Explorations #1

The Vegetable Industry in Tropical Asia: *India*

An Overview of Production and Trade

Greg I. Johnson
Katinka Weinberger
Mei-huey Wu

About *Explorations*

AVRDC – The World Vegetable Center's *Explorations* series seeks to inform discourse on the convergence of science, technology, and practice in vegetable breeding, production, and marketing. Envisioned as a catalyst for enterprise and research, the series enables diverse communities to explore expertise, ideas, and common frameworks.

AVRDC – The World Vegetable Center

AVRDC – The World Vegetable Center is an international not-for-profit organization committed to alleviating poverty and malnutrition through research, development, and training.

AVRDC – The World Vegetable Center
P.O. Box 42
Shanhua, Tainan 74199
TAIWAN

Tel: +886 6 583 7801
Fax: +886 6 583 0009

Email: info@worldveg.org
Web: www.avrdc.org

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– Greg I. Johnson
Horticulture 4 Development
PO Box 412
Jamison, ACT 2614
Australia

– Katinka Weinberger
– Mei-huey Wu
AVRDC – The World Vegetable Center
P.O. Box 42
Shanhua, Tainan 74199
Taiwan

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INDIA
PAKISTAN
JAMMU & KASHMIR
Srinagar
HIMACHAL PRADESH
Shimla
Chandigarh
PUNJAB
Dehradun
UTTARANCHAL
HARYANA
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1 Summary

This report examines the role of the vegetable industry as a key asset for productivity improvement, market development, income generation, and livelihood improvement in India.

1.1 Key statistics for India

Statistics gathered from (FAOSTAT, 2007; Wiesmann, 2006)

Land area:	3.2 million km^2
Latitude:	8º4" to 27°6" N
Longitude:	28°7" to 29°25"E
Climate:	Six broad types. Mainly tropical for most of the subcontinent except northeast and Himalaya foothills.
Population:	1.14 billion
Global Hunger Index:	1981-41.2% > 1992- 32.7% > 1997- 25.7% > 2003-25.7%
Production[1]:	83.1 mt
Area:	8.0 m ha (2005)
Availability:	183 g/capita/day (2005 (provisional) - FAOSTAT, 2007) or 146 g/capita/day (2004-05 calculated from NSS data).
Main crops:	(area) – chili, onion, eggplant, tomato, okra, cabbage, peas, cauliflower. (volume) – eggplant, tomato, onion, cabbage, cauliflower, okra, peas, chili.
Exports:	1.6 mt (fresh/processed) worth US$ 508 million***.** Fresh: onions, mushroom, green peas, eggplant, okra (Working Group on Horticulture, Plantation Crops and Organic

1 Data in summary excludes potato.

Farming, 2007). Processed: gherkin, dried onion, frozen mixed vegetables to Bangladesh, Sri Lanka (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007)

Imports*: 46,000 t (fresh/processed) worth US$ 25.2 million. Fresh: onion, garlic, cabbage and other brassicas. Processed vegetables: Wide variety, too numerous to list individually. * (includes chili, ginger) (2005 [provisional] FAOSTAT, 2007).

1.2 Industry issues

Assuring production and *marketing*	• Priority policy formulation and regulatory changes for the 11th 5-Year plan aim to improve productivity, enhance farmer incomes, and stimulate agribusiness. • Implementation at national, state, district, and farmer levels is the key to improving the rapidity and ease with which change can occur. • Dialogue and active consultation at all levels are critical for avoiding overlap and for realizing national, state, and district initiatives. • Implementation may be a challenge where political or socio-cultural issues clash. Government focus on legal frameworks and funding for infrastructure, farmer, and SME incentives at local level will be paramount, especially in remote and marginalized areas.
Benefiting farmers and consumers	• Enhancing food safety, quality, and supply chain management, and reducing postharvest loss reduction are key issues. • Boosting literacy at village level, and enhancing practical skills, business knowledge, and "produce-care" capabilities of farmers, workers, and consumers are essential for agricultural modernization. • Governments and communities must also devise opportunities for those who are marginalized by the changes within the farming and trading sectors.
Expanding trade and value adding	• India could easily feed its entire population and expand trade if postharvest losses could be halved (from levels as high as 40%). More processing of vegetables will add value and reduce losses. • Foster investment and ease regulatory controls while improving quality and food safety standards. • Key challenges: to harness the strengths and achievements in research while paving the way through capacity and new modalities of training for the "new India" as the IT-savvy youth generation, who dominate the population now, become a more significant force in the economy.

Assuring quality and increasing consumption	• Attention is needed not only to improve technical skills, logistics, and Good Agricultural Practice, but more critically to human resource development. The "All-India" coordinated projects for research and development, and the links between the Ministry of Agriculture Indian Council of Agricultural Research (ICAR) agencies and state and district level initiatives are impressive. However, R&D will be implemented more effectively by boosting partnerships with the private sector and with local and international NGOs.

1.3 Recommendations for development

Marketing and economics

- Build capacity in agribusiness marketing and policy development for the vegetable sector.
- Improve collection and analysis of horticulture production and marketing data, and strengthen information flows for internet-based, community-level access.
- Develop cost-benefit and supply/demand models for transitional and high-value production systems, particularly for rain-fed and remote areas, for use in decision making, state/district level investment, and promotion of the vegetable sector.

Industry development

- Encourage demand-focused growth in domestic production while improving marketing and value-adding.
- Strengthen market-focused approaches to trade development.
- Streamline approaches to trade and agribusiness development, to optimize benefit flows to regions most in need/capable of benefiting from investment**.**
- Continue liberalization of market and trade regulation**.**

Systems and technology

- Adopt systems and supply chain management approaches to planning and improvement.
- Increase developmental work for suitable varieties and productivity improvement under high temperatures. Foster uptake and improvement of low-cost structures, fertigation, and microirrigation systems.
- Reduce overuse of chemical fertilizers and enhance precision application through fertigation and use of biofertilizers.
- Reduce pest and disease losses while minimizing reliance on chemicals for pest and disease management by improving pest management practices.

Collaboration and engagement

- Engage with the private sector to streamline modernization of the retail and whole sectors.
- Focus government investment on logistic and infrastructure improvement and trade promotion, and policy reform on easing regulations and social disruption and increasing consumption.

2 Introduction

Extending between 8°4" and 37°6" N, and 68°7" and 97°25" E, India is the world's second most populous nation (est. 1.14 out of 6.62 billion (UNFPA, 2007). Bound by the Himalayas to the north, and tapering into the Indian Ocean between the Bay of Bengal and the Arabian Sea, the Indian subcontinent covers 3.29 million km^2 —just 2.4% of the world land area, yet it supports 15% of the global population. One-third of India's population is under the age of 15.

Rainfall patterns vary across the subcontinent. There are six broad climatic types, from arid desert to alpine to humid tropical, with four seasons: winter (January-February), summer (March to May), monsoon (June to September) and post-monsoon (October to December). The Himalayas block cooling winds from the north, so winters in India are milder and summers hotter. The climate is essentially "tropical" for much of the subcontinent aside from the northeastern areas and the Himalayan foothills (Wikipedia, 2007d, 2007a).

Cropping is in two seasons: *kharif* and *rabi*. Rabi is the spring harvest season, with crops sown September to November and extending up into February and March, with most productivity in areas that receive the north-east monsoon. The kharif is the main cropping season in much of India, commencing in June with the south-west monsoon and extending into autumn (September to November). Most of the rain, tank, and canal-fed areas are cropped in the kharif.

As the world's largest parliamentary democracy, India has made impressive progress in development, particularly since 1990. The economy ranks 6^{th} in foreign exchange reserves (US$ 204,009 billion), after China, Japan, the Eurozone, Russia, Taiwan, and South Korea.

Along with progress in development, the proportion of the population who do not receive adequate food is also decreasing. However, levels of household food inadequacy are highest among agricultural workers, and in the states of West Bengal (10.6%) followed by Orissa (4.8%), with shortages highest from December to March. Food inadequacy levels are lowest in the states of Haryana and Rajasthan (NSS, 2007b). The Global Hunger Index for India dropped from 41.2% in 1981, to 25.7% in 1997, but then declined more slowly to a predicted 20.9% in 2007 (Wiesmann, 2006; Dutta, 2007).

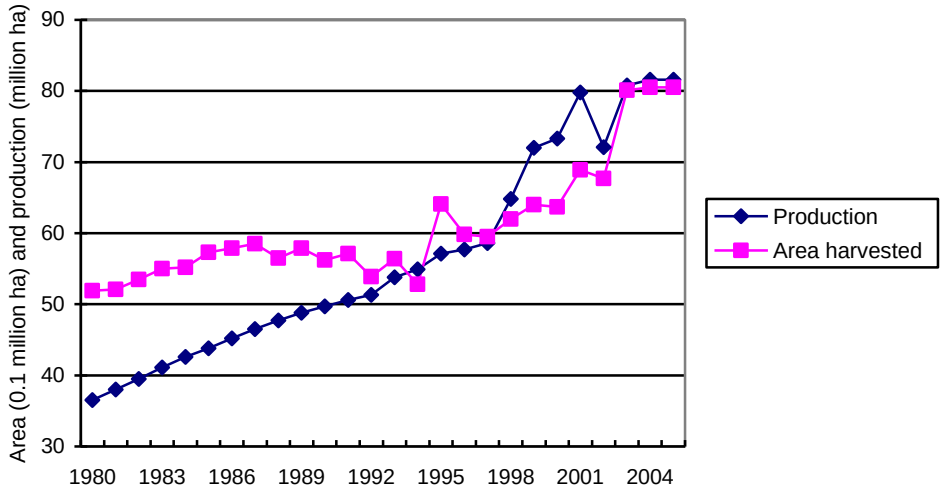
The slowdown in hunger reduction is disappointing, considering that the 2006 economic growth rate was 9.2%. This reflects low growth in the agricultural

sector[2], which employs > 60% of the population, yet contributes only 18.5% of GDP (ADB, 2007). The low contribution is due to the policy focus on self-sufficiency in low-income generating grains, despite the rapid growth in demand for high-value products (fruit, vegetables, livestock products, and fish), which boost farm incomes (von Braun et al., 2005). To stimulate growth and development, India could boost pro-poor rural investment and cut input subsidies; enhance strategies that benefit the landless poor; reform the water supply sector; focus on high-value agriculture, including horticulture; and liberalize trade and market policies (von Braun et al., 2005).

2.1 Significance of the vegetable industry in Indian agriculture

Of the total land, an operational area of 166 million ha (107 million farms) are available for agriculture (1991 = latest available data) (INDIASTAT, 2007) with 4% used for vegetables. Smallholders dominate both Indian agriculture and vegetable production. Across all production sectors, more than 80% of farms of are ≤ 2 ha, and on average, 0.6 ha. Income from staple crops is inadequate, so farmers supplement with off-farm and non-farm income, and increasingly grow high-value crops such as vegetables (Birthal and Joshi, 2007). In 1999, vegetable production involved 15.3% of farmers, with farms of < 1 ha producing 34.3% of national vegetable production from on average 20.3% of their land. Another 26.7% of vegetables were produced on farms of 1-2 ha from on average 15.3% of the farm. Across all farm sizes, on average, 14.9% of the farm area was used for vegetables (GoI, 1999; Birthal and Joshi, 2007).

[2] Growth of less than 2% from 1997/98 to 2002/03.



Source: FAOSTAT (2007)

Figure 1. Trends in vegetable production and area, 1984-2005

India is the world's second largest vegetable producer (11%) after China, and ahead of Brazil. From 1984 to 2005, harvested area ranged from 5.5 to 8.0 million ha. Production increased steadily between 1980 and 1997, while harvested area remained relatively stable, ranging from 5 to 6 million ha (**Figure 1**) (FAOSTAT, 2007). Aside from peaks and drops in 2001 and 2002 respectively, production grew more sharply from 1998 to 2002, but plateaued from 2003 to 2005. The harvested area grew gradually from 1996 to 2002, then increased sharply in 2002-2003 before plateauing up to 2005 (**Figure 1**, **Table 1**).

Table 1. Indian vegetable production, area harvested and trade, 1995-2005

	1995	1997	1999	2001	2003	2005
Population (1000)	935,572	970,041	1,004,200	1,037,809	1,070,800	1,103,371
Area harvested (ha)	6,405,300	5,950,200	6,401,100	6,889,000	8,009,000	8,049,000
Production (tonnes)	57,077,800	58,622,400	72,017,800	79,770,300	80,778,500	81,628,500
	1995-96	**1997-98**	**1999-00**	**2001-02**	**2003-04**	**2005-06**
Exports (tonnes) (APEDA)	591,887	684,755	677,629	921,189	1,388,543	1,986,743
Export (APEDA) as% of production (FAO)	1.04	1.17	0.94	1.15	1.72	2.43
Exports (tonnes) (FAO)	543,950	538,450	474,540	764,760	1,229,140	1,554,100
Export Value (US $ 1000) (FAO)	222,720	195,033	203,271	254,520	379,391	508,454
Imports (tonnes) (IARI)	na	1,093,187	295,240	na	na	na
Imports (tonnes) (FAO)	7,770	17,320	39,270	90,360	67,780	46,050
Imports Value (US $ 1000) (IARI)	Na	12,.938	4,405	na	na	na
Imports Value (US $ 1000) (FAO)	2,777	4,546	15,986	33,007	22,835	25,189

Note 1: Potato, sweet potato and tapioca are included as vegetables in APEDA and IASRI data. Since processed fruits, other than mango pulp and chutney, are included under "Other processed fruits & vegetables" in APEDA and IASRI data, the total vegetables listed in this table are calculated without deducting these processed fruits.

Note 2: Vegetables + dry chili + melons + ginger were included in FAOSTAT.

Sources: Population, area and production, selected trade - FAOSTAT (2007) (accessed September 2007); other export data - APEDA (2007a); other import data - IASRI (2006).

