ANNEX 3

Overview and Situation of Vegetables Production in Thailand
(Focus on Chinese broccoli and chili pepper)

1. Introduction

Thailand is located wholly within the tropics, between 5° 37' - 20° 27' N and 97° 22' - 105° 37' E, with a land area of 51.3 million hectares and a population of 64 million (UNFPA, 2012). The climate is tropical with three seasons, summer (February-May), rainy (June-Sept), and winter (Oct-Jan). Rainfall averages 1700 mm, with about half of Thailand receiving < 80 rainy days/year, 28% receiving 80-120 rainy days/year and 22% receiving > 120 rainy days/year. Typhoons are rare (Johnson *et al.,* 2008).

Despite several political upheavals in the last 20 years and the 1997 economic crisis, Thailand has recovered well; by many measures it is no longer a developing country. The economy is fairly robust, with a healthy manufacturing sector and good agricultural productivity. In 2007 Thailand was ranked 17th for foreign exchange reserves, 4th after Singapore, Brunei, and Malaysia for Southeast Asian nations, and ahead of Australia and the USA. Poverty levels (such as the Global Hunger Index) declined from 23.4% in 1981 to 13.8% in 1997, to 12.4% in 2004 (Wiesmann, 2006), and have remained almost unchanged since. However, the development needs and the level of poverty is highest in the northeast and in hill tribe communities in northern border areas.

Thailand has been a strong supporter of regional and international bodies (ASEAN, WTO, APEC), and has sound agricultural R&D and education systems and a dynamic private sector that contribute effectively to national and regional development.

2. VEGETABLE PRODUCTION AND POTENTIAL

In Thailand, the demand for vegetables has been growing annually. Until recently, the government gave high priority to research and development of cereals and other staple food crops, vegetable crops remaining largely neglected. Though some attempts have been made to promote vegetables in home gardens and fences for self consumption, these are only short-term promotions.

2.1 PLANTED AREAS

Data on the production of main crops in Thailand (Table 1) show that areas allocated for root, tuber and pulse production are decreasing, while there is an increased production of vegetables with a corresponding increase in planted areas. Due to an increase in the domestic demand for the produce and competition for land resources, farmers are being obliged to improve yields through the use of more efficient technology, such as better agronomic techniques, improved seeds and other planting materials.

2.2 PRODUCTION AND PRODUCTIVITY

The long-term trend in the acreage of vegetables seems to fluctuate with a slight increase over 2008-2010 (Table 1). Although overall yields have shown a steady increase, the magnitude of increase in productivity is insufficient to create a significant impact on the food situation in the country.

Kale is among one of the top ten vegetables that is common produced and popular demand for the local market. Among 18 types of common vegetables consumption in Thailand, cabbage and yard long bean are the highest production over 800,000 tons during 2010-2012 (Table 2).

Table 1. Area, Yield and Production of fresh vegetables in Thailand, 2008-2010

	2008	2009	2010
Area Harvested (Ha)	126,785	126,225	128,185
Yield (Hg/Ha)	84,233	85,352	85,615
Production (tonnes)	1,067,950	1,077,360	1,097,450

Source: FAOSTAT (2012)

2.3 REGIONAL VARIABILITY

Vegetables sold in fresh markets contribute mainly to household food security. In view of the recommended per capita availability of vegetables, only the Northern and Western regions of the country are adequately supplied. The production of vegetables also varies considerably within regions (Table 3).

Table 2. Main crop area and production, 2010-2012

Crops	Harvested area (Rais)			Production (Tons)		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**
1. Chinese lettuce	74,993	74,860	75,180	114,214	112,660	115,180
2. Lettuce	22,733	22,350	22,720	31,326	29,170	30,310
3. Shallot	77,168	81,340	82,450	149,320	164,310	168,610
4. Tomato	37,580	38,440	39,600	124,390	126,122	131,870
5. Snow peas	2,840	3,730	3,770	5,220	6,910	7,490
6. Yard long bean	139,758	137,160	139,970	206,283	200,254	207,580
7. Long cucumber	38,385	39,380	39,990	86,059	88,920	91,700
8. Cucumber	108,169	106,025	107,370	150,247	129,987	134,110
9. Bitter Gourd	15,701	15,364	15,620	35,327	34,446	35,740
10. Cabbage	64,012	65,160	66,310	222,058	226,890	232,550
11. Chinese cabbage	32,742	31,110	31,550	78,221	77,330	78,780
12. Chinese mustard green	28,160	27,940	28,500	61,276	61,200	62,680
13. Kale	88,725	87,750	87,930	143,912	139,440	140,780
14. Swamp Cabbage	103,271	102,840	103,160	133,013	134,720	136,120
15. Swamp Cabbage white stem	80,096	78,480	79,250	87,785	87,270	88,760
16. Hot chili, Dry	151,131	152,640	154,050	46,850	47,620	50,990
17. Chili, Dry	297,640	302,100	309,240	112,030	125,070	130,190
18. Ginger	64,051	64,570	65,010	172,681	177,050	179,750

Source: Office of Agricultural Economics (2012)

Table 3. Regional production for vegetables in Thailand, 2010

Regional	Total area	Agricultural area	Vegetable and flower area
North	106,027,680	33,391,176	410,494
Northeast	105,533,963	64,992,799	193,274
Central	64,938,253	30,805,833	791,784
South	44,196,992	22,733,111	127,236
Total	**320,696,888**	**151,922,919**	**1,522,788**

Source: Office of Agricultural Economics (2012)

The Central plain is the most fertile rice growing area with a hot and humid climate. The seasonal floods irrigate the rice crops and bring sediment to enrich the soil and to create conditions for an abundance of food. When flooding is over, the plain becomes rich in fresh vegetables, shrimps and fish. Due to a changing pattern of agricultural land use to nonagricultural land, regional supply is very low with yearly per capita availability of 21.80 kg. The most common vegetables are kangkong, Chinese chive, Chinese broccoli, pak choi and mini cucumber. Availability can be further improved through:

- intensive vegetable cropping systems which can increase productivity;
- improving water control by dam projects and regulating water flow; and
- flooding control and irrigation.

The Eastern coastal climate is known for tropical fruit growing. The regional supply of vegetables for the fresh market is relatively low (66.64 kg/cap/yr.). The crops include cucumber, yardlong bean, Chinese broccoli and pak choi. Future development of the per capita availability should focus on:

- providing adequate water supply in vegetable growing areas; and
- improving the vegetable marketing channels.

The Northeast region has the biggest area and population, but a moderately low supply of vegetables. The Northeast plateau drains with a number of smaller rivers into the Maekhong River on the Laos border. The area has features of a typical rainfed agriculture with inadequate water during the hot and dry seasons. Vegetables are grown as crops after rice, with limited use of modern technology. Important vegetables

for fresh markets include chili, multiple onion, shallot and long cucumber. The average availability is 38.19 kg/cap/yr. The local availability can be improved by:

- improving water resources;
- promoting integrated farming systems, cultivating vegetables and other crops with livestock; and
- cultivation of under-utilized vegetables in the region.

The long narrow Southern region mainly consists of orchards and rubber plantations, and the area for vegetable production is limited. The climate is tropical and sometimes hit by typhoons and tropical depressions. There are small rivers, which drain from the western mountains into the Andaman Sea. In spite of the limited area for vegetable cultivation, vegetables such as watermelon and sweet corn are produced in large quantities. Cucumber, pumpkin, yardlong bean and pak choi are the most commonly available vegetables in the fresh markets. The per capita availability of fresh vegetables is the lowest (18.80 kg) in this region. In general, Southern food is spicy and is eaten with fresh vegetables. The per capita availability can be improved through:

- cultivation of under-utilized vegetables that are rain-tolerant and adapted to the Southern climate;
- intensive vegetable cropping systems in peri-urban areas;
- research on vegetable production under rain protection; and
- breeding for tolerance to water logging cultivars.

The Northern region has fertile soil of plain areas in the basin of the Ping, Wang, Yom and Nan Rivers which are tributaries to the Chao Phraya River (Figure 1). Water supply for agricultural land is adequate, and the weather is cooler as compared to the Northeast. The climate is suited for both lowland and highland vegetable farming, and the region reflects a high per capita availability of vegetables (123.36 kg/cap/yr). Vegetable consumption may be limited in areas where seasonal transportation is inconvenient (as in hill tribe villages), or when inadequate and uncertain incomes make it difficult for people to purchase vegetables from the market.

Figure 1 Map of Thailand

The Western region (Figure 1) consists of an alluvial basin of the Mae Klong and Tha Chin Rivers, which drain into the Gulf of Thailand. The landform in general, is an alluvial plain of moderate slopes from the western mountains to alluvial flat along the Mae

Klong River on one side and gradual sloped plain from the North to the South. There are many vegetable farms in Suphan buri, Kanchanaburi, Ratchburi, Nakhon Pathom and Samut Sakhon provinces that produce the oversupply of 192.15 kg/cap/yr. However, the urban growth is now threatening the agricultural environment (Nath *et al.,* 1999). Production sustainability can be achieved by:

- controlling the draining of polluted waters from factories; and
- providing revolving funds to farmers for making long term investments in land
- improvement for vegetable cultivation.

2.4 MARKETING

Although there is much concern about the efficacy of the current marketing system, the situation does not appear to be a serious problem. In most places, an army of middlemen operate and assist the movement of produce from regions with well organized transport to local and urban wholesale markets. The middlemen serve as suppliers of credit, in addition to their role as buyers. They ensure the smooth flow of produce to the larger markets.

Organized groups of growers formed with the assistance of the Department of Agricultural Extension (DOAE) also have their own markets from which most of the produce reaches the central market near Bangkok and the market in the South. From these points, vegetables are distributed all over the country. Exports to Singapore and Malaysia are done from the Southern wholesale market. For certain commodities that are subject to processing, the marketing channels are slightly different.

For the marketing of contract grown commodities such as asparagus, okra, extra-fine beans and baby corn, companies from importing countries carry out their own system of marketing.

Wholesale markets in the Central region are in Pathumthani (Simoom Muang, Talaad Thai), in the North in Chiang Mai and Phitsanuloke, the Northeast in Udonthani and Nakhonratchasima, the West in Nakhonpathom and Angthong and Nakhonsithamarat in the South.

The marketing of perishable commodities is one of the most challenging enterprises. The system of marketing could be improved further by the introduction of more modern postharvest technologies in handling operations. The problem is aggravated during periods of oversupply. The only alternative is to develop infrastructure facilities, such as irrigation in the main production areas as well as off-season production technologies in order to spread production throughout the year and develop the processing sector further, to siphon off surpluses when they occur.

2.5 EXPORT

Vegetable exports are mainly in dried and processed forms. Thailand's vegetable export was only 5.8 percent of the total vegetable production in 2010-2011 (Table 4). There is great potential and scope for export of processed vegetable products and selected fresh vegetables in the regional markets. In addition, there is a good opportunity for exporting good quality seed to markets globally.

Major imported country of vegetables are China, Hongkong, Japan, Indonesia and the US, which are 75.96% of the whole imported vegetables market. Besides the potential market for export are Vietnam (148.24%) and South Korea (79.81%) Table 5.

Table 4. Situation of vegetable production and export, 2010-2011

Crops	Year				Growth rate (percent).	
	2010		2011		2010	2011
	Yield (Tons)	Value (Million Baht)	Yield (Tons)	Value (Million Baht)		
Fresh Vegetables;, chilled, frozen and dried.	190,874	6,579.14	219,427	7,315.97	-1.84	11.20
(1) Fresh Vegetables; chilled	114,218	3,550.88	133,975	3,902.85	-3.25	9.91
(1.1) Asparagus	5,999	413.30	5,997	470.74	-31.16	13.90
(1.2) Onion, small onion and garlic.	49,988	491.33	70,893	888.93	37.96	80.92
(1.3) Chili	12,457	93.19	13,680	172.62	-18.07	85.24
(1.4) Baby corn	2,360	134.23	1,480	117.81	6.45	-12.23
(1.5) Okra (white)	1,102	136.15	2,125	325.73	399.76	139.24
(1.6) Mushrooms	2,864	147.71	2,611	137.35	-37.26	-7.02
(1.7) Others	39,447	2,134.96	37,189	1,789.66	-3.44	-16.17
(2) Frozen vegetables	65,042	2,591.44	70,668	2,846.31	1.75	9.84
(2.1) Legume	32,165	1,749.62	33,327	1,766.91	7.02	0.99

(2.2) Sweet corn	9,118	328.92	12,707	474.60	-5.16	44.29
(2.3) Okra	1,295	80.20	1,822	121.91	-14.79	52.00
(2.4) Mixed vegetables	15,506	72.82	15,975	81.27	-11.80	11.61
(2.5) Others	6,957	359.88	6,836	401.62	-7.37	11.60
(3) Dried vegetables	2,308	211.69	2,598	230.78	-3.31	9.02
(4) Others vegetables	9,306	225.13	12,186	336.02	-15.64	49.26

Source: Data adapted from Department of International Trade Promotion (a), 2012

Table 5 Imported vegetables market ranking top ten during year 2010-2011

Country	Value (Million USD)		Growth rate		Proportion	
	2010	2011	2010	2011	2010	2011
1. China	204.16	463.87	1.83	127.21	27.18	38.49
2. Hong Kong	97.06	160.75	-12.62	65.62	12.92	13.34
3. Japan	113.75	127.67	10.55	12.23	15.14	10.59
4. Indonesia	57.64	113.21	-.09	96.41	7.67	9.39
5. U.S.A.	47.55	49.99	14.62	5.13	6.33	4.15
6Vietnam	19.11	47.43	7.78	148.24	2.54	3.94
7. Taiwan	15.55	21.09	-24.73	35.67	2.07	1.75
8. Malaysia	18.48	20.28	24.26	9.70	2.46	1.68
9. United Arab Emirates	13.94	16.76	9.02	20.22	1.86	1.39
10. Singapore	11.94	16.61	8.95	39.15	1.59	1.38
Total of 10 countries	599.17	1,037.66	1.45	73.18	79.77	86.09
Others	151.94	167.62	16.20	10.31	20.23	13.91
Total	**751.12**	**1,205.27**	**4.12**	**60.46**	**100.00**	**100.00**

Source: Data adapted from Department of International Trade Promotion (b), 2012

3. The vegetable supply chain

3.1 Industry status

While individual farm size has been decreasing, a key trend in the production sector has been the development of cooperative and contract production and marketing arrangements. Under contract to processors, exporters, or supermarket suppliers, farmers usually gain increased market security but they must also improve quality management, production efficiency, and cost control. The traditional marketing chain is characterized by many steps and players, while the modern trend is toward simplification, fewer steps, improvements in transport, logistics, and cool-chain handling (Figure 2) and increasing use of returnable containers (DOAE, 2007a).

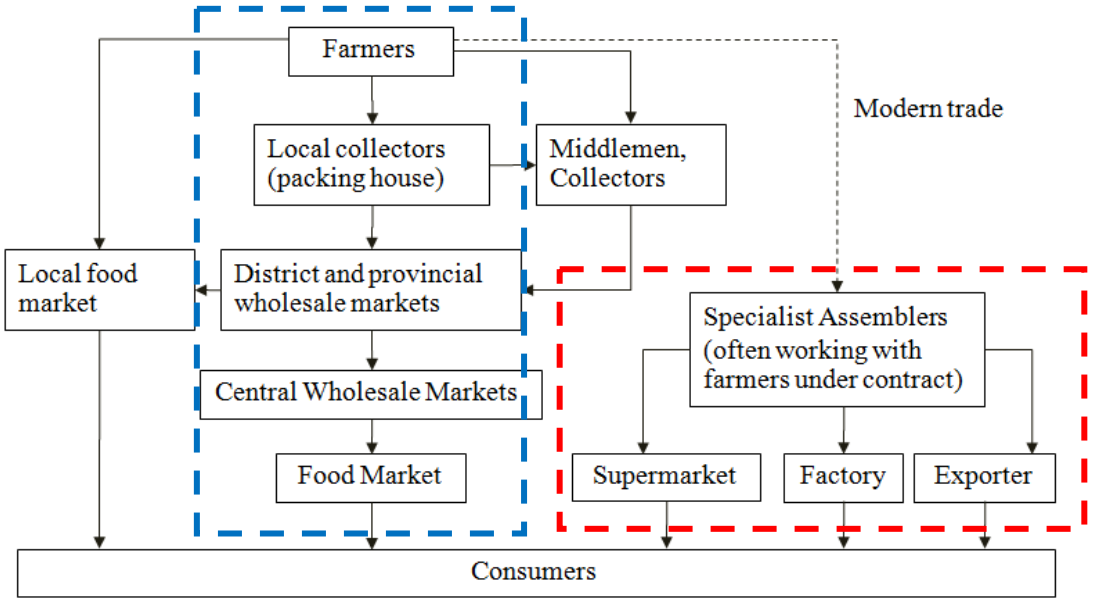

Figure 2. Vegetable distribution channels in Thailand. Middle: Traditional multi-step chain through local collectors and middlemen. Right: Contract farming with fewer steps to end-markets

3.2 Production sector

Nath *et al.* (1999) and Sootsukon *et al.* (2000) provide concise accounts of the vegetable industry in Thailand, focusing on more traditional types, with useful information about key production issues and the nutritional contents of major vegetables. Vanit-Anunchai (2006) has reviewed the opportunities and risks in producing and marketing safe vegetables in Thailand.

Between 2000 and 2006, ongoing R&D, investment by the private sector, and the stimulation of export crop development has further improved industry status.

The current industry is based on several production sectors, with differing needs, threats, and opportunities (Table 6). Major crops (by production area) are chili (22.4%), sweet corn (9.0%), baby corn (8.1%), yard-long bean (3.8%), Chinese broccoli (3.6%), watermelon (3.3%), cucumber (3.0%), water spinach (3.0%) and pumpkin (2.3%) (9 crops = 58.5% production) with considerable R&D support coming from the private sector (especially the seed industry). Newer export crops (baby corn, okra, asparagus, green soybean) contribute significant export income and are a focus of public sector R&D (% estimates from DOAE, 2007b). Figure 3 and Figure 4 show trends in area and production of vegetables from 2000-2005 based on FAOSTAT detailed data.

