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Food security: The Challenges of agricultural management in India

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Food security: The challenges of agricultural management in India[1]

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Abstract:

Historically, Indian rulers were able to ensure that adverse weather conditions – such as periodic drought – did not lead to famines. This was done by husbanding water and other resources through wise practices. However, this system was thrown out of equilibrium during the age of European imperialism, because the new rulers had mercantile agendas, and because they used techniques that had an adverse impact on the land and on the people.

Today's prevailing western-style agricultural management is based on intensive cultivation that degrades the land, wastes water, depends heavily on fossil fuels without adequate use of organic matter, and makes indiscriminate use of newly evolved high yielding varieties, all of which are unsustainable.

The UN World Summit on Food Security which was held in Rome on November 16th to 18th 2009 said that the fact that there are one billion hungry people in the world was "our tragic achievement in these modern days." Particularly appalling from an Indian point of view is that a large proportion of these hungry people, perhaps as many as 40%, are probably Indians. The Summit further suggested that the "gravity of the current food crisis is the result of 20 years of under-investment in agriculture and neglect of the poor." Here too, India is guilty as charged: despite rhetoric, agriculture has been the Cinderella in the Indian policy-maker's agenda since independence.

India has proved Malthus wrong by achieving a record four-fold grain output in a span of five decades, yet, paradoxically, a majority of its rural population faces hunger and malnutrition. If India applies sound long-term management principles and makes the right political decisions, it may well gain food security and become the greatest agricultural power. India has a competitive advantage in agriculture because of genetic diversity, the proportion of arable land, and age-old practices honed through millennia of experience.

India has a long history of remarkably good agricultural practices. A number of staple foods, including rice, not to mention livestock, are believed to have been domesticated in India. Some of the earliest agricultural settlements in the world (ca. 7000 BCE) have been discovered at Mehrgarh at the foot of the Bolan Pass in Baluchistan (now part of Pakistan).

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Contrary to popular belief based on colonial-era stereotypes and the enduring current misery, India was not a land of starving millions throughout history. It was only after 1750 that India became impoverished, in synchronicity with the growing prosperity of Britain. Among other things, the British destroyed the existing water-management system, expropriating it and diverting it towards cash crops and away from food crops – this was to lead directly to famine.

India suffers periodic and punishing droughts due to the El Nino phenomenon. Roughly once every twelve to fifteen years, India suffers from erratic and below-average monsoons, as in 2009. Since El Nino-related trouble was anticipated, Indian society adapted through the centuries – the kings and other local rulers built up stockpiles, evolved mechanisms of employment and cash payment in times of drought-induced stress, and thereby avoided famine. The result of proper management is starkly evident from the data: during the imperial era of 200 years, there were 31 major famines, as compared to only 17 in the preceding 2,000 years!

Finally, India has great genetic diversity. Major crops enjoy variety: for instance, some fifty different types of rice were grown in Kerala in the 19th century CE. Some of this is natural variation based on the different climatic and soil conditions. But a great deal of it must be carefully tended variation based on observation, experimentation, and cross-breeding over millennia.

Unfortunately, this diversity is in peril and India is on a path that mirrors the dangerous monoculture of the United States. Experts have pointed out the problems of the current system of agricultural management in that country, which, while productive in the short term, is not sustainable long-term. Besides, a single pest, such as the potato blight that caused the Irish famine of the 1840s, could wipe out much of American agriculture, typified by mile after mile of monoculture corn in the prairie. This offers a window of opportunity for India to offer its own differentiated, organic, high-genetic-diversity products, much as France has been able to brand itself as a high-value-added producer.

There are risks in this approach: the subsidies offered to farmers in developed countries, and possible water shortages, as well as the effects of global warming.

Still, India has the potential to be the world's largest and most diverse food producer. There is no good reason why India cannot use its comparative advantage in agriculture and increase its trading and strategic clout. All that is needed is vision, leadership and management. We explore some steps that can turn India into a breadbasket for the world, and, not incidentally, offer full food security to its own citizens.

Introduction:

It is well-known that civilization arose in the major river deltas of the world, such as the Indus-Sarasvati in Northwestern India, the Euphrates-Tigris in Mesopotamia, the Nile in Egypt, and the Yellow River in China. This is not surprising: once nomadic humans established permanent settlements and turned from hunter-gatherers into farmers, the river valleys provided two of the critical elements for agriculture – dependable water supply and the rich deposits of silt borne by the rivers.

Contrary to popular belief based on colonial-era stereotypes and the enduring current misery, India was not a land of starving millions throughout history. In fact, according to the economic historian Angus Maddison in his magisterial study on the world economy for the OECD[i], India was the richest country through most of the time frame 0-2000 CE. It was only after 1750[ii] that India started becoming impoverished, in synchronicity with the growing prosperity of Britain. Among other things, the British destroyed the existing water-management systems that had evolved over many years, expropriating it and diverting it towards cash crops and away from food crops – this was to lead directly to famine.

Indian manufacturing declined precipitously in the wake of the British invasion, and in dramatic synchronicity with the rise of British manufacturing, as can be seen in the following table:

	1750	1800	1830	1860	1880	1900
Britain	1.9	4.3	9.5	19.9	22.9	18.5
India	24.5	19.7	17.6	8.6	2.8	1.7

Table 1: Percentage of World Manufacturing Output. Source: B R Tomlinson "Economics: The Periphery" in Andrew Porter (ed), "The Oxford History of the British Empire: The Nineteenth Century", Oxford 1990, p. 69

Indian agricultural production declined in lockstep with the hollowing-out of Indian manufacturing to serve the interests of the imperialists' own industrial centers. Punitive taxes imposed on farmers (virtually all of their output was to be expropriated as taxes) impoverished them and left them no investible surplus to improve capital stock, seeds, maintenance of irrigation facilities and so on. This, by itself, would naturally have led to food shortages, but there was another factor on top of it: climate.

It is now known that India suffers periodic and severe droughts due to the El Nino phenomenon. The temperature variations in the waters of the Pacific have an impact on the monsoon rains, and the general outcome is less rain. Roughly once every twelve to fifteen years, India suffers from erratic and below-average monsoons. It was forecast that this would be the case in 2009[iii] as well, and indeed the rains were erratic this year.

In centuries past, since El Nino-related trouble was anticipated in traditional knowledge systems, Indian society adapted– kings and other local rulers built up stockpiles, evolved mechanisms of employment and cash payment in times of drought-induced stress, and thereby avoided famine. Drought did not automatically lead to famine; there was a measure of food security.

The result of proper management is starkly evident from the data: during the imperial era of 200 years, there were 31 major famines, as compared to only 17 in the preceding 2,000 years! Mike Davis, in his astonishing and wide-ranging study of the causes of the great famines, titled, appropriately, "Late Victorian Holocausts",[iv] shows that many of these nineteenth-century famines could have been avoided, but the imperialists instead chose to let as many as 30 million Indians starve to death, especially following a series of severe droughts in the late 1800s.

Drought is thus a fact of life for the Indian farmer, and India is one of the countries whose water table is under high stress, according to reports[v]. If the water issue can be managed, Indian agriculture has great strengths. India has tremendous climatic variety, anything ranging from Alpine highlands to semi-arid plateaux to tropical rainforests to coastal plains, and so it is possibly to grow practically anything somewhere in India.

