Horticulture for Nutrition Security
Prof. K.V. Peter is basically a horticulturist, a plant breeder and a University Professor. He is an acknowledged and decorated scientist and science manager. A post graduate from G.B. Pant University of Agriculture and Technology, he did post doctoral research at BARC Beltsville Maryland USA and worked at Laboratories at AVRDC Tainan and Guadeloupe (French West Indies). He was associated with development and release of improved and high yielding varieties/hybrids in tomato, brinjal, chilli, bittergourd, melons, amaranths and cowpea. Sources of resistance to bacterial wilt in tomato, chilli and brinjal, aphids in cowpea and viral leaf curl in chilli were located by him and are now used in breeding programmes. Prof. Peter provided managerial support to the Indian Institute of Spices Research, Calicut to possess the World’s largest germplasm of black pepper and cardamom. A prolific writer and academic editor he authored/edited 74 books published both in India and abroad. He received 7 scholarships and fellowships at various stages of education. He is member in the Board of Examiners in 12 Universities, Chairman/member in 130 committees of Government /research institutes, Fellow in 3 National Academies and 3 Scientific societies, member in 18 Scientific societies. His publishers include Taylor and Francis, Elsevier, National Book Trust, I.C.A.R., New India Publishing Agency, Astral International Pvt. Ltd., Studium Press (USA), Universities Press, Hyderabad and Kerala Language Institute, Trivandrum.

Prof. Peter is recipient of several awards like Rafi Ahmed Kidwai Award 1996-1998 for outstanding research in Horticulture-ICAR, New Delhi; Recognition Award 2000–National Academy of Agricultural Sciences, New Delhi; Dr. M.H. Marigowda National Award for the Best Horticulturist–2000; Silver Jubilee Medal for outstanding contributions in Vegetable Research; Dr. Harbhajan Singh Award 1993; Silver Jubilee Memonto; Biotech Product and Process Development Award 2003; Shiva Sakthi-hsi National Award for Life Time Achievement in Horticulture-2008 and Dr. K. Ramiah Memorial Award-National Academy of Agricultural Sciences, New Delhi for outstanding contribution to Crop Improvement-2009. He was Director when the Best Institution Award was conferred to IISR, Calicut by ICAR, New Delhi. He was Vice-Chancellor when Sardar Patil Award 2003 for the best ICAR institution was conferred to Kerala Agricultural University.

Family: Vimala is wife, Anvar and Ajay sons, Anu and Cynara Daughters-in-law and Antony Ajay Peter, grand son and Anna Vimala Anvar, grand daughter. Parents are Late Kuruppacharil Devassey Varkey and Late Rosa Varkey.
The book HORTICULTURE FOR NUTRITION SECURITY is devoted to Prof. M.S. Swaminathan, Father of Green Revolution for his commitment to make India hunger free by 2030. He coined the much quoted “There is a horticulture remedy for every nutritional malady”. Voted one among the three great Asians-Mahathma Gandhi, Rabindranath Tagore and M.S. Swaminathan- he becomes history and a household name.
Acknowledgement

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I acknowledge FAO of UN, Rome for permission to reproduce preamble-I: The State of Food and Agriculture-2014 in Brief: Innovations in Family Farming.

I acknowledge Mr. Anil Mittal of Astral International Pvt. Ltd., New Delhi for publishing the book well in time in a near error free format.
Foreword

The National Food Security Bill-2013 was enacted by the Parliament of India ‘to provide for food and nutritional security in human life cycle approach by ensuring access to adequate quantity of quality food at affordable prices to people to live a life with dignity and for matters connected therewith or incidental there off’. India is also signatory to the UN resolution of Millennium Development Goals (MDGs-8) which range from halving extreme poverty rates and eliminating child mortality to halting the spread of HIV/AIDS and providing universal primary education by 2015. Despite great strides in food production (52 million tones in 1951 to 236 million tons in 2014), 26 per cent of Indian population is still below poverty line (per capita income lesser than US $ 1.5/capita/day) and has limited access to nutritious food. India also houses 60 per cent of the world’s anemic. Every third child is born with low birth weight and is condemned to poor mental and physical development and immunity unless rehabilitated within the first year of life.

“There is a horticultural remedy for every nutritional malady’ says Prof. M.S. Swaminathan, the Father of Green Revolution in India. Horticulture has emerged as a core sector with a crop coverage of 21 million ha and an annual production of 240.5 million tones. This includes vegetables, fruits, root and tuber crops, mushrooms, ornamentals, medicinal and aromatic plants, nuts and plantation crops (industrial crops). Though these crops occupy hardly 11 per cent of cropped area, they contribute over 30.4 per cent to the gross agricultural output in the country. Fruits and vegetables are also rich sources of vitamins, minerals, protein, anti-oxidants, lipids, fiber and several beneficial phyto-chemicals. The per capita consumption of fruits (65g/day) and vegetables (120g/day) in India is very low against the recommended minimum
of 120g and 280g respectively. With the present level of population, the annual requirement of horticulture produce will be 360 million tones by 2020-21 against the present 240.5 million tones. Family Farming, Nutrition gardens at each homestead, urban horticulture, vertical gardens and protected cultivation are now promoted to attain self sufficiency in horticulture produce. The FAO of UN declared the year 2014 as year of Family Farming and 2015 as year of Soils. The National Academy of Agricultural Sciences, New Delhi has released two Policy Papers- No. 7 on ‘Diversification of Agriculture for Human Nutrition’ and No. 30 on ‘Organic Farming: Approaches and possibilities in the context of Indian Agriculture’. As former President of the Academy, I am happy that Prof. K V Peter, a Fellow of the Academy, has made use of these policy papers as Preambles to the book. The Indian National Science Academy, after wide consultations, issued a policy paper on ‘Micro-nutrient Security for India-Priorities for Research and Action-2011’. Viable water and soil are prerequisites to successful horticulture crop production for freedom from pesticide and other undesirable residues. The issue of hidden hunger leading to loss of working hours and causing debility disorders can be addressed by encouraging family farming and nutrition garden in each homestead.

The present book HORTICULTURE FOR NUTRITION SECURITY has 21 chapters covering both basic and applied aspects by 35 active working scientists. I congratulate the Editor, Prof. K V Peter, and the publisher, The Astral International Pvt. Ltd New Delhi, for undertaking this project. I co-edited the book ‘HANDBOOK OF INDUSTRIAL CROPS’ with Prof. K V Peter which was published by Taylor and Francis. The book was received very well. Likewise, it is my conviction that the present book will be an asset for students, teachers and policy planers.

V.L. Chopra

More than 500 million family farms manage the majority of the world’s agricultural land and produce most of the world’s food. We need family farms to ensure global food security, to care for and protect the natural environment and to end poverty, undernourishment and malnutrition. But these goals can be thoroughly achieved if public policies support family farms to become more productive and sustainable; in other words policies must support family farms to innovate within a system that recognizes their diversity and the complexity of the challenges faced.

*The State of Food and Agriculture 2014: Innovation in family farming* analyses family farms and the role of innovation in ensuring global food security, poverty reduction and environmental sustainability. It argues that family farms must be supported to innovate in ways that promote sustainable intensification of production and improvements in rural livelihoods. Innovation is a process through which farmers improve their production and farm management practices.
This may involve planting new crop varieties, combining traditional practices with new scientific knowledge, applying new integrated production and post-harvest practices or engaging with markets in new, more rewarding ways. But innovation requires more than action by farmers alone. The public sector - working with the private sector, civil society and farmers and their organizations - must create an innovation system that links these various actors, fosters the capacity of farmers and provides incentives for them to innovate.

Family farms are very diverse in terms of size, access to markets and household characteristics, so they have different needs from an innovation system. Their livelihoods are often complex, combining multiple natural-resource-based activities, such as raising crops and animals, fishing, and collecting forest products, as well as off-farm activities, including agricultural and non-agricultural enterprises and employment. Family farms depend on family members for management decisions and most of their workforce, so innovation involves gender and intergenerational considerations. Policies will be more effective if they are tailored to the specific circumstances of different types of farming households within their institutional and agro-ecological settings. Inclusive research systems, advisory services, producer organizations and cooperatives, as well as market institutions are essential.

The challenges of designing an innovation system for the twenty-first century are more complex than those faced at the time of the Green Revolution. The institutional framework is different due to a declining role of the public sector in agricultural innovation and the entry of new actors, such as private research companies and advisory services, as well as civil society organizations. At the same time, farmers are having to address globalization, increasingly complex value chains, pressures on natural resources, and climate change.

**Family Farms: Size and Distribution**

There are more than 570 million farms in the world. Although the notion of family farming is imprecise, most definitions refer to the type of management or ownership and the labour supply on the farm. More than 90 percent of farms are run by an individual or a family and rely primarily on family labour. According to these criteria, family farms are by far the most prevalent form of agriculture in the world. Estimates suggest that they occupy around 70 - 80 percent of farm land and produce more than 80 percent of the world’s food in value terms.

The vast majority of the world’s farms are small or very small, and in many lower-income countries farm sizes are becoming even smaller. Worldwide, farms of less than 1 hectare account for 72 percent of all farms but control only 8 percent of all agricultural land. Slightly larger farms between 1 and 2 hectares account for 12 percent of all farms and control 4 percent of the land, while farms in the range of 2 to 5 hectares account for 10 percent of all farms and control 7 percent of the land. In contrast, only 1 percent of all farms in the world are larger than 50 hectares, but these few farms control 65 percent of the world’s agricultural land. Many of these large, and sometimes very large, farms are family-owned and operated.

The highly skewed pattern of farm sizes at the global level largely reflects the dominance of very large farms in high-income and upper-middle-income countries.
and in countries where extensive livestock grazing is a dominant part of the agricultural system. Land is somewhat more evenly distributed in the low-and lower-middle-income countries where more than 95 percent of all farms are smaller than 5 hectares. These farms occupy almost three-quarters of all farm land in the low-income countries and almost two-thirds in the lower-middle income group. In contrast, farms larger than 50 hectares control only 2 percent and 11 percent, respectively, of the land in these income groups.

Exactly what can be considered a small farm—below 0.5 or 1 hectare, or some other size—will depend on agro-ecological and socio-economic conditions, and their economic viability will depend on market opportunities and policy choices. Below a certain level, a farm may be too small to constitute the main means of support for a family. In this case, agriculture may make an important contribution to a family’s livelihood and food security, but other sources of income through off-farm employment, transfers or remittances are necessary to ensure the family lives a decent life. On the other hand, many small or medium-sized family farms in the low- and middle-income countries could make a greater contribution to global food security and rural poverty alleviation, depending on their productive potential, access to markets and capacity to innovate. Through a supportive agricultural innovation system these farms could help transform world agriculture.

**Family Farms, Food Security and Poverty**

In most countries, small and medium-sized farms tend to have higher agricultural crop yields per hectare than larger farms because they manage resources and use labour more intensively. This means that the share of small and medium-sized farms in national food production is likely to be even larger than the share of land they manage.

A large proportion of family farmers with small land holdings also depend on other natural resources, especially forests, pastureland and fisheries. The intensive resource use on these farms may threaten sustainability of production. These small and medium-sized farms are central to global natural resource management and environmental sustainability as well as to food security.

While smaller farms tend to achieve higher yields per hectare than larger farms, they produce less per worker. Labour productivity—or output per worker—is also much lower in low-income countries than in high-income countries. Increased labour productivity is a precondition for sustained income growth, so enabling farming families in low- and middle-income countries to raise their labour productivity is essential if we are to boost farm incomes and make inroads into reducing rural poverty.

Although smaller farms tend to have higher yields than larger farms within the same country, cross-country comparisons show that yields per hectare are much lower in poorer countries, where smaller farms are more prevalent, than in richer countries. This seeming paradox simply reflects the fact that yields in low-income countries are far lower, on average, than in richer countries and far lower than they could be if existing technologies and management practices were appropriately adapted and more widely adopted in low-income countries. Innovation aimed at
increasing yields in developing countries could have significant impacts in terms of expanding agricultural production, increasing farm incomes and lowering food prices, thereby reducing poverty and enhancing food security by making food more affordable and accessible to both rural and urban populations.

The potential to improve labour productivity and yields can only be realized if family farmers are able to innovate. There are two main, but interrelated, pathways through which farmers’ productivity may be increased: the development, adaptation and application of new technologies and farm management practices; and the wider application of existing technologies and practices. The first expands the potential for more productive use of existing resources by pushing out the production possibility frontier. The second allows farmers to achieve more of this potential.