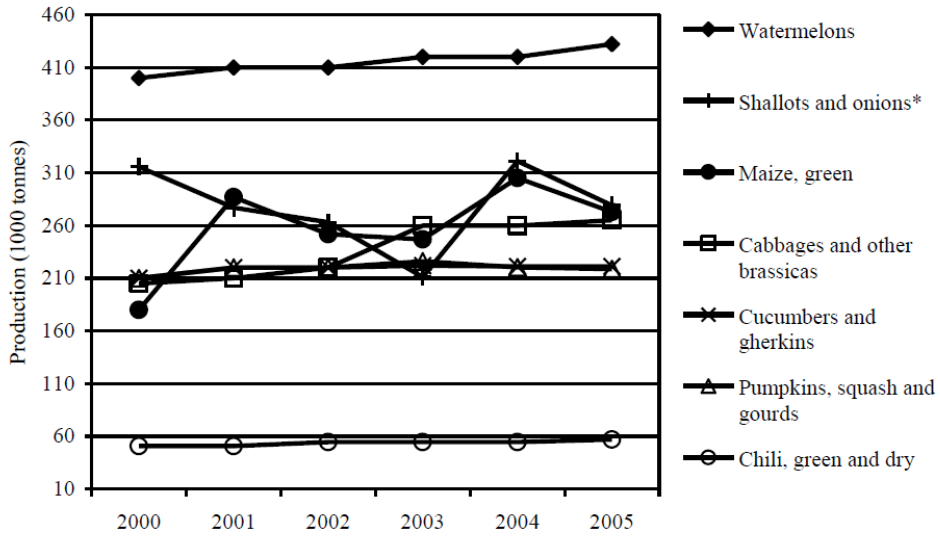

Figure 3. Trends in production under major vegetables in Thailand

Source: FAOSTAT (2007)

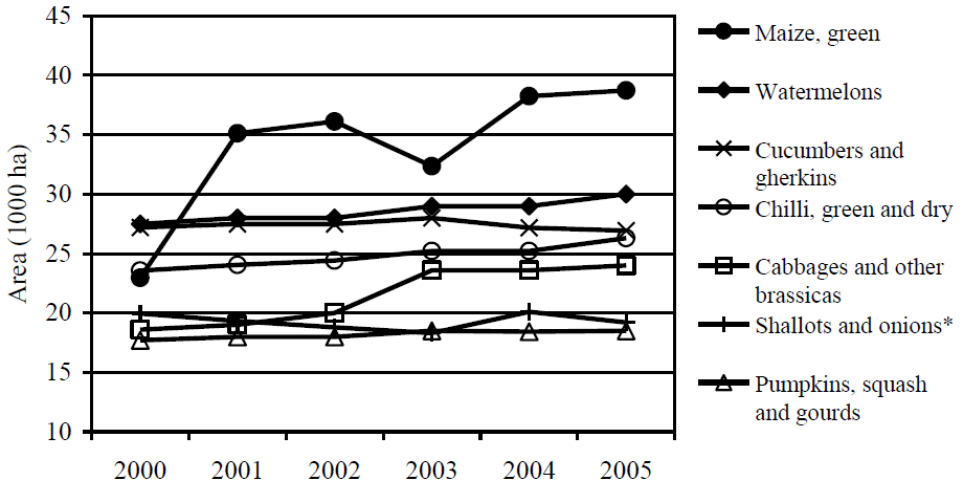

Figure 4. Trends in area under major vegetables in Thailand

Source: FAOSTAT (2007)

Table 6. Production sectors and key issues in the Thai vegetable industry

Sector	Trends and issues
Subsistence farming and home gardens	
	Production mainly for family use – producing hot chili, galangal, lemongrass, and leafy vegetables. Gradually declining as a proportion of national production, those dependent on excess "subsistence" production for income will face increasing difficulties and marginalization in marketing as quality and safety standards rise and resource access becomes more limiting, especially if integrated systems are not adopted. (Tipraqsa, 2006; Tipraqsa *et al.,* 2007).
Peri-urban intensive systems supplying the cities	
Open air cultivation	Production systems are highly intensive, with commercial agricultural inputs (F1 and hybrid seeds, fertilizers, pesticides). Production areas range from 0.16-2.4 ha, for producing fast-growing crops to meet market demands (Chinese broccoli, water spinach, chili, Pak Choi, lettuce, chives, Chinese radish, cauliflower, loofah, yard-long bean, cucumber), with some farms having specific areas for export crops such as asparagus, okra and chili. Supermarkets and exporters favor more progressive growers who can meet Thai

	GAP (for local) or EUREPGAP (EurepGAP, 2007) certification.
Protected cultivation	Fewer growers are involved and production costs are higher, but the area and investment levels are likely to increase. Plastic or nylon netting may be used to exclude insects. Evaporative cooling systems in plastic houses can be used for high-value crops such as sweet pepper, table tomatoes, and cantaloupe.
Hydroponic production systems	Hydroponics enable intensive production with high turnaround (e.g. salad leaves), efficient use of water and fertilizer, minimal use of land, early and regular harvesting, with fewer pests. Hydroponic systems are being used for salad crops, sweet capsicum, and cherry tomato. The high cost of systems is a constraint, but further expansion is inevitable as product demand grows.
Farms cropping vegetables after rice (especially in northeast Thailand)	
	Fewer inputs are used (open pollinated (O.P.) seed, less fertilizer). Some crops are grown for processing factories (tomato, bean, carrot). Some are regional specialties such as garlic, onion, and shallot. Import competition (especially garlic, chili) is affecting viability, and new alternatives are needed. This sector will continue to be involved in vegetable production, but crops will diversify.
Organic production	
	Chemical-free and organic certified production is increasing rapidly, with products selling at higher prices and demand growing in both the domestic and export sectors. Sources of reliable organic fertilizers and reliable pest/disease control strategies are needed (Ellis *et al.,* 2006; Kramol *et al.,* 2006; Vanit-Anunchai, 2006).
Large-scale commercial farming	
	Focused on exports and processing, with crops grown by farmer groups under contract (baby corn, sweet corn, okra, and asparagus). Costs need to be contained and logistics improved to enhance competitiveness. EUREPGAP certification is becoming essential. This sector is consolidating and enhancing certification compliance capabilities (GTZ-CMU, 2006).
Royal Project sites	
	Focused on crop diversification and opium substitution in remote communities in northern border areas. Supported by advice from 37 extension stations, 3000 families in five provinces of northern Thailand produce 140 kinds of vegetable crops. Production

	increased from 235 tonnes in 1997 to 7,655 tonnes in 2004 (Boonyakiat, 2003; Jayamangkala, 2004).
Vegetable seed production	
	Open-pollinated and hybrid cultivars for domestic and export markets are produced by farmers under contract or by seed companies themselves. Seed companies provide training and advice to growers.

Contract farming

Farmers who specialize in higher value crops or market segments have greater investment costs and more demanding quality management standards, but data cited by Poapongsakorn (2006) suggests growing vegetables under contract can be more profitable, with net revenue to farmers for instance growing baby corn under contract gave twice the return from alternative revenue options.

3.3 Inputs and supply chain logistics

Growth and improvements in the input and supply chain logistic sectors and better access to finance and utilities have been key factors enabling expansion and diversification of the vegetable industry. The key sectors are:

3.3.1 Seed

The seed sector has been a major contributor to industry development and is a major exporter. Several major seed companies and the Asia Pacific Seed Association (APSA) are headquartered in Thailand. Thai farmers have good access to a wide range of quality seed of superior cultivars, but the cost of some hybrid seed deters use. Some companies are developing and offer a range of inputs and services to farmers to improve their productivity. An overview of the Thai seed sector has been provided by Sagwansupyakor *et al.* (2003).

3.3.2 Agricultural chemicals

Monitoring and regulation of quality standards of registered products is reasonable, but weedicide use is increasing and traceback systems are needed (Salakpetch, 2007; Thailand Chemical Safety Website, 2007). Overuse by some farmers and overpromotion by some chemical companies contribute to excess residue problems. Vanit-Anunchai (2006) presents data on total use of insecticides, fungicides, and herbicides in Thailand and suggests their use in vegetables follows the same upward trend as overall use. Use of illegally

imported chemicals of uncertain quality can cause additional problems (ineffective control, toxic contaminants, hazards to workers, disposal). Worksafe education for migrant laborers that apply the chemicals is a key need. More resistant cultivars and natural pest and disease strategies are needed to reduce reliance on chemicals.

3.3.3 Fertilizers

Almost all chemical fertilizer is imported. Total imports increased from 3.7 million tonnes in 2000, to 4 million tonnes in 2005, but use for vegetable and flower production fell from 420,000 tonnes in 2000, to 363,000 tonnes in 2005, with further declines. Thailand Central Chemical Public Company Ltd produces more than 90% of locally formulated granular fertilizers (Osotsapar and Sakulyong, 2006). There are industry and consumer concerns about overuse of fertilizers. More options are needed for organic alternatives (e.g. formulated for specific purposes). Development of fertigation rates and industry expertise for microirrigation require attention.

3.3.4 Farm machinery

Adaptive technology development by the private sector and research agencies is enabling change. Fuel efficiency, user safety, and labor-saving innovations need attention.

3.3.5 Irrigation and watering systems

Thailand has an abundance of water, but growing demand, regional deficiencies and problems with contamination have placed pressure on the resource. Largescale deforestation also has increased watershed degradation (UNESCO, 2006a, 2006b). Only 5.76 million ha are irrigated (mostly for rice), with 46% in central, 26% in the northern, 17% in the northeast and 12% in the southern regions (DOAE, 2007a). With increasing pressures on supply, cost-effective strategies are needed to ensure sustainability. Improved technologies are available but costs (and also access in some areas) are a constraint. Strategic use of on-farm storage can lift productivity in dry areas (Tipraqsa *et al.,* 2007).

3.3.6 Labor

In 2002, 42% of workers were in the agricultural sector (13.8 million) vs 52.5% (15.5 million) in 1993 (Mephokee, 2003). Some farmers capitalize on the availability of migrant laborers willing to accept lower wages and conditions, but language difficulties and inadequate education hamper their effectiveness in modern production and handling. Labor-saving technologies are needed, along with capacity building for farm and supply chain workers, to assist the transition to greater technology use and adoption of GAP.