Finally, India has great genetic diversity. Major crops enjoy dramatic variety: for instance, some fifty different types of rice were grown in Kerala in the 19th century CE. Some of this is undoubtedly natural variation based on the different climatic and soil conditions. But a great deal of it must be carefully tended variation based on observation, experimentation, and cross-breeding over millennia.

Unfortunately, much of this diversity is in peril[vi] and India is on a path that mirrors the dangerous monoculture of the United States. Experts such as Michael Pollan[vii] of the University of California at Berkeley have pointed out the perils of the current system of agricultural management in that country, which, while productive in the short term, is not sustainable long-term. Besides, a single pest, such as the potato blight that caused the Irish famine of the 1840s, could wipe out much of American agriculture, typified by mile after mile of monoculture corn in the MidWest.

From the aforesaid perspective, it is clear that India has the potential to be the world's largest and most diverse food producer. There is no good reason why India cannot use its comparative advantage in agriculture and increase its trading and strategic clout. All that is needed is vision, leadership and management.

The other side of the picture is grim. The recently-concluded UN Summit on World Food Security has noted with chagrin that the number of the hungry has skyrocketed in recent years, after a steady decline into the mid 1990s. The number of malnourished people in the world rose to over a billion this year, as seen in the following figure from *The Economist,* dated Nov 19th, 2009 ("If words were food, nobody would go hungry").

When seen in conjunction with the following data from the late Victorian Holocausts, as described in more detail in a later section, this is a frightening statistic for India. A large proportion of the currently undernourished billion are likely to be Indians; the horrendous toll of famine, which literally depopulated parts of the country by up to 25% is a stern warning that unless proper steps are taken the scale of human suffering may begin to approach what happened in the late 1880s. However, in a modern world, the chances are that there will be severe political disturbances, and there will be blood

on the streets. Food riots and violence, as seen in 2008 in several countries because of skyrocketing prices, are a possibility unless the State gets it act together.

Figure 1: Number of hungry people worldwide. Source: *The Economist*, Nov 19, 2009

Note how entire districts were depopulated in the late 1800s famines, by as much as 25%, meaning millions of people died in these cataclysms.

	Bellary	Kurnool	Cuddapah
1872-1881	-20.34	-25.80	-17.03
1872-1901	3.89	-4.63	-4.41

Table 2: Demographic Change in Madras Famine Districts (%), Source: G Rao andD Rajasekhar, "Land Use Patterns and Agrarian Expansion in a Semi-Arid Region: The Case of Rayalaseema in Andhra, 1886-1939", Economic and Political Weekly, 25 June 1994

Although Madras Presidency was the worst affected, especially the dry districts of the Deccan Plateau, almost no part of the country escaped unscathed, including lush and fertile Kerala. As we mention below, even in Kerala there had to be innovation: the Maharaja of Travancore encouraged his subjects to plant (the non-native) tapioca as a buffer against future El Nino catastrophes.

Province	Affected Population	Average Number Receiving Relief	Deaths
Madras	19.4	.80	2.6
Bombay	10.0	.30	1.2
NorthWest	18.4	.06	.4
Mysore	5.1	.10	.9
Punjab	3.5	-	1.7
Hyderabad and Central Provinces	1.9	.04	.3
Total	**58.3**	**1.3**	**7.5**

Table 3: Number of people affected in the 1876-78 Famine in India (millions), Source: Ira Klein, "When the Rains Failed", IESHR, *1984*

The world has woken up to the dangers of food insecurity. In July, there was the L'Aquila Joint Statement on Global Food Security[viii], where the G8 group of rich nations agreed to the following, in part:

> "We support the implementation of country and regional agricultural strategies and plans through country-led coordination processes, consistent with the Accra Agenda for Action... special focus must be devoted to smallholder and women farmers and their access to land, financial services, including microfinance and markets. Sustained efforts and investments are necessary for enhancing agricultural productivity and for livestock and fisheries development. Priority actions should include improving access to better seeds and fertilizers, promoting sustainable management of water, forests and natural resources, strengthening capacities to provide extension services and risk management instruments, and enhancing the efficiency of food value chains..."

The UN Summit on World Food Security in November noted the sad fact of increasing hunger, and that it would take an agricultural output 70% greater than today's to be able to support a projected 9 billion global population in 2050. The Summit also agreed to a Joint Statement[ix] with the following Five Principles:

1. Invest in country-owned plans, aimed at channelling resources to well-designed and results-based programmes and partnerships

2. Foster strategic coordination at national, regional and global level to improve governance, promote better allocation of resources, avoid duplication of efforts and identify response-gaps

3. Strive for a comprehensive twin-track approach to food security that consists of: 1) direct action to immediately tackle hunger for the most vulnerable and 2) medium- and long-term sustainable agricultural, food security, nutrition and rural development programmes to eliminate the root causes of hunger and poverty, including through the progressive realization of the right to adequate food

4. Ensure a strong role for the multilateral system by sustained improvements in efficiency, responsiveness, coordination and effectiveness of multilateral institutions

5. Ensure sustained and substantial commitment by all partners to investment in agriculture and food security and nutrition, with provision of necessary resources in a timely and reliable fashion, aimed at multi-year plans and programmes.

Interestingly, both these declarations look upon food security as a management problem, not a technological problem. As we argue in this paper, management is indeed the biggest issue in assuring India of food security.

In the age of kings: Husbanding the land and water

The most prosperous parts of India as late as the 1700s were the rich agricultural deltas of the Brahmaputra and the Kaveri, namely Bengal and Madras, which—not coincidentally—were the first targets of the British in India, simply because they were wealthy. Along with two other major delta regions, the Pearl River delta and the Yangtze River delta in China (the areas around Canton and Hong Kong), they accounted for half the world's manufacturing[x].

Similarly, the Vijayanagar Empire, celebrated for its riches[xi], also depended principally on the agricultural abundance made possible by its location on the Tungabhadra river.

It is not surprising that the arts and other pursuits of leisure thrived in those parts of India which produced an agricultural surplus. Obviously food items could be traded at a profit. The efficiency of large-scale food production meant that the entire population did not need to spend its time on cultivation and related activity, as would be case when a living has to be scratched from poor, arid land. They could afford to sustain poets, artists, sculptors, et al, and could afford to build soaring structures, such as the giant temples of the Kaveri delta.

Even though the availability of water is not uniform either in time or in space – large amounts of water are dumped on India during the brief monsoon season, and some parts get far more rain than others – on average India gets a reasonable amount of rainfall. The country is blessed with good land – as much as 57% of the land is arable if irrigated[xii], as compared to just 14% of their landmass for both the US and China+Tibet.

However, the water has to be managed. The fact that this was known to Indian rulers is exemplified by the fact that in South India alone there were as many as 180,000 'tanks' or managed water bodies that were collectively owned and looked after. In addition, large-scale waterworks, such as the Grand Anicut built by Karikala Chola in semi-arid, rain-shadowed Tamil Nadu 2,000 years ago, still work and still offer testimony to the water-management skills of Indians. Similarly, Parakramabahu[xiii] built large water-works in neighboring Sri Lanka to get water across a mountain range to a drought-ridden rain-shadow region.