Table 2. Vegetables and spice[3] exports/import values (US$ "000), 2001-2005

	2001	2002	2003	2004	2005
Exports: Vegetables	191,601	219,278	306,066	294,826	409,323
Exports: Selected spices (chili, ginger, and turmeric)	67,257	86,206	101,825	132,771	136,773
Total Exports	**258,858**	**305,484**	**407,891**	**427,597**	**546,096**
Imports: Vegetables	24,891	21,119	11,770	9,989	11,172
Imports: Selected spices (chili, ginger, and turmeric)	4,188	5,988	11,991	9,614	16,686
Total Imports	**29,079**	**27,107**	**23,761**	**19,603**	**27,858**

Source: ITC (2007)

3 Spice data included because data includes chili, and several of the spices are cultivated in tandem with vegetables.

Trade

Vegetable exports more than tripled by volume in the decade from 1995 to 2005 (FAOSTAT, 2007; APEDA, 2007a) and now represent about 2.5% of production (APEDA, 2007a) (**Table 1**). The value of exports of vegetables and spices almost tripled from 1999 to 2005. ITC data on export and import value for India 2001-2005 (**Table 2**) are generally higher than the data of FAOSTAT (perhaps ITC is capturing more of processed vegetable data) and suggest export value has doubled between 2001 and 2005 while imports have remained static, representing less about 5% of the value of exports in 2005.

India is finalizing the planning for its 11th 5-year plan (Planning Commission, 2007a, 2007b, 2007c, 2007d, 2007e), and a productivity increase of 5% is proposed for the horticulture sector to contribute 19% of agricultural GDP (Mehta, 2007). The adoption of policies, including a focus on high-value horticulture such as vegetables coupled with trade and market reform, could contribute substantially to several of the plan's socioeconomic targets.

2.2 Vegetable demand

The cuisine of India, and much of South Asia, is noted for its use of spices in a range of dishes, often described by the term "curry"[4]. India's long history of vegetarianism is a strong influence. Meals typically include pulses (e.g. dhal), wheat-based flatbreads or rice, with vegetable dishes and accompaniments including curd (yoghurt), chutney, and raita; non-vegetarian meat or fish dishes have Mughal influences (Wikipedia, 2007e). In 2006, an estimated 31% of Indians were vegetarian (341 million), with the lowest proportion in the coastal areas of Kerala (2%), West Bengal (3%), Andhra Pradesh (4%), Tamil Nadu (8%), and Orissa (8%). The inland states in the north and west have the highest proportion of vegetarian families: Uttar Pradesh (33%), Madhya Pradesh (35%), Gujarat (45%), Punjab (48%), Haryana (62%), and Rajasthan (63%) (Yadav and Kumar, 2006). Even among non-vegetarians, per capita availability levels of vegetables and pulses are higher than availability levels in some other parts of tropical Asia.

Per capita availability of vegetables (excluding potato, sweet potato) has been estimated at 183 g/capita/day (2005 (provisional) - FAOSTAT (2007)) and 146 g/capita/day (2004-05 calculated from NSS data (NSS, 2007a)).

[4] Possibly from "Kari," the Tamil term for any secondary dish eaten with rice (Wikipedia, 2007b).

The growth in horticulture is driven by consumer demand and the need for farmers to enhance incomes through high-value crops. In India between 1983 and 1999/00, per capita availability of vegetables has doubled, while cereal consumption has declined by 10% (Birthal and Joshi, 2007). But based on projections to 2010, further increases in vegetable production will be needed to meet demand. Most of the supply increase could be achieved through higher per-unit productivity and reduction in postharvest losses. Production also needs to be boosted in non-irrigated areas, and in home and village gardens, especially in remote and mountain areas (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007) where availability levels are particularly low.

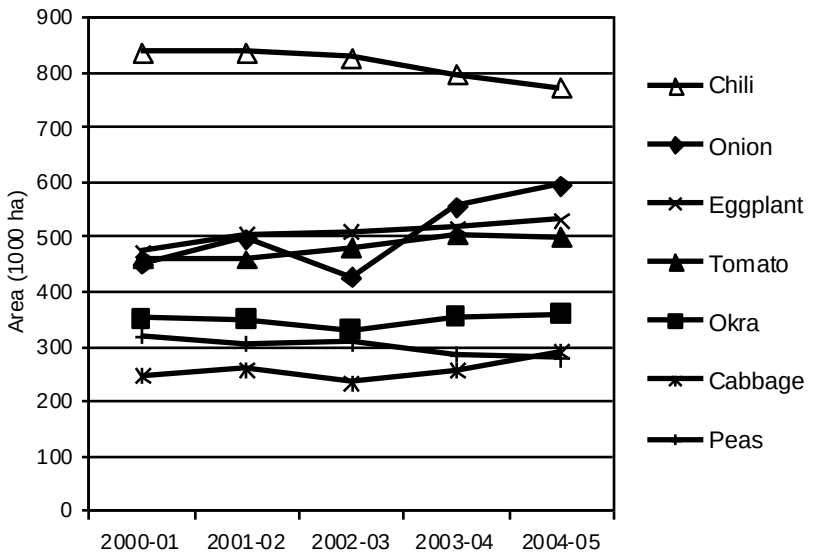
3 The vegetable supply chain

3.1 Production sector

Figure 2 and **Figure 3** show trends in the area under vegetables and total production data from 1999/00 to 2004/05 (for tabulated data see Appendix 1). India ranks first in global production of okra; and second in cabbage, cauliflower, eggplant, pea, onion, and tomato; and third for potato. However, yields/ha are not world-ranking, except in the case of tomato (highest in world ranking of yield), okra, and cauliflower (equivalent to world averages) (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

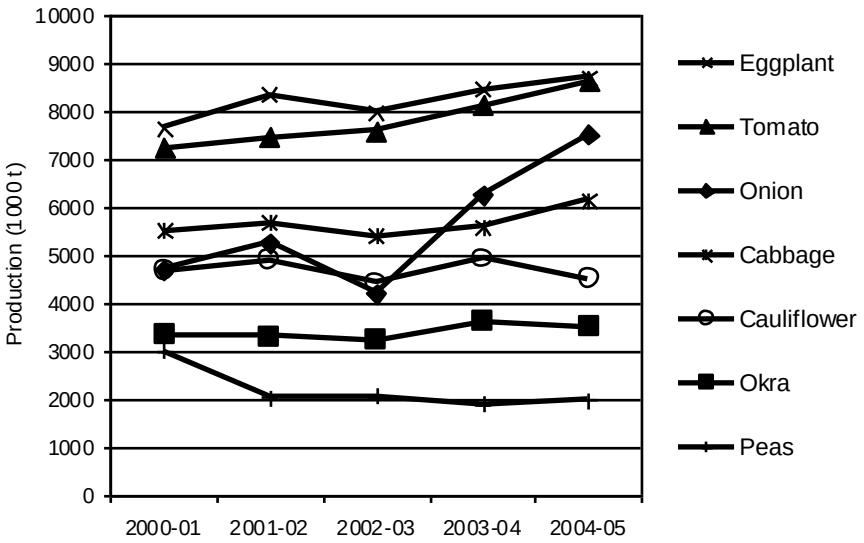
Between 2000/01 and 2004/05, production changes of major commodities varied from a reduction of -4.2%/annum (for cauliflower), to an increase of 37.2% /annum (for onions), with onion production showing strongest growth from 2002/03 to 2004/05. Area under production for most major commodities expanded more slowly, or declined (cauliflower) between 2000/01 and 2004/05, with the area under onions rising sharply between 2002-03 and 2005/05 to meet export opportunities.

Production of spices also is very significant (Appendix 1). The area of harvest of chili (771,200 ha) exceeded that of eggplant (530,300 ha) in 2004-05 but productivity was low (NHB, 2006; Spices Board of India, 2007).



Sources: NHB (2006); IASRI (2006); Spices Board of India (2007).

Figure 2. Area under major vegetables (including chili) in India 2000-2005



Source: NHB (2006)

Figure 3. Production of major vegetables (including chili) in India, 2000-2005

Area under vegetables and annual production vary considerably among states and regions with production highest in West Bengal, Uttar Pradesh, and Bihar (**Table 3** and **Table 4**). Some production from several states also supplies major cities. Of the states with populations exceeding 2 million, state-wise per capita production is highest in West Bengal, Orissa, and Nagaland, and lowest in Rajastan , Madhya Pradesh, and Manipur (**Table 4**).

Key production sectors for vegetables are described in **Table 5**.

Table 3. State-wise area of vegetables[5] for India 1999/00 to 2002/03

States / Union Territories	Area ('000 ha)					
	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Andhra Pradesh	230.1	249.9	222.5	213.3	248.0	258.4
Arunachal Pradesh	16.9	21.0	20.8	20.5	20.2	20.4
Assam	255.9	238.3	237.4	232.0	198.8	194.5
Bihar	626.0	707.8	578.9	609.9	815.0	816.6
Chhattisgarh		84.2	104.1	97.1	61.1	125.1
Delhi	45.7	114.8	111.0	43.7	43.7	43.7
Goa	7.6	7.6	7.6	7.0	7.8	7.8
Gujarat	201.0	205.6	232.2	248.3	248.3	33.1
Haryana	135.0	141.7	150.4	163.1	203.9	207.8
Himachal Pradesh	40.6	44.8	34.6	44.3	59.3	59.1
Jammu & Kashmir	41.4	45.7	50.8	24.9	34.7	52.1
Jharkhand		149.8	158.5	118.2	110.6	223.6
Karnataka	361.6	343.7	358.1	354.0	363.3	367.2
Kerala	159.7	114.8	114.3	112.7	99.2	107.6
Madhya Pradesh	258.7	238.5	136.4	136.8	164.7	184.4
Maharashtra	385.3	409.0	402.4	405.0	370.0	372.2
Manipur	7.4	9.7	10.6	11.6	13.4	13.4
Meghalaya	29.2	37.7	35.7	38.1	32.7	32.7
Mizoram	8.3	7.9	6.8	4.3	5.7	5.7
Nagaland	20.9	26.9	26.3	6.7	11.9	11.9
Orissa	788.1	702.5	643.4	616.8	655.3	655.9
Punjab	135.4	131.0	135.0	138.3	153.0	158.6
Rajasthan	98.7	95.1	99.3	90.3	116.5	124.1
Sikkim	9.6	13.5	14.2	14.1	16.1	17.0
Tamil Nadu	209.1	220.2	213.8	166.6	187.1	215.3
Tripura	18.4	31.8	31.3	31.6	32.0	32.0
Uttaranchal	81.9	104.8	93.8	70.6	41.0	72.8
Uttar Pradesh	688.9	668.1	777.9	853.5	819.5	840.9
West Bengal	1122.3	1075.0	1139.0	1208.5	1165.9	1189.0
Andaman & Nicobar #	3.1	3.1	3.1	3.6	4.0	7.1
Chandigarh#	0.1	0.1	0.1	0.1	0.1	0.1
Dadra & NagarHaveli #	1.5	1.5	1.5	1.5	1.5	1.5
Daman & Diu #	0.1	0.1	0.1	0.1	0.0	0.1
Lakshadweep#	0.3	0.2	0.2	0.2	0.2	0.2
Pondicherry #	2.6	3.7	3.7	4.1	4.4	4.5
Total	**5991.4**	**6250.1**	**6155.7**	**6091.8**	**6308.9**	**6755.6**

Note: # Previous year data. Source: NHB (2006); IASRI (2006)

[5] Data includes, potato, sweet potato and tapioca.

Table 4. State-wise production of vegetables[6] for India 1999/00 to 2004/05

States / Union Territories	Production ('000 t)						Population 2001-02 (1000)	Production/ capita 2001-02 (kg)
	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05		
Andhra Pradesh	2839.1	3147.7	2586.7	2357.9	2882.3	3861.9	76,210	34
Arunachal Pradesh	80.9	83.7	83.9	81.5	80.9	78.8	1,098	76
Assam	3089.4	2693.1	2935.2	2464.4	1958.9	2020.4	26,656	110
Bihar	9548.8	10219.7	8022.9	8288.5	13296.9	13349.1	82,999	97
Chhattisgarh		1146.3	1355.3	1357.2	155.1	1266.3	20,834	65
Delhi	652.0	862.7	747.4	628.1	626.8	626.8	13,851	54
Goa	70.0	76.0	76.0	68.5	74.7	74.7	1,348	56
Gujarat	2647.0	3070.8	3278.2	3517.9	3515.2	4867.9	50,671	65
Haryana	2094.5	2191.5	2151.9	2051.8	2703.9	2980.4	21,145	102
Himachal Pradesh	660.9	734.2	639.1	775.7	877.2	1013.5	6,078	105
Jammu & Kashmir	584.4	757.9	728.9	332.9	462.9	843.0	10,144	72
Jharkhand		2109.5	1736.3	1300.1	1197.2	3394.9	26,946	64
Karnataka	6796.9	5763.0	4173.2	3707.9	4176.9	4382.9	52,851	79
Kerala	2857.1	2530.9	2541.9	2547.4	2602.9	2490.1	31,841	80
Madhya Pradesh	3632.0	3501.9	1817.5	1827.0	2377.0	2659.6	60,348	30
Maharashtra	4828.6	5142.0	5128.3	4768.9	4132.1	4044.4	96,879	53
Manipur	53.1	67.4	66.1	71.9	86.0	86.0	2,167	31
Meghalaya	252.9	303.6	265.9	338.9	270.5	270.5	2,319	115
Mizoram	56.3	47.3	44.1	31.9	24.0	24.0	889	50
Nagaland	235.7	253.6	286.0	78.5	88.1	88.1	1,990	144

[6] (Data includes, potato, sweet potato and tapioca)

Orissa	9096.0	8089.1	7447.4	7126.2	8030.9	8045.6	36,805	202
Punjab	2285.0	2310.0	2275.6	2319.4	2888.1	2677.4	24,359	93
Rajasthan	472.6	386.4	432.5	358.3	527.6	650.2	56,507	8
Sikkim	43.0	59.7	60.0	59.1	75.0	76.5	541	111
Tamil Nadu	5660.3	5939.3	5444.6	4223.3	4672.7	6218.3	62,406	87
Tripura	232.8	328.1	353.2	360.3	352.2	373.4	3,199	110
Uttaranchal	733.2	1138.1	737.3	507.5	447.3	951.8	8,489	87
Uttar Pradesh	13842.4	13030.4	15044.8	15791.4	14862.0	15792.8	166,198	91
West Bengal	17413.8	17779.4	18075.3	17376.5	18510.6	18103.2	80,176	225
Andaman & Nicobar #	15.8	15.8	15.8	16.3	23.3	30.8	356	44
Chandigarh#	1.2	1.7	1.7	1.7	1.7	1.7	901	2
Dadra & NagarHaveli #	13.5	13.5	13.5	13.5	13.5	13.5	220	61
Daman & Diu #	1.1	1.1	1.1	1.1	0.0	0.0	158	7
Lakshadweep#	0.2	0.2	0.2	0.2	0.2	0.2	61	3
Pondicherry #	32.6	54.2	54.2	63.7	71.9	74.7	974	56
Total	**90,823.0**	**93,849.8**	**88,622.0**	**84,815.4**	**93,165.0**	**101,433.5**	**1,028,610**	**86**

Note: # Previous year data.

