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Achieving the Goal of Food Security and Nutrition for All

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In recent years, the political will and associated action for eliminating poverty induced chronic hunger have shown signs of strengthening. Mr Lula da Silva, former President of Brazil introduced the bold concept of "Zero Hunger" over a decade ago. This programme has led to a substantial drop in the number of children, women and men going to bed hungry in Brazil. In 2013, Mr. Ban Ki-moon, Secretary General of the United Nations launched a Zero Hunger Programme with the following five components and a time frame of 2015 to 2025:

1. Zero stunted children less than 2 years
2. 100% access to adequate food all year round
3. All food systems are sustainable
4. 100% increase in smallholder productivity and income
5. Zero loss or waste of food

I had recently summarised the strategy for achieving Zero Hunger and the steps we need to take to achieve the Zero Hunger target by 2025[1].

Dimensions of the zero hunger challenge

The dimensions of the Zero Hunger Challenge were highlighted in the recent issue of National Geographic Magazine[2]:

- Farming is the world's largest private sector enterprise
- Only 55% of global crops go to nourish people
- 48 million Americans rely on food assistance
- Rice is earth's most important food crop
- 65% of Africa's labor force works in agriculture
- Nearly 100% of all biofuels come from food crops
- Half of all food waste in the UK comes from private homes
- One in eight people – 805 million worldwide – goes to bed hungry every night

The Indian Scenario

Millennium Development Goals: India's position

In spite of the various steps taken from time to time to address the problems of hunger and poverty, we have not been able to achieve the UN Millennium Development Goal of reducing the prevalence of hunger by half by 2015. The National Family Health Survey 3 showed that as of 2002-6, 45% of children in India under 3 years of age were stunted and undernourished. One in 3 undernourished children lives in India and undernutrition is associated with higher under-5 deaths. Long-term effects of early undernutrition include cognitive and physical growth deficits across multiple generations and reduction in immunity to infections.

Global Hunger Index: India's position

The International Food Policy Research Institute (IFPRI) has developed a Global Hunger Index calculated on the basis of the following criteria:
Undernourishment: the proportion of undernourished people as a percentage of the population (reflecting the share of the population with insufficient calorie intake);
Child underweight: the proportion of children under the age of five who are underweight (that is, have low weight for their age, reflecting wasting, stunted growth, or both), which is a widely used indicator of child undernutrition; and
Child mortality: the mortality rate of children under the age of five (partially reflecting the often fatal synergy of inadequate food intake and unhealthy environments).

India ranks 55 among 76 countries on the Global Hunger Index. The Global Nutrition Report published by IFPRI has ranked India among the severely malnourished countries. Obviously, we have not fulfilled Mahatma Gandhi's hope that we will be a nation without hunger since, to quote him (from his speech at Noakhali in 1946) "To the hungry, God is Bread".

India's current food and agriculture scenario

India has 2.4% of the global land mass and 4.2% of the world's water. The cultivated land area is 142 million hectares of which 60 million are irrigated; the cropping intensity is 138%. Our country is home to

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16% of the global population and 11% of the global livestock. Currently, India is an exporter of rice, wheat, cotton and plantation crops, together accounting for 16% of total national exports (Rs.2.4 lakh crore). The agriculture sector contributes 13.7% of the GDP. More than 85% of the farmers are small holders (with <2 ha land), cultivating 44% of the total cultivated area and contributing 50% of the output. This category of farmers is likely to account for 91% in the year 2030. Current production figures for various food commodities is shown in Table 1[3].

In addition, India produces over 140 million tonnes of milk, ranking as the world's number one milk producer. Given this overall production scenario, there should be no reason for the prevalence of undernutrition and malnutrition in the country. Obviously, we need to look beyond mere production figures.

From Green Revolution to Evergreen Revolution

Green Revolution

At the time of Independence, India was not self-sufficient in food production and had to depend on imported food grains – referred to as 'ship-to-mouth existence'. With the advent of the Green Revolution India achieved self-sufficiency in food production in the 1970s and has since then remained self-sufficient. The Green Revolution was possible only because of a 'symphony approach' resulting from synergy of scientific skill, political will and farmers' toil. In 1968, Prime Minister Indira Gandhi released a special stamp titled "Wheat Revolution" to mark the achievement of Indian farmers and scientists in making as much progress in wheat production in four years (1964-68) as during the preceding 4000 years.

The South Asian Enigma

India's situation reflects what has come to be known as the South Asian Enigma. South Asia has witnessed good economic growth and benefited from the Green Revolution. In spite of relatively adequate food production and access to food grains at an affordable cost, 39% of children are stunted in South Asia[4]. The major factors responsible for this may be inadequate purchasing power (due to lack of jobs) and the absence of synergy and convergence among the food and non-food components of nutritional security. All these have to be simultaneously addressed.