When the Tarun Bharat Sangh[xiv] embarked on their remarkably successful effort to reverse years of degradation of the Aravalli Hills in Rajasthan, they found that the rich local memory of age-old weirs and check-dams was the best guide they could depend on. When they rebuilt some of these structures, and the villagers imposed restrictions on grazing in the foothills, the environmental degradation in the denuded hills was reversed, and dry riverbeds suddenly became perennial rivers again. The hills, left alone, soon acquired a green cover as well.

As a result of these superb management practices, the agricultural yields in traditional India were high. Data from inscriptions and from colonial-era records show that, in fact, productivity has diminished over time. There may be various reasons for this, including variations in water supply and land degradation, but the trend lines are clear. The historic data mostly from Tamil Nadu for paddy[xv] compares well with

the current, post-Green-Revolution crop yields from Punjab, usually the highest in India. Overall current Indian yields are much lower than typical yields in the west or even China.

Date	Location	Source	Productivity
900 CE	Thanjavur	Inscriptions	15 tons of paddy/hectare
1100 CE	South Arcot	Inscriptions	14.5 tons/hectare
1325 CE	Ramanathapuram	Inscriptions	20 tons/hectare
1770 CE	Chengalpattu	British survey	9 tons/hectare
1803 CE	Allahabad, Uttar Pradesh	European report	7.5 tons of wheat/hectare
1807 CE	Coimbatore	European report	13 tons of paddy/hectare
1993 CE	Ludhiana, Punjab	Govt of India	4.3 tons of wheat/hectare; 3.5 tons of paddy/hectare

Table 4: Traditional Crop Yields. Source: J Bajaj, MD Srinivas "Timeless India, Resurgent India"

The imperialists were astonished at the agricultural management practices that they encountered in India, which were superior to their own. In fact, Prasannan Parthasarathi[xvi], as quoted by Mike Davis, argues that the average farm laborer in South India was better off than the average farm laborer in Britain in the 1700 CE time-frame:

> "Indeed, there is compelling evidence that South Indian labourers had higher earnings than their British counterparts in the eighteenth century and lived lives of greater financial security".

Continues Mike Davis:

> "Because the productivity of land was higher in South India, weavers and other artisans enjoyed better diets than average Europeans. More importantly, their unemployment rates tended to be lower because they possessed superior rights of contract and exercised more economic power. But even outcaste agricultural labourers in Madras earned more in real terms than English farm labourers. (By 1900, Romesh Dutt estimated that the average British household income was 21 times higher.)"

The issue of superior contractual rights is corroborated in the paper cited below from Dharmpal. This is a further pointer to the role of governance and the historical Indian State in preserving the economic well-being of its farmers and its farm laborers.

Reports maintained in the British Library archives, obtained by Dharampal[xvii]suggests that the British marveled at agricultural innovations in India such as:

- Croprotation, manuring, sowing via the drill plough[xviii]
- Propagation (eg. of rice) using cuttings
- Transplantation
- Irrigation.

Another British paper on cultivation in India and particularly in the Malabar region[xix], also published by Dharampal, suggests that "agriculture is an important and honorable occupation". It continues, with admiration:

> "The practice of watering and irrigation is not peculiar to the husbandry of India, but it has probably been carried there to a greater extent, and more laborious ingenuity displayed in it than in any other country. The vast and numerous tanks, reservoirs, and artificial lakes as well as dams of solid masonry in rivers which were constructed for the purpose of fertilising their fields, show the extreme solicitude which they had to secure this object. These works were not always executed at the expense of Government: they were often defrayed by the zeal of wealthy individuals, and sometimes by women."

The fact that plant life was carefully monitored (especially for its medicinal value) is evident from the monumental twelve-volume encyclopedia of the flora of Kerala, *Hortus Malabaricus*[xx], printed in Amsterdam in Latin in 1680-1703 CE, based mostly on the scholarship of local ayurvedic physician Itty Achuthan Kollatt. The traditional medical (and outstandingly precise[xxi] botanical) knowledge codified in the book had come from centuries of keen observation by generations of *vaidyas.*

However, after 1857, when the British State began to directly rule much of India, they effected systemic changes that were highly detrimental to Indian agriculture[xxii]. To quote Mike Davis, "The traditional system of household and village grain reserves regulated by complex networks of patrimonial obligation had been largely supplanted since the Mutiny [sic] by merchant inventories and the cash nexus". This was to have disastrous effects.

The imperial era: Exploitation, drought, famine and the El Nino paradox

Mike Davis paints an extraordinary picture of famine mortality in India in the El-Nino-related droughts of the late 1800s CE. The following is an extract from a table in *Late Victorian Holocausts*:

Time	Numbers of victims	Source of estimate
1876-79	10.3 million	Digby[xxiii]
	8.2 million	Maharatna[xxiv]
	6.1 million	Seavoy[xxv]
1896-1902	19.0 million	The Lancet[xxvi]
	8.4 million	Maharatna/Seavoy
	6.1 million	Cambridge[xxvii]
Total	12.2 to 29.3 million	

Table 5: Estimated Famine Mortality, late 1800s. Source: "Late Victorian Holocausts", Mike Davis

One of the reasons for the high mortality was the uncaring nature of the imperialists. The imperialists, aware that there would be no consequence even if millions of their conquered subjects were to perish, were not motivated enough to put in place proper famine-management measures. Unlike the local rulers before them who to a great extent felt they ruled at the pleasure of their subjects, the imperialists felt no particular sense of obligation to the masses.

The famine-relief camps the British set up in the Deccan, one of the worst-affected areas, were basically death camps, because the desperate and destitute people who came there were treated with disdain. The daily rations for the victims of famine were as follows, and as can be seen, the calories provided would not sustain a grown man even at rest; whereas the people in the camps were forced into heavy labor. The correspondence between the British local administrators and their superiors in the UK suggests that a) the colonialists were not aware of the scale of the damage they were doing to Indians, b) that even if they knew, they didn't really care, c) in some cases, the starving and dying were accused of malingering. The callousness is on a scale that is simply breath-taking.

Indian scholar and chronicler of those times, Dadabhai Naoroji, wrote[xxviii]:

> "How strange it is that the British rulers do not see that after all they themselves are the main cause of the destruction that ensues from droughts; that it is the drain of India's wealth by them that lays at their own door the dreadful results of misery, starvation, and deaths of millions?... Why blame poor Nature when the fault lies at your own door?"

It is instructive to compare the calories provided to camp inmates to what was provided to Jews in German concentration camps: the Buchenwald ration was actually higher than the Temple Ration (named after Richard Temple, the British administrator). Not surprisingly the death toll was horrendous:

	Caloric Value	Activity Level
Basal metabolism (adult)	1500	No activity
British ration in Madras Presidency (1877)	1627	Heavy labor
Buchenwald ration (Nazi concentration camp) (1944)	1750	Heavy labor
7-year-old child, approved diet (1981)	2050	Normal activity
Minimum war ration, Japan (1945)	2165	Moderate activity
Indian adult, subsistence (1985)	2400	Moderate activity
British ration in Bengal Presidency (1874)	2500	Heavy labor
Survey of Bengali laborers	2790	Heavy labor
Indian adult male, approved diet (1981)	3900	Heavy labor
Voit-Atwater standard (1895)	4200	Heavy labor

Table 6: British famine rations in the Deccan, compared to Nazi death-camp rations. Source: "Late Victorian Holocausts", Mike Davis

On top of this, the British were actually exporting grain to world markets at the height of the famine, as seen in the table below. Interestingly, some of the showpieces of the British presence in India, which are praised by some as “positive effects” of India's “encounter with the major empire of the time”, were used to effect this transfer.

The telegraph and the railway, which are often trumpeted as benevolent introductions, turned out to be murderous instruments. For, the railway was used by merchants to ship grain from drought-stricken areas to central warehouses for hoarding, and also for shipping overseas. In fact, the population, as a result of starvation deaths, decreased more in districts which were served by railways than those that were not.

The telegraph was, similarly, used to coordinate pricing in thousands of locations, regardless of local supply-demand conditions, thus exacerbating the effects of the lack of a cash income for the stricken.

Year	(Thousands of Quarters)
1875	308
1876	757
1877	1409
1878	420

Table 7: Indian wheat exports to the UK, 1875-78, Source: Cornelius Walford, "The famines of the world, past and present", London 1879, as quoted by Mike Davis in "Late Victorian Holocausts"

This data merely scratches the surface the mismanagement of food (from a food security perspective) by the imperialists. It is clear that the issue then (and to an extent now), was not only the paucity of food, but also the distribution of food, including the deliberate diversion of food away from the starving. There was also the lack of purchasing power, as impoverished peasants simply did not have the cash reserves or cash income to buy whatever grain was available.

The same issues were to recur much later, during the great Bengal Famine of the 1940s, when millions died in lush Bengal not because there was no rice – there was only a shortage – but because it had all been commandeered for the British war effort, and there was none for the people. It was clearly a man-made famine, an outrage, and a crime against humanity, which caused several million deaths.

Another example of the deleterious effect of mercantilist efforts by the imperialists that hurt the public was the diversion of waterways. Traditionally, the water bodies had been maintained by village committees—there are inscriptions in Chengalpattu district in Tamil Nadu, for instance, that provide details about how they were to be managed collectively by the village *panchayat*. The primary intent was irrigation for food crops, including not only rice and wheat, but also coarser grains like jowar, bajra, ragi, and so on.

However, British commercial interests preferred to use water resources only for exportable cash crops such as wheat and especially cotton, as well as indigo and opium[xxix]. This led to the expropriation of water bodies and the loss of traditional knowledge about managing them.

The imperial era thus provides the best example of the need for better management. If for thousands of years, El Nino droughts had not led to catastrophic famines, why did they happen during the imperial era? The answer is poor management. While it is true that India has not been afflicted by major famines since 1947—and this has been ascribed to the fact that the new rulers were beholden to the masses for votes at least—the fact of the matter is that the Government of India has been, and continues to be, ineffectual in its support of agriculture. This is the main reason for the persistence of hunger in India.

Post-independence: The persistence of hunger

One of the persistent images of India is that of a country holding out a begging-bowl for food. The situation was particularly grim during the 1960s when it appeared as though the country was waiting for PL-480 shipments of surplus grain – some of which was considered unfit for human consumption – that was shipped by a charitable American government. India then looked like a basket-case, much like some poor nations in sub-Saharan Africa look today – a country dependent on the kindness of strangers.

The government of independent India did declare agriculture a priority sector and it did build a large number of dams for irrigation and generation of electricity. In spite of that, from independence to 1961, India was forced to import food grains during drought years. There was a close race between population growth and agricultural production. Progress in production was slow and took place largely through the increase in cropped area and irrigated area rather than increase in productivity.

From 1961 came the era of intensive agricultural development during which a package of services including credit and market support were made available to farmers and helped them adopt the technology that augment production. However, the large farming community was not motivated to adopt the technology because the success was not perceptible or obvious.

Later on, agricultural technology from 1968 was associated with the Green Revolution, which embraced the cultivation of genetically superior strains of wheat, rice, sorghum and maize under improved agro-techniques. Extension of irrigation facilities, greater use of fertilizers, increased area under high yielding varieties, adoption of improved management practices have all complimented to the production potential. Consequently, wheat production in India doubled in a span of five years.

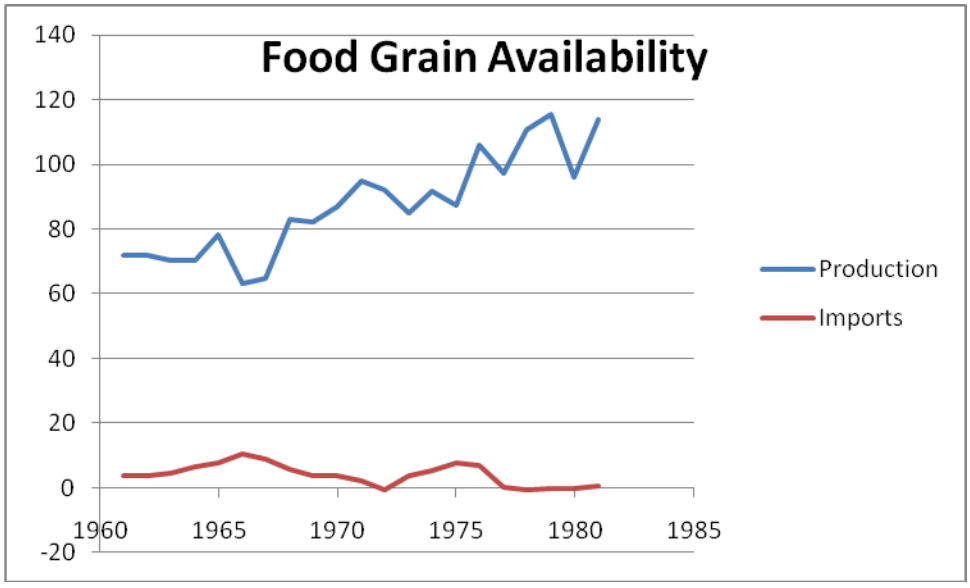

Figure 2: Food Grain Availablity 1961-1981 Source: "India, the Emerging Giant", Arvind Panagariya

Major Issues in Agricultural Production Management

Decentralized, farmers' participatory approach in variety development

One of the criticisms of the Green Revolution has been that it promoted only a few or limited number of high yielding varieties evolved by the scientists at the research institutes for commercial cultivation of farmers. This centralized system of variety development and release does not give adequate weightage to the preferences of farmers. Moreover, a variety which has performed well under the ideal, controlled conditions of an experimental station may be a disaster in poor, varied situations prevalent in farmers' fields. Farmers' participatory approach needs to be brought to focus in each and every stage in the development and dissemination of varieties. Moreover, farmers' varieties are hardy, well adapted to specific agro-ecological conditions with preferred quality characteristics and possess valuable genes for resistance/tolerance to many biotic stresses. Hence local farmers should be encouraged to grow promising cultivars selected by them with the technical support and assistance of the research and extension personnel.

Judicious fertilizer use

Chemical fertilizers played a key role in the accomplishment of India's green revolution. Fertilizer production and consumption in India has increased manifold during the past five decades. The country has attained self sufficiency in N[xxx] and P fertilizers whereas the entire K requirement is met through imports. Fertilizer consumption during the past 50 years has increased manifold and reached a peak of 18.128 million tons in 2000-01.