3.3.7 Quality certification

Thailand has a major focus on development of farmer compliance with ThaiGAP/QMark and EurepGAP, and the development of appropriate local and internationally recognized certification schemes (Salakpetch, 2007). Success in export development depends on efficient technologies and logistics, and the capability of exporters to supply the standard of quality required by customers. The experience in application of integrated pest management (IPM) is helping farmers to reduce pesticide residue risks and meet EurepGAP and traceability requirements (Poapongsakorn, 2006).

3.3.8 Postharvest technology

Technologies are available, but commodity-specific tailoring and cost savings are needed, along with capacity building for harvest, packhouse, storage, and transport personnel. Access to forced-air cooling and cold storage/refrigerated transport can be a constraint; their use will add to costs.

3.3.9 Logistics

Infrastructure is generally adequate, but transit times could be reduced and delays minimized. Freight handling is being strengthened through attention to logistics, facilities, and infrastructure/technology, with improvements in airports, the deep-sea port, multiple transport links, and moves to e-logistics and paperless customs (Crawford, 2005). Costs and bureaucratic requirements need to be reduced or streamlined. Strategies for consolidation of small consignments and use of environmentally acceptable packaging need to be explored. Cross-border trade with China could be improved (e.g. by allowing through transport on Thai trucks with Thai drivers, to reduce handling and time in transit), as the China market has good growth potential, particularly for the supply of tropical spices/medicinals and vegetables during winter (November to February).

3.3.10 Value adding for food processing and catering services

Thailand has at least 30 companies manufacturing or distributing frozen fruit and vegetables, and 64 manufacturers or distributors of canned, pickled, or pureed fruit and vegetables. The majority of companies are in outer Bangkok, and in the production areas of Rayong, Chantaburi, Chiang Mai, and Lampoon (BOI, 2007b).

In 2005, major frozen vegetable exports (bean, sweet corn, and okra) were to Japan, USA, and the European Union (EU). Major exports of canned vegetables (baby corn, sweet corn, mushroom, and tomato) were to the EU and USA. While most processors focus on the export sector, opportunities exist in building the domestic market for processed products.

4. Marketing fresh produce: wholesale and retail sectors

4.1 Wholesale

The fresh produce sector is based upon major wholesale markets supplying the retail and catering sectors, and distribution centers supplying supermarkets and processors. The wholesale sector includes 17 large markets (with three in Bangkok—including Talaad Thai Wholesale Market and the Pak Klong Talad market covering 80 ha and handling 15,000 tonnes of transactions/day,) (DOAE, 2007a). As a major fresh produce sector, improvement of wholesale market facilities and operations has been a priority for government. Efficiency has been improved by modernization of infrastructure and supply chain management, and attention to quality management, cleanliness, and access (Hau and von Oppen, 2004).

4.2 Retail

Significant growth has occurred in the supermarket sector, which has now overtaken the traditional trade (Poapongsakorn, 2006). This is driving change in supplier-and-farmer practices and relationships, with a two-tier approach to retailing to extend market penetration (supermarkets/hypermarkets and neighborhood convenience stores).

Retailers established in Thailand include 7-Eleven (franchise of CP Group15 -3,700 stores (2006)), Carrefour (72 stores), Royal Ahold (no longer in Thailand; all operations sold to partner the Central Group in 3/2004), Tesco Lotus (366 stores open: 57 hypermarkets; 17 value stores; 23 Talad Lotus stores; 269 Express stores), Makro (29 stores in 2006) (Pingali, 2004 - with updates on store numbers obtained during 2007 from Wikipedia listings and company sites).

Smallholders are integrated into supermarket supply chains via contract farmers and buyers who are preferred suppliers, and via farmer associations (Pingali, 2004). Although supermarkets tend to source from preferred suppliers, they are also providing training in quality and supply requirements for new suppliers. Inevitably, the emphasis on quality standards by supermarkets will lead to improvement of quality in the traditional markets due to spillover effects and higher customer expectations.

Due to concerns about growth of the supermarket sector and its impact on small retailers, a Retail Business Act is being fast-tracked in Thailand; if the legislation is passed, this may slow investment, at least in the short term (Planet Retail, 2007; Thailand Law Forum, 2007; The Nation, 2007).

The Challenges of the Thai vegetable Industry

The challenges for the Thai vegetable industry and some issue involves with food safety can be highlighted on Chinese broccoli and Chili.

Chinese broccoli

(*Brassica oleracea L. var.alboglabra* Bailey)

Chinese broccoli, also called Chinese broccoli or Kai-lan, is similar in use and appearance to broccoli. The primary difference is that Chinese broccoli is paler in appearance and its flavor is sweeter. It is a leafy vegetable, in the mustard family, that has glossy, blue green leaves with a crisp, thick stem that reaches 7-9 inches tall. It has a small number of tiny, vestigial flower heads similar to those of broccoli. Chinese broccoli is a summer season crop with some frost tolerance but may be grown all year round in temperate regions.

Chinese broccoli is widely eaten in Chinese cuisine, especially Cantonese cuisine. Unlike broccoli where only the flowering parts are eaten, with Chinese broccoli the leaves and stems are eaten also. Chinese broccoli is the green leafy vegetable, which is high in vitamin A and vitamin C. It also is a good source of calcium, iron and phosphorus and considered as one of the most nutritious of vegetables (Drost and Michael, 2010).

Varieties and how to grow

Varieties

There are many good Chinese broccoli varieties for sale in local gardening outlets and through seed catalogs. Most cultivars grown in Thailand are open-pollinated types. The hybrid cultivars are both expensive as well as doubtful in their superiority as the Chinese broccoli has a very short growing season. In general, the cultivars fall into three types:

Broad Leaf: It is the old type of Chinese broccoli. This type includes Fang No.1 (DOA) and Large leaf (Chia Tai) cultivars. They are widely adapted cultivars that can be grown under a wide range of conditions. The plant has a large stem and short internodes. The leaves are broad, round thick and crispy making it popular among consumers.

Pointed Leaf: This type is represented by the cultivar P.L.20 (DOA). The plant has a large stem, long internodes and smooth pointed leaves. It is heat and disease tolerant and is widely grown at present. Other well-known cultivars are Long Stalk (Chia tai) and Red Arrow (Eastwest). The crop takes 30–55 days from seeding to harvest.

Long Petiole: This type is grown for its stem and petiole. The cultivars include Maejo No.1 (DOA) and Super 094 (Chia Tai F1). The plant has a large stem and long internodes.

The leaves are narrow, pointed, with a thick-long petiole. It is well suited for inter-regional transport and distribution as it has better keeping quality (Yupayong, 2003).

How to grow

Soils: Chinese broccoli prefers fertile, well drained soil rich in organic matter (pH 6-7.50) for best growth. Most soils in Thailand are suitable for Chinese broccoli production. Before planting, incorporate up to 2-4 inches of well composted organic matter and apply 100 kg. of all purpose fertilizer (16-16-8 or 10-10-10) per Rai.

Planting and spacing: Seeded or transplanted Chinese broccoli should be spaced 12-18 inches between plants in the row with rows 2 feet apart. Chinese broccoli grows best when temperatures do not exceed 40 °C. Transplants should be planted 4-5 weeks before the last frost free date for the growing area. Seeded Chinese broccoli may be planted at the same time. For fall maturing Chinese broccoli, select early maturing cultivars and plant 50-75 days before the anticipated maturity date. The maturity date should be about 2-3 weeks after the first fall frost. Plants can be left in the garden throughout the winter to supply greens out of season. High summer temperatures reduce growth, decrease quality, and cause bitter or off flavors to develop.

Water: Water Chinese broccoli deeply and infrequently while trying to maintain even soil moisture. About 1-2 inches of water are required per week. Use drip irrigation if possible to conserve water. Applying mulch around the plant also helps conserve soil moisture and reduce weed growth. Moisture fluctuations will cause leaves to become tough and develop off flavors.

Fertilization: Apply 1/2 cup per 10 feet of row of a nitrogen-based fertilizer (21-0-0) 4 weeks after transplanting or thinning to encourage rapid plant growth. Place the fertilizer 6 inches to the side of the plant and irrigate it into the soil.

Mulches and Row Covers: Plastic mulches help conserve water, reduce weed growth and allow earlier planting and maturity, especially with transplants. Fabric covers are used to protect seedlings and transplants from frosts and insect pests. Apply organic mulches when temperatures increase. Mulches will help keep the soil cool and will reduce water stress. Organic mulches such as grass clippings, straw, and shredded newspaper also help control weeds.

Harvest and Storage: Chinese broccoli is harvested 40 to 50 days after seeding, when the plant is still immature. It is hand harvested and should be harvested frequently to prevent bolting and toughening, especially in the summer. About three cuts can be obtained from one stem. Chinese broccoli should be harvested in the early morning to minimize water stress. Chinese broccoli can be stored for 2-3 weeks at 0°C and 95% relative humidity. Most of the Chinese broccoli grown in Thailand is for the local farmers markets.

Productivity

The total area under Chinese broccoli for 89,000 rai in 2009 – 2011. There are fluctuations in production from year to year. Chinese broccoli occupies a total area of 89,000 rai with a production of 140,000 tons per year (Table 7), which production value of 2,000 million Baht per year (Fig. 5)

Table 7 Harvested area and Production of Chinese broccoli, 2009-2011.

