Agricultural Sciences in India and Struggle against Famine, Hunger and Malnutrition

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Abstract

India has a history of famines and hunger. However, starting with the British initiatives in the beginning of the 20th century, followed by US AID assistance and help after its independence in 1947, and later with its own massive developments in agricultural research under the Indian Council of Agricultural Research (ICAR), education and extension, India has now achieved self-sufficiency in food grains. Government of India has also developed a well-organized public distribution system (PDS) for distribution of food grains especially for below poverty line people (BPL). There has been no famine in India after it gained independence in 1947. In addition to food grains, agricultural science and technology has also helped India in taking strides in the production of fruits and vegetables, milk and fisheries and meat. India thus presents as an excellent example of application of agricultural sciences toward a country's development to other developing nations of the world and work in this direction in collaboration with USAID is in progress.

Key words: Etawah Project, Famine Commission Reports (FCRs), Global hunger index (GHI), Grey or Blue Revolution, Imperial Department of Agriculture, Indian Agricultural Research Institute (IARI), Mexican dwarf wheats, AB Stewart Report, US AID, White Revolution, Yellow Revolution.

1 Introduction

Food has always been in short supply in India since ancient times and food grains were known as *annadevatā* (Grain God). *Prasāda* (effortry) offered to God in Hinduism and other Indian religions included rice, barley, jaggery, milk and milk products, fruits etc., and after worship it was distributed to those who came to the place of worship. *Prāsada* was offered to God, so that He would return it in plenty to the people. Still droughts and famines were frequent in the past and people had to struggle for food. With all the advances made in agriculture, food still remains a matter of concern in many parts of the world. Sikh *Gurūdvārāsa* offer free meals (known as *langara*) to all, who come, every day. Similarly, ISKCON temples are known for providing free *prasāda* meals to all who come, as they believe that this is not only feeding the poor but also providing them with Lord Krishna's mercy as well. ISKON launched Food for Life Global (FFLG) in 1995 with its office in Delaware, USA.[1] Thus food is and will

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[1]Food for Life Global–Americas Inc., 3911 Concord Pike #8030 , Wilmington, DE 19803, USA, 1995.

continue to be a global concern for the humans for the times to come. This paper briefly reviews the struggle and final victory of Indian agricultural scientists against famine and hunger.

2 Famines and their occurrence in India

Famine is conflagrated by an acute widespread scarcity of food (Kelly, 1992) and can be defined in terms of malnutrition, hunger, starvation related diseases and mortality (Ghosh, 1982; Arnold, 1993; Banik, 2007). According to the United Nations, a famine can be declared in a country or a region, when: (a) at least 20% of households face extreme food shortage with a limited ability to cope, (b) over 30% of the population experiences acute malnutrition, and (c) in a given time period, every day, hunger is declared as the cause of two of every 10,000 deaths.[2]

Famine and droughts have been well known to occur in India since ages (Bhatia, 1985). To mention a few, these included famines in the 1st century during Gupta period in north India (Drez, 1988) and during Ashoka period in Orissa (Keay, 2001); famines in Tamil Nadu during 13th to 14th century (Currey and Hugo, 1984; Walsh, 2006); famines in the Deccan, Mahrashtra and Gujarat during 15th to 17th century (Walsh, 2006; Attwood, 2005). A 12–year drought and famine is mentioned in Mahābhārata (Roy, 1889). A recent study at the Indian Institute of Technology at Kharagpur has revealed that the Indus Valley Civilization was wiped out 4,350 years ago by a 900-year-long drought (Pandey, 2008). Murton (2000, pp. 1411–1427) reported as many as 23 famines during 1707–1943. Famines also occurred elsewhere in the world including Europe. A great famine occurred in the entire Europe during 14th century (1315–1317) (Lucas, 1930). Later localized famines occurred in France during 1330–34, 1349–51, 1358–60, 1374–75, and 1390 and even England, the most prosperous kingdom, was affected by the Great Famine in 1315–1317 and later famines in 1321, 1351, and 1369 (Ruiz, 1996). Famines are occurring even in 21st century (Dando, 2012). Famines occurred in Somalia and West Africa during 2011–12 and a famine is ongoing in Yemen since 2016.[3]

In India records of fatalities in famines during 18th and 19th centuries associated with British period are available and are given in Table 1. Millions of people died in these famines due to hunger and malnutrition because of lesser food production and poor management. The then British Government constituted a Famine Commission in 1880, which recommended an improvement in Indian agriculture to overcome the food shortages (Randhawa, 1983, p. 422). Yet in 1899–1900 famine, about 55 million people were affected and there were one million fatalities. J. E. Scott, an American missionary observed "The misery is terrible, but still worse is the fearful emaciation: living skeletons on every side" (Scott, 2018, p. 298). To improve the agriculture in India, state departments of agriculture were established and the Imperial (now Indian) Agricultural Research Institute was established in 1905 at Pusa (Bihar), which was later shifted to New Delhi in 1935 due to the destruction of the institute building by an earthquake (Prasad, 2013). Despite these improvements, India's freedom followed the aftermath of Bengal famine of 1943–44, where hunger and starvation was the principal cause of excess mortality, filling the emergency wards in hospitals in Calcutta and accounting for the majority of deaths in some districts, while diseases, such as Malaria, diarrhea and dysentery were the secondary cause of mortality (Goswami, 1990).[4]

3 Development of agricultural research in India

3.1 British period

One major consequence of the occurrence of famines during the British Raj was that the then British Government appointed Famine Commissions, which recommended the development of agricultural research in India. Thus agricultural research in India owes its initiation to the reports of the Famine Commissions appointed by the then British Government.[5] Some important actions are listed in Table 2.