National Food Security Act

I wish to recall Dr. C. Gopalan's analysis made over 50 years ago that undernutrition or inadequate consumption of calories is the most important food security challenge faced by our country. Indian diets are cereal-based and food grains are the major source of energy; inadequate cereal intake is the major factor responsible for undernutrition. The country made several efforts to provide cereals at a subsidised cost to the poor during the last four decades. In 2013, Indian Parliament approved a National Food Security Act which is designed to convert the right to food into a legal obligation. This Act contains several interesting features such as the adoption of a life-cycle approach to food entitlements, special attention to the first 1000 days in a child's life, recognition of the eldest woman in the household as the head of the household from the point of view of receiving the entitlement, and the enlargement of the food basket to include millets like ragi and other minor millets in the Public Distribution System. The National Food Security Act will help to overcome undernutrition and thereby lay the foundation for achieving the Zero Hunger target. The target year for the total elimination of hunger is 2025. When implemented, the Indian Food Security Act will help to provide not only wheat and rice but also a whole range of what I call "Climate Smart Nutricereals" at a very low cost. This will help to halt genetic erosion among what are known as "orphan crops". It is of historic interest that a country which was leading a "ship to mouth" existence 50 years ago is now the first in world where the legal right to food is enshrined in a Parliament-approved legislation.

Table 1 .Production of food commodities (2013)

Commodity	Current production(MT)	Global rank
Food Grains	265	(III)
Rice	106.5	(II)
Wheat	95.6	(II)
Maize	24	
Pulses	19.5	(I)
Oilseeds	32.7	(V)
Fruits and Vegetables	280	(II)

Evergreen Revolution

I coined the term "Evergreen Revolution" to emphasise the need for integrating ecological principles in technology development and dissemination. For example, the world will require 50% more rice in 2030 than in 2004, with approximately 30% less arable land than today. Securing "Food for all and for ever" will be possible only if the evergreen revolution pathway, which involves increasing productivity in perpetuity without ecological harm, is adopted. There has been a growing appreciation of my concept of evergreen revolution as the following quotes from Prof. E. O. Wilson(the noted American naturalist & author) and U.S. President Obama would indicate.

"The problem before us is how to feed billions of new mouths over the next several decades and save the rest of life at the same time, without being trapped in a Faustian bargain that threatens freedom and security. No one knows the exact solution to this dilemma. Most scientists and economists who have studied both sides of it agree that the benefits outweigh the risks. The benefits must come from Evergreen Revolution[5]." "Together, we can strengthen agriculture. Cooperation between Indian and American researchers and scientists sparked the Green Revolution. Today, India is a leader in using technology to empower farmers, like those I met yesterday who get free updates on market and weather conditions on their cell phones. And the United States is a leader in agricultural productivity and research. Now, as farmers and rural areas face the effects of climate change and drought, we will work together to spark a second, more sustainable Evergreen Revolution[6]."

Preserving soil health

In the late 1960s, I observed that our farmers, particularly in Punjab, started using more fertilizers and groundwater which could result in long term ecological harm. Therefore, I made the following statement in my Presidential address at the Science Congress held in Varanasi in January 1968.

"Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increase in the incidence of cancer and other diseases, through the toxic residues present in the grains or other edible parts. Unscientific tapping of underground water would lead to the rapid exhaustion of this wonderful capital resource left to us through ages of natural farming. The rapid replacement of numerous locally adapted varieties with one or two high yielding strains in large contiguous areas would result in the spread of serious diseases capable of wiping out entire crops, as happened prior to the Irish potato famine of 1845 and the Bengal rice famine of 1942. Therefore, the

initiation of exploitative agriculture without a proper understanding of the various consequences of every one of the changes introduced into traditional agriculture and without first building up a proper scientific and training base to sustain it, may only lead us into an era of agricultural disaster in the long run, rather than to an era of agricultural prosperity." These words are every bit as relevant today.

Strategy for a Hunger-free India

While developing a strategy for achieving a hunger-free India we should pay concurrent attention to overcoming in the following three major forms of hunger:

- Undernutrition caused by the inadequate consumption of calories (most widely prevalent)
- Protein hunger, caused by insufficient consumption of pulses, milk, eggs or other protein - rich foods
- Hidden hunger caused by the deficiency in the diet of micronutrients such as iron, iodine, zinc, vitamin A, Vitamin B^{12}, Vitamin D, etc.

The first of these, inadequate calorie consumption, can be largely overcome through effective implementation of the National Food Security Act.

Protein hunger poses a greater challenge. Fortunately, the UN has declared 2016 as the International Year of Pulses. Pulses are the major source of protein in Indian diets. Pulse production has been stagnant for over forty years at about 13 million tonnes. With the impetus given under the National Food Security Mission, pulse production has increased in the last few years. Currently, the country is short of requirements by only 2 to 3 million tonnes. MSSRF has been promoting the concept of Pulses Panchayats to encourage the cultivation and consumption of pulses in villages. For example, the Panchayat of *Edaiyappatti* village in Tamil Nadu has converted itself into a Pulses Panchayat. Also, thanks to the growth of the cooperative movement scientifically mentored by the late Dr. V. Kurien, our country is now producing over 140 million tonnes of milk a year, which represents the largest production of milk in the world. Egg and fish production have also gone up substantially. Optimal use of these should make it be possible for the country to overcome protein hunger.

Hidden hunger has to be addressed mainly by increasing the consumption of vegetables and fruits, which are the major sources of minerals and vitamins in Indian diets. The Horticulture Mission can help to provide horticultural remedies for nutritional maladies.