Year	Harvested area (Rais)	Production (Tons)
2552	88,538	142,546
2553	88,725	143,912
2554	87,750	139,440

Source: Department of Agricultural Extension, 2012

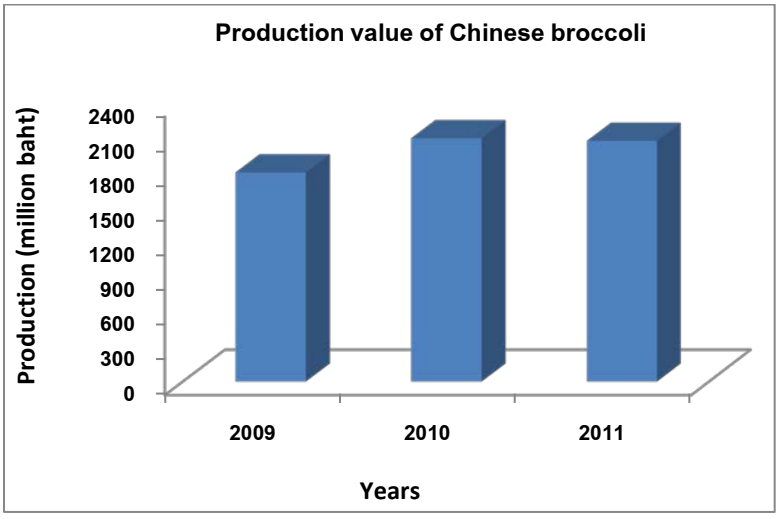

Figure 5. Production Value of Chinese broccoli, 2009-2011

Source: Department of Agricultural Extension, 2012

Chinese broccoli is mainly grown in Nonthaburi Suphan Buri and Nakhon Pathom, whereas upland Chinese broccoli is widely grown throughout the country and is most common in the Northeast are.Nakhon Ratchasima and Khon Kaen (Figure 6). Data of Area production and yield of Chinese broccoli by province from January 2554 - December 2554 showed in Table 8.

Table 8 Area, production and yield of Chinese broccoli by province, 2011

Province	Production area (Rais)	Harvested area (Rais)	Yield (kg.)
Nakhon Pathom	12,699	11,426	21,566,310
Khon Kaen	10,657	7,916	18,526,432
Phitsanulok	9,661	9,394	23,358,800
Kanchanaburi	6,812	5,680	11,410,440
Suphan Buri	6,591	5,732	12,354,260
Nakhon Ratchasima	5,717	5,189	7,915,685
Lamphun	4,094	3,581	2,934,405
Pathum Thani	3,204	2,760	4,855,834
Chiang Mai	3,008	2,290	2,326,530
Samut Sakhon	2,716	2,640	6,031,850
Nakhon Si Thammarat	2,649	2,123	4,381,110
Ratchaburi	2,328	2,144	3,872,560
Nonthaburi	2,179	2,011	2,414,360
Kamphaeng Phet	2,067	1,794	3,707,700
Loei	2,004	1,956	2,895,955

Source: Department of Agricultural Extension, 2012

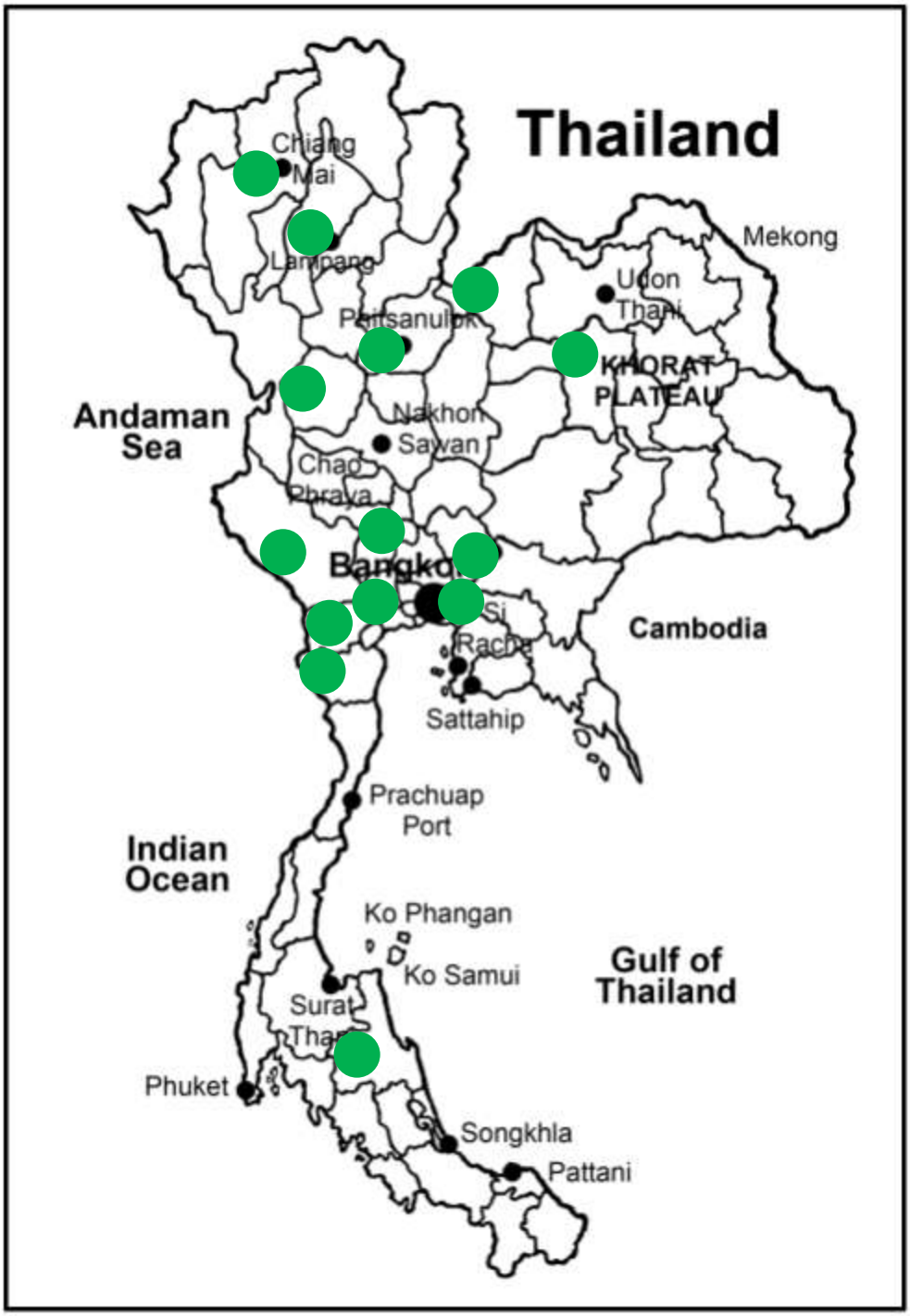

Figure 6. Area of Chinese broccoli Production ( ) in Thailand

Source: Adapted from Department of Agricultural Extension, 2012

Problem

Weeds: Plastic and organic mulches effectively control weeds. Be sure to control weeds when plants are small and be careful not to damage roots when cultivating.

Disease and Insects

The major pest problem in Chinese broccoli production is weeds. They compete with the crop during establishment for water, nutrients and light. Once established, weeds become less of a problem. The weed pests in Thailand include lambsquarter, redroot pigweed, kochia, barnyard grass and other common weeds of irrigated agriculture. Insects are another pest in Chinese broccoli and the key pests are aphids, diamondback moth, cabbage looper and imported cabbage worm. Chinese broccoli has few if any disease problems.

Table 9 Disease and Insects

Disease and Insects	Identification
Damping off.	*Pythium* sp *Phytophtora* sp *Fusarium* sp *Rhizoctania* sp
Downy mildew	*Peronospora parasitica*
Leaf spot	*Alternaria brassicae A. brassicicola*
Leaf blight or black rot	*Xanthomonas campestris*
Cabbage looper.	*Trichoplusia ni* Hubner
Cabbage webworm.	*Hellula undalis* Fabricius
Leaf minor flies	*liriomyza brassicae* Riley
Leaf eating beetle	*Phyllotreta sinuata Steph andP. chontalisa* Duvivier
Dimondback moth	*Plutella xylostella* Linnaeus
Bee armyworn	*Spodoptera Exigua* Hubner
Common cut worm	*Spodoptera litura*

Pesticides contamination

Pesticide residues in Chinese broccoli are a major concern to consumers due to their negative health effects. The monitoring of vegetables from various sources in Thailand to determine pesticide residues showed that 20 types of Organophosphate pesticide were contaminated in Chinese broccoli, which were dimethoate, malathion, monocrotophos and methyl parathion (Somsamai *et al.,* 2004). Data from Agricultural Production Sciences Research and Development Office (1997-2006) also reported that Chinese broccoli were contaminated with residues of cypermethrin, chlorpyrifos, profenofos, triazophos and dimethoate, which sample having residues exceed MRL. Then, Lamai *et al.* (2009) reported that 66.7% of Chinese broccoli were contaminated with pesticides residues, i.e. cypermethrin, chlorpyrifos and profenofos. Recently, Watcharaporn *et al.* (2012) reported that Chinese broccoli from Northeast (sample were collected during 2008- 2011) were contaminated with pesticides, especially cypermethrin and chlorpyrifos. Therefore, Thai vegetable products next decade should focus on the quality of products, consumer's health to increase the quantitative and safety of fresh, frozen, processed, minimally processed and ready to consume. The pesticide residue free certificate for vegetables and herbs should also be taken into consideration.

Chili Peppers

Capsicum spp.

Chili (*Capsicum* spp.) is an important vegetable in the Family Solanaceae. Term of *Capsicum,* pepper, chili, chile and chilli can be used interchangeably to describe the plants the pods the cooking of the genus *Capsicum***.** Chili is loaded with vitamin A, vitamin C and the capsaicin levels which beneficial to health. Flesh of chili can be eaten fresh or processed in the food industry such as dried, paste, sauce, pickle, canned or using as an ingredient in many kind of foods. Moreover, chili can be used in the pharmaceutical/medicinal aspect due to effect of capsaicin. Chili has been widely produced in Thailand for local consumption and exported to many countries such as Malaysia, Japan, USA, Europe, etc (DITP, 2012).