[2]When a food crisis becomes a famine, United Nations, Vienna, UN News 21 July, 2011.

[3]Yemen on brink of famine, warns UN food relief agency chief, appealing for resources and access. UN News Center 13 March 2017.

[4]Famine Inquiry Commission, August 1945, Final Report, Government of India Press, Madras, 1945.

[5]Report of the Indian Famine Commission, Her Majesty's Stationery Office, London, 1880 and 1998, presented to both Houses of Parliament by Command of her Majesty. Also report of the Indian Famine Commission, 1901, Office of the Superintendent of Government Printing, Calcutta, 1901.

Table 1 Famines of India during British Raj, affected Regions and Human fatalities (Sen, 2010).

Year	General Name	Regions affected	Human Fatalities	Reference
1769–70	Great Bengal Famine	Bihar, Northern and Central Bengal	10 million	Cambridge Univ. (1983)
1783–84	Chalisa famine	Delhi, Western UP, Eastern Punjab, Rajasthan, J&K	11 million	Grove (2007)
1791–92	*Doji bara* famine or Skull famine	Tamil Nadu, Telangana, Southern Maharashtra, Gujarat, and Rajasthan	11 million	Cambridge Univ. (1983)
1837–38	Agra famine	Northwestern UP, Delhi, Hisar	0.8 million	Fieldhouse (1996)
1860–61	Upper Doab	Agra, Delhi, Hisar, Eastern Rajasthan	2 million	Fieldhouse (1996)
1865–67	Orissa famine	Orissa, Bihar; Bellary (Karnataka) and Ganjam (Orissa)	1 million	Cambridge Univ. (1983)
1868–70	Rajasthan famine	Western UP (Agra region), Eastern Punjab Rajasthan	1.5 million (mostly in Rajasthan)	GOI (1907) [a]
1873–74	Bihar famine	Bihar	Almost nil	Hall-Matthews (2008)
1876–78	South India famine	Karnataka and Telangana	6.1–10.3 million	Davis (2001)
1896–97	Indian famine	UP, MP, Haryana, Rajasthan, Telangana, Tamil Nadu, Maharashtra	5 million	GOI (1907) Fieldhouse (1996)
1899–1900	Indian famine	MP, Maharashtra, Rajasthan, Haryana, Gujarat	1 million	Fieldhouse (1996)
1943–44	Bengal famine	Bengal	3.5 million	Cambridge Univ. (1983)

[a] Imperial Gazetteer of India vol. III, Government of India, 1907, p. 488.

In addition to above, a number of Indian agricultural scientists had their higher education in U K; the three great leaders of Indian agriculture, namely, B. P. Pal, M. S. Swaminathan and A. B. Joshi had their Ph.D. Degree from the University of Cambridge. A number of other agricultural scientists also obtained their Ph.D. degrees from the UK universities including Oxford, London, Edinburgh and Wales.

3.2 Post-independence

After India attained freedom in 1947, its first priority was to increase food production (Bhatia, 1970) through agricultural research and development. US AID (US Agricultural International Development) helped India in building up its agricultural research system. Development of rural areas received the first priority and a pilot project was launched in Etawah, Uttar Pradesh in September 1952 (Mayer, 1958). The success of this project led to the launching of a community development programme on 2nd October 1952 all over the country (Maheshwari, 1985). Some of the important initiatives taken up by India in agricultural research and development are listed in Table 3. USAID also funded the visits of several Indian agricultural scientists to State Agricultural Universities/Colleges in USA during 1960s. In addition to USAID programme, a large number of Indian agricultural scientists obtained their Ph.D. degrees from or did Post-Doctoral research at American universities including University of California (Riverside & Davis campuses), Cornell University, University of Chicago, University of Florida, University of Illinois, Iowa State University, Kansas State University, Louisiana State University, Michigan University, University of Minnesota, Mississippi State University, North Carolina State University, North Dakota University, Ohio State University and University of Wisconsin on Assistantships/Fellowships provided directly by these universities. A number of agricultural scientist went to UK, Germany, Netherland and other European countries for their Ph.D. degree or postdoctoral research. Thus by mid 1960s, India had a large number of highly educated agricultural scientists, which provided the base for agricultural research in the country.

The Indian Council of Agricultural Research with Head Quarters at New Delhi coordinates and controls the agricultural research, education and development in the country. In addition to 67 Agricultural Universities, there are 63 Central/National Institutes, 15 National Research Centres and 13 Directorates/Project Directorates dealing with different aspects of agricultural research in India. There are also a large number of ICAR Coordinated Research Projects. In addition, each state has its own Department of Agriculture.

4 Food imports

As India gained its independence in 1947 after the Bengal famine of 1943–44, its first priority was food for everyone. Keeping this in view the Indian Government considered importing food from abroad. On July 10, 1954, Dwight D. Eisenhower signed the Agricultural Trade Development and Assistance Act or Public Law (P.L.) 480, an action which simultaneously created the Office of Food for Peace (Laxminarayan, 1960). In 1961, President John F. Kennedy termed the law "Food for Peace," stating:

> Food is strength, and food is peace, and food is freedom, and food is a helping hand to people around the world whose goodwill and friendship we want.

