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THE VEGETABLE SECTOR IN THAILAND A REVIEW

This document is the outcome of a study on the vegetable sector in Thailand prepared by Dr Prem Nath. Mr Minas Papademetriou, Dr Kasem Piluek and Dr Edward M Herath

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ABBREVIATIONS

AsDB	Asian Development Bank
AFTA	Asian Free Trade Association
ARC	Asian Regional Centre
AVDRC	Asian Vegetable Research and Development Centre
CMS	Cytoplasmic Male Sterility
DEC	Department of Economic Commerce
DNA	Deoxyribonucleic Acid
DOA	Department of Agriculture
DOAE	Department of Agricultural Extension Development
FAO RAP	Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GMS	Genic Male Sterility
GSP	General Specific Preferences
IDA	Iron Deficiency Anemia
IDD	Iodine Deficiency Disorders
IPM	Integrated Pest Management
KURDI	Kasetsart University Research and Development Institute
MOAC	Ministry of Agriculture and Cooperative
MOC	Ministry of Commerce
MOF	Marketing Organization for Farmers
MPH	Ministry of Public Health
NA	Not Available
NSO	National Statistical Office
NVRI	National Vegetable Research Institute
OAE	Office of Agriculture Economics
OP	Open Pollination
TVRC	Tropical Vegetable Research Centre
USA	United States of America
VAD	Vitamin A Deficiency
WTO	World Trade Organization
1 rai	=1 600 square metres
1 hectare	=6.25 rai
1 U.S. dollar	=38 Baht

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FOREWORD

Mother nature has provided an abundance of sunlight, high rainfall, varied elevations, vast arable area and wide bio-diversity in vegetable crops to grow in the tropical world.

One of the dramatic achievements in the Asian region has been the remarkable progress in reducing the extent of famine, hunger and starvation. The recent economic crisis in the region, including Thailand has further emphasized the critical role of agriculture on the road to economic recovery. There is an increased pressure on domestic food production and supply to meet the needs of growing population. Our current and achievable challenge, therefore, is to build upon and accelerate the progress registered in Thailand to ensure safe, secure and nutritious food in the next millennium.

One of the priority aims of most countries in the region is the production of adequate food, in terms of quality and quantity, for the well-being of their rapidly increasing population. Although the bulky staples like cereals, legumes and tubers have received considerable attention in the past, the production of fruits and more particularly vegetables was taken for granted until recently, in spite of their nutritional importance.

In Thailand, the interest in vegetable production has increased rapidly as a result of greater appreciation of the food value of vegetables in human diet. Today, people in every walk of life are consuming more fresh vegetables than ever before, thus making the growing of more vegetables vitally important.

To properly feed the expanding population in a land where vegetable production is relatively inadequate and where the people have become quality conscious, it is incumbent on us, the agricultural scientists to improve the existing inferior varieties and to modernize the agro-techniques to get maximum quality harvest from them. The bottom line indicators for success in agricultural development should, therefore, not merely be increased food production and income, but the quality and diversity of food and its contribution to achieve nutritional security in nations, communities and households.

This publication has attempted to highlight the extent of bio-diversity in vegetable crops which are in commercial production and consumption, as well as those under-utilized species commonly being used. The present status of commercial vegetable production and distribution has been described, as well as areas of improvements in production technology. Against this background, this publication is considered timely and useful for policy makers, educationists, researchers, extension officers and individuals interested in the vegetable industry. In addition, this publication will be of interest to producers and consumers alike and university students.

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1. INTRODUCTION

1.1 BACKGROUND

Thailand is predominantly an agricultural country with a land area of 513 115 sq. Km and a population of around 62 million. The agricultural sector comprises mainly of small farms, 5.1 million in number, and farmers engaged in agriculture constitute 59.66 percent of the total population. The growth rate of the gross domestic product (GDP) from agriculture improved from -4.6 percent in 1990 to 5.5 percent in 1994. GDP per worker from the agricultural sector and non-agricultural sector in 1994 was reported to be US$ 494 and US$ 6 230 respectively.

Of the country's total land area of 51.08 million hectares, approximately 20.8 million ha (41 percent) was classified as arable land, 0.8 million has as permanent pasture, 13.5 million ha (26 percent) as forest and woodland, and 15.989 million ha (31 percent) was un classified land in 1994.

There has been a steady decrease in the size of farm holdings with a corresponding increase in the number of farms and total population. These farm holdings are broadly classified into rice (11.01 million ha), upland crops (5.25 million ha), fruit and tree crops (3.33 million ha), vegetables and flowers (0.14 million ha) and pasture (0.12 million ha). Irrigation facilities are available for 21 percent of the total arable area. The agricultural base comprising of 5.1 million farming families are engaged in the production of food for domestic consumption as well as for export. Crop production remains the major agricultural activity, but the share of the country's GDP has been steadily decreasing in recent years and currently contributes only half of what is achieved in the manufacturing and service sectors.

Until the advent of the recent economic crisis, the agricultural sector had been able to keep in line with the increase in population. In general, food production levels exceeded consumption, and the excess produce of certain commodities was exported. It is, however, a matter of concern that there could be shortages of food for the poorer classes of the rural population, especially those who do not have the purchasing power to feed themselves. Malnutrition among the nutritionally vulnerable groups is also receiving greater attention from national planners. Thailand has vast natural resources and adequate human potential to increase productivity of the food crop sector. With the right policies and latest technologies, sustainable agriculture and food security can be attained to revive the agriculture GDP and feed the population.

1.2 CLIMATE

The climatic conditions prevailing in the country are conducive to vegetable production. The central part of the country is tropical and receives most of its precipitation from the Southwest monsoon from May to October. Annual rainfall ranges from 695 mm to 4 160 mm. The Northeast monsoon that operates from November to March brings rain to the South, and the rest of the country receives cool dry weather from winds that originate in China.

The Climate in the North is near sub-tropical with conditions favorable for the production of cool-season crops almost throughout the year. The Northern latitudes of the country receive nearly 14 hours of day length in summer, while the rest of the country in the South receives around 13 hours during this period. In the winter months, day length duration is slightly

below the 12-hours photoperiod. Consequently, the Northern regions of the country offer better prospects for the increased productivity in many crops including vegetables, due to higher net assimilation rates from the long-day effect, as well as from the higher diurnal range of temperature and greater heat unit accumulation at higher elevations.

1.3 AGRICULTURAL SECTOR

The agricultural sector comprises mostly of small farmers engaged in farming and fishing. Until recently,the level of food production was adequate for the country to feed itself. The country has advanced technologically, and with the right policies and use of its vast natural resources, the country's farmers have been able to achieve sufficiency in the production of cereals, staple substitutes, oil crops, legumes and horticultural commodities. With the advent of the Asian economic crisis, some concern has been expressed with regard to stability of the agricultural sector and the ability to continue with the food surpluses the country has been achieving. The drop in the economy has affected somewhat the small farmers, who depend heavily on their production base for their livelihood. With the projected increase in the population to around 90 million within the next 20 years, planners are sceptical whether food production can be kept ahead of domestic consumption with the use of currently available technologies and without the active involvement of the country's farming community. Socio-economic conditions in the rural sector and the ability to maintain the purchasing power of low-income groups to sustain equitable food security and nutrition is a matter of deep concern. Since the land area available for agriculture is progressively shrinking, the only possibility is a vertical increase in production and productivity using newly developed technologies and better crop husbandry techniques.

Despite the country's vast natural resources, the per capita availability of arable land is decreasing with the increase in population. For instance, arable land decreased from 45 percent in 1993 to 41 percent in 1994. The forest cover has shown a slight decrease from 27 percent in 1993 to 26 percent in 1994. Pasture land and non-agricultural land has however remained relatively unchanged. Hence, high yields per unit area can be achieved in the small farm sector only through the production of crops like vegetables, which have far greater productivity than other crops. The yield per unit area can be increased many times by application of the appropriate technologies such as irrigation, use of high quality seed and the application of appropriate agronomic techniques. In comparision to a pulse crop or cereal, vegetables can give yields as high as 10–30 tons/ha.

There are several kinds of commercial vegetables grown and consumed locally, a brief description of which is included in Appendix 1. Many indigenous species and their edible portions are also utilized as vegetables nation wide (Appendix 2). In addition, there are vegetables such as Chinese cabbage, head cabbage, tomato, ginger and shallot that are either grown or processed for export. The agro-climatic conditions prevailing in the country make it possible to produce vegetables throughout the year, and consequently, fresh vegetables are readily available in the local markets. Fresh vegetable exports find their way to neighboring countries such as Malaysia and Singapore, while the processed vegetables are exported to the USA, Japan. Hong Kong and countries of Europe. Private seed company entrepreneurs based in Northeast Thailand have also developed a lucrative business in the export of F1 hybrid seed of tomato and other vegetables.

The contribution from vegetables (covering 2.8 percent of the arable crop area) to total crop production in Thailand was only nine percent in 1997 (Table 1). Although the country may

produce sufficient to remain in a food surplus situation at present, the low economic status of rural and urban communities who are nutritionally vulnerable, may pose a serious problem if the smaller production units are not given adequate attention. Vegetable cultivation is part and parcel of rural and peri-urban living in the country. Increasing production through appropriate intervention programs would be the most logical strategy for achieving food security. This would require the infrastructure developers, rural development planners, agricultural scientists and extension personnel, credit and input supply agencies, post-harvest handling and marketing specialists, to help small farmers increase the efficiency of their production systems. Food security and better nutrition can be achieved by increasing agricultural productivity and by higher income generation, to improve the purchasing power of impoverished communities.

Table 1. Crop production statistics – 1997

Crop	Area in 1 000 rai (in ha)	Percent of total arable area	Production (in 1 000 tons)	Percent
Cereals	11 505 (1 840.8)	67.6	26 097	45.9
Roots/Tubers	1 220 (195.2)	7.2	18 210	32.0
Pulses	452 (72.3)	2.7	314	0.6
Fruits	3 359 (536)	19.7	7 139	12.5
Vegetables*	479 (76.6)	2.8	5 129	9.0
Total	17 015	100.0	56 916	100.0

Source : FAO 1998.
* DOAE calculated statistics

1.4 SOCIO-ECONOMIC ASPECT OF VEGETABLE PRODUCTION

Vegetable production is essentially a small-farm venture that benefits thousands of families in urban, peri-urban and rural communities. Growing vegetables provides self-employment to families who are engaged in all aspects of the business: propogation, production, harvesting, preparation for the market, and even selling. In recent years however, production costs have increased by about 50–60 percent. Most farmers are compelled to use family labour in order to cut costs and remain competitive in local markets. High costs compel resource-poor farmers in limiting their inputs, such as fertilizer and agro-chemicals resulting often in crop losses and lower outputs. Growers are also forced to use open pollinated varieties and traditional land races since they are unable to purchase hybrid seed that can give much higher yields and incomes. Market gardeners and peri-urban growers on the other hand, use intensive production systems around the periphery of large cities to maximize outputs from small plots of land. Often, there is an overuse of harmful chemicals, which endanger the health of consumers and pollute the environment. In the peri-urban and irrigated areas including Pathumthani, Nonthaburi, Nakhonpathom, Ratchaburi, Nakhon Ratchasima, Chiang Mai, Songkhla, etc., the main source of income is from vegetable cultivation. In times of food shortages, vegetables provide sustainability and food security when other sources of food are scarce.

2 DIET, NUTRITION AND VEGETABLES

Vegetables are an important supplementary source of food and nutrition. Due to their wide adaptability and availability, vegetables can fit into cropping systems under diverse agro-ecological conditions. Thailand depends also to a large extent on the production of root and tuber crops, which contribute to food security as staple substitutes. The local diet comprises of the staple rice and an accompaniment of meat, seafood, fresh water fish and several vegetables. The latter provides bulk and fibre to the diet and supplies major nutrients. In times of crisis and natural disasters, vegetables can be produced for consumption within a short period of time to avert food deficit situations.

Vegetables as a food group constitute an important component of the Thai diet. They enrich the local diet with essential nutrients such as vitamins and minerals (Table 2).

Leafy vegetables such as amaranth, spinach and piper constitute good sources of iron and calcium, essential for the growth and development of bones and teeth, and to prevent iron deficiency anemia. Vegetables are rich sources of Vitamin A, B, and C, essential for the prevention of Scurvy and Vitamin B deficiency in the body. Dark, green leafy and yellow vegetables (sweet basil, carrot and awl tree) are rich in Provitamin A (Beta-Carotene) with the young shoots containing more than the mature leaves. Vegetables such as torvum eggplant and acacia shoot are rich sources of fibre in the diet. Although fibre is not considered as a nutrient and is not absorbed in the body, it is essential for normal digestion and satiety. Fibre is known to lower incidence of blood cholesterol levels, high BP, heart disease, diabetes, gallstones and colon cancer. It is also used effectively in diets preventing and treating obesity because of its bulk and low energy value.

Many vegetables such as celery, eryngo and lettuce, add flavor and taste to bland dishes, making them more attractive and appetizing.

Some vegetables such as starchy roots and tubers are good sources of calories, and are often used as substitutes for staple grains. With the exception of legumes, vegetables are poor sources of protein. Soybeans (legume) contain as much as 20–40 percent protein and contribute a substantial intake of protein in the Thai diet. Legumes also contribute an inexpensive source of protein to diets, when meat and fish are very expensive. They have also been extensively used in alternative forms of medicine and health foods.

Vegetables also aid digestion due to the high fibre content and are believed to have therapeutic and medicinal benefits.

Over-cooking vegetables may destroy essential vitamins and minerals. For example, about 35 percent of Vitamin C is lost on boiling for ten minutes. Water-soluble Vitamin B is lost if water used for cooking is thrown away. Other vitamins like A, D, E, and K are also lost in varying amounts through the cooking process.

In addition to the nutritional importance, vegetables provide variety and taste to everyday meals.

Table 2. Vegetables rich in vitamins and minerals
(common English names, with Thai names in parents thesis)
(listed in decreasing order of amounts per 100 gm of edible portion)

Vitamin A above 7,600 international units (IU)
Awl tree leaves (yo baan), white basil (maeng lak), sweet basil (horapa.), carrot, coccinia (phak tamlueng), spinach (phak khom), sesban tree (khae baan), amaranth (phak khom nham). Asiatic pennywort (boa Bok), roselle (krachiap prieo), acacia shoot (cha-om), piper (chaa phluu), ipil-ipil (kra thin Thai), and Siamese cassia (kheelek).

Niacin (B-complex)-above 1.9 mg
Piper (chaa phluu), acacia shoot (cha-om), coccinia, and spinach.

Vitamin C-above 100 mg
Horseradish tree (ma rum), coriander (phak chee), Chinese kale (kha Na), hot pepper (prik yuak), spinach, and leaf mustard (phakkat khieo plee).

Calcium (Ca)-above 200 mg
Piper, amaranth, neem flower (sadao), awl tree leaves, sesban tree, water mimosa (phak krachet), sweet basil, and spinach.

Iron (Fe) -above 150 mg
Sesban tree/shoot, spinach, sweet basil, amaranth, white basil, neem flower, Chinese celery (kuen chai), and pepper mint (Sara nhae).

Figure 1. Kangkong : served with papaya salad, sticky rice

2.1 UTILIZATION OF VEGETABLES

Thailand utilizes vegetables in different ways : the uncooked vegetables are commonly used as a side dish; cooked vegetables are often eaten as a side dish or mixed in stew with meat, fish and other foods; other variations include curried, fried, broiled or baked vegetables. During the festive season, some vegetables like parsley (from highlands), carrot, radish, onion and tomato are used as a garnish to decorate meat or fish dishes and may or may not be eaten.

A common Thai meal consists of rice, cooked vegetables, and a curry dish. Vegetables are often cooked with water, oil, coconut milk and sometimes wine, blanched and served with traditional chili sauces, and even eaten in the raw form. Chili sauce was believed to have been originally prepared with local bird peppers as the major ingredient rather than chili pepper or hot pepper. It is believed that foreign traders around the middle of the Ayutthaya period introduced the two latter types to Thailand.

A low-income meal consists of at least plain or glutinous rice, indigenous vegetables consumed with traditional chili sauces and dry fish or roast chicken. Most vegetables are consumed unprocessed. Canned, pickled and dehydrated vegetables are mainly used as ingredients in making soups.

2.2 NUTRITIONAL STATUS OF THE THAI POPULATION

The habitual Asian diet is cereal based, with an energy intake of 2 513 kilocalories, the average for Central and Southeast Asia, and 2 389 kilocalories the average for South Asia, amounting to over 60 percent of dietary supply (DES). The Thai diet in particular relies heavily on rice as the main source of calories and protein. Thailand's average per capita availability of calories was 2 351 kilocalories per day during 1994-96.

Like most developing countries in Southeast Asia, the majority of Thailand's under five-year old population is under-weight. In 1987 almost 25.8 percent of under five-year old children in Thailand were under weight, 22.4 percent were stunted and 5.7 percent were wasted. The average infant mortality rate (1995–2000) was estimated to be 3.0 percent (Table 3).

Table 3. Some population indicators affecting nutritional status (1995-2000)

Country	Estimated population (1 000) 1997	Average annual rate of change percent 1995–2000	Infant mortality rate 1995–2000	< 5 children suffering from (percent)				
				Year of surveys	Sample size	Under weight	Stunting	Wasting
Cambodia	10 515	2.23	102	-	-	-	-	-
Indonesia	203 479	1.47	48	1987	28 169	39.9	-	-
Laos	5 195	3.07	86	1984	6 055	36.7	40.1	10.5
Malaysia	21 018	2.04	11					
Myanmar	46 765	1.8	78	1983–85	6 255	38	49.7	11
Philippines	70 724	2.02	35	1987	2 250	32.9	38.6	4.5
Thailand	59 159	0.76	30	1987	1 856	25.8	22.4	5.7
Vietnam	76 548	1.75	37	1987–89	7 044	45	56.5	9.4

Source : FAO, 1998.

2.3 MICRONUTRIENT DEFICIENCIES

The per capita consumption of vegetables in Thailand is lower than in other countries of the region. The general population is often unaware of the micronutrient content of foods, and as a result the most common nutritional deficiencies prevalent in the country are Vitamin A deficiency (VAD), Iron deficiency Anemia (IDA) and Iodine Deficiency Disorders (IDD). People need to be made aware of micronutrient food sources and advised towards making the right choice of food, food groups and food combinations, which will provide an essential 'package' of balanced nutrients.

Thailand has faced a micronutrient deficiency of varying degrees of severity. Though clinical VAD is not a problem in Thailand, sub-clinical deficiencies exist in many rural areas. About 17 percent of pre-school and school age children in the Northern province of Ubonratchathani, and 5.7 to 10.8 percent in the Southern provinces are estimated to exhibit sub-clinical symptoms of Vitamin A deficiency (Table 4 and 5). The prevalence of Vitamin A deficiency amongst preschool children varies within the provinces. The highest prevalence was reported in Pattani province (Table 5).

Table 4. Rates of VAD in pre-school children of Ubonratchathani province, 1977

Vitamin A deficiency status	Prevalence
Normal (percent)	13
Low (percent)	70
Deficiency (percent)	17
Total	**100**

Source : Wangthong, 1997.

Table 5. Vitamin A deficiency status among pre-school children in 5 provinces

	Percent prevalence in provinces					
Status	**Narathivat**	**Yala**	**Pattani**	**Song Khla**	**Satun**	**Average**
Normal	90.2	92.2	89.2	93.8	94.3	92.0
Deficiency	9.8	7.8	10.8	6.2	5.7	8.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source : Sinawat and Maleevong 1998.

Sub-clinical Vitamin A deficiency may be caused due to food insufficiency that stems from a reliance on i) purchased foods, ii) seasonal variations in food availability, iii) unstable food consumption patterns and iv) limited bioavailability of Vitamin A in foods consumed.

A possible factor in the etiology of VAD, apart from other factors, is the poor intake of green leafy vegetables and yellow-orange vegetables. Dietary food combinations, with the use of traditional cooking practices which have nutritional benefits in terms of improving micronutrient bioavailability, should be encouraged to prevent VAD.

In 1992, the assessment on iron deficiency anemia (IDA) in school children (6–14 years) by regions recorded the highest prevalence (20.9 percent) in the Northeast with an average prevalence of 18.3 percent in the country (Table 6). By 1993, the prevalence of IDA was reduced to 7.3 percent as a result of the School of Agriculture Lunch Project (Table 7), which provides school children with more access to food and vegetables in the daily diet.

Table 6. Assessment on iron deficiency anemia (IDA) in school children (6–14 yr.) by regions, 1988–92

(in percent)

Region/Year	1988	1989	1990	1991	1992
Central	23.4	12.7	16.7	17.0	12.6
North	26.3	19.2	18.4	15.9	16.1
East	24.5	25.1	16.6	19.7	18.7
Northeast	35.6	14.6	18.1	19.6	20.9
South	26.3	19.2	18.4	15.9	16.1
Average	**27.3**	**16.5**	**18.6**	**19.0**	**18.3**

Source : Wangthong, 1997.

Table 7. Iron deficiency anemia in school children under the School of Agriculture for Lunch Project. 1986–1993.

(in percent)

Prevalence of Iron deficiency Anemia	1986	1987	1988	1993
	26.4	15.8	12.1	7.3

Source : Wangthong, 1997.

The lack of utilization of a suitable food combination is an important cause for the poor bioavailability of iron in diets. The Thai diet requires the incorporation of the right kind of food combination to promote iron absorption by the body. For example, a typical Thai meal consisting of rice, vegetables and spices will yield 0.16 mg of absorbed iron, but this can be doubled to 0.4 mg with the inclusion of fish. The inclusion of citrus fruits, sour fruits, and food rich in Vitamin C, such as tamarind, soy bean, fermented foods and fresh foods are also beneficial in enhancing the absorption of iron from the diet.

The share of fruits and vegetables in dietary energy supply (DES) in the region is shown in Table 8.

Table 8. Fruits and vegetables in percentage of total dietary energy supply (DES) in the Asian region, 1994–96 averages.

Percent of DES by region		
Food group	**South Asia**	**Southeast Asia**
Fruits	2.7	2.8
Vegetables	1.5	1.1

Source : FAO, 1998.

The data indicates that the contribution of vegetables to daily per capita energy supply in South Asia is higher than in Southeast Asia. In the case of Thailand, vegetables contribute to the daily per capita energy supply next to fruits. The per capita availability of fruits and vegetables in South and Southeast Asia from 1994 to 1996 is shown in Table 9.

Table 9. Asian average daily per capita availability from fruits and vegetables, 1994–96

(in kilocalories)

Food group	South Asia	Southeast Asia
Fruits	65.70	68.25
Vegetables	35.00	30.00

Source : FAO, 1998.

Recent data on fruit and vegetable intake in Thailand is lacking. Research studies, on 60 home gardens in Thailand show that 230 different species of plants are available, and there is a need for sustainable farming and reliance on a wide range of crops, especially horticultural crops which are a good source of micronutrients.

The national nutrition survey (MPH, 1986) revealed that dietary intakes of micronutrients was generally adequate while calcium intake was inadequate. However, in view of the likely impact of the current economic crisis and the need to provide healthy diets and lifestyles as part of the FAO's mandate in improving nutritional status of the population, it is essential that vegetable and fruit consumption should be enhanced in the daily diet.

2.4 FOOD BASED DIETARY GUIDELINES (FBDGs)

The FBDGs highlight the nutritional benefits of vegetables in alleviating micronutrient deficiencies and promote their daily consumption in the diet (MPH, 1998).

There is a need to promote dietary food combinations through the FBDGs developed for the region. Production of micronutrient rich fruits and vegetables for consumption is a priority, with an emphasis on local horticultural crops indigenous to the region e.g. leafy vegetables (all varieties of spinach, leaves of the horseradish tree, colocasia leaves, etc.), sweet tamarind, guava, papaya, mango and others. Various green leaves and plants, which are typically used in Thai diets such as coccinia *(phak tamlueng)*, and which can be grown even in home gardens are a rich source of Vitamin A.

FBDGs should emphasize on developing food combinations, food preparation methods and traditional cooking practices that enhance nutrient intake and absorption. As part of the FBDGs in Thailand, certain practical suggestions have been given for the population to improve micronutrient intake in their diets.

2.5 RECOMMENDED DIETARY INTAKE

A recommended dietary intake for Thai people is outlined below (MPH, 1986):

- Eat a variety of foods from each of the five food groups and maintain proper body weight.
- Eat an adequate amount of rice or alternative carbohydrate source.
- Eat plenty of vegetables and fruits regularly.
- Eat fish, lean meat, eggs, legumes and pulses regularly.
- Drink milk in an appropriate quality and quantity for one's age.
- Follow a diet containing appropriate amounts of fats.
- Avoid sweet and salty foods.
- Eat clean and safe foods.
- Avoid or reduce the consumption of alcoholic beverages.

Fibres present in vegetables and fruits help the body to remove waste, eliminate carcinogenic compounds and reduce cholesterol levels. Raw vegetables such as carrots, green vegetables (including crucifers) and tomatoes are found to be protective against the risk of developing certain types of cancer. Substances that may also help include dithiolthiones, isothiocynates, indole-3-carbinol, allium compounds, isoflavones, saponins, phytosterols, lutein, folic acid, betacarotene, selenium, Vitamin E, flavonoids and dietary fibres. The FBDGs advise the population to increase vegetable and fruit intake in the diet.

3 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.

3.1 PLANTED AREAS

Data on the production of main crops in Thailand (Table 10) 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.

During the economic crisis, many urban people laid off from their jobs have returned to farming, mainly growing vegetables.

Vegetables are grown both in upland and irrigated land. For the upland crops. Thailand's variable rainfall (and consequent risk) has discouraged farmers from using higher levels of technology, such as the increased use of fertilizer. However, 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.

3.2 PRODUCTION AND PRODUCTIVITY

The long-term trend in the acreage of vegetables seems to fluctuate with a slight increase over 1976–98 (Table 11).

Mean yields presented give an indication of the current yields achieved by farmers under organized production systems using an above average level of technology. Although these figures for 1998 give an idea of the current productivity levels, there is much room for improvement. Using hybrid seed, it should be possible to double the current yields.
Annual production increases have been as low as 2.1 percent, which is not high enough to keep pace with the rate of population growth of 1 percent. Much of this increase has come from expansion of production into new areas in the cooler regions of the North, Northeast and some arid regions. Despite the attempts to increase current yield levels, the situation has remained somewhat static. 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. The vegetable processing sector has shown better performance, which may be due to more organized large-scale culture, using more advanced methods of production, post-harvest handling and processing.

Table 10. Main crop area, production and yields, 1987–1997

Crop	Year					Percent change 1987–97
	1987	1994	1995	1996	1997	
Cereal Crops						
Area (1 000 ha)	10 673	10 515	10 446	11 694	11 505	-0.1
Yield (kg/ha)	2 006	2 410	2 527	2 293	2 268	1.5
Production (1 000 t)	21 414	25 339	26 398	26 808	26 097	1.3
Roots and Tubers						
Area (1 000 ha)	1 393	1 403	1 281	1 285	1 220	-2.1
Yield (kg/ha)	14 205	13 103	13 737	14 240	14 931	-0.2
Production (1 000 t)	19 784	18 377	17 592	18 292	18 210	-2.3
Pulses						
Area (1 000 ha)	593	450	448	458	452	-4.0
Yield (kg/ha)	721	847	803	737	753	-0.1
Production (1 000 t)	427	381	359	338	341	-3.8
Fruits						
Area (1 000 ha)	NA	NA	NA	NA	3 359	NA
Yield (kg/ha)	NA	NA	NA	NA	2 125	NA
Production (1 000 t)	5 693	7 343	7 133	7 231	7 139	2.4
Vegetables*						
Area (1 000 ha)	187	373	353	515	479	3.3
Yield (kg/ha)	9 464	8 638	10 997	9 318	10 707	0.4
Production (1 000 t)	1 770	3 222	3 882	4 799	5 129	2.1

Source: FAO, 1998.
* DOAE calculated statistics

Table 11. Cultivated area and production of vegetable crops (1976–1998)

Year	Area (1 000 rai)		Production (1 000 tons)	
	Total	Average/year	Total	Average/year
1976–80	7 387	1 477.4	7 905	1 581.1
1981–85	9 820	1 964.0	10 371	2 074.2
1986–90	7 492	1 494.4	10 878	2 175.6
1991–95	10 216	2 043.2	16 115	3 223.2
1996–98	9 283	3 094.3	15 302	5 100.7

Source: Centre for Agricultural Information, 1996.

3.3 AVAILABILITY

In spite of the impression that Thai cuisine is based on vegetables, Thailand has a yearly per capita consumption of fresh vegetables that is considerably below the minimum per capita requirement of 73 kg/cap/yr. In 1992, Thailand's vegetable availability was only 44.5 kg/cap/yr. (Devarrewaerre, 1995). In November 1994, FAO organized an Expert Consultation Meeting on the Regional Network on Vegetable Crops. The Meeting drafted a list of recommendations for improving vegetable production in the region and enhancing cooperation on research. Greater advocacy for promoting a balanced diet has resulted in an increased demand for fresh vegetables. Policy makers have realized the need for giving priority to vegetable production. In 1998, the per capita availability of vegetables increased to 88.36 kg/cap/yr. based on the overall supply of vegetables and the availability for fresh consumption averaged at 60.25 kg/cap/yr. (Table 12).

3.4 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 (average per capita availability of 123 and 192 kg/cap/yr. respectively. The production of vegetables also varies considerably within regions (Table 12).

Table 12. Regional production and per capita supply of vegetables, 1998

Region	Overall production (tons)	Overall vegetable production per capita (kg)	Fresh market production (tons)	Fresh market vegetable production per capita (kg)
Central	325 533	26.99	262 892	21.80
North	2 130 940	176.26	1 491 446	123.36
East	331 193	81.57	270 539	66.64
Northeast	1 232 251	58.40	805 725	38.19
West	1 085 928	304.50	684 060	192.15
South	268 446	33.76	149 443	18.80
Total	**5 374 291**		**3 664 105**	
Average		**88.36**		**60.25**

Source : Centre for Agricultural Information, 1996.

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 non-agricultural land, regional supply is very low with yearly per capita availability of 21.80 kg. The most common vegetables are kangkong, Chinese chive, Chinese kale, pak choi and mini cucumber. People living along side water ways have easy access to vegetables because of the practice of picking green swamp vegetables like kangkong, water mimosa, water lily and sesbania (sano) shoots and flowers in addition to availability from markets. 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 kale 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. Accessibility of vegetables in low income groups is limited to gardening and gathering indigenous vegetables in birchwood and forests. 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. A number of under-utilized vegetables such as species under genus *Parkia* also play an important role, particularly in the islands isolated from the mainland where distribution of vegetables is difficult. 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. 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.

The Western region 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 over supply of 192.15 kg/cap/yr. However, the urban growth is now threatening the agricultural environment. 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.

3.5 THE ROYAL PROJECT ON CROP SUBSTITUTION

Northern Thailand, encompassing the provinces of Chiang Mai, Chiang Rai, Lamphun and Mae Hong Son, represents one of the most important regions of the country from the socio-economic, agro-ecological as well as political point of view. These four provinces account for about one quarter of the country's forest area and the majority of hilltribes - Hmong. Yao, Muser, Karen, Akha, Lisu and Chinese Haw live in the region. The population of the hilltribes has been growing rather fast, and has caused expansion of slash and burn agriculture in the region.

Part of the northern provinces lie within the infamous "Golden Triangle" region, where more than half of the heroin consumed over the world was being produced. Thailand has had a very difficult time in dealing with this national and international problem. His Majesty the King was the first to provide comprehensive plans, and initiated projects to tackle the problem. The strategy has been based on gradually replacing opium production by growing other cash crops.

During 1987, it was reported that there were about 260 villages in the North growing opium poppy over an area of about 6 000 ha (FAO, 1987). To combat the problem of eradication of poppy growing, His Majesty has had six main research stations, 21 project development centres and 24 crop replacement promotion centres. Furthermore, over 30 farming promotion centres, each responsible for the crop replacement in 5–10 villages are being set up. More than 300 researchers, extension workers and key farmers are regularly involved in this project.

Besides introduction and intensification of highland staple food crops, such as rice, wheat and maize, a large number of fruit, vegetable, medicinal, flower and ornamental crops have been screened for their suitability in the highlands, as well as for returns from these crops as compared with those from opium poppy. The temperate climate fruits produced are Chinese peach, Chinese pear, persimmon, plum, grape, Chinese apricot, strawberry, passion fruit and fig. Those species being researched are kiwi fruit, "soft kernel" pomegranate, raspberry and blueberry. The flowers produced include gladiolus, gerbera, statis, rose, gypsophilla, carnation, alstromeria, African violet, lily, chrysanthemum and freesia. There are over 50 kinds of vegetables, such as Brussels sprouts, leek, celery, zucchini, turnip, Japanese cucumber, parsley, Chinese cabbage, (Hong Tae), cross lettuce, white bitter cucumber, potato, radish, fennel and endive. Exotic crop species are currently being introduced for field experimentation and adaptation. Propagating materials have been received from the governments of Australia, France, India, Indonesia, Iran, Israel, Japan, Lebanon, New Zealand, United Kingdom and Germany.

During a recent visit to some of the Royal project sites in Chiang Mai and Chiang Rai area, the successful replacement of opium with fruits, vegetables and flowers was evident. The main contributing factors toward the successful substitution of opium cultivation with the introduction of high value crops like fruits, vegetables and flowers, were the use of improved varieties, suitable cropping patterns, the provision of irrigation facilities, post-harvest and handling facilities with proper harvesting, packaging, grading and the development of infrastructure facilities with storage, transport and adequate access to markets. Fresh vegetables, strawberries and dried flowers are exported, fruits and vegetables are sold directly to leading hotels and supermarkets in Bangkok, and processed and canned produce is marketed under the brand name Doi Kham. Several farmers interviewed were satisfied with the income earned, which was either equal or sometimes higher than that earned through a single opium crop, because of multiple crops of vegetables, flowers and herbs annually.

The Royal project has received the active participation of various institutes and agencies in Thailand and abroad. Some of these include the University of Chiang Mai, Kasetsart University, Maejo University, Ministry of Agriculture and Cooperatives, Department of Industrial Promotion, Ministry of Industry, Border Patrol Police, Government of Thailand, Thailand Institute of Scientific and Technological Research and the Agricultural Research Service of the United States Department of Agriculture (USDA).

Under His Majesty's inspiration and leadership, the Royal crop substitution project in Northern Thailand has been successful in imporving the lives of the rural poor, especially the hilltribes through appropriate income generation activities, which include the cultivation of vegetables.

3.6 URBAN AND PERI-URBAN AGRICULTURE

The world's current population of 5.9 billion is split equally between urban and rural areas, with urban areas expected to surpass rural areas in population around the year 2005 (Dent and Nath, 1999). Regionally, there are significant differences in the degree of urbanization. Just over three quarters of the populations of North America, Latin America, and Europe live in urban areas, while only slightly more than one - third of the populations of Asia and Africa are urban. Expansion of cities is driven by economic growth and/or by migration from rural to urban and peri-urban areas as agricultural and rural employment opportunities decline or lag behind population growth.

“Urban” agriculture refers to small areas (e.g. vacant plots, gardens, balconies, and containers) within the city for growing crops and raising small livestock or milk cows for their own consumption or sale in neighbourhood markets. “Peri-urban” agriculture refers to farm units close to town, which operate semi or fully commercial farms to grow vegetables and other horticultural crops, raise chickens and other livestock, and produce milk and eggs.

Horticulture, mainly vegetable production, has expanded in and around cities in many developing countries as an informal activity practiced by poor and landless city dwellers. The broad diversity of horticultural crop species allows year round production, employment and income. Growers have realized that intensive horticulture can be practiced on small plots, making efficient use of limited water and land resources. Horticultural species, as opposed to other food crops, have a considerable yield potential and can provide upto 50 kg of fresh produce per sq. m per year depending upon the technology applied. Leafy vegetables provide a quick return to meet the families daily cash requirements for purchasing food. Leafy vegetables are particularly perishable and post-harvest losses can be reduced significantly when production is located close to consumers.

In Bangkok, His Majesty King Bhumibhol has allowed 22 rai of land at Sammakorn to be developed by the Department of Agriculture for the production of pesticide free vegetables and fruits. The King's aim is to show that empty land can be used by local people for producing hygienic vegetables and fruits. Pest control will be achieved by using bio-pesticides, while for improving soil quality (land-fill in this case) the DOA will use various types of organic material depending on the results of soil analysis. Mineral fertilizers will only be used in low amounts during the first stage until soil quality is good enough for crop production. The project is planned in two stages. The first stage, now underway, is to develop plots for cultivation and to set up infrastructure (irrigation trenches, roads, buildings and electricity). The second stage is to allow local people to farm the plots under the supervision of the DOA.

A second urban agriculture scheme under His Majesty The King's patronage is “Lemon Farm” run by Mongkhol Chaipattana Co. Ltd., which has developed a “chemical free vegetable farm” located on 6 rai of empty land-fill in the middle of Bangkok along the Ekamai-Ram Indra expressway. The farm consists of 220 raised beds (1.5 m × 2 m each). Soil improvement has been achieved by using molasses-based compost, rice husks, straw and

waste neem, with natural compost and fermented, indigenous plant extracts being applied during the growth period. A variety of biopesticides are utilized and the plots are irrigated by a locally manufactured sprinkler system drawing water from Klong Phlaba. The farm products are delivered to Lemon Farm Shops within the city and since October 1998, vegetables have also been offered for sale at the farm itself with a "pick your own" system in operation since January this year. The main objective of the initiative is to set up a tangible example of urban consumer communities in support of rural communities, following the self-sufficiency concept of His Majesty The King to revive the Thai society and economy.

3.7 ORGANIC FARMING AND HYGIENIC VEGETABLE PRODUCTION

The problem of harmful chemical residues in vegetables has been highlighted in this document. Most vegetable farmers are either ignorant or do not heed extension advice on the use of harmful pesticides. The result is overuse of these chemicals, which end up as part of the food chain. His Majesty the King has launched a programme to encourage vegetable growers to produce vegetables without the use of any chemical input. There are several projects which are now being initiated by the Ministry of Agriculture and some private organizations to produce and market chemical-free vegetables. The DOA is also offering assistance to farmers by providing insect-proof net-houses to grow vegetables without spraying. There is some promise in this venture, but the practicability of spreading this concept countrywide is somewhat questionable as it could only be practiced on a very small scale. The use of IPM and bio-pesticides has much wider scope. Another novel approach that the DOA is planning involves the development of indigenous vegetables that already have built-in resistance to most pests and diseases, as opposed to imported varieties of commercial vegetables that seed companies supply. Most of these varieties that are completely alien to Thailand do not have genetic material from indigenous sources of resistant germplasm. Consequently, when they are grown in the country they cannot be successfully produced unless large quantities of agro-chemicals are used. The use of the local gene pool in future breeding programmes of the private and public sectors is therefore worth exploring.

Figure 2. Kangkong : supermarket packed, in foam tray

Figure 3. Community market

Figure 4. Street vegetable vendor

Figure 5. Car vegetable vendor

3.8 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 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 post-harvest 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.

3.9 EXPORT AND IMPORT

Vegetable exports are mainly in dried and processed forms. Thailand's vegetable export was only 5.8 percent of the total vegetable production in 1997 (Table 13). 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.

Imports of vegetables are mostly in the form of vegetable seeds, other planting materials, and sometimes dry chili for making various processed foods. Dried mushrooms and dried lily flower are also imported in small quantities.

Table 13. Situation of vegetable production and export, 1994–98

(in 1000 tons)

Year	Vegetable Production (VP)	Vegetable Exports (VE)	Percent of VE to VP
1994	3 222	302.9	9.40
1995	3 882	312.9	8.06
1996	4 799	311.4	6.49
1997	5 129	301.0	5.88
1998	5 374	NA	NA

Source : Centre for Agricultural Information, 1996;1998.

4 RESEARCH AND DEVELOPMENT

4.1 RESEARCH

A number of institutions are involved with the improvement of vegetable crops. Among these are the Institute of Horticulture, Department of Agriculture, Kasetsart University, Chiang Mai University, Khon Kaen University, Prince of Songkhla University, Ramkhamhaeng University and several private seed companies who have contributed to the development of technologies. These institutions have been responsible for the development of many cultivars, mainly for high productivity and tolerance to diseases, since instability of production is brought about by damage from pests, diseases and sometimes poor adaptability to local weather conditions.

4.1.1 Current research strategies

While vegetable research is being carried out by the institutions mentioned above, Agricultural Colleges and regional institutes also handle small-scale programmes. The main research work covers varietal improvement, production management, pest and disease control, post harvest technology development and biotechnology.

Cooperative research among the national institutions is organized under the auspices of the Sub-Committee on Vegetable Research and Development Coordination (SVRDC). This subcommittee consists of representatives from the universities and many departments of the Ministry of Agriculture and Cooperatives. The National Research Council serves as the coordinating agency. Research on vegetables under the SVRDC is divided into four working groups comprising of tomato, legume vegetables, crucifers and the corn industry development programme. The Department of Agriculture concentrates its research efforts on crops such as asparagus, crucifers, bitter gourd, cucumber, pumpkin, garlic, ginger, indigenous vegetables, mushroom, onion, potato, shallot, sugar pea, sweet potato, tomato, kangkong and yardlong bean.

The DOA and DOAE jointly implemented a pilot project for commercial production of vegetable seed to help minimize the import of seeds of major vegetables. During 1997, Thailand imported 395 million baht worth of seed, and the pilot project was launched to explore the possibility of substituting exports. The private seed sector has been actively involved in this area of activity and helped the country to earn 781.5 million baht through seed exports.

4.1.2 Research priorities

The current research on vegetable crops focusses on the following areas:

- Evaluation and screening of vegetable germplasm for yield, quality, resistance to pests and diseases and environmental stresses.
- Varietal improvement through breeding and selection.
- Improved cultural practices to enhance productivity e.g. balanced use of fertilizers, water management and weed control.
- Control of pests and diseases through application of appropriate technologies e.g. biological control, cultural methods, and minimizing the use of insecticides and fungicides.

- Development of simple and cost effective processing technologies.
- Standardization of vegetable seed production technologies.

4.1.2.1 Varietal improvement

The institutions and the vegetable species on which work on varietal improvement was carried out are as follows :

Institution	Vegetable species
Horticulture Research Institute, Department of Agriculture	Leaf mustard, non heading Chinese cabbage, Chinese Kale, Chinese radish, chili, sugar pea, asparagus bean, shallot, tomato, potato, sweet potato, water convulvulus and okra
Kasetsart University	Chinese radish, asparagus bean, tomato, Chinese cabbage, okra and tomato
Khon Kaen University	Tomato, chili, musk melon and leaf mustard
Chiang Mai University	Heat tolerant tomato and Chinese cabbage
Private Seed Companies	OP and hybrid cultivars of hot pepper, tomato, eggplant, cucumber, bitter gourd, luffa, watermelon, melon, pumpkin, squash, cabbage, cauliflower, Chinese cabbage, pak choi, broccoli, Chinese kale, radish, leaf mustard, carrot, yardlong bean, okra, lettuce, sweet corn, asparagus, spinach, bush bean, sugar pea, bottle gourd, sweet basil, hoary basil, holy basil, kohlrabi, leek, Chinese celery, corriander and water convulvulus

The Horticultural Research Institute has released new OP cultivars of okra, cucumber, yardlong bean, garden pea, kangkong, taro, chili, eggplant, tomato, sweet potato and potato over the last 19 years. The private sector has concentrated more on the development of hybrids for all vegetables listed above. Its role in the development of the vegetable sector in the country is most commendable as more than 50 seed companies are actively involved in producing better cultivars from which farmers in Thailand have benefited immensely.

4.1.2.2 Crop management research

The Horticultural Research Institute has conducted several agronomic investigations to optimize vegetable yields, improve quality and minimize production costs of the major vegetables grown in the country. The Institute operates a national programme through a network of research stations, which conduct multi-location testing of various technologies, assist the vegetable sector in selecting the correct cultivar and the most appropriate technology package for each region. Some of the notable contributions are growing shallot from botanical seeds, seed production technology for water convulvulus and potato, protected culture methods to minimize pesticide use, development of small-farm machinery such as potato harvester and ginger cleaning machinery, and IPM technology for asparagus, onion, tomato, chilies, yardlong bean and cabbage by using biocontrol organic compounds, micro-organisms, predatory insects etc. as substitutes for harmful insecticides. Other areas of research that have been carried out are on water management, soil fertility management, crop density studies and related cultural practices in each agro-climaticologocal region. Other activities include post harvest technology to minimize losses in the domestic sector as well as quality control in the export and processing sectors.

4.2 PRODUCTION DEVELOPMENT POSSIBILITIES

Presently the annual increase in vegetable production is about 2.1 percent, which is not enough to keep up with a population growth of 1 percent. The increase comes mainly from new areas of production through expansion into the North and Northeast, with cooler and arid conditions. Possible increase in yield per unit area could be achieved through improved cultural practices and appropriate use of critical inputs. Farmers should be encouraged to make the maximum use of arable land by intensive practices in which two or more crops are grown on the same land in a year. This can be accomplished by (a) sequential cropping, e.g. in ditch-and dyke system; (b) ratoon cropping, e.g. in okra production: (c) intercropping, for example yardlong bean and cucumber, chili and garlic, bitter gourd and Chinese celery; or (d) relay intercropping, for example yardlong bean after sweet corn. Better water management through appropriate irrigation systems can also improve the yield per unit area.

The use of hybrid seed in some vegetable crops also contributes greatly to increased yields, reduced use of pesticides and standardized products with improved keeping qualities (Nath, Velayudhan and Singh, 1994). Thai farmers now have exposure to hybrid and high quality seed. Recently the use of hybrids in Thailand has seen a breakthrough with hybrid seed being used for many tropical crops such as tomato, cucumber, watermelon and pumpkin. Further research on F1 hybrid cultivars would also increase the use of hybrid seed in Thailand.

In Thailand, the operations of domestic commodity trade, wholesale, export and retailing have been regulated by the MOAC. More market channels particularly in remote areas would encourage vegetable production.

4.3 ROLE OF THE GOVERNMENT SECTOR IN VEGETABLE RESEARCH AND DEVELOPMENT

The state organizations responsible for the development of the vegetable sector are mainly concerned with the development of technologies and transfer of the information to the production sector. As in all developing countries of the region, Thailand has invested heavily in the staple food sector and until recently, the vegetable sector had not been given much priority. This has resulted in lower outputs from national programmes. The extension services are extremely strong in the cereal and food crop sectors, and somewhat weak in activities related to vegetables. The field programme is currently handled, along with other crops, by personnel with no special training in vegetable crops. Most of the field staff are general purpose extension officers. Two subject matter specialists in each province have to handle all vegetable crops, whilst the districts have a lesser qualified specialist responsible for all production activities on these crops as well as others.

The country considers technology transfer as one of the critical areas for intervention to help farmers to increase their productivity and income. Realizing its importance, a separate Department of Agricultural Extension (DOAE) was set up under the Ministry of Agriculture and Cooperatives, parallel to with the Department of Agriculture. Horticultural development is handled through three divisions, which overlook the activities of fruit production, vegetable production and floriculture. There are six subject matter specialists in the vegetable division at the headquarters in Bangkok, who handle the national program of training and technology transfer. In addition, each province has two subject matter specialists who are jointly responsible for the operation of the regional programmes. There is also one subject matter specialist in each district to coordinate the activities of field-level staff. These officers are also expected to handle other crops in addition to vegetables. The specialists at headquarters

conduct regular in-service training programmes for the field staff. The provincial subject matter specialists possess a basic degree in addition to their training given by the DOAE. The district-level subject matter specialists are high school graduates with some training in agriculture.

The main functions of the DOAE involve the organizing farmers who are interested in growing vegetables into groups, training these groups, coordinating with the private sector marketing agents, negotiating for fair prices, zoning areas with high potential for certain crops, and coordinating with the Agricultural and Cooperative Bank for credit when required.

Technological recommendations resulting from on-farm trials are introduced to farmers through demonstrations at various levels, such as demonstration plots, verification trials and field days. These demonstrations are carried out for each vegetable in high potential areas. Extension advisory services are carried out not only for pre-harvest activities but also for post-harvest activities such as grading, packaging, transporting and marketing. The division assists farmers in the formation of producer groups to enable them to dispose off their produce at suitable prices. DOAE staff in all regions have carried out many multi-location trials. There are, however, serious gaps between potential yields and actual on-farm yields.

Tropical Vegetable Research Centre (TVRC) and Asian Regional Centre (ARC)

The Thailand Outreach Programme was established with the approval of the Royal Thai Cabinet in 1982, as a cooperative programme at Kasetsart University for the Thai government, the Asian Development Bank (ADB) and the Asian Vegetable Research and Development Centre (AVDRC).

In order to improve technology in vegetable production and to enhance collaboration in AVDRC activities, the Tropical Vegetable Research Centre (TVRC) was established under the Kasetsart University Research and Development Institute (KURDI) in 1988. It coordinates and collaborates closely with the Asian Regional Centre (ARC) which was established in 1992 in the Kamphangsaen campus at Kasetsart University, in order to provide facilities for international training on vegetable crops specific to the Asian region.

ARC forges linkages with other research institutes to further its research mandate. In Thailand, on-farm trials on tomato, vegetable, soyabean, pepper, Chinese cabbage, and the other principal crops are conducted year-round in coordination with the TVRC-KU. Likewise it has maintained its home garden programme seeking new and improved techniques to ensure that vegetables are nutritious and at the same time, profitable to grow. ARC with the help of AVRDC and other international research institutions has established its own germplasm collection. Now, it is one of the few centres with a rich source of vegetable germplasm in this region.

Apart from the five-month vegetable production and research course, ARC also coordinates and at times supports short term training courses in and out of Thailand. ARC's research findings, activities, and other relevant information are disseminated to its network, training alumni and other research institutions through publications, news releases and instructional materials. Through the years, ARC has focussed its attention on delivering improved varieties of its principal vegetables. To date, it has released in Thailand and other countries in Asia, a total of 14 legume varieties for large scale production.

In Thailand, the use of improved varieties increased up to three times the Thai national average yield for all crops; for tomato, the yield was ten times higher. The release of three tomato varieties developed at ARC enabled Thai farmers to produce the much preferred small, pink tomato, even during the hot monsoon season.

4.4 ROLE OF THE PRIVATE SECTOR IN VEGETABLE DEVELOPMENT

Since no improvement programmes have been initiated for many local vegetables such as kangkong, bitter gourd, taro, water spinach and yam bean, productivity in these crops has either declined or remained stagnant due to a lack of good varieties. In the case of cucumber and luffa, however, seed companies have supplied new varieties and production has improved.

The DOAE undertakes the multi-location testing of new vegetable varieties supplied by the universities, the Horticultural Research Institute and the private seed companies before these are released to farmers. The DOAE has excellent seed processing facilities, which are not being utilized at present. However, yield gaps are common between field trials and farmers' fields, probably due to deficiencies in the technology transfer programmes. Seed is the most important tool of the extension worker. The timely availability of seed to the farmer is vital to the success of an extension programme. Seed companies have been successful in supplying seed of many new varieties to the production sector, and have been instrumental in some varietal improvement programmes. There is a large number of vegetable seed importers and exporters. They are mainly responsible for the introduction, testing and distribution of a large number of open pollinated varieties and hybrids in the country.

During the last two decades or so, the Government of Thailand decided to liberalize the vegetable seed industry by inviting foreign investment. This has resulted in significant growth of the private seed industry, and at present, probably 80 percent of the improved seed is supplied by the private sector. Hybrid seed may be costly, but the production system today operates on unwritten agreements between middlemen and farmers. It is reported that the middlemen, who are aware of the way market forces operate, reach farmers in various regions and engage them as contract growers for crops that have immediate demand. Improved seeds, including hybrid seeds, are offered with the agreement to purchase all the produce at a pre-determined price. This agreement assures the farmer of a ready market for his/her produce. There is keen competition among the multinational and national seed companies that operate in the country to gain the confidence of the farmers to accept their new cultivars. The universities have also contributed to a small extent to the sector by joining hands with the private sector to support the industry, and have provided elite breeding material and trained agricultural graduates for the seed industry. The liberal policies of the government of Thailand have also boosted trade of seed to the neighbouring countries in the region.

In the informal non-organized seed sector, farmers produce seed of some indigenous vegetables, which is usually maintained and traded by farmers, and in some instances, purchased and distributed by seed merchants. However, the bulk of the vegetables seeds used in the country is imported. The government has certain restrictions on quotas in order to prevent over-supply, but there is no import duty on seed. About 75 percent of the annual needs is met by imports. In 1997, the country imported seed to the value of 395.1 million baht. Seed companies based here, also exported seed valued at 781.5 million baht.

As seen from the above, vegetable seed supply is monopolized by the private sector with over 50 companies and distributors. This also includes multi-national seed companies operating from this country, using it as a base for their regional operations. They have taken advantage of the low-cost labour for the production of hybrids, which are highly variant to satisfy local needs. However, it is possible to produce seed of some fruit vegetables only, as those crops that need low temperatures for successful bolting cannot be produced here. The government provides many incentives to the private sector to enable private companies to satisfy the needs of local farmers.

The hybrids that are produced by these companies are mainly for export and have been developed from imported parent genetic materials which are more adaptable to conditions in neighbouring countries. Most of the OP varieties are sold in Thailand. Local farmers depend heavily on imported hybrids that usually come from Taiwan and Japan. Seed production and post-harvest seed technology in the government sector is relatively under-developed, mainly because of the lack of sufficient local expertise, despite the fact that the DOAE has some of the best seed processing facilities in the region, but production capability needs improvement. Consequently, the government seed sector supplies only a negligible amount of seed to local farmers. The research institutions and universities conduct basic research in collaboration with seed companies to backstop the seed industry.

On the whole, the private seed industry which has received facilities from the government continues to expand, with some of the best multi-national companies competing with each other. This has benefited local farmers due to a large array of varieties being offered to them. The government policy of liberalizing the seed industry has paid large dividends, and at present, seed is not a constraint to the vegetable production development effort. The only concern is the plight of the low-income small farmers, who are compelled to use their own seed because they are unable to benefit from highly priced improved seed.

4.5 FAO'S ASSISTANCE

Vegetables have received the attention of FAO at global, regional and national levels through regular and field programmes. Considering the growing importance of vegetables in the Asia-Pacific region, FAORAP organized an Expert Consultation on Vegetable Crops in 1994; over 20 countries from the region, including Thailand, participated and concluded on the frontiers of hybrid technology in vegetable crops. On regional basis, Thailand has participated in the regional project on vegetables (UNDP/RAS/89/941), along with China, DPR Korea, Pakistan, Bangladesh and Nepal. Likewise, Thailand has benefited fully from the regional project (GCP/RAS/153 DEN) on the Establishment of a Seed Association for Public and Private Seed Enterprises in the Asia-Pacific region (APSA). During June 1999, FAO in collaboration with APSA and the Thai Ministry of Agriculture and Cooperatives organized a successful conference on seed policy issues covering the region. Thailand is also an active member of the on-going regional project on Integrated Pest Management in Vegetables (GCP/RAS/160/NET).

On the national level, the following FAO/UN projects supported the vegetable sector in Thailand:

1956/1957	-	Home Economics
1960	-	Nutrition Education Programme
1965	-	Nutrition Education and Training Programme
1975	-	Coordination of Plant Production Research
1984	-	Rehabilitation of Agriculture Sector with Provision of Vegetable Seeds (TCP/ THA/2313)
1984	-	Mushroom Cultivation (TCP/THA/4403)
1986	-	Vegetable Cash Crop Production for Opium Replacement in the Highlands of Northern Thailand (TCP/THAI/6653)
1987	-	Fruit and Vegetable Processing (TCP/THAI/6764)

Among the on-going projects, the TCP project (TCP/THAI/8821) is assisting mushroom training for disabled people, whereas, two TeleFood Projects (TFD-97/THAI/001 and TFD-97/THAI/002) are supporting farmers with vegetable seeds and seedlings, along with other related activities.

5 CONSTRAINTS

The constraints faced in the production of vegetables can be broadly classified as climatological, technological and others including socio-economic limitations.

5.1 CLIMATE

Other than the Northern region and parts of the Northeast, the rest of Thailand is hot and humid with little differences in day and night temperature and some seasonal variation in temperatures between summer and winter months. The Central and Southern parts of the country remain hot and wet throughout the year. The South in particular receives the benefit of the Northeast and Southwest monsoons. The conditions for growing most commercial vegetables are not suitable. Consequently, the South produces the least amount of vegetables. Depending on the monsoons is risky, however, as uncertainties in weather shifts, can cause problems with food production. The Central and Northeastern regions have facilities that can assist farmers to produce regular crops. The distribution of rainfall is satisfactory in the North and the cooler climate permits the production of a large number of vegetables. In the South and Central regions, unpredictable monsoons can bring about a high incidence of diseases and pests. Under these adverse conditions, vegetable production in summer is uncertain. During the winter months, many crops can be grown with the result that frequent surpluses occur during this period, while a shortage may occur in the summer months. The range of crops grown during summer is also limited. Those who subsist on vegetable diets have to depend more on leafy vegetables during warmer months. There is however a moderately well organized distribution and supply system within the country, but prices may go beyond the reach of the low-income groups for some vegetables.

5.2 TECHNOLOGY

5.2.1 Information database

There are practical difficulties in collecting accurate statistics on the status of the vegetable sector. Using surveys from markets and major production areas, it is possible to get estimates of production but the veritable millions of homestead gardens which also contribute substantially to the food budget of so many homes could never be accurately estimated. Data collection on vegetables is highly inadequate as fewer personnel are deployed when compared to other major food and industrial crops. Although Thailand is better equipped than most countries in the region for gathering information in vegetables, more investments are needed to upgrade information gathering systems.

5.2.2 Improved varieties and seed

The fact that most vegetable crops have shown insignificant increases in productivity clearly indicates the low coverage of new improved varieties across the country. The number of improved varieties available to farmers is also limited in that some crops and imported varieties do not always perform well under local conditions. Although floating kangkong is very popular in several regions, there are no developed varieties and growers depend on unselected local germplasm that grows in an almost semi-arid state. For popular vegetables such as Chinese kale, pak choi and chili, varieties are limited in number and local hybrid material is not available. The same is true for garlic and shallots, which are important

vegetables in Thailand. The climatic conditions are not favorable for garlic seed production and farmers have to depend on unselected planting material. Some attempts have been made to produce a true botanical seed source for such crops.

The indigenous vegetable seed sector is mainly dependent on farmer saved seed than the formal seed sector. Only semi-commercial and commercial farmers have access to good seed from public and private sectors. The rest of the farmers in rural areas have only their traditional varieties to depend upon. In 1994, Thailand produced 3.2 million tons of vegetables with an average yield of 8.6 t/ha. In 1997 the country produced 5.1 million tons of vegetables with an average yield of over 10.7 t/ha. Whilst these figures show some progress, the country is far behind performances recorded by the Republic of Korea, North Korea, Taiwan, China and Japan. Since 1994, the area under hybrid vegetables has shown an increase from about 300 000 ha covered for the major crops such as cabbage, Chinese cabbage, radish, cucumber, bitter gourd, luffa, cauliflower, water melon and melon. Although many private seed companies are active in this field, unless a greater percentage of area is covered, a quantum leap in vegetable production to meet the challenges of the coming years will not be easily achievable.

Vegetable varieties have to be developed by seed companies to cater to the climatic and soil needs of different agro-ecologies. The most vital input in vegetable production is a quality seed. Whilst it is nearly impossible for the extension services to provide superior seed to the entire farming community, small farmers who are the most disadvantaged need to be assisted in procuring seed from reliable sources. The ultimate success of production programmes will depend to a large measure on the availability of many varieties that can help year round culture of more important vegetables. Good seed ensures high yields and, consequently, better returns to farmers. If production targets are to be reached, hybrid seed should be made available even to small farmers at reasonable prices. Some effort should also be made to produce hybrids using indigenous germplasm which has better resistance to biotic stresses than imported hybrids.

There is an important category of under-utilized vegetables grown by rural communities across the country that needs improvement. These are currently produced largely from traditional varieties and they provide a large volume of food to low income communities. Any varietal improvement in this area will be beneficial to the rural farming sector since their food and nutritional value is well known. The seed production of several OP varieties could also help if appropriate community based seed programmers are organized to encourage lateral spread of such seed between farmer and producer groups in areas where seed is currently not available. The fact that some regions such as the South and Central are unable to produce sufficient vegetables is ample evidence that the seed supply of appropriate varieties is not adequate. This problem needs to be addressed through the dissemination of suitable varieties to such constrained environments.

The vegetable sector is plagued with pest and disease problems. Very few varieties are locally available that are tolerant or resistant to biotic stresses. In the summer season, production is seriously affected by these problems as waves of pests attack the crops. When farmers have to depend on seed imported from the temperate zones, their crops become highly susceptible to tropical pests and diseases or to unfamiliarly high temperature regimes. In earlier times, many hybrid sweet corn varieties were introduced from the United States and other countries which did not adapt well to the climatic conditions in Thailand. These varieties produced kernels of poor quality and succumbed to corn leaf blight caused by

Helminthosporium maydis. Solanaceous crops like potato and tomato were susceptible to bacterial wilt, late blight and high temperatures. Unfavourable weather conditions also affected the lettuce varieties introduced from the west which often suffered from leaf tip burn. Several cruciferous vegetables were affected by soft rot caused by *Erwinia corotovora*.

Specific constraints due to non-availability of good varieties and seed for major vegetable crops are briefly summarized below:

5.2.2.1 Lack of disease and pest resistant varieties

Vegetable production is a risky business in Thailand as most currently available varieties are unable to survive repeated attacks by pests and diseases. For example:

- In tomato, the absence of heat tolerant, bacterial wilt resistant, late blight resistant and leaf curl virus resistant varieties.
- In Chinese cabbage, heat tolerant and soft rot resistant varieties.
- In leaf mustard, lack of heat tolerant varieties.
- In cauliflower, lack of heat tolerant varieties.
- In all cruciferous vegetables, lack of diamond back moth resistant varieties.
- In lettuce, non availability of tip-burn resistant to late blight.
- In cucumber, lack of resistance to downy mildew disease.

Since farmers have to depend on seed supplied by private seed companies, commercial high quality hybrids and OP varieties seldom have the resistance to local biotic stresses. As a result farmers are compelled to use heavy doses of pesticides to produce crops from these imported varieties. It is however gratifying to note that the Horticulture Research Institute has launched a programme to develop indigenous vegetables which have built-in resistance to most pests and diseases, and which will minimize the use of harmful pesticides. Over one hundred species have been identified and collected for further development.

5.2.2.2 Inadequate production and distribution of quality seed

In the production and distribution of quality seed, the specific limitations are:

- The limited research investment into development of new varieties/hybrids and production of hybrid seeds, as national institutions have hardly embarked on any programme to utilize local germplasm.
- The inability of the public sector agencies to produce, process, and distribute seed of improved open pollinated varieties of vegetable crops.
- The lack of decentralized seed increase programmes using the informal seed sector.
- The unsatisfactory pricing structure for vegetable seed.
- The lack of seed certification service to ensure seed quality standards.
- The non availability of participatory seed programmes at farmer-level.

In Thailand about 75 percent of the vegetable seeds of both open pollinated varieties and hybrids is supplied by 50 companies (multinational and local) operating in the country. Approximately 5 percent is supplied by government agencies, and the remaining 20 percent comes from seeds saved by farmers themselves. Cost of imported or locally developed hybrid seed, and even some OP varieties, is too high and resource poor farmers are seldom given the incentive to use quality assured seed by providing a subsidized price structure. Most hybrid seed costs are beyond the reach of the resource poor farmers, whereas, commercial growers can easily afford these high costs as seed costs amount to only about six percent of their total

production costs. One of the major constraints in this field is the lack of sufficient trained manpower to handle seed programmes. In recent years, however, there has been synergism in the formal seed sector where private companies have seemed to actively supplement and support government efforts to improve the seed sector.

5.2.3 Appropriate technology package

The development of appropriate technology packages is the collective responsibility of farmers, researchers and extension personnel. Such participatory programmes are not well organized to achieve high outputs. The traditional knowledge of farmers and the incorporation of their techniques into newly developed technologies would assure high adoption rates. This incorporation should encompass appropriate varieties, seed and seedling management, fertilizer use, water and pest management, and pre and post-harvest technologies. Such packages are needed for each ecological and socio-economic setting such as rainfed, irrigated, low input, high input and for homestead, market gardens, semi-commercial and large-scale production systems. Both research and extension need to take a holistic view to integrate all components of a production system. Due to the lack of a precise technology for each of the above situations, productivity has suffered, and gaps remain between potential and actual yields.

5.2.4 Post-harvest technology

Farmers are usually unaware of the correct pre-harvest practices required for each crop. For instance, withdrawal of irrigation two weeks before harvest of a potato or onion crop hardens the crop, which facilitates curing and long-term storage and reduces post-harvest losses. Harvesting of fruit vegetables with high moisture content should be done in low ambient temperatures and away from direct sunlight to reduce perishability and ensure better keeping quality. In Thailand, fruit flies attack every cucurbit crop unless the farmer has protected the crop by covering, as spraying with pesticides has no guarantee of success and is expensive and risky.

Most vegetables are bulky and perish within a short time if not carefully handled. Poor handling conditions account for over 30 percent of losses in vegetables. Unless leafy vegetables and some fruit vegetables are harvested at the right stage of maturity and carefully packed, losses between 10–30 percent can occur at the consumer level.

Unless a disposal system works with the least possible delay from the time of harvest and the time of disposal at retail outlets, losses are bound to happen. Having temporary storage facilities, preferably with temperature control, can reduce the losses. For more durable vegetables, such as potatoes, conditioned long-term storage is necessary.

Packaging of perishables is somewhat critical under local conditions. High ambient temperatures prevailing almost throughout the year make it essential to ensure adequate ventilation and moisture control on packages. Transporters may also pack vegetables very tightly resulting in high losses.

Most local markets have poor infrastructures to facilitate the efficient handling of perishable goods. Vegetables that come badly packed are stacked in open exposed areas, un-protected, and without adequate temperature control.

5.3. OTHER FACTORS

5.3.1 Market information and systems

Except for the contract farmers and those who are financed by middlemen, there are no production contracts with buyers for the majority of vegetable farmers. Crops are produced without any knowledge of the market demand; consequently, farmers are then at the mercy of middlemen who offer low prices. It is reported that the DOAE has recently launched a programme of organizing farmers into production groups who can negotiate prices. However, the production sector is so widely scattered, it will take much more personnel and effort to create a significant impact.

Low prices for the produce may also be due to the poor planning of a cropping calendar. Growers do not have a planned programme targeting market demand. Any crop grown a few weeks ahead of the main season will attract better prices. For example, advancing a tomato crop by two weeks earlier than the main season by raising seedlings well in advance, will help the farmer to get the first harvest earlier than others and obtain premium prices. Also, by choosing early varieties he/she could achieve the same result. Any crop slightly out of season, either early or late, means better profits.

It is often seen that the grower is not in tune with market intelligence. They are not aware of the specific needs of consumers. Consumer preferences can vary with different classes of consumers and if this information is known, production can be geared to cater to special consumer groups who are very quality conscious.

Many vegetable growers are ignorant about off-season production of vegetables. They are unaware of varieties to be grown, cultural practices to be followed, and the production systems necessary to raise successful off-season crops. Most farmers are unaware of the availability of different maturity groups of vegetable crops. The economic advantages in terms of saving on production costs by the choice of early, mid-season or late varieties needs to be explained.

The bulk of the vegetable produce is marketed through informal channels from growers to consumers in the absence of producer groups. The system operates with some success among the contract farming groups, which currently number about 131, and involve 500 000 farming families. These farmers grow crops under contract to supply exporters. Similar arrangements are only beginning to be established elsewhere.

Most collection centres in the growing areas are ill-equipped to handle large consignments of vegetables, especially during the peak vegetable season. Facilities for cleaning, trimming, grading and packaging are virtually absent. These centres only act as transporting outlets and do not provide any other assistance and services to farmers. No value addition to the vegetable produce is done here. However, the centres at the Royal Projects in Kanchanaburi and Chiang Rai are equipped with facilities to ensure proper handling of produce. The vegetable sector gets marginal support from governmental marketing agencies, and the entire industry is primarily a private sector operation.

5.3.2 Training and technology transfer

As mentioned earlier, high seed prices discourage farmers from using quality seed. Other than the semi-commercial and commercial farmers, high quality hybrid seeds are beyond the reach of an average small farmer. In cases where a middleman markets an expensive seed, small farmers neither have the purