the emphasis on human well-being and include the use of metrics that go beyond standard income measures, such as surveys of subjective well-being and happiness, as introduced by many countries and the Organization for Economic Cooperation and Development.

D. Towards the formulation and launch of the agenda

112. The special event of the President of the General Assembly to be convened on 25 September will review current efforts to achieve the Millennium Development Goals and provide a timely opportunity for rallying political support for their acceleration. The event will also serve as an occasion to reflect on the broad contours of the development agenda beyond 2015.
113. Member States should therefore use the special event to generate clarity and a solid momentum for the important discussions and decisions that will follow. In the outcome of the event they could issue a call for convening a United Nations summit in 2015 to adopt the new development agenda. To that end, the Assembly could request its President to hold consultations on a procedural resolution for initiating preparations for the summit, in which it could request the Secretary-General to prepare a report on modalities, format and organization for submission to the Assembly by March 2014. That report could serve as the basis for the Assembly's consultations on a comprehensive resolution on the timing, scope, format, participation and expected outcome of a summit in 2015.
114. The General Assembly could launch the final phase of the intergovernmental consultations on a post-2015 development agenda at its sixty-ninth session. Those consultations could draw on the outcomes of several intergovernmental events, including the high-level meeting on disability and development, to be held in September, the high-level dialogue on international migration and development, to be held in October, the third International Conference on Small Island Developing States, the climate change summit in 2014 as well as the next conference on financing

for development. Our goal must be to make 2015 a defining moment for people and the planet and to show what the United Nations and Member States, working together, can achieve.

IV. Recommendations

115. **I call upon all Member States and the entire international community to take every step possible to achieve the Millennium Development Goals.** This will require political courage and enlightened leadership on the part of all countries, regardless of their level of development. But we must, as stated in the Millennium Declaration, spare no effort to deliver on our policy and financial commitments. This is our duty — our responsibility to humanity today and in the future. With political will and adequate resources, much can be accomplished before the 2015 deadline. Even then, some goals may not be met. Others, even if met, were designed to address only part of the challenge. The post-2015 development agenda will therefore need to complete the Millennium Development Goals, scale up their success, expand their scope and address new challenges.
116. **I call upon Member States to adopt a universal post-2015 development agenda, with sustainable development at its core.** Poverty eradication, inclusive growth targeting inequality, protecting and managing the natural resource base of our planet within a rights-based framework and cognizant of the nexus between peace and development — these are the overarching objectives of sustainable development. To realize this agenda, all countries need to recognize the profound transformations required to address the emerging challenges of sustainable development. These include economic shifts to sustainable patterns of production and consumption, effective governance and a renewed global partnership and means of implementation.
117. **I call upon the international system, including the United Nations, to embrace a more coherent and effective response to support this agenda.** I welcome the leadership of Member States as they establish the high-level political forum, tasked with providing coordination and coherence at the highest political level to foster sustainable development in every country. The United Nations system will continue to reform and make itself “fit for purpose” so as to respond to the challenges of this new path to sustainable development.
118. **I encourage Member States to provide clarity on the road map to 2015.** As Member States consider the processes leading up to 2015, they could be supported by a report of the Secretary-General during the main part of the sixty-ninth session of the General Assembly. This would draw upon the outcomes of the Open Working Group on Sustainable Development Goals, the Intergovernmental Committee of Experts on Sustainable Development Financing and other bodies. The intergovernmental process

could lead to an agreement on the vision, principles, goals and targets of the post-2015 development agenda, as well as on the renewed global partnership for development.

V. Conclusion

119. Acting upon our common challenges demands a renewed commitment to international cooperation. Multilateralism is being tested. The United Nations, as a global beacon of solidarity, must do its part to strengthen collaboration and show that it can be effective in building the just, prosperous and sustainable world that people want and have a right to expect. Defining the post-2015 development agenda is thus a daunting yet inspiring and historic task for the United Nations and its Member States.
120. In so doing we must continue to listen to and involve the peoples of the world. We have heard their calls for peace and justice, eradicating poverty, realizing rights, eliminating inequality, enhancing accountability and preserving our planet. The world's nations must unite behind a common programme to act on those aspirations. No one must be left behind. We must continue to build a future of justice and hope, a life of dignity for all.



Preamble 3

Transforming Indian Agriculture: by Loving Some Agriculture Less and the Rest More*

Arvind Subramanian, Chief Economic Adviser, Government of India

1. Background

It is an honour to be here today to deliver the Foundation Day Lecture –2017 which also, appropriately, the World Environment Day. The topic I have chosen does not need any justification either in terms of its contemporary or historical importance. The Government has made doubling farm incomes as one of its top policy priorities. To this end, it has taken a number of important policy actions to boost agriculture: instituting soil health cards, emphasizing efficient irrigation, strengthening government procurement of pulses, introducing neem- coating of urea, building more assets under MGNREGS, expanding crop insurance for farmers, and building a common agricultural e-market via e-NAM.

The historical salience derives from the fact that this is the one hundredth anniversary of the Champaran movement. The first salvo of satyagraha was fired by the Father of our Nation on behalf of farmers, the indigo farmers oppressed and exploited by colonial rule. Perhaps as a result, the farmer has acquired a mythic

Acknowledgement: National Academy of Agricultural Sciences, New Delhi-12 status in Indian legend: pure, unsullied, hard-working, in harmony with nature and yet poor, vulnerable and the victim, first of the imperial masters and then of indigenous landlords and middlemen. Bollywood (and Kollywood and Tollywood), has of course, played a key role in creating and reinforcing the mythology of the Indian farmer (I have in mind movies such as *Mother India*, *Do Beegha Zameen*, *Upkaar*, and more recently *Peepli Live* and even *Lagaan*).

*Foundation day lecture delivered at National Academy of Agricultural Sciences, New Delhi on 5th June 2016.

To support and protect the farmer is also a professed ideology and mantra of politicians of all stripes and all times reflected, for example, in the periodic granting of loan waivers and the perennial lure of announcing free power.

But the question I want to pose today is this: has this mythological status actually come in the way of really being good to him?

2. Why Agriculture Matters: An Irony

The reasons that agriculture matters are well-known: it provides sustenance to so many, food to all, and employment to many. In addition to these intrinsic positive reasons to invest in agriculture, there are other instrumental reasons: poor agricultural performance can lead to inflation, political and social disaffection, and restiveness— all of which can hold back the economy. There are intrinsic as well as instrumental reasons for prioritising agriculture.

But we must be clear and honest about one important link. The Nobel Prize winner, Sir Arthur Lewis, showed that economic development is always and everywhere about getting people out of agriculture and of agriculture becoming over time a less important part of the economy (not in absolute terms but as a share of GDP). But this must happen along with rapid productivity growth, ensuring rising farm incomes and adequate food supplies for the people. The reason why agriculture cannot be the dominant source of livelihood is that levels of productivity and hence living standards can never approach— and have historically never approached— those in manufacturing and services. That, of course, means that we must get our industrialization and urbanization right for the alternatives to agriculture to become meaningful, prosperous alternatives.

When Dr. Ambedkar, famously derided the village as ‘a sink of localism, a den of ignorance, narrow mindedness and communalism, he was perhaps on to a deeper truth— an Indian social complement to the Lewisian economic insight— that in the long run people need to move and be moved out of agriculture. Dr. Ambedkar was warning about the patronization of agriculture masquerading as a romanticization of rural India.

So the irony is this: we must care deeply about farmers and agriculture today because we want there to be fewer but more productive and prosperous farms and farmers tomorrow.

In other words, all good and successful development is about facilitating this transition in the context of a prosperous agriculture and of rising productivity in agriculture not least because that will facilitate good urbanization and rising productivity in other sectors of the economy.

So, today, I am going to provoke to force us all into collective self-reflection on the state of agriculture and its future. It is easy for me --or for anyone – to list 10 or 20 different

things that need to be done to improve our agricultural performance: stem the deterioration in agricultural research, educational, and extension institutions, improve resilience, incentivize drip irrigation, etc. But it is as easy to list them as it is perhaps useless. Because for any improvement or reform that all the experts recommend, we have to ask the simple question: “If that is so obviously good for agriculture why hasn’t it happened already? Or, put differently, “What it is about today that will make these proposals successful when they have demonstratively failed to persuade in the past?”

Rather, I want to ask a question or tentatively pose a hypothesis: is it possible that we actually love some crops (cereals) and their farmers too much and, for all the pious professions and mythologizing, and other crops and their farmers not enough. To put it more bluntly, perhaps we are now smothering cereals with too much government support and other crops—pulses, dairy, oilseeds, livestock, and fruits and vegetables—not enough?

3. The Successes

Before I elaborate on the main themes of my talk today, I would like to take stock of our achievements and shortcomings in agriculture. Given where we began in 1947, Indian agriculture has come a long way. We have achieved food security – at least on the major crops; rural poverty rates have declined substantially; agricultural incomes have risen; nutrition levels have risen.

In terms of successes, I would highlight the following:

The green revolution transformed Indian agriculture by increasing yields of wheat and rice, especially in Northern and then in Southern India. Credit here goes to international research but perhaps even more so to Indian scientists, agronomists and researchers, extension workers in public institutions that completed the link from technology to actual farm output.

The white revolution that transformed the Indian dairy sector, increasing milk production, reducing dependence on imports, creating vibrant and participating institutional structures on agriculture and founding a vibrant consumer goods industry based on dairy. Credit here goes, of course, to Dr. Kurien, leader of the Kheda Cooperative movement, and enlightened leadership of the NDDB.

In addition to these sectoral successes, there have been, other regional achievements--cotton in Gujarat, Maize in Bihar, Sugar in Uttar Pradesh, wheat in Madhya Pradesh, potatoes in West Bengal.

4. Glass Less-than-half Full

But (and you knew a but was coming), despite these successes, the honest story here is one of the glass being less than half – full. Two statistics support my assertion: overall agricultural labour productivity is less than a third of that in China and about 1 percent of

that in the frontier countries. Land productivity (measured as yield per hectare) is also well below the frontier. For example, in the case of rice, Indian yields are about 50% of those in China and one-third those in the US.

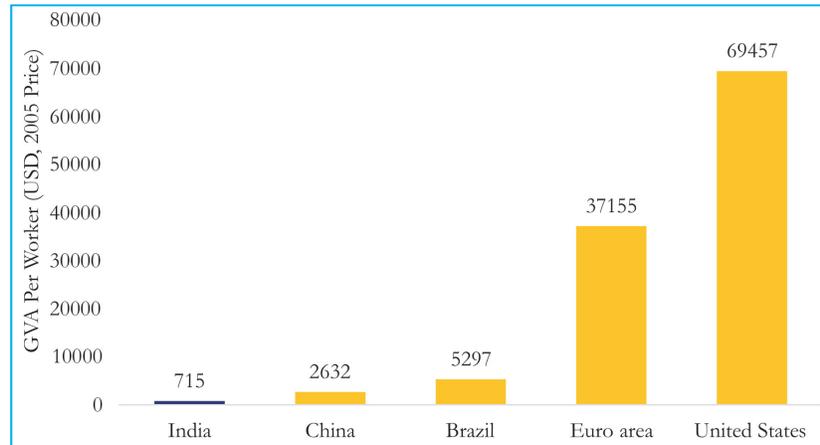


Figure 1. Overall Agricultural Productivity: Still Very Far From Frontier

Second, agricultural incomes (as measured by income from cultivation, net of cost and unsold produce valued at local market rates) are still meagre. The median household net farm income was about Rs.19,250 in 2012-13 or about Rs. 1600 per. Data based on Agricultural Situation and Assessment Survey, NSS for 2012-13. month, which is not very far above the poverty line. To be sure there is enormous variation, but the truth is it simply does not pay to be a farmer in India.

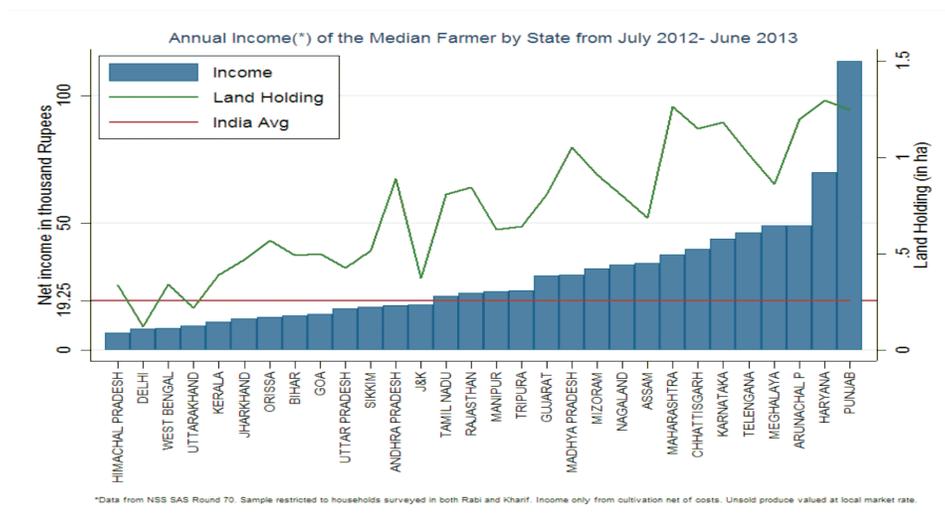


Figure 2. Agricultural household income

5. The New Malthusian Challenge

Before I elaborate on my central hypothesis, I just want to alert you all to the new and serious challenge: raising agricultural productivity and reducing vulnerability are going to get harder because of what I call the re-emergence of the Ghost of Malthus. The four key agricultural resources: atmosphere, water, land, and soil quality are all moving in very unfavourable directions. Climate change will reduce agricultural productivity and increase variability (all the models show a disproportionate impact on Indian agriculture); water is becoming perilously scarcer for climactic reasons and because of over-use and misuse domestically, especially in Punjab and Haryana (as Figure 3 shows); soil quality is depleting, and the pressures on land are mounting as population surges and alternative uses are becoming more attractive.

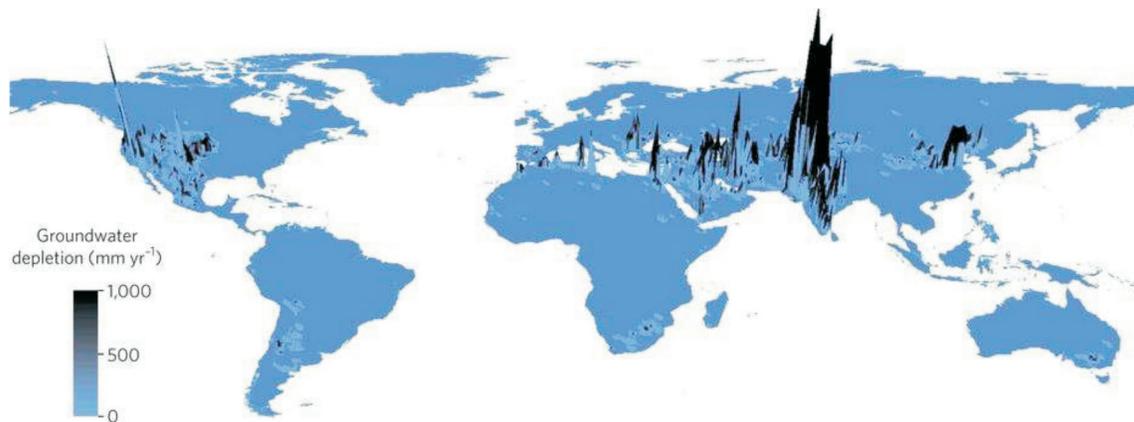


Figure 3. Ground Water Depletion

6A. Smothering with love: Cereal-Centricity

Think of how and how much we support cereal and especially rice production. They are too numerous to exhaustively enumerate. The government helps the farmers through policies that affect the prices of outputs and inputs; through schemes and through institutions.

We provide minimum support prices to farmers and the benefits accrue mainly to farmers who produce marketable output and that too mostly in cereals and wheat, which in turn is confined largely to a few States, notably in the North (Punjab and Haryana).

We then provide subsidies for power, water, fertilizer (now the second largest subsidy), seeds, credit, we exempt agricultural income from income taxes, and we periodically grant loan waivers.

Look again at Figure 2 and see how clearly agricultural incomes in Punjab and Haryana exceed those in the rest of India to get a sense of this biased smothering with love.

6B. Smothering with love: Big not Small Farmers

There is a second aspect to this smothering with love: not only does it mainly benefit the cereal farmers, it also tends to favour larger farmers, or at least it does not adequately reach the smaller farmer.

Several examples: by definition, the exemption of agricultural income from tax favours those with larger incomes. In fertilizer, we estimated in the Economic Survey that only about one-third of the total subsidy went to small and marginal farmers. On agricultural credit, there is now growing evidence that not all of this goes to farmers. On the loan waiver, it is surprising how little the small and marginal farmer borrow from formal financial institutions (less than 50%) and how much from informal sources, while the large farmer relies on formal sources to the extent of about 75%; on power, we estimated in the Economic Survey that the bottom quintile received about 10% of the total subsidy while the top quintile about 37% because of highly skewed electricity consumption.

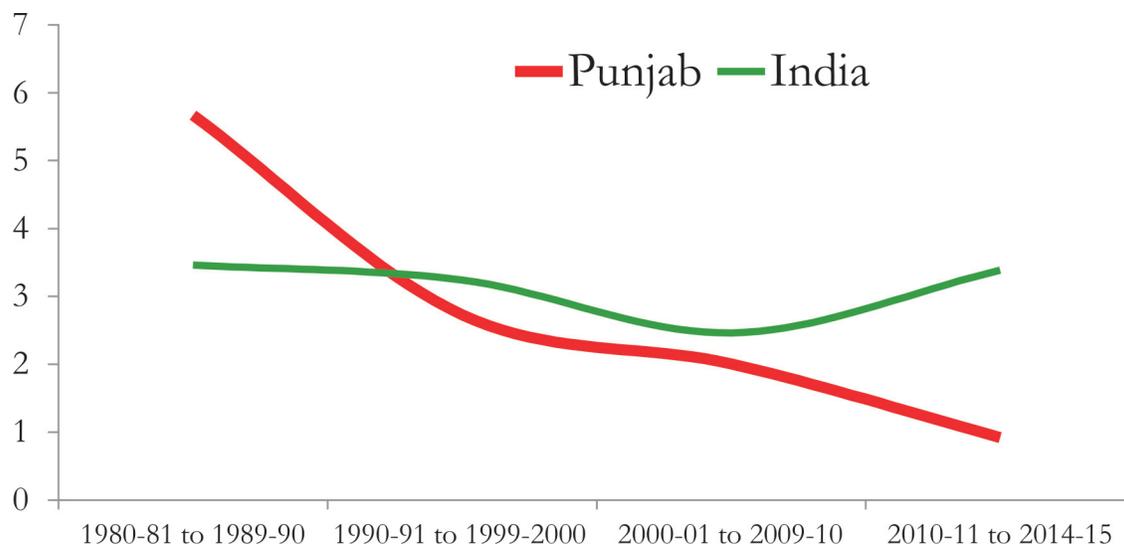


Figure 4: Agricultural Growth in Punjab and India (Average decadal, %)

But is there something as loving too much? The experience of Punjab is perhaps suggestive. Thanks to support, incomes are high and amongst the highest but there is growing evidence that this is proving now to be counter-productive. Punjab has lost most of its earlier agricultural dynamism. Between 1971-72 and 1985-86, agricultural growth was 5.7 percent compared to the All-India number of 2.3 percent. Since 2005-06, its average agricultural growth has declined to 1.6% compared to India's 3.5% (Figure 4).

Consequently, overall dynamism has suffered as its overall growth has slipped from being substantially above the Indian average to well below (Figure 5) and

Punjab has slipped from being the richest large state (excluding special category states) in 1984 to the 9th richest state by 2014. Of course, this analysis is merely suggestive but Professor Ramesh Chand’s excellent analysis points in a similar direction.

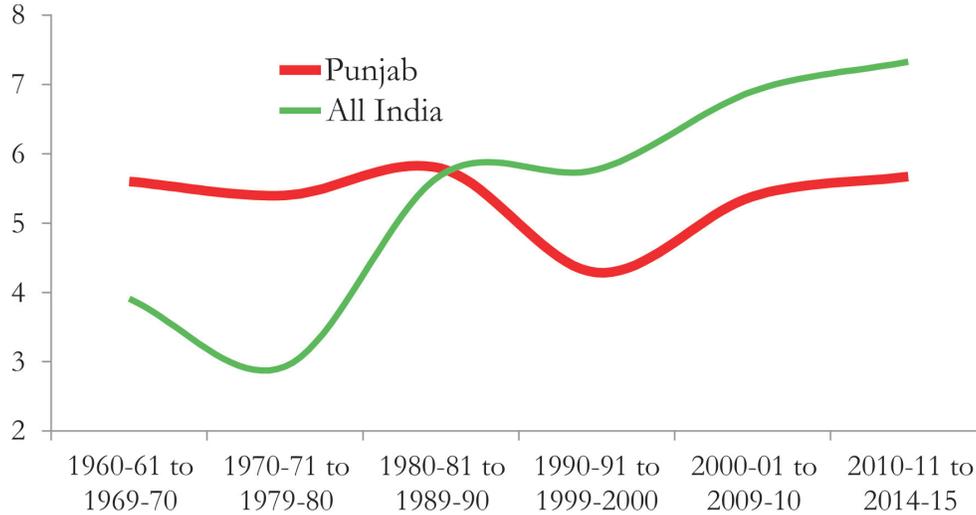


Figure 5: Overall GDP Growth in Punjab and India (Average, decadal, %)

One can hazard that Punjab’s dynamism will only be restored if it weans itself off its agriculture that has taken a toll of its water resources, soil quality, and human health (refer to cancer district). Its fading dynamism may be in part due to the excessive support that its agriculture receives.

7. Loving Too Little

If we love some crops too much, perhaps we love many of the others too little. I have in mind here pulses, dairy and livestock, fruits and vegetables, and oilseeds. How do we love them too little?

In the case of pulses, commendable efforts have been made to increase procurement at MSP (MSP without procurement, it must be emphasized, offers little comfort for farmers) and this Kharif season there was indeed a substantial increase to 2 million (out of a total output of 8.7 million). Despite this, it is estimated that about 60% of the record Tur output was sold at less than MSP, resulting in depressed income. Stock limits and export restrictions kept market prices low; had they been eased the fortunes of farmers would have been better.

I think we misunderstand an important economic insight here that we highlighted in the pulses report. Some of the loving-too-little occurs because of the perception of a tension between farmer and powerful middle-class consumer interests. This leads to a response that

creates policy volatility and pro-cyclicality, which increases price uncertainty for farmers: so when prices go up, export restrictions are imposed, and when prices decline, import restrictions are imposed and so on. But this perception and the consequent policy action do not adequately recognize a fundamental alignment of interests. Lower farmer prices today will adversely affect future agricultural supplies (especially in crops that are predominantly produced domestically such as pulses, fruits and vegetables) which will increase consumer prices tomorrow. So, even over reasonable planning and political horizons, what is good for the farmer is good for the consumer.

On fruits and vegetables, restrictions on selling imposed via APMCs are perhaps taking a toll. The government has created an electronic common market and the results are awaited.

On dairy and livestock, two points are worth emphasizing. Governments have the right to choose their social policies. But in doing so they must be fully aware of the economic costs of these policies. If social policies impede the workings of the livestock market, the impact on the economics of livestock farming could be considerable. These must be costed for appropriate choices to be made.

Second, it must be recognized that the economics of livestock farming, and hence the fate and future of this source of livelihood will depend critically on the terminal value of assets, in this case the no-longer-productive livestock. If social policies drive this terminal value precipitously down, *private* returns could be affected in a manner that could make livestock farming less profitable (and recent research by Anagol, Etang and Karlan (2013)—NBER Working paper No. 19437—suggests that returns to livestock farming are in any case very low and even negative) . This declining terminal value arises both because of the loss of income from livestock as meat and the additional costs that will arise from having to maintain unproductive livestock. But there is more. It is possible that social policies could affect *social* returns even more adversely. Stray cattle, and a lot of it, will have to be looked after, otherwise diseases (foot and mouth) could spread, leading to health hazards and social costs.

(Let me add as an aside that responding to changing consumer preference for proteins, which Indians under-consume to the detriment of their health, needs both reduced cereal-centricity, and at the same time promoting—not hindering— alternative sources of protein from pulses, dairy and livestock).

Finally, there is technology that again is especially important for pulses, oilseeds and dairy. Harish Damodaran has written persuasively about the choices we face on GM. To paraphrase him, it seems that the patronization of farmers masquerading as romanticization is rife. This must be addressed rationally even beyond mustard. If we want farmers to benefit from new technology we must allow them these benefits regardless of the provenance

of the technologies just as we do in other sectors. Expropriating property rights retroactively and undermining sanctity of contracts as sought by voices on opposing ends of the ideological spectrum could impede the flow of technology and thus end up hurting not helping farmers. To be sure, we must absolutely ensure that there is no abuse of patent rights or other monopolistic practices but the right instruments must be chosen; moreover, there must always be an underlying cost-benefit analysis but an analysis as farmers themselves would do it rather than as how the analysis might be done for them.

8. Conclusions

How do we redress this imbalance between the two sets of crops?

On the loving-cereals-too-much challenge, it will be politically impossible to reduce current levels of support. Entitlements have been created and exit from entitlements is fiendishly hard not just in India but the world over. The only possible way forward is to keep the magnitude of support and change its form in order to change incentives. Professor Ashok Gulati has recommended that support for fertilizers and power be each provided as a direct transfer than as a conditional subsidy. Perhaps this idea could be expanded into a quasi-universal basic income by combining some of the major support—power, fertilizer, even MNREGA— into an unconditional basic support for all farmers or farmers below a certain farm size. Our estimate is that if these three forms of support were replaced by direct support the amount provided could be about Rs. 1 lakh per year per cultivator.

In any event, as a minimum, ways must be found of reducing the addiction of agriculture in Punjab and Haryana to free power and cheap fertilizer.

On the other category of crops that are loved too little, I think the challenge is equally daunting and really the flip side of the cereals challenge. Here one cannot but help come to the conclusion that policies can only seriously and sustainably be implemented if they—farmers in pulses, dairy, livestock, oilseeds etc. acquire more political voice to countervail other voices. Top down efforts clearly have not been enough and pressure from below seems a necessary condition for redressing the balance. How that will happen I will leave better minds than mine to dwell on.

A final and simple proposal. I have drawn a distinction –and I don't know how valid it is--between these two categories of objects of government love in agriculture; and I have made some suggestions for re-balancing this love. We could at least make a start by making highlighting and making clear this differential treatment. I would urge the CACP in its MSP calculations to quantify not only the private costs and returns of various crops but also their true social costs. For example, the social cost of cultivating rice in north-western India far exceed private costs because of damage to soil quality, depletion of water

tables, damage to human health, and spewing of pollution into the atmosphere. The disinfectant effect of more information and clarity might be a small technical step that could help in responding appropriately to the challenge.

In conclusion, I would suggest that perhaps more hard-nosed realism rather than woolly romanticization of the Indian farmer is what the doctor must order to transform Indian agriculture.



Market Liberalization for Horticulture Revolution at Small Farms*

Ramesh Chand, NITI Aayog,

Fruits and vegetables give 4-10 times the return from other crop groups namely cereals, pulses and oilseeds. A study on sources of growth indicate that diversification towards horticultural crops is the most powerful factor in raising growth rate of GDP agriculture. A one per cent shift in area from non horticultural crops to horticultural crops adds 0.46 percentage points to growth rate of agriculture sector. Due to changes in taste, preferences and food habits, the consumption pattern in India has been shifting towards fruits and vegetables. Such changes are also happening globally. Studies on food demand indicate that 1 per cent increase in per capita expenditure results in 1.9% and 1.02% increase in demand for fruits and vegetables respectively. Thus, per capita intake of fruits and vegetables in the country will keep rising in coming years. Moreover, there is large deficiency of these items in Indian diet. India's import of fruits is rising by 20 per cent per year. All these indicators suggest that demand side prospects for fruits and vegetables are very bright.

Technological developments in horticultural crops have facilitated some diversification. Varieties of horticultural crops have been developed for cultivation in off season, under diverse climatic conditions and with various attributes to attract consumers. Despite favorable demand and supply side factors area under fruits and vegetables in the country has remained below 10 per cent. Even with one tenth share in area, fruits and vegetables contribute more than one fourth of earnings from crop sector in the country.

Highly elastic demand for fruits and vegetables, preference of consumers for fresh farm produce and new e-commerce offer vast scope for increase in production of fruits and vegetables and farmers' income in the country. The major constraint however is marketing.

*Acknowledge NITI Aayog for permission.

This is reflected in slowdown in diversification towards horticulture crops, very high growth in horticultural imports, large price spread between producers and end users, high level of post harvest losses, frequent and often violent price fluctuations, low level of processing, and very low post harvest value addition. The main constraint to expand production of fruits and vegetables is the system of marketing and inadequate processing facility.

Horticultural crops, particularly vegetables, are more popular with smaller size land holdings as they have advantage in terms of family labour required for labour intensive production. However, such farmers are severally constrained by scale factor in marketing of produce.

Acknowledgement : NITI Aayog

In most cases a horticultural crop does not come to maturity at the same time and harvestable produce is distributed over a span of a few weeks. Being perishable, these crops cannot be stored at home to make a economical lot for taking to market. This further lowers the scale of marketable lot of farmers. The standard mode of disposal of marketable surplus is sale in nearby market yards (mandi) which is subject to APMC rules and regulations. This requires produce to pass through long market channel which involves payment of approved and unapproved taxes, market charges, and margins to a large number of intermediaries. Recently some states have brought perishable fruits and vegetables out of purview of APMC Act but it has made difference only to small quantity of produce. The practice of marketing, required by market regulation, has prevented application of e-commerce in fruits and vegetables and kept producers and consumers apart. Recently in many cities online sale of fruits and vegetables has been started by some innovative vendors but it has no back-end support. Market regulations constrain online purchases from the farmers/producers which can be of immense benefit to producers as well as consumers.

India's experience of milk marketing, which ushered in the white revolution, offers interesting lessons for harnessing its horticulture potential. Milk and horticulture have lot of similarities. Both are high value, perishable, labour intensive, and income augmenting enterprises. Very stable and robust growth in milk production is attributable mainly to three market factors, namely, institution of milk cooperatives, complete freedom to milk producers and buyers for sale/purchase of milk throughout the country and deregulation of dairy sector. With similar market conditions India can achieve horticulture revolution in a much shorter period than White Revolution. We need two simple measures for this. One, take fruits and vegetables out of APMC Act and make their sale and purchase completely free. This will allow setting up vegetable/fruit collection centres by local entrepreneurs, like milk collection centres, where farmers can sell even a few kg of their produce. In some cases integrators will start pooling the produce for marketing, like informal milk vendors in the countryside. They

can make economic lot and sell the produce in a market or they can have direct contact with vendors or other buyers in towns, cities and various consuming centres. This will also encourage private sector to go for contract farming and having assured supply of suitable material for processing. Many innovative vegetable and fruit sellers in urban areas will be attracted to develop back-end linkage to get direct supply from the producers. India has waited for development of modern value chain in horticulture for a long time but this has not been happening due to legal hurdles and restrictions on free and direct marketing. Two, horticulture producers companies or associations of various types, like dairy cooperatives, can also help farmers in marketing their produce without involvement of long chain of market intermediaries. Some progress has been made in this area in the last two years and there are some impressive success stories; such experiences need to be scaled up. Three, as delicensing of dairy in 1991 and the amendments in Milk and Milk Product Order in year 2002 attracted large investments in milk marketing and processing, free marketing of horticultural produce will attract lot of investments in horticultural processing and value chains.

Demand side factors and technology are highly favourable for horticulture revolution at small farms. What is needed is policy support for market liberalization, producers organizations and processing. These require action both by the states and the Central government. The onus for freeing market for horticultural produce rests with the states while support of Central government is crucial for promoting producers' organizations and fruits and vegetable processing.

Mismatch between Policies and Development Priorities in Agriculture*

National Academy of Agricultural Sciences, New Delhi

1. Nature of the Mismatch

Food insecurity and poverty are great threats to humanity, and have worldwide serious economic, social and political implications. India, with nearly 200 million undernourished, hungry and poor, accounts for nearly one-fourth of such deprived people globally. Unfortunately, a large part of them are smallholder farmers. And, this unethical situation has persisted over the years. Since mid-1990's, against the overall national GDP growth rate of 7-9%, the agricultural growth rate was only 2.5 to 3.5%. Contribution from agriculture to the GDP thus declined from 23% in 2003-2004 to 14% now. This has resulted in further widening of the income gap between farmers and non-farmers from 1:3 to 1:5. This slower growth in agriculture has caused further marginalization of rural population; widened urban-rural and inter-state divides, and created hot spots of acute distress, indebtedness, deprivation and even farmers suicides. A few of the causes for this agrarian crisis are: continuous decline in investment in agriculture (barring the past two years); neglect of the interest of farmers; deterioration in terms of trade for agriculture; predominance of marginal and sub-marginal farmers; stagnating farmers income which meets hardly 80% of their needs and requirements resulting in debt crisis; ineffective and negligible output price interventions especially in agriculturally underdeveloped regions; and fast decreasing farm holding size, etc. The serious gaps among policies, strategies, programmes, actions and implementation must be filled to remove the glaring developmental asymmetries.

*Acknowledgement: National Academy of Agricultural Sciences, New Delhi-110012

We are also quite aware that public investment, particularly for research and technology and agro-infrastructure development, did not keep pace with the needs of output growth. During past Plans, highest agriculture investment was in irrigation, but there was hardly any increase in net irrigated area, and cropping intensity continues to be low. Although the amount of credit had tripled over the past few years, but the number of borrowers has declined and bulk of the credit has been cornered by large farmers. Moreover, credit flow to the sunrise sectors, such as livestock, remained truncated. Majority of the marginal and sub-marginal resource poor farmers and other rural poor met over 80% of their credit needs from non-formal sources. Layers of debts and unusual stresses have thus intensified especially in rainfed areas. Rural markets and related infrastructure and farmers-market linkages are extremely poor. Further, about 30% of the produce is wasted, and value addition in agriculture commodities is less than 10%.

India has the largest bulge of youth who are unemployed. But, the youth is generally least attracted to agriculture as a profession. Therefore, measures should be initiated which could help attract and retain the youth in farming by making it knowledge driven and economically rewarding, and by harnessing the power of economy of scale in favour of small and marginal farmers both in production and post-harvest phases of farming. In order to overcome the problem of unemployment of youth, attempt should be to skill each agricultural graduate to become an entrepreneur, rendering them job creators rather than job seekers.

There is a serious mismatch also among record foodgrain production and food availability, food production growth rate, hunger and nutrition indices, and farmer's income and livelihood security. In recent decades, India has averaged annual GDP growth rates of about 7%, whereas the nation's ranking in terms of Human Development Index (HDI) has remained unchanged; we were ranked an abysmal 134 in 1980; we remained at this level even in 2011. It is pertinent to recall the statement of the economist and Nobel laureate Amartya Sen saying "I do not think there's enough clarity on economics here. I do not judge the performance of the Indian economy by growth alone. I am disturbed by the fact that India has the largest ratio of undernourished people in the world. That is why we have to take a broader view. Bangladesh has taken over India in longevity, infant mortality, immunization rate, female illiteracy and all social criteria and our ranking worsened than advanced in the period of high growth rate, then I think the vulnerability of the political economic strategy of catering primarily to growth and not the human capability expansion would get much more tension, and the fact is that human capability expansion is also very critical for economic growth" (TOI Jan.12, 2012).

The asymmetries obviously point fingers at the mismatch among resource allocation, governance, development, and our claims. All this tells us to live with ground reality and find

measures which can bring real social growth rather than mere growth. The very policies and priorities are questioned and call for a serious review of our priority setting, policies formulation, and implementation mechanisms in real terms. Large projects of the government *viz.* Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), National Food Security Mission (NFSM) and farmers' loan waving are questionable on scale of social growth. In fact, I am reminded of an old Chinese saying: "give a man a fish and you feed him for the day. Teach a man how to fish and you feed him for a life time", similarly giving alms to the poor may feed them for a day, but if you want long-term and sustainable solution to the problem, the only way is to set up agriculture raw material based modern factories/ industries in rural settings. There is no substitute for the kind of low-wage manufacturing jobs that Malaysia and South Korea went through earlier, or that China is going through now.

Despite being one of the world's largest producer of milk, wheat, rice, sugar etc., rising food prices kept millions of Indians chained to poverty said a UN report. By 2020, about 37 percent of population will be in age group of 15-29 years and 29 percent of population in 30-49 years and the largest part with rural background. The challenge is to provide them the education and skill and develop job opportunities especially in rural settings. Development of human capital is one of the most crucial instruments of development and education plays an important role at every stage of development. Attempting to achieve economic development in absence of relevant education, the process is like trying to attain economic development in vacuum.

The Quality of education has (direct) relationship with veritable development. Poor quality education results in poor economic growth, inequality, and poverty. Level of education impacts rural- urban migration and brain drain, family size and fertility, agricultural growth, rural development, and human development. Therefore, education cannot be seen merely as an investment of one kind, but is the core element of all developments. Our leaders have emphasized that change in agriculture should be the highest priority in government policy but the roadmap has not been clearly defined. Given the status and centrality of agriculture, detailed action plan for agricultural transformation must be prepared soonest and implemented judiciously.

In order to deliberate critically on these important issues, the NAAS organized a Brain Storming Session (BSS) on 16.12.2013 under the convenership of Prof Panjab Singh. The Policy Paper is the outcome of this BSS and based on the views and experiences shared by the distinguished participants which is recently updated by the convener.

2. Debatable Issues

- How to achieve comprehensive sustainable agriculture-led growth with social justice and not just growth should be the basis to decide priorities, programs and resource

allocation. When we all say that the return on investment in agricultural R& D is much higher than any other sector then what prevents us investing more in this sector?

- How long the farm sector (farming and farmers) will be neglected and social growth denied? Emphasis on agricultural growth and creation of employment opportunities in rural settings for sustained growth can no longer be ignored.
- How to train and utilize the huge demographic dividend of youth between 15-30 years of age group, which is about 30 percent of our population. Which are the main potential sectors for employment in agriculture and how to assign priorities in resources allocation?
- Production and productivity increases are important but equally or more important is to save produce from different kind of losses. Our plan and strategies to minimize colossal post-harvest and storage losses and our efforts for food processing and value addition for domestic and export needs are yet to get our required attention. Why this neglect and what needs to be done to correct the situation?
- Our policies, plans, strategies, and actions in mitigating degradation of natural resources and adaptation of agriculture to climate change should be explicitly detailed.
- Mismatch between technology generation and technology dissemination for want of institutional architecture and industrial carriers along with needed drivers to take the technology to users are yet to be set in place. This has kept the farm productivity low, which we must not ignore any more.
- How to bring fearless and debureaucratized work environment in science, education and research and ensure efficiency and integrity?
- Agriculture sector is witnessing radical changes and challenges at national and global levels. The demand for agricultural commodities is steeply rising; food preference of next generation consumers are changing and agriculture sector is struggling with decelerating profitability which is dragging its performance. Ensuring household food and nutritional security, bridging urban-rural disparity by increasing farmer's productivity and income, alleviating poverty, minimizing production risk on account of climate change and consequential hazards and ensuring natural resource management and environmental security are the current and emerging challenges before Indian agriculture. Appropriate strategies, policies, institutions and technologies would play a decisive role in facing the challenges.