It will be advisable for the Horticulture Mission to associate Home Science Colleges or Nutrition Departments in every State in designing farming systems which are nutrition-sensitive.

I have developed a methodology for designing farming systems in order to address the nutritional needs of various geographical areas. This method, known as Farming System for Nutrition (FSN) is now being implemented in several parts of the country[7]. Some of the opportunities available for introducing horticultural remedies for nutritional maladies are indicated in table2. Existing kitchen gardens should be redesigned to make them 'nutrition gardens'.

Community participation

In every panchayat, a few persons should be identified to be trained as 'Community Hunger Fighters' to master the science and art of leveraging agriculture for nutrition. The empowerment of local communities with knowledge of the malnutrition problems prevailing in their areas and of methods of overcoming them will be the most effective and least costly method of addressing calorie deprivation, protein hunger and hidden hunger in a concurrent manner. With support from the Department for International Development (DFID), MSSRF coordinates a multi-country multi-institutional project titled "Leveraging Agriculture for Nutrition in South Asia".

Biofortification for combating Hidden Hunger

'Hidden hunger', as micronutrient deficiency has been referred to, is becoming a serious problem due to lack of balanced diets. A food-based approach to solve this problem will be better than a drug- or tablet-based approach. This involves strengthening the science of biofortification. Biofortification of diets can be achieved through the following methods, both at the stage of cultivation and during preparation for consumption.

- Diets should include naturally occurring biofortified plants like moringa, sweet potato, pomegranate, nutri-millets and fruits and vegetables, as well as milk, eggs and other forms of animal protein
- Biofortified varieties of plants should be selected by breeding, eg, iron rich pearl millet and zinc rich rice
- Genetically biofortified crops like Golden Rice and iron-rich rice should be promoted

The first approach involves selecting naturally biofortified plants to enrich diets. The second approach involves the addition of nutrition in plant breeding and selection programmes. For example, bajra has

Horticultural remedy for nutritional malady

Nutritional Malady	Horticultural Remedy
Proteins (g)	Broccoli, Spinach, Banana , Strawberry, Water melon
Calcium (mg)	Almond, Broccoli, Chinese cabbage, Kale, Orange
Iron (mg)	Dark leafy greens
Vitamin A (mg)	Asparagus, Cabbage, Carrot, Lettuce, Mango, Sweet potato
Thiamin (mg)	Green leafy vegetables (Asparagus, Avocados, Broccoli , Cabbage)
Riboflavin (mg)	Mushroom, Plantain, Spinach , Apple, Tamarind
Niacin (mg)	Asparagus, Broccoli, Mushrooms, Pea nuts
Vitamin C (mg)	Grape fruit, Guava, Lemon, Sweet potato, Tomato , Water melon
Total Folate (mg)	Asparagus, Broccoli, Lettuce, Spinach , Strawberries , Beets
Free Folic Acid (mg)	Dark Leafy Vegetables

been enriched with iron in a joint programme between ICRISAT and Nirmal Seeds. Biofortified crops developed by selection or breeding include rice and wheat fortified with zinc, pearl millet and beans fortified with iron and zinc, and cassava and maize fortified with provitamin A. These are also becoming available under the "Harvest Plus" programme of CGIAR.
The third approach is genetic modification of the kind achieved in the case of rice.

The Golden Rice project

In the 1960s and 1970s, Vitamin A Deficiency (VAD) was reported to be responsible for 1–2 million deaths, 500,000 cases of irreversible blindness and millions of cases of xerophthalmia in India annually. Children and pregnant women are at particularly high risk. To prevent clinical vitamin A deficiency in children, massive dose vitamin A supplementation programmes of biannual administration chemically synthesized vitamin A has been implemented in many developing countries . This has been shown to be an efficient and generally safe strategy. However, supplementation programmes with a periodic mass distribution have been difficult to sustain because of high transaction costs.

Because rice is the staple food in many of the countries where children had vitamin A deficiency, developing genetic modifications so as to make rice produce the vitamin A precursor beta-carotene was seen as a viable approach. It would be simpler and less expensive than administering vitamin supplements or ensuring sufficient consumption of green vegetables or animal products. The rice plant can naturally create beta-carotene within its leaves, where it is involved in photosynthesis. However, the plant does not normally produce the pigment in the endosperm, where photosynthesis does not take place. 'Golden rice', named for its yellow colour due to the beta-carotene present in the grain, was created by transforming rice with only two beta-carotene biosynthesis genes. Bioavailability of the carotene from golden rice has been established, and it has been found to be an effective source of Vitamin A for humans. It is estimated that 144 grams of the most high-yielding strain would supply the Recommended Daily Allowance of Vitamin A[8].

Role of Genetic Engineering

It is now 62 years since the beginning of the new field of genetics based on the discovery of the double helix structure of the DNA molecule by Watson, Crick and Wilkins. It is also 32 years since the production of transgenic plants first started. The science of molecular genetics has been applied with great benefit in the fields of medicine, industry, environment and agriculture. In the case of medicine, the public have been experiencing several beneficial fallouts such as new vaccines, insulin and genetic medicine. The major concern in medical genetics is one of ethics, as for example, the application of recombinant DNA technology for reproductive cloning. Therapeutic cloning, on the other hand, has been welcomed. In the case of environmental biotechnology, there is great interest in bioremediation methodologies since there is growing pollution of ground and river water. In food and agricultural biotechnology, there are public concerns about biosafety, environmental safety, biodiversity loss, and health of humans and farm animals.