Source: NHB (2006); IASRI (2006)

Table 5. Production sectors and key issues in the Indian vegetable industry

Production sector	Trends and issues
Intercropping with wheat or rice	Peas are grown as a short duration crop during October-November in wheat farming systems under contracts for processing with SAFAL[7] and others.
Peri-uban production	Production areas within 3-400 km radius of major cities are producing vegetables for fresh market (some under contract with SAFAL) and cucumbers/gherkins for processing. Contract farming in India is not regulated.
Potato production systems	Potato has been mostly excluded from this study because it contributes primarily as a dietary staple. But the potato production system is one that includes vegetable production in rotation. Retail sector can source potatoes from up to 2000 km away.
Protected cultivation and Production with micro-irrigation or hydroponics (supplying within 500 km radius)	*Protected cultivation* is providing opportunities for improving productivity by reducing climatic extremes (temperature, rainfall, pest incursion) in hot and cool elevated areas. The National Horticulture Board provides financial support. Production is expanding in elevated regions up to 600 m, particularly in Uttar Pradesh and Karnataka. Although systems are expensive, yield increases of up to 300% for high-value, high-quality produce offset costs (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). • Walk-in tunnels (including low-cost structures) have been evaluated for off-season vegetable and seedling production. • Insect-proof houses are also being used to reduce pest levels, pesticide use and virus incursions (e.g. tomato and bell pepper). • Polyhouses and polytrenches are being used in cold desert areas for early and late season production, with leafy vegetables being produced even in winter (Singh and Sirohi, 2006). • The 11th 5-year plan sets targets of 100 ha of high-tech greenhouses, 500 ha of low-tech greenhouses, 2000 ha of low tunnels, 200 ha of shade nethouses and 4000 ha of hail/bird netting for fruit, vegetable flower production, with proposed government subsidy of 50% of cost (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). *Micro-irrigation systems* are also being used with and without protective structures to improve water use efficiency. • In March 2006, > 800,000 ha under drip irrigation, and 1.9 million ha under mini-sprinklers, but just 1.9% was for vegetables (*c.* 15,900 ha under drippers and 10,000 ha under mini-sprinklers), the majority being for fruit trees and plantation crops. Four states: Andhra Pradesh, Karnataka, Maharastra, and Tamil Nadu, have > 100,000 ha of crops under drip irrigation, and seven states - Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharastra, Rajasthan, and West Bengal, have > 100,000 ha under mini-sprinklers (Appendix 2). Costs (2006) are estimated at Rs 45,000/ha for drip irrigation and Rs 15,000/ha for mini-sprinklers. (Working Group on Horticulture, Plantation Crops and Organic

[7] A program of the National Dairy Board for fruit and vegetable production - SAFAL = Combination of Hindi words for vegetables (*sabji*) and fruit (*fal*).

	Farming, 2007). • Regular and split applications of nutrients using fertigation can increase yields by 25-35% and improve produce quality. • 11th 5-year plan proposed elimination of duty on plastic raw materials, and sales tax on microirrigation systems, to reduce investment costs (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). *Hydroponics.* Savings of 20 to 40% in fertilizer use could be achieved by use of fertigation systems with hydroponics. • High cost of totally soluble NPK fertilizers is slowing investment in microirrigation and hydroponics. Imported soluble fertilizers cost Rs 50 to 60/kg, compared to locally manufactured (but not fully soluble) fertilizers for Rs 4 to 6 /kg. High costs of equipment for fertilizer injection, and inadequate information about local crop/climate needs are further disincentives (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).
Organic production	The organic sector consists of a small export-focused cultivation industry, and a large "wild harvest" industry. Areas of production are reported variously as a large "wild harvest" industry of > 2.5 million ha (Gouri, 2007), sourcing a range of "organic" herbs, spices, and medicinal products, (particularly from Uttar Pradesh and MP (Gouri personal communication, 2007)), and a cultivated organic production area of 180,000 ha (2005 data) (Gouri, 2007). The area of certified production was reported as 339,113 ha for 2006-2007 (APEDA, 2008). The national program for organic production is coordinated through the Ministry Commerce and Industry, and guidelines for production and certification have been produced (APEDA, 2005). India was the first country to achieve "group certification" for organics. APEDA certification for organics is accredited by 11 certification bodies, is recognized by the US (Feb. 2006), and has achieved equivalence with the EU (June 2006) and Switzerland (Dec. 2006) (Gouri, 2007).
Vegetable seed industry	India's comparative advantage is in production of hybrids that require hand pollination.

One trend that is boosting the growth of vegetable production (and thus cropping diversification), is the expansion of contract farming in many states (Ahluwalia, 2005) fostered by marketing alliances (such as the village-level associations promoted by Mother Dairy Fruits and Vegetables Ltd, a subsidiary of the National Dairy Development Board (Birthal and Joshi, 2007) and restrictions in India's laws on agricultural land, which prevent corporate bodies (investors) from operating large-scale farms. Under such cooperative arrangements, corporate buyers select suitable areas, organize farmers to produce the crops they require under contract, and provide them with planting material and technical supervision. This reduces risks for farmers and improves buyer access to the quality and types of produce needed (Ahluwalia, 2005). Cooperative marketing is considered further as a case study (Chapter 4).

3.2 Inputs, finance, and utilities

Inputs and supply chain logistics

Across all agricultural sectors, agricultural enterprises (such as the input suppliers, and marketing and processing sectors that service the farming or plantation sectors) are a major employer in India. In 2005, there were 42 million enterprises engaged in economic activities, with about 15% in the agriculture sector, and more that 50% of the agri-enterprises in just five states (Tamil Nadu, Maharashtra, West Bengal, Andra Pradesh and Uttar Pradesh) (DES, 2005). As market demand for vegetables continues to increase and more farmers, processors, and exporters become involved in the industry, the opportunities and needs for support industries and inputs will also increase. Key input sectors supporting the vegetable industry are:

Seed

India is one of tropical Asia's major vegetable seed producers and exporters. Seed quality regulation needs improvement. The production and marketing system for certified seed of improved varieties needs to be streamlined and promoted; farmers depend too much on "saved seed" (perhaps 2/3 of vegetable production) due to inadequate knowledge of the importance of good seed, and lack of access to good seed. Under the 11th 5-year plan, a Production Scheme to meet breeder requirements for vegetable seeds is proposed, as well as increased attention to the supply of planting material for spices and aromatic and medicinal plants (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). A new Seed Bill has been under committee in the government and the seed industry has concerns about provisions in relation to seed selling by farmers, regulation of prices, and "regulation" of private seed companies (India Info Line, 2007a, 2007b; 2007c; Century Seed, Pers. Com., 2007).

During 2007, the Department of Agriculture and Cooperation (DAC) have promoted seed treatments to improve productivity (DAC, 2007) (Appendix 3).

Agricultural chemicals

Pesticide use for vegetable production is "alarmingly high," and consumers are relatively unaware of the risks. Progress has been made in the IPM approaches (> 1.1. million farmers trained in horticulture sector in last seven years) such as pheromone lures for control of shoot-tip borer and other pests in eggplant; the use of a range of biopesticides; and the development of genetically modified plants with *Bt*-mediated control of pests in eggplant and brassicas; however, GMOs have not yet been released. Progress is also being made in integrated disease management strategies (multiple resistant cultivars, resistant stock grafting, cultural practices, and bio-fungicides or "soft" chemicals) (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

Fertilizers

Fertilizers are one of the highest input costs in vegetable production. Usage is imbalanced, and more scientific approaches are needed. Estimated consumption of NPK across all crops was 22.4 million tonnes in 2006-07, up from 20.3 million tonnes in 2005-06, with the Department of Fertilizers coordinating supplies across states to reduce the risk of shortages (Agri-Coop, 2007). Over-application of nitrogen fertilizers has resulted in high levels of nitrates in wells near vineyards in Maharashtra and Karnataka states, making the water unfit for irrigation or human consumption (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). Fertilizer subsidy schemes need to be rationalized, to discourage over-application of nitrogen. Knowledge of micronutrient needs is inadequate, and soil testing, with provision of sound nutrition advice, is needed. Biofertilizers present a promising alternative to the use of chemical fertilizers, and production and promotion of their use is a priority under the 11th 5-year plan (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

Labor

Increasing vegetable production and postharvest activities provides an employment benefit for women. Weinberger and Lumpkin (2005) noted estimates of 80 and 124 labor days/ha for production of cereals and vegetables respectively. When labor access is limiting, or work excessively arduous, greater mechanization will be needed to sustain or improve productivity. Throughout India, micronutrient deficiencies, particularly in women, may also reduce labor productivity. Weinberger (2004) suggested boosting current iron intake levels by 50% (for example, through increased consumption of leafy vegetables) could

improve household productivity by 5 to 17%. Singh (2003) considered the challenges associated with the high levels of employment of women and children in the vegetable sector, and offered suggestions about how to improve benefit flows to them.

Farm machinery

The government does not have an overall policy on mechanization for Indian agriculture (Sirohi, 2006). Some mechanization is occurring, mostly in land preparation, but mechanization of harvesting has boosted potato production in the Punjab (Sahal, pers comm. 2007). Mechanization of grain and legume cropping also frees up labor for vegetable production.

Irrigation and watering systems

Since 2006, a microirrigation scheme to promote water conservation was implemented in 13 states (284 districts). The initiative involved installation of drip and sprinkler irrigation, with training and capacity building for farmers and trainers. There is potential to invest further resources in hardware for the systems and scale up to other regions (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). This would seem to be an ideal opportunity to build involvement of the private sector. Recent plans to bring more of the rain-fed areas under irrigation (India Info Line, 2007a, 2007b, 2007c) could provide additional opportunities for vegetable production as a supplementary crop in cereal or legume farming.

Postharvest technology

Postharvest losses in India are very high—probably enough to feed at least 20% of the population. According to the Indian Government, US$ 14.3 billion worth of perishable and durable agri-produce is wasted, while > 200 million people remain underfed, and almost half of the children are underweight. Wastage occurs at various stages due to fragmentation of the supply chain, deficiencies in the Agricultural Produce Marketing Act, and inadequate infrastructure (India's Minister of State for Food Processing Industries Subodh Kant Sahai quoted on India Info Line, 2007a, 2007b, 2007c). Rolle (2006) indicated fresh produce losses ranged from 10 to 40% globally, with losses in India at the high end. Chikkasubbanna (2006) has reviewed some of the issues and priorities for improving the postharvest sector for vegetable handling.

Logistics

Logistics are generally inadequate and in need of improvement. Improvements to technology and infrastructure are critical for improving cost efficiencies in the vegetable industry. The government has a key role in provision of improved

transport and infrastructure, and the private sector can play a significant role in terms of system improvement, technology adoption and infrastructure access.

Financial services and utilities

Fuel and electricity

Under the 11th 5-year plan, the government aims to connect all villages to electricity by 2009, with 24-hour supplies by the end of the plan. The plan sets targets of all-weather road connections to all communities with populations over 1000 (500 in hilly and tribal areas) by 2009, with extensions to all significant habitations by 2015. It also proposes connection of every village by telephone by 2007, with broadband connectivity to all villages by 2012 (Planning Commission, 2007b, 2007d).

Demand for electricity will continue to grow. India's forward needs for electricity have been fairly well established, and the market reasonably well understood; however, governance of distribution utility, the inexperience of state regulatory commissions, and fuel supply bottlenecks are slowing industry commercialization (Zaheer, 2006). Zaheer (2006) noted the policy framework for the industry had improved considerably, and regulatory frameworks were becoming more competent and transparent. He noted, however, that enterprise-level reforms were needed to enable mobilization at the scale of investment, and that private and public companies were unable to solve the financing shortfalls without government help.

Financial services

In recent years, the public sector commercial banks have responded well to government requests for improvement of credit access for farmers, but the cooperative system has deteriorated due to state interference in co-ops. The Indian government is reviewing options for their revival but this requires agreement and support of the states for changes to governance and more professional public sector management (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

Value-adding, food processing, and provedore sectors

Chikkasubbanna (2006) noted the industrialization of India had shifted food, feed, and fiber industries from rural to urban areas, resulting in a drain of capital and reduced employment opportunities. He suggested that stimulation of small and medium processing of fruit and vegetables in rural areas would boost development. Processing currently represents a minor proportion of total production. Processing is likely to account for 5-10% production for the next

decade, but may rise to 15-20% in the longer term. Institutional purchasing of processed vegetables will continue to become more significant in this period, with 40% of production going to institutions (including the Defence Department) and 30% to exports (TIFAC, 2007).

Until recently, the food laws needed revision, and multiple laws hampered operation, but the Food Safety and Standards Bill (2005) has consolidated eight laws governing the food sector and makes provision for the establishment of a Food Safety and Standards Authority (FSSA) to regulate the sector (Ahluwalia, 2005; Madhavan and Sanyal, 2006)[8].

Kachru (2003) reviewed the agro-processing industries (all commodity sectors) in India and their growth, status, and prospects, and noted only 3% of the workforce was employed in the sector compared to an average of 14% in developed countries. In 2005 more than 63% of Indian households bought at least three categories of processed foods, with 28% buying five types of processed food (Mr. P. K. Mohapatra, Chairman, Foodpro 2005 (CII, 2005)). However, the agro-processing sector in India is underdeveloped. Although it represents a key opportunity for helping in vegetable industry diversification, current taxation arrangements are a disincentive; indirect taxes are applied, there are no rebates on input taxes, and there are restrictions on enterprise size for certain types of product (CII, 2005).