**Innovation Systems for Family Farming**

Innovation happens when individuals and groups adopt new ideas, technologies or processes that, when successful, spread through communities and societies. The process is complex, involving many actors, and it cannot function in a vacuum. It is furthered by the presence of an effective innovation system. Among other things, an agricultural innovation system includes the general enabling economic and institutional environment required by all farmers. Other key components are research and advisory services and effective agricultural producers’ organizations. Innovation often builds on and adjusts local knowledge and traditional systems in combination with new sources of knowledge from formal research systems.

One fundamental driver for all innovators - including family farmers - is access to markets that reward their enterprise. Farmers with access to markets, including local markets, for their produce - whether it be food staples or cash crops – have a strong incentive to innovate. Technologies help farmers to enter the market by allowing them to produce marketable surpluses. Innovation and markets depend on, and reinforce, each other. However, investments in physical and institutional market infrastructure are essential to allow farmers to access markets both for their produce and for inputs. Efficient producers’ organizations and cooperatives can also play a key role in helping farmers link to input and output markets.

Because family farms are so diverse in terms of size, access to markets and other characteristics, general policy prescriptions are unlikely to meet the needs of all of them. Public support for innovation should take into consideration the specific structure of family farming in each country and setting, as well as the policy objectives for the sector.

Some family farmers manage large commercial enterprises and require little from the public sector beyond agricultural research to ensure long-term production potential and the enabling environment and infrastructure that all farmers need to be productive, although they may require regulation, support and incentives to become more sustainable. Other, very small, family farms engage in markets primarily as net food buyers. They produce food as an essential part of their survival strategy, but they often face unfavourable policy environments and have inadequate means to make farming a commercially viable enterprise.
Many such farmers supplement both income and nutrition from other parts of the landscape, through forests, pastures and fisheries and from off-farm employment. For these farmers, diversification and risk spreading through these and other livelihood strategies will be necessary. While agriculture and agricultural innovation can improve livelihoods, they are unlikely to be the primary means of lifting this group of farmers out of poverty. Helping such farmers escape poverty will require broad-based efforts, including overall rural development policies and effective social protection. In between these two extremes are the millions of small and medium-sized family farms that have the potential to become economically viable and environmentally sustainable enterprises. Many of these farms are not well integrated into effective innovation systems and lack the capacity or incentives to innovate.

Public efforts to promote innovation in agriculture for family farms must focus on providing inclusive research, advisory services, market institutions and infrastructure that the private sector is typically unable to provide. For example, applied agricultural research for crops, livestock species and management practices of importance to smallholders are public goods and should be a priority. A supportive environment for producer organizations and other community-based organizations can also help promote innovation among family farms.

**Promoting Sustainable Productivity on Family Farms**

Demand for food is growing while land and water resources are becoming ever more scarce and degraded. Climate change will make these challenges yet more difficult. Over the coming decades, tanners need to produce significantly larger amounts of food, mostly on land already in production. The large gaps between actual and potential yields for major crops show that there is significant scope for increased production through productivity growth on family farms. This can be achieved by developing new technologies and practices or through overcoming barriers and constraints to the adaptation and adoption of existing technologies and practices. Overcoming poverty in low- and middle-income countries also means boosting labour productivity through innovation on family farms as well as providing farming families with other opportunities for employment.

It is not enough to produce more. If societies are to flourish in the long term, they must produce sustainably. The past paradigm of input-intensive production cannot meet the challenge. Productivity growth must be achieved through sustainable intensification. That means, inter alia, conserving, protecting and enhancing natural resources and ecosystems, improving the livelihoods and well-being of people and social groups and bolstering their resilience - especially to climate change and volatile markets.

The world must rely on family farms to grow the food it needs and to do so sustainably. For this to happen, family farmers must have the knowledge and economic and policy incentives they need to provide key environmental services, including watershed protection, biodiversity conservation and carbon sequestration.

**Overcoming Barriers to Sustainable Farming**

Smaller family farms tend to rely on tried and trusted methods because one
wrong decision can jeopardize an entire growing season; but they readily adopt new technologies and practices that they perceive to be beneficial in their specific circumstances. Nevertheless, several obstacles often stand in the way of farmers adopting innovative practices that combine productivity increases with preservation and improvement of natural resources. Key impediments include the absence of physical and marketing infrastructure, financial and risk management instruments, and secure property rights.

Farmers often face high initial costs and long pay-off periods when making improvements. This can prove to be a prohibitive disincentive, especially in the absence of secure land rights and of access to financing and credit. Farmers are also unlikely to undertake costly activities and practices that generate public goods (such as environmental conservation) without compensation or local collective action. Furthermore, improved farm practices and technologies often only work well in the agro-ecological and social contexts for which they were designed, and if solutions are not adapted to local conditions, this can be a serious impediment to adoption.

Local institutions, such as producers’ organizations, cooperatives and other community-based organizations, have a key role to play in overcoming some of these barriers. The effective functioning of local institutions and their coordination with the public and private sectors and with farmers themselves, both men and women, can determine whether or not small family farms can introduce innovative, sustainable improvements suited to their needs and local conditions.

**Agricultural Research and Development: Focusing on Family Farms**

Investing in agricultural research and development (R&D) is important for boosting agricultural productivity, preserving the environment and eradicating poverty and hunger. A large body of evidence confirms that there are high returns to public investments in agricultural R&D. In many countries such investment is currently insufficient. Private-sector research is increasingly important, especially in high-income countries, but it cannot replace public research. Much agricultural research can be considered a public good, where the benefits of the knowledge generated cannot be appropriated by a private company and is therefore unlikely to attract the private sector. Returns to agricultural R&D often take a long time to materialize and, in addition, research is cumulative, with results building up over time. In this context, a continuous long-term public commitment to agricultural research is fundamental. Innovative forms of more short-term financing can help, but stable institutional funding is needed to maintain a core long-term research capacity.

All countries need a certain level of domestic research capacity because technologies and practices can rarely be imported without some adaptation to local agro-ecological conditions.

However, countries need to consider carefully what research strategy is best suited to their specific needs and capacities. Some countries, particularly those with too few funds to run strong national research programmes, may need to focus on adapting the results of international research to conditions at home. Others, with
bigger research budgets, may also want to devote resources to more basic research. The establishment of international partnerships and a careful division of labour between international research with broader applications and national research geared to domestic needs is a priority. There is also scope for South-South cooperation between large countries with major public research programmes and countries with less national research capacity facing similar agro-ecological conditions.

Research that meets the needs of family farms in their specific agro-ecological and social conditions is essential. Combining farmer-led innovation and traditional knowledge with formal research can contribute to sustainable productivity. Involving family farmers in defining research agendas and engaging them in participatory research efforts can improve the relevance of research for them. This may include working closely with producers’ organizations and creating incentives for researchers and research organizations to interact with family farms and their different members, including women and youth, and to undertake research tailored to their specific circumstances and needs.

Promoting Inclusive Rural Advisory Services

While investments in agricultural R&D are needed in order to expand the potential for sustainable production, sharing knowledge about technologies and innovative practices among family farmers is perhaps even more important for closing existing gaps in agricultural productivity and sustainability between developing and developed countries. Agricultural extension and advisory services are critical for this challenge, but far too many farmers, and especially women, do not have regular access to such services. Modern extension features many different kinds of advisory services as well as service providers from the public, private and non-profit sectors. While there is no standard model for delivery of extension services, governments, private businesses, universities, NGOs, and producer organizations can play the role of service providers for different purposes and for different approaches. Strengthening the various types of service providers is an important component of promoting innovation.

Governments still have a strong role to play in the provision of agricultural advisory services. Like research, agricultural advisory services generate benefits for society that are greater than the value captured by individual farmers and commercial advisory service providers. These benefits- increased productivity, improved sustainability, lower food prices, poverty education, etc.- constitute public goods and call for the involvement of the public sector in the provision of agricultural advisory services. In particular, the public sector has a clear role in providing services to small family farms, especially in remote areas, who are unlikely to be reached by commercial service providers and who may have a strong need for neutral advice and information on suitable farming practices. Other areas include the provision of advisory services relating to more sustainable agricultural practices, or for climate change adaptation or mitigation through reduced greenhouse gas emissions or increased carbon sequestration. The public sector is also responsible for ensuring that the advisory services provided by the private sector and civil society are technically sound and socially and economically appropriate.
For rural advisory services to be relevant and have the necessary impact, the needs of different types of family farms as well as different household members in farming families need to be addressed. Engaging women and youth effectively and ensuring that they have access to advisory services that take into account their needs and constraints are central to ensuring effectiveness. Participatory approaches, e.g. farmer field schools in which farmers learn from other farmers, peer-learning mechanisms and knowledge-sharing activities, provide effective means for achieving these aims. More information and evidence is needed on experiences with different extension models and their effectiveness. Efforts to gather and share such information should be promoted at the national and international levels.

**Developing Capacity for Innovation in Family Farming**

Innovation presupposes a capacity to innovate at the individual, collective, national and international levels. The skills and capacities of individuals involved in all aspects of the agricultural innovation system - farmers, extension service providers, researchers, etc. - must be upgraded through education and training at all levels. Special attention needs to be given to women and girls based on their needs and roles in agriculture and rural livelihood strategies. A further focus must also be on youth in general, who tend to have a greater inclination to innovate than elder farmers and represent the future of agriculture. If youth perceive agriculture as a potential profession with scope for innovation, this can have major positive implications for the prospects for the sector.

Collective innovation capacity depends on effective networks and partnerships among the individuals and groups within the system. Producers’ organizations and cooperatives are of particular importance. Strong, effective and inclusive organizations can facilitate the access of family farms to markets for inputs and outputs, to technologies and to financial services such as credit.

They can serve as a vehicle for closer cooperation with national research institutes; provide extension and advisory services to their members; act as intermediaries between individual family farms and different information providers; and help small farmers gain a voice in policy-making to counter the often prevailing influence of larger, more powerful interests. Furthermore, family farmers who depend on other resources, such as forests, pastures and fisheries can benefit by linking with producer organizations within these sectors. Linking producer organizations across these sectors can further strengthen the case for clear tenure rights and better coordination between policies and service providers.

At national and international levels, the right environment and incentives for innovation are created by good governance and sound economic policies, secure property rights, market and other infrastructure, and a conducive regulatory framework. Governments must support the development of effective and representative producers’ organizations and ensure that they participate in policy-making processes.
Micro-nutrient Security for India:
Priorities for Research and Action

Report by Indian National Science Academy, New Delhi

Recently, the Indian National Science Academy (INSA) brought out a position paper on “Nutrition Security for India—issues and the way forward” based on deliberations in a symposium and subsequent discussions. This policy paper has been prepared as an off-shoot of the earlier effort, to focus specifically on priorities for research and action, for addressing the issue of micronutrients (MN) deficiencies – the hidden hunger. (INSA, 2009 www.insa.ac.in). It is beamed at researchers, funding agencies and policy makers and planners.

Malnutrition in India, particularly among women, children and adolescents is an emergency needing immediate attention if the country has to have inclusive growth and development. Health portfolio tends to concentrate on infectious diseases (vaccination, oral rehydration, treatment of infections), and noncommunicable diseases like cancer and cardiovascular diseases. Important as these are, nutrition cannot be subsumed under these. Nutrition has to be the basis of judging national development. Without good nutrition, neither communicable nor non-communicable diseases can be controlled. Malnutrition is the worst form of noncommunicable disease and is an important risk factor for chronic diseases at a later date. Maternal malnutrition has multigenerational adverse effects on human health and development.

Nutrition Security implies ‘Physical, economic and social access to balanced diet, clean drinking water, safe environment, and health care’. Nutrition literacy and
leadership at all levels is needed to understand and act. After 63 years of independence, India has among the highest incidence of under-nutrition in the world. Almost 50 per cent of children under 5 are under weight (weight for age) and stunted (height for age). Over 30 per cent of adults are also undernourished. Besides deficiency of calories and protein, deficiency of micronutrients (MN) (vitamins and minerals) is rampant. MN deficiency is referred to as the hidden hunger since often times it is not an obvious killer or crippler, but extracts heavy human and economic cost. Though anthropometric deficits are attributed to protein calorie malnutrition, MN deficiencies contribute significantly, because MNs are needed for utilisation of proteins and calories and to fight infections from a young age.