Regulatory mechanisms for research in Genetically Modified (GM) crops

In the case of technologies which carry both benefits and possible risks, it is important to have regulatory mechanisms which can help to analyse risks and benefits in an impartial, transparent and professionally competent manner. This is why, the Government of India introduced last year in Parliament a Biotechnology Regulatory Authority Bill. Unfortunately, the validity of this Bill from the point of view of debate and decision has now expired with the conclusion of the term of the previous Lok Sabha. This gives ICAR, DBT, ICMR, CSIR, UGC, the Ministry of Environment and Forests and other agencies a wonderful opportunity to go through the text of the Bill once again, taking into account the numerous comments, criticisms, and suggestions which have been received, and to get a new Bill prepared for introduction in the current Parliament. While it may take time to set-up a Parliament-approved National Biotechnology and Biosafety Regulatory Authority, guidelines for safe field testing should be developed. Enforcement of procedures for the release of GMOs for commercial cultivation may take time, but field testing under well defined safeguards should proceed without further delay. Meanwhile, procedures for their release can be finalised through appropriate discussion and legislation.

An Agricultural Biotechnology Committee which I chaired in 2003 and which submitted its report early in 2004 had recommended a Parliament-approved Regulatory Agency as well as the necessary infrastructure for conducting All India Coordinated Trials with GMOs. Such a special All India Coordinated Trial to be organised by the ICAR should have as its Coordinator an eminent biosafety expert. The necessary precautions, such as the needed isolation as well as demonstration of the importance of refuge, should be undertaken under this coordinated project. Ten years have passed since this recommendation was made and we should lose no further time in implementing it. We should place in position a trial and safety assessment system which answers the concerns of anti-GMO advocates and environmental organisations. The present moratorium on field trials with recombinant DNA material is serving as a serious handicap as well as a disincentive in harnessing the benefits of the wide array of transgenic material currently available with various public and private sector research organisations and universities. Many of the GMOs in the breeders' assembly line have excellent qualities for resistance to biotic and abiotic stresses as well as improved nutritional properties. Much of this work has been done in institutions committed to public good. Also much of the work has been done by brilliant young scientists who are getting discouraged because of the lack of a clear official signal on the future of genetic modification in agricultural research.

While urgent steps are needed for putting in place a widely accepted regulatory system, full advantage should be taken of the molecular marker-assisted selection procedures of breeding. Many of the desired goals can be achieved through marker-assisted breeding. Varieties developed through marker-assisted selection are accepted for organic certification. Agriculture is a state subject and it is very important that the State Agricultural Universities and State Departments of Agriculture are involved in the design and implementation of the field trials. It takes nearly 10 years for a new variety to be ready for cultivation by farmers. Therefore, speed is of the essence in organising field trials and gathering reliable data on risks and benefits.

There is need for universal political support in India for promoting safe and responsible genetic engineering research. Every research institution should have a Project Selection Committee which will examine carefully whether recombinant DNA technology is necessary to achieve the desired breeding goal. In many cases, marker assisted selection would be adequate for developing a variety with the necessary characters. Recombinant DNA technology should be resorted to only when there is no other way of achieving the desired objective. The report of the Parliamentary Committee headed by Shri Basudeb Acharya (2012) has to be carefully studied and the suggestion of the Committee that we should set up a Biosafety Regulatory Authority on the Norwegian Model should be examined for appropriate action and adoption.

Roles of public sector and private sector

Return from investments in biotechnology research is high. The Public Sector institutions should accord priority to the development of high-yielding, climate-smart and disease-resistant varieties of plants. Obviously the private sector will prefer to produce hybrids whose seeds will have to be brought every year by farmers. Public and private sectors should develop a joint strategy which will help to ensure the inclusiveness of access to improved technologies among

all farmers, small or large. The Public Sector R&D institutions should give high priority to the breeding of varieties which can help farmers to minimise climate-related risks as well as market risks. Also, seed companies should provide to small farmers insurance policies which will save them from total monetary loss in seasons characterised by drought or other natural calamities beyond the control of farmers.

Ensuring Stability and Sustainability of Agricultural Production

The National Food Security Act 2013 mandates the government to procure wheat, rice, and nutri-millets (often called coarse cereals). Such procurement at a remunerative price is the pathway for stimulating interest among farmers to produce more. India is also just beginning to uncover the potential of agri-business, diversification, marketing and exports, as well as increasing the value addition to food production. The country is exploring whether, with proper protections for the poor and vulnerable, commercial agriculture can be a catalyst for economic development. Also, climate change, manifested in adverse alterations in temperature, precipitation and sea level, will add to the problems of farmers and farming.