In 2000 there were more than 5000 fruit and vegetable processing units registered in India under the *Fruit Products Control Order* (1955), but most were cottage and small-scale enterprises. Modern processing enterprises (mango pulp, tomato paste) began establishing with the liberalization of foreign investment. In 1999-2000 alone, more than 1000 industrial licenses (with foreign investment) were approved for various enterprises linked to export, including mushroom canning, onion drying, and frozen vegetables, with the Agricultural and Processed Food Products Export Development Authority (APEDA) guiding ISO certification, HACCP, and Quality Control certification (Ministry of Food Processing Industries, 2007). Food Safety India (2007) has published guidelines for safe handling and nutritional contents of vegetables

Marketing fresh produce: wholesale and retailing sectors

[8] The legislation covers international practices in guiding and regulating manufacture, marketing, processing, handling, transportation, import, and sale of food. It sets scientific standards and transparency to meet the dynamic needs of the food trade and industry sector and also international trade practices in processed food. http://pib.nic.in/release/release.asp?relid=20357

Wholesale

Development of the vegetable industry is constrained by poor marketing arrangements; there is a large gap between farmer and retail prices. There are three main types of market (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007):

Rural periodic market

The farmers' market, a village *haat* that operates on a specific day or days each week, with farmers selling direct to consumers (from a shelter/building, or the open air). There are more than 27,000 rural periodic markets operating. Quantities sold are small, but sales go direct from farmer to customer, so profit share can be reasonable.

Assembly markets

These are similar to farmers' markets, except that produce is sold to traders who assemble, consolidate, and transport for sales elsewhere in the city or market. They are especially important in eastern India and in areas of concentrated production. Operations can be informal and involve the use of temporary "collection centers" in production areas by traders/transporters. Farmer produce is assembled for transport to a city market, with the payment to farmer depending on the sale price at the regulated market.

Terminal markets

At these markets, produce is sold to consumers or processors, or assembled further for a distant market or export. These markets involve well-organized merchants and are located in major cities (Bangalore, Delhi, Mumbai, Chennai and Kolkata).

The Indian Government has aimed to control produce marketing through "regulated" markets to encourage greater transparency and fair business. Today there are more than 7,000 of these markets, with state government-enacted Agricultural Produce Marketing Regulation legislation regulating competition, transactions, and market charges.

Although the laws have improved market function, reduced costs for producers/sellers, and provide frameworks for regulation and consultation, the agricultural marketing system is very inefficient. The government-regulated monopoly on wholesale markets has prevented development of competitive

marketing, failed to help to farmers in direct marketing, retailing, or the supply of produce for processing, and prevented innovation in marketing and technology use (GoI, 2003).

Currently, the wholesale markets are dominated by a small number of traders. Transactions lack transparency. Grading and handling facilities are poor, and wastage is high due to poor logistics and lack of cool chain facilities. Although upgrading of government-regulated markets in the fresh produce sector has been proposed by the Indian Government, it will be critical to implement cost-efficient systems that optimize delivery of fresh produce to consumers and exporters through supermarkets and other retail outlets.

To assess benefit flows to farmers, Gandhi and Namboodiri (2004) examined the wholesale marketing of fruit and vegetables in Ahmedabad, Chennai, and Kolkata Markets. In vegetable marketing, direct contact between market commission agents and farmers was very low (< 50%) and secret bidding and simple transactions dominated. Farmer-share of the consumer rupee for vegetables varied from 40-69% in the main wholesale markets of Ahmedabad, Kolkata, and Chennai, but was as high as 85-95% at a smaller market in Chennai. Regulation and supervision of an equitably represented market committee and perhaps the enforcement of open auctions would improve benefit flows, as could opening up the markets to more traders and buyers. Market infrastructure also needed attention: cool storage, loading and weighing facilities, provision of up-to-date information, and internet and telecommunications links (Gandhi Vasant and Namboodiri, 2004).

To improve competitiveness, legislative changes are needed to enable various modes of ownership of markets, to stimulate private investment in private and public markets, and to "professionalize" operations. Most state governments have adopted, or are in the process of adopting, the *State Agricultural Produce Marketing (Development and Regulation) Act* 2003, to enable the proposed transformations (GoI, 2003; Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). Revisions to laws will free up marketing by co-ops and the private sector. The changes have been a key enabler of the establishment of the Reliance supermarket chain in some states.

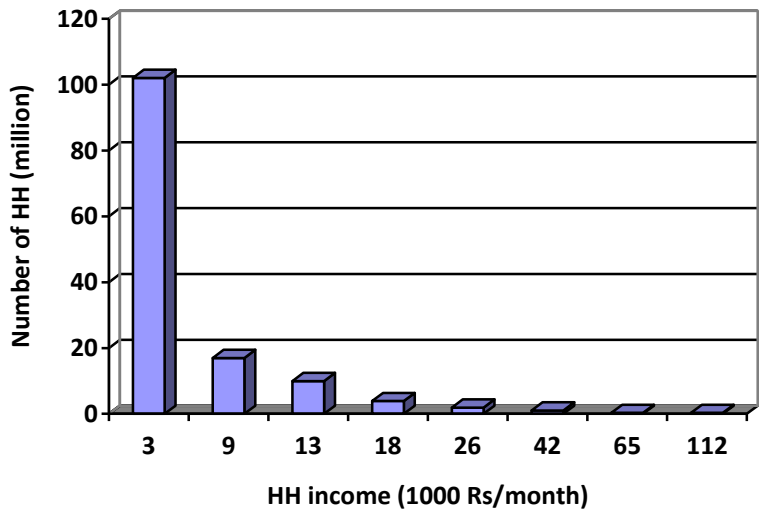
Retail

Over the last decade, the Indian retail sector has expanded dramatically, with the retail food sector growing at 5% and sales of US$ 168 billion in 2005 (NCA, 2007). Small independent shops dominate 99% of retail food sales, with the advantage of supplying low-income products that are affordable for most people, with convenient locations, local produce sourcing, and loyal customer

followings (Majumder, 2007). The Mother Dairy (MDFVL) outlets are potentially in this category, but have modern advantages such as electronic scales, freezer/refrigerated products, etc.

By contrast, supermarkets and modern retail stores have until recently occupied only 1% of the market. Asthana (2007) indicated the vast majority of Indian families (est. 102 million households) live on household incomes of less than Rs 3000 per month (**Figure 4**). The emerging supermarket sector wants to cater to the needs of this poorest sector, which constitutes the largest consumer group in the country (Asthana, 2007). Chains operating in India include Foodworld (98 stores), Food Bazaar, Nilgiri's and Spencers (8 hypermarts) (Wikipedia, 2007c). The opening of more than 160 Reliance Fresh stores across India in 2006-2007, with projected expansion to 4000 stores within five years, will have a dramatic impact on this sector (Reliance, 2007). Wal-Mart from the US may enter the Indian market in 2008, and the UK company Tesco may follow (Majumder, 2007).

In the areas where supermarkets have opened, local vendors (small stalls, peddle carts, pavement sellers) are reputed to be losing 40% of their business (Indu Prakash Singh, Action Aid (quoted by Majumder, 2007)). But the change to supermarkets is led by customer demand and will revolutionize produce handling; strategies will be needed to facilitate the transition and minimize the impact of the changes on disadvantaged traders.



Source: Asthana (2007).

Figure 4. Income distribution (thousand Rs/month) among the 135 million rural households (HH) of India

Exports

The Agricultural and Processed Food Products Export Development Authority (APEDA) has oversight of market development for Indian exports (APEDA, 2007a, 2007b). APEDA has developed HACCP certification and pesticide residue monitoring guidelines, and their effective implementation is critical for fresh and processed vegetable export development (APEDA, 2007b).

A "Special Agricultural Produce Scheme" promotes incentives for the export of a range of Indian produce, including vegetables and value-added products grown and processed domestically. Exporters are eligible for duty credit of 5% of the "free-on-board" (FOB) value of exports (Ministry of External Affairs, 2007).

Recent export data (APEDA, 2007a; FAOSTAT, 2007) is shown in **Table 6**. In general the data from APEDA (2007a) is somewhat higher that that from FAOSTAT (2007). In 2005-06, fresh vegetable exports of 1.2 million tonnes were worth US$ 220 million, with 0.96 million tonnes of onions worth US$ 174 million, with mushroom, peas, eggplant, and okra as the other major commodities (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007; APEDA, 2007a). Fresh vegetables are being exported out of Mumbai, mainly by air to the Middle East, with basic export requirements established by the government (MSAMB, 2007b).

Table 6. Import and export statistics for Indian vegetables (and chili, ginger) showing data from two sources (APEDA and FAOSTAT).

		2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Export quantity (tonnes) (APEDA, 2007a)	Fresh vegetables	477,246	611,940	771,731	1,048,260	1,060,906	1,177,788
	Processed vegetables	398,453	309,249	327,817	340,283	496,424	808,955
	Total vegetables	875,698	921,189	1,099,548	1,388,543	1,557,330	1,986,743
Export value ('000 US $) (APEDA, 2007a)	Fresh vegetables	103,904	123,302	133,412	207,488	193,623	221,204
	Processed vegetables	240,631	181,938	186,922	189,415	272,515	473,839
	Total vegetables	344,535	305,240	320,334	396,904	466,138	695,043
Export quantity (tonnes) (FAOSTAT, 2007)	Fresh vegetables	425,820	579,140	744,390	952,740	924,330	1,082,210
	Processed vegetables	168,600	185,620	247,700	276,400	347,520	471,890
	Total vegetables	594,420	764,760	992,090	1,229,140	1,271,850	1,554,100
Export value ('000 US $) (FAOSTAT, 2007)	Fresh vegetables	92,844	120,287	125,573	189,556	166,046	200,706
	Processed vegetables	136,690	134,234	161,619	189,834	231,832	307,748
	Total vegetables	229,533	254,520	287,192	379,391	397,878	508,454
Import quantity (tonnes) (FAOSTAT, 2007)	Fresh vegetables	12,160	75,130	64,290	25,290	22,390	12,240
	Processed vegetables	14,750	15,230	22,300	42,490	23,180	33,810
	Total vegetables	26,910	90,360	86,590	67,780	45,570	46,050
Import value '000 US $) (FAOSTAT, 2007)	Fresh vegetables	3,097	26,499	18,009	7,028	6,260	4,058
	Processed vegetables	5,837	6,507	9,448	15,807	12,056	21,130
	Total vegetables	8,934	33,007	27,457	22,835	18,315	25,189

Note 1: Temporal currency exchange rates from http://www.oanda.com/convert/fxhistory

Note 2: Potato, sweet potato, and tapioca included as vegetables in APEDA data. As well, "processed fruits, other than mango pulp and chutney" are included under category of "Other processed fruits & vegetables" in APEDA data so "processed vegetables" listed in this table are calculated without deducting these processed fruits.

Processed vegetables amount to 17% of the world horticultural trade. In 2004, processed vegetables accounted for 31% of India's total horticultural[9] exports, with gherkin, dried onion, and frozen mixed vegetables making up 60%, and

[9] N.B. This grouping included plantation crops: coffee, cocoa, tea, rubber, and tapioca.

Bangladesh, Sri Lanka, USA, UK, and the Middle East as main markets (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

Although India is a major producer of spices, only 7% of production was exported in 2003, due to high internal demand, with India gradually becoming a major importer of spices (e.g. black pepper) (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). Vegetable seed exports are significant and growing (**Table 7**).

Table 7. Vegetable seed exports (tonnes) from India

Commodity	Year			
	2003-04	2004-05	2005-06	Growth (%)
Cabbage	113	149	266	53
Peas	3	474	110	506
Radish	44	31	1	-85
Tomato	13	13	44	84
Other vegetables	2623	2508	3002	7
Total	2796	3,175	3,423	11

Source: APEDA (2007a)

Table 8. Import of vegetable products[10] by India (import share & value)

Products	Quantity (t)			Value (million Rs)			% share of value 1999-00
	1997-98	1998-99	1999-00	1997-98	1998-99	1999-00	
1. Seeds							
Fruits & vegetables seeds	420.6	172.8	768.1	298.60	320.70	587.36	8.0
2. Fresh vegetables							
Fresh onions	1,711.5	3,799.4	18,870.7	12.54	47.25	250.71	3.0
Other fresh vegetables	5354.3	5522.5	14.3	51.58	102.24	2.03	Neg.
3. Processed vegetables							
Dried & preserved vegetables	1,064,418.9	1,511,208.1	267,041.2	12,798.87	15,926.82	3,728.65	49.0
Pickles & chutneys	25.6	35.9	45.2	1.37	2.28	3.67	Neg.
Other processed fruits & vegetables	1,676.6	6,290.7	9,269.0	73.79	225.30	420.40	6.0

Source: IASRI (2006).

[10] Note that some figures group vegetable and fruit products.

Imports

By comparison to exports, total vegetable imports have been miniscule, but are increasing (**Table 6** and **Table 8**). More recent data was located only on FAOSTAT (2007) and indicated about a doubling in import volumes and a tripling in value between 2000-01 and 2005-06. The ten-fold increase in the volume of onion imports between 1997-98 and 1999-00 (**Table 8**) reflected the phase out of quantity quotas in the late 1990s.

For horticultural produce more generally, imports (fresh and processed) in 2003 were worth about US$ 1.06 billion, a three-fold increase in a decade. Imports have mainly been of apples, but growth of dried vegetables, especially dried peas, has been significant, with vegetable imports as a percentage of total horticultural product imports (by value) of: peas - fresh or chilled (8%), potatoes - fresh or chilled (2%), other vegetables/fruits - preserved (7%), and dried vegetables (4%). Increases in processed vegetable imports are driven by domestic demand when world prices are high or rising (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

3.3 Institutional framework and operational environment

Policy and regulatory agencies

In the 1980s, Indian policy makers shifted focus from food self-sufficiency to increasing rural incomes, with a special focus on smallholders and extending productivity increases to non-irrigated areas. These efforts were complemented by targeted anti-poverty programs for vulnerable groups. As a consequence, agricultural productivity grew at 4.7% compared to 1.4% in the 1970s.