During 1954–1965, India imported wheat and its flour worth US $ 2086 million (Mann, 1966). However, with Green Revolution setting in 1968, India gradually overcame the need for food imports. USA has played an active role in increasing food production throughout the world through a chain of institutions under CGIAR (Consultative Group for International Agricultural Research), such as, International Rice Research Institute at Los Banos, Philippines; International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), at Hyderabad, India; International Maize and Wheat Improvement Center (CIMMYT) at El Batan, Mexico etc. There are about 14 such international centres of agricultural research under CGIAR (Dowie, 2001; Ozgediz, 2012).

5 Food production

5.1 Cereals and pulses (Foodgrains)

The efforts made to improve agricultural research, education and extension in India paid well and the foodgrain production increased from 50.9 Mt in 1950-51 to 252.2 Mt in 2015–16; a five-fold increase with only 22% increase in area under cultivation (Table 4). A real breakthrough

Table 2 Agricultural Research related Actions initiated by the British Authorities in India.

British Officer	Year	Action
Colonel Robert Kyd	1786	Establishment of Botanic Garden at Kolkata; excellent work on Systematic Botany was carried out at this garden by Dr. William Roxburgh, who is known as the father of Botany in India.
Marquis of Hastings	1817	Establishment of Botanic Garden at Saharanpur in Uttar Pradesh; Dr Govan was appointed as the first Superintendent of the garden.
Sir John Malcolm	1828	Establishment of Botanic Garden at Dapooree (near Pune) in Maharashtra.
	1877	Establishment of Department of Agriculture at Pune in Maharashtra. This was followed by establishment of departments of agriculture in other states of India.
Secretary of State on the basis of initiative by Lord Mayo, the Vice Roy of India & recommendations of Famine Commission Report 1980	1881 1890 1892 1893	Created Imperial Department of Agriculture 'John Augustus Voelkar appointed as Agricultural Chemist. Dr. J. W. Leather followed J. A. Voelkar as Agricultural Chemist-initiated basic research in agricultural chemistry and soil science. He is known as Father of Soil Science in India. He also initiated permanent manorial trials at a number of research stations. Establishment of Agricultural College & Research Station at Kanpur in Uttar Pradesh.
Lord George Nathaniel Curzon, Viceroy of India	1901 1905 1906 1907 1908 1929 1935	Created the posts of Inspector General of Agriculture, Imperial Economic Botanist, Imperial Mycologist and Imperial Entomologist Established Imperial Agricultural Research Institute at Pusa in Bihar State with the help of a donation of US $30,000 by Mr. Henry Phipps of Pennsylvania, USA. Research was started for developing better varieties of wheat, barley, gram, pigeonpea, linseed and maize. The following scientist provided the leadership. Dr. Albert Howard, the Imperial Economic Botanist; Dr Edwin John Butler, the Imperial Mycologist and the Dr. Thomas Bainbridge Fletcher, Imperial Entomologist. Establishment of Agricultural College & Research Station at Nagpur in Madhya Pradesh. Establishment of Agricultural College & Research Stations at Pune in Maharashtra and at Coimbatore in Tamil Nadu. Establishment of Agricultural College & Research Station at Sabour in Bihar. Establishment of The Indian Council of Agricultural Research at New Delhi. Shifting of the Imperial Agricultural Research Institute from Pusa to New Delhi due to destruction of the institute building by an earthquake at Pusa. After India's gaining freedom in 1947, the institute was renamed as Indian Agricultural Research Institute.

Table 3 Some Important Initiatives in Agricultural Research, Education and Development.

Year	Initiative/ Program/ Project
1952	Etawah Blok Development Project in Mahewa village of Etawah district, Uttar Pradesh as a concept of Col. Albert Meyer of USA.
1952–53	Scheme of Simple Fertilizer Trials (SFT) by the Indian Council of Agricultural Research (ICAR) all over the country on the basis of the report of A B Stewart of the Macaulay Institute of Soil Science, University of Aberdeen, Scotland (Stewart,1947); 1955–56: Scheme of Model Agronomic Trials (MAT) all over the country; 1968 the two schemes merged into All India Coordinated Agronomic Research Project (AICARP) ; 1989: AICARP changed to Project Directorate of Cropping System Research (PDCSR), with HQ at Modipuram (Uttar Pradesh); 2009–10 PDCSR changed to Project Directorate of Farming System Research (PDFSR)
1957	All India Maize Improvement Project with HQ at New Delhi.
1958	Indian Agricultural Research Institute (IARI) approved as a deemed university.
1960	First agricultural university "GB Pant University of Agriculture & Technology" established at Pantnagar (Uttarakhand) in technical collaboration with the University of Illinois, USA. There are now 60 State Agricultural Universities (SAUs), 3 Central Agricultural Universities and 2 Deemed Agricultural Universities (Total 67 Universities covering agriculture, horticulture, veterinary & animal science, dairying and fisheries). This has enabled creating a large number of trained agriculture scientists in the country.(See also the year 2005)
1963	Introduction of semi-dwarf high yielding varieties of wheat from CYMMIT, Mexico. This led to the Green Revolution.
1966	Introduction of semi-dwarf high yielding varieties of rice TN-1 from Taiwan and IR8 from the International Rice Research Institute, Philippines.
1970	Operation Flood launched by National Dairy Development Board. This led to White Revolution.
1973	Creation of Department of Agricultural Research & Education (DARE) in the Ministry of Agriculture, Government of India, at New Delhi.
1979	National Agricultural Research Project (NARP) for overall agricultural development.
1986	The Technology Mission on Oilseeds (TMO), later changed to The Technology Mission on Oilseeds & Pulses. This led to Yellow Revolution.
1994	Model Act for the establishment of State Agricultural Universities (SAUs). There are now 67 SAUs and Institutes covering agriculture, horticulture, dairying and veterinary.
1998	National Agricultural Technology Project (NATP) for high value agricultural products & Contract farming.
2005	US-India Agricultural Knowledge Initiative (USIAKI) based on a grant of US $ 400,000 by The US Cooperative State Research, Education and Extension Service (CSREES). The year 2005 grants went to Tuskegee University, University of Delaware, North Carolina State University and Florida International University for developing agricultural programmes in different areas with Indian agricultural universities and institutions(Arunachalam, 2008)..
2006	National Agricultural Innovation Project (NAIP) for end to end solving agricultural problems.