What steps should we take to ensure sustainable advances in agricultural productivity and production, so that undernutrition can become a problem of the past? In my view, we should attend to six key areas in this regard:

First, we should ensure that soil health is not only conserved but improved continuously. This will require concurrent attention to the physics, chemistry and microbiology of soils. Also, we should take steps to ensure that good farm land is conserved for agriculture. The year 2015 has been designated as the International Year of the Soil. This is to emphasise that sustainable food security will depend on soil conservation and soil health enhancement.

Second, irrigation security will have to be ensured through integrated attention to harnessing rainwater, river and other surface waters, ground water, treated waste water and sea water. Rain water harvesting at the farm level should be made mandatory all over the country. Sea water constitutes 97% of the world's water resource, and we should promote sea water farming, based on Sylvi-aqua farms along the coast, as is being done by MSSRF.

Third, technology and inputs need to be tailored to the agro-ecological and socio-economic conditions under which farmers work. Technology is the prime mover of change and a technology upgradation via the introduction of biotechnology, IT and agricultural mechanisation is essential to attract and retain youth in farming.

Four, farmers should receive appropriate credit and insurance support. Credit should be made available at 4 per cent or even lower interest rates as recommended by the National Commission on Farmers (NCF). Insurance procedures should promote group insurance on an agro-ecological basis. Government should promote an Indian Single Market, so that agricultural commodities can move across state frontiers without hurdle. This single step would help to eliminate a major cause of price volatility particularly in the case of perishable commodities like tomato, onion and potato.

Five, assured and remunerative marketing ultimately holds the key for economically viable agriculture. Procurement at the minimum support price (MSP) is the greatest incentive to farm families. The MSP should be C2 (total cost of production) plus 50 per cent as recommended by NCF. The WTO regulations may come in the way of providing our small farmers prices which can help to keep them above the poverty line. Fortunately, our government has taken the stand at WTO negotiations that in the case of countries like India, where over 50 per cent of the population depend for their livelihood on crop and animal husbandry, fisheries and agro-forestry, sustainable food security should be the basis of pricing policies, since this is in no way trade distorting. Policies for achieving the Zero Hunger target should not be considered as violations of WTO rule.

Finally, there is need to empower and ensure economy of scale to small holders. This can be in the form of cooperatives, which have been very effective in the dairy sector, or producer companies. Group farming through self-help groups can also be promoted. Today, the small farmer has neither the holding capacity nor the bargaining power to ensure that he is able to get a reasonable price for his produce. Also, some kind of group cooperation is essential to promote ecologically sustainable production measures like integrated pest management, scientific water management, and improved post-harvest management.

Managing Climate Change

Three aspects of climate change need particular attention. The first relates to a rise in mean temperature probably up to 2ºC by the end of this century. This will have adverse effects on the food and water security of countries in South Asia. In contrast, a rise in mean temperature will confer some benefit to countries in the Northern latitudes since the duration of the cropping season will get extended, thereby potentially increasing the yields. India could lose about 5 to 6 million tonnes of wheat production if the duration of the wheat growing season is reduced by about 6 days in Punjab and Haryana.

The second aspect of climate change relates to changes in precipitation, leading to more frequent droughts and floods. Here again we have to initiate anticipatory research which can help us to adapt to the new situation. For example, there are varieties of rice which can withstand flooding. Genes are available for the elongation of plant height. We should have crop varieties ready which can help to reduce the loss of grain during flood. Drought is another fall-out of climate change, and here anticipatory action will be needed both to reduce the adverse impact of water scarcity and to maximise productivity per unit of water. Unfortunately, we tend to give more importance to supply augmentation than demand management in the case of water. Both these aspects of water security need concurrent attention. The farmers of *Kuttanad* in Kerala developed methods of below-sea-level farming 150 years ago. This innovation by farm families has led to Kuttanad being recognised by FAO as a Globally Important Agricultural Heritage Site (GIAHS).

The third aspect of climate change relates to sea level rise. The 2014 Working Group II report of the Intergovernmental Panel on Climate Change warns that low lying coastal areas will be exposed to risks from sea level rise. Anticipating this problem, MSSRF initiated in 1990 a research programme to enhance the coping capacity of coastal communities to withstand the adverse impact of sea level rise. This programme has taken several forms like the standardisation of techniques for sea water farming, development of mangrove and non-mangrove bioshields and the establishment of a genetic garden of halophytes which can provide genes of sea water tolerance. Already at MSSRF, there are varieties of rice with genes for salinity tolerance derived from Avicennia marina and for drought based on genes from Prosopis juliflora. Since these are derived by genetic modification, availability to farmers will depend upon government policies and regulatory procedures.

Integrated approach to food and nutrition security

The Evergreen Revolution approach will ensure the physical availability of food for all Indians, including through the National Food Security programme. Pulses Villages and Pulses Panchayats will help to overcome the demand – supply gap in pulses and tackle protein hunger. Biofortification will enable the addition of nutritional properties to various foods. The CGIAR runs a "Harvest Plus" research network to add micronutrients like iron, zinc, Vitamin A, etc. to staple diets. By introducing an integrated approach to food and nutrition security and by adopting the biofortification pathway of leveraging agriculture for nutrition, we can make speedy progress in achieving the goal of Zero Hunger. FAO has started acknowledging the importance of nutrition security by using the term "Food

Security and Nutrition". While the Evergreen Revolution in crops and farming systems, alongside the biofortification revolution, can ensure both food and nutrition security.