3. Components of a New Policy Framework

3.1 Production and Protection: Save and Grow

Raising agricultural productivity is a key challenge for ensuring national food security. Exploiting the potential yield gap across ecological zones offers a tremendous opportunity. Future productivity gains will need to rely on: narrowing the gap between average farm yield and the experimental yields potential of the crop (i.e. improving technical efficiency) and reversing the slowdown in spending on research and development to generate new yield enhancing technologies (i.e. technological change). A mission mode program on “bridging the productivity gap” with real missionary zeal and effective monitoring is required to be launched with meticulous planning as a matter of priority. Bringing yet another Green Revolution in eastern India is a welcome step in this direction. This requires development of infrastructure and mechanism to provide effective price support.

There is a need to adopt farming system (system diversification) approach to synergize productivity and profitability, input use efficiency, cropping intensity, resource conservation, employment generation, environmental security, and poverty alleviation. Identification, evaluation and up-scaling of integrated farming systems in different agro- ecological regions is the way forward. Optimal integration of crops, livestock, fishery, forestry etc. is essential for various categories of farmers and farming situation with a viable basket of options.

Targeting rainfed and ecologically marginal areas for dissemination of improved technologies and development of markets would help raise production, increase farm income and reduce regional disparities. These gray areas can soon be made green to harness a second green revolution. Role of technologies, policies and infrastructure would be very important in realising the potential of rainfed agriculture. The Rainfed Area Authority of India is a step forward which needs a proper policy framework, legal and funding supports as well as empowerment for effective coordination and monitoring of all rainfed related programmes run by various ministries/departments in states and central domain.

Mechanization is a potential source of improved labour productivity, higher input use efficiency by timely and precise farm operation. An important area of support for improved access to and use of mechanization in agriculture and allied areas is through leasing market (to reduce lumpiness of machinery investment). Small farm management revolution is an essential component in securing productivity enhancement and household food security.

Over 80 percent of our farms are below one hectare in size, this structure of farm holdings in favour of smaller size calls for a land reforms programme. There has been significant revolutionary development in small farm management in respect of all the subsectors i.e. crop, animal husbandry and fisheries. This process is needed to be encouraged to provide

the power of mass production to this mass of small farmers. Institutional mechanism enabling this process should encompass: a decentralized production for increasing the availability of quality seed, breed, planting material, fingerlings with the required insurance coverage; delivery of improved technology and associated services to farmers; and aggregation of produce to improve market access, which essentially should target 'end to end' approach covering production, processing, marketing etc. A holistic producer oriented approach will make wheel rolling in this perspective. A small farm management revolution will help in achieving the objective of inclusive growth.

Climate change will have far reaching consequences for agriculture that will disproportionately affect the poor. Greater risk of crop failures and livestock death are already imposing economic losses and undermining food security, and they are likely to get far more severe as global warming continues. Future productivity gains will need to offset the productivity loss from climate change and still generate sufficient gains to meet rising food demand - a double challenge. Adaptation to climate change will be critical, but agriculture can also help mitigation. Therefore, investment options for both adaptation and mitigation, and policies which can help in reducing the impact of climate change, are urgently needed. Climate resilient suitable crop varieties, cropping system (including diversification), conservation agriculture, run off and run on-farming, precision agriculture, carbon sequestration are some of the R &D aspects which require greater support, besides incentive to small farmers for the adoption of such technologies and practices. Central government initiative on "climate resilient agriculture" is a step forward in this direction and still greater policy framework is needed in context to farmers participatory research and development, developing early warning systems, weather advisory services etc.

While increased productivity is an essential component of a vibrant agricultural sector, improved post-harvest handling, processing is equally essential to ensure that high quality products reach the markets. Due to lack of impressive post harvest technological perspective, as high as 18-25 percent losses occur in the active food supply chain from production to consumption. At present only about 30 percent of agricultural produce is commercially processed and the net value addition is paltry 10 percent. The present share of processed product in Indian diet is about 15 percent and is likely to rise to 50 percent by 2030 on account of changing demography at workplace and reduced time available for cooking. Technology to integrate agriculture production catchment with processing and marketing is needed so as to reduce post harvest losses, facilitate value addition, product diversification and utilize agro-industries. India's large market with growing income and changing life style also credits incredible market opportunities for food producers, food processors, equipment makers, food technologist and service providers in this sector.

A three pronged strategy is needed to reduce post-harvest losses- (i) compress supply chain by linking producers and market, (ii) promote processing of food commodities in production catchments to add value before being marketed, and (iii) develop small scale processing units and cold storages using conventional and non-conventional sources. This would require multidisciplinary and multi-stakeholder research for agro-commodities and also investment priorities.

3.2 Investment and subsidies

In recent years, the share of gross capital formation of agriculture and allied sectors in total GCF has hovered between 6 to 8 percent whereas it was around 18 percent during the early 1980s. This indicates that the non-agriculture sectors are receiving higher investment as compared to agriculture and allied sectors over the Plan periods resulting in growth disparities. Keeping in view the pressure of high population dependency on agriculture for their sustenance and also that the sector is a potential employer of rural youth in their settings, the need for substantial increase in investment in agriculture cannot be postponed any longer.

Another aspect, which impacts agricultural development, relates to subsidies. The biggest of all the input subsidies is fertilizer subsidy which has led to an imbalanced use of N, P & K leading to deterioration in quality of land impacting total factor productivity (TFP). The expenditure on subsidies crowds out public investment in agriculture research, irrigation, rural roads and power and subsequently deteriorating quality of public services. Research studies also show that the marginal returns evident in terms of poverty alleviation or accelerating agriculture growth are much lower from input subsidies than from investments in rural roads or agri R & D or irrigation. There is always a trade-off between allocating money through subsidies or by increasing investments.

Public investment in agriculture decreased from 5 percent of Ag GDP in 1980/81 to 3 percent in 2006 to 2007. This has slightly improved now, but needs greater push. In early 1980s, the share of the public sector and private sector in gross capital formation in agriculture was roughly equal but by 2005 the share of private sector was four times larger than the share of public sector. Moreover, the private sector responds much better and faster to the incentive sector in agriculture. Hence along with bringing in greater public investment in agriculture there is need for bringing in reforms in incentive structures.

Irrigation remains the most dominant component in the overall investment in agriculture as more than 80% is allocated for major and medium irrigation schemes. Even in the case of private investment in agriculture, almost half is accounted for by irrigation (minor, primarily though ground water, but also increasingly drip etc.). Despite this, efficiency of investment has been far from satisfactory and calls for reorientation in allocation which can help improve quality and efficiency of the investment.

While the overall credit to agriculture has been growing phenomenally during the last five years or so, and the interest rates for farmers have also been reduced, the biggest challenge remains in terms of increasing access to credit, particularly for the bottom 45 %. More innovative models are needed to reach this category as they rely largely on informal sector for credit with a high rate of interests.

The significance of agriculture sector in India is not restricted to its contribution to GDP, but its complementarities with other sectors as well. It has far reaching ability to impact poverty alleviation and rural employment. Among others, areas of importance for agriculture growth include investment in education, research, effective transfer of technology along with institutional reforms in the research setup to make it more accountable and geared towards delivery; conservation and enhancement of natural resource base (land, water and biological resource), development of rainfed agriculture, minor irrigation, timely and adequate availability of inputs, support for marketing infrastructure, an increase in flow of credit particularly to the small and marginal farmers. These need to be addressed through the formulation and implementation of suitable policy options.

The transition from traditional to high-value agriculture will be primarily driven by private investment, which is three-fourths of total investment in agriculture. However, to ensure that this happens smoothly and rapidly, government policy needs to act as a catalyst by way of providing greater investment in R&D, roads, public irrigation etc. A strategic vision must factor in three important elements; India's comparative advantage (demographic dividend); efficient market at home and free trade; and environmental sustainability.

3.3 Natural Resources

Future agricultural production program will have to be based on a strategy which leads to increased production without associated ecological and social harms. This will call for conservation and enhancement of ecological foundation essential for agriculture growth through an integrated package of government regulation, education and social mobilization (through panchayat and local bodies).

Land inventories on soil characteristics, climate and hydrological data, vegetation cover, land capability / suitability and land irrigability need to be prepared and updated regularly for relevant reform measures from time to time. Such a planning should also attempt to solve general problem of under development and arrest area specific non-sustainable trends and patterns of under development. Land reforms, land administration and land acquisition should become more responsive to land quality to promote integrated management, planning, implementation and monitoring. Thus, the Land reforms policy needs to be revisited to address issues like land tenure, land records etc.

Since land holding size is declining and fragmenting owing to laws of inheritance, a provision for contract farming may be included in the policy document. Similarly, mechanism of regulating special economic zones (SEZs) should be developed to prevent any adverse impacts on prime agricultural lands. Land management policies should also aim at determining an economically viable size of land holding in different agro-ecological zones to meet the basic needs of an average family. Appropriate biological measures need to be included as an integral component of land development. Soil use policy framework is also required for sustainable use of soil resources. Subsidizing soil testing fee, soil health card, rapid soil testing kit, remote sensing and geographical information based decision support are ways to faster program on assessment, mapping and monitoring land use performance under given ecological conditions.

Long term sustainability of water resources and its ability to sustain future food and water requirements is of great concern. High inefficiencies in water delivery, distribution and nonfarm use are adversely affecting agricultural production besides impacting land, soil and water quality base of agriculture. Rain water management is crucial to economic efficiencies of all kinds of water bodies. Water use also needs to be improved in rainfed agriculture which accounts for about 42 percent of agricultural production. Efforts are needed to enhance policy, technical, governance, regulation aspects of sustainable water management and use through incorporation of broader river basin management, enhanced water use efficiency, local water user associations and improved use of shared water use efficiency.

3.4 Linking farmers to markets and strengthening value chain

Orientation of agricultural development should shift from increasing production to raising farm income. This is important to check the widening rural-urban disparity and to diversify rural livelihood options covering crop, livestock, fisheries and horticulture activities. Hence, linking farmers to market must receive priority in future policy formulation. In market driven economic scenario, changes in demand pattern, institutions and policies will be as important source of growth as technological change. New knowledge and emerging demand pattern will create better opportunities and incentive to agricultural activities (resource, service, production, processing, distribution etc.) in an effective manner, beside such a venture will also facilitate bridging gap between technology leading to production and that of post harvest processing, value addition and product diversification. Review of ongoing micro-financial reforms including price structure, scaling relevant agribusiness models for market integration, safety nets, market information network and market intelligence, expansion of infrastructure (road, electrification, primary processing centres, godowns etc.), strengthening produce organizations, self help groups and access to finance are some of the important aspects in this regard.

A new orientation needs to be given to the schemes meant for the betterment of farmers. The policy initiative in future should help develop the skills and knowledge of resource poor farmers, increase their income levels and help empower them to enhance their role in social, economic and political systems. In future, new initiatives for economic development and social empowerment should include farm labours, beside the farmers.

3.5 Institutions

Growing small holdings, decelerating farm profitability, rising demand of agricultural commodities, increasing uncertainties, unfolding globalization and emerging private sector in agriculture research and agribusiness call for designing policies, developing institutional mechanism, evolving decision making process, mobilising political support, and improving governance of service providers in the value chain. Emergence of the intellectual property rights also needs to be converted into an opportunity. Policy formulation, implementation mechanism and ground level action must be given equal emphasis for successful interventions. Any policy and institutional change should be transformational in nature rather than touching upon peripheral issues. A systematic approach is needed to evolve long term development strategies to overcome problems/constraints faced by farmer and to that extent, policy implementation be placed to resolve the problems. Institutional mechanism should entail the study of impacts of policies and programs.

One of the important implications from present agriculture scenario is growing inter dependence among agriculture, social, and economic development. Rapid developments in Indian economy will influence the nature of changes in agriculture, the actors in development being, sources of knowledge, institutions and even scale of operation. Stagnant agriculture with a high growth in non-agriculture sector may not be sustainable because of deteriorating investment climate due to social unrest on account of rising unemployment and economic inequality and lack of market demand. Therefore, agriculture sector must contribute substantially to the overall economic growth. This could be possible through: persistent growth in agricultural productivity; enhanced farm income through production, diversification, value addition and better market access; sharing employment opportunities from agricultural to other sectors of economy, including rural non- farm sector; reducing risk and vulnerability; enhancing environmental services and sustainability (conserving our natural resources –land, water, biodiversity, non-renewable energy & environmental need).

Changes in demand pattern, institutions and policies will be as important source of growth as technical change in a market driven economic scenario. New knowledge and emerging demand pattern will create better opportunities and incentives to organize agricultural activities in an efficient manner. These process changes or innovations will take place across all types of institutions, including economic, social, political, legal etc. and will add value to

existing practices and improve their outcome. The capacity to generate, integrate and apply new knowledge will be critical to the innovation process. Hard core infrastructure, facilitating regulation and other domains like information services, credit and rural institution services, social (i.e. gender) group etc. will also influence the innovation process.

Every calamity presents also an opportunity for new innovations. An innovative small farmers self help groups based agriculture is the answer to threat to reduced crop yield and uncertain food security arising from adverse change in climate. Access to essential services is critical to enhance productivity and profitability. A person is poor because his endowments of capital, land, labour and skill are meagre, also because his access to public goods, services, and natural resource is limited. Often, a poor person is trapped in the prison of illiteracy. In case of female, disease and ill health prevents her from getting the most out of the one asset she has, her labour. Without training and skill, she cannot aspire to do a better job. Without an all-weather road, that connects her habitation to the nearest market, she cannot get a fair price for her produce. Without electricity and access to credit, her ability to enhance productivity of land or of artesian activity is limited. So is the case with drainage, water supply, protection of life and property without which she cannot function effectively. Thus access to basic facilities such as health, education, clean drinking water etc. impact directly on welfare, in the longer run, it determines economic opportunities for the future. Without access to these services one cannot be considered to have equality of opportunity. Since access to these services for majority of population, particularly rural poor, depends not only upon their income levels but upon the delivery of these services through public funded system. Therefore, futuristic strategies and policy regulations must address in commensuration with expansion in supply of these services through joint centre-state interventions.

Strategy for Transformation of Indian Agriculture for Doubling Farm Income and Improving Farmers Welfare*

National Academy of Agricultural Sciences, New Delhi

Introduction

Transformation of agriculture entails structural changes in the growth pattern, production mix, inputs use and institutions serving the sector. The share of agriculture in national gross domestic product and labour force employed in agriculture declines and the production systems become more knowledge and technology intensive, with greater use of modern inputs. Within agriculture sector, share of high value and processed product increases and the system serving agriculture (markets and public services) are also replaced with well-organized, professional entities with greater participation of private sector. This transformation is a continuous process and Indian agriculture has come from a stage of subsistence to transition to a commercial agriculture, which began with the Green Revolution and subsequently reinforced by advancements in other sectors like livestock, horticulture, fisheries, etc. Indian agriculture now needs to reach where the North American and European agriculture is today in terms of technology penetration, production structure and market orientation. This is in consistent with global development processes but challenges and transformation pathways may vary (World Bank, 2008). This transformation has to be completed within a short period of time, a timeframe much shorter than what developed countries have taken to transform their agriculture. The event like deficit monsoon during the last two years slows down agricultural growth process, which needs to be accelerated for sustainable and inclusive

*Acknowledge National Academy of Agricultural Sciences, New Delhi

development. Also, the focus should shift to doubling farm income during the next five years and include small farmers and other rural workers in the growth process. This target will require increasing crop productivity, savings on costs and a shift towards high income generating activities like dairy, floriculture, special products like organic food etc. Addressing binding production constraints to higher yields, value addition through processing and realization of economies of scale are other options. How can these changes be achieved? Even if farm income is doubled, will it be adequate to sustain farm family and attract youth to agriculture. The brainstorming session organized by the Academy discussed these issues and this paper summarises the main conclusions, which emerged during the discussion.

Pattern of Agricultural Growth

The major growth trends analysed since 1970s indicate that Indian agriculture grew close to 4 percent per annum during the last decade or so. This growth rate was much above the growth achieved during the green revolution (2.6 percent) and during the post-green revolution, *i.e.* late eighties and the nineties (2.8 percent, Fig 1). In 2013-14, the country had the highest ever food grain production (265 million tonnes). Most of this growth came from the states where productivity was low. As a result, there is greater convergence in agricultural (land) productivity (Balaji and Pal, 2014). As seen subsequently, much of the higher growth could be attributed to higher public investment in agriculture, better price incentive and improved delivery of agricultural inputs. All signs indicate that this growth trend will continue in future also.

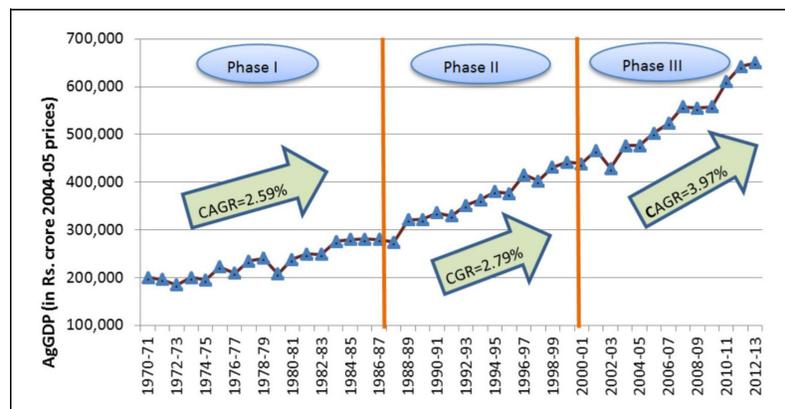


Fig 1: Growth trends in Indian agriculture

Another major characteristic of agricultural growth is that this was largely driven by livestock and horticulture sectors. Both these sectors now contribute more than half of agricultural gross domestic product (AgGDP). Both the sectors are dominant in arid and semi-arid regions and, therefore, growth in these sectors has contributed to regional

convergence. It may be noted here that because of urbanization and income growth, demand for horticultural and livestock products have risen, which has provided better incentive to farmers to respond to the demand growth. Of course, technology, inputs and institutional developments have provided opportunity to the farmers to enhance their productivity and link their produce with markets. As a result, there is acceleration of growth in the total factor productivity of crop and livestock sectors (World Bank, 2014).

The present growth trends are likely to continue in future but there are other concerns which need to be addressed. The first concern is about sustaining productivity growth of small holders, which often lack resources and future agriculture is going to be capital intensive. The East Asian experience has shown that high productivity growth can be achieved on small farms, provided there are adequate investments in infrastructure and technology. But whether higher productivity growth would translate into an income level adequate to sustain a farm household? Therefore, improved resource use efficiency, higher productivity and transfer of labour force to other sectors are important for increasing rural income and thereby reducing rural-urban income disparity. This transformation process needs to be stepped up. The strategy for agriculture transformation should entail proactive policy, technology and institutional support, and investment in development of farmers' knowledge and skills. The following could be major areas of interventions.

Productive Capacity

First and foremost requirement for increasing the productivity is investment in agriculture and priority areas are irrigation, rural infrastructure, research and development (R&D) and agro-processing. There was significant increase in public investment for irrigation and other rural infrastructure since the mid-2000s, but it slowed down in the recent years (Fig 2). As a result, the share of public investment in the total public expenditure on agriculture reduced to 20 percent, a level that was in 1990s when the public investment growth was low. This trend should be corrected and growth in the public investment for agriculture must be sustained. However, a positive aspect of public investment is that its allocation across the regions has been quite equitable and the states with low productivity received adequate resources as per their area share and economic contributions. The private investment in agriculture is rising but farm household investment may not be sustained because of decline in share of term loan in total lending to agriculture. This trend must be arrested. Also, the sectoral priorities need to be translated into regional priorities. The experience of attracting corporate investment in other sectors can also be useful. Business sector investment in agro-processing and development of market infrastructure will be helpful in increasing farm income.