Recommended Varieties

There are many varieties of chili (peppers) in local market of Thailand. However, Thai Agricultural Commodity and Food Standard (TACFS 1502-2004) categorized into two groups including *Capsicum annuum* and *Capsicum furtescens*

Capsicum annuum is the most extensively cultivated throughout the world and because it cross pollinates so easily there are probably thousands of varieties existing. Annuums

are really divided into two categories: sweet (or mild) and hot. Too many leaf variations to describe but flower corollas are white with no spots. Popular *annuums* in Thailand including bell pepper (Thai: พริกหวาน), sweet pepper (Thai: พริกหยวก) and Cayenne pepper (Thai: พริกชี้ฟ้า)

Capsicum frutescens is original in the Amazon basin in Brazil and Mexican. Now it spreads to India and the Far East where they are called bird pepper such as bird's eye chili or phrik khi nu (Thai: พริกขี้หนู**)**

How to Grow

Chili requires sunny, semi-tropic or tropical conditions and annual rainfall.

Soils: It prefers well-drained loose soil rich in organic matter for best growth. The optimum pH of soil is 6.0-8.0.

Soil Preparation: The soil should be plowed 30-40 cm deep twice and left under the sun for 2-3 weeks interval.

Plants: Chili can be grown from seed to transplants. Seed should be planted 0.5 cm deep and spaced 10 cm between plants in the size of bed 1x5-10 m, and then transplanted to adjacent areas. Transplants should have 5-7 mature leaves and a well developed root system before planting. Seeded or transplanted chili should be spaced 50 cm between plants in the row with rows 100 cm apart. However, the best space for Cayenne chili is 50 and 50 cm.

There are 2 types of growing conditions during the dry season and the rainy season. For the dry season, chili is grown by seeded in mid of August- October, transplanted in September-December and then harvested in November-August. For the rainy season, cultivation is started by seeding in April-June and harvested until December. However, cycle of planting may be adjusted upon when the rainy season starts.

Water: Chili needs a lot of water but not wet. In the early stage of planting, chili should be watered daily while trying to maintain even soil moisture. Applying mulch around the plant also helps conserve soil moisture and reduce weed growth.

Fertilization: After planted 45 days apply fertilizer (15-15-15) 25 kg/Rai (1,600 cm^2), to encourage rapid plant growth. Place the fertilizer 30 cm to the side of the plant and irrigate it into the soil. Re-apply fertilizer (15-15-15) 25 kg/Rai after planted 60-90 days. Applying compost 300-500 kg/Rai with either fresh *Tricoderma* 3-5 kg or chicken manure 1-2 tons/Rai also helps harvesting period extension.

Mulches and Row Covers: Hay or plastic mulches help conserve water, reduce weed growth and allow earlier planting and maturity.

Problems

Weeds: Plastic and organic mulches effectively control weeds. Be sure to control weeds when plants are small and be careful not to damage roots when cultivating.

Insects and Disease:

Microorganim, Insect and Disease	Control
Meloidogyne incognita (Thai: โรครากปมจากไส้เดือนฝอย) *Sclerotium rolfsii* (Thai: โรครากเน่าโคนเน่า)	– Soil preparation, plant *Crotalaria juncea* 5 kg/Rai in the chili planting area until the plant ages 45-50 days, plough up and over, leave for 2 weeks before transplant.
Fusarium oxysporum (Thai: โรคเหี่ยวเชื้อรา)	– Adjust soil to pH 6-6.8 – Soaking transplants in fresh *Trichoderma hazianum* solution (250g/ water 10 L) 30 min. – Not apply fertilizer urea 46-0-0 and 35-0-0 due to acidic soil .
Phytophthora parasitic Dastur (Thai: โรคต้นเน่า)	– Soaking transplants in fresh *T.hazianum* solution. – Elevate seeding tray up high from the ground. – In rainy season, seeding under plastic roof could reduce disease by 100%.
Collectotrichum sp. (Anthracnos)	– Soaking chili seed in hot water (55°C) 15-20 min. – Terminate all infected fruit before applying chemical pesticide – Controls with appropriate pesticides and *Bacillus subtilis*
Bactrocera latifrons Hendel (Solanum fruit fly)	– Controls insects with appropriate insecticides and biological control such as *Bacillus thuringiensis* (BT) – Trap with methyl eugenol.

Harvest and Storage:

Chili can be harvested when the plant ages 100-120 days and the fruits are mature or reach full size, investigated by firmness and color of the fruit. Chili with the stem should

be harvested by hand in the morning. After harvested, chili should be collected in plastic basket and put under shade before transport to collecting house.

At the collecting house, damage chili should be sorted out and the good flesh should be washed with clean water, drained until the flesh dried, graded upon size and color. To prevent spoilage from mold, chili should be immerged in hot water (53-55°C) 4 min. To control color development from green to red, green chili should be storage under condition of 20-25°C, RH > 95%. Pre-cooling should be done before storage at low temperature, the condition of storage room is 10°C, RH 85-90%. At this condition, chili can be kept for 2-3 weeks. Chilling injury is found if kept under 7°C.

Productivity

Demand of chili consumption in Thailand is almost stable during 2008-2011 (Table 10). Productivity of *C. annuum* trends to increase, but *C. frutescens* (Bird's eye chili) slightly decrease in 2011. Production of chili is widespread all over the provinces of Thailand. Bird's eye chili is the popular type. In 2011, main production areas of Bird's eye chili are Kanchanaburi, Nakhon Si Thammarat and Nakhon Ratchasima; however, the most production yields are from Ubon Ratchathani, Si Sa Ket and Nakhon Ratchasima (Table 11). For *C. annuum* including bell pepper, sweet pepper and Cayenne pepper, these varieties prefer cool weather, main production areas which provide the highest yields are Sukhothai Chiang Mai and Phrae.

Table 10. Productivity and price of chili in Thailand

Productivity/Price	**Year 08/09**	**Year 09/10**	**Year 10/11**
Demand: thousand MT			
Fresh consumption	297.48	307.50	298.90
Processed chili	52.50	54.27	52.75
Production of *C. frutescens* (Bird's eye chili): thousand MT	349.976	361.769	351.646
Price: Jinda type (Fresh) Baht/kg	31.23	29.57	38.62
Production of *C. annuum*: thousand MT	144.052	152.949	161.015
Price: Baht/kg	20.17	19.74	23.62

Source: Department of Internal Trade (2012)

Table 11. Planting area, production and yield of *C. frutescens* (Bird's eye chili) by province in 2011

Province	Planting Area (Rai)	Production Area (Rai)	Yeild
Amnat Charoen	491	424	229,710.00
Ang Thong	502	1239	781,010.00
Bangkok	94	103	56,300.0
Bueng Kan	11	41	23,800.00
Buri Ram	3,967.25	12,473.00	3,394,635.00
Chachoengsao	2,276.50	6,125.50	2,707,785.00
Chaiyaphum	39,561.75	28,307.75	18,186,138.00
Chanthaburi	4,030.75	5,725.00	2,014,910.25
Chiang Mai	32,580.50	24,069.00	20,265,150.00
Chiang Rai	2,131.00	2,137.50	2,187,155.00
Chon Buri	1,564.00	9,805.75	1,380,705.00
Chumphon	2,361.50	5,602.25	1,076,589.00
Kalasin	2,163.00	989.00	284,561.00
Kamphaeng Phet	240	154	88,000.00
Kanchanaburi	19,285.50	65,145.50	27,100,820.00
Khon Kaen	9,684.25	8,959.50	14,169,557.00
Krabi	584	1,743.00	709,949.00
Lampang	1309.5	1114.25	970,921.00
Lamphun	2,659.00	4,863.00	2,805,999.00
Loei	8,243.75	7,237.75	8,113,760.00
Lop Buri	5,925.75	4,361.00	2,226,037.00
Mae Hong Son	8,713.50	7,728.00	2,740,485.50
Maha Sarakham	597.25	566.25	546,425.60
Mukdahan	334	172	98,617.00
Nakhon Nayok	14	29	5,700.00
Nakhon Pathom	2,304.25	11,791.25	9,295,520.00
Nakhon Phanom	3,706.50	4,649.50	4,088,531.00
Nakhon Ratchasima	33,159.75	31,289.75	38,414,011.25
Nakhon Sawan	5,383.75	6,864.00	4,768,840.00
Nakhon Si Thammarat	30,408.75	49,760.25	10,339,631.00
Nan	3,664.75	2,367.75	2,872,400.00
Narathiwat	847	1,386.50	775,391.50
Nong Bua Lum Phu	113	141	67,251.00
Nong Khai	5,775.50	4,361.00	3,259,750.00
Nonthaburi	36	124	48,710.00
Pathum Thani	214	432	207,950.00
Pattani	506.5	606	440,366.50
Phang-Nga	2,404.75	5,458.50	1,905,650.00
Phatthalung	3,144.50	4,942.25	1,171,971.80
Phayao	1,445.50	1,138.75	935,295.00