MN deficiency has a complex aetiology. Besides poor diet (due to poverty, ignorance, low agricultural productivity, and cultural factors); inadequate access to safe drinking water, clean disease-free environment, and health-care outreach also contribute. Infections result in loss of appetite, impaired absorption and utilisation of nutrients, particularly micronutrients. Environmental xenobiotics also impair MN utilisation. The present paper specifically focuses on feasible approaches and research needed to improve dietary access to MN.

Magnitude of the Problem of Micro-nutrient Deficiencies in India

Among the MN deficiencies, iron deficiency anaemia (IDA) is the most serious public health problem. Estimates of IDA in women and children have varied from 50-70 per cent; pregnant women being particularly susceptible. Iodine deficiency disease (IDD) is another worrisome public health problem. Though, its magnitude has declined in recent years after the introduction of iodised salt, the problem still persists, and not confined to the Sub Himalayan regions as earlier thought. Fortunately, some of the severe vitamin-deficiency diseases such as beri beri (thiamine-vitamin B1 deficiency), pellagra (niacin deficiency), and scurvy (vitamin C deficiency) have disappeared. Blindness due to vitamin A deficiency and rickets due to vitamin D deficiency remain as clinical rather than public health problems. However, milder clinical manifestations and biochemical (sub-clinical) evidence of these deficiencies is rampant. Also osteoporosis in adults, particularly women after menopause due to calcium and vitamin D deficiency is common. Functional significance of sub-clinical MN deficiencies needs to be established.

Dietary Aetiology of MN Deficiency in India

Repeated diet surveys done by the National Nutrition Monitoring Bureau (NNMB) (National Institute of Nutrition, ICMR) in 9 states of India and some other surveys, indicate, the following.

Cereal-pulse based Indian diets are qualitatively deficient in micronutrients particularly iron, calcium, vitamin A, riboflavin and folic acid (hidden hunger), due to low intake of income-elastic protective foods such as pulses, vegetables particularly green leafy vegetables (GLV), fruits, and foods of animal origin. In recent years, there has been substantial erosion of area under cultivation of coarse grains and millets and share of these nutritious grains in total cereals produced and consumed.
More than 70 per cent of preschool children consume less than 50 per cent RDA of iron, vitamin A and riboflavin.

Within a family dietary deficits are more marked for preschool children due to inequitable distribution of food. This is because of lack of awareness of children’s nutritional needs, and inability of child to articulate. While income cannot be blamed if the family has enough food for adults, time constraint on the mother who has to go out to work to supplement the family income, is a factor. In recent years concern has been expressed about the inadequate intake of other micronutrients such as zinc, vitamin D, calcium and vitamin B12.

More research is needed to establish the extent of dietary deficiency and requirement of these nutrients.

**Consequences of Micro-nutrient Deficiencies**

Apart from human suffering due to morbidity and mortality, malnutrition in general and MN deficiencies in particular have a high economic cost. ‘Productivity losses due to poor nutrition are estimated to be more than 10 per cent of lifetime earnings for individuals, and 2-3 per cent of GDP to the nation. Cost of treating malnutrition is 27 times more than the investment required for its prevention’7. According to a panel of Nobel laureates, of the top 10 priorities selected for advancing global welfare using methodologies based on the theory of welfare economics, in Copenhagen Consensus, 2008, 5 were in the area of nutrition, micro-nutrient supplements, micro-nutrient fortification, biofortification, de-worming and other nutrient programmes at school and community level8. These are also needed to achieve the millennium development goals.

**Iron Deficiency Anaemia (IDA)**

Moderate and severe IDA adversely affects immunity (resistance to fight infections), cognitive and motor development, physical performance (and hence productivity) and reproductive health: (premature birth, low birth weight and perinatal mortality)9,10. It is estimated that anaemia is the direct cause of maternal deaths in 20 per cent and contributory cause in another 20 per cent. Apart from dietary deficiency, helminthic infections, inhibitors of iron absorption, in the diet and repeated pregnancies (in women) also contribute.

**Iodine Deficiency Disorder (IDD)**

Goitre is the clinical manifestation of iodine deficiency disorder. The functional consequences are: permanent brain damage, (cretinism, - mental retardation, and deaf mutism), reproductive failure, and decreased child survival. Milder deficiency also adversely affects mental development9,10.

**Vitamin A Deficiency (VAD)**

The earliest ocular manifestation of vitamin A deficiency (VAD) is night blindness, and Bitot spots on the white of the eye. Severe vitamin A deficiency leads to keratomalacia (ulceration and sloughing of the cornea) and total blindness. Though keratamalacia is no longer a public health problem, night blindness is prevalent
particularly in pregnant mothers and subclinical deficiency (low Serum levels of Vitamin A), is still encountered. In addition to the ocular manifestations, vitamin A deficiency has been shown to cause growth retardation, decreased resistance to infections, and even death\(^9,10\). Opinion regarding efficacy of vitamin A supplementation in reducing mortality even in populations with sub-clinical vitamin A deficiency is however divided\(^11,12,13\).

**B-Complex Deficiencies**

Though there is marked dietary, biochemical and clinical evidence of riboflavin (vitamin B2) deficiency (metabolically a very important vitamin), it has not received adequate attention because its deficiency is neither a killer nor a cripper. Impaired psychomotor performance in school children and adults and impaired reproduction in animals associated with riboflavin deficiency has been reported\(^9,10,14\). There is evidence of dietary and biochemical folic acid deficiency in India\(^9,10\). It can cause megaloblastic anaemia due to impaired red cell maturation. Folic acid deficiency has also been implicated in congenital malformation (neural tube defects), Folic acid supplementation in early pregnancy or even pre-pregnant state has been shown to prevent it. Folic acid deficiency leads to raised levels of serum homocysteine – an independent risk factor for cardiovascular disease (CVD)\(^9,10,15,16\). Fragmentary evidence suggests that Indians do tend to have high levels of homocysteine which responds to treatment with folic acid\(^16\). Till recently, vitamin B12 deficiency was not considered to be a problem in India since its daily requirement is only 1 microgram. However, reports of vitamin B12 deficiency in developing countries like India and its link with homocysteinaemia, besides megaloblastic anaemia, have started appearing\(^17\). Both folic acid and B12, besides vitamin B6 and B2 are required for homocysteine metabolism.

*In view of the rising incidence of CVD in India, B-complex vitamin deficiency needs to be taken more seriously and its link with homocysteinaemia and CVD needs to be investigated. Research is also needed to examine the role and dosage of folic acid for prevention of neural tube defects—which are not uncommon in India. A balance of folic acid with vitamin B12 has to be ensured.*

**Vitamin D Deficiency**

Main function of vitamin D is in bone calcification by facilitating calcium absorption and maintaining blood calcium levels. Since generation of vitamin D in the skin from its precursor 7-dehydrocholesterol is through exposure of skin to sunlight, adequacy of vitamin D in a tropical country like India was assumed. However, recent studies suggest existence of vitamin D deficiency in all age groups in India. As mentioned earlier, osteoporosis associated with calcium and vitamin D deficiency is common in post-menopausal women. Low levels of vitamin D are also associated with chronic diseases like certain malignancies, and chronic inflammatory and autoimmune diseases like type 1 diabetes, and impaired resistance to infections\(^5,9,10\). However, according to a recent review “Health-benefits often reported in the media—were from studies that provided often mixed and inconclusive results and could not be considered reliable”\(^5\).
Research is needed to determine the dietary requirement of vitamin D to ensure adequate vitamin D status.

**Vitamin C Deficiency**

Vitamin C is a powerful antioxidant. Dietary vitamin C deficiency does exist, but severe clinical manifestation (scurvy) has become rare. Vitamin C is an iron absorption promoter and hence its deficiency can contribute to IDA. Antioxidants delay degenerative diseases\(^9,10\).

**Zinc Deficiency**

Zinc is essential for growth and development. Zinc supplementation has been reported to help linear growth, reduce severity and duration, of diarrhoeas, and respiratory infections and reduce child mortality\(^10\).

The magnitude and consequences of zinc deficiency in India need to be determined. For the purpose suitable indicators have to be developed to assess zinc deficiency.

**Strategies for Increasing Access to Micronutrients – Current Response and Research Opportunities**

Basically there are four types of approaches to augment MN intake. 1) Pharmaceutical supplements, 2) Food fortification 3) Biofortification and 4) Food fortification (dietary diversification).

**Micronutrient Supplementation**

**National Nutritional Anaemia Control Programme (NACP)**

In this programme supplements containing 100 mg of elemental iron + 500 ìg folic acid are given to pregnant women for 100 days during pregnancy; 20 mg elemental iron and 100 ìg folic acid are given daily to preschool children for 100 days in the year.\(^9,10\) Recently adolescent girls have also been included as part of the life cycle approach with same dose as pregnant women, and weekly once administration throughout the year. Unfortunately despite scientific basis for the programme, ironfolic acid supplementation has failed to have an impact on the incidence or severity of anaemia, allegedly due to 1) lack of awareness regarding its importance and consequently poor compliance and 2) poor outreach in a vast country like India. NFHS 3 survey shows less than 20 per cent full compliance in pregnant and lactating women.\(^4\) 3) Uniformly giving one tablet of IFA (which is meant for preventing anaemia in non-anaemic women) regardless of the severity of anaemia. Screening of all pregnant women for anaemia and treatment of anaemic women besides the prophylactic treatment with iron, folic acid has been recommended to reduce the prevalence and severity of anaemia in pregnancy.

**Suggestions for Research to Improve NACP**

Public-private-NGO partnership may have a role in improving the outreach. Absorption of non-haeme Iron from the diet is only 3-5 per cent. The challenge is to translate filling of iron stores in to improvement in haemoglobin.
Research is needed to find out socio-cultural, behavioural factors and administrative bottle neck to improve the efficiency of NACP.

All pregnant women should get Hb estimation done using reliable method and anaemic women treated with appropriate route and dose of iron, folic acid.

Children coming to hospital for any illness and undernourished children should be screened and those found anaemic should be appropriately treated.

Prevalence of iron, folic acid and B12 deficiency in non anaemic and anaemic pregnant women in different regions of the country should be assessed to find out if the current practice of prescribing iron and folic acid without B12 is appropriate.

Efficacy of present regimen of giving uniformly one tablet of iron–folic acid needs re-evaluation and replaced with treatment after screening.

Since nutrients, besides iron and folic acid, are also involved in haemoglobin synthesis/formation of red blood cells/absorption of iron, inclusion of MN like vitamins B12, C, B2, and zinc may improve the efficacy of the oral supplements.

Clinical research in a hospital setting with appropriately worked out dose and schedules for multi-vitamin supplements Vs IFA supplements should be conducted.

Massive Dose Vitamin A Supplementation to Prevent Nutritional Blindness

In this programme children between 6-60 months are given 200,000 IU of vitamin A, every six months as prophylactic dose. The rationale is: vitamin A being fat soluble, is stored in the liver and a massive dose would ensure adequate storage to last for at least 6 months. This programme also suffers from the infirmity of the other programmes viz., poor outreach, inadequate and irregular supplies. As mentioned earlier the severity of vitamin A deficiency has reduced despite inefficient operation of this programme and several eminent nutrition scientists have raised doubts about its continuation[11,12,13]. However, as of now, this programme should continue in areas where vitamin A deficiency is a public health problem (incidence of Bitot spots more than 0.5 per cent).

According to the Annual Report of Micronutrients Initiatives India, an International Non Government Organization, out of 32 Million US Dollars available in the Annual Budget 2009-2010, more than 20 Million US Dollars were spent on Vitamin A Procurement and Interventions. A meager sum of 2.5 Million US Dollars was spent on Iron interventions (Umesh Kapil, personal communication). Children with VAD should be identified and should be administered VA. The present Universal VAS approach needs to be reviewed.

There is need for operation/translational research to improve efficiency of the programme

Food Fortification

Iodised Salt

Food fortification is a powerful method of reaching out a deficient nutrient to populations, provided the vehicle used for fortification is consumed by the poorest of
the poor. In India salt is the only such vehicle and it has been effectively used for reaching out iodine. This is one successful programme in the country\textsuperscript{3,9}, but its efficiency has to be improved in terms of stability of iodine in the salt, pricing, and outreach. Private companies tend to seek easy urban markets even if the problem is more acute elsewhere.

**Iron Fortified Iodised Salt (IFIS, also called Double Fortified Salt-DFS)**

This technology was developed by the National Institute of Nutrition, Hyderabad to address the dual problem of iron and iodine deficiency.\textsuperscript{9,10,18} Government order for its production has been released. Its efficacy has been tested in small scale studies.

*Systematic programme for scaling up is needed to examine the effectiveness of DFS in preventing iron and iodine deficiency and replacing iodised salt with IFIS. Evaluation of DFS should be done by an independent agency rather than ICMR.*

**Iron Fortified Wheat Flour (Atta) and Rice**

Since staple grains are consumed in substantial quantity, their fortification makes sense. In some countries wheat flour is fortified with iron and other micronutrients. Doubts have been raised about bio-availability of iron from wheat ‘atta’ because of high phytate (inhibitor of absorption) content. The inhibitory effect of phytate may be bypassed by some potential compounds like Na-Fe-EDTA and or enzyme phytase. The higher cost of this salt may be off-set by better bioavailability and hence lesser dose of fortification.

For more than a half the population in India, rice is the staple. Fortification of rice has been tried by mixing fortified extruded grains from rice flour with rice (Ultra rice). More research is needed to make this technology cost-effective and acceptable.\textsuperscript{19}

*Programmatic studies are needed to examine the effectiveness of fortifying cereals with iron.*

**Fortification of Cereal Products with Folic Acid**

In many countries, cereal products are fortified with folic acid to reduce the incidence of neural tube defects. Folic acid fortification, perhaps along with vitamin B12 may also reduce serum homocysteine levels.

*In view of the rising incidence of CVD in India, this strategy needs to be researched.*

**Fortification of Oil with Vitamins A and D**

Gujarat has taken the initiative. *Impact studies are needed.* Fortified oil should be packed in dark bottles to cut off UV radiation, and prevent oxidation of vitamin A. Vehicles like sugar or soya sauce used in some countries are not suitable for India.

**Fortification of Food for Supplementary Feeding**

India has large feeding programmes like supplementary feeding of preschool children through ICDS and school children through Mid Day Meal. Opinion of nutritionists is divided about fortifying these foods with MNs – sprinklers (micronutrient powder- MNP), spreads.
Well planned field research to examine efficacy, feasibility and cost of fortification vs. enrichment with MN rich foods, of meals for supplementary feeding need to be undertaken. Impact of Golden rice rich in provitamin A, ultra rice rich in iron and other MN and red palm oil in feeding programmes needs to be researched for feasibility, acceptability and cost effectiveness.

Food fortification is suitable only for prevention of MN deficiencies and not for treating severe forms of the disease. Food fortification programme for country should consider the Recommended Dietary Allowances (RDA) of different nutrients for Indians, the types of foods to be fortified, nutrients to be added and the percentage of the RDA to be supplied through fortification etc. to avoid excess intakes by the rich and deficient intakes by the poor. Fortified foods should be affordable by the poorest of the poor, and reach the unreachable in a vast country like India.

Bio-fortification

Enriching germplasm with MNs through conventional breeding methods, molecular breeding and genetic engineering is a promising method for increasing dietary access to MNs. Bio-fortification is a sustainable intervention being a seed-based technology. There is no recurring cost, once the varieties are developed and adopted. It can benefit the farmer as well as the consumer if the cost of seed is kept low and not exploited by seed companies. Bio-fortified plants grow better. Potential nutritional impact of iron biofortificaion in India seems to be encouraging. The Harvest Plus: bio-fortification challenge programme is an interdisciplinary, global alliance of research and implementing institutions. India is part of this. It includes: α–carotene (pro-vitamin A)- rich sweet potato, and cassava, zinc and iron rich rice, wheat, maize, pearl millet, and beans. DBT network project on biofortification of rice, wheat and maize is currently being implemented by ICAR Institutions and state agriculture universities and National Institute of Nutrition. Golden Rice rich in provitamin A; high- iron rice (high ferritin gene from mangrove); are examples of transgenic technologies.

For conventional breeding or molecular breeding to improve the MN content of foods, sufficient within species diversity with appropriate gene pool would be necessary. Also this approach is slow. GM route with genes from other plant species, preferably edible varieties, is faster and with suitable safe guards regarding safety to health, protection of biodiversity, and cost; is a useful option for a country like India. While the conventional strategies of food fortification and plant breeding to improve nutritional quality should be pursued, the GM technology despite some concerns needs to be vigorously investigated. This technology has received support from many science academies of the world including Indian academies.

Food–Food Fortification – Dietary Diversification

The problem of MN deficiency can to a great extent be addressed by encouraging dietary diversification and household access to MN-rich foods. Overall emphasis of agriculture, horticulture and livestock breeding has been to ensure calories, income and export. MNs are not on the antenna of agriculture planning. Decentralised planning to ensure district, village and household level adequacy of MN- rich foods
is required. India being a vast country, long distance transport of perishable foods like vegetables and animal products may not be feasible. Promotion of homestead gardens even in urban areas, with emphasis on MN-dense varieties, back-yard poultry, dairy, fish ponds etc is needed.

**Operation research to study the impact of such a strategy needs high priority. Farm based approaches are low-cost, and sustainable if the community is empowered.**

While it may be difficult to meet the requirement of some nutrients like iron and riboflavin through low-cost diets, there is ample supply of â-carotene (pro-vitamin A) in nature in green leafy vegetables and yellow orange fruits and vegetables. This wealth needs to be exploited through education and advocacy. Low bio-availability of beta carotene is an issue. Food habits may be hard to change.

**Research is needed to establish the factor for conversion of â-carotene to vitamin A and improve its bioavailability. Red palm oil is an important source of â-carotene and can be used in supplementary feeding programmes if supply and acceptability can be assured.**

Absorption and utilisation of micronutrients is influenced by competition between nutrients, (particularly minerals and trace elements), and other biotic (microorganisms, helminthic) and a-biotic (chemical agents like phytates, tannins, xenobiotics etc).

**These influences have to be researched to improve utilisation of dietary MNs. Treatment with phytases and tannases needs to be considered.** Bioavailability studies to examine the interaction within nutrients, and between nutrients and promoters, inhibitors and xenobiotics (biotic and abiotic), have to be planned.

**Enhanced Production to Consumption of Millets and Pulses**

MN rich coarse grains and millets are being forgotten. They are referred to as orphan grains, but with the threat of global warming, they may well be the grains of the future. There is 2-3 fold gap between optimal productivity of millets and farm-level productivity. Apart from being high in proteins, pulses are also rich in MN. Their production and consumption is on the decline.

**Productivity of these grains has to be increased through research and robust extension effort. Agriculture research needs to give high priority to millets and pulses – a production to consumption strategy.** Some of the World Bank funded National Agriculture Innovation Projects (NAIP) are attempting to do that.

**Plant Foods as Speciality Foods for Protection against Chronic Diseases**

This is a vast field for research since plant foods are rich in health giving phytochemicals-nutraceuticals. Some nutrients like vitamin C, E, Se also have antioxidant properties.

**Economic Logic**

World Bank has compared the benefits of MNs (iron) supplementation vs. Food fortification in terms of 1) cost per life saved, 2) productivity gained- a measure of
efficient use of resources and defined as least cost discounted method of reducing clinical deficiency in the population and 3) social benefit cost- DALY or healthy life years saved. For saving life at least cost, targeted iron supplementation to pregnant women is more effective than iron fortification of flour or other staple. However, for enhanced productivity delivered by a programme and social benefit cost, iron fortification is most cost effective (For details see, Hunt\textsuperscript{23}).

Similar analysis is needed in the Indian context. Farm-based interventions are believed to have high benefit-cost ratio in terms of economic cost. They also help the farmer and empower the community.

**Food Analysis**

India is rich in biodiversity with lots of local foods with potential benefits in terms of MN as well as health-promoting phytochemicals. Food analysis labs equipped to do co-ordinated MN analysis with proper quality control should be set up in agriculture universities and home science colleges which have the expertise and country-wide research programmes to analyse local foods and identify MN rich foods should be started so that their production and consumption can be enhanced.

**Food Storage and Processing**

Almost 30 per cent of farm food perishes due to lack of storage facilities and value addition. Development of suitable storage structures not only for grains but also for vegetables, fruits and animal products and promoting those which are already available is urgently needed. There are indigenous time-tested traditional technologies for storage. Those have to be re-discovered and promoted.

Value addition should not take away food from the poor. Both, high-end and low-cost, processed foods need to be developed with public private partnership, with the triple objectives of reducing wastage, generating employment and enhancing nutrition value and security.

**Bioavailability and Stability of Micronutrients in Processed Foods**

While minerals are reasonably stable during processing, vitamins, particularly vitamins A and C are sensitive to light and heat. Microencapsulation is done to increase the stability, but that increases the cost. Low-cost technologies to increase the bioavailability and stability of MNs in processed foods are needed to make processed foods accessible to all sections of the society.

**Nutrition Security and Climate Change**

Rise in temperature due to climate change is associated with increase in atmospheric carbon dioxide. While the latter helps to increase plant growth if there is enough supply of other nutrients in the soil, in tropical climate, further temperature rise has an adverse effect. It is suspected that apart from plant growth, climate change may also affect the nutrient composition (protein and minerals) in foods. No information is available on vitamin content of foods and climate change\textsuperscript{24}. 
Impact of climate change on productivity and nutrient composition of major food items in India needs to be researched.

Monitoring, Surveillance and Management Information System for Early Detection

India needs a robust monitoring and surveillance programme in nutrition for early identification of the problems and capacity building to tackle them in a decentralized way. For every frank case of deficiency, there are dozens of others who suffer from subclinical deficiencies which contribute substantially to human suffering, medical expenses and economic cost.

*Sensitive biochemical and functional tests to detect such deficiencies, using new knowledge of molecular and cellular biology and state of the art instruments need to be developed.*

Nutrition and Health Education

Behavioural Change Communication (BCC) programmes to targeted audience can improve both nutrition and health status. Nutrition education for professionals-(agriculture, medical, social scientists and others), needs to be strengthened.

*I Innovative strategies need to be developed and tested not only to improve knowledge and attitudes but practices as well. Behavioural modification modules are needed. Nutrition education policy is nonexistent. Awareness among school children, teachers, consumers and women has to be enhanced. Women empowerment is essential to improve diets and health. Nutrition component of medical and agriculture curricula needs to be strengthened.*

Conclusion

The current mindset of looking at food security only in terms of energy security has to change. Pumping cereals alone to quench hunger will not ensure nutrition and health. The goal should be to ensure a balanced diet adequate in macro- and micronutrients. Laboratory, clinical, and community (operations)-based research is needed to ensure MN security. An optimum mix of food-food fortification, (dietary diversification), biofortification, and early detection and effective treatment of clinical deficiencies needs to be worked out. Extension methodology has to be robust. Media support for creating awareness and compliance is important. The most important low-cost intervention is following WHO guidelines for breast feeding- early initiation, exclusive breast feeding for 6 months and complimentary feeding with continuation of breast feeding up to 1 year. This requires media blitz to educate the community.

Summary Table of Recommendations for Research and Action

The following table attempts to prioritize the suggestions made as priority 1+ (very high), which has evidence-based strength and need immediate action and scale up. Priority 1, (high) has some evidence, but needs more research. Priority 2 (moderately high) needs more evidence and research inputs. Research areas have been grouped under: 1. Translational and operation research other than agriculture, 2. Laboratory, clinical and controlled field research (other than agriculture),...
3. Agriculture. The term agriculture includes horticulture, livestock and fisheries. Nutrition being a complex and multidimensional subject, inputs are needed from various areas and hence the wish list is long.

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Research Area</th>
<th>Type of Research</th>
<th>Agency Priority</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Improve the efficiency of Micronutrient supplementation programmes-NACP, Massive dose vitamin A supplementation, iodised salt distribution</td>
<td>Multi-dimensional investigations to find out administrative and outreach bottlenecks and socio cultural, behavioural factors</td>
<td>Health ministry should contract it out to a good management research group</td>
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<td></td>
<td></td>
<td>Efficacy of present regimen of giving uniformly one tablet of iron-folic acid needs re-evaluation and replaced with treatment of anaemia with higher dose after screening.</td>
<td>ICMR</td>
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<tr>
<td>2.</td>
<td>Replace iodised salt with iron fortified, iodised salt (double fortified salt)</td>
<td>Study the effectiveness, and acceptance in a scaled-up programme</td>
<td>ICMR, Ministry of Health, Ministry of</td>
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<td>Civil supplies, Private sector, Home Science Colleges</td>
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<td>3.</td>
<td>Nutrition monitoring, surveillance and management information system (MIS)</td>
<td>Put in place effective system for early detection of nutritional problems in the community</td>
<td>Ministry of Health in collaboration with ICMR, Dept. of Women and Child Development and Department of Space, Home Science Colleges</td>
</tr>
<tr>
<td>4.</td>
<td>Infant and child feeding-promotion of breast and complimentary feeding according to WHO norms</td>
<td>Large scale awareness programme through media blitz</td>
<td>Ministry of Health, HRD, I and B, Space, Home Science Colleges etc.</td>
</tr>
<tr>
<td>5.</td>
<td>Fortification of cereals-wheat flour and rice with iron</td>
<td>Investigate the effectiveness, outreach, and cost benefit ratio.</td>
<td>ICMR, CSIR, DST, DBT, Ministry of Health, Ministry of Food processing industries, international agencies</td>
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<td></td>
<td></td>
<td>2. Nutrition education at all levels</td>
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<td>7.</td>
<td>Fortification of oil with vitamins A and D- Gujarat experiment</td>
<td>Investigate the effectiveness/cost benefit ratio, stability of the fortificants. Learn from Gujarat</td>
<td>Gujarat state government, ICMR, Ministry of Health</td>
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<tr>
<td>Sl.No.</td>
<td>Research Area</td>
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</tr>
<tr>
<td>1.</td>
<td>Multi nutrient pill containing besides iron and folic acid, zinc, and vitamins B12, B2 and C for anaemia prophylaxis</td>
<td>Controlled laboratory and clinical trials to examine the efficacy, and cost benefit</td>
<td>ICMR</td>
</tr>
<tr>
<td>2.</td>
<td>Bioavailability studies to examine interaction between nutrients and promoters and inhibitors-biotic and abiotic</td>
<td>Select research studies at institutional level</td>
<td>ICMR, ICAR, CSIR, DST, DBT</td>
</tr>
<tr>
<td>3.</td>
<td>Bioavailability of beta-carotene from plant foods - Conversion factor for beta carotene to vitamin A in Indian context. Effect of vitamin A deficiency</td>
<td>Controlled laboratory and clinical studies</td>
<td>ICMR, CSIR, DBT</td>
</tr>
<tr>
<td>4.</td>
<td>Role of B-vitamins deficiencies in aetiology of raised levels of homocysteine--an independent risk factor for CVD. Genetic predisposition</td>
<td>Controlled laboratory and clinical studies</td>
<td>ICMR, CSIR, DBT</td>
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<td>5.</td>
<td>Development of non-invasive methods for assessing MN status. e.g. Dry blood spot method</td>
<td>Laboratory studies in select well equipped institutions.</td>
<td>ICMR, ICAR, CSIR, DST, DBT</td>
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<td>6.</td>
<td>Ready to cook, MN fortified foods suitable for institutional meals-ICDS, MDM, and homes. Comparison with food-food fortification with vegetables, fruits and products like red palm oil</td>
<td>Field studies to compare chemical fortification with food-food fortification</td>
<td>ICMR, ICAR, CSIR, DST, DBT, Ministry of Food Processing industries, NGO, Home Science Colleges</td>
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<td>7.</td>
<td>Assessment of the magnitude of deficiency and requirement of less-recognised MN like zinc, vitamin B12, an vitamin D by developing appropriate laboratory tests</td>
<td>Laboratory studies in select well equipped institutions.</td>
<td>ICMR, CSIR, DST, DBT</td>
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<td>8.</td>
<td>Functional significance of subclinical MN deficiencies</td>
<td>Laboratory/clinical studies in select well equipped institutions.</td>
<td>ICMR, CSIR, DST, DBT</td>
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<tr>
<td>9.</td>
<td>Plant foods containing nutraceuticals as speciality foods</td>
<td>Laboratory and clinical studies in select institutions.</td>
<td>ICMR, CSIR, DST, DBT</td>
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<tr>
<th>Sl.No.</th>
<th>Research Area</th>
<th>Type of Research</th>
<th>Agency</th>
<th>Priority</th>
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<tbody>
<tr>
<td>10.</td>
<td>Bioavailability and stability of MN in processed foods</td>
<td>Laboratory and field studies</td>
<td>CSIR, DST, DBT, Ministry of Food Processing Industries</td>
<td>II</td>
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<td></td>
<td>Agriculture, (including horticulture livestock research)</td>
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<tr>
<td>1.</td>
<td>Increased production to consumption of pulses, coarse grains and millets</td>
<td>Agriculture extension work to bridge the productivity gap where products exist</td>
<td>ICAR, Central and State Agriculture Universities, Home Science Colleges, ICMR</td>
<td>I+</td>
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<td>2.</td>
<td>Food-food fortification-dietary diversification through decentralized agriculture planning, including homestead production</td>
<td>Field trials to examine the impact of village-level and household production of vegetables, fruits, dairy, and poultry, fish using improved varieties, on household food security</td>
<td>ICAR, Central and State Agriculture Universities, Home Science Colleges, ICMR, NGOs</td>
<td>I+</td>
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<tr>
<td>3.</td>
<td>Biofortification using conventional and molecular breeding</td>
<td>Research and development. Scaled up field trials with products available</td>
<td>DBT, ICAR, Central and State Agriculture Universities</td>
<td>I+</td>
</tr>
<tr>
<td>4.</td>
<td>Genetic engineering to develop micronutrient - enriched foodgrains, vegetables and fruits</td>
<td>Research for health and environment safety etc. Develop new products.</td>
<td>ICAR, Central and State Agriculture Universities</td>
<td>I</td>
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<tr>
<td>5.</td>
<td>Golden rice to improve vitamin A nutrition</td>
<td>Validation studies</td>
<td>ICMR, ICAR, DBT</td>
<td>I</td>
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<tr>
<td>6.</td>
<td>Development of storage and packaging methods to preserve the MN content of foods, and prevent infestation.</td>
<td>R&amp;D work, identification of time tested traditional methods. Promotion of methods already developed</td>
<td>CAR, Home Science Colleges</td>
<td>I</td>
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<td>7.</td>
<td>Analysis of local foods for micronutrients and health promoting phytochemicals. (These can also be resource for molecular breeding studies)</td>
<td>A large scale multi-centric effort using quality control at reference laboratories</td>
<td>Select institutions from ICAR, Agriculture Universities, Home Science Colleges with NIN and CFTRI as reference laboratories</td>
<td>II</td>
</tr>
<tr>
<td>8.</td>
<td>Impact of climate change on productivity and micronutrient content of staple foods</td>
<td>Controlled simulation studies in agriculture institutions and select laboratories</td>
<td>ICAR, DBT, Agriculture Universities</td>
<td>II</td>
</tr>
</tbody>
</table>

### References


7. Coalition for sustainable nutrition security for India, Leadership agenda, 2010; http://www.nutritioncoalition.in/publication.asp


During the era of Green Revolution, introduction of high-yielding varieties, extension of irrigated areas, use of high analysis NPK fertilisers and increase in cropping intensity, propelled India towards self-sufficiency in food production. In the process, relative contribution of organic manures as a source of plant nutrients vis-a-vis chemical fertilizers declined substantially. With increase in cost of production inputs, inorganic fertilizers became increasingly more expensive. Another issue of great concern was the sustainability of soil productivity as land began to be intensively tilled to produce higher yields under multiple and intensive cropping systems. Water logging and secondary salinisation have been the banes associated with excess and irrational irrigation. Groundwater table declined sharply as more and more deep bore wells were drilled. Recharging of groundwater has also been reduced due to severe deforestation. Indiscriminate use of chemical pesticides to control various insect pests and diseases over the years, has destroyed many naturally occurring effective biological control agents. An increase in resistance of insect pests
to chemical pesticides has also been noticed. Health hazards associated with intensive modern agriculture, such as pesticides residues in food products and groundwater contamination are matter of concern. The occurrence of multi-nutrient deficiencies and overall decline in the productive capacity of the soil due to non-judicious fertiliser use, have been widely reported. Such concerns and problems posed by modern-day agriculture gave birth to new concepts in farming, such as organic farming, natural farming, biodynamic agriculture, do-nothing agriculture, eco-farming, etc. The essential features of such farming practices imply, i.e., back to nature.

**Organic Farming and Country’s Food Security**

The primary concern of all organized communities and civilized societies is to meet the food requirements of its people. The cultivated area required to maintain the present level of food grain production in India without using the fertilisers, reaches more than the total geographical area of the country. At present, there is a gap of nearly 10 million tones between annual addition and removal of nutrients by crops which are met by mining nutrients from soil. A negative balance of about 8 million tones of NPK is foreseen in 2020, even if we continue to use chemical fertilizers, maintaining present growth rates of production and consumption. The most optimistic estimates at present, show that only about 25-30 per cent nutrient needs of Indian agriculture can be met by utilizing various organic sources. It is proved beyond doubt that on long-term basis, conjoint application of inorganic fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality and soil productivity. The organic sources should be used in integration with chemical fertilizers to narrow down the gap between addition and removal of nutrients by crops as well as to sustain soil quality and to achieve higher crop productivity. The food security demand of the country requires that inorganic fertilizers be used in balanced doses.

**Issues**

Organic farming has the twin objectives of the system being sustainable and environmentally benign. In order to achieve these two goals, it has developed some rules and standards which must be strictly adhered to. There is a very little scope for change and flexibility. Organic farming thus, does not require best use of options available but the best use of approved options. These options are usually more complex and less effective than the conventional ones. The philosophy of the proponents of organic farming presents considerable difficulty to the scientists as the organic movement generally resists the comparisons between the two systems.

The organic farming movement presents a challenge to the scientists who cannot and would not want to abandon a scientific approach. The present lower productivity of the system is a result of constraints that its practitioners have put upon themselves. Difficulty faced is with evangelising statements, that the products of the organic farming system - food and fibre - are in some way better than those from conventional agriculture. The Indian farmer should get the advantage of emerging global market on organic farming which is at present around 26 billion US dollars, and is expected
to grow to 102 billion US dollars in 2010. Currently, 130 countries are producing certified organic products. A vast scope for promotion of organic farming in the export market, without compromising with the national food security exists in the country, as farming by tribals and under rainfed conditions is generally organic, since very little chemical inputs are used.

Organic farming as a concept/philosophy is well tested in some of the western countries, though the same is not unknown to most of the nations. But in the Indian context, it needs to be looked into more critically, seeking answers to the following questions: What level of crop productivity is acceptable? Is it suitable for a country like India with such a large population to feed or can it fit in the niche areas? Are available organic sources of plant nutrients sufficient for organic farming in the form it is advocated? Are organic farming technologies sustainable in the long run?

Various aspects relating to organic farming were addressed and discussed in a workshop organised by the NAAS. Following issues were taken up:

- Redefining the concept of organic farming in Indian context.
- Opportunities and constraints in organic agriculture.
- Organic agriculture perspective and future challenges.
- Soil quality, biodiversity and fertility in organic farming system.
- Standards in organic farming and quality markers for organic produce.
- Setting up of certification and accreditation agencies for export.
- Setting up of testing units for soil and organic produce for chemical residues and quality control.
- Market development and assessment of organic produce for export.
- Evaluation of organic/biodynamic farming vis-a-vis integrated nutrient and pest management.
- Documentation and confirmation of existing Indigenous Technological Knowledge (ITK) on biodynamic farming.
- Development of bio-control measures for various plant diseases and pests.
- Research agenda for comparing organic and conventional agriculture.
- Holistic approaches in organic farming research and development.

**Recommendations**

Major recommendations that emerged from the workshop are listed below:

**1. Organic Farming: Prospects and Limitations**

- For India with its ever increasing population, the sustainable agriculture has to be based on site-specific balanced and adequate fertilization, and an integrated plant nutrient supply system (IPNS) involving organics, inorganics and biofertilizers. What the country needs today, is the conjunctive use of organic and inorganic sources of plant nutrients for sustainable productivity.
Organic farming is a market demand-driven agriculture, aimed to cater to the foreign export and affluent section of the society in the country. However, in order to make a dent in the export market, we need to develop high-tech organic technology with strict quality control, meeting international quality standards prescribed for organic produce.

Niches of the organic farming need to be identified. However, the real niches will be determined by the market infrastructure and the international links. The practice should be considered for lesser endowed regions of the country rather than in resource endowed regions which serve as the backbone of the country’s food security.