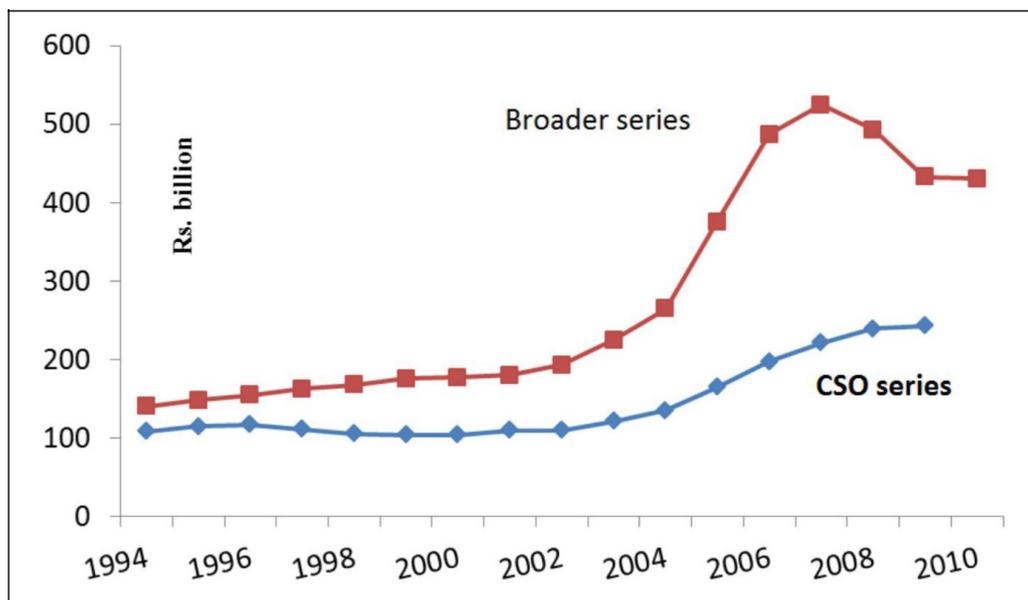


Fig 2: Trends in real public investment in agriculture (in Rs. Billion)

Source: Division of Agricultural Economics, IARI

The second important aspect of sustaining productivity capacity has been investment and policies for sustainable use of natural resources, particularly irrigation water. With the increase in benefits of irrigation, competition and use of irrigation water, particularly groundwater, is increasing, which has led to higher cost of extraction and unsustainable use of groundwater. Therefore, with the scarcity of water resources cooperation among water users, *i.e.* farmers for its sustainable use should be encouraged. This may involve use of technology increasing water-use efficiency like micro-irrigation and providing incentive like subsidy on water saving practices and technology. As regards surface irrigation, water harvesting in low to medium rainfall areas, water transfers and improved irrigation method should be encouraged. Surface water management assumes greater importance in the context of climate change and, therefore, its management should be given high priority. Inter-year and inter-season regulation of river flow, inter river basin water transfers and improved management of water distribution infrastructure (canals and minors) are also equally important to improve water use efficiency in irrigation. Since water harvesting and use require interventions by all the farmers in the target or command areas, participation of farmers in maintenance of water structures and sharing of irrigation water are helpful in sustainable management of water resources. It is found that degree of participation and cooperation of farmers increases in water scarce areas (Joshi *et al.*, 2003). The participation is also effective when size of the farmers group is

manageable and homogenous, and there are democratic traditions to manage the farmer user associations (Gandhi, 2011).

IPCC (2014) has brought out likely impacts of climate change on ecosystems and agricultural productivity, which are enormous if suitable corrective measures are not taken by the global community and the impact would be far more serious in tropical regions. The Academy has discussed at length this concern (NAAS, 2013) and made suitable recommendations. But this concern goes beyond economic impacts and impacts on poverty reduction and income inequality could be equally challenging. Therefore, there should be incentives and institutions to influence peoples' actions to follow the practices, which build resilience and promote climate smart agriculture. The incentives should encourage conservation agriculture, promote water and energy use efficiency, carbon sequestration and improve flow of ecosystem services like contribution to ecological foundations, green-house gas reductions, etc. The mechanism of carbon trading has not picked up to the desired level and this mechanism along with direct transfer of benefits to farmers should be explored.

Institutional Change

There is a major shift towards commercialization of agriculture and now 60-90% produce is sold in the market. There are institutional changes in both input and product markets. The size of operation is increasing and there is greater participation of multinational companies, especially in provision of inputs and agro-processing. This trend will continue in future also, but can these innovations ensure inclusiveness of small farmers? Another important dimension is attracting participation of organised private sector in agricultural markets and regulating private organizations in a cost-effective way (World Bank, 2014). These regulations should facilitate markets, reduce cost of compliance and protect interest of small farmers.

Inputs use

There are some major changes in inputs markets for agriculture. First major change is rising share of purchased inputs in the cost of cultivation. In particular, there is tremendous growth in the use of quality seed since the mid-2000s. There is also significant growth in use of chemical fertilizers per hectare as it has risen more than 50 percent since 2001, except last two years when it was either stagnant or declined, which is a temporary phenomenon. Seed, fertilizers, pesticides, electricity, farm machinery, etc. now form larger share of the total cost. Secondly, most of these inputs are supplied by private agencies and also embodied improved technology, and, therefore, share of these inputs in the total cost is rising fast. Thirdly, production of these modern inputs like fertilizers, pesticides, farm machinery, etc requires higher use of commercial energy. This coupled with increasing use of electricity and diesel for irrigation and post-harvest operations increase the share of energy-based inputs and

consequently energy-use intensity of agriculture is rising rapidly. As seen from Fig 3, use of commercial energy has risen very fast during the last decade or so and agricultural output-energy ratio has shown a steady decline since the green revolution period. It is estimated that energy requirement will double within next decade or so, and this will rise very fast if the low productivity states “catch up” with the states like Punjab, and there is faster growth of agro-processing sector (Jha *et al.*, 2012). The rise in energy demand is faster because of farm mechanization and given rising trend in agricultural wages and higher share of wages in the total cost, pressure for farm mechanization will be greater, requiring more commercial energy. Thus, use of inputs and their delivery are going to transform rapidly with advancement in technology and commercialization of agriculture.

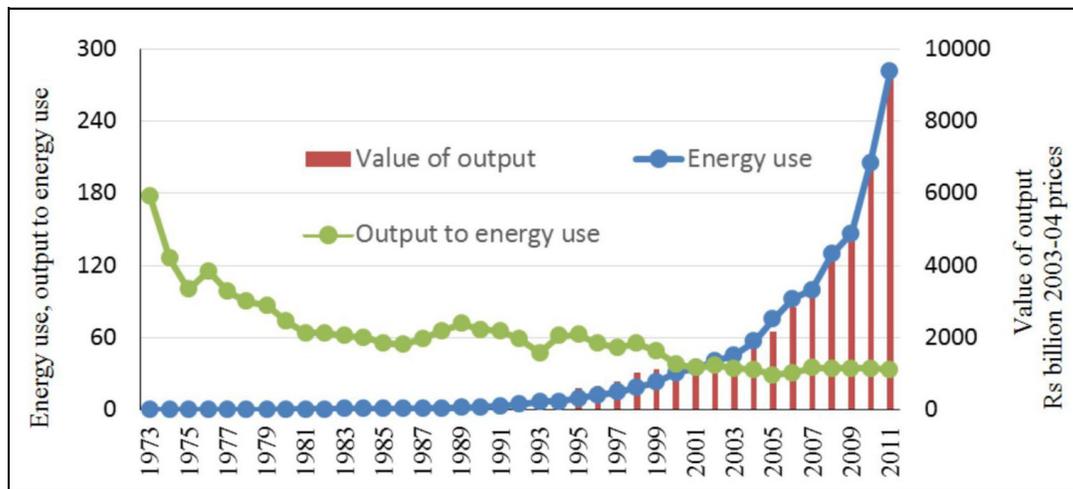
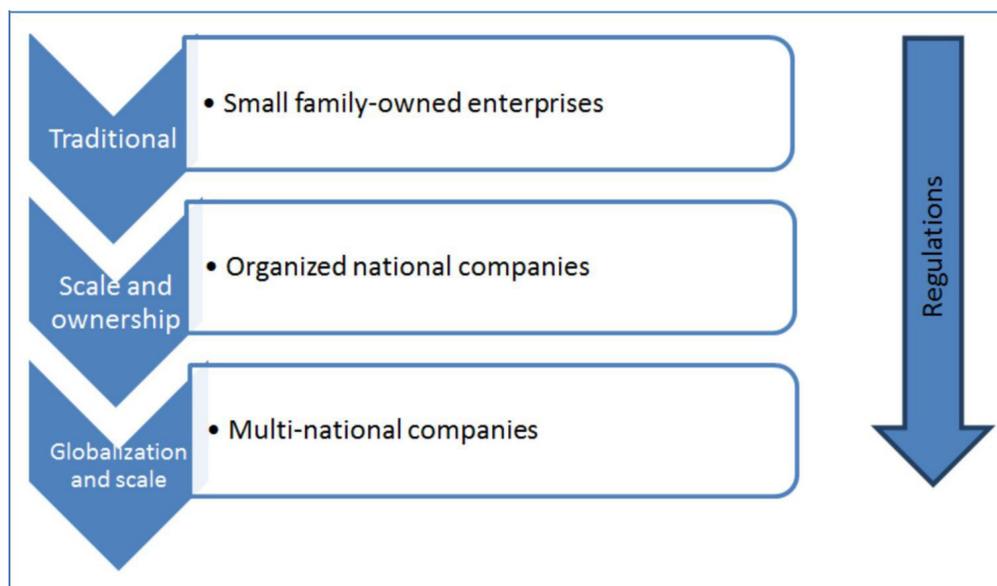


Fig 3: Structural change in use of inputs and energy

Source: Jha *et al* (2012)

The role of private sector will rise in delivery of agricultural inputs and services and marketing of produce. Consequently, input markets will be more organized and diversified with continuing role of public sector in some of the areas. This process of diversification and transformation to more organized markets will be seen with some marked differences (see the box). Firstly, there shall be increase in size of operation along with shift in ownership of private agencies serving agriculture. As the participation of larger companies including multinational companies increases, there shall be larger scale of operation and globalization of their business. This will be a greater departure from small scale business to multinational companies. Also, in order to govern these companies and inputs and services they supply, more formal (legal) regulations shall be required. These regulations shall be related to ease of entry and exit barriers, protection of trade interest, intellectual property rights, dispute

settlement, competition laws, quality assurance, consumer protection and many more (Pal *et al.*, 2016). Therefore, enactment of these regulations and their enforcement will be critical for market transformation process.



Box 1: Transformation of agri-input and service sectors

Linking farmers with markets

Agricultural marketing is primarily regulated by the APMC Act which prohibits purchase of farm produce outside the regulated markets. However, a model act is proposed to liberalize this, which allows products like fruits and vegetables to be transacted outside the regulated market. The market reforms are also directed to attract private investment in market infrastructure and enhance value creation, so that there is greater competition facilitating improved marketing efficiency and price discovery. The progress in terms of market reforms is, however, mixed across the states and the same holds true for their impacts (Niti Aayog, 2015). In successful examples of market reforms, supply chains are getting shorter by the elimination of those intermediaries, which do not add any value. These institutional innovations reduce the marketing cost, link production with consumption and improve the overall efficiency. In the process, as noted above inefficient value chains and institutions are replaced by the better ones. Most of these innovations have been for fruits, vegetables and livestock products, which are largely handled by private sector. For institutional viability of these innovative business models three things are important: (a) farmers' access to information on prices, etc, (b) the model with adequate institutional and technological support, and (c) preferably, desirability of having farmers as partners in the value chains for increasing their

share in value distribution. One of the important concerns is to serve smallholders who now occupy more than 44 percent of agricultural lands. There are a few examples which suggest the possibility of inclusion of smallholders. These are mostly high value products where size of operation is rather small, but amount of turnover is high. Notable examples are high value vegetables, floriculture, poultry and milk. However, capital requirement, technology and access to public services like extension are needed for inclusion of small farmers in value chains. In addition, small marketable surplus, limited access to markets due to remoteness and limited information restricts smallholders' participation in modern value chains (Reardon *et al.*, 2009; NAAS, 2015). There are efforts to promote farmers organizations, which are very thin and likely to be more successful in high value, commercial products, and products with high price volatility. Therefore, institutional support required for linking farmers with markets is critical. In fact, small farmers will have limited access to the markets of field crops like paddy, wheat, cotton, pulses and oilseeds because of size of their marketable surplus and local traders shall continue to play role of aggregator, albeit comparative lower prices realized by farmers. This is more visible for paddy in eastern India where prices realized by farmers are much lower than the minimum support prices (Fig. 4).

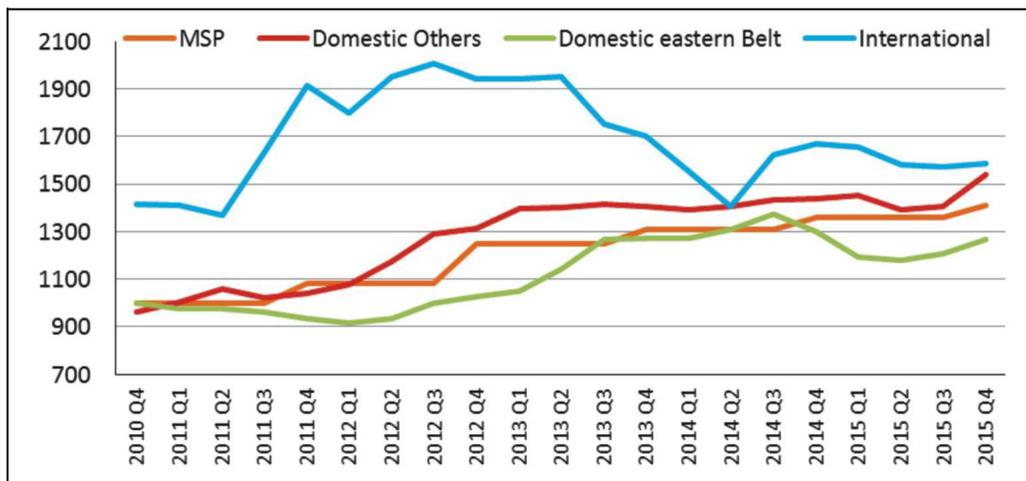


Fig 4: Trends in MSP and market prices of paddy (in Rs per quintal), source: CACP

There are some successful examples of contract farming where farmers are contracted by a processing industry for supply of products of a particular quality. Also in such cases, supply of products is in short of their demand. The models are quite successful but transaction cost of dealing with small farmers is high. Some local arrangements like appointing farmer supervisors, etc., and better control of small farmers on product quality can address this constraint to some extent. Contract farming is successful because of incentives to farmers in terms of better price, better access to inputs and advisory services (Joshi *et al.*, 2007), but

it needs legal protection or a mechanism for dispute resolution when industry defaults procurement. Despite success of contract farming in different regions, its large scale application is limited, which is possible when the business model meets the requirements amenable to scaling up, financial sustainability and better economic efficiency.

Technology

Technology will continue to be a dominant driver of agricultural growth and, therefore, it must be paid due attention. There are four issues which need attention for bringing a transformative change in production systems. These are: (a) application of existing stock of knowledge to harness productivity potential, (b) access to proprietary technology, (c) farm mechanization for higher input use efficiency, and (d) technology for agro-processing. There are some technologies, especially related with resource and crop management, which have not reached farmers. These need focus on adaptive research and transfer of technology in partnership with the state line departments. On the other hand, there are technology gaps relating to stress tolerance varieties of pulses and oilseeds, farm mechanization, etc. How these gaps will be addressed in the emerging innovation systems is a matter of applied research and technology transfer in partnership with state agencies and private sector. There is also a need to prioritize crops which are likely to experience a technical change similar to that observed in maize (single cross hybrid), cotton (Bt for bollworm resistance) and hybrids in vegetables and flowers and implementation of programs in 'mission mode.' Along with such technological innovations, last mile delivery of technology, skill development and information flow to farmers should be strengthened.

One of the important policy instruments in India has been sustained public funding for agricultural R&D. As a result, an uptrend in the funding has been seen since 1960s, but a sharp trend is visible after the late 1990s, attaining an expenditure intensity ratio of 0.52 percent of agricultural gross domestic product in 2011 (Pal *et al.*, 2012). Earlier most of the funding was used for the public institutions, but subsequently funding reforms were directed to attract a broad range of actors, including private sector for a diversified research system. Besides infrastructure and basic research support, incentive in the form of protection of intellectual property has become more important for attracting private sector in R&D. Therefore, effectiveness of new IPRs regime on technology development, spillovers, and partnerships are becoming increasingly important. A suitable strategy to use IPRs to evolve a diversified innovation system and to realize their potential of IPRs to access improved technology should be followed. The evidence available so far about impact of strengthened IPRs regime in India show that there is no major shift in research priorities of public and private sectors, but organizations from both the sectors are participating in protection of their intellectual property like plant varieties (Venkatesh and Pal, 2013). Patenting activity

has also geared up in India and an increasing proportion of patent applications are filed by foreign private companies, especially in chemical technology. There is increase in technology spillovers through patents in the area of pesticides, vaccines and tissue culture. All these developments indicate greater access of farmers to improved technology, albeit at a higher cost (Kandpal *et al.*, 2015). Cost-effectiveness of R&D regulations, including those of biotechnology shall, therefore, affect participation of private sector. This is more visible from a concern relating to regulation of licensing of proprietary technology which has come up recently, and this concern should be addressed without compromising interest of farmers.

As regards transfer of technology, greater concern should be diversity of institutions and partnerships in delivery of extension services. Private sector will now be an important player and delivery of proprietary technology, usually embedded with farm inputs (*e.g.* seeds and chemicals) and machinery, shall be effective as the private sector has incentive to promote commercialization of these technologies. Similar technology from public sector can also be disseminated to farmers in partnership with private sector or public extension system. But transfer of resource conservation, crop management and other sustainability promoting technology shall be a challenge. New initiatives like establishment of Agricultural Technology Management Agency and increase in number of *Krishi Vigyan Kendras* are welcome steps, but these agencies have to work more closely with the state line departments, who are responsible for implementation of agricultural development programs. These institutional innovations should be backed with more investment in extension, manpower training and increasing information flow to farmers.

Farm mechanization is another method to promote resource use efficiency and reduce cost in view of rising farm wages. There are states like Punjab which have significantly mechanized agricultural operations. This began with investment in tube-well irrigation for higher productivity and use of tractor for farm operations. Now combine harvesters and threshing machines are becoming common in these areas. Some farmers are also investing in the equipment like laser land leveller, indicating an increasing trend towards farm mechanization. As a result, machine charges as shown by the cost of cultivation data, which were less than 4 per cent of the operational cost in 1970-71, rose tremendously to 24 per cent in 2009-10 in the case of wheat. In Tamil Nadu, the share of machine labour in the cost of rice cultivation has risen to 11 per cent during 2000s as compared to only 2 per cent in 1980s. Moreover, farmers even in the poorer states depend more on farm machines. There are several farm operations like cotton picking and rice transplanting, which can be done mechanically. The demand for farm mechanization will increase with the shortage of labour and rising agricultural wages, but concerted efforts shall be needed to develop and popularize farm machines for small farmers. Several of these machines are already in use in other countries and these will find their way in India as the presence of private sector increases.