Balance-of-payment problems affected growth in the early 1990s, and structural reforms helped get the economy growing again, but growth in agriculture was slower than predicted. Increasing numbers of farmers found agriculture unprofitable; market uncertainties associated with diversification increased their vulnerability to declining groundwater levels, and indebtedness increased. In response, the government reviewed agriculture strategies and proposed: increased public investment in irrigation and rural roads; better management of existing irrigation systems and water resources in rain-fed areas; strengthening of agricultural research and extension systems; improvement in production and distribution of certified seed; improvement of access and delivery of rural credit; and innovation in marketing and contract farming. Attention to these issues will continue under the 11th *5-Year Plan*.

How can the vegetable sector contribute to, or benefit more from, the 11th 5-Year Plan (2007-2011)? The vegetable industry is a key sector that could be further stimulated, to boost outcomes in selected socioeconomic targets of the plan:

Enhancing income and reducing poverty
Enhanced vegetable production and marketing could contribute to increasing the agricultural GDP growth rate to 4% per year and ensuring a broader spread of benefits; helping meet the target of 70 million new work opportunities; reducing educated unemployment to below 5% (e.g. in retail, processing and export sectors); boosting rural-sector returns, to help meet proposed wage rate increases of 20% for unskilled workers; and helping to reduce the headcount ratio of consumption poverty by 10 percentage points by the end of the plan.

Community health
Promoting enhanced vegetable consumption (especially leafy vegetables) can help to reduce malnutrition among young children to half its present level, and help to meet the target of reducing anemia among women and girls by 50% by the end of the plan.

Infrastructure
Opportunities for small-scale agro-processing and market access for the vegetable sector could be enhanced by the plan targets of ensuring electricity connection to all villages by 2009, and round-the-clock power by the end of the plan; ensuring all-weather road connection to all habitations with populations greater than 1000 and (500 in hilly and tribal areas) by 2009; ensuring coverage of all significant habitation by 2015; connecting every village by telephone by November 2007; and providing broadband connectivity to all villages by 2012.

Environmental management
Sustainable technologies for production and more energy-efficient technologies for postharvest processing, storage, and management would improve energy efficiency in the vegetable industry and other agricultural sectors, and help meet the plan target of increasing energy efficiency by 20 percentage points by 2016-17.

How well will these strategies benefit the increasing numbers of smallholders who have incorporated vegetable production and other high-value commodities into their enterprises? Potentially all of the strategies can benefit smallholders and enhance vegetable industry growth and its contribution to national development and food security, provided policy does not become over-focused on grains, legumes, and water distribution. Some specific initiatives proposed in the 11th Plan Discussion paper for Horticulture (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007) are listed in Appendix 4. The challenge will be to balance resources and efforts that favor other sectoral initiatives and liberalize land access.

The R&D sector in India is highly developed, with both the public and private sectors contributing significantly to industry development. A national network to develop F1 hybrids of nine important vegetables (initiated by 15 centers in the ICAR Research network) has been in operation since 1995 (Mathur, 2001), and there are strong programs in all areas of vegetable production. In the last few years, more attention has been given to postharvest technologies.

A key current policy initiative involves the establishment of a Rain-fed Areas Authority to bring additional areas under irrigation, launch a special wheat production program (boosting mean yield from 1.5 to 2.5 tonne/ha), and an action plan to increase pulse production (boosting improved seed supply). The action plan for food security also aims to increase rice productivity from 1.5 to 2.5 tonnes per hectare in Assam, Bihar, Chhattisgarh, Orissa, and eastern Uttar Pradesh (India Info Line, 2007a, 2007b, 2007c). But these targets need to be reached while continuing to promote growth and expansion of the vegetable sector

The rising global prices of wheat and pulses have added to the urgency of boosting production. The Indian Prime Minister, Manmohan Singh, has instructed the Planning Commission and the Ministry of Agriculture to promote state-specific agricultural strategies and devise incentives for states for their adoption. The Prime Minister noted poverty, unemployment, and regional disparities were interrelated and could be addressed by boosting productivity and incomes. The government has focused on addressing productivity problems in districts where farmer suicides were common. The key element of the new strategy is "inclusive growth," which will not come from following a business-as-usual approach.

Agricultural yields increases of 40%-100% in the next three or four years would be sought, by focusing on yield-gap reduction and expanding areas of cultivation (India Info Line, 2007a, 2007b, 2007c). While there is a clear imperative for

increasing production of wheat and pulses, their stimulus alone will not improve farmer incomes. To achieve higher incomes, investment in the production and marketing of high-value crops, including vegetables, and in agribusiness will be needed.

Some of the laws relevant to the agriculture sector are listed in Appendix 5.

Research and development, human resource development

Research infrastructure

India's agricultural research system is among the most complex in the world, but the government and international donors have provided strong support for what has become an institutionally diverse and significantly productive system (Pal and Byerlee, 2006). India is perhaps more than any other country associated with the successes of the Green Revolution. It is now self-sufficient in major foods, but faces new challenges as natural resource constraints and changes in marketing and quality expectations accrue, placing new demands on the research system (Pal and Byerlee, 2006).

Both the public and private sectors contribute strongly to agricultural R&D. Pray and Basant (2001) considered that public sector outputs were being compromised by the inadequacy of research funding at national and state levels. They found that private sector R&D was greatest in the food industry, followed by pesticides, seed, and agricultural machinery.

The Department of Agriculture & Co-operation (DAC) of the Ministry of Agriculture (MOA) is the key agency responsible for vegetable industry development. The DAC Division of Horticulture is supported by the National Horticulture Board, which promotes postharvest infrastructure for horticultural crops and modern production initiatives such as protected cultivation and micro-irrigation (**Table 9**).

The DAC implements its programs through the State Departments of Horticulture, providing leadership and coordinating activities for the promotion of horticulture. In total, 10 central institutes, with 27 regional stations, 12 national research centers, 9 multidisciplinary institutes, 15 All-India Coordinated Research Projects with 223 centers, 5 network projects, 330 ad-hoc research projects and 29 revolving fund schemes, are involved in different areas of horticultural R&D (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). In addition, the National Committee on Plasti-culture Application in Horticulture has 17 centers working on the use of plastics in

agriculture. Unfortunately, however, the agricultural extension system has deteriorated; this hampers dissemination of best practice (Ahluwalia, 2005).

In addition to the institutional R&D focus in horticulture under the 10th 5-year Plan, special attention was given to promoting horticulture in the northeast region and the Himalayan States, and to the National Horticulture Mission. Under the former, a Central Institute of Horticulture for technology dissemination and capacity building has been established in the northeastern development region, Nagaland (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

The National Horticulture Mission was launched in 2005 to strengthen supply chain and systems/multi-agency and pubic-private partnership approaches to horticulture industry development. It has a mandate covering production, postharvest technology, processing, and marketing, with a focus on areas with strong potential for horticulture. It promotes, where appropriate and feasible, the National Dairy Development Board (NDDB)/Mother Dairy model of cooperatives to ensure equitable involvement and returns to farmers (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). With the rapid growth of the retail supermarket sector and associated distribution centers, the approaches of the National Horticulture Mission may need to be reviewed.

Table 9. Ministry of Agriculture agencies in India

Ministry of Agriculture

Departments
- Department of Agricultural Research and Education (DARE)
- Department of Agriculture and Co-operation

Attached Offices
- Directorate of Plant Protection, Quarantine and Storage
  - Central Integrated Pest Management Centre (CIPMC)
  - Plant Quarantine Organization of India (PQOI)

Subordinate Offices
- All India Soil and Land Use Survey Organization (AISLUS)

Autonomous Bodies
- National Institute of Agricultural Extension Management (MANAGE)
- National Institute of Agricultural Marketing (NIAM)

Boards
- Central Insecticides Board and Registration Committee
- National Dairy Development Board (NDDB)
- National Horticulture Board (NHB)

Commissions
- National Commission on Farmers

Councils
- Indian Council of Agricultural Research (ICAR)

PSUs and Joint Ventures
- State Farms Corporation of India Limited (SFCI)

Others
- Agricultural Resources Information System (AgRIS)
- Agriculture Marketing Information System Network (AGMARKNET)
- Department of Agriculture and Co-operation Network (DACNET)
- National Agricultural Co-operative Marketing Federation of India (NAFED)

National Agricultural Technology Project (NATP)
- National Co-operative Development Corporation (NCDC)
- National Horticulture Mission
- Networking of Social Scientists

Source: MOA-India (2007)

In addition to the Ministry of Agriculture, support for R&D and policy issues relevant to the vegetable industry also comes from the Ministries of Commerce and Industry, Science and Technology, Human Resource Development (Department of Education) and Women and Child Development (Food and Nutrition Board) (**Table 10**). Other institutes involved in strategic research relevant to horticultural include CSIR Institutions (CSIR, 2007), the Central Food Technology Research Institute (CFTRI, 2007) in Mysore, the Central Mechanical Engineering and Research Institute (CMERI, 2007) in Durgabad,

aided by the Department of Biotechnology (DBT), the Bhabha Atomic Research Centre (BARC), and the Indian Space Research Organization (ISRO) (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007).

The Ministry of Women and Child Development (MWCD) was upgraded to Ministry status in 2006, to foster more holistic development for women and children. Responsibilities of MWCD relevant to the vegetable sector include: National Nutrition Policy, the National Plan of Action for Nutrition, the National Nutrition Mission, and the Food and Nutrition Board (WCD, 2007b).

The Food and Nutrition Board is responsible for the development and popularization of subsidiary and protective foods and nutrition extension (WCD, 2007b; FNB, 2007). Activities of the board include nutrition education and training (e.g home preservation of fruit and vegetables, and nutrition), mass awareness campaigns (e.g. National Nutrition Week in September), mass media communication (e.g. nutrition wall calendar), infant and child nutrition (national guidelines on infant and young child feeding (FND, 2006)), food analysis and standardization (four quality labs for analysis of processed fruit and vegetables and other supplements), recipe development and promotion of locally available, low-cost nutritious foods.

As well as national guidelines on infant and young child feeding (FND, 2006), the FNB has produced short films on nutrition (*Poshan aur Rashtra Nirman*) in northeast regional languages, a radio program in 20 languages (*Poshan aur Swasthya*) (8/2006), audio jingles on child and adolescent nutrition in regional languages (2004-2005), and video spots on nutrition (2005) (FNB, 2007; WCD, 2007a).

India's 41 state agricultural universities also have a significant role in vegetable R&D (SAU, 2007), with one fully fledged State Agricultural University of Horticulture & Forestry, and 25 with horticulture as a discipline (Jha and Kumar, 2006). In addition, other SAUs and general universities undertake policy, business, and economic R&D.

Table 10. Other ministries supporting the vegetable sector in India

Ministry of Commerce and Industry
Departments
Department of Commerce
Attached Offices
Directorate General of Foreign Trade (DGFT)
Office of the Economic Adviser
Subordinate Offices
Directorate General of Commercial Intelligence and Statistics (DGCI&S)
Office of the Controller General of Patents, Designs and Trade Marks (CGPDTM)
Special Economic Zones
Autonomous Bodies
Agricultural and Processed Food Products Export Development Authority (APEDA)
Federation of Indian Export Organizations (FIEO)
Councils
Export Inspection Council (EIC)
PSUs and Joint Ventures
Export Credit Guarantee Corporation of India Limited (ECGC)
India Trade Promotion Organization (ITPO)
National Centre for Trade Information (NCTI)
State Trading Corporation of India Limited (STCI)

Ministry of Science and Technology
Departments
Department of Bio-Technology (DBT)
Department of Science and Technology (DST)
http://www.tifac.org.in/abt/abt.htm monitors global trends and proposes technology options for India.
Department of Scientific and Industrial Research (DSIR)
Autonomous Bodies
Council of Scientific and Industrial Research (CSIR)
National Accreditation Board for Testing and Calibration Laboratories (NABL)
National Centre For Plant Genome Research (NCPGR)
Councils
State Councils for Science and Technology
PSUs and Joint Ventures
National Research Development Corporation (NRDC)
Others
Bio-Technology Information System
Consortium on Micropropagation Research and Technology Development
Farm Net Asia
Indian Biosafety Rules and Regulations
Indian GMO Research Information System (IGMORIS)
National Good Laboratory Practice Compliance Monitoring Authority

Ministry of Food Processing Industries
http://www.mofpi.nic.in/ regulates FPO. Licences under FPO.
http://www.mofpi.nic.in/venturesetup/licensing/licensing.htm

Ministry of Health and Family Welfare
http://www.mohfw.nic.in
Directorate General of Health Services http://mohfw.nic.in/dghsindex.htm
Prevention of Food Adulteration Act http://mohfw.nic.in/pfaact.pdf
http://foodsafetyindia.nic.in/fruits.htm

Ministry of Human Resource Development
Departments
Department of Higher Education

Ministry of Women and Child Development
Departments
Department of Women and Child Development wcd.nic.in
Food & Nutrition Board

In addition to the efforts of national agencies and the private sector in agriculture R&D for the vegetable industry, several international and regional agencies contribute substantially to industry development and policy analysis through local and regional bases, including the World Vegetable Center, the FAO, the Asian Development Bank (ADB), the World Bank, the United National Commission for Trade and Development (UNCTAD), USAID and UNDP, the International Food Policy Research Institute (IFPRI), the French International Research Centre for Agriculture Research and Development (CIRAD) (CIRAD, 2006), the German Technical Agency (GTZ) and other European agencies, the Japan International Co-operation Agency (JICA) and the Japan International Research Center for Agricultural Sciences (JIRCAS).

Private sector research is dominated by the food industry, followed by the pesticide, seed, agricultural machinery, and fertilizer industries (Pray and Basant, 2001). The seed industry priority areas for R&D are increasing yields, pest resistance ,and quality of tomato, cabbage, okra, and hot chili (Pray and Basant, 2001). Support also comes from industry bodies, such as the Asia and Pacific Seed Association (APSA) and CropLife Asia, and numerous NGOs.