The availability of organic manures in adequate amounts and at costs affordable by the farmers is a major problem. The increased mechanization has further reduced the availability of manures with the farmers and this problem will become more acute in future. In such circumstances, post-harvest residues should be utilized to the fullest extent. However, to accomplish this objective, feasible technologies are needed for in situ recycling/rapid composting of on-farm residues and wastes, in addition to extension efforts to change the mindset of the farmers. Possibilities of using non-traditional organic sources e.g., slaughter house waste, should be exploited to partly supplement, plant nutrient needs of the organic farming systems.

2. Organic Farming: Its Relevance to Indian Agriculture

In Indian context, organic farming has to be practiced without synthetic pesticides, but complete exclusion of fertilizers may not be advisable under all situations. A holistic approach involving integrated nutrient management (INM), integrated pest management (IPM), enhanced input-use efficiency, and adoption of region-specific promising cropping systems would be the best organic farming strategy for India.

As organic farming is attracting worldwide attention, and there is a potential for export of organic agricultural produce, this opportunity has to be tapped with adequate safeguards so that the interest of small and marginal farmers is not harmed.

Organic farming may be practiced in crops, commodities and regions where the country has comparative advantage. To begin with, the practice of organic farming should be for low volume high-value crops, like spices, medicinal plants etc., beside fruits and vegetables, for which R and D support is required.

Organic farming should not be confined to the age old practice of using cattle dung, and other inputs of organic/biological origin, but an emphasis needs to be laid on the soil and crop management practices that enhance the population and efficiency of below-ground soil biodiversity to improve nutrient availability. Performance of cultural techniques for weed control and that of biopesticides for pest management need to be evaluated under
field conditions, preferably under cultivators’ management conditions. Besides the identification of regions suitable for the adoption of organic farming, the crops and their products should also be identified which are amenable for production through organic ways and have the potential to fetch a premium price in the international organic market.

3. Organic Farmers and NGOs

☆ Region-specific resource inventory, including animal wealth, farm residues/by products and their competitive uses, nonconventional nutrient sources of organic/biological origin etc., has to be prepared, for development of rational technology packages of organic farming.

☆ A strong technological back-up by scientific community should be provided in order to verify, confirm and further refine some selected ITKs like, Agnihotra, Panchgavya, pertaining to organic farming.

☆ Crop-specific and farming situation-specific package of practices for organic cultivation should be developed and after thorough on-farm validation, recommended for adoption. Such proven technology packages need to be documented in regional languages.

☆ Entrepreneurial potential with respect to production of organic inputs, processing and marketing of organic food should be fully exploited.

4. Trade and Certification Issues

☆ Certification of organic produce is an important issue that is central to organic production itself, as the prime goal of organic farming is and will be to fetch premium price in domestic and international market for the producers.

☆ For desired economic gains out of organic farming, the upcoming global market on organic produce has to be exploited, for which strict phyto-sanitary measures have to be followed.

☆ A strong research back up has to be put in place to develop and improve national standards for organic farming. The policy documents brought out so far by APEDA and DAC, including the report of Task Force on Organic Farming etc., should be considered in developing such scientifically sound standards, mainly for the crops and commodities that have export potential. The national standards should be the same for domestic market and for export.

☆ Weak links in the certification systems have to be identified and researchable areas flagged.

☆ Whereas organic certification will continue to be a process certification, strong research set-up/laboratories are required to monitor the quality of organic produce so as to prevent the sale of substandard material in the name of organic produce, and to save the interests of producers and consumers.
Organic produce fetches premium price owing to better quality, and for credibility in the market it ought to be quality goods. Therefore, there should be adequate provision for their grading, packaging, storage and transportation. Marketing outlets on the lines of milk unions, may be established.

There is a need to organise Producers’ Cooperative Marketing Societies and establish credible marketing channels for steady flow of organic foods and materials in accordance with the demand, as also to safeguard the interest of small farmers opting for organic agriculture.

5. The Quality Aspects of Organic Food

There is an urgent need to compare the quality of organically produced food with conventionally produced food. There appears to be a widespread perception amongst consumers, that organically produced foods are of superior nutritional quality. However, to prove or disapprove this contention, very limited research has been conducted, and whatever meagre scientific data is available, is often out-dated or based on inadequate study designs, lacking proper controls. In view of this, the following points merit consideration.

No clear-cut evidence is available to support consumer perceptions regarding potential health benefits of organic foods. An in-depth research on quality aspects is required to arrive at any valid acceptable conclusion.

Valid nutritional quality comparisons between organic and conventional food requires that plants be cultivated in similar soils, under identical climatic conditions, be sampled at the same time, pretreated similarly, and analysed by validated methods.

Well-designed controlled studies in animal models and human subjects are needed.

It is also necessary to undertake well-controlled studies to evaluate sensory properties, shelf life, and nutrient load of organic produce vis-a-vis produce from the conventional farming techniques.

More importantly, organically and conventionally produced food should also be analysed for pesticide residues and microbiological safety i.e., presence of pathogenic organisms which could pose health hazards.

6. Research Agenda

Develop package of practices for integrated pest management for organic farming in different agro-climatic regions for specific crops involving components like bio-inoculants, pheromones etc., among others.

The issue of microbial contamination of food arising from the use of manures has to be addressed, and measures suggested to mitigate it.

It is frequently documented that fertilizers and pesticides applied at recommended rates have had no adverse effect on soil biological activity,
and that integrated farming systems are best for nutrient management, yield sustainability and soil biodiversity conservation. There is thus, a need to develop modern organic farming system integrating the best available options.

☆ There is a need to establish referral laboratories for analysis of pesticides, heavy metals and mycotoxins in the produce with appropriate accreditation to help organic farming movement. The maximum residue limits in organic food must be set in accordance with the CODEX standards.

☆ The Green Revolution technologies have been alleged to have caused depletion of soil organic carbon. The critical values of soil organic matter that can support the sustainable crop production under organic management have to be worked out.

☆ The patterns of rate and amount of nutrients released from various organic sources and their goodness of fit with the nutrient requirement of the crops at different growth stages need to be worked out. This information could be used in evolving appropriate nutrient management schedule, so as to ensure optimal nutrient supply to the crop at active physiological stages having peak nutrient demands.

☆ Allelopathic effects of various plant species need to be tapped, particularly for weed and pest management.
The current agricultural production scenario reflects some disturbing tendencies from the point of view of human nutrition, particularly in rural areas where production and consumption are directly linked, and for the poor everywhere. Decline in areas of coarse cereals and pulses and other so-called ‘low-value’ crops which provide access to better nutrition for the poor, illustrates this concern. On the other hand, substitution of these crops by those with higher productivity has improved calorie availability and incomes of farmers who can increasingly afford better nutrition. Over the last 10-15 years, there has been a remarkable spurt in production of horticultural crops, livestock and fisheries, driven largely by buoyant domestic demand. Average per capita consumption of these commodities has increased.

Data on nutritional status in the country in relation to norms developed by nutrition scientists, on the other hand, reveal the appalling status of nutrition, in general and of vulnerable sections of the population in particular. The National Academy of Agricultural Sciences organised a symposium, to deliberate on these issues. Some salient observations, policy issues and recommendations emerging out of the deliberations are summarised below.
Food and Nutrition Security

Thanks to the Green Revolution, per capita availability of foodgrains has increased. With 200 million tonnes of foodgrains, calorie and protein deficiencies have largely been overcome. The country has achieved basic food security in terms of foodgrains. The averages, however, conceal some important differences. For example, distribution of food is highly unequal and the poor, who constitute nearly one-third of our population, continue to be food-deprived. Interregional and intrahousehold deficiencies are also significant.

Also, almost all the increase in foodgrain production has come from wheat and rice. The production of coarse grains (millets) and pulses has declined or remained stagnant, implying a decline in per capita availability of these commodities over time. Coarse grains have been important in the diets of the poor. These have relatively higher nutritive value in terms of proteins, vitamins and minerals compared to rice. Declines here, thus, affect food security of the poor qualitatively. Similar are the implications relating to pulses which are the major source of protein in vegetarian diets. Both pulses and coarse grains are important crops for dryland and fragile environments where poverty levels are high. Legumes have been the traditional restorer of soil fertility and declining area poses a threat to sustainability. Finally, the spectacular increase in foodgrain production and a reasonable overall agricultural performance has failed to eradicate malnutrition.

Nutritional security, thus, goes beyond food security as we understand the term. The latter means ensuring adequate availability of foodgrains to provide calorie and, may be, protein needs of the people, the former implies adequate supply of micronutrients such as vitamins and minerals as well. As we move up the development ladder, this becomes more relevant indicator of food security. To ensure nutritional security, increased availability of diverse types of food, such as millets, pulses, fruits and vegetables, foods of animal origin (milk, eggs, meat, fish), besides cereals, is essential. While fruits and vegetables are rich sources of micronutrients, animal-based foods abound in quality proteins as well. Vegetables and fruits also contain some health-giving phytochemicals which are powerful antioxidants and detoxifying agents which protect against degenerative diseases. Marine fish is a rich source of long chain n-3 fatty acids which have important physiological role.

Diversification Scenario

Cropping patterns have traditionally been dominated by food needs. Commercial crops were confined to some regions and on relatively larger farms. The system we inherited at the time of independence became unsustainable as rapid population growth outstripped our capacity to produce food. Fruits, vegetables, milk, meat, fish, became luxury foods, whose demand was confined to the very small rich class in rural and urban areas. A food insecure nation, despite devoting bulk of its agricultural resources to food production, became chronic importer of food. Even extension of cultivation to marginal and sub-marginal lands did not help.

The Green Revolution transformed this scene. In less than a decade we were able to achieve reasonable food security. High growth in productivity of cereals spurred
agricultural growth and incomes. Rising incomes prompted shifts in consumption patterns and demand for non-cereal food became buoyant. By mid-eighties expansion of area under cereals ceased. Producers too began to look for alternatives and the process of diversification set in. It became the mantra for agricultural development in the nineties. The following paragraphs document these developments briefly:

- In the horticulture sector, there has been 2-3 fold increase in production of fruits and vegetables in the last 10-15 years. Their area has gone up, particularly in rainfed, hilly, and coastal regions prompting fears of diversion of land from foodgrains. This has so far not materialised. Among fruits, banana, papaya, citrus and mango have contributed to the significant increase. All these are nutritionally rich fruits and their increased production has resulted in decline in real prices and penetration in rural markets.

- Livestock production has been increasing at 10-15 per cent over the last decade or two. Milk, eggs and meat production have registered spectacular growth. Despite these increases, the annual per capita availability is much below the amounts recommended by ICMR. In terms of these, the present availability is 86.4 per cent for milk, 16.7 per cent for eggs and 29.6 per cent for meat.

- Fish is one of the best sources of protein and fisheries sector has grown substantially. Marine products’ industry is the largest foreign exchange earner. Scientific aquaculture and deep sea fishing have contributed to the growth of these sectors in the nineties. There are, however, reports that these developments have been unsustainable and have not contributed to livelihood security of small fishermen in coastal areas. The sector faces infrastructural constraints which inhibit exploitation of the potential.

- Genetic engineering is a powerful tool for improving the yields and quality of both plant and animal foods. Both macro- and micro-nutrient content can be enhanced with the now available and evolving biotech tools. Some promising breakthroughs in improving the protein and micronutrient content of crops, such as maize, rice, rapeseed, tomato, etc., have been achieved. However, safety aspects of GMO foods have become an area of concern and debate, globally.

**Issues**

**Changes in Food/Nutritional Security Status**

There is agreement that increased per capita availability of cereals and a number of other foods has contributed to greater food security at the national level. At the household level, consumption expenditure surveys by the National Sample Survey Organisation reveal declining consumption of cereals and increases in livestock and horticultural products, sugar and edible oils implying an average improvement in nutritional status. These, as well as, results of the surveys of the National Nutrition Monitoring Board, bear out gains in calorie and protein content of diets, essentially from improvements in non-grain food consumption, driven by income growth and
poverty reduction. These surveys, however, also reveal the inequities across regions, farms of different sizes, sociocultural groups, as well as in intrafamily distribution of food. To illustrate, nearly 26 per cent of the rural farming households, mainly sub-marginal and marginal farmers, were nutritionally deprived.

Nutritionists evaluate nutritional security in terms of adequacy of macro- and micronutrient with reference to clinical nutritional norms. NNMB surveys indicate that, in general, the consumption of cereals and millets in rural and tribal groups was comparable to balanced diets, but the intakes were low in urban slums. The consumption of micronutrient-rich foods, such as green leafy vegetables, other vegetables and fruits falls below recommended levels, particularly among the poorer population groups. These studies also show sub-standard consumption of green leafy vegetables, milk, fats and oils, sugar and jaggery in the diets of children. The deficit in mean energy intakes among children of preschool and school age was about 25 per cent, but intake of iron, vitamin A and riboflavin was higher across the board. In case of rural pregnant and nursing women, vitamins A, C, and B complex and calcium deficits were higher than those of energy and protein. Both these kinds of surveys, suggest the need to look beyond total production, availability, and average profiles.

Economists view food consumption as driven by self-provisioning, food habits and changes therein, education, incomes, prices, and availability. These and other interacting variables determine the food choices of households as consumers. Empirical studies on recent Indian data indicate that, on the average, calorie consumption has ceased to be income-responsive, implying a switch to non-calorie food with further income growth. At lower end of the income distribution, however, overcoming calorie deficiency remains a priority. All such analyses point to the need for proper targeting of food intervention programmes. Universal public distribution kind of programmes have outlived their utility.

Diversification

Driven by self-sufficiency motive, cropping patterns in India were locked to foodgrain production for a long time—a few regions devoting some resources for commercial crops like cotton, sugarcane, groundnut, etc. or plantation crops. As foodgrain production saturated markets, a trend towards diversification set in. Changes in pattern of domestic demand and, to some extent, export demand in the wake of trade liberalisation, resulted in changes in resource use and increasing diversification of enterprises. States which diversified the crop sector in a big way, have attained relatively higher growth in the net state domestic product of agricultural sector during the past two decades.

The factors that led to diversification of agriculture have varied, over time. During the first 15 years following the onset of Green Revolution, irrigation played the most important role, predominance of small holdings discouraged it. Abundant and cheap supply of electricity also fostered specialisation. Since early eighties, credit availability emerged as a significant determinant of diversification. Smaller farms continued to face rigidity in cropping patterns because of binding food production constraint. They diverted their attention to livestock enterprises. At the end of the millennium,
there was consensus that diversification to higher value enterprises like, vegetables, fruits, other specialty crops, livestock products, fisheries, value-added agricultural products etc., was the new pathway for income growth in agricultural and rural sector. This would also help in bridging the quality gaps in terms of nutrition. Most of these enterprises were traditionally supplementary in nature and had become the domain of women. This bias adds to the strength of this paradigm.

**Concerns and Constraints**

- There is some apprehension that increasing diversification of land to non-food crops may affect basic food security adversely. Stagnation or decline in area under foodgrains would undermine our self-sufficiency in food. Some projections suggest massive imports of foodgrains, driven by rising food needs of a growing population and for animal consumption. A country of our size cannot reliably depend on the world market to meet these needs.

- This perception is countered by the scientific community. They contend that productivity levels are very low for most of the crops and animals. Exploitation of this yield gap through research can ease the pressure on land resources substantially. It was also pointed out that animal production systems in India are based on byproduct and waste utilisation. Increased efficiency of this system would moderate demand for foodgrains for animal consumption.

- In fact, there have been instances of ecological degradation in the wake of growth in such enterprises. Brackishwater aquaculture, massive use of pesticides on fruits and vegetables, biodiversity erosion, salinisation and waterlogging in Punjab-Haryana and parts of Rajasthan, are examples sometimes alluded to, as consequences of diversification.

- These instances need to be carefully diagnosed because analysts also attribute these negative externalities to deficiencies in policies relating to pricing, investments, etc. The real challenge would be to achieve such intensification in an ecologically benign manner, through appropriate policies and technologies.

- High post-harvest losses significantly undermine the prospects of diversification, particularly through high-value perishables, like horticultural and livestock produce. Losses through inefficient handling, transport, storage etc., rise exponentially as scale of output expands. There are increasing instances of total loss in the fields as farmers cannot even cover harvest costs due to crash in prices at harvest time. We need to strengthen processes, institutions and R and D efforts to tackle these constraints. The priority accorded to agroprocessing industries is a welcome policy initiative in this direction.

- Also important are infrastructural constraints. Most of the commodities in the new diversification basket were traditionally confined to local markets in unprocessed form and in small volumes. Facilities like cool chains, refrigerated transport, modern abattoirs, processing plants and other
infrastructure were not relevant. Now the market is global and weak support in infrastructure restricts growth prospects. Similar constraints emerge in institutional infrastructure. Extension, market, credit, information—all have focused on food and commercial enterprises of major importance. In the present context, these create bottlenecks.

There is evidence to show that because of binding food needs, small farmers are able to diversify only to a limited extent. This implies that as this process accelerates, such farms will lose ground further in terms of income growth. There are special programmes like IRDP which provide support for diversification in respect of small and poor farmers, but more needs to be done. Increase in productivity of their basic staples would provide a significant leeway for incorporation of other enterprises. Small producers also face scale related constraints—the size of their output is small and incomeenhancing options like access to superior markets, value addition, storage, etc. become non-viable. New institutional arrangements are necessary if this handicap is to be overcome.

There is also an apprehension that shift from traditional foods many of which are rich in vitamins and micronutrients, would result in decline in nutritional quality of diets. Substitution of millets by wheat and rice, for example, does not augur well for poor consumers who cannot afford supplementary alternatives. Fall in consumption of pulses is also a cause for concern. This nutritionally regressive substitution in production patterns arises from technology and price changes which affect profitability and incomes of producers. Lack of nutritional awareness leads to undervaluation of nutritive food by consumers and in the marketplace. Nutrition scientists highlight such dimensions of commercially-driven diversification and plead for investment in nutrition education.

Conclusions and Recommendations

Shifting agricultural resources to higher-valued options is the new strategy for agricultural development. Buoyancy in domestic demand for such commodities has generated congenial incentive environment for such transition and the process has begun. Good export prospects reinforce this trend. Non-conventional crops like aromatic and medicinal plants, floriculture, etc., figure importantly in this strategy but the major impetus comes from horticulture, livestock, dairy poultry, fisheries, etc., which have traditionally been minor constituents of Indian diets. The nutritional implications are obvious. Growth in incomes has spurred demand for these commodities even as food grain consumption stabilises, and producers have responded to such market signals.

General inadequacy of Indian diets in terms of micronutrients and vitamins is well established. For the poor, access to even macronutrients is constrained. As overall wellbeing improves with future growth in incomes, special attention will have to be paid to nutritional aspects. Salient recommendations relating to diversification and nutrition emanating from the symposium are summarised below.
1. Policy Imperatives

- Thrust on raising productivity of foodgrains must remain a central feature of agricultural policy. Only through this route can the twin objectives of self-reliance and rapid rural income growth be realised. It will enable unlocking of resources which would otherwise remain tied to less remunerative enterprises.

- Diversification of production base of Indian agriculture requires massive investments in rural and other infrastructure. Apart from roads, electricity, irrigation, greater emphasis on storage, specialised handling and transport, assembling, wholesale and retail markets, effective market intelligence, etc. will be needed.

- The emerging economic regime requires dismantling all distortions in input-output pricing. These impart incorrect price signals and farmers are distracted from efficient production patterns. Massive irrigation subsidy and its effect on cropping patterns is an illustration. The structure of tariffs is also a case in point.

- A reorientation of the institutional support for agriculture will be necessary for exploitation of new opportunities by small producers who constitute more than 80 per cent of the farming households. Input-output marketing, value addition and processing, credit, insurance, R and D, extension, etc. need to shift from foodgrain and large-farm-based approaches to a more holistic paradigm. Leasing and tenancy reforms will be necessary.

- Agroprocessing investments must move to the countryside where production is concentrated. While technology and quality considerations may necessitate foreign investments in this sector, mechanisms will have to be developed to ensure effective small farm participation.

- A task of this magnitude and complexity will necessitate a dominant role for the private sector. The public sector will need to withdraw from some areas and strengthen others, like R and D, information, natural resource management, regulatory processes and so on. A set of policies to provide incentives to the private sector will be necessary.

- A large population will continue to be economically and nutritionally deprived. People below the poverty line, women and children, particularly in rural areas, and urban slums, will need strong safety nets. Weaknesses in existing programmes have been well identified and are being addressed. These need to be pursued more vigorously.

- These challenges are beyond the competence and resources of governments. It will be necessary to involve people in planning and executing decentralised initiatives. Nongovernmental organisations, self-help groups, cooperatives, panchayats will need to play a greater role and these must be strengthened.
2. Nutrition

- Nutrition education must be made part of regular curricula in schools. Sustained drives using mass media, particularly in rural areas and urban slums are necessary to create greater awareness.

- Programmes like homestead gardening, urban gardening, household preservation and enrichment of food, etc. must be actively supported. Health and hygiene, sanitation, etc. make significant contributions to nutritional well-being and should be accorded greater priority.

- Food enrichment, fortification strategies need to be supported. Assessment and incorporation of indigenous ingredients offer considerable opportunities and should be exploited.

- National nutrition monitoring effort must be further strengthened and focused on target themes and populations.

3. R&D

- Continuous increase in productivity of agricultural enterprises—crops, animals, fish, is essential. This would ease the subsistence pressure on natural resources, relating them to commercial enterprises. The research system must continue to accord high priority to food crops, particularly those which are of importance to the rural poor and tribal farmers.

- Advances in modern sciences, particularly biotechnology, offer exciting opportunities for incorporation of marketable and nutritional qualities in food crops of various kinds. Even as research on genetically modified organisms is accelerated, proper testing and safeguard procedures need to be put in place. The point to note is that this area of research can tackle several constraints inhibiting yield, quality, and nutrition.

- More resources should be allocated for nutrition research. There are basic as well as applied research issues relating to indigenous food, nutraceuticals, formulations, food safety, standards, etc. which need to be investigated. There is enormous variability in food habits, tastes and preference products etc. across the country and these must be captured and analysed.

- Unmindful pursuit of market opportunities often exacerbates pressure on natural resources and ecology. Safeguarding future production potential and ecological balance should be high priority for research.

- Wide diversity in growing conditions implies a wide range of options for diversification and income growth. This is a big strength for Indian agriculture, but this necessitates decentralised research approaches which maximise comparative advantage of different regions. A careful regional prioritisation of research is called for.

- Preventing post-harvest losses has emerged as a critical element, and so has value addition and processing. Known technological options in these areas are highly capital intensive and not really appropriate for small scale
operations which are characteristic of the Indian rural scene. The research system faces this unique challenge of developing efficient small scale technologies which will benefit small scale rural producers and entrepreneurs.

Finally, success of the diversification strategy would demand research on a number of socioeconomic parameters like, market structure, conduct and performance, input-output demand, comparative cost and returns, price analysis, organizing producers’ and entrepreneurs’ private sector role, etc. While the research system is gearing up to meet production research challenges, this area must also receive attention.
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Introduction

The Tamil saint poet Thiruvalluvar wrote in the classic Thirukkural “What else is more painful than poverty? Poverty alone as painful as poverty”. He further writes “Farmers are the linchpin of the whole world as they feed even those not in the field”. Gandhiji liked to be addressed as a humble farmer. He wrote in the visitors book at Buckingham Palace against the column ‘occupation’ A Farmer. He encouraged the inmates of Sabarmathi Ashram to grow fruits and vegetables to meet their nutritional requirements. The infamous Bengal Famine during 1942-43 devastated millions of people. The resurgence of India from the status of ‘ship to mouth economy to farm to ship’ with a buffer stock of 82 million tones of food grains demonstrates the symphony among policy support, science and technology and hard working farmers. The three “A”-availability, access and absorption-are the key words of food and nutrition security. Purchasing power is key to access the food which unfortunately is not within the hands of 360 million people in India. Malnutrition-under and over-is rampant and the most worrying is undernutrition and hidden hunger. After more than 70 years of independence, India continues to battle with pre-transition diseases like infections and under nutrition. Over 50 per cent of pre-school children and 30 per cent adults are undernourished as judged by anthropometric indices and over 70 per cent of women and children suffer from iron deficiency anaemia. Every third child is borne with low birth weight, and is condemned to poor mental and physical development and immunity unless rehabilitated within the first year of life. Intrauterine malnutrition epigenetically predisposes to cardiovascular diseases in later life. Almost 60 per cent of deaths and 42 per cent DALYs (disability adjusted for year) lost are due to communicable diseases, perinatal and maternal conditions and nutritional deficiencies. Post-transition life-style related diseases like obesity and
chronic degenerative diseases are increasing, with India becoming world capital of
diabetes. Over 10 per cent of Indians are obese, the incidence being almost 20 per cent
in urban areas. Apart from human sufferings due to morbidity and mortality,
malnutrition is severely denting India’s productivity and development and adding
to medical expenditure.