Access of small farmers to these machines can be facilitated by custom hiring of these machines. However, financing of long-term loan for purchase of these machines must be scaled up. Also, there shall be greater pressure on improving availability of energy, mainly diesel and electricity, to utilize them optimally.

Increasing focus on farm mechanization will change the structure of energy consumption in Indian agriculture. There is already a huge shift from animal and human labour towards tractor for different farming operations and electricity and diesel for irrigation. The share of these energy inputs in agriculture has undergone a drastic change. Energy consumption per hectare of net as well as gross cropped area has increased over time and therefore, as seen above, output per unit of energy use has declined (Fig. 3). This shows that Indian agriculture has become more energy-intensive and this trend will continue in future also. It is likely that demand for commercial energy for agricultural purpose will almost double in the next decade or so (Jha *et al.*, 2012).

Development of agro-processing sector needs lot of investment from business sector, availability of required infrastructure like road and electricity and technology suitable for Indian raw material. The Government has improved foreign direct investment in this sector, but the progress is rather limited. There are some successful examples like potato, tomato and mango where processing and entire value chain has gone significant transformation. This success should be replicated to other products to create value and reduce losses, particularly in fruits and vegetables. The progress to some extent is constrained by delay in implementation of APMC reforms by the states, allowing private sector to buy directly from farmers. Promotion of organized food retail chains will further increase demand for processed products and thereby promote food-processing.

Livestock and fisheries

Issues discussed above are also relevant for livestock and fisheries, but these sectors also have some specific needs. First and foremost is that the growth should be driven by innovation and technology to enhance productivity per animal unit rather than population growth of animals. In livestock, about 70 percent of cattle and 82 percent buffaloes are non-descript (NAAS, 2016). Therefore, conservation of germplasm and promotion of pure breeds should get high priority. This should be followed by maintenance of pure breeds on livestock farms, and indiscriminate cross-breeding of cattle should be checked. Achieving higher coverage and success rate of conception in Artificial Insemination (AI), reduction in puberty age in dairy animals, namely, cattle and buffalo, and greater focus on nutrition, bio-security and health management can significantly increase the productivity of animals. Participation of private sector in the delivery of reproductive and other technologies, and inputs can accelerate the

rate of growth and transformation in livestock sector. Another important area where private sector can take lead is modernization of milk, egg, fish and meat value chains. Presently, most of these products are in unorganized sector, and the situation demands that this pattern should reverse by 2030 when 75 percent of this should be in the organized sector. This transformation should be facilitated by availability of capital, processing technology and entrepreneurship, and, therefore, there is role for R&D, and financial and private institutions. For providing health and AI services and increasing productivity of milch animals, infrastructure, manpower and resources at the district and block level should be strengthened, and there could be need-based outsourcing of some of the services to private sector. In fisheries, freshwater aquaculture is one of the fastest growing sub-sectors of agriculture registering a 5.1% rate of growth per annum in last 60 years. In order to maintain its sustainability we need to ensure availability of quality seed in desired quantity that is the precursor for accelerated growth. Adding value to surplus fish production can be thrust area for micro and macro enterprises in aquaculture industry. The challenges in years ahead will be to harness the appropriate marketing channels and mapping links in chain. We need to fine tune existing policies and support leasing out of various types of water bodies for fish farming, allocation of water for aquaculture and streamlining the technology delivery mechanism. Thus fishery sector has great potential to contribute significantly to farmer's income, improve his welfare and promote fish-based entrepreneurship in value addition, processing and modern marketing as well. Therefore, transformation of dairy, fish and poultry sector shall provide nutritional security, increase farm income and help to reduce poverty significantly, as a large proportion of livestock population is owned by small farmers and landless labourers. Similarly these small holder farmers can, in an integrated model, produce fish from small size ponds in their farm that are created as water holding structures to irrigate their crops.

Farm and non-farm linkages

Transformation of agriculture would certainly increase productivity and farm income, but this income will not be adequate to reduce urban-rural disparity and sustain a farm household. Farm income and wage earning of agricultural workers have grown but these could not keep pace with the growth in income of non-agriculture workers (Chand and Saxena, 2015). Recent NSSO survey (70th round) indicates that average annual income of farm household was Rs.77,112 in 2012-13 and only 60 percent of this income was from agriculture and rest from non-agricultural wages or business (NSSO, 2014). Therefore, transfer of workers to non-agricultural sector and promotion of other sources of income should be promoted in rural areas. Some of these rural non-farm activities may be driven by agricultural development. As seen from Table 1, this process of transfer of workers from agriculture to non-agriculture sector has begun but this is more for agricultural labour and the notable

states are Gujarat, Maharashtra, Karnataka and Tamil Nadu. The number of workers self-employed in agriculture has decreased largely in Haryana, Jharkhand, and Kerala. Most of these workers are engaged as wage earners in non-agricultural sector and their share in work force has increased from 28 percent in 2004-05 to 36 percent in 2009-10 in the country. Thus, there is casualization of workers in the country and greater focus on development of skill and entrepreneurship among rural youth will help in promotion of self or regular employment and thereby providing a decent-level of income to rural households. The benefits provided under “Skill India” along with access to financial institutions under different government schemes should be used.

Table 1: Work force employment pattern (%)

State	Self-employed in non-agriculture sector		Agricultural labour		Self-employed in agriculture		Others	
	2004-05	2009-10	2004-05	2009-10	2004-05	2009-10	2004-05	2009-10
Andhra Pradesh	27	29	24	19	24	21	25	32
Gujarat	22	23	21	14	30	30	28	33
Haryana	20	18	10	8	42	33	28	41
Jharkhand	23	27	7	3	41	28	28	35
Karnataka	26	28	23	17	30	26	21	34
Kerala	18	20	15	10	24	16	43	54
Madhya Pradesh	19	20	18	16	42	38	21	26
Maharashtra	22	24	23	15	28	27	27	33
Punjab	18	17	16	12	34	31	31	41
Tamil Nadu	19	18	26	20	19	17	27	45
All India	22	24	15	11	35	28	28	36

Source: Based on NSSO data

Policy Imperatives

The foregoing discussion underscores the need for acceleration of transformation of Indian agriculture, involving structural changes in the production, inputs use, markets and employment. This process shall be facilitated by institutional innovations in delivery of inputs and services, marketing of produce, and value chain development. These innovations coupled with technological innovations for better resource use efficiency, climate-smart farm practices and quality assurance shall transform agricultural production systems into more efficient, sustainable and income generating systems. These innovations shall however be

encouraged by availability of necessary infrastructure, incentives to the innovators and access to improved technology and capital. Therefore, public investment, price support, trade and credit policy shall have major impact on the innovation capacity and increasing agricultural productivity. It is likely that present policy of low input and low output prices will continue because of food security reasons, and there will be increasing focus on increasing availability of institutional credit, which should provide some resources for investment in agriculture, but public investment should also be enhanced. Agricultural exports though important for higher farm income, support for infrastructure and capacity to comply with SPS requirement should be in place, particularly for products like fruits, milk and milk products, meat and meat products, fish and fish products. Foreign direct investment (FDI) in agro-processing and organized retail is important policy instrument and recently the government has liberalized this sector, allowing 100 percent FDI. This policy shift should accelerate development of agro-processing sector, promote innovations and value creation along the supply chains. Finally, one can't rule out the need for strengthening of institutions at village and community level to improve delivery of services, increase economy of scale, better targeting of development programs, and promote entrepreneurship. The government should invest in these institutions, along with capacity building of farmers, rural youth and women, which are necessary to bring structural changes in rural employment and income patterns. The economy of scale in the production and marketing can also be enhanced by legalizing tenancy and, therefore, reforms in this area should be stepped up and larger responsibility for this and other market reforms rests with the state governments.

Farmers welfare

Low farm income, decreasing land-man ratio and high risk will make farmers vulnerable to various shocks. This coupled with eroding village social safety nets like joint holdings, shrinking common property resources, and individualistic approach shall make farmers more vulnerable. Therefore, there will be need for government programs to improve farmers welfare. The need for focusing on farmers welfare has also been emphasized by the National Commission on Farmers (2004). Initiative of the Union Government to double farm income by 2022 and covering most of the farmers under Pradhan Mantri Fasal Bima Yojana are welcome steps to ensure higher and stable income. In addition, strengthening of farm services, health and other family welfare programs shall provide much needed support to enhance capacity of rural workers and farmers for income generation. In this context, farm women and agricultural labour will need special interventions. Also, opportunities to augment farm household income like non-farm employment, security of land, and responsiveness of local institutions will be needed. Individualistic approach in use of natural resources is likely to increase rural conflicts, especially in hilly and rainfed areas, and the local institutions should have capacity for resolution of these conflicts. One can also consider the role corporate sector

can play in using the resources earmarked for corporate social responsibility for farmers' welfare. Finally, farmers often face problem with regard to quality of services and inputs and therefore making the consumer protection mechanism effective shall help farmers in overcoming several production constraints and reducing income losses.

Recommendations

1. There is a need for doubling public investment in agriculture for infrastructure development and the priority areas are irrigation, R&D and markets. A significant proportion of these resources must come from the states.
2. In order to facilitate institutional innovations, regulations governing agricultural sector should be revisited and corrective measures should be undertaken to liberalize the sector. A notable example is speedy implementation of model APMC Act in different states.
3. It is important that private sector shall be an important ally of central and state governments in agricultural development and, therefore, present policy of private sector participation should continue in all sub-sectors of agriculture. Important areas are product market, agro-processing and delivery of inputs.
4. Implementation of agricultural market reforms is slow by different states governments and this should be taken by them on priority. Legal framework for contract farming and direct procurement of farm produce by processing industry, retail chain, aggregator etc. should be promoted.
5. Capital requirement for increasing household investment in agriculture and business investment in modernization of value chains should be met with greater focus on term-loan by financial institutions, besides continuing emphasis on crop loan.
6. In order to transfer work force from agriculture to non-agriculture sector, institutions for skill development for rural youth and access to venture capital should be given priority under 'skill India' and MUDRA initiatives of the government.
7. Extension of Jan-Dhan-Yojana, Aadhar and Mobile (JAM) and implementation of tenancy reforms are important initiatives of the government. These initiatives along with Pradhan Mantri Fasal Bima Yojana would help farmers manage risk and extend benefits of other schemes directly to cultivator farmers. These programs should be supported with modernization of land records for effective implementation of the scheme.
8. In order to learn from the reforms, there is a need for assessment of these policy reforms and development programs of the governments and their outcomes. The

- gaps in implementation of these programs by the states and recommendations made by various committees may also be assessed for addressing the bottlenecks.
9. There are some good examples of acceleration of the transformation of agriculture in different states. These examples often relate to balancing the roles of centre, states, private sector and civil society organizations in various development programs, farm services like extension and market reforms. Lessons from these examples should be drawn for their out-scaling in other states.
 10. Technology transfer programs should be given priority for use of available knowledge and technology for raising productivity of crops like pulses and oilseeds, sustain natural resource base in the context of climate change, and improve animal health. In order to reduce rising wage bills, farm mechanization with focus on small farmers in partnership with private R&D should be encouraged.
 11. There are sector-specific requirements for their transformation like capital and entrepreneurship development for dairy and meat. These sectors should be paid adequate attention and the government should provide necessary infrastructure and policy support. These sectors have specific requirement for quality assurance and SPS compliance, and actors at different stages of value chain must ensure product quality as per global standards.
 12. Doubling of farm income by 2022 needs targeting efforts for increasing productivity, diversification of product mix and realization of better prices. Bridging yield gaps and delivery of technology for higher total factor productivity and irrigation management can provide immediate benefits in terms of higher yields and farm income. This should be followed by diversification of production system towards high value crops for which demand is rising faster. This shall be a demand driven growth and diversification facilitated by dissemination and adoption of improved technology.
 13. Post-harvest management of produce, processing and value addition are other important areas which need priority in terms of attracting investment. In this context, facilitating regime for allowing corporate investment, technology delivery, and linkages with R&D and financial institutions are necessary. Development of post-harvest sector shall not only create value for realization of higher prices for farmers but will also reduce pressure on farm for employment, and thus, generating higher income and surplus for further investment on farms.
 14. Management of market risk shall be an important component of the strategy for improving farmers welfare. Besides PMFBY for yield risk, financial products and market mechanisms to manage price risk shall go a long way in protecting farmers against risk. Similarly, assurance of quality of farm inputs like seed, pesticides and

animal health products is another area where existing mechanism like consumer forums should be made effective. Also, associations of companies can join forces to assure discipline and quality in input markets.

R E F E R E N C E S

- Balaji S.J. and Pal Suresh, 2014. Agricultural productivity growth: is there regional convergence? *Economic and Political Weekly*, 49(52): 74-80.
- Chand Ramesh and Saxena R., 2015. Estimates and analysis of farm income in India, 1983-2011. *Economic and Political Weekly*, L(22): 139-145.
- Gandhi V.P. (2011). Reforming institutions for natural resource management for inclusive and sustainable growth. In Suresh Pal (Ed), *Agriculture for Inclusive Growth*, IARI, New Delhi.
- IPCC (2014). *Climate Change 2014: Impacts, Adaptability and Vulnerability*. Fifth IPCC Assessment Report, Cambridge University Press.
- Jha G.K., Pal Suresh and Singh Alka, 2012. Changing energy use pattern and the demand projection for Indian agriculture. *Agricultural Economics Research Review*, 25(1): 75-82.
- Joshi P.K., Tewari L., Jha A.K. and Shiyani R.L. (2003). Impact of watershed program and people's participation. In Suresh Pal, Mruthyunjaya, P.K. Joshi and R. Saxena (Eds), *Institutional Change in Indian Agriculture*, NCAP, New Delhi.
- Joshi P.K., Gulati A. and Cummings R.W., 2007. *Agricultural Diversification and Smallholders in South Asia*. Academic Foundation, New Delhi.
- Kandpal A., Bhooshan N. and Pal Suresh, 2015. Recent trend in patenting activity in India and its implications for agriculture. *Agricultural Economics Research Review*, 28(1): 139-146.
- National Commission on Farmers, 2004. *Summary Recommendations*. Ministry of Agriculture, New Delhi.
- NAAS, 2013. *Climate Resilient Agriculture in India*. Policy Paper 65, New Delhi, 20 p.
- NAAS, 2015. *Linking Farmers With Markets for Inclusive Growth in Indian Agriculture*. Policy Paper 75, New Delhi, 16 p.
- NAAS, 2016. *Breeding Policy for Cattle and Buffalo in India*. Policy Paper 82, New Delhi, 36 p.
- NSSO, 2014. *Key Indicators of Situation of Agricultural Households in India*. MoSPI, New Delhi.
- Niti Aayog, 2015. *Raising Agricultural Productivity and Making Farming Remunerative for Farmers*. Report of the Task Force on Agricultural Development, New Delhi.
- Pal, Suresh, Jha G.K., Balaji S. and Kandpal A., 2016. Accelerating agricultural transformation. In C. Ramasamy and K. Ashok (Eds), *Agriculture in Fast Growing Economy in India*, Academic Foundation, New Delhi.
- Pal, Suresh, Rahija M. and Beintema N., 2012. *India: Recent Developments in Agricultural Research, ASTI Country Note*. International Food Policy Research Institute, Washington DC and Indian Council for Agricultural Research, New Delhi.

- Reardon T., Barrett C.B., Berdegue, J.A. and Swinnen, J.F.M., 2009. Agrifood industry transformation and small farmers in developing countries. *World Development*, 37(11): 1717-1727.
- Venkatesh P. and Pal Suresh, 2013. Determinants and valuation of plant variety protection in India. *Journal of Intellectual Property Rights*, 18: 448-456.
- World Bank, 2008. *World Development Report 2008*. Agriculture for Development, Washington, D.C.
- World Bank, 2014. *Accelerating Agricultural Productivity in India*, Washington, D.C.



The Challenge of Hidden Hunger-micronutrient Deficiencies

K. Madhavan Nair and Mahtab S Bamji

“Ten commandments for a healthy life free from agonies of ill health are: Meditate and exercise, Eat moderate, Go vegetarian, Have 2-3 litres of water daily, Eat 3 hours before sleep, Check your words, Vibrate love, Live gratitude, Care mother earth and Manage your stress”- The World Wellness Organization and Empower India Movement.

The health and vitality of human beings depends on a diet that includes adequate amounts of all vitamins and minerals (besides carbohydrates, proteins, and fats) which are indispensable for normal growth, reproduction, brain and other neural functions, immune response and energy metabolism. The body needs relatively minute quantities (micrograms to milligrams) of vitamins and minerals and they are hence referred to as micronutrients (MN). They constitute less than 0.005% of body weight. According Institute of Medicine (IOM, 2011) 13 vitamins and 13 minerals have been recognized as important micronutrients for health. Table-1 lists the micronutrients and their important functions.

The article addresses the nutritional importance of micronutrients, their mechanisms of action, their dietary deficiencies and strategies for combating deficiencies. Major emphasis is on micronutrient deficiencies of public health importance such as iron, iodine, zinc, and vitamins A, D, folic acid, B₁₂ and C. Though Indian diets are markedly deficient in riboflavin (vitamin B₂), the deficiency has not assumed public health importance, perhaps because most critical enzymes needing this vitamin as co factor lose it only in extreme deficiency.

Dietary sources and deficiencies of micronutrients in India

An adequate intake of all micronutrients is possible only through daily access to diversified micronutrient-rich foods of plant and animal origin. Plant foods in general contain more of iron, provitamin A, vitamin C, and B-complex vitamins as against flesh foods which are

considered as a major source of bioavailable nutrients like, iron, zinc, and vitamins A, D and B₁₂. A compilation of average micronutrient content of various food groups based on food composition data base is provided in Table 2. Among these micronutrients, dietary sources of vitamin D are limited and fortified milk and oils are considered as the dietary sources.

Table 1: Vitamin and mineral micronutrients and their functions and deficiency disorders in humans

Vitamin	Function / Deficiency disorders	Mineral	Functions/ Deficiency disorders
Vitamin A β-Carotene	Vision, 11-cis retinal binding to membrane bound opsin-rhodopsin cycle Functions by binding to nuclear receptors//Night blindness, hyperkeratinosis/compromise immunity and growth.	Iron	Haemoglobin and other haem protein synthesis and involved in oxygen and electron transport for energy metabolism/ microcytic hypochromic anaemia
Vitamin D	Regulator of serum calcium by facilitating calcium absorption / Rickets in children and osteomalacia in adults	Zinc	Numerous enzymes involved in energy metabolism and in transcription and translation/Retarded growth
Vitamin E	Antioxidant/ Increase in red blood cell fragility	Iodine	Constituent of thyroid hormones/Iodine deficiency disorders, goitre and growth retardation
Vitamin K	Conversion of inactive to active prothrombin, vitamin K dependent carboxylation/ Hemorrhagic syndrome	Selenium	Glutathione peroxidase; interaction with heavy metals/ Keshan disease an endemic cardiac myopathy found in China
Vitamin B1 Thiamin	As a coenzyme TPP form in oxidative decarboxylation and transketolase reaction/ Beriberi, neurological	Molybdenum	Enzyme cofactor in xanthine, aldehyde, sulfite oxidases/Deranges cysteine metabolism
Vitamin B2 Riboflavin	As coenzyme FAD functions as the prosthetic groups of numerous holoenzymes one and two electron oxidation-reduction reactions/Glossitis, angular stomatitis	Copper	Oxidative enzymes, interaction with iron; cross-linking of elastin/ Anaemia, low lysyl oxidase and failure of elastin and collagen cross linking
Niacin	As coenzyme NAD and NADP in electron acceptor or donor, electron carrier for intracellular respiration/ Pellagra, glossitis, dermatitis, weight loss, diarrhoea,	Manganese	Cofactor of metalloenzymes in mucopolysaccharides metabolism, superoxide dismutase/Not well characterized in humans, defective carbohydrate metabolism
Vitamin B6 Pyridoxal 5 ¹ - phosphate	As coenzyme(PLP) binds in a Schiff base linkage with the ε- amino group of active site lysine/Overall deficiency B-complex vitamins	Fluorine	Structure of teeth, possibly of bones, possibly growth effect/ Fluoride toxicity (>2 mg/L) such as dental and skeletal fluorosis,
Folic acid	As a coenzyme for one carbon transfer reactions for biosynthesis of purine nucleotide and deoxythymidylic acid for RNA and DNA synthesis/Macrocytic anaemia/NTD	Chromium	Potentiating insulin function/ Impaired glucose tolerance
Biotin	As a cofactor in carboxylase reaction/Deficiencies in long antibiotic therapies	Nickel	Cofactor in metalloenzymes/ Impaired iron absorption
Pantothenic	In coenzyme A the free sulphhydryl group as the site for acyl transfer reactions/Rare, similar to B vitamins	Boron	Macromineral and steroid hormone metabolism/ Postmenopausal women elevated Ca and Mg excretion
Vitamin B ₁₂	Facilitates cyclic metabolism of folic acid for thymidine and DNA synthesis/ Haemopoiesis, Pernicious anaemia and neuropathy	Silicon	Calcification; possibly function in connective tissue/Osteoarthritis and in aging process
Vitamin C	Hydroxylation of proline to hydroxyproline and lysine to hydroxylysine/ Scurvey, anaemia, haemorrhaging	Vanadium	Cofactor no specific function has been identified

Surveys carried out in rural areas of India during 2011-12 show very low dietary intakes of fat and most of the protective foods like pulses, milk and milk products, green leafy vegetables and fruits. The data also highlight significant over the years drop in the consumption of cereal and millets from about 500 grams per day to 360 grams per day (NNMB, 2012). According to the recent survey on diet and nutritional status of urban population in India, the average household consumption of foodstuffs as percentage of recommended dietary intakes followed a pattern suggestive of high intake of cereal, fats and oil and lower intakes of pulses (legumes), green leafy vegetables (GLV), and milk and milk products (NNMB, 2017). Even the monthly per capita expenditure –uniform reference period (NSSO, 2015) indicate high expenditure of 61% (rural) and 52% (urban) for cereals and low expenditure for milk and milk product (7 and 9 %) and vegetables and fruits (1.85 and 2.62) supporting the NNMB data. The per capita expenditure pattern of less than 1% (0.82 and 1.13%) for meat, fish and egg in rural and urban India is also very low and is in accordance with the estimated per capita consumption of meat of 5.2 kg which is about 9 times lower than the world average of 45 kg (FAOSTAT, 2014). Satisfying the daily requirement of micronutrients from diet has to be viewed in the context of overall poverty, population pressure, urbanization, agriculture intensification. Thus there are widespread deficiencies of multiple micronutrients or hidden hunger in India and reducing nutrient deficiencies in children has been our National Nutrition Policy since 1993. Due to lifestyle changes deficiencies of vitamins D, B₁₂ and C and zinc are the new challenges facing Indians (Table- 3).

Functions, deficiencies, public health: Importance of micronutrients and challenges

Iron

In Indian diets, non-haem iron from plant foods which has poor bioavailability of 3-5% (Nair and Iyengar, 2009) constitutes 90-95% of the intake. The rest comes from better absorbed haem iron from animal origin foods like meat, poultry, and fish.

Iron deficiency anaemia occurs when the body's iron supply cannot support the production of haemoglobin in adequate amounts to supply enough oxygen to the muscles, brain, and other tissues. This causes weakness, fatigue, and reduced physical ability to work. Among adults it reduces work productivity. Severe anaemia resulting from iron deficiency reduces a woman's ability to survive during and after childbirth and may result in premature and/or low birth weight babies with a higher risk of death. Iron deficiency in children reduces intellectual and motor development (Haas and Brownlie, 2001).

Screening for anaemia and treating is suggested as an important process in the life cycle by the National anaemia control programme (NIPI, 2013). Though there are specific

Table 2: Micronutrient content (100 g raw weight) of plant and flesh foods† (Average values)

Nutrients	Plant foods								Flesh Foods		
	Cereals/ Millets	Pulses, Legumes	Green leafy Vegetables	Other Vegetables	Fruits	Roots and Tubers	Nuts and Oil seeds	Meat, Fish, Egg	Milk		
Iron mg	2.4/5.6	5.5	4.2	0.9	0.4	0.7	6.2	1.5	0.2		
Zinc mg	2.1/2.4	3.0	0.5	0.5	0.2	0.3	4.9	2.7	0.3		
Provitamin A (β-carotene)/ Vitamin A†† µg	186 maize	60	1-17540	2-1500	1.5-2700	1-5420	<10	6690 Liver sheep††	55††		
Vitamin D2/D3* µg	20.0/17.1	10.0	6.0	30.0 Mushroom	3.0	1.0	16.3	2.0*	1.6		
Total Folate µg	35/31	186	74	40	10	33	58	6/>1000/55	9		
Vitamin B ₁₂ µg	ND	ND	ND	ND	ND	ND	ND	3.5††	0.2††		
Total Ascorbic acid (Vitamin C) mg	ND	ND	45	25.4	38.4	12.7	ND	ND	2.4		

*Vitamin D₃, †IFCT (2017) and ††NVIF(1989)

Table 3: Percent prevalence of micronutrient deficiencies in India

Micronutrient	Biomarker population	% Prevalence	Reference
Iron	Haemoglobin < 10.9 g/dL		
	Children 6-59 months of age	58.4	Nair et al(2015)
	Pregnant women 15-49 years	50.3	NFHS 4 (2016)
Zinc	Serum zinc <70 µg/dL		
	10-16y adolescent girls	67.5	Sucharitha (2013) and Kawade (2012)
Iodine	Urinary iodine <100? µg/L		
	General population	46.6	Pandav et al (2013)
Vitamin-A	Serum vitamin A <20 µg/dL		
	Children 6- 59years	62	Laxmaiah et al (2011)
Folate	Serum folate<3ng/mL		
	Pregnant women	5.7	Yalla et al (2017)
Vitamin B12	Serum vitamin B₁₂<200 pg/mL		
	Pregnant women	30	Yalla et al (2017)
Vitamin D	Serum vitamin 25 OH D< 20 ng/mL		
	General population	79	Ritu and Gupta (2014)
Vitamin-C	Serum vitamin C < 2 µg/ml		
	6-16 years children	59.6	Sivakumar et al (2006)

biomarkers for assessing stages of iron deficiency, measurement of haemoglobin concentration is considered as a proxy for iron deficiency, which is in fact the end stage of iron deficiency. Serum ferritin is a good indicator of body iron stores. However, ferritin is an acute phase reactant protein and its serum concentrations can be elevated, irrespective of a change in iron stores, by infection or inflammation. The biomarker soluble transferrin receptor (sTfR) in serum which is mostly derived from developing RBCs is considered to estimate the magnitude of the functional iron deficit once iron stores are depleted. The ratio of sTfR to ferritin was designed to evaluate changes in both stored iron and functional iron and is thought to be more useful than either TfR or ferritin alone (WHO/UNICEF/UNU, 2001).

Persistent high prevalence of anaemia in India has substantial health and economic costs and is considered as one of the leading risk factor causing disease burden (ICMR, PHFI and IHME, 2017). This report identified a negative relationship between risk of disease burden and the level of the epidemiological transition level (ETL, which is the ratio of the number of DALYs (disability associated life years) in a population due to communicable, maternal, neonatal, and nutritional diseases to the number of DALYs due to non-communicable diseases and injuries together) of the state. It is interesting to note that the states with high prevalence of iron deficiency anaemia are low ETL state (Bihar, Chhattisgarh, Orissa, MP, UP, Rajasthan) compared to the high ETL states (HP, Punjab, Goa, TN and Kerala). These state level estimates are expected to help in planning, prioritisation and assessing impact of large-scale

interventions directed towards anaemia. The challenge is to balance the economic transition and reducing the risk factors of disease burden including iron deficiency anaemia.

The primary causes of iron deficiency include low intake of bioavailable iron; increased iron requirements as a result of rapid growth, pregnancy, menstruation, and excess blood loss caused by pathologic infections, such as hook worm causing gastrointestinal blood loss and impaired absorption of iron. Other risk factors for iron deficiency in young women are high parity, and the iron cost during each pregnancy amounting to more than 700 mg (ICMR, 2010). Thus, in the Indian context control and prevention of iron deficiency requires addressing the twin determinants; enhancing iron content and simultaneously improving the bioavailability of added iron through food synergy. Inclusion of vitamin C rich fruits and vegetables in the habitual diets of population has been shown to establish the food synergy for doubling the iron absorption (Nair and Augustine, 2018, Nair *et al*, 2013). Other strategies that need to be followed are strategies to reduce worm infestation including making India free of open defecation and creating an enabling environment for the provision of WASH, and public awareness. These are the real challenges facing the nation.

Iodine

Iodine is essential for the healthy functioning of the thyroid gland and is the only recognized role of iodine as a component of the thyroid hormone. Iodine must be obtained from environment through water-soil-plant-animal cycle. It cannot be stored in the body for long periods and the daily required amounts are needed regularly. The RDA of iodine is in the range of 90 µg/d for infants >6 mo to 250µg/d for pregnant and lactating women (ICMR, 2010).

Environmental iodine deficiency has been the major cause of iodine deficiency across the globe and the most common cause of preventable brain damage in the world today. Iodine deficiency during pregnancy can cause stillbirths, spontaneous abortions, low birth weight, and congenital abnormalities such as cretinism and goitre. Iodine deficiency in children leads to lower IQ. Iodized salt is the most common intervention to prevent iodine deficiency disorders for many decades (Brahmam, 2016).

The median urinary iodine concentration reflects current iodine intake and responds rapidly to the correction of iodine deficiency and is the recommended methods of assessment within a population along the prevalence of total goiter. The endemicity of iodine deficiency occurs where the median urinary iodine concentration is <100µg/L, or in areas where more than 5% of children aged 6-12 years have goitre (WHO, 2013).

Due to deficiency of iodine in the soil of the Indian subcontinent and consequently the food derived from it, many regions are endemic and the entire population is susceptible to

IDD. The iodized salt coverage (which was implemented during 1990s) has been reported to be more than 90% and the programme in India is a public health success story (Pandav *et al*, 2013).

Vitamin A

The recommended dietary allowances of vitamin A for Indians vary from 350 µg/d for infants to 950 µg/d during lactation (ICMR, 2010). The major dietary source in the Indian context is the provitamin A carotenoid pigment β -carotene from plant origin. Its requirement to satisfy vitamin A (conversion factor) is 8 times that of vitamin A (1400 µg/d -3800 µg/d).

Vitamin A deficiency is a major underlying determinant of child mortality and blindness in the developing world. It causes xerophthalmia, a serious eye disorder that can lead to blindness if untreated. In children, vitamin A deficiency compromises the immune system, increasing the risk of severe illness from diarrheal diseases and from measles (FAO/WHO, 1998). Though clinical manifestations of vitamin A deficiency have come down considerably, subclinical vitamin A deficiency (serum vitamin A < 20µg/dL) is still a concern in the Indian context (Table -3). The National Health Policy (2017) and National Nutrition Strategy (2017) has come into existence to revitalise the multipronged strategies for addressing vitamin A deficiency including operationalisation of vitamin A fortified milk and oils, targeted supplementation and dietary diversification including biofortified foods (NHP, 2017 and NITI Aayog, 2017). Currently the coverage of the national 6 monthly vitamin A supplementation programme for 9-59 months children is around 60% (Goa at 89.5% and Nagaland at 27.1%) (NFHS 4). The real challenge facing the country is to reduce the dependence on the national vitamin A supplementation programme and increase the adoption of medium term and long term food-based strategies.

Zinc

Unlike other metals, zinc is virtually non-toxic owing to tight cellular homeostatic control of entry into, distribution in and excretion from cells. Other unique properties that make zinc biochemically very versatile are its amphoteric nature at neutral pH and ability to assume multiple coordination geometries due to a variable oxidation (IZiNCG, 2004). The three main biochemical functions of zinc are in its (1) catalytic role (2) structural role and (3) regulatory role.

As a catalyst, it participates in reactions of more than 200 enzymes involved in regulating the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients. Zinc offers its potential antioxidant property by increasing the activity of superoxide dismutase, in maintaining membrane stability and cells

integrity, cell differentiation, proliferation and gene expression. It facilitates the folding of proteins into three-dimensional configurations, for their biologic activity through chelation of zinc with cysteine and histidine amino acids to form zinc fingers. Zinc performs its structural function also by taking part in formation of insulin hexamer complex which is the storage form of insulin in pancreas. Zinc dependent protein folding is essential for 11-cis – retinal to trans-retinal through rhodopsin cycle. The regulatory functions of zinc are performed through zinc finger motif which is a protein and is known to bind DNA, RNA or protein. It has a central role in tissues that have a rapid differentiation and turnover, including those of the immune system and those in the gastrointestinal tract.

Deficiency of zinc has been reported to impair immune function, growth and brain development, bone mineralization, and wound healing. The extent of zinc deficiency worldwide is not well documented due to lack of reliable biomarker that reflects early changes in zinc nutritional status. Positive impact of zinc supplementation on the growth of stunted children, and on the prevalence of selected childhood diseases such as diarrhoea, suggests that zinc deficiency is likely to be a significant public health problem, especially in developing countries like India.

Absorption of zinc from rice based meals among Indian adolescents (13-15 yrs) is in the range of 25-30% (Nair *et al*, 2013). The Indian RDA for zinc varies from 5 mg in 1-3 yrs old children to 12 mg in adults. Based on serum zinc concentration ($<70 \mu\text{g/dL}$) prevalence of zinc deficiency of 67 % has been reported from various parts of India, especially among 10-16yrs adolescent girls (Table-3). The challenge is to develop point of care biomarkers that are able to detect early changes in zinc status.

Vitamin D

Vitamin D is a generic name for a group of anti-rachitic substances, the most important of which are cholecalciferol (vitamin D₃) and ergocalciferol (vitamin D₂). From a nutritional perspective, the two forms are metabolized similarly in humans, are equal in potency, and can be considered equivalent.

In humans, vitamin D is formed from the action of sunlight on the skin and converts 7-dehydrocholesterol in epidermis which then undergoes thermal isomerisation to vitamin D₃. This is taken up into the bloodstream tightly bound to a vitamin D-binding protein and metabolized in the liver through hydroxylation pathway to 25-hydroxyvitamin D (25(OH)D), the major circulating and storage form. A further hydroxylation pathway, mainly in the kidney produces the active form of vitamin D, 1,25-dihydroxyvitamin D (1,25(OH)₂D). The mechanism of action of vitamin D is through the sequential events of binding of 1,25(OH)₂D to the cell surface receptor, nuclear receptor and to a specific vitamin D–

responsive element in DNA. This enhances transcription of mRNAs which code for calcium transport proteins, bone matrix proteins, or cell cycle-regulating proteins (Bikle, 2014). This in turn along with parathyroid hormone stimulates intestinal absorption and mobilization of calcium and phosphate by stimulating bone resorption. Thus, the nutritional significance of vitamin D is in preserving skeletal health; by maintain normal blood levels of calcium and phosphate which in turn establishes normal mineralization of bone, muscle contraction, nerve conduction, and general cellular function in all cells of the body.

The recommended daily allowance of vitamin D₃ under situations of minimal exposure to sunlight is 400 IU/day (ICMR, 2010) and 600 IU/day (IOM, 2011). Vitamin D status is assessed by measuring serum concentrations of 25-OH-D and is a reliable biomarker. Clinical diagnosis of skeletal health is also assessed by bone mineral density (BMD) by DEXA (dual energy X-ray absorptiometry) scan.

Vitamin D deficiency is recognized as a major global public health problem (Palacios and Gonzalez, 2014). The available data indicates that vitamin D inadequacy (<20 ng/mL) is above 79 % in different groups (Table 3) and is emerging as a public health problem in India (Puri *et al*, 2008, Marwaha *et al*, 2011). Though vitamin D fortification of milk and oil has been introduced in the country, national data base on vitamin D status using robust methodology and cut-offs for quantifying the deficiency prevalence is of prime importance and is a challenge. Adoption of sun exposure as a strategy needs critical analysis for its feasibility for national policy directions.

Folate

Folate is the generic term for compounds that have vitamin activity similar to that of pteroyl-glutamic acid and is an anti-anaemic and growth factor. The term for chemically synthesized form is folic acid and the natural form is the food folate. Folates consist mainly of 5-methyltetrahydrofolate and 10-formyltetrahydrofolate. In general, rapidly growing and multiplying cells require an adequate supply of folate. Tetrahydrofolate acts as a co-enzyme in single carbon transfers leading to the biosynthesis of purine nucleotides and deoxythymidylic acid essential for DNA and RNA synthesis.

Folate deficiency limits *cell division*, erythropoiesis- bone marrow to produce RBCs which are characterized by large immature *cells* leading to megaloblastic *anaemia*. During early pregnancy folic acid is an essential nutrient for the closure of the neural tube which occurs around the 28th day of pregnancy. Incidence of neural tube defects (NTD, spina bifida and anencephaly) is reduced by introduction of folic acid fortified flour and folic acid supplement (400µg/d) before conception and during the first month of pregnancy (Imbard *et al*, 2013).

The overall prevalence of *neural tube defects* in *India* is high compared to other regions of the *world* (4.5 per 1000 total births compared to 0.7 in US and Canada and 0.9 Chile and 1 per 1000 births South Africa (Allagh *et al*, 2015). Biochemical assessment of folate status is done by measuring serum and RBC folate levels. Serum folate essentially reflects current intake and red cell levels represent long term tissue stores. Based on serum folate (<3ng/mL) about 5.7% of pregnant women have been reported to have inadequacy of folate status (Yalla *et al* 2017).

Vitamin B₁₂

Vitamin B₁₂ is a complex molecule containing a corrin (4 pyrrole) ring with a central cobalt atom. Microbial (bacteria and algae) synthesis is the only source of vitamin B₁₂ in nature, but no species of plants have the *enzymes* necessary for *vitamin B₁₂* synthesis. This fact has significant implications for the dietary sources and availability of *vitamin B₁₂* in the *Indian context for meeting the RDA of 1µg/day*. Animals and humans get it from their natural bacterial flora or from other animals. Vitamin B₁₂ is widely present in animal foods such as liver, meat, fish, egg and milk (Table 2).

In mammalian cells there are only two vitamin B₁₂-dependent enzymes. One of these enzymes, methionine synthase, uses methylcobalamin. The other enzyme, methylmalonyl CoA mutase, uses vitamin B₁₂ with a 5'-deoxyadenosyl moiety attached to the cobalt, 5'-deoxyadenosylcobalamin, or coenzyme B12.

Vitamin B₁₂ is indispensable for the proliferation of all of the haematological cell lines in bone marrow. Intrinsic factor (IF) present in intestines is needed for vitamin B₁₂ absorption. Malabsorption of vitamin B₁₂ can occur at several points during digestion mainly due to the auto-immune disease called pernicious anaemia (PA), deficiency of IF. In most cases of PA, antibodies are produced against the parietal cells causing them to atrophy, lose their ability to produce intrinsic factor, and secrete hydrochloric acid. In the absence of vitamin B₁₂, progenitor cells enlarge without division into generations of daughter cells, leading to hypoproliferative anaemia with giant, immature, macrocytic red cells in the circulation. *Megaloblastic anaemias* result most often from deficiencies of vitamin B₁₂ and folate. A moderately high intake of folic acid might mask an underlying vitamin B₁₂ deficiency which becomes apparent once the irreversible neurological disorders set in (Selhub and Paul, 2011).

A low or decreased serum vitamin B₁₂ level is a specific test for deficiency. Serum vitamin B₁₂ levels lower than 200ng/mL is the cut off of deficiency and levels decline gradually in

the normal elderly patient. About 30% of pregnant women have been reported to have inadequacy of vitamin B₁₂ (Yalla *et al*, 2017). It is important to ensure there is no vitamin B₁₂ deficiency before starting folic acid replacement, as this therapy may worsen the associated neurologic symptoms (IOM, 2011).

Vitamin C

Vitamin C is a redox system comprised of ascorbic acid and dehydroascorbic acid, and as such acts as an electron donor. Oxido-reduction and chelating property of vitamin C are responsible for its physiological functions. It is involved in collagen synthesis, detoxification of toxic substances in liver, production of neurotransmitters and building immunity. It is also an important antioxidant and a potent promoter of non haem iron absorption in the presence of inhibitors such as phytates and tannins. The RDA of vitamin C for Indians is 40 mg/day.

Vitamin C is found in a wide variety of fruits like guava, papaya, orange, lemons, other citrus fruits and vegetables like GLV, red capsicum, cabbage, parsley, sprouts (Table -2). Although severe vitamin C deficiency (scurvy) is now relatively rare, the prevalence of milder or marginal deficiency is probably quite high. The clinical symptoms of scurvy include follicular hyperkeratosis, haemorrhagic manifestations, swollen joints, swollen bleeding gums and peripheral oedema, and even death. These symptoms appear within 3–4 months of consuming diets with a very low vitamin C content (<2mg/d as against RDA of 40 mg/d). In infants, manifestations of scurvy include a haemorrhagic syndrome, signs of general irritability, tenderness of the legs and pseudoparalysis involving the lower extremities. The adverse effects of mild deficiency are uncertain, but may include poor bone mineralization (due to slower production of collagen), lassitude, fatigue, anorexia, muscular weakness and increased susceptibility to infections (ICMR, 2010 and IOM, 2011). Inadequate vitamin C status of about 60% has been reported among 6-16 yrs old Indian children (Table-3).

A low intake of vitamin C will exacerbate iron deficiency problems, especially in individuals who consume only small amounts of meat, fish or poultry as practiced in India. Simultaneous ingestion of vitamin C along with meals or iron fortified foods greatly improves the absorption of the iron (Nair *et al*, 2013). In Chile, for example, vitamin C is added to iron-fortified dried milk consumed by young children to significantly improve their iron status (WHO/FAO, 2006). Innovative strategies addressing this concept can bring down iron deficiency among vulnerable segments of the population, especially children and adolescent girls.

Combating micronutrient deficiencies

Micronutrient (MN) deficiencies can be combated through prevention or treatment; former being the preferred approach. Nutritional deficiencies are caused by dietary inadequacy or non-dietary factors such as poor access to sanitation, safe drinking water, and health care outreach resulting in diseases and iatrogenic losses of nutrients from the body. Women's education and empowerment can play an important role in ensuring family's health and nutrition. Non-dietary factors though very important are outside the scope of this narrative and will be mentioned only in passing.

Country-wide diet surveys done by the National Nutrition Monitoring Bureau (NNMB, 2012 and 2017), and others show that the cereal –pulse- based Indian diets are qualitatively grossly deficient in some micronutrients discussed in earlier sections. While calorie adequacy may ensure protein adequacy, it most often fails to quench the hidden hunger –MN deficiency (Table-3).

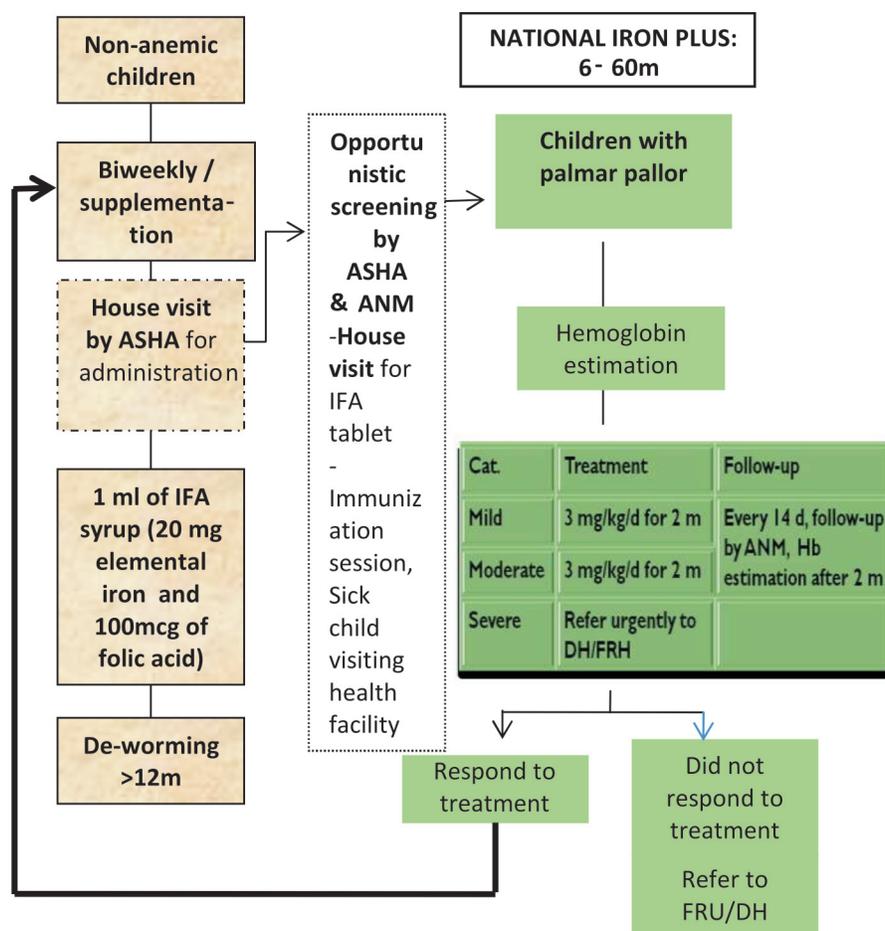
Three basic strategies for combating dietary micronutrient deficiencies are: (i) administration of pharmaceutical supplements, (ii) food fortification, and (iii) dietary diversification to ensure the inclusion of micronutrient-dense foods in the diet. Biofortification of crops using conventional breeding, marker assisted molecular breeding, or genetic engineering is a powerful tool to increase micronutrient density of common plant foods (WHO/FAO, 2006).

Administration of Pharmaceutical Supplements

This strategy is adopted when the deficiency is severe like severe nutritional anaemia (Hb<7 g/dL), or vitamin A deficiency blindness. The two major MN supplementation programmes in India are: the National Nutritional Anaemia Prophylaxis Programme (NNAP) and Massive dose vitamin A supplementation programme to prevent nutritional blindness.

National nutritional anaemia prophylaxis programme

In this centrally sponsored programme started in 1970, all pregnant and lactating women receive 60 mg of elemental iron and 500 µg of folic acid (IFA tablets daily) for at least 100 days during pregnancy and 100 days in post-partum period. Preschool children receive 20 mg of elemental iron plus 100 µg of folic acid daily. Due to administrative infirmities and lack of awareness regarding the adverse effects of anaemia, the programme has failed to achieve the desired results. In 2013 the Ministry of Health and family Welfare (MHFW), India launched the National Iron Plus Initiative (NIPI, 2013). The treatment protocol for 6-60 mo children is given diagram 1.



Education and de-worming are important adjuncts to help the programme. Since the national programme provides only iron and folic acid, suggestion has been made to investigate the impact of including other micronutrients like vitamin B₁₂, zinc (which also have a role in erythropoiesis) and vitamin C, which facilitates iron absorption (INSA, 2011).

Massive dose of vitamin A supplementation programme to prevent nutritional blindness

Bi annual vitamin A supplementation for children 9-59 months: Vitamin A being a fat soluble vitamin can be stored in the liver if a large dose is administered and released gradually as required. Based on this rationale and subsequent extensive clinical and field trials by the National Institute of Nutrition, Hyderabad, India, a programme of administering massive dose of 200,000 IU of vitamin A at six monthly intervals to children between 1-5 years was introduced in 1970. Though the implementation of the programme has been very patchy

and coverage poor, clinical manifestations of vitamin A deficiency-keratomalacia has come down and blindness due to vitamin A deficiency is no longer a public health problem, perhaps due to other factors like better sanitation. This has created a controversy regarding persisting with the programme, and the opinion of the nutritionists is divided. However, signs and symptoms such as Bitot spots and night blindness (particularly in pregnant women) persist. Also dietary deficiency of vitamin A is marked, and a hasty decision to scrap the programme would not be wise. The programme should continue at least in areas where symptomatic deficiency of vitamin A is relatively high- incidence of Bitot spots more than 0.5%. Strengthening the existing programme has been identified by the NITI Aayog and the role has been entrusted to MHFW (NITI Aayog 2017).

Programmes of this nature which have to rely on centralised supply of tablets or syrup will succeed only if the delivery system is efficient and compliance is good. For the latter the community should be educated regarding the importance of the programme.

Food Fortification

Food fortification is done either to restore nutrients lost during processing or to enrich foods with nutrients. Food fortification has been defined as “Addition of one or more essential nutrients to a food, whether or not it is normally contained in the food, for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrients in the population or specific population groups” (FAO, 1995)”. It’s a convenient, powerful and minimally expensive tool for combating micronutrient deficiencies and has been extensively used for nutrients like vitamins A, D, some B-vitamins and minerals such as iron and zinc. The choice of vehicle for fortification has to be done carefully. It should be a food item that is universally consumed by the poorest of the poor. Bioavailability has also got to be ascertained before launching a programme.

Wheat flour is the most common vehicle for fortification with B vitamins and minerals for which WHO/FAO have provided guidelines (WHO/FAO, 2006). Fortification of cereal products with folic acid is being done in some countries to reduce the incidence of neural tube defects in new born infants. However, such a strategy has been shown to exacerbate biochemical as well as clinical manifestations of vitamin B₁₂ deficiency. Hence food fortification programme that includes folic acid should also include vitamin B₁₂ (Selhub and Paul, 2011). Such a strategy has been introduced in India for some staple foods (FSSAI, 2017) to reduce anaemia and may also help in reducing serum homocysteine levels. Raised level of homocysteine is an independent risk factor for cardiovascular diseases- an emerging health problem.

For fortification with vitamin A, vehicles such as sugar (Central America) and monosodium glutamate (Philippines) have been used. In India, *Vanaspati* (*hydrogenated* fat), was fortified

with vitamins A & D. Since hydrogenated fat is not a good source of fat due to trans fatty acids, cooking oil and packaged milk are being considered as vehicles for fortification with vitamins A and D in India (FSSAI, 2017). Access of such packaged foods to the poor in rural areas needs to be examined.

WHO (2011) has given guidelines for the fortification of home food for infants and children with multiple micronutrient powders. Similar strategy is being contemplated for food cooked for preschool children under the ICDS scheme in India. Positive impact of fortification of all foods with iron on anaemia in children has been reported (Athe *et al*, 2013 and Pachón *et al*, 2015).

The universalisation of iodine fortified salt has had a marked impact on reducing the incidence of goitre due to iodine deficiency. Salt double fortified with iodine and iron (DFS) has been developed by the National Institute of nutrition, Hyderabad and several studies have demonstrated its impact on iron deficiency anaemia (Bamji and Nair, 2016). Large scale implementation of MN fortified foods is being planned in the country. Stakeholders are operationalising various fortified food products (DFS, iron, folate and B₁₂ fortified wheat flour and rice, vitamin A and D fortified milk and oils and fortified processed foods) for making them available in the open market and for introducing them in the government safety net programmes like ICDS, MDM and PDS by Central line Ministries/ Departments and State Governments (FSSAI, 2017). Its implementation in programmatic mode has to take into consideration several contextual factors such as (1) regional disparity (2) food vehicles for fortification (3) single vs multiple micronutrients (4) technology for fortification (5) bioavailability and (6) monitoring and evaluation for efficacy and possible adverse effects.

Dietary Diversification-Farm-Based Approach to Combat Hidden Hunger

Thanks to the green revolution, India is self sufficient in the production of cereals like wheat and rice. With white revolution, India tops the countries of the world in production of milk. It is the second highest producer of vegetables and fruits. Despite these achievements, it is worrisome to find that diet surveys show gross inadequacy in the consumption of these foods (milk, vegetables and fruits) even by farmers who produce them. Though at one time cereal consumption met the recommended dietary allowance, in more recent times there has been progressive decline even in the consumption of cereals (NNMB, 2012 and 2017).

Two important crops- millets and pulses have missed the green revolution. Nutritious millets have been replaced by rice and wheat, thanks to their highly subsidised availability through public distribution system. Pulse production does not meet the country's requirement and pulses are imported. Remedial steps are however being taken in recent years. Excessive pre-harvest and post-harvest losses, particularly of vegetables and fruits enhance the gap

between supply and demand. High cost of production forces the farmer to sell the produce rather than use it for home consumption. Poor understanding of the adverse health consequences of dietary deficiency of protective foods rich in micronutrients (pulses, millets, vegetables, fruits, and animal products) also adds to the problem. The challenge therefore is to promote nutritionally sensitive and environmentally sustainable agriculture through technological and social engineering. Behavioural change communication (BCC) is needed to stress the importance of dietary diversification to ensure a balanced diet. Prof MS Swaminathan refers to it as agricultural remedies for nutritional melodies, and is developing “Farming Systems for Nutrition (FSN)” ([www. MSSRF.org](http://www.MSSRF.org), August 2017).

Homestead gardens for combating vitamin A deficiency

The concept of homestead gardening was initially mooted in India to enhance the consumption of pro-vitamin A-rich vegetables and fruits in villages of Andhra Pradesh by the National Institute of Nutrition, Hyderabad and in West Bengal by the All India Institute of Hygiene and Public Health (Vijayaraghavan *et al*, 1997, Chakravarty, 2000). In both the studies, farmers were encouraged to grow β -carotene-rich fruits and vegetables (green leafy vegetables, orange-yellow vegetables and fruits) in their back yard gardens or farms, by supplying planting material; technical know-how and do-how along with BCC. Local government functionaries were kept informed. In both the locations; post-intervention, there was marked increase in the number of households raising homestead gardens with β -carotene-rich plants. Knowledge Attitude Practice (KAP) surveys showed remarkable improvement in the knowledge of mothers regarding foods rich in vitamin A and signs (Bitot spots) and symptoms (night blindness) of vitamin A deficiency. In West Bengal there was significant improvement in the incidence of Bitot spots, but in Andhra Pradesh the results were equivocal. Faber and Benade (2003) in South Africa also observed effectiveness of integrating home gardening with community-based growth monitoring activities in alleviating vitamin A deficiency. There was significant reduction in the prevalence of low serum vitamin A ($< 20\mu\text{g/dL}$) from initial 58% to 34%. There was no impact on growth of the children.

Homestead gardens for combating multiple micronutrient deficiencies

In more recent studies in the Medak district of Telangana (former Andhra Pradesh), one of the authors (MSB) and colleagues are testing the concept of Diversification from agriculture to nutritionally promotive and environmentally sustainable horticulture. (Bamji *et al*, 2011, Murty *et al*, 2016). Impact was assessed through acceptance of homestead gardens (gardens raised near the house or in farmers' fields), KAP surveys and household consumption of vegetables. Emphasis was on micronutrient-dense (naturally biofortified) vegetables like a variety of green leafy vegetables, beans, tomatoes etc. Few experimental gardens of orange-flesh sweet potato rich in β carotene (Table -4; procured from Regional centre of Central

Tuber Crops Research Institute, Indian Council of Agricultural Research, Bhubaneswar, Odisha, courtesy Dr. Archana Mukerjee Principal Scientist) and iron –rich Bajra (Nirmal seeds) were also raised.

Apart from distributing seeds of vegetables, women raised nurseries of plants like Moringa (drum stick), *Basella alba* (creeper spinach), curry leaves and papaya in their back yards. The saplings were purchased from them for distribution, fetching the women some income. Technological knowhow and do-how were combined with health and nutrition education (BCC) of pregnant women and mothers registered at the ICDS centres, besides the community

Table 4: Carotenoid content of orange-flesh sweet potato ($\mu\text{g}/100\text{g}$)*

Variety	Total carotenoids	Lutein	β crypto-xanthin	β carotene	α carotene
Kamalsundari -1	12,128	8.7	16.	9619	
-2	11,989	10.7	27	9581	205
ST - 13 (1)	8374	4.6	42	6893	
ST-14 (2)	8174	10.9	44	6793	46
Gouri-1	947	10.9	ND	243	
-2	950		37	357	27
Srikanaka	3444	37.91	14	2911	

*Analysis done at the National Institute of Nutrition, Hyderabad

at large. Like in the earlier studies KAP surveys showed remarkable improvement in knowledge (and hopefully practice), of mothers with preschool children on issues of diet, nutrition, infant feeding practices and health. There was significant increase in the frequency (Bamji *et al* 2011, Murty *et al* 2016) as well as quantum (Bamji *et al*, 2011) of household consumption of green leafy vegetables. In the case of other vegetables, home-grown produce largely replaced that purchased from the market with insignificant impact on household consumption. However, in one of the studies where control non-intervention villages were included, there was a marked decline in the consumption of vegetables over time due to sharp increase in market price. This suggests that homestead production at least shields against escalating market price. About 25-50% of home-grown vegetables other than GLV were sold, since perceived priority was income rather than health and nutrition.

An extensive programme of improved homestead gardens and backyard poultry along with nutrition education was implemented by Hellen Keller International in Bangladesh, Cambodia, Nepal and Philippines to increase access to micronutrient –rich foods in poor communities (Bushamuka *et al*, 2005; Iannotti *et al* 2009; Rahman *et al*, 2008 and Talukdar *et al*, 2010). There was a significant increase in vegetables and eggs consumed by mothers

and preschool children, and mothers' knowledge of nutrition. Reduction in the prevalence of anaemia was seen in Bangladesh and Phillipines, but not the other two countries. Families also earned some income.

Currently, MS Swamintahan Research Foundation in Chennai, India is systematically examining the impact FSN model to leverage agriculture for nutritional outcomes in few villages of Wardha District of Vidarbha region of Maharashtra, and Koraput district of Odisha (Nagrajan *et al*, 2014 and Das *et al*, 2014,). Community nutrition gardens were also tested (Das *et al*, 2014). The main components of the model are: 1) survey to identify the major nutritional problems, 2) design context- specific suitable agricultural interventions to address the local nutritional problems, 3) improve small farm productivity and profitability, 4) undertake nutrition awareness programmes and build a cadre of hunger fighters, and 5) introduce monitoring systems for assessing impact on nutrition outcomes. To address the problem of micronutrient deficiencies, vegetable and fruits, genetically well endowed with micronutrients, suitable for the location are promoted in the homestead gardens. Prof. Swaminathan advocates establishment of genetic gardens for better nutrition security (For details refer to "Farming systems for Nutrition" by Prof. Swaminathan, [www. mssrf.org](http://www.mssrf.org), August, 2017).

Amongst the vegetables, green leafy vegetables (GLV) are most promising in terms of micro-nutrient content, variety, yearly availability, and ease of growing. However the taste preference of people is generally for other vegetables. Nutrition education along with development and promotion of GLV in culturally acceptable recipes like 'dal', 'roti' and other preparations should receive priority. Apart from micronutrients, vegetables are also rich in health promoting phytochemicals and fibre.

Scope for Biotechnology

Within plant species, if genetically well-endowed varieties are available, conventional breeding or molecular breeding techniques can be applied (as in the case of orange flesh sweet potato or iron –rich bajra), to enhance its nutrient content as well as attributes like higher productivity or pest resistance. However, sometimes that is not possible with plants where specific micronutrient- endowed varieties are not available in nature. In such instances genetic engineering involving gene transfer from the other edible crops or even others offers tremendous opportunity. One such promising food is a carotene-rich yellow rice. Health and environment safety of such genetically engineered foods has to be ensured in an unbiased and dispassionate manner.

Impact of Homestead Production of Livestock

As mentioned earlier, India is the largest producer of milk in the world. In recent years, poultry has also shown quantum jump. However, emphasis has been on income rather than nutrition. Also major beneficiaries are urban population. Though goat rearing is common among marginalised farmers, goat milk is seldom consumed. Emphasis on income generation should be combined with BCC to promote household consumption of home produce.

Among foods of animal origin, poultry has many advantages. Egg is one of the most wholesome nutritious foods, with good quality protein and rich in micronutrients. Recent studies have questioned the harmful effects of eggs for raising blood cholesterol since most of the cholesterol in human body is synthesised endogenously. Back-yard poultry is a cost-effective intervention needing little space and investment, since these birds graze. However some inclusion of better feed helps. Compared to 30-40 eggs produced by local poultry, high-egg yielding breeds can yield up to 160 eggs per year (Rao and Pretam, 2009). For sustained impact, regular supply of pedigree birds have to be ensured or local cocks should be removed to prevent contamination of breed since these are free roaming birds. Positive impact of such a strategy of BYP in villages of Medak district of AP (now Telangana State) have been reported (Murty *et al*, 2013 and 2016). Interested farmers purchased 3 hens with one male or female bird given free by way of incentive. With each household having only few birds, eggs that were produced were consumed at home. Few eggs were occasionally sold at higher price for hatching. In the participating households there was 2 fold increases in the consumption of eggs making this approach promising from nutrition point of view. In Telangana state, and perhaps other states, eggs are routinely given to children participating in ICDS programme (Anganwadis). Farmers can be encouraged to set up poultry units with high egg-yielding breeds to supply the eggs to anganwadis and earn money.

Summary and conclusions

Micronutrient (vitamins and minerals) undernutrition is a serious problem in India since monotonous cereal-based Indian diets are qualitatively poor in content and bioavailable vitamins and minerals. Though florid clinical manifestations of other deficiencies are rare, biochemically detectable, subclinical deficiencies of public health concern are those of: iron, iodine, zinc, vitamins A, D, folate, B₁₂ and C. These represent hidden hunger. Among the micronutrient deficiencies, continuing high prevalence of anaemia among vulnerable segments of the population due to iron deficiency is one of the leading risk factors of disease burden in India. Hidden hunger of other micronutrients also compromise immunity, mental and physical performance, and productivity.

Three basic strategies for improving intake of these micronutrients are administration of pharmaceutical supplements, food fortification, and dietary diversification to ensure the inclusion of micronutrient-dense foods in the diet. Pharmacy –based interventions like anaemia

prophylaxis programme and massive dose vitamin A programme have had success in reducing severe forms but had limited success in addressing mild to moderate forms of MN deficiencies.

Food fortification is a successful technology of addressing prevention and correction of multiple micronutrient deficiencies across the globe. Universal iodisation of salt has helped to reduce the incidence of iodine deficiency disease. Salt double fortified with iodine and iron has shown promise and needs to be universalised. Efficient introduction of fortification strategies and their sustainability and continuous monitoring is vital for a rightward shift in the MN status in India. Biofortification can help to increase the micronutrient density (iron, zinc and β -carotene) of plant foods. Strategies for enhancing bioavailability of iron, zinc and β -carotene from plant foods and reducing infections in the target groups are indispensable for controlling hidden hunger.

Table 5: The domains and the challenges of hidden hunger-micronutrient deficiencies

Domains in the area of controlling micronutrient deficiencies	Challenges in controlling micronutrient deficiencies
Establishing dietary deficiency and subclinical prevalence	<ul style="list-style-type: none"> National data base on dietary intake and prevalence of micronutrient deficiency using robust methodology and cut-offs Developing point of care biomarkers that are capable of diagnosing micronutrient deficiencies of public health concern and utilise the national MN supplementation programme.
Understanding contextual factors	<ul style="list-style-type: none"> Assessing the food consumption pattern , including food availability, food accessibility, and food choice, which in turn are influenced by geography, demography, disposable income, socioeconomic status, urbanization, globalization, religion, culture, marketing, consumer attitude and lifestyle changes
Strategies	<ul style="list-style-type: none"> Focusing on targeted national micronutrient supplementation programmes and to increase the adoption of medium food fortification and long term food-based strategies.
1. Supplementation	
2. Food fortification	<ul style="list-style-type: none"> Implementation of food fortification in programmatic mode taking into consideration regional disparity in prevalence and intake of micronutrients, food matrix, use of single vs multiple micronutrients, technology of fortification, optimising food synergy. Dove tailing non-food strategies such as strategies for control of morbidity (malaria and respiratory) and worm infestation (Open Defecation Free) and creating an enabling environment for the provision of WASH, and public awareness.
3. Horticulture	<ul style="list-style-type: none"> Developing Farming Systems for Nutrition Promote nutritionally sensitive and environmentally sustainable agriculture through technological and social engineering Behavioural change communication to adopt dietary diversification to ensure a balanced diet, and clean and healthy life style. Realistic target group specific dietary guidelines (children, pregnant women) for meeting the daily requirement of micronutrients from a diversified diet

Farming systems should leverage nutritional concerns besides aiming at only income and export. Augmenting homestead production of micronutrient- dense vegetables and fruits, along with education (behavioural change communication-awareness) is a promising and sustainable strategy, because it empowers the community leaving decision making in their hands. Millets, legumes and animal products are also rich sources of micronutrients. Backyard poultry with just a few birds have shown marked increase in household consumption of eggs. Awareness and access at affordable cost to micronutrient- dense foods to non-farming families in villages and in urban areas should be ensured through appropriate strategies for marketing and distribution. The challenges of reducing hidden hunger in India are listed in the table (Table-5) and should address them contextually and holistically.

REFERENCES

- Allagh KP, Shamanna BR, Murthy GVS , Ness AR, Doyle P, Neogi SB and Pant HB 2015, Folic Acid project team, Birth Prevalence of Neural Tube Defects and Orofacial Clefts in India: A Systematic Review and Meta-Analysis, *PLOS ONE*, March 13, 1-15
- Athe R, Rao MVV and Nair KM 2013, Impact of iron fortified foods on Hb concentration in children (<10yrs): a systematic review and meta-analysis of randomized controlled trials. *Public Health Nutrition* 17(3), 579–586.
- Bamji M.S, Murty P.V.V.S, Rao V.M, and Satyanarayana G 2011, Diversification from agriculture to nutritionally and environmentally promotive horticulture in a dry-land area. *Sight and Life* 25, 38-42.
- Bamji MS and Nair KM 2016, Food-based approach to combat micronutrient deficiencies. Thematic issue on nutrition. *Proc. of the Indian National Science Academy*, 82:1529-1540.
- Bikle DD 2014, Vitamin D Metabolism, Mechanism of Action, and Clinical Applications, *Chem Biol.* 20: 319–329
- Brahmam GNV 2016, Iodine deficiency disorders. Nutrition and anaemia, in Text book of Human Nutrition, Eds. MS Bamji, K. Krishnaswamy and Brahmam GNV. Oxford & IBH, Publishing company . Fourth Edition, pp 305-16.
- Bushamuka VN, de Pee S, Talukdar A, Kiess L, Panagides D, Taher A, and Bloem M 2005, Impact of homestead gardening program on household food security and empowerment of women in Bangladesh. *Food and Nutrition Bulletin*, 26: 17-25.
- Chakravarty I 2000, Food-based strategies to control vitamin A deficiency. *Food and Nutrition Bulletin*, 21: 135-143.
- Das PK, Bhavani RV and Swaminathan MS 2014, A farming system model to leverage agriculture for nutritional outcomes. *Agric Res* 3: 193-203.
- FAO 1995. Technical consultation on food fortification: technology and quality control. Micronutrient fortification of food: technology and quality control, Rome, Italy, 20-23 November 1995.

- FAO/WHO 1998, Vitamin and mineral requirements in human nutrition: report of a joint FAO/WHO expert consultation, Bangkok, Thailand (Vol. 270). pp. 21–30.
- FAOSTAT 2014. Food and agriculture organization of the United Nations Statistics Division. <<http://faostat3.fao.org/home/e>>
- FSSAI 2017, Food Safety Standards Authority of India, Large Scale Food Fortification in India The Journey So Far and Road Ahead, Food Fortification Resource Centre, FSSAI, MHFW, GoI, New Delhi.
- Haas JD and Brownlie T 2001, Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. *J Nutr* 131(2S-2):676S-88S; discussion 88S-90S.
- Iannotti L, Cunningham K and Ruel M 2009, Improving diet quality and micronutrient nutrition. Homestead food production in Bangladesh. IFPRI discussion paper 00928, prepared for the project on Millions fed: Proven Successes in Agriculture Development, pp 1-44. www.IFPRI.org/millions_fed.
- ICMR 2010 Indian Council of Medical Research. Nutrient requirements and recommended dietary allowances for Indians. In A report of the expert group of the Indian Council of Medical Research, National Institute of Nutrition, Hyderabad, India.
- ICMR, PHFI and IHME 2017, Indian Council of Medical Research, Public Health Foundation of India and Institute for Health Metrics and Evaluation, India: Health of the Nation's States The India State-Level Disease Burden Initiative. New Delhi, India.
- IFCT 2017, Indian Food Composition Tables, National Institute of Nutrition, Hyderabad.
- Imbard A, Benoist JF and Blom HJ 2013, Neural Tube Defects, Folic Acid and Methylation, *Int. J. Environ. Res. Public Health*, 10: 4352-4389.
- INSA 2011, Indian National Science Academy. Micronutrient security for India. Priorities for research and action.
- IOM 2011, Institute of Medicine, Dietary Reference Intakes (DRIs): Recommended Dietary Allowances and Adequate Intakes, Vitamins and Elements Tolerable Upper Intake Levels, Vitamins and Elements Food and Nutrition Board, National Academies, , www.nap.edu.
- IZiNCG 2004, International Zinc Nutrition Consultative Group (IZiNCG) technical document #1. Assessment of the risk of zinc deficiency in populations and options for its control, *Food and Nutrition Bulletin*, 25: (1 Suppl 2):S99-203.
- Laxmaiah A, Nair MK, Arlappa N, Raghu P, Balakrishna N, Rao KM, Gal Reddy CH, Sharad Kumar, Ravindranath M, Vikas Rao V and Brahmam GNV 2012, Prevalence of ocular signs and subclinical vitamin A deficiency and its determinants among rural pre-school children in India. *Public Health Nutr*, 15:568-77
- Kawade R 2012, Zinc status and its association with the health of adolescents: a review of studies in India. *Glob Health Action* 5: 7353. doi:10.3402/gha.v5i0.7353
- Marwaha RK, Tandon N, Garg MK, Kanwar R, Narang A, Sastry A, Saberwal A and Bandra K 2011, Vitamin D status in healthy Indians aged 50 years and above. *J. Assoc. Physicians India*, 59:706–709.

- Murty PVVS, Rao VM and Bamji MS 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 *Agri Res* doi 10.1007/s40003-016-0206-x.
- Murty PVVS, Bamji MS, Rao VM and Prasad VLK 2013, Promotion of backyard poultry for augmenting egg consumption in rural households. *IndJ Nutr Diet* 50: 150-155.
- Nagarajan S, Bhavani RV and Swaminathan MS 2014, Operationalising the concept of farming system for nutrition, through the promotion of nutrition-sensitive agriculture, *Current Science*, 107: 959-963.
- Nair KM and Augustine LF 2018, Food synergies for improving bioavailability of micronutrients from plant foods. *Food Chemistry*, 238: 180-185.
- Nair KM, Augustine LF and Konapur A 2016, *Food-based interventions to modify diet quality and diversity to address multiple micronutrient deficiency*. *Front.Public Health* 3:277. <https://doi.org/10.3389/fpubh.2015.00277>.
- Nair KM, Brahmam, GNV, Radhika, MS, Dripta, RC, Ravinder P, Balakrishna N, Chen Z, Hawthorne KM and Abrams SA 2013, Inclusion of guava enhances non heme iron bioavailability but not fractional zinc absorption from a rice-based meal in adolescents. *J. Nutr*, 143: 852–858.
- Nair KM, Fernandez-Rao S, Nagalla B, Kankipati, RV, Punjal R, Augustine LF, Hurley KM, Nicholas T, Harding KB, Greg R, and Black MM 2016, Characterization of anaemia and associated factors among infants and pre-schoolers from rural India. *Public Health Nutr*.19, 861-871
- Nair KM and Iyengar V 2009, Iron content, bioavailability & factors affecting iron status of Indians. *Indian J Med Res* 130: 634–645.
- NFHS 4 2016, National Family Health Survey 4. India Fact Sheet. Ministry of Health and Family Welfare, Government of India. International Institute of Population Sciences, Mumbai 2015-16.
- NHP 2017, National Health Policy, Ministry of Health and Family Welfare, GoI.
- NIPI 2013, National Iron Plus Initiative. Guidelines for control of iron deficiency anaemia. Adolescent Division, Health and Family Welfare, GoI.
- NITI Aayog 2017, The National Institution for Transforming India, Nourishing India. National Nutrition Strategy, Government of India.
- NNMB 2012, National Nutrition Monitoring Bureau. Diet and nutritional status of rural population and prevalence of hypertension. Third repeat survey. NNMB Technical report series 26. National Institute of Nutrition.
- NNMB 2017, National Nutrition Monitoring Bureau. Diet and nutritional status of urban population in India and prevalence of obesity, hypertension, diabetes and hyperlipidemia in urban and rural men and women. NNMB Technical report series 27. National Institute of Nutrition.
- NSSO 2015, Nutritional Intake in India: Based on 68 Round of NSSO 2011-12, National sample survey organization. [NSSO_68 Nutrition-Intake-of-Indian-Population.pdf](#)
- NVIF 1989, Nutritive value of Indian foods. National Institute of Nutrition (ICMR), Hyderabad, India

- Pachon H, Spohrer R, Mei Z, and Serdula MK 2015, Evidence of the effectiveness of flour fortification programmes on iron status and anaemia: a systematic review. *Nutrition Reviews*, 73: 780-795.
- Palacios C and Gonzalez L 2014, Is vitamin D deficiency a major global public health problem? *J Steroid Biochem Mol Biol*.144PA: 138-145.
- Pandav CS, Yadav K, Srivastava R, Pandav R and Karmarkar MG 2013, Iodine deficiency disorders (IDD) control in India. *Indian J Med Res* 138(3); 413-33.
- Puri S, Marwaha RK, Agarwal N, Tandon N, Agarwal R, Grewal K, Reddy DH and Singh S 2008, Vitamin D status of apparently healthy schoolgirls from two different socioeconomic strata in Delhi: relation to nutrition and lifestyle. *Br J Nutr*. 99(4):876-882.
- Rahman F.M.M, Mortuza M.G.G, Rahman M.T and Rokoinuzzaman M 2008, Food security through homestead vegetable production in the smallholder agricultural improvement project (SAIP) area *J Bangladesh Agril Univ* 6 261-69.
- Raman L and Sarma, KVR 2016, Nutrition and anaemia, in Text book of Human Nutrition, Eds. MS Bamji, K. Krishnaswamy and Brahmam GNV. Oxford & IBH, Publishing company.
- Ritu G and Gupta A 2014, Vitamin D Deficiency in India: Prevalence, Causalities and Interventions. *Nutrients*, 6: 729-775
- Rao VST, and Pretam C 2009, Breeding strategies for improved birds in backyard poultry. Lead paper presented at National Workshop on 'Synthesising experiences in promotion of backyard poultry' July 9-10, Hyderabad, India.
- Selhub J and Paul LK 2011, Folic acid fortification: why not vitamin B₁₂ also. *Biofactors*, 37, 269-271.
- Sivakumar B, Nair KM, Sreeramulu D, Suryanarayana P, Ravinder P, Shatrugna V, Kumar AP, Raghunath M, Rao, VV, Balakrishna N, Udaykumar P and Raghuramulu N 2006, Effect of micronutrient supplement on health and nutritional status of school children: Biochemical status. *Nutrition* 22: S15
- Sucharitha KV 2013, Zinc status in adolescent girls of low income groups. 2nd International conference and exhibition on Nutritional science and therapy. Philadelphia, US. Available at: <http://www.omnicsgroup.com/conferences/nutritional-science-therapy-2013/>
- Talkukdar A, Haselow N.J, Osel A.K *et al* 2010, Homestead food production model contributes to improved household food security and nutrition status of young children and women in poor populations. *Field Actions Science Reports* factsreports.revues.org/index404.html
- Vijayaraghavan K, Nayak, U.M, Bamji M.S, Ramana G.N.V, and Reddy V 1997, Home gardening for combating vitamin A deficiency in rural India. *Food and Nutrition Bulletin* 18 337-343.
- WHO 2011, Guideline: Use of multiple micronutrient powders for home fortification of foods consumed by infants and children 6-23 months of age. Geneva, World Health Organization, http://whqlibdoc.who.int/publications/2011/9789241502047_eng.pdf

- WHO 2013, Urinary iodine concentrations for determining iodine status in populations. WHO/NMH/NHD/EPG/13.1. who.int/iris/bitstream/10665/85972/1/WHO_NMH_NHD_EPG_13.1_eng.pdf
- WHO/FAO 2006, Allen L, de Benoist B, Dary O, Hurrell R, editors. Guidelines on food fortification with micronutrients, Geneva, Switzerland.
- WHO/UNICEF/UNU 2001, Iron deficiency anaemia: assessment, prevention, and control. Geneva: World Health Organization.
- Yall A, Kasula S, Ravinder P and Nair KM 2017. Prevalence of vitamin B₁₂ deficiency in pregnant women and its effect on fetal outcome. *Indian J Obstet and Gynecol.* 5:190-194.

“ Prof. Swaminathan's life's work has been an inspiration to me and the entire country and I wish him a long healthy life to serve the nation through science and technology. ”

Dr. Manmohan Singh
Hon. Ex-Prime Minister of India

“ Prof. Swaminathan is the voice of farmers, and his contributions in the enactment of The Food Security Bill - 2013 are legion. ”

Prof. K.V. Thomas
Member of Parliament

ZERO HUNGER INDIA

POLICIES AND PERSPECTIVES

Zero Hunger India: Perspectives and Policies is based on 6 philosophical Preambles, first of which is by Prof. M.S. Swaminathan. The book discusses the multi-faceted solutions on eradicating hunger and malnutrition of India. Advancements in agriculture, horticulture, aquaculture, fisheries, husbandry, climate change, raising farmer's income, extension services, gender inequalities and many more have been discussed by eminent personalities of each field with the single focus of making India hunger free. Foreword is by Hon. Ex-PM Of India, Dr. Manmohan Singh, a keen academic himself, Dr. Singh was the Prime Minister during the period of passage of the food security bill. Six messages from Members of Parliament and Present and Former Director Generals of ICAR, New Delhi provide views by men and women of eminence. The also book carries an Extended Foreword by Prof. K V. Thomas M.P., the then Minister of Agriculture and Civil Supplies, GOI who piloted the National Food Security Act-2013 successfully.

The book is dedicated to Prof. M S Swaminathan, the man who's vision bridged us from a nation borne out of hunger to its current state of agricultural surplus, on his 93rd birthday on 7th August 2018.



BRILLION Publishing

Brillion Publishing
For e-version of the book contact info@brillionpublishing.com
www.brillionpublishing.com
New Delhi

ISBN 9789387445147



9 789387 445147