Phetchabun	9,208.50	8,047.50	9,025,549.00
Phetchaburi	4,688.75	4,630.25	4,547,701.00
Phichit	860	2,359.00	1,190,285.00
Phitsanulok	1,176.00	1,345.00	1,376,400.00
Phra Nakhon Si Ayutthaya	272.75	76.75	61,737.50
Phrae	64.25	16.25	16,250.00
Prachin Buri	36	45	13,055.00
Prachuap Khiri Khan	725	2,369.00	1,099,360.00
Ranong	340.5	1083	275,727.00
Ratchaburi	4,560.00	7,079.00	10,577,118.00
Rayong	651.5	2,292.00	640,790.00
Roi Et	1,508.25	960.75	1,172,817.00
Sa Kaeo	1123	1,991.00	800,590.00
Sakhon Nakhon	5,864.00	5,559.25	5,458,903.00
Samut Songkhram	431	596	412,650.00
Saraburi	905	1,183.00	1,735,717.00
Satun	1,234.50	1,449.50	763,935.00
Si Sa Ket	43,155.25	26,589.00	46,910,292.00
Sing Buri	36	62	7,857.00
Songkhla	6,350.00	3,612.75	2,084,775.00
Suphan Buri	1,960.00	2,624.00	3,567,390.00
Surat Thani	5,963.50	6,132.00	2,023,474.50
Surin	1,392.95	2,491.95	5,866,960.50
Tak	43,352.25	29,856.25	20,129,976.00
Trang	2,168.50	2,312.25	668,645.00
Trat	5,060.50	8,774.00	3,255,687.00
Ubon Ratchathani	20,452.95	24,830.70	57,123,975.00
Udon Thani	804	877	551,842.00
Uthai Thani	608	1,139.25	384,080.00
Uttaradit	666.5	564	468,400.00
Yala	580	789.5	605,436.00
Yasothon	871	847	701,454.00
Total	**409,509.65**	**477,011.40**	**374,274,816.90**

Source: Modified from Department of Agricultural Extension (2012)

Table 12. Planting area, production and yield of *C. annuum* by province in 2011

Province	Planting Area (Rai)	Production Area (Rai)	Yield
Amnat Charoen	135.5	117.5	6,040.00
Bangkok	40	30	12,000.00
Bueng Kan	1	1	400
Buri Ram	62	32	19,840.00
Chaiyaphum	133	58	20,828.00
Chanthaburi	23	100	81,005.00
Chanthaburi	38	205	88,505.00
Chiang Mai	7,086.50	5,914.50	10,772,965.00
Chiang Rai	1,172.50	1,152.70	2,774,646.00
Kamphaeng Phet	107	194	270,000.00
Kanchanaburi	360	800	919,545.26
Khon Kaen	1913	1425	3,081,500.00
Lampang	1005.25	1,141.25	15,470.00
Lamphun	762	690	1,056,016.00
Loei	1,063.00	1,048.00	921,400.00
Lop Buri	10	3	140
Mae Hong Son	89	37	14,550.00
Maha Sarakham	12	8	6,200.00
Nakhon Pathom	182	573	359,417.00
Nakhon Ratchasima	214.5	1,139.50	2,116,900.00
Nakhon Sawan	1,824.00	0	0
Nakorn Phanom	30	50	57,750.00
Nan	3,461.00	2,460.00	5,841,087.00
Narathiwat	199.25	229.75	150,630.00
Nong Bua Lum Phu	12	0	0
Nong Khai	1052	677	890,665.00
Pattani	382	237	285,470.00
Phatthalung	1	2	170
Phayao	370.75	207.75	596,400.00
Phetchaburi	253.25	264.5	260,683.00
Phetchaburi	1,446.00	1,094.00	1,748,100.00
Phichit	527	1,710.00	1,201,309.00
Phitsanulok	131.5	98	175,500.00
Phra Nakhon Si Ayutthaya	174.25	81.5	8,880.13
Phrae	9,662.20	5,362.20	8,616,256.63
Prachuap Khiri Khan	145	415	374,000
Ratchaburi	1208	3,065.00	3,242,620.00
Rayong	7	66	9,860.00
Sa Kaeo	2	3	1,200.00

Sakhon Nakhon	249.85	245.85	297,700.00
Saraburi	102	152	299,126.00
Songkhla	48	44	52,400.00
Sukhothai	6,286.00	4,225.50	12,947,879.00
Suphan Buri	216	197	335,650.00
Tak	465.5	678.5	648,000.00
Ubon Ratchathani	276	238	117,100.00
Udon Thani	0	3	400
Uthai Thani	5	1	667
Uttaradit	100	0	0
Yala	19	6	4,200.00
Total	**43,064.8**	**36,483.00**	**60,701,070.02**

Source: Modified from Department of Agricultural Extension (2012)

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1. Effect of flooding on Thailand's fruits and vegetables supply chain

Flooding: General overview

In 2011, Thailand as the country endured enormous damage in the wake of the worst flooding in at least five decades. Some of the likely reasons for the floods included excessive rainfall, urbanization, high tides, insufficient drainage and flood protection systems, subsidence, the possible role of sudden release of waters from upstream dams and the general slope of land. The most extensive flooding occurred between late July and early December across nearly every section of the country. In total, 65 of Thailand's 77 provinces were impacted during this timeframe and damage was widespread and severe in many locations. The maximum flood extent across central and northern Thailand on November 15, 2011 is shown in Fig 1.

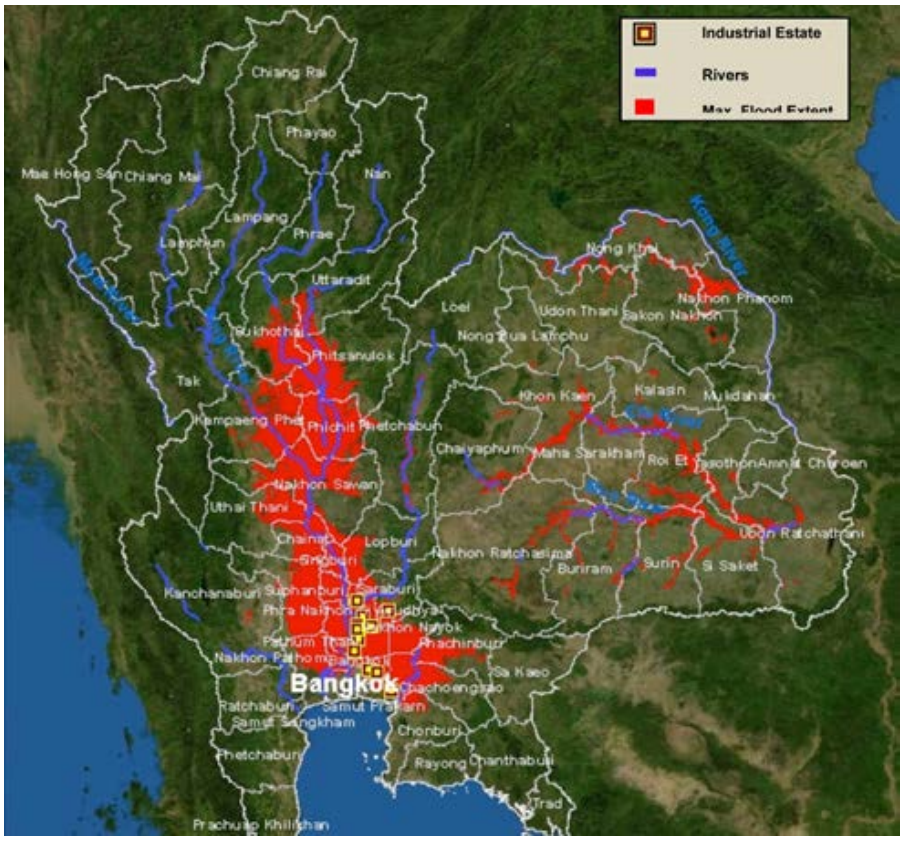

Figure 1. : Maximum Flood Extent as of November 15, 2011

(Source: Thailand's GISTDA, Impact Forecasting)

More than 884 people were killed and millions of residents were either left homeless or displaced due to significant flooding (Fig 2.). Many of the primary sectors that form the backbone of the Thai economy (such as agriculture, manufacturing, tourism and personal property) were severely suffered during the flooding of 2011. Economic losses were estimated by the World Bank at THB1.4 trillion (USD45.7 billion).

Fig. 2 : General Flooding of Thailand in 2011

(Source: U.S. Marines)

Flooding: Damage Impacts

Damage impacts of the flooding between late July and early December were widespread across the vast majority of Thailand. In total, as many as 10 million people were affected

in some way by the floods across 65 of the country's 77 provinces. These damage impacts include:

1. Personal property effects

Approximately 1.5 million homes and other structures were impacted throughout the duration of the floods. According to the Thai Real Estate Information Center (REIC), as many as 300,000 homes were damaged in the greater Bangkok metropolitan region alone. When counting additional damage to all residential facilities in the region, the REIC noted that 700,000 total residential units were impacted. The World Bank reported that total economic losses to households were estimated at THB84.0 billion (USD2.7 billion).

2. Commercial Effects

Electrical appliances and equipment, medical equipment, automobiles and food and beverage manufacturers were severely affected by the flood. The Department of Industrial Works reported that more than 7,510 industrial and manufacturing plants were damaged by floods in 40 separate provinces. Ayutthaya Province was one of the most heavily impacted areas, where at least 900 out of 2,150 factories were heavily damaged (Fig. 3 and 4). Some of the notable companies who were forced to halt production in the industrial estates included: Toyota, Honda, Mazda, Nissan, Mitsubishi, Sony, Nikon, Sanyo Semiconductor, Canon, Western Digital, Hitachi, Hutchinson, Microsemi, ON Semiconductor and Matsushita. The World Bank noted that the overall economic cost to manufacturing nationwide (including business interruption) was THB 1.0 trillion (USD32.5 billion).

Fig. 3 Flood Inundation at the Rojana Industrial Park, Ayutthaya Province

(Source: U.S. Marines)

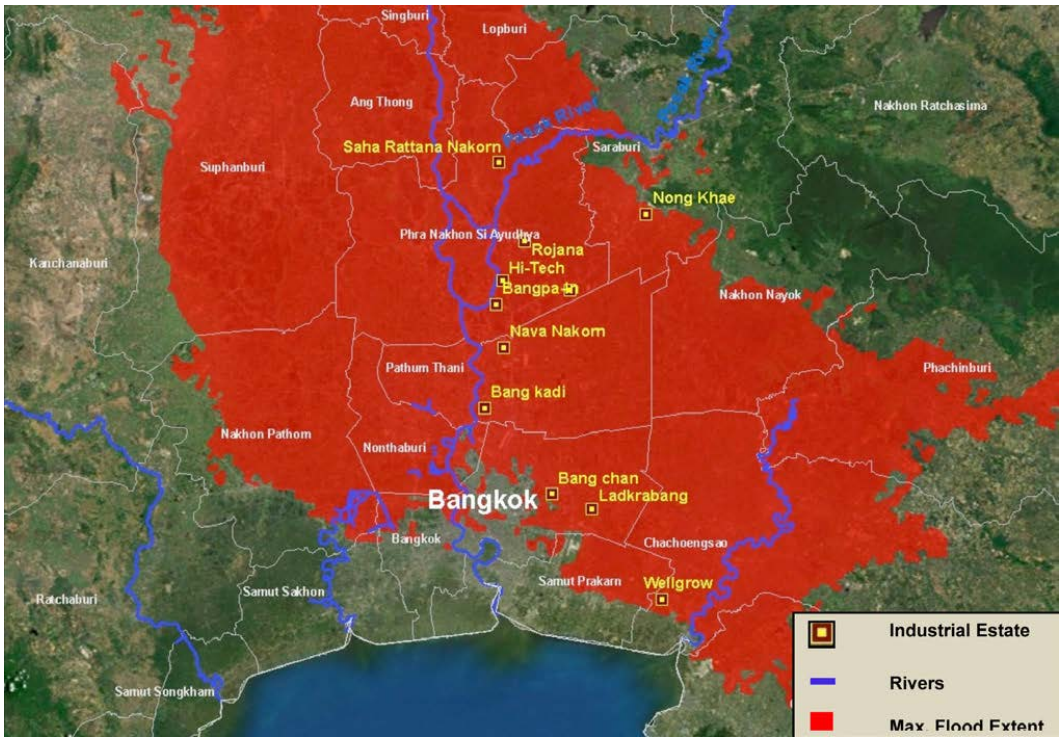

Fig. 4: Selected Industrial Estates Embedded within the Maximum Flood Extent on November 15, 2011 (Source: GISTDA)

3. Infrastructure Effects

The agricultural and transportation infrastructures were both heavily impacted during the floods.

3.1. Transportation Infrastructure

The transportation infrastructure sustained major damage during the floods, with a high number of roads and bridges having been submerged or washed away. The Department of Highways and the Department of Rural Roads reported that parts of 1,700 roads, highways and bridges were damaged or destroyed (Fig. 5). The economic cost to roadways alone was listed at THB139.0 billion (USD4.5 billion). Don Mueang Airport, Bangkok's secondary airport was forced to close in October 2011 after floodwater crept into the main terminal building and also over the facility's runways. The president of Airports of Thailand reported that approximately THB150.0 million (USD4.8 million) was necessary to repair the runway. Train services were also disrupted as rail tracks were left submerged or washed away on multiple routes.

Fig. 5: Flooded Highway (Source: U.S. Marines)

3.2. Agricultural Infrastructure

More than 1.9 million hectares (4.7 million acres) of land, including 1.4 million hectares (3.3 million acres) of rice fields, were damaged. This represented 12.5% of all available cropland nationwide. The country's rice crop was particularly affected, where some estimates suggested that up to 25.0% of the crop sustaining damage. Thai government estimates stated that total economic losses to the farm sector from the floods was THB73.0 billion (USD2.4 billion).

Flooding: Economic Impacts

According to the World Bank, total economic losses from the July-December floods were estimated to be THB1.4 trillion (USD45.7 billion). In the World Bank report, majority of losses (90%) belonged to the private sector. Table 1. shows damages and losses of different sectors estimated by the World Bank:

Table 1. Summary of damage and losses by sector in Thai baht, millions

	Disaster Effects		Ownership
	Damage	Losses	Public
Infrastructure			
Water Resources Management	8,715	–	8,715
	8,715		–
Transport			
Telecommunication	23,538	6,938	30,326
Production			
Agriculture, ▌ivestock and Fishery	5,666	34,715	–
	40,381		40,381
Manufacturing	513,881	493,258	–
Social			
Health	1,684	2,133	1,627
Education	**3,817**		2,190
Cross Cutting			
TOTAL	**630,354**	**795,191**	**141,477**

Source: DALA estimates, NESDB, and Ministry of Industry

Note: Losses for each sector include higher expenditures due to floods

Supply chain of fruits and vegetable in Thailand

The stakeholders in the fruits and vegetables supply chain are composed of suppliers of farmers, farmers, group of farmers or cooperatives, collectors, manufacturers, central markets, exporters, wholesalers, retailers, and consumers. In addition, the government sector also has an important role to the fruits and vegetables supply chain such as to control the standard of farms and practice under Good Agriculture Practice (GAP) by Ministry of Agriculture and Cooperatives and to monitor and control the price by the Ministry of Commerce.

Farmers acquire the necessary supplies from suppliers, and some medium- and large sized farmers hire laborers from local or other areas to grow fruits and vegetables.

Currently, most farmers use chemical fertilizers and pesticides. However, the number of farmers using organic fertilizers is increasing due to several factors, such as the high price of chemical fertilizers and customer requirements. In some villages, small farmers jointly conduct agricultural and marketing activities on the basis of self and mutual assistance among the members. These groups can be farmers groups, cooperatives, or community enterprises. The government supports group activities and cooperation among farmers, but there is a lack of local leadership in some small villages. Local collectors are the merchant located near farms and they gather the fruits and vegetables from one or more farmers and distribute them to their customers. Collectors either pick fruits and vegetables directly from farmers or farmers deliver their produce to the collecting points. Their activities include grading, packing, and delivering to customers. Some local collectors are also farmers. Then, wholesalers buy large quantities of fresh produce from farmers, group of farmers or local collectors and distribute to retailers. The wholesalers are located in the central markets or their own locations. Retailers are the merchants in local markets, supermarkets or hypermarkets who sell produce directly to consumers. Some manufacturers or importers process fresh produce by grading, packing or processing into products such as frozen fruits and vegetables, juices, snacks etc. and some manufacturers are also exporters.

The upstream activities are harvesting, grading, handling, and transporting to customers. If the upstream stakeholders handle fruits and vegetables properly but the downstream ones do not, then the quality will deteriorate quickly before delivery to consumers. Another problem is that the price of fruits and vegetables fluctuates due to several factors such as supply, demand, selling season, quality, etc. The price of premium-grade fruits and vegetables can be up to ten times of the lower grade such as mangosteen.

Flooding: Impact on Agriculture Sector and Supply Chain of Fruits and Vegetable in Thailand

Agriculture sector (especially the central and northeastern of Thailand) and supply chain of fruits and vegetable in Thailand were greatly affected by flooding incident in late 2011. The total economic losses to the farm sector from the floods were estimated to be THB73.0 billion (USD2.4 billion). Flooding damaged about 14% of rice farms or about 9.98 million. Approximately, 0.74 million Rais of gardens (fruits and vegetables) were destroyed by the flood. Agriculture infrastructures (plantation areas) were heavily damaged (discussed in previous section). People were unemployed because farms were destroyed. Since raw materials were damaged, then it did not only affect the upstream supply chain, but also the downstream supply chain such as collectors, central markets, restaurants, distribution centers, retailers, food manufacturers and fresh produce exporters. Some factories and packing houses were closed due to flood and some were short of raw materials for production. The farms of fruits and vegetables such as durian, guava, pomelo, chili, kale, morning glory, cabbage, cucumber, eggplant in North and

Central regions were destroyed. In addition, many roads were closed and the distribution centers of modern trades and central markets were flooded or surrounded by water. Then, it was difficult to distribute raw materials and products to the whole country. The transportation time was increased doubly. This caused fruits and vegetables perishable before delivery to customers. Most people were affected by flood, then the consumptions of fruits and vegetables were reduced and this affected the sellers in central markets and local markets. On the other hand, fruits and vegetables prices were increased due to higher cost and less supply so it affected both domestic consumers and export markets. Due to flooding, the prices of vegetables have gone up in some cases by as much as 200%. The shortage of vegetable products and a significant price increase did not only occur domestically. During the flood, the price of Chili paste in Malaysia was also dramatically increased because the shortage of raw material (chili) from Thailand.

Benefit of six-months extending period for the project

After massive flood in Thailand during late 2011, Thai government established different supportive programs to help people affected by the flood. Kasetsart University (Bangkhen campus) has been resumed normal activities since January, 2012. Most project staffs have returned to their residence and repaired infrastructure damage of their residency since January, 2012. Thai farmers and others who affected by the flood have received compensation from the government and joined debt suspensions and extending loans programs. Thai government initiate repairing damaged infrastructure programs in different provinces.

The six-months extending period for the project allowed working team to fully resume to their normal function after taking care of their personal damage of the flood. The six-months extending period also allowed the working team to develop strategies to access to farmer and processor, who may suffered from the heavily flood. With the six-months extending period the working team has successfully organized train-the-trainer both for producers and manufacturers. In addition, during this extending period, the working team was able to to establish new connection with government authorities and be able to visit the plantation area in September, 2012.

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