However, for a healthy and productive life we need not have just physical and economic access to balanced diets, but also clean drinking water and sanitation to prevent infections and enable efficient utilisation of food in the body. We also need to provide adequate primary healthcare and nutritional literacy to the population. Recently the country has embarked on a 'Clean India' programme which, if implemented with community participation, should help to overcome problems associated with poor sanitation and shortage of toilets. Measures like these will go a long way towards helping India to reach its food and nutrition security goals.

Role of diet in disease: Need for a food-cum-drug approach

The role of nutritious diets in boosting immunity and preventing infections and diseases is well recognised. For instance, good nutritional status is the best "vaccine" against tuberculois. Undernutrition increases the risk of developing tuberculosis. Using data from many countries, a significant log-linear relationship was found between low BMI and incidence of tuberculois. In India, tuberculois is 4 times more common in the lowest socio-economic quintile than the highest. About 55% of tuberculosis cases in India are attributable to undernutrition, with the prevalence being higher in rural areas and among scheduled castes and tribes. The same is true in the case of other diseases like leprosy and HIV/AIDS. In the case of chronic diseases requiring prolonged treatment, optimal nutrition can play a pivotal role in increasing the effectiveness of drugs[9]. This was also a major recommendation of the Committee on Leprosy eradication by 2000, chaired by me (1982).
Attention to good nutrition in illness can reduce the burden on the health system and restore patients to good health more speedily.

Towards a malnutrition-free India
Let me end with a statement that mirrors the goal of Dr C Gopalan's lifelong struggle for a malnutrition-free India.

New Frontiers of the mind and technology are before us, and if they are pioneered with the same vision, boldness and drive with which the battle against food shortage was fought through the green revolution, we can achieve the goal of Food for All sooner than generally considered possible. 'adapted from a statement on the American Dream by former U.S. President Franklin Delano Roosevelt'.

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FOUNDATION NEWS

- **Annual Foundation Day and C. Ramachandran Memorial Lecture:** The Annual Foundation Day of NFI was celebrated on 27 November 2014. On this occasion, Dr. V.M. Katoch, Secretary, Department of Health Research and Director General ICMR delivered the C. Ramachandran Memorial Lecture on "Shaping nutritional research to face the health challenges in India".

- **Symposium:** NFI had organized a one day symposium on "Reference standards for assessment of nutritional status" on 28th November 2014. The program of the symposium is given below:

  - Dr. Anura Kurpad (St John's Medical College): RDA for Indians – how does it fit requirements across ages.
  - Dr. Vinod Paul (AIIMS): Intrauterine growth chart: Indian context.
  - Dr Santosh Bharghava (S L Jain Hospital): Birth weight: impact on survival and growth in Indian children.
  - Dr. Nita Bhandari (Society for Applied Studies): Building up the Indian cohort for MGRS.
  - Dr. Deepti K Sharma (GSK): Assessment of nutritional status of school children in dual nutrition burden era.
  - Dr. Saakshi Bhushan (GSK): Assessment of adiposity in school children.
  - Dr. A Laxmaiah (NIN): Controversies in anthropometric reference standards in identification of at risk persons.
  - Dr. Prema Ramachandran (NFI): Grading of anaemia based on functional de-compensation.

The symposium was well attended and there were useful discussions after the presentations.

NUTRITION NEWS

- The 46th Annual Conference of the Nutrition Society of India was held at Dayanand Medical College and Hospital, Ludhiana (Punjab) on 7 -8 November, 2014. There was a pre-conference workshop on 6 November 2014. The theme of the conference was 'Nutritional Approach for Combating Non Communicable Diseases in India'.

The 38th Gopalan Oration was delivered by Prof. Michael S. Kramer Dept. of Paediatrics and Epidemiology, McGill University, Montreal, Canada on "International Standards For :
Birth Weight – Does One Size Fit All ?.

The 26th Dr. Srikantia Memorial Lecture was delivered by Dr. Anura V. Kurpad, Prof. & Head, Division of Nutrition, St. John's Research Institute, St. John's National Academy of Health Sciences, Bangalore .
The 5th Dr.Rajammal P. Devadas Memorial Lecture was delivered by Prof. G. Subbulakshmi Retired Director, PG Dept. &HOD FSN Dept. SNDT Women's University on "Farm Foods and Pharm Foods".

Dr. B.K.Anand Memorial Award instituted by the NSI was presented to Dr Prema Ramachandran, Director, NFI.

A symposium on "New Nutritional concepts in Foetal Programming" was organised during the meeting.

- The 47th Annual National Conference of IDA was held from 21st to 23rd December, 2014 at All India Institute of Medical Sciences, New Delhi.