Nutrition security implies physical, economic and social access to balanced
diet, clean drinking water, safe environment and health care-preventive and curative-
for every citizen. Education and awareness are needed to utilize these services.
Malnutrition has a complex aetiology and its prevention requires awareness and
access at affordable price to all the above-unreached and undernourished-. Diet
surveys show that Indian diets are qualitatively more deficient in vitamins and
minerals(hidden hunger) than proteins due to low intake of income elastic foods like
fruits, vegetables and foods of animal origin. Nutritious millets are disappearing.
Within the family, diet of pre-school children is particularly inadequate due to
ignorance and time constraints on mothers rather than affordability (Mahtab Bamji,
2009). More than 70 per cent of preschool children consume<50 of recommended
amount (RDA) of iron, vitamin A and some Bvitamins, particularly riboflavin and
folic acid.

India is committed to achieve millennium development goal (MDG) of UN by
2015 especially reducing the percentage of people below poverty level to half (13 per
cent). The National Food Security Bill-2013 enacted by Indian Parliament makes
access to food as a fundamental right especially to people below poverty level. The
bill “provides for food and nutritional security in human life cycle approach, by
ensuring access to adequate quantity of quality food at affordable prices to people to
live a life with dignity and for matters connected therewith or incidental thereto”. Indian horticulture is in sound footing, the sub-continent hosting two hotspots of
biodiversity, suitable soils and climate for an array of fruits, vegetables, tuber crops,
spices and plantation crops and above all indigenous traditional knowledge
supplemented with world’s largest scientific man power support. India is also the
second largest domestic market making horticulture crops production attuned to a
demand-supply chain. Threats to Indian horticulture is the high harvest and post
harvest losses (30-40 per cent) and poor infrastructure like near absence of cold
storage chains and packing. The recent interest in Protected Cultivation of fruits and
vegetables under fertigation is creating newer opportunities. Urban and peri-urban
horticulture are providing new opportunities, challenges and threats. Demands for
fruits and vegetables have gone up in urban markets and production nearby areas is
turning conventional horticulture into a commercial venture.

India inhabiting 1200 million people has around 240 million homesteads. With
urbanization, industrialization and migration area under traditional agriculture is
going down. Homesteads are evolving to production centres for self consumption
and marketing in near by markets. Concepts of co-operative farming and farmers co-
operatives are adding to family income and family nutrition. The state of Kerala
alone has 6 million homesteads and efforts are made to transform them to homestead
vegetable/fruit/spice gardens. Named kitchen garden, nutrition gardens and home
garden, they are saving space, water, nutrients, energy and in addition provide
remuneration to family members. Nutrition garden therapy is highly recommended to people suffering from depression and also to differentially disabled. The Japanese system of “double digging” where one meter depth pits with four meter long and two meter width is enough to produce fresh vegetables to a family of 5 members. Recently vertical farming, terrace gardening, container gardening, hydroponics, aeroponics and vegetable forcing are providing concepts and opportunities to produce green and fresh vegetables.

Four policy papers one on ‘Innovation in family farming’ by Food and Agricultural Organization of United Nations, second on ‘Micro-nutrient security for India: Priorities for research and action’ by Indian National Sciences Academy, New Delhi, third on ‘Organic farming: Approaches and Possibilities in the context of Indian Agriculture-Policy paper 30’ and fourth on ‘Diversification of Agriculture for Nutritional Security-Policy paper 7” by the National Academy of Agricultural Sciences, New Delhi are given as preambles to the book. The book HORTICULTURE FOR NUTRITION SECURITY carries 21 chapters dealing with crops, farming systems, soil fertility, green technologies for plant protection, emerging technologies like nano technology, hybrids using male sterility and the last common man’s greens and potatoes. The year 2014 being the year of family farming, the book is designed to explain the strategy, policy initiatives, targets and perceived action points.

K.V. Peter
Chapter 1

Aetiology and Consequences of Malnutrition and Way Forward

Mahtab S. Bamji

The term malnutrition implies both under-nutrition and over-nutrition. After over 60 years of independence, India— a country in developmental transition continues to battle with the pre-transition diseases like infections and under-nutrition. Over 50 per cent of preschool children and 30 per cent adults are undernourished as judged by anthropometric indices and over 70 per cent of women and children suffer from iron deficiency anaemia. Every third child is born with low birth weight, and is condemned to poor mental and physical development and immunity unless rehabilitated within the first year of life. Intra-uterine malnutrition epigenetically predisposes to cardiovascular diseases in later life. Almost 60 per cent of deaths due to major infections and diseases are caused by superimposed malnutrition. In India, 36 per cent deaths and 42 per cent DALYs lost are due to communicable diseases, perinatal and maternal conditions and nutritional deficiencies. In the mean time post-transition life-style related diseases like obesity and chronic degenerative diseases are increasing, with India becoming world capital of diabetes. Over 10 per cent Indians are overweight or obese, the incidence being almost 20 per cent in urban areas. Apart from human suffering caused due to morbidity and mortality, malnutrition, is severely denting India’s productivity and development, and adding to medical expenditure.

Nutrition Security implies physical, economic and social access to balanced diet, clean drinking water, safe environment, and health care (preventive and curative)
for every individual. Education and awareness are needed to utilise these services. Thus malnutrition has a complex aetiology and its prevention requires Awareness, and Access at Affordable price to all the above. Women’s health, nutrition, education and decision making through empowerment are important for nation’s nutrition security but remain neglected due to cultural and allegedly scriptural biases.

Countrywide diet surveys show that Indian diets are qualitatively more deficient in vitamins and minerals (hidden hunger) than proteins due to low intake of income-elastic foods like vegetables, fruits, pulses and foods of animal origin. Nutritious millets are disappearing. Within the family diet of preschool children are particularly inadequate, due to ignorance and time constraint on mothers rather than affordability. More than 70 per cent preschool children consume < 50 of recommended amount (RDA) of iron, vitamin A, and some B vitamins particularly riboflavin and folic acid.

Within India states like Kerala and Tamil Nadu have relatively better nutrition parameters than states with higher calorie intake (Madhya Pradesh) or economic growth (Gujarat, Maharashtra) suggesting that the situation is more complex than mere access to food (calories) or income, important as they are. Time trends suggest that over the years intake of all the food groups and nutrients has declined, but the magnitude of malnutrition, has not worsened, in fact there is marginal improvement and severe clinical forms are rare, except anaemia, whose incidence and severity have not changed- in fact marginally increased.

Nutrition-infection is a vicious cycle. Malnutrition reduces immunity and infections and disease reduce appetite, impair absorption and lead to catabolic losses of precious nutrients. Thus apart from physical and economic access to food, access to clean environment and drinking water are areas of great concern. Increasing incidence of obesity and chronic diseases is due to more sedentary lifestyles, shift to less fibre, high fat refined carbohydrate diets, stress and addictions. Crowded urban areas leave little space for physical activity like walking or play even for children.

Neither government nor scientists can be faulted for being silent spectators. Efforts have been made, but something is missing and situation continues to be grim. Food grain (wheat and rice) production went up markedly and kept ahead of population till mid nineties, but is tending to plateau. Unfortunately pulse production has stagnated and per capita availability has declined. There is erosion of millets production and consumption. Milk, fruit and vegetable production has increased markedly with India holding 1st and 2nd positions respectively, but that is not reflected in the diet of the poor due to poor purchasing power, and lack of awareness about their nutritional importance among the producers. Loss of almost 30 per cent of farm produce is occurring due to inadequate post harvest storage facilities, and food processing for value addition. New technologies for bio-fortification of crops have been developed, but languish due to uninformed opposition and inability to put in place convincing safety guidelines and measures. Several programmes, missions and acts including a National Nutrition Policy (1993), National Nutrition Plan of Action (1995) and National Nutrition Mission (2001), have been formulated with scientific and technological underpinning. But they have failed to achieve nutrition
goals. Some of the reasons are:

1. Nutrition is a poor cousin even in health and agriculture planning and execution.
2. Nutrition improvement is not a stated goal with measurable parameters for monitoring, in missions like National Food Security Mission, National Horticulture Mission and even the recent National Rural Health Mission, leave aside others aimed at income, sanitation and drinking water.
3. Top-down approach without preparing the community and making them partners in planning and execution.
4. Poor targeting, accountability, and governance.
5. Inadequate importance to nutrition in school, college and even professional (health, agriculture, social science) education.
7. Vertical programmes with poor convergence and synergy between functioning of ministries and departments.

The Way Forward

Concentrate on proven interventions which have reduced the scale of malnutrition in less endowed countries. Some of these and other implementable suggestions are:

1. Proper breast feeding and complimentary feeding practices, as prescribed by WHO/UNICEF and support systems to enable infant care.
2. Nutrition management during illness, including diarrhoeas.
3. Early detection and effective home-based management of mild and moderate under nutrition and referral and therapeutic feeding for rehabilitation of severe under nutrition.
4. Full immunisation.
5. Women’s education, health and empowerment- a life cycle approach.
6. Access to clean environment, drinking water, and food safety
7. Increased food production using conventional and new technologies, nutritionally oriented cropping pattern, decentralised planning for food production including homestead production of income-elastic protective foods and advocacy for dietary diversification.
8. Distribution of salt fortified with adequate iodine and ensuring its consumption in all areas particularly endemic areas for iodine deficiency. Now that salt double fortified with iron and iodine with proven efficacy is available, it should replace iodised salt.
9. Effective distribution of iron folic acid tablets for pregnant and lactating women, children and adolescent girls and de-worming.
10. Bi-annual supplementation of massive dose vitamin A in areas, where vitamin A deficiency is a public health problem. Emphasis should be on
promotion of nutritionally well endowed vegetables and fruits for food-food fortification. There is enough pro-vitamin A in dark green leafy vegetables, leafy portion of some vegetables like cauliflower, radish etc. and yellow orange fruits and vegetables, and they should be promoted.

11. Popularisation of the Food guidelines for Indians through media and educational blitz.

12. Universalisation of public distribution system and broadening the basket with inclusion of millets, pulse and blended oils

13. Integrated post-harvest management including establishment of silos in every block should receive high priority to prevent wastage and generate employment.

14. Town planning should ensure lung space and place for walking and exercise. All schools should have play ground and physical training.

15. Nutrition should be clearly stated as an important input and output parameter for judging development and should not be treated as trickle down beneficiary of economic and industrial development. It should not get subsumed under curative or preventive health care in general, where emphasis tends to be on chronic diseases and immunisation- important as they are. Without Nutrition, neither communicable nor non-communicable diseases can be prevented and hence it should have an important status as an independent entity. Malnutrition is the worst form of non-communicable disease.

16. Leadership and efficient governance is required at all levels to ensure synergy through convergence between Programmes/Missions/Acts which impact nutrition directly or indirectly (income, sanitation, drinking water, feeding programmes etc.) run by different departments/ ministries like health, women and child development, agriculture, civil supplies, etc.

17. Planning and execution should be done with community participation and involvement of trained nutrition leaders from the community. Anganwadi workers, along with ASHA workers in collaboration with KVK functionaries should be trained as first-contact health and nutrition activists (‘hunger fighters’).

18. Greater dialogue and interaction between nutrition scientists and scientists belonging to agriculture, food technology, medicine, public health, and basic sciences as well as social scientists is needed.

19. National Nutrition Monitoring Bureau (NNMB) which now operates in 9 states should cover all the states and have wider coverage, with additional component of Nutrition surveillance.

This long wish list cannot be curtailed if the dream of Nutrition Security has to become reality.

Apart from human suffering, developing nations like India suffer substantial economic loss due to malnutrition. World Bank and other economists have emphasised the importance of nutrition for national development as follows:
“Malnutrition is costing poor countries up to 3 percent of their yearly GDP. Malnourished children are at risk of losing more than 10 percent of their lifetime earnings potential. Malnutrition may increase the risks of HIV infection, while reducing the numbers of children and mothers who survive malaria. Developing nations should reposition nutrition as central to development.”

According to a group of economists including three Nobel laureates (the Copenhagen Consensus 2004) “investment in nutrition is one of the ‘best buys’ that developing countries can make for economic growth”.

Source: Current Science C V Raman Avenue P B No.8001 Bangalore-560080.