in foodgrain production was made with the introduction of high yielding dwarf Mexican wheats under the leadership of M. S. Swaminathan at the ICAR-Indian Agricultural Research Institute (IARI), New Delhi and the wheat (*Triticum aestivum*) production increased from 12 Mt in 1964 to 17 Mt in 1968 (Swaminathan, 2013). This was celebrated by the release of an Indian Postal stamp bearing a picture of IARI Library building by the then Prime Minister Indira Gandhi in July 1968. This success was given the name "Green Revolution" by William S. Gaud, the administrator of the US Agency for International Development (US AID).The major gain due to Green Revolution was made in wheat production, which in 2015–16 increased 15 times of that in 1950–51; of course area under wheat also increased three fold during this period. Simultaneous progress was also made in rice production with the introduction of semi-dwarf high yielding varieties of rice from the International Rice Research Institute in Philippines (Prasad, 2017a). Further dwarf Mexican wheat varieties required low temperatures for good germination and this made a shift in sowing of wheat from the traditional mid-October to mid-November in the north India, providing an additional month to *kharif* season crops. This brought in the rice-wheat cropping system, the most intensive and productive cropping system in India (Prasad, 2005). Development of high yielding Basmati rice varieties at the Indian Agricultural Research Institute, New Delhi (Singh, 2000) made the rice the most export earning crop of India. During the year 2017–2018, India exported Basmati rice worth INR 26,870 Crores (US $ 3.7 billion) (Ghosal, 2018). Most increase in food-gain production was due to increase in productivity due to improved technology including higher yielding varieties, increased use of fertilizers and increased irrigation.

Note: 1. Crop year in India is July-June; 2. Rice yield is reported as white rice (It is about 2/3 of the brown rice yield as reported world over); 3. includes coarse cereals and millets.

5.2 Oilseeds

Similarly, with the establishment of Oilseed Mission in the Ministry of Agriculture, oilseed (groundnut, rapeseed–mustard, soybean, sunflower, sesame, safflower, niger seed, castor and linseed) production has almost been trebled over a period of 40 years (TE 1982 to TE 2012) (Table 5).

5.3 Fruits and vegetables

India has also made rapid strides in the production of fruits and vegetables. India is the second largest producer of fruits in the world; in 2013 the eight leading fruit producing countries were: China (154.3 Mt), India (82.6 Mt), Brazil (37.8 Mt), USA (27.0 Mt), Spain (17.7 Mt), Mexico (17.5 Mt), Italy (16.4 Mt) and Indonesia (16.0 Mt).[6] As per National Horticulture Database published by National Horticulture Board, during 2015–16, India produced 90.2 million metric tons of fruits and 169.1 million metric tons of vegetables. The area under cultivation of fruits stood at 6.3 million hectares, while vegetables were cultivated at 10.1 million hectares. India is the largest producer of ginger and okra amongst vegetables and ranks second in production of potatoes, onions, cauliflowers, eggplant (brinjal) and cabbage. Amongst fruits, the country ranks first in the world in the production of bananas (25.7%), papayas (43.6%) and mangoes (including mangosteens and guavas) (40.4%).

5.4 Milk

Milk production also increased with the launch of "Operation Flood" by the National Dairy Development Board. It increased from 17 Mt in 1950–51 to 176.35 Mt in 2017–18; an over ten-fold increase.[7] Per capita availability of milk increased from 124 g day^{-1} in 1950-51 to 337 g day^{-1} in 2015–16, which is a significant achievement. For comparison, per capita milk consumption (g day^{-1}) in 2000 was 1359 in European Union, 786 in USA, 216 in India, 30 in China and only 22 in SR Vietnam (Prasad, 2017b).

5.5 Fish and prawns

India has 8,129 km of marine coastline and its fresh water resources consist of 195,210 km of rivers and canals, 2.9 million hectares of minor and major reservoirs, 2.4 million hectares of ponds and lakes, and about 0.8 million hectares of flood plain wetlands and water bodies.[8] Fish production increased from 0.8 Mt in 1950 to 6.4 Mt.h in 2017. In addition to fish, freshwater prawn farming

[6]India 2nd largest fruit producer in the world by V Mohan, Times of India, January 18, 2016.