The low efficiency of fertilizer in India is a concern. N use efficiency of rice is only 30-35 per cent. Phosphatic fertilizers are the costliest on Rs/kg of nutrient basis, but their efficiency is only 20-25 per cent; while the efficiency of K is around 70-80 per cent. Efficient utilization of fertilizers, therefore, is key to the economics of fertilizer application and environment-friendly sustainable agriculture. Adoption of best time, method and dose of fertilizer application is essential to achieve higher efficiency of fertilizer use. Soil testing to determine fertilizer need, suitable drills for placement of fertilizer, promotion of slow release materials, improved agronomic practices will help increasing efficiency of fertilizer.

There are also variations in the fertilizer-intensity of various crops. The FAO[xxxi] provides indicators about different crops, and their need for fertilizer use, which varies widely: for instance bananas are high in demand: they consume 427 pounds of N, P and K fertilizer per acre of production, whereas peas and beans require just 35 pounds per acre, as they can fix nitrogen directly from the air.

Promotion of short-duration green manure crops and bio-fertilizers

Indiscriminate use of chemical fertilizers is a major concern that needs to be addressed urgently. Continuous use of chemicals in the soil alters the physical, chemical and biological properties of the soil, which, along with pollution and contamination, can make the soil dead. A remedy to the problem is the use of different bio-fertilizers along with a lot of organic matter.

Bio-fertilizers are organisms that enrich the nutrient quality of the soil. The main sources are bacteria, fungi and blue green algae. They have a symbiotic relationship with plants and deliver many benefits such as plant nutrients, disease resistance, tolerance to adverse conditions, correcting salinity, alkalinity etc. Growing short duration leguminous crops and incorporating them in the field before planting the main crop would supplement organic matter and nitrogen in the soil thereby enriching the soil. Use of vermin compost is another option for maintaining optimum soil health. Bio-fertilizers are not intended to replace chemical fertilizers, but their judicious application along with chemical fertilizers can help enhance nutrient availability and sustain soil health.

Promotion of hardy food security crops in a Mission mode

One of the mechanisms that may help improve food security is the provision of alternative crops as food staples. Of course, this may require a significant marketing campaign to convince the consuming public of the value of these alternatives. There is a precedent: because of persistent rice shortages in the 1960's, wheat was promoted to traditionally rice-consuming South Indian households. As a result, wheat consumption in South India has soared.

i) Millets

So far we have been giving undue importance for rice and wheat. Almost all important food security strategies have been built around these crops which are fussy and oversensitive to environmental and climatic changes. Today, deficient rainfall in many parts of the country has started showing stress on the progress of sowing of kharif crops. According to figures released by the Ministry of Agriculture, as of 1st week of July 2009, the sowing of paddy was down by about 25 per cent compared to last year.

The country is blessed with an array of hardy grain crops like sorghum, bajra, ragi, and minor millets grown in drier environments. They are important staple food of the poorest of the poor in the semi-arid tropics of Asia and Africa and main source of energy, protein, vitamins and minerals. Concerted efforts need to be made for large scale cultivation of these neglected food security crops in poverty stricken, drought-hit rural areas. These crops should be promoted and included in the public distribution system.

ii) Root and Tuber crops

Tropical crops such as tapioca, sweet potato, yams and aroids should be cultivated intensively in poverty prone rural areas. These crops have enormous food production potential, are tolerant to adverse conditions and can be successfully grown with minimum management practices. The greatest advantage is that food is available right in the homestead and can save the poor from starvation and hunger.

A classic success story can be cited from the history of Kerala. Visakham Thirunal Rama Varma was the Maharaja of the erstwhile Kingdom of Travancore from 1880-1885 CE. Famine and starvation had become a recurrent phenomenon as part of the El Nino problems referred to above. The king realized the potential of tapioca – a tuber native to South America, which was introduced into Kerala by the Portuguese -- to bring about food security, and issued a proclamation which made it mandatory for

every household to grow as many tapioca plants as possible. In a span of a few years hunger and starvation has become a thing of the past and tapioca continued to be a secondary staple food in Kerala till recently.

This incident also illustrates what we described in the section above as the active management of food security during the era of native kingdoms.

Storage, utilization and value addition of fruits and vegetables

The diverse climatic zones in India make it possible to grow almost all varieties of fruits and green vegetables making India the second largest producer of fresh vegetables in the world which accounts for about 15 per cent of the world's production of vegetables. But India's wastage of fruits and vegetables are estimated to be nearly 35 per cent valued at Rs 33,000 crores due to the non-availability of proper processing and storage facilities, as well as of distribution channels. These may be conservative estimates; in any case the wastage is appalling.

India has neglected to build an adequate infrastructure for agriculture. There are no enough cold-storage facilities or secure grain elevators; there are no roads to get produce to market; there is insufficient initiative to manufacture value-added products on a competitive level so that utilization is utmost and wastage is negligible.

From planning for failure to planning for success

As an example of self-fulfilling prophesies, India's central planners have believed that agriculture is an albatross, something to be merely tolerated. Therefore it has in fact turned out that way, if you look at the economic results. Indian agricultural productivity is low, and it has stagnated. But that is not surprising: as in anything else, unless there is investment, it is usually unlikely that there will be returns. The lack of investment in agriculture has been a primary reason why the sector has languished so badly in comparison to industry and services in the recent past. An analysis by Goldman Sachs[xxxii] economists shows the appallingly poor performance of the sector as compared to the others:

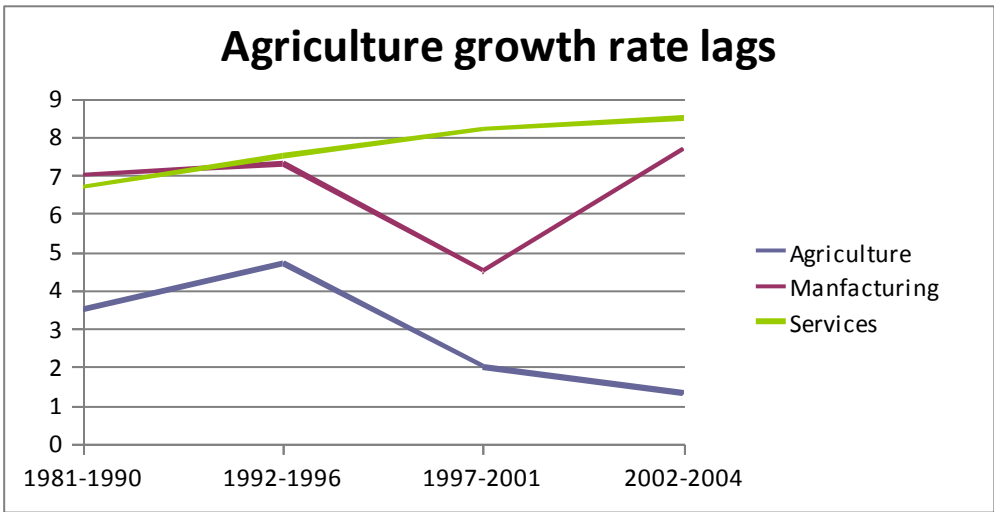

Figure 3: Output growth rates % increase year on year, by sector. Source: Goldman Sachs

To some extent, there is today a realization that food is an important product (after all, the total revenue of the food industry in the US alone is about $1.5 trillion), and that if the inefficiencies were to be removed from the system, there could be far better value generated by the industry. There are large inefficiencies because of the complex supply chain—since there may be five to seven levels of distribution, a lot of the value is captured by intermediaries.