Reviews and comments

Anthropometric parameters: measurement, interpretation and use for rational nutrition interventions

Prema Ramachandran

In India, assessment of nutritional status, and detection and management of nutrition problems have always been considered important components of health care. Anthropometric parameters were the most widely used method for assessing nutritional status in all age groups. In the middle of the previous century under-nutrition was the dominant public health nutrition problem. Clinical examination for detecting signs of nutritional deficiency, and measuring the weight to assess under-nutrition were the parameters used for assessing nutritional status and initiating appropriate interventions. India, like all developing countries, has been undergoing a nutrition transition. Currently, the country faces a dual nutrition burden, with both under- and over-nutrition being public health problems. There has been technological improvement in the instruments available for measuring anthropometric parameters and newer standards have been evolved for assessing both under- and over-nutrition. This article reviews the evolution over time in anthropometric indices used for assessing nutritional status, and how these improvements have helped in the prevention, detection and management of both under- and over-nutrition seen during the dual nutrition burden era .

Evolution of instruments to measure anthropometric parameters

In the 1950s the health infrastructure was predominantly urban and hospital based. Anthropometric equipments were expensive and cumbersome; skilled personnel needed for measuring anthropometric indices accurately were available only in large hospitals. As under-nutrition was the major problem, weight was the most widely used parameter for assessing nutritional status. The importance of measuring height, though well understood, was done only in selected centres which had the necessary equipment.

Over the years, there have been substantial improvements in the instruments available for measuring height and weight. The heavy weighing machines of the earlier era (one for newborns, another for children and yet another for adults) were replaced in the 1970s by portable spring balances; these made weighing in community settings possible; however they were not very accurate. More recently, light-weight, battery-operated inexpensive weighing machines with 100-gram accuracy have become available, making accurate weight measurement not only possible but affordable in the community as well as hospital settings. During the 1980s the heavy stadio meter that had been used earlier for measuring height was replaced by the anthropometry rod, which is more portable. But the use of an anthropometry rod to measure height in children required a skilled person; in the hands of most health workers, the measurements were not accurate enough for measuring growth in children. With improvement in buildings, there are now plastered vertical walls and good flooring both in urban and rural areas; these have made it possible to use light-weight and inexpensive wall-mounted portable stature meters for measuring height accurately, even in children, in all settings.

Evolution of indices for assessing nutritional status

Weight (and weight for age in children) was the most widely used indicator for assessment of nutritional status. In growing children height for age was used for assessing linear growth. WHO had provided standards for weight for age and height for age in children and these were used to assess nutritional status in children. There are massive differences in height among adults in the population. Height is a major determinant of body weight. If only weight were to be used to assess nutritional status, a short fat adult may be misclassified as (underweight) undernourished. Therefore, Body Mass Index, which takes into account the appropriateness of weight for current height of the person (weight in kg/height in m2) was used to assess nutritional status of adults. On the basis of BMI, persons can be classified into those with current energy inadequacy (thinness) or excess (adiposity). However, BMI for age was not used as an index of nutritional status in children because of lack of standards.

Data from research studies have shown that, for a given BMI, Indians have higher body fat as compared to Caucasians. The higher adiposity and, what is equally important, the location in the body where fat is deposited render Indians more prone to cardiovascular diseases. In view of this, it has become essential to add adiposity measurement to the already existing anthropometric parameters. Where skilled personnel are available, fat fold thickness can be measured and accurate estimations of body fat can be made. Arm, hip and waist circumference measurements provide valuable insights into distribution of body fat. However, where such skilled professionals are not available, bio electrical impedance measurement equipment can be used for measuring body fat and its distribution.

WHO growth standards for children

The emergence of the global dual nutrition burden right from early childhood gave an impetus to the development and use of standards relating to BMI for age in children. The WHO released growth reference standards for 0-5 years (2005)[1] and 5-18 years (2006)[2] and recommended that BMI (which provides information on the appropriate weight for the current age and height) is the appropriate index for assessment of current nutritional status in the dual nutrition burden era, especially in countries where stunting is common. In 2007 India adopted the WHO standards. Where height and weight measurement are available it is relatively easy to teach all front line workers how to calculate BMI (weight in kg/height in m^2); ready access to computing tools such as mobile phones and calculators has made computation of BMI an easy task. Plotting the BMI of the 0-18 year old against the BMI for age chart provides a readily available method for assessing nutritional status of children using this parameter.

The rationale for adding BMI for age as an additional index for assessment of nutritional status in children, and how it will help in prevention, early detection, and effective management of both under- and over-nutrition in children, have been widely discussed among research scientists and academics for over two decades. But these were not adequately explained and discussed with front line practitioners who provided health and nutrition services to the population

Assessment of nutritional status in children using WHO standards (2005)

The National Family Health Survey 3 (2007)[3] was the first nation-wide survey to report data about prevalence of under- and over-nutrition in children as assessed by height, weight, and BMI for age (as per WHO standards, 2005). Data reported from the survey illustrated the differences in undernutrition rates as assessed by each of these parameters. Nearly half of all preschool children were stunted (low height for age) and a similar proportion were underweight (low weight for age) but only 1/6th were 'thin' (low BMI for age). These findings have major implications for intervention

programmes. Low current height reflects the cumulative impact of past energy inadequacy, low weight reflects past and current energy deficit, while BMI assesses current energy deficit or excess. Both current energy deficiency (wasting) and current excess (over-nutrition) can readily be corrected with appropriate intervention. It is possible to bring about rapid reversal of wasting through food supplementation and treatment of infections. It is also possible to reverse overnutrition by ensuring more physical exercise and expenditure of energy. As for stunting, it can only be prevented but cannot be reversed. Reduction in stunting rates in a population is slow. Short children with normal BMI will weigh less than children with normal height and normal BMI because height is a major determinant of the weight of the child. Short children can be underweight but still be overnourished (e.g., a very short child with high BMI). Using BMI for age revealed that nearly 2% of Indian preschool children had high BMI (overweight for their height and age), indicating that over-nutrition may begin right from very early childhood, even infancy; early detection and effective intervention are essential for preventing a rise in the prevalence of over-nutrition.

Interpretation of the anthropometric data in children

There are huge differences in the prevalence figures of 'undernutrition' in children in India depending on whether the assessment is made on the basis of height and weight for age or on the basis of BMI for age. Health workers who had used weight and height for age in children to assess and report undernutrition find it difficult to understand how the use of BMI as the primary assessment parameter results in a much lower undernutrition rate.They have numerous doubts such as

- Many Indians are short; are all short Indians undernourished?
- Are short persons more prone to under-nutrition or obesity?
- How do we classify short but fat Indians?
- Wasting can be corrected by feeding but can obesity be reversed?

Also, the general population who read about the data from the survey often wonder how the same data could be interpreted by experts in two diametrically different ways:

- half of all Indian children are undernourished (stunted and/or underweight), and we need to step up efforts to combat undernutrition; and
- India is in the midst of an obesity epidemic (high BMI) rendering Indians at high risk for NCD.

There is an urgent need to answer these queries and clarify these doubts. A clear understanding of the overall situation by policy makers and frontline workers will ensure more effective implementation of intervention strategies to improve the nutritional status of Indians.

'Stunting in Indian children'

Weight and height at birth are important determinants of weight and height throughout life. At birth, Indian children are shorter and weigh less as compared with international norms. Stunting in children, which is still widely prevalent in India, can also be the cumulative result of past low dietary intake, leading to poor linear growth. Improvements in dietary intake can prevent further stunting, but stunting that has already occurred at any time point cannot be reversed. Reduction in stunting rates in a population occurs relatively slowly, usually over generations.

Current Energy Status holds the key

The weight of a person is determined largely by the height. Low weight for age in growing children could be due to low height (chronic udnernutrition) and/or thinness (current undernutrition). Stunted children with weights appropriate for height and age (i.e., appropriate BMI for age) will weigh less than children of normal height; but they do not require any special nutritional intervention. Children who are underweight because of thinness/wasting (low BMI) due to current energy deficiency require supplementary feeding and or treatment of infections. When treated appropriately, there is rapid reversal of wasting; the reversal can be monitored by recording the weight periodically. Reversal of current energy deficit (as shown by low BMI) will halt the stunting process and prevent further stunting.

In the past, weight was the most widely used indicator for assessment of nutritional status of children, because chronic current energy deficiency due to low dietary intake was causing both stunting and thinness/wasting concomitantly in children. Today the situation is more complex, and therefore requires a more nuanced approach. A short, underweight child with normal BMI requires no nutritional intervention. All children who have low BMI irrespective of their height (tall, normal or short) and weight require intervention to bridge the energy gap. All children who have high BMI irrespective of their height (tall, normal or short) and weight have to increase their physical activity to regain normal BMI. It is important to identify these different categories correctly on the basis of height, weight, and BMI, and provide appropriate and targeted intervention. In the current dual nutrition burden era, overfeeding in childhood can lead to obesity right from childhood to adult life and render them at risk for non-communicable diseases (NCDs).

Conclusion

Accurate measurement of height and weight and computing BMI has now become an easy task. For children from 0-18 years WHO reference standards for assessing nutritional status on the basis of anthropometric parameters are readily available. It is essential that all the health and nutrition functionaries learn to interpret the height, weight and BMI for age data correctly. In this dual nutrition burden era, BMI which is the index of current energy status, deficit or excess has to be used to identify under- and over-nutrition and initiate appropriate intervention. Health workers should be trained to measure heights and weights accurately and compute BMI. On the basis of BMI they should:

identify the thin/wasted child (low BMI for age) and correct the energy deficit through food supplements and/or treatment of infections; BMI will return to normal, stunting, if any, will be halted, and further stunting will be prevented.

- identify the child with stunting and low weight but normal BMI. This child requires no nutrition intervention. Monitor the child to ensure that BMI remains normal and the child is growing along the normal linear trajectory.
- identify the overnourished child (high BMI for age) and ensure that there is a sustained increase in physical activity and improvement in lifestyle; slowly BMI will return to normal.

Use of BMI clearly shows that prevalence of under- and over-nutrition rates in India are relatively low; a majority of Indians are normally nourished as per their current energy status. People generally understand the concept that lean persons are undernourished and need feeding, and that fat persons are overnourished. Therefore it will not be a difficult task to get them to understand and ensure effective implementation of programmes aimed at reduction of under-nutrition and preventing further rise in over-nutrition. The country should take this opportunity to show how it can cope with the major challenge of dual nutrition burden effectively within a short period, at an affordable cost.

The author is Director, Nutrition Foundation of India.

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