[7]Milk production up by 6.6% at 176.35 MT in 2017-18, *Business Line, New Delhi, 27 July, 2018.*

[8]India–National Fishery Sector Overview, Food and Agriculture Organization of the United Nations. Rome, Italy, 2006.

Table 4 Food-grain production (Mt), Area under crops (Mha) and Average yield (kg ha^{-1}) (MOA & FW, 2017).[a]

Crop year[1]	Item	Rice[2]	Wheat	Total Cereals[3]	Pulses	Total Food Grains
1950-51	Production	20.6	6.5	42.5	8.4	50.9
	Area	31.0	10.0	80.6	20.6	101.2
	Yield	668	663	527	441	502
2015-16	Production	104.3	93.5	235.7	16.5	252.2
	Area	43.4	30.2	97.4	25.2	122.6
	Yield	2404	3093	2420	652	2057

[a] Pocket Book of Agricultural Statistics 2016, Department of Agriculture Cooperation & Family Welfare, Ministry of Agriculture & Family Welfare, Government of India, New Delhi, 2017.

Table 5 Area, production and yield of oilseeds (groundnut, rapeseed–mustard, soybean, sunflower, sesame, safflower and niger seed, castor and linseed) in India(Viswanath Reddy and Immanuelraj, 2017).

Triennium ending (TE)	Area (Mha)	Production (Mt)	Yield (kg ha^{-1})
1982	18.09	10.48	578
1992	25.09	19.11	762
2002	22.30	17.98	804
2012	26.50	29.05	1095

Table 6 Milk production in India (source: MoA and NDDB).

Year	Production (Mt)	Per capita availability (gday^{-1})
1950–51	17.0	124
1960–61	20.0	124
1970–71	22.0	112
1980–81	31.6	128
1990–91	53.6	176
2000–01	80.6	220
2010–11	121.8	281
2015–16	155.5	337

in India has grown rapidly since 2000 and in 2016, India became the biggest exporter of shrimps by overtaking Vietnam. Frozen shrimp is the top item of export among seafood, accounting for 38.28 per cent in quantity and 64.50 per cent of the total earnings in 2016–17 (CIRIS, 2017). Combining the production of all types of fisheries (including aquaculture), the total fish production in the country reached at about 11.41 Mt in 2016–17 at an export value of US $ 5.78 billion (Singh, 2017). During the year 2017–18 India's shipment of 1377244 Mt of seafood earned US $ 7.08 billion (Nambudiri, 2018).

5.6 Meat production

Meat production in India has some ethical problems. All Jains and a fair percentage of Hindus do not eat meat and beef is strictly prohibited. Thus increase in meat production has been rather slow. Presently India possesses 108.7 million buffaloes, 190.9 million cattle, 135.2 million goats, 65.07 million sheep, 10.3 million pigs and 729.2 million chicken (19th Livestock census) and as per FAO Statistics 2014, 6.2 Mt of meat was produced in India, out of which 1.2 Mt was exported (Kochewad, 2017).The contribution by cattle, sheep, goats and poultry in 1998–99 was about 30%, 5%, 10%, 10.2% and 11.5%, respectively.

6 Procurement, storage, and distribution of foodgrains through TPDS in India

Increase in food production alone was not enough. To control the fall in prices of food grain at harvest, the Government announced minimum prices much before the harvests and made arrangements for the procurement of the same. Further, for making the foodgrains available at an affordable low price, a Public Distribution System of Food (PDS) was evolved for general public and was launched in 1940s and was revamped as Targeted Public Distribution System (TPDS) in 1997 to assure that BPL people also get enough food at an affordable price (Balani, 2013). Further special provisions were made for the poorest of the poor under the Antyodaya Anna Yojana (AAY) on 25th December 2000 (Balani, 2013). The Government of India started procurement of rice and wheat for distribution to people under the Targeted Public Distribution System (TPDS) through at about 400,000 outlets, popularly known as 'ration shops'; pulses were also recently added to TPDS.[9] Procurement, transportation to godowns, their storage and distribution to public through PDS is a complicated process and the Ministry of Agriculture, Department of Food and Food Corporation of India (FCI) did this job meticulously for so many years in the past, despite off and on criticism. The procurement of foodgrains by the government helped in creating buffer stocks and also worked as a buffer for controlling the prices during the harvest season by private traders. The buffer stocks of foodgrains have varied from 15.5 Mt in 1980 to 55 Mt in 2010. Recently the government has involved National Commodity and Derivatives Exchange (NCDEX) to help in storage and distribution of foodgrains. According to NCDEX Institute of Commodity Market and Research (NICR) the foodgrains stored in the FCI godowns are known as buffer stocks and there are two categories, namely, Operational and Strategic Reserve (NICR, 2016). The operational buffer stock is for the supply to TPDS outlets, while emergency buffer stock is for controlling the prices of foodgrains in off season. Amount of buffer stocks of foodgrains in 2016 as per NICR are given in Table 7.

The number of families benefitting from TPDS are given in Table 8. Although there are some problems in the TPDS (Dubey et al, 2010; Velmurugan and Lavanya, 2017) the system has greatly helped in combating hunger in India.

In addition to regular subsidized prices at ration shops, specially reduced prices (₹ 1–3 per kg) for the BPL and AAP people are announced by the State Governments at the time of elections[10] in some parts of the country.

7 Fight against hunger

Hunger should not be judged only from the percentage of undernourished people in a country. International Food Policy Research Institute (IFPRI) at Washington, DC, USA has developed the global hunger index (GHI) as an index of hunger in a country. The GHI combines 4 component indicators: 1) the proportion of the undernourished as a percentage of the population; 2) the pro-

[9] Pulses should be included in Food schemes and PDS: Industry Body. First Post 24th April (2018).

[10] One rupee per kg scheme to take off from November 1 in Andhra Pradesh. *Hindu*, 2nd October, 2011; Rice at 1 rupee a kg in Karnataka. *Hindu*, 19th April, 2013; Wheat at Rs 2 per kg, rice at Rs 3 to be provided till 2018, *Indian Expres*s 7th May, 2018.

Table 7 Operational and strategic reserve stocks in India in 2015–16 (NICR, 2016).

As on	Operational Stock (Mt)		Strategic Reserve (Mt)		Total (Mt)
	Rice	Wheat	Rice	Wheat	
April 1, 2015	11.58	4.46	2	3	21.04
July 1, 2015	11.54	24.58	2	3	41.12
October 1, 2015	8.25	17.52	2	3	30.77
January 1, 2016	5.61	10.80	2	3	21.41

Table 8 Number of beneficiary families and food entitlement under AAP, BPL and APL under TPDS (Balani, 2013).

Category	Number of families (millions)	Foodgrains/family/month
Antyodaya Anna Yojana (AAP)	24.3	35 kg
Below Poverty Line (BPL)	40.9	35 kg
Above Povert Line (APL)	115.2	15-35 kg
Total	180.4	

portion of children under the age of five suffering from wasting; 3) the proportion of children under the age of five suffering from stunting; 4) the mortality rate of children under the age of five (von Grebmer et al, 2017). The GHI ranks countries on a 100–point scale, with 0 being the best score (no hunger) and 100 being the worst. Values from 0 to 9.9 reflect low hunger, values from 10.0 to 19.9 reflect moderate hunger, values from 20.0 to 34.9 indicate serious hunger, values from 35.0 to 49.9 reflect alarming hunger, and values of 50.0 or more reflect extremely alarming hunger levels (Von Grebmer et al, 2018). GHI values for India and its neighboring countries for the years 2000 onwards are given in Table 9. With all the gains in food production, the GHI data show, that neighbor countries, Myanmar, Nepal and Bangladesh are better off than India in fighting hunger. The major cause for hunger in India is its ever increasing population; adding the population of countries like Greece or Portugal each year. India's population in 2015-16 was 3.6 times of that in 1950–51 (Table 10). In addition, due to open borders with Nepal there is sizeable inflow of Nepali people, who come to India for doing various working jobs, such as, watchmen, drivers, cooks, cleaners, household workers, farm workers etc. (Table 11). Further, there could be about 20 million illegal immigration from Bangladesh.[11]

With ∼2% of the world's land mass and ∼18% of the world's population, India's struggle with food will continue and there is no room for complacency, since the latest Global Nutrition Report 2018 points out that as regards stunted children, India tops with 46.6 million, followed by Nigeria (13.9 million) and Pakistan (10.7 million). India also accounted for 25.5 million children who are wasted, followed by Nigeria (3.4 million) and Indonesia (3.3 million).[12] Stunting, or low height for age, is caused by long-term insufficient nutrient-intake and frequent infections, while wasting, or low weight for the specific height is a strong predictor of mortality among children under five. It is usually the result of acute significant food shortage and/or disease.

8 Spreading India's success in agriculture to other Asian and African countries

In addition to above within country programmes, India signed an agreement with the US AID in June 2016 to train agricultural workers from 6 Asian countries (Afghanistan, Cambodia, Laos, Mongolia, Myanmar and SR Vietnam) and 12 African countries (Botswana, DR Congo, Ghana, Kenya, Liberia, Malawi, Mozambique,

[11]Two crore illegal Bangladeshi living in India: Govt. Business Standard / Press Trust of India, 16 November 2016.

[12]India has one-third of world's stunted children: Global nutrition report 2018, The Economic Times 30 November, 2018 (PTI Nov 29, 2018).

Table 9 GHI Values for India and some of its Neighboring Countries (Von Grebmer et al, 2017).

GHI Rank	Country	2000	2005	2010	2018
68	Myanmar	44.4	36.4	25.9	20.1
72	Nepal	36.8	31.4	24.5	21.2
86	Bangladesh	36.0	30.8	30.3	26.1
103	India	38.8	38.8	32.2	31.1
106	Pakistan	38.3	37.0	36.0	32.6

Table 10 Increase in India's Population over Years.

Year	1950–51	1960–61	1970–71	1980–81	1990–91	2000–01	2010–11	2015–16
Population (million)	361	439	548	683	846	1006	1231	1299
Population (times that in 1950–51)	1.00	1.22	1.50	1.89	2.34	2.78	3.41	3.60

Table 11 Emigration (absentee population) of people from Nepal to India in different census periods of Nepal (Kansakar, 2003).

Census Period	Absentee population living in India	Percentage of the total absentee population of Nepal (%)	Male (%)	Female (%)
1952/54	157,323	79.4	87.7	12.3
1981	375,196	93.1	82.1	17.9
1991	587,243	89.2	83.8	16.2
2001	589,050	77.3	88.4	11.6

Rwanda, Sudan, Tanzania, Uganda and Zambia) at National Institute of Agricultural Extension & Management (MANAGE), Hyderabad.[13] This is to extend the success made in agriculture by India to other Asian and African countries.

9 Conclusion

India owes its beginning of agricultural research and efforts to increase food production in late 19th century and early 20th century to three Famine Commission Reports (1889, 1898, and 1901). Imperial Department of Agriculture was established in 1981 and an agricultural chemist was appointed in 1890, which was followed by the establishment of Agricultural College and Research Station at Kanpur (Uttar Pradesh) in 1893 and the establishment of Imperial Agricultural Research Institute at Pusa (Bihar), later shifted to New Delhi in 1935. After independence, the country was helped by US AID, first by supply of wheat under PL 480 and by second by the establishment of the first agricultural university at Pantnagar (Uttrakhand) on the pattern of land grant colleges in USA. Now there are 67 agricultural universities carrying out the job of creating trained agricultural manpower for agricultural research and development in the country. A real breakthrough was made by introducing dwarf Mexican wheat varieties, which led to the *Green Revolution* in 1967–68. There has been no looking back in agricultural research and food production since then. There have been three more agricultural production revolutions, namely, *Yellow Revolution* (increased edible oilseed production), *White Revolution* (increased milk production) and *Grey or Blue Revolution* (increased fisheries production) and the efforts to increase food production continue. Government of India has also taken adequate measures for the procurement and distribution of food grains through an organized public distribution system (PDS), especially to below poverty line people (BPL). However, due to continued increase in population, a real nutritional security throughout the country is yet to be achieved. Agricultural research and development has been the backbone of India's struggle to keep the famines away and to alleviate hunger and malnutrition. Now, India in collaboration with US AID is involved in training agricultural manpower in some developing countries in Asia and Africa.

[13] US-India Triangular Cooperation. US AID, 14 November, 2018 (retrieved 27 November, 2018).

Bibliography

[1] Arnold, D. Social crisis and Epidemic Disease in the Famine of the Nineteenth century, India, *Social Hist Med*, 6.3 (1993): 385–404.

[2] Arunachalam, S. US-INDIA: Collaboration in Agricultural Education, *University World News* Issue No: 50, 26 October 2008.

[3] Attwood, D. W. Big is Ugly? How large-scale Institutions prevent Famines in Western India. *World Development*, 33 (2005): 2067–2083.

[4] Balani, S. *Functions of the Public Distribution Systems–An analytical report, Policy Research System (PRS)-Legislature Research*, New Delhi, 2013.

[5] Banik, R. C. *Starvation and India's Democracy*, Routledge, New York, 2007.

[6] Bhatia, B. M. *India's Food problem since Independence*, Somaiya Publications, Mumbai, 1970.

[7] Bhatia, B. M. *Famines in India: A Study in Some Aspects of the Economic History of India with Special Reference to Food Problem*, Konark Publishers, Delhi, 1985.

[8] Currey, B. and Hugo, G. *Famine as a Geographical Phenomenon*, Springer, Netherlands, 1984.

[9] Dando, W. A. (Ed.), *Food and Famine in the 21st Century*, ABC-CLIO, Santa Barbara, CA, USA, 2012.

[10] Davis, M. *Late Victorian Holocausts*, Verso Books, London, UK, 2001.

[11] Dowie, M. *American Foundations: An Investigative History*, MIT Press, Cambridge, Ma, USA, 2001.

[12] Drèze, J. *Famine Prevention in India*, Development Economics Paper No. 3, London School of Economics, London, 1988.

[13] Dubey, A., Garg, A., Nasim, A., Misra, M., Tiwari, V. and Malhotra, V. Public Distribution System in India: The Problems and Dimensions, *SSRN Electronic Journal* (2010) (DOI10.2139/ssrn.1608431)

[14] Fieldhouse, D. For Richer, for Poorer? In: P. J. Marshall (Ed.), *The Cambridge Illustrated History of the British Empire*, Cambridge University Press, Cambridge, 1996, pp. 108–146.

[15] Ghosal, S. Basmati rice Exports face an uncertain Outlook, *The Economic Times* 19 September, 2018.

[16] Ghosh, A. K. Food supply and Starvation: A study of Famines with reference to Indian sub-continent, *Oxford Econ Papers, New Series*, 34.2 (1982): 368–389.

[17] Goswami, O. The Bengal Famine of 1943: Re-examining the data, *Indian Econ. Social History Rev.*, (1990) 27: 445–463.

[18] Grove, R. H. The Great El Nino of 1789–93 and its Global Consequences: Reconstructing an Extreme Climate even in World Environmental History, *Medieval History J*, 10 (2007): 75–98.

[19] Hall-Matthews, D. Inaccurate conceptions: disputed measures of nutritional needs and famine deaths in colonial India, *Modern Asian Studies*, 42 (2008): 1–24.

[20] Kansakar, V. B. S. International Migration and Citizenship in Nepal. In *Population Monograph of Nepal*, Central Bureau of Statistics, Kathmandu, 2003, pp. 110–11.

[21] Keay, J. *India: A History*. Grove Press, New York, 2001.

[22] Kelly, C. J. Scarcity and Poor Relief in Eighteenth-Century Ireland: The Subsistence Crisis of 1782-84, *Irish Historical Studies*, 28.109 (1992): 38–62.

[23] Kochewad, S. A. Meat Production in India–A review, *International Journal of Animal and Veterinary Science*, 4 (2017): 24–29.

[24] Laxminarayan, H. Indo–US Food agreement and State Trading in Foodgrains, *The Economic Weekly*, September, 24, 1960.

[25] Lucas, H. S. The Great European Famine of 1315, 1316, 1317, *Speculum*, 5.4 (1930): 343–377.

[26] Ruiz, T. F. *Medieval Europe: Crisis and Renewal. An Age of Crisis: Hunger*, The Teaching Company, Chantilly, VA, USA, 1996.

[27] Mann, J. S. Food for Peace Program and India, *Minnesota Farm Business Notes* No.488. October, 1966.

[28] Mayer, A. *Pilot Project India: The Story of Rural Development at Etawah*, Uttar Pradesh, University of California, Berkeley, CA, USA, 1958.

[29] Maheshwari, S. R. *Rural Development in India: A Public Policy Approach*, SAGE Publications, New Delhi, 1985.

[30] Murton, B. Famine, In: *The Cambridge History of Food*, Cambridge, New York, 2000.

[31] Nambudiri, S. India's Seafood Exports cross Seven billion, *The Economic Times*, 2 June, 2018.

[32] NICR, NCDEX Group of Companies, Buffer stock Management involving Private Players, July (2016) (via internet).

[33] Ozgediz, S. *The CGIAR at 40- Institutional Evolution of World's Premier Agricultural Research Network*, PDF, USDA, Bethedsa, Maryland, USA, 2012.

[34] Pandey, J. M. 900–year Drought wiped out Indus Civilization: IIT–Kharagpur, Times of India 16th April, 2018.

[35] Prasad, R. Rice–Wheat Cropping Systems, *Advances in Agronomy*, 86 (2005): 255–339.

[36] Prasad, R. Population growth, Food shortages and Ways to alleviate Hunger, *Current Science*, 105 (2013): 32–36.

[37] Prasad, R. Current status, Challenges and Opportunities in Rice Production, In: B Chauhan et al. (Ed.), *Rice Production Worldwide* (), Springer International Publishing, 2017a.

[38] Prasad, R. Historical Aspects of Milk Consumption in South, Southeast and East Asia, *Asian Agri-History* 21.4 (2017b): 287–307.

[39] Randhawa, M. S. A *History of Agriculture in India*, Vol. III, Indian Council of Agricultural Research, New Delhi, 1983.

[40] Roy, P. C. *The Mahabharata of Krishna-Dwaipayana Vyas- Krishna Parva* (tr.), Bharata Press, Calcutta, 1889.

[41] Ruiz, T. F. *Medieval Europe: Crisis and Renewal. An Age of Crisis: Hunger*, The Teaching Company, Chantilly, VA, USA, 1996.

[42] Scott, J. E. *Famine Land: Observations and Experiences in India, During the Great Drought of 1899-1900* (Classic Reprint–Paperback), Forgotten Books, London, UK, 2017.

[43] Sen, S. Scientific Enquiry in Agriculture in Colonial India: A Historical Perspective, *Indian Journal of History of Science*, 45.2 (2010): 199–233.

[44] Singh, R. M. India becomes Second Largest Fish producing Country in the World, *Press Information Bureau, Chennai*, 13 December 2017.

[45] Singh, V. P. Rice varieties/hybrids, In: *A Text Book of Rice Agronomy*, R Prasad (ed.)., Jain Brothers, New Delhi, 2000.

[46] Stewart, A. B. *Soil Fertility Investigations in India*, Indian Council of Agricultural Research, New Delhi, 1947.

[47] Swaminathan, M. S. Genesis and Growth of the Yield Revolution in Wheat in India: Lessons for shaping our Agricultural Policy, *Agricultural Research* 2(2013): 183–188.

[48] Velmurugan, R. and Lavanya, D. Problems in Public Distribution System at Coimbatore, *Int J Pure and Applied Math*, 116(2017): 17–26.

[49] Viswanath Reddy, K and Kingsley Immanuelraj, T. Area, Production, Yield Trends and Pattern of Oilseeds Growth in India, *Economic Affairs* 62(2017): 327–334.

[50] Von Grebmer, K., Bernstein, J., Hossain, N., Brown, T., Prasai, N., Yohannes, Y., Patterson, F., Sonntag, A., Zimmermann, S. M., Towey, O and Foley, C. *2017 Global Hunger Index: The Inequalities of Hunger: Synopsis*, International Food Policy Research Institute (IFPRI), Washington, DC, 2017.

[51] Von Grebmer, K., Bernstein, J., de Waal, A., Prasai, N., Yin, S. and Yohannes, Y. *2015 Global Hunger Index - Armed Conflict and the Challenge of Hunger*, International Food Policy Research Institute (IFPRI), Washington DC, 2018.

[52] Walsh, J. E. A Brief History of India, *Facts on File*, New York, 2006.