A positive trend is the rise of "farm to fork" integrated supply chains. Large companies such as ITC and Reliance are offering new services to farmers as well as to consumers. By creating rural collection centers (ITC's are called e-*choupals* after a Hindi word for market), ITC has managed to disintermediate, and thereby increase farmers' incomes. By then putting in place infrastructure, including refrigeration and transport mechanism, and the ability to value-add through processing, canning/packaging and marketing, as well as offering retail outlets, these companies are hoping to bring about a revolution in agri-business. This would be wonderful news for rural areas, as it may lead to improved livelihoods for many, and as a positive corollary, would reduce the migration of poor farmers to urban slums such as Mumbai's Dharavi in search of work.

There is also the signal success story of Amul, a dairy-farmers' co-operative in Gujarat, serving millions of small suppliers, and producing and marketing branded, value-added milk-based products; they enriched their members, and provide well-received products to consumers.

The striking example of France's success in branding its agricultural products (such as with geographic appellations including "Champagne" and "Camembert") should be a good example for India to follow. The French success in differentiating and marketing its products – for instance, French wine still has a certain cachet, although in blind taste-tests Californian or Australian or South African products do just as well – would be good to emulate. India does have the advantage of many native genetic strains, and

these need to be marketed to an increasingly choosy consumer base around the world as more wholesome than the factory-farmed varieties. For instance, given that much agriculture in India is indeed organic, it should be possible to use what retailers like Whole Earth in the US and the Body Shop in the UK have demonstrated: that large numbers of people are willing to pay significantly more for sustainable and organic products.

This sort of branding and marketing may well be a public-private partnership with makers of agricultural products such as ITC, Reliance and even MNCs such as Pepsi, which have operations in India.

Just as Thai cuisine has taken the world by storm, thereby leading to increased consumption of well-packaged Thai food items around the world, the increasing popularity of Indian food can also act as a spearhead for those farther down the supply chain to make investments in marketing.

If the State invests in agriculture, and that is a big if, this can be a source of sustained advantage for India. Innovation will also be key here: for instance, using advanced bio-technologies, including genetic engineering; using the diversity of crop varieties available indigenously in India; and re-creating traditional cropping and water-harvesting techniques, are all within the capabilities of Indian scientists.

Fortunately, innovation is alive and well at the grass-roots level. Just as Aravind Eye Care and Narayana Hrudayalaya have revolutionized medical practices through process innovation in the areas of eye and heart surgery, respectively, there are many inventors coming up with appropriate technology for rural needs in India. At the IIM, Ahmedabad, SRISTI and the Honey Bee Network, focusing on rural innovations, have successfully brought a number of them to market. They also help protect the intellectual property rights of tribal populations, which have typically been commandeered by industrialists.

The key seems to be the State's actions: not interfering where it cannot add value, and interceding where only it will invest with a long-term perspective. If India's omniscient mandarins could bring themselves to treat agriculture with the respect it deserves, we may see minor miracles.

Food Security Strategies

The persistence of poverty, hunger and malnutrition along with the growing availability of food has rendered the rationale of both poverty alleviation and food self sufficiency policies suspect and paradoxical. The existence of these problems has undermined the very process of democratic governance. By definition, food security involves every individual gaining physical and economic access to a balanced diet and safe drinking water so as to lead a healthy and productive life.

Food availability and food access are two major and complementary issues . Food availability can be a function of home production or imports whereas food access depends upon the purchasing power of individual. On a gross level, Indian agriculture with all the inherent problems has attained the goal of producing enough food for its people. But due to lack of employment opportunities and income in the rural areas, poor people could not access or procure food which is a gross violation of right to life enshrined in the constitution.

In this context, the central government's flagship program for rural poverty alleviation -- **the National Rural Employment Guarantee Scheme (NREGS**) -- needs special mention. The political success of the program reflects the coming of age of the initiative for rural uplift with the end result of putting cash in the pockets of rural poor in exchange for the unskilled manual labor. Despite initial teething trouble and malfunctioning due to corrupt practices , it has now taken off well with telling effect among a large segment of the rural mass.

The scheme , which covered 200 districts when it was launched in 2006, is now implemented in 604 rural districts. Manpower can be constructively utilized on watershed management, rain-water harvesting, drought proofing, flood protection, land development, minor irrigation, rural connectivity and afforestation. The Finance Minister has promised to provide a daily minimum wage of Rs100 for all the workers and 100 days of guaranteed unskilled manual work . Its impact could be visualized due to the fact that rural India is home to an estimated 73 per cent of the county's poor. Although NREGS cannot be a permanent solution to rural poverty, it can be a temporary measure with vital impact.

There are dangers inherent in a scheme such as NREGS – there is likely to be leakage at a micro level, and at a macro level, as is happening today, it might suffer from scope creep. The NREGS is being turned into an omnibus social security mechanism: rather than a short-term solution, it is in danger of becoming the panacea for rural poverty, which isn't its charter. Instead of addressing the real problems of under-investment and neglect, there is a tendency to see NREGS as the solution, whereas it is only a band-aid on a bleeding wound. Handouts are not the answer, as in the proverb about how if you give a man a fish, he eats for a day; but if you teach him to fish, he eats every day.

The National Food Security Act that the current UPA government has pledged to enact, if implemented, would entitle every family below the poverty line 25 kg of rice or wheat a month at Rs. 3 a kg . The Act seems to hold promise in spite of serious debate about the wrong inclusion and exclusion of BPL and APL categories. Such radical measures could ameliorate the ignominy suffered by India at being ranked

a low 66 in the World Hunger Index of 88 countries and a poor 132 among 179 countries for the Human Development Index.

Need For a Second Green Revolution

India needs to produce a second "Green Revolution" to boost food supplies for the nation's 1.2 billion people. But so far there has been no major sign of concrete steps to make that happen. The first Green Revolution quadrupled food production and made India self-sufficient.

India's agriculture has been in decline in recent years and growing at a far slower pace than the overall economy. In 2006, it was forced to import wheat for the first time in years ringing alarm bells about food security. Indications are that in 2010, India will have to import rice for the first time in 22 years.

Two criticisms of the first Green Revolution were that : i) it did not benefit dry land agriculture and ii) it was not scale neutral and benefited only large farmers and big farms. So a second Green Revolution should focus on dry-land agriculture and benefit small and marginal farmers. It should involve non-food crops like fruits, vegetables, oilseed crops and should provide sustainable livelihood to small farmers. Marginally productive waste land should be brought under cultivation. Livestock development and dairy husbandry should be promoted with special focus on generation of gainful self employment among the poor and weaker sections of society.

There continues to be considerable concern about endemic crop failure and related farmer suicides. Much of this may be attributable to the lack of low-cost rural credit, the unavailability of crop insurance, poor choices in what to cultivate, and above all, the effects of huge agricultural subsidies given by developed nations to support their high-cost farming. Interestingly, research into actual causes of suicide shows the following—and it may appear that the global reasons are not so relevant.