Extension and training

More than 60% of farmers have no access to sources of information on modern agricultural technologies. Access to all forms of media is relatively low in rural India, and this affects modalities for extension. Televisions are in more than 75% homes in three states (Tamil Nadu, Andra Pradesh, Karnataka), but penetration is lower in others. Radio: 27% of the population listens each week. Literacy: 64.8% of the rural population is literate vs. 85.3% of urban dwellers; 19% of rural dwellers vs. 45% of urban dwellers have access to newspapers or magazines at least once a week. The internet reaches 1.2% for all of India vs. 3.4% for urban populations (NRSC, 2006).

Agricultural extension from government agencies gives priority to outreach for small, marginal and women farmers and dry lands. Extension also aims to enhance reforms in technology uptake, labor provision, and use. Key elements include: empowerment of farmer organizations associated with commodities or enterprises and farmer-led extension. Extension practices emphasize systems approaches, and optimum use of labor and other resources, with attention to gender and agribusiness links. Explicit allocation of funding (30%) for extension reforms aimed at women is proposed under the 11th 5 Year Plan (Extension-WG, 2007).

Public extension efforts are not adequate to achieve the results required, and greater engagement with the private sector, NGOs, input suppliers, and agri-

enterprises is needed. Extension also needs to have more of a market-led approach to increase farmer awareness of market opportunities and requirements (Extension-WG, 2007).

Human resources

Jha and Kumar (2006) studied research resource allocation in agriculture, focusing on personnel levels. In 2001-2002, there were 21,869 scientists (10,350 FTE[11]) in 564 establishments. Of these, 96% of agricultural scientists were in the public sector (State Agricultural Universities (SAUs) 63% and ICAR 20%). But, 78% of institutions were outside the public sector, and the private sector employed just 4.3% of scientists, but accounted for 10-12% of total research investment.

Time allocations across the sector were 47% for research, 27% for teaching, 15% for extension, and 9.5 to 15.1% for administration. Of the total agricultural scientist cadre, on average, 5.9% were involved in vegetable research (vs. 22.9% in cereals, and 8% on fruit), although the relative level of involvement in vegetable research was 13% for the private sector, 7% for SAUs, and just 3.7% for ICAR. Within the vegetable sector, resource allocation rankings by commodity focused on onion, tomato, eggplant, and cucurbit, while public sector rankings were cucurbits, eggplant, tomato, and okra (Jha and Kumar, 2006).

Public sector resource allocation for R&D was 34% for germplasm, 27% for crop protection, 22% for soil and water, and 9% for socioeconomics. Across regions, the public sector resource allocations amounted to 40% for the Gangetic plain and coastal areas, with 50% for rain-fed, semi-arid, arid, and hill zones.

An assessment of resource orientation revealed that ICAR set the trends, and SAUs participated in the national agenda as well as integrating with grassroots and public sector institutions. The study concluded that more resources were needed for vegetable R&D, and some climatic zones required more balanced attention. Other conclusions were: the need for greater capitalization of research, more recruitment of young scientists, and that the central, state, and local institutional division was valid in terms of the roles they undertook. However, more resources should be sent to state and grassroots organizations, and private-public dialogue had to progress to become real partnerships (Jha and Kumar, 2006).

[11] FTE = Full time equivalent employees

4 Achievements and Lessons Learned: Case Studies

With its vast population—25% of which lives below the poverty line—the production of large volumes of affordable vegetables is a key priority for India. Under-production leads to shortages and can deny the poor access to essential foodstuffs, so the government has restricted export of some commodities to preserve production for domestic use. This means the usual approach by many countries of focused promotion on exports is more challenging for India.

The case studies here consider three approaches, those for eggplant, which largely supplies the domestic market; onion, which supplies both domestic and export markets; and cooperative marketing, under which a range of vegetables are produced for the domestic market or specifically for export/processing.

4.1 Cooperative marketing

> ***Lesson 1.*** Linking farmers to markets under cooperative arrangements helps assure a return on farmers' investments, and the supply of what the retailer or processor needs.

Cooperative marketing, contract farming, and grower associations have emerged in recent years to provide alternative marketing mechanisms and shorten the supply chain. While some have viewed the trends positively (Birthal et al., 2005; Birthal and Joshi, 2007), others have raised concerns, particularly when contracts are involved (Key and Runsten, 1999; Singh, 2002, 2003). Here the perspectives on marketing as implemented by village level SAFAL [12] associations (Birthal et al., 2005; Birthal and Joshi, 2007) and under contracts with tomato processors (Key and Runsten, 1999; Singh, 2002, 2003) are considered.

SAFAL associations

NDDB: The National Dairy Development Board (NDDB) was established in 1965 for the promotion, financing, and support of producer-owned organizations which cooperatively collect, process and market dairy products throughout India. The NDDB provides a range of input services to members (NDDB, 2007)[13]. It is now regarded as an exemplar of cooperative marketing success, in

[12] SAFAL = Combination of Hindi words for vegetables (*sabji*) and fruit (*fal*)

[13] In 2006, India"s 1.2 million dairy cooperatives joined to become 170 milk unions and 15 federations which collect on average 21.5 million liters milk/day (NDDB, 2007).

integrating millions of smallholders, who often own just one or two cows, into a national milk marketing scheme (Goldberg et al., 1998).

MDFVL – SAFAL: Based on their success in milk marketing, and taking advantage of the NDDB cooperatives and infrastructure, the NDDB is also involved in fresh produce marketing (since 1988). There are at least 225 fruit and vegetable (SAFAL) associations located in niche production areas, supplying fruit, vegetables, and dairy through 300 retail outlets of a NDDB subsidiary, Mother Dairy Fruit and Vegetables Ltd (MDFVL, formerly SAFAL) in Delhi, as well as through a 100% export-oriented processing business in Mumbai. The SAFAL associations have been promoted by MDFVL as a mechanism for helping farmers to produce and supply produce more effectively (Goldberg et al., 1998; NDDB, 2007).

MDFVL fosters the development of associations of individual farmers, who can supply at least one tonne of fruit or vegetables a year, and deliver on a regular basis. No formal contracts are involved, but MDFVL indicates its supply needs to SAFAL associations ahead of the season to allow association and individual farmer planning to meet (or exceed) agreed requirements. MDFVL also provides technical and input support for associations, and the system has been cited as a model of success, with small (< 2ha) and large (> 2 ha) SAFAL members earning higher returns than similar farmers who are not members of a SAFAL association (Birthal et al., 2005; Birthal and Joshi, 2007).

Producer associations

Birthal et al. (2005) examined the involvement of two SAFAL producer associations, one in rural Delhi, and one in Sonepat district of Haryana State (near Delhi), that supplied Mother Dairy Fruit and Vegetables Ltd (MDFVL), and compared their involvement in marketing with farmers who were not members of SAFAL associations.

Birthal et al. (2005) found that unlike traditional marketing arrangements, the SAFAL associations ensured procurement of contracted produce from the producers' doorsteps—thus allowing savings on transport, travel, and labor compared to uncontracted farmers. The associations also provided input services at wholesale rates, and new technologies that reduced the rate of production. Birthal et al. (2005) examined how the associations developed new institutional arrangements and benefited farmers by promoting high value food commodities. The findings were that SAFAL member vegetable farmers made 78% more profit than non-contracted vegetable farmers. Birthal et al. (2005) considered that the vertical association, which resulted from some marketing alliances for

high-value foods, helped lower transaction costs and market risks of small holders, and was on balance a positive trend for smallholders.

Advantages of association membership: Birthal et al. (2005) concluded that profit was a strong motivation for farmers to join cooperative associations. The advantages that farmers in associations had over non-members were savings in production (26% saving) and marketing costs, with the majority of the saving due to lower transaction costs (only 2% of total costs, compared to 21% for non-contract vegetable farmers). Birthal et al. (2005) also noted that SAFAL member farmers were taking advantage of new institutional arrangements that reduced costs of travel and transport of inputs and produce, and provided access to information and new technology. Transaction costs were lower due to savings in time, transport, and labor costs for produce marketing, because the commodities were collected by companies from the producers' villages. Access to markets and information about new technology, at almost no cost, motivated farmers to become involved in the farmer associations.

Vertical coordination through the SAFAL associations benefited both companies and farmers. For companies, it assured timely supply of the produce needed, with more control over operational and fixed costs for the company, and minimized the risk of under-utilization of capacity and per-unit capacity costs. It also helped companies improve their reputations for supply, quality, and price, and improved market assurance for farmers. Improved market access enhanced farmers' capacity to withstand production and price fluctuation risks, and enabled better access to inputs, capital, technology, and information. The benefits increased farmer participation in the SAFAL arrangements: 76% of farmers in SAFAL associations had increased the scale of their operations between 1999 and 2000. In this period, non-SAFAL farmers had also increased the scale of their operations, but at a lower rate (54%), suggesting that production as practiced in the SAFAL associations provided greater net benefits for production and marketing.

Impact of membership on income: To determine whether scale affected access to benefits, Birthal and Joshi (2007) further assessed the SAFAL association benefits to member vegetable farmers, with benefits accrued by non-member farmers supplying retail outlets in Delhi. Under SAFAL association marketing, the daily wholesale price in the Delhi wholesale market served as a base price for producer payments from SAFAL associations with some additional premium for quality. Non-SAFAL member farmers were more dependent on daily fluctuations and vulnerable to trader influences in price determination.

Table 11 shows the participation rate, production, and net returns of surveyed farmers. The study found that SAFAL members, whether small or large holders,

enjoyed higher net returns than independent producers, with smallholders particularly enjoying benefits compared to non-member smallholders.

Table 11. Production and net returns for small and large holders (Rs/tonne) who are SAFAL association, or independent producers of vegetables in India.

	SAFAL members		Independent producers	
	Small < 2 ha)	Large (> 2 ha)	Small < 2 ha)	Large (> 2 ha)
Number of growers surveyed	13	13	12	7
Crop yield (tonnes/ha)	9.7	8.1	8.6	8.1
Net Revenue (Rs)				
Over pecuniary costs	2,309	2,241	1,531	1,657
Over total costs	1,818	1,779	920	1,126

Source: Birthal and Joshi (2007)

Conclusions: Birthal and Joshi (2007) analyzed the factors that contributed to the increased profitability, and concluded that despite their limited access to land, smallholders participated more in vegetable production and made sizeable contributions to industry production. In addition, smallholders had greater endowment of family labor, and were more efficient in production of labor-intensive crops like vegetables. Lack of access to markets and higher transaction costs were major barriers of high-value agriculture in small farms; the vertical coordination of supply chain through the SAFAL grower associations linked to MDFVL alleviated these constraints.

Birthal and Joshi (2007) also noted significant policy issues: Production of vegetables is limited to a small proportion of farmers because of high production and market risks; institutional linkages between production and markets enable farmers to cope with such risks, contribute to more efficient markets and extension, and reduce public institution costs. Birthal and Joshi (2007) also concluded that some agribusiness firms enhanced skills and provided training in clean production, and provided inputs, technology, credit, and services to improve competitiveness. As well, while the global markets for high-value products were increasing, quality standards were becoming very stringent and it was critical for processors and government to prepare farmers for "quality-driven" markets. They suggested it was also important to enhance value-adding and processing efficiency by investing in technologies and scaling up of processing. Birthal and Joshi (2007) further noted that improvement of vertical coordination also required investment in infrastructure (roads and transport) and enabling policies to stimulate private sector investment in processing.

While the conclusions of Birthal and Joshi (2007) appear sound, some additional factors contribute to the success of the SAFAL associations: the advantages conferred by the link with Mother Dairy Fruit and Vegetables Ltd (MDFVL) and the infrastructure and linkages through the milk marketing cooperatives under the National Dairy Development Board; the proximity of producers of fresh produce in the SAFAL associations to Delhi; and labor inputs of women and working children that reduce labor costs.

Vegetables for processing

Tomato processing: Singh (2002; 2003) examined contract production of tomatoes for multinational and national tomato processing companies in the Punjab, where there has been a downward trend in statewide vegetable production. They concluded that the surveyed firms dealt preferentially with large farmers, and that contracts were biased against the farmer, perpetuating existing problems such as high chemical use and social differentiation. However, contracting led to higher farm incomes and more employment for labor. Singh (2002) speculated that the contractual arrangements and links in particular areas might not last due to lack of trust between processors and farmers and the tendencies for farmer benefits to decline and processor benefits to increase over time.

Local vs. multinational: Singh (2002) considered that the local company was better able to relate to farmers than the multinational, because the contracts of the local company were in the local language, and because it involved a larger number of smaller farms than the multinational. Singh (2002) considered that greater farmer empowerment (such as grower associations) would improve the balance of power between processors and farmers, with the role of government to facilitate, regulate and arbitrate. He noted that in some developed countries such as Japan, greater legal protection was given to subcontracting parties dealing with large companies, and suggested that some of their framework principles could be adopted for India. Singh (2002) also concluded that while non-governmental organizations (NGOs) were useful at the local level in improving farmer benefits, their efforts were scattered and uncoordinated.

Labor under contracting: Analysis of labor conditions under contracting to tomato processors (Singh, 2002) revealed that few additional benefits were flowing to women and children, who were key workers for some processes. Singh (2002) suggested that a more proactive approach was needed to enhance benefits to these workers (skills development, education, pay levels, job security) and suggested that contract farm labor associations could help negotiate better conditions.

Better approaches needed: Singh (2002) noted that some farmers in the Punjab had profited well from the Green Revolution, but the current contractual arrangements between farmers and processors did not provide a satisfactory outlet for the financial reserves of these growers. Singh (2002) suggested that new thinking was needed to develop approaches to crop diversification that better engaged the resources accruing from the Green Revolution, and that improved rather than diminished the involvement of the state in promotion and regulation of development.

Future development

In many countries in the region, the emergence of supermarkets is providing new opportunities for vegetable farmers who are able to meet requirements for quality and supply continuity. In India, the supermarket sector is just beginning to grow in significance in terms of supply needs as a proportion of total production. Demand for premium and low pesticide products will increase, and the supermarkets will use their own supply centers to source product (Reliance, 2007). Inevitably this will affect the existing arrangements between SAFAL Association members and Mother Dairy Fruit and Vegetables Ltd, and between contracted farmers and tomato processors. The additional competition for farmer links will introduce a measure of competition that could improve benefit flows to farmers. But as noted by Singh (2002), it will be critical for the government to be involved in facilitation, regulation and oversight.

4.2 Eggplant (Brinjal[14])

> ***Lesson 2.*** *Don't put all your egg (plant)s in one basket*. Productivity increases, while very important, need to be achieved using low-impact technologies that reduce health risks to consumers.

Production. Eggplant (*Solanum melongena*) is a major vegetable crop in India and South Asia. Produced throughout the year, even in the wet season, eggplant, along with onion and tomato, are the main vegetables the urban and rural poor can afford. Plantings will generally crop for 5 to 6 months, and can be harvested daily to provide a ready source of vitamins and minerals. Statewide production and area under eggplant are highest in West Bengal, while productivity is highest in Bihar, with Orissa and Gujarat as 3rd and 4th largest producers by state (**Table 12**).

[14] From the Persian *badingān*, probably from Sanskrit *vātingana* (Wikipedia, Eggplant), later a 17th century Anglo-Indian adaptation of Portuguese *berinjela*. The Sanskrit name, *vātingana*, was bestowed because consumption of the fruit had a carminative effect upon the digestive system (Everything, 2007).

Table 12. Leading eggplant producing states (2004-05) of India

States	Area ('000ha)	Production ('000MT)	Productivity (MT/ha)
West Bengal	148.3	2,701.7	18.2
Orissa	127.7	1,852.2	14.5
Bihar	53.7	1,073.0	20.0
Gujarat	49.2	745.6	15.2

Source: Working Group on Horticulture, Plantation Crops and Organic Farming (2007)

The area and production of eggplant grew significantly between 1993-94 and 1996-97, but productivity (yield/ha) actually decreased (**Table 13**). Growth in area then slowed sharply, while production increases tapered more slowly, with productivity increasing substantially between 1996-97 and 2001-02, and then declining slightly. The productivity increases in between 1996-97 and 2001-02 were probably due to improved crop management and the adoption of improved cultivars (including hybrids).

Table 13. Area, production and productivity of eggplant in India

Year	Area 000"ha	Increase %/ annum	% of total Veg. Area	Production (000" MT)	Increase %/ annum	% of total Veg. Production	Productivity (MT/ha)	Increase %/ annum
1993-94	300.7	-	6.2	4,612.2	-	7.0	15.3	-
1996-97	464.0	18.10	8.4	6,585.6	14.60	8.7	14.2	-2.4
2001-02	502.4	1.65	8.2	8,347.7	5.35	9.4	16.6	3.4
2004-05	530.3	1.78	9.0	8,703.8	1.42	10.3	16.4	-0.4

Source: After Working Group on Horticulture, Plantation Crops and Organic Farming (2007).

Pest control: In maintaining crop productivity, effective pest control is critical, and high levels of insecticide have been used to control the main pest—fruit and shoot borer—but with mixed success. To tackle the high losses and excessive reliance on pesticides, two approaches have been developed: an effective integrated pest management (IPM) strategy has been developed and promoted[15] in South Asia (Alam et al., 2006), and a genetically modified *Bt*-eggplant has been developed and field tested in India (Kolady and Lesser, 2005; Span, 2007).

While the IPM and *Bt*-eggplant may not offer substantially higher productivity, compared with yields obtained by use of high levels of insecticide, they offer two key advantages: reduction of chemical use, and improved returns through

[15] Within a DFID funded project (R7465) involving AVRDC and South Asia partner institutions on implementation and promotion of IPM of eggplant fruit and shoot borer. The IPM strategy involves (a) field sanitation, (b) prompt crop sanitation, and (c) bait trapping and delaying insecticide use to promote natural enemy proliferation.

lower input costs (Alam et al., 2006). An additional benefit of the promotion of the IPM approach is that small and medium enterprises have been established to produce and market the pheromone lure used in bait sprays, providing employment and income in rural communities (Alam et al., 2006).

Bt-eggplant: Kolady and Lesser (2005) have looked at the economics of potential adoption of *Bt*-eggplant, drawing on studies of adoption of hybrid and open pollinated eggplant cultivars. They concluded that the likelihood of farmer adoption of *Bt* hybrid seed increased with farmers who had higher total landholdings, increased expenditure on chemicals to control shoot and fruit borer, and good access to banks, and with prior knowledge of *Bt* technology. The availability of open-pollinated varieties in villages decreased the probability of adoption of *Bt* hybrids, but increased the likelihood of adoption of *Bt* open-pollinated varieties. Kolady and Lesser (2005) found a positive correlation between past adoption of hybrids, and expected adoption of *Bt* hybrids, and a negative correlation between past adoption of hybrids and expected adoption of *Bt* open pollinated varieties.

IPM: An economic evaluation of the IPM approach in Gujarat found that labor costs were reduced from Rs 40,004/ha to Rs 26,002/ha after adoption of IPM, and total production costs decreased from Rs 169,743 to Rs 118,693/ha, with mean net returns increasing from Rs 224,000 to Rs 141,037/ha (Alam et al., 2006). The IPM approach has clear benefits, but ongoing evaluation of the strategy has found that additional insect pests begin to proliferate when fruit and shoot borer is well-controlled; additional research will be needed to extend the control strategy. *Bt*-eggplant represents part of a potential solution to the additional pests, and could further reduce crop management costs, provided it is accepted by consumers and can be made available to farmers at an affordable price.

4.3 Onions

> ***Lesson 3.*** *Know your onions.* In developing export markets, ensure that domestic supplies remain affordable, and strengthen adherence to Good Agricultural Practice.

Onions are the most vital ingredient in Indian food, and seasonal shortages can cause price increases and social unrest. During February 2007, the average worker found that weekly expenditure on vegetables rose from Rs. 100 to c. Rs 150 (US $2.25 to $ 3.40) over the month, with the street price of onions rising from Rs. 12 to 24/kg. The increase was attributed to an increase in exports, a shortage of supply, and transport and storage bottlenecks, but many wondered if

the increase in onion prices were symptomatic of an overheating economy. In India, governments can be won or lost for the price of onions, so maintaining supply and affordability are key issues for government[16] (Gentleman, 2007; Srivastava, 2007).

Production: Onion production increased continuously from the 8th through to the 10th 5-year plans (1992-2007), with increases especially high under the 9th and 10th plan. The result seems to be primarily due to an expansion of the cultivation area, as mean productivity (yield/ha) in 2004-05 was substantially lower than that of 1991-02 (**Table 14**).

Table 14. Area, production, and productivity of onion in India

Year	Area ('000 ha)	Increase %/ annum	% of total Veg. Area	Production ('000 MT)	Increase %/ annum	% of total Veg. Production	Productivity (MT/ha)	Increase %/ annum
1991-92	331.8	-	5.9	4705.8	-	8.0	14.2	-
1996-97	410.0	23.6	7.4	4180.0	-11.2	5.6	10.2	-28.2
2001-02	495.8	20.9	8.1	5252.1	25.6	5.6	10.6	3.9
2004-05	593.9	19.8	10.1	7515.4	43.1	8.9	12.7	19.8

Source: Working Group on Horticulture, Plantation Crops and Organic Farming (2007)

The main onion producing state is Maharashtra, with highest area and production, followed by Karnataka in area, and Gujarat in production. Highest productivity is in Gujarat, followed by Bihar (**Table 15**). The volume of onion exports increased significantly starting 2003-04, and reflected liberalization of exports. Until 1998, all Indian onion exports were controlled through the National Agricultural Co-operative Marketing Federation of India (NAFED), but since then various agencies (mainly state level cooperatives in the main producing states) have been involved.

In Maharashtra, production increased from about 597,000 tonnes in 2001/02, to 770,000 in 2005/06, with most exports to the South Asia Association for Regional Co-operation (SAARC) region, and a few countries in East Asia and the Middle East (MSAMB, 2007a). Onions have the advantage of being robust enough for shipment by sea (to most markets) and by road, but losses are high, and (road) consignments to Pakistan suffer additional delays for security checks on the Indian side (Mir, 2007)

[16] In 1998, the Bharatiya Janata Party (BJP) lost power in elections in Delhi (the price of onions at that time rose to Rs 60 per kilogram) and Rajasthan, as the cost of the vegetable soared by 600 percent. The "onion factor" also contributed to the defeat of the now defunct Janata Party in the 1980 general elections. (Gentleman, 2007; Srivastava, 2007).

Table 15. Leading onion producing states in India (2004-05)

States	Area (000'ha)	Production (000'MT)	Productivity (MT/ha)
Maharashtra	121.7	1422.3	11.7
Gujarat	58.5	1340.6	22.9
Bihar	48.8	975.2	20.0
Karnataka	115.2	724.5	6.3

Source: Working Group on Horticulture, Plantation Crops and Organic Farming (2007)

Improvements in production technologies in the summer (*kharif*) crop, and superior cultivars—Agrifound, Arka Kalyan, Dark Red and N 53—have contributed to expansion of the area and productivity, but there can be seasonal shortages and price increases compounded by high storage losses and pressures to meet export contracts.

Improving marketing: To capitalize on enhanced opportunities and ensure that supplies are ample and affordable in the domestic market, some technical challenges need to be addressed (Masalkar et al., 2005) including: improvement of productivity, extension of storage life, and reduction in postharvest decay and sprouting. Other options include expansion of the production area through winter cropping, and expansion of watering technologies for rain-fed areas. Improved nutrient management (in particular potassium supply) might also reduce storage losses and sprouting.

Onion exports need to expand beyond SAAC and Asia, by enhancing price competitiveness, meeting quality and storage life expectations, and simplifying export procedures. The onion will remain an important commodity for domestic and export trade and the emergence of supermarkets will provide new opportunities for farmers in more distant states to produce supplies for the cities.

5 Conclusions

5.1 Policy and human resource issues

India is a vast country with sprawling cities, high levels of poverty, under-developed infrastructure for food delivery, and an agricultural system that focuses on grain and legume food security. It is the second largest vegetable producer, and per capita availability levels are rising as incomes improve, but one-quarter of the population lives below the poverty line, and a larger proportion are malnourished.

Although India's economy is booming, agriculture has lagged behind and growth has been sluggish. The national and state governments have recognized the need to stimulate the sector to increase productivity, enhance farmer incomes, and promote agribusiness. To earn more income, increasing numbers of farmers are producing vegetables on a portion of their land, and new marketing arrangements are emerging, along with some export opportunities (onions, processed vegetables, organics). Key opportunities are: to intensify production for urban markets, to promote more production in rain-fed areas, and to encourage more garden and village production in remote regions to improve nutrition and diversify village economies.

5.2 Industry issues

Vegetable marketing is a major challenge, with high levels of loss and logistic and retailing deficiencies, but some successful models have emerged amid the chaos: for example, the Mother Dairy Fruit and Vegetables Ltd co-operative marketing, and the more recent growth of modern supermarket chains, including Reliance Fresh, which opened more than 1500 supermarkets with associated distribution centers in 2006-07. But problems and challenges are likely to arise when supplying to processors under contract, as in the case of tomato growers in the Punjab; farmers and traders who are not able to compete may be marginalized.

As a proportion of production, export/import trade development is relatively low. Food security concerns, and the importance of ensuring domestic food remains affordable, have in the past enforced government restrictions on development. But restrictions are now being eased (or reduced at least, in some states), and there are opportunities to expand the existing export markets (onions), develop new ones (organics, ready-to-eat "Indian"), and capitalize more on low-end imports (to ease shortages) and high-end market opportunities.

The vegetable processing sector is also underdeveloped, and as the retail sector modernizes and incomes rise, demand will skyrocket for processed and ready-to-eat vegetable meals (30% of Indians are vegetarian). To facilitate growth and modernization, incentives for private sector investment are needed, along with an easing of restrictions that limit some processing activities at the village level (e.g. chutneys). At the same time, however, new thinking by government will be needed, and greater empowerment of farmers encouraged, to ensure greater equity during contract and price negotiation, and to enable closer monitoring of produce quality and safety.

5.3 Issues for focus

Land availability is a major constraint. Increasing productivity per unit of land and water are key imperatives. Self-sufficiency production needs to be boosted in remote and marginalized communities to improve community nutrition and reduce reliance on supplies from other areas. This means improved varieties with better yield, IPM, pest and disease resistance, and protected cultivation technologies should be promoted.

High levels of poverty are a major factor affecting vegetable consumption by the poor. But consumption will not increase if vegetables become unaffordable due to inadequate supplies or excessive demand.

For all sectors, food safety, quality improvement, postharvest loss reduction, and supply chain management are strategic priorities for improving system efficiency and reducing costs (Working Group on Horticulture, Plantation Crops and Organic Farming, 2007). If the reported high loss levels nearing 40% for fresh produce could be halved (Choudhury, 2006; Rolle, 2006), India could easily feed its entire population—and expand trade. Attention is needed to improve technology and logistics, enhance the comparative keeping quality of different vegetable types and varieties, and establish good agricultural practices. But the most critical need is the development of human resources for the industry.

Boosting literacy at village level, addressing concerns about the roles of women and child labor, and enhancing the practical skills, business knowledge, and "produce care" capabilities of farmers, workers, and consumers are critical aspects of agricultural modernization. It will also help deliver a new future for those who may be marginalized within the farming and trading sector as the industry evolves.

The policy formulation and regulatory changes underpinning the current situation and driving change have been well-articulated in the discussion papers for the 11th 5-Year Plan. Implementation rates for the proposed changes at national, state, district, and farmer levels will determine how rapidly and easily change can occur. Progress may be slower where political or sociocultural issues clash. Additional dialogue and incentives from government may be needed to coordinate and encourage implementation by the states, with farmer encouragement and social support as paramount considerations.

India is a democratic society with established processes for two-way communication and coordination of national, state, and district initiatives. The "All-India" coordinated projects for research and development, the links between the Ministry of Agriculture Indian Council of Agricultural Research (ICAR) agencies, and state- and district-level initiatives have generated impressive outputs. There is also considerable unrealized potential for more productive R&D implementation in partnership with the private sector and local and international non-governmental organizations.

In terms of personnel involved in R&D and the vegetable industry, a generational change is occurring, and this must be planned for. A key challenge will be to harness the strengths and achievements in research while paving the way through capacity building and new modalities of training for the "new India" as an IT-savvy younger generation, the dominant demographic in India's population, begin to become a more significant force in the economy.

6 Recommendations for R&D

Build capacity in marketing and policy
Build capacity in agribusiness marketing and agricultural policy development for the vegetable sector. Capacity needs to be built at all levels of government and among agribusiness and farmers.

Enhance statistics collection and analysis
Improve horticulture and marketing statistics collection and analysis and strengthen internet-based, community-level access. Improvement of data collection and information access is particularly crucial for trade data.

Undertake more cost-benefit modeling
Develop cost-benefit models for transitional and high value production systems, particularly for rain-fed and remote areas, for use in decision making and state/district level promotion of the vegetable sector. Farmer access to affordable credit needs to be enhanced to facilitate the move to or expansion of vegetable production and marketing. Options include strengthened support for protected cultivation, hydroponics and microirrigation, capacity building and promotion of organic cropping, and organic input manufacture and certification compliance capabilities. Links to the trading, processing, and marketing sectors need to be strengthened with improvement of production systems.

Promote growth and market development
Facilitate growth in domestic production while improving marketing and value-adding. Attention to Good Agricultural Practice and food safety will become more significant as the retail sector changes and export and food processing opportunities increase.

Promote market–focused approaches
Strengthen market-focused approaches to trade development. In broadening exports, key challenges are maintaining competitiveness, improving export market intelligence, gathering to identify and meet opportunities, and meeting SPS and pesticide residue requirements. Meeting requirements and reaching an agreement with China on vegetable exports has been challenging, but the process will strengthen capacity for accessing other potentially higher value markets. The approval of mango exports to Japan (2006) and the US (2007) may pave the way for niche export opportunities (organics, bitter melon).

Streamline trade and agribusiness
Streamline approaches to trade and agribusiness development to optimize benefit flows to regions most in need/capable of benefiting from investment. Continue liberalization of fresh produce marketing, to reduce losses and improve cost efficiencies and profits to farmers. High domestic demand for most vegetable production places additional pressures on export market development, particularly when government regulates export permission to assure domestic supply and price stability.

Continue liberalization of market and trade regulation
Onion exports need to expand beyond SAAC and Asia through gaining price competitiveness, meeting quality and storage life expectations, and simplifying export procedures.

Promote supply chain improvement
Adoption by government agencies of systems and supply chain approaches to industry assessment and planning will enhance their understanding of critical gaps and deficiencies, and of key leverage points for industry improvement.

Improve productivity
Increase development work on suitable varieties for, and productivity under, high temperatures, and foster uptake and improvement of low-cost structures, fertigation and irrigation systems. Focus on farmer uptake and engagement with the private sector, including the seed industry, to optimize the chance of uptake and to reduce duplication of effort.

Optimize crop nutrition
Reduce overuse of chemical fertilizers and enhance precision application through fertigation and use of biofertilizers. Improve production, standardization and use of fertilizers, and increase training and promotion. Look at practical and affordable options for measuring and monitoring nutrient needs at farm level.

Optimize pest management
Reduce pest and disease losses while minimizing reliance on chemicals for pest and disease management by improving pest management practices. A key issue is the need to boost capacity in quarantine and food safety surveillance for imports, to maintain biosecurity for local production and protect consumers. Reducing pesticide residue levels in produce through safer application practices, improving pesticide monitoring, regulation, and traceback capabilities, and better enforcement by regulatory agencies, will enhance market prospects provided pests are sill adequately controlled.

Work more with the private sector

Engage with the private sector to streamline modernization of the retail and wholesale sectors and farming, and encourage government attention to logistics infrastructure and social planning and investment. A key challenge is to modernize and grow while minimizing impacts on inefficient farmers and the small retailers who will need to adapt or else retreat from the industry as their livelihoods decline.

Do more to facilitate investment

Focus government investment on logistic and infrastructure improvement, regulatory systems and trade promotion, and policy reform on easing regulations, monitoring legal aspects of trade and finance, alleviating social disruption, and increasing vegetable consumption. Harmonization of trade and financial system processes with other countries will assist in integration and reduce transaction costs. Wherever vegetable consumption has been promoted, consumption levels have risen.

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8 Appendixes

Appendix 1: Production area (A) and (B) volume for vegetables and selected spices in India

A.

Crops	Area ('000 ha)					
	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Eggplant	500.3	472.1	506.9	507.3	516.4	530.3
Cabbage	258.3	245.4	251.1	233.8	255.1	290.3
Cauliflower	248.3	256.3	267.7	254.6	267.9	238.2
Okra	348.8	349.1	350.9	329.2	353.1	358.3
Onion	493.3	448.9	495.8	424.7	553.8	593.9
Peas	272.6	319.3	201.7	305.2	285.2	276.7
Tomato	456.5	458.7	238.9	478.8	502.8	497.6
Chili	959.2[a]	836.5	836.2	827.9[b]	794.1[b]	771.2[b]
Turmeric	141.2[a]	191.7	167.1	154.2	150.8[b]	158.4[b]
Ginger		101.1[b]	102.4[b]	104.2[b]	105.7[b]	108.8[b]
Others	2074.0	2487.4	1882.2	1882.0	1736.9	2010.2
Total	**5,993.0**	**6,248.5**	**6,044.4**	**6,091.7**	**6,308.9**	**6,755.6**[17]

B.

Crops	Production ('000 t)					
	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05
Eggplant	8117.2	7676.9	8372.0	8001.2	8477.3	8703.8
Cabbage	5909.4	5617.1	5546.9	5392.0	5594.6	6147.7
Cauliflower	4717.8	4694.6	4859.1	4444.1	4940.2	4507.9
Okra	3419.1	3344.6	3340.9	3244.5	3631.4	3524.9
Onion	4899.5	4721.1	5252.1	4209.5	6267.6	7515.4
Peas	2712.0	3007.6	1329.5	2061.8	1901.2	1971.8
Tomato	7426.8	7277.1	6515.9	7616.7	8125.6	8637.7
Chili	1052.8[a]	983.7	970.1	900.7[b]	1273.9[b]	1237.8[b]
Turmeric	668.5[a]	714.3	562.8	573.9	567.3[b]	718.1[b]
Ginger		416.4[b]	432.3[b]	422.7[b]	457.1[b]	500.8[b]
Others	28628.8	35339.8	19570.4	20127.6	19172.6	22123.9
Total	**90,830.7**	**93,921.5**	**87,528.2**	**84,815.3**	**93,165.0**	**101,433.5**

Note: Mushroom production not included: 40,000 tonnes in 2004-05; total includes potato, sweet potato and tapioca (not included in "Vegetable Others"), while the three spices (ginger, chili and turmeric) are not included.

Sources: [a] IASRI (2004); [b] Spices Board of India (2007); remaining data from IASRI (2006) in 1999-00 to 2002-03 and NHB (2006) in 2003-04 and 2004-05.

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Appendix 2: Area ('000 ha) under microirrigation in India

State	Drip	Sprinkler	Total
1 Andhra Pradesh	155.441	124.51	279.951
2 Arunachal Pradesh	0.613	0	0.613
3 Assam	0.116	0.129	0.245
4 Chhattisgarh	1.979	3.765	5.744
5 Goa	0.746	0.306	1.052
6 Gujarat	53.707	96.374	150.081
7 Haryana	4.258	503.877	508.135
8 Himachal Pradesh	0.116	0.581	0.697
9 Karnataka	114.433	157.028	271.461
10 Kerala	10.562	1.548	12.11
11 Madhya Pradesh	6.483	100	106.483
12 Maharashtra	341.848	153.507	495.355
13 Manipur	0.03	0	0.03
14 Mizoram	0.072	0.106	0.178
15 Nagaland	0	3.962	3.962
16 Orissa	2.036	20.22	22.256
17 Punjab	5.101	10	15.101
18 Rajasthan	10.025	554.708	564.733
19 Sikkim	0.8	10.03	10.83
20 Tamil Nadu	116.665	26.332	142.997
21 Uttar Pradesh	4.609	10	14.609
22 Uttaranchal	0.038	0.006	0.044
23 West Bengal	0.11	150.02	150.13
Grand Total.	829.788	1,927.009	2,756.797

Note: Area as on March, 2006.

Source: Working Group on Horticulture, Plantation Crops and Organic Farming (2007).

Appendix 3: Recommendations for seed treatment for major vegetable crops in India

Crop	Disease	Seed Treatment	Remarks
Chilies	Anthracnose spp. Pseudomonas spp.	Seed treatment with *Trichoderma viride* 4g/kg, Carbandazim @ 1g/100 gm seed.	-do-
	Soil borne infection of fungal disease	*Trichoderma viride* or *Trichoderma harzianum* @ 2 gm/kg. seed.	-do-
Pea	Root rot White rot	Seed treatment with - *Bacillus subtilis* - *Pseudomonas fluoresgens* Soil application @ 2.5 – 5 kg in 100kg FYM or - *Carbendazim* or *Captan* 2 gm/kg. seed *Trichchoderma harziarum* 4 gm/kg seed *Thiram+Carbendazim* 2gm/kg seed *Carbendazim* or *Captan* 2gm/kg seed	-do-
Onion	Smut	*T. viride* @ 2 gm/100gm. seed. Benlate or Vitavax @ 0.01%	-do-
Tomato	Soil borne infection of fungal disease Early blight Damping off	*Trichoderma harzianum* and *T. viride* @ 2 gm/100gm seed.	For seed dressing metal seed dresser/earthen pots or polythene bags are used.
Coriander	Wilt	*Trichoderma viride* *Trichoderma harzianum* @ 4 gm./kg seed.	-do-
Brinjal	Soil borne infection of fungal disease	*Trichoderma viride* *Trichoderma harzianum* @ 2 gm/100gms. seed.	-do-
Cucurbits	Soil borne disease	*Trichoderma viride* @ 2 gm/100gms. seed.	-do-
Leguminous Vegetables	Soil borne infection Nematode	*Trichoderma viride* @ 2 gm/100gms. seed. Carbofuran/Carbosulfan 3% (w/w)	-do-

Source: DAC (2007).

Appendix 4: 11th 5-Year Plan: Selected recommendations for Indian horticulture

Enhancing Crop Productivity

- National Centre for Plant Disease Diagnosis at Bangalore
- Promotion of move to use of F1 Hybrids
- Promoting leafy vegetables for nutrition, especially in villages and tribal areas
- Expanding protected cultivation of vegetables for export
- Encouraging kitchen gardening
- Improving availability of vegetables in short supply
- Promoting technologies for year-round production of vegetables like onion
- Develop high yielding, disease-free spice varieties
- Develop multi-crop cultivation and intercropping options for spices
- Investment in infrastructure for disinfestations (VHT, irradiation) in partnership between central and state governments to enhance opportunities for export
- Encourage seed production zones for hybrid seed production of vegetables
- Provide infrastructure and financial support for commodity associations to strengthen their activities

Policy

- Abolish import duties on plastic raw materials and reduce excise duty on microirrigation systems
- Promote entrepreneurship and subsidize transport to promote horticulture in northeast and underdeveloped states like Bihar.
- Strengthen capability for use of geographical place name/commodities
- Consolidate all programs for horticulture under MoA
- Create member “Horticulture” for planning commission

Source: Working Group on Horticulture, Plantation Crops and Organic Farming (2007)

Appendix 5: Laws relevant to the Indian vegetable industry

Laws

Patent (Amendment) Act, 2005
The Food Safety and Standards Bill, 2005
Biological Diversity Act, 2002
Seed Bill, 2004 http://agricoop.nic.in/seeds/seeds_bill.htm
PPV & Farmer's Rights Act, 2001

Agricultural Produce and Marketing Acts

The Indian Ministry of Health and Family Welfare released final amended product labeling requirements to the Prevention of Food Adulteration Rules on August 20, 2006.

2005 Customs Tariff Act
Destructive Insects and Pest Act 1914

(Sources: Central Board of Excise and Customs (2007); Department of Agriculture and Co-operation (2007); Govindan (2007))

The Genetic Engineering Approval Committee (GEAC) of the Department of Biotechnology is the regulatory authority for food products containing Genetically Modified Organisms (GMOs). The 1989 Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Micro Organisms, Genetically Engineered Organisms or Cells provides the regulations for the import of products containing GMOs.

As apart of the 1989 Rules, any producer wanting to import confectionery products containing GMOs must first receive approval from GEAC. Approvals are valid for four years and are renewable for two-year periods.

(Sources: The Prevention of Food Adulteration Act of 1954, Food Adulteration Rules of 1955, Department of Biotechnology) (NCA (2007))

Ministry of Commerce Directorate General of Foreign Trade Exim Policy 1997-2002 http://dgft.delhi.nic.in/exim/2000/pol/contents.htm

India Agricultural Produce Export-Import Policies
http://www.agriculture-industry-india.com/export-import-policies/

Agro industry export-import (EXIM) policies

Customs Duty on Agro and Agro Products
Section - 1 : Live Animals; Animal Products
Section - 2 : Vegetable Products
Section - 3 : Animal or Vegetable Fats and Oils and their Cleavage Products; Prepared Edible Fats; Animal or Vegetable Waxes
Section - 4 : Prepared Foodstuffs; Beverages, Spirits and Vinegar; Tobacco and Manufactured Tobacco Substitutes

Acts and regulations

Plant Protection Division
The Insecticides Act
Insecticides (Amendment) Act , 2000
Notifications issued recently under the Insecticides Act, 1968
The Insecticides Rules, 1971
The Destructive Insects and Pests Act,1914
Recent Amendments To PFS Order, 1989

Cooperation Division
The National Cooperative Development Corporation Act, 1962
The Multi-State Cooperative Societies Act, 1984
No.51 Of 1984 The Multi-State Cooperative Societies Rules, 1985

Seeds Division
The Seeds Rules 1968
The Seeds ACT, 1966
The Seeds (Control) Order, 1963
Salient Features Of The Protection Of Plants Varieties & Farmers Rights Bill, 2000

Agricutural Implements And Machinery Division
The Dangerous Machines (Regulation) Act, 1983
The Dangerous Machines (Regulation) Act, 1984
http://ideas.repec.org/p/iim/iimawp/2004-06-09.html

Prevention of Food Adulteration Act
http://mohfw.nic.in/pfaact.pdf