Reasons for farmer suicide	Percent
Habits like drinking, gambling, overspending	20.4
Failure of crops	16.8
Other reasons (eg. chit fund)	15
Family problems with spouse or others	13.3
Chronic Illness	9.7
Marriage of daughters	5.3
Political Affiliation	4.4
Property disputes	2.7

Debt burden	2.7
Price crash	2.7
Borrowing beyond paying capacity	2.7
Loss in non-agricultural activities	1.8
Failure of bore wells	0.9

Table 8: Reasons given for farmer suicides. Source, "Suicides by Farmers in Karnataka: Agrarian Distress and Possible Alleviatory Steps", R S Deshpande, EPW 2002

But tariff and other barriers on agricultural products imposed by rich countries[xxxiii] are a contributing factor to the continuing problems of farmers in India. The US, for instance, provides subsidies to the tune of more than $20 billion a year for five major crops: wheat, rice, soy, cotton and corn. Thus, Americans are able to dump their produce at prices that simply cannot be matched by Indian farmers who may have to pay for the full cost of production. Active intervention by the Indian government in the Doha and future round of trade talks is necessary to ensure that Indian agriculture is not burdened with this disadvantage.

Threats to India's food security

There are some other, self-imposed problems. One is the stress that is being put on water resources due to unsustainable practices. The water table has dropped in many parts of the country, in particular in the Green Revolution states, because of perverse incentives. Since rich farmers get electricity free, they see no reason to not dig deeper and deeper to pump out ground-water, which is now being exploited much faster than the replenishment rate.

The destruction of forest habitat is a double blow. On the one hand, slash-and-burn agriculture has caused the all-important hills in parts of the country to be devastated. Examples are in Kerala and Meghalaya. Traditional practices involving sacred groves, as in the Khasi Hills of Meghalaya, had ensured that forests would not be clear-cut, and that areas would be left untouched. But with modernization and new technology, the rainforests have been decimated, which leads to the second problem: runoff of topsoil, which leaves the hills denuded and the rivers silted-up. It may also lead to reduction in rainfall.

In Kerala, the hills have not been denuded, and they look quite green, but it is an illusion: they are green deserts of monoculture plantations. The ecological balance has been disturbed; in addition, Kerala's rivers are dying because of illegal sand-mining for construction purposes. Thus water management—India is likely to be among the nations most seriously affected by dwindling water supplies—is a major issue.

On top of this there are external threats. The Chinese are proceeding with plans to dam the Brahmaputra River in Tibet (where it is called the Tsang-po). Current plans, which are at an advanced

stage, indicate a smaller dam. But their future plans call for a gigantic dam and diversion of the river northwards at a big bend in the river, which would substantially reduce the supply of water downstream. This could be a disaster of mammoth proportions. The Chinese have already dammed the Mekong, reducing the flow to lower riparian states such as Cambodia.

There are also problems based on poor policies. In Kerala, paddy cultivation in some of the best-watered and fertile areas in India has come to a halt due to political reasons. What used to be a rice-bowl is now a large importer of rice from neighboring states, all because of labor militancy and wrong-headed approaches by the State. Acting with the best of intentions, the socialist and left-leaning politicians of Kerala imposed a minimum wage for agricultural laborers which they thought would enable them to make a livelihood.

Unfortunately they set the price so high that it became economically nonviable for the landowner to cultivate rice. It became more rational for the landowner to let the paddy field lie fallow for five years, fill it in and sell it as real estate. This is exactly what has happened. In an example of the principle of unexpected consequences, the laborers lost their jobs instead of getting a minimum wage. Furthermore, things have been exacerbated by labor militancy. There are a few brave paddy farmers still in Kerala; in 2008, when they produced a bumper crop, militant laborers would neither harvest the crop nor allow mechanical harvesters to be brought in; unseasonable rains destroyed the large standing crop, causing losses upwards of Rs. 2000 crores.

The future: The Organization of Food-Exporting Countries?

If India were to think big, there is an opportunity in food. It is now universally recognized that Western-style factory-farming has large risks, and it is environmentally unsustainable. Given the persistence of 2008's food price increases into 2009 (India's food price inflation is of the order of 10+ percent), it appears that there might be a systemic change: world food prices are on a permanent upswing, and it is not because of the increased cost of petroleum products. According to the *Economist*[xxxiv], "[world] food prices rose by 9.8 per cent [in 2009], prompting fears of a resumption of the surge that began in 2007."

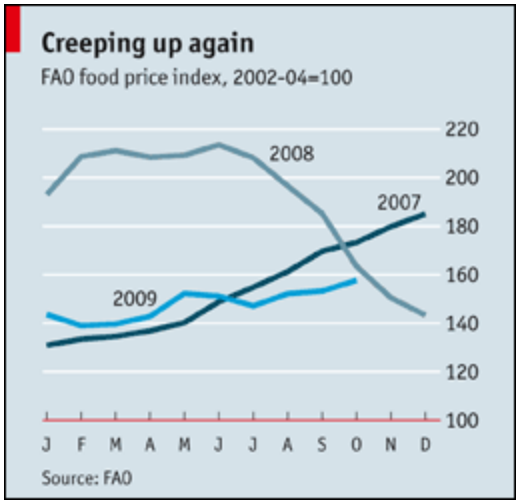

Figure 4: Food prices, 2007, 2008, 2009, from the Economist, Nov 19, 2009

There are a number of reasons, including climate change (which are turning some of the granaries of the world less productive as rainfall patters change), increased demand for meat from people in emerging countries who are prospering (meat requires considerably more per calorie in inputs in grain and water than does vegetarian food), the diversion of food crops such as corn towards bio-fuels, and the greater input costs of monocultures as hardy native species are discarded. According to the *Economist*[xxxv],

> "Between now and 2050 the world's population will rise by a third, but demand for agricultural goods will rise by 70% and demand for meat will double. These increases are in a sense good news in that they are a result of rising wealth in poor and middle-income countries. But they will have to happen without farmers clearing large amounts of new land (there is some scope for expansion, but not much) or using up lots more water (in parts of the world, water supplies are stretched to their limit or beyond)."

India, with its traditional-knowledge systems not yet completely wiped out by imported western knowledge, may be able to fill the gap as others suffer: for instance, major exporter Australia has faced grueling droughts for years. There is still some knowledge of old water-management practices and of native breeds that may resist global warming. Given the ingenuity of the Indian farmer, and the desired

improvement in investment and management practices that have been touched upon in this paper, it may well be feasible for India to emerge as an agricultural super-power in future.

This has positive implications. Today many nations are recognizing the value of agricultural land and are taking steps to assure themselves of production to meet the needs of their population (a modern form of "land-grabbing"). For instance, China has leased or bought several million hectares across Africa, because they have degraded their own land. The *Economist* magazine estimates that there are 150 million Chinese permanently pushed off the land and forced to be migrant factory labor – part of the reason is that much farmland has been paved over, polluted, and turned into non-cultivable acreage; they are also suffering from progressive desertification in certain parts of their country.

Saudi Arabia has leased large acreage in Pakistan, in effect acknowledging that their efforts to grow food in the desert have failed. Kuwait and South Korea have also contracted for land overseas. In total, about 20 million hectares of the best farmland in several poor countries has been acquired by the land-grabbers.

Thus it appears that food will become a more valued commodity in future. Just as the OPEC (Organization of Petroleum Exporting Countries) was able to extract a much higher value for their product by cartelization, it may well be possible to form an OFEC (Organization of Food Exporting Countries) which will have a monopoly power over food stuffs that other countries need. After all, food availability is a critical, literally life-and-death matter.

Even if an OFEC-like body does not materialize, the value of food will increase. In an era of volatile currencies, there might be elaborate barter schemes based on David Ricardo's theory of comparative advantage: for instance, it may be possible to exchange a few kilos of chicken for a barrel of oil. India should be prepared for such an eventuality, where it can use it competitive advantage in food production to improve its balance of trade, not to mention the nutrition of its own people. International benchmarks suggest that Indian children are underfed to an alarming degree – on average their nutrition levels are even below those of desperately-poor sub-Saharan African nations.

Despite the mythology based on rapid generalization from poverty in the colonial era and later, there is no reason to conclude that Indians were historically underfed. The 21st century may well be the time for Indians to catch up to their historical levels of healthy nutrition.

Conclusion

Based on historical data, it appears as though India should be able to manage food security for its population if only certain sensible steps were taken to ensure that its competitive advantage in agriculture is utilized optimally. In times before colonialism, India had been able to assure its inhabitants of food security through careful observation of the problems of drought and famine, and taking appropriate steps to ameliorate them. This fell by the wayside under the imperial era, and millions perished in El-Nino-related, and probably avoidable, famines.

The record of the post-Independence Indian State is mixed. While the Green Revolution has enabled the country to provide a certain measure of food security, large numbers still go to bed hungry. Through proper management of resources, it should be possible to ensure that India becomes a consistent food exporter.

If India is able to emerge as one of the world's bread-baskets, so to speak, that would a remarkable turnaround from the nation that waited for American ships to deliver grain so that it might feed its starving masses. This dream is within India's grasp today.

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[i] Angus Maddison, "The World Economy: A Millennial Perspective", OECD, Paris, 2001.

[ii] The Battle of Plassey took place in 1757 and marked the beginning of the imperial domination of India

[iii] http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.html "El Nino/Southern Oscillation Diagnostic Discussion", 9 July 2009, Climate Prediction Center, US National Weather Service: "El Nino weather conditions will continue to develop and are expected to last through the Northern Hemisphere Winter 2009-10"

[iv] Mike Davis, "Late Victorian Holocausts: El Nino Famines and the Making of the Third World", Verso, London, 2000

[v] http://info.k4health.org/pr/m14/m14table.shtml#table1 Water stress is defined as the situation in which the annual availability per inhabitant is less 1,700 cubic meters a year. India is expected to fall below this threshold between now and 2025

[vi] An example is the loss of diversity in bananas and plantains. Where once regional variants astonished by their differences, a visit to a supermarket in India today shows the preponderance of the standardized Robusta or Cavendish, at the cost of hardly local cousins

[vii] Michael Pollan, "The Omnivore's Dilemma: A Natural History of Four Meals", Penguin, New York, 2006

[viii] L-Aquila Joint Statement on Global Food Security http://www.g8italia2009.it/static/G8_Allegato/LAquila_Joint_Statement_on_Global_Food_Security[1],0.pdf

[ix] "Declaration of the World Summit on Food Security", Rome, 16-18 Nov 2009, ftp://ftp.fao.org/docrep/fao/Meeting/018/k6050e.pdf

[x] Paul Bairoch, "International Industrialization Levls from 1750-1980", Journal of Eureopan Economic History 11 (1982), p. 107

[xi] The city of Vijayanagar, whose ruins can now be found in the village of Hampi, Karnataka, was, at its peak, the largest and wealthiest city in the world, spread out on some 500 square kilometers. Visitors in the 14th and 15th century CE were astonished at the wealth of the city, as is evident from records left, for instance, by the Portuguese and Persian ambassadors

[xii] J Bajaj and M D Srinivas, "Timeless India, Resurgent India", Center for Policy Studies, Chennai. The arable land in India is 160 million hectares as compared to 177 million hectares for the US, and 124 million hectares for China + Tibet

[xiii] http://en.wikipedia.org/wiki/Parākramabāhu_I_of_Sri_Lanka

[xiv] http://www.tarunbharatsangh.org/

[xv] "Timeless India, Resurgent India", op. Cit.

[xvi] Prasannan Parthasarathi, "Rethinking Wages and Competitiveness in Eighteenth Century Britain and South India", *Past and Present,* February 1998

[xvii] Dharampal,"Indian Science and Technology in the Eighteenth century: Some Contemporary European Accounts", Impex India, Delhi, 1971

[xviii] Captain Thos Halcott "On the Drill Husbandry of Southern India", Dec 1795: "Until lately I imagined the Drill plough to be a modern European invention, but a short time ago, riding over a field, I observed a Drill plough at work, very simple in its construction, which upon inquiry I find is in general use here, and has been so from time immemmorial."

[xix] Major General Sir Alexander Walker, 1820 "Indian Agriculture" "In Malabar, the knowledge of husbandry seems as ancient as their History...They have provided a code of rules for good husbandry. A system is laid down for the proper cultivation of the soil. The rights of the proprietor and of the mere occupier of the land are distinguished and explained... One of the most remarkable rites of Hindoo worship probably owes its origin to their respect for agriculture. Their sacred Bulls, and their superstitious regard for the cow, have their foundation in the great service they rendered to husbandry..."

[xx] *Hortus Malabaricus* is described in detail at http://www.ias.ac.in/currsci/nov252005/1672.pdf

[xxi] It is interesting that the *Hortus Malabaricus* may well provide "prior art" protection, and may thus lead to the overturning of patents where traditional knowledge is being unfarily expropriated in cases of alleged Intellectual Property infringement, as has already taken place with turmeric.

[xxii] Incidentally, they also systematically burned all the Ayurvedic texts they could find in Malabar!

[xxiii] William Digby "'Prosperous' British India", London, 1901

[xxiv] Anup Maharatna, "The Demography of Famines: An Indian Historial Perspective", Oxford University Press, Delhi 1996

[xxv] Roland Seavoy, "Famine in Peasant Societies", New York, 1986

[xxvi] The Lancet, London, May 16, 1901

[xxvii] "Cambridge Economic History of India", Cambridge University Press, 1983

[xxviii] Dadabhai Naoroji, "Poverty and Un-British Rule in India", London 1901, pp. 212 and 216

[xxix] Indian opium was used by the British to subvert the Chinese economy, as this was just about the only product China was willing to buy.

[xxx] N = nitrogen, P = phosphate, K = potash

[xxxi] Http://www.fao.org/ag/agi/fertistat, the statistics from the Food and Agriculture Organization pertaining to the intensity of fertilizer use for various crops

[xxxii] Tushar Poddar, Evi Yi, "India's Emerging Growth Potential", Global Economics Paper No. 152, Goldman Sachs, https://portal.gs.com

[xxxiii] There is supposedly a "wine lake" and "butter mountain" in Europe, metaphors for overproduction because of subsidies to farmers. http://www.euro-know.org/europages/dictionary/w.html

[xxxiv] The Economist, "If words were food, nobody would go hungry", Nov 19, 2009 http://www.economist.com/world/international/displaystory.cfm?story_id=14926114

[xxxv] The *Economist,*"How to feed the world", Nov 19, 2009 http://www.economist.com/opinion/displaystory.cfm?story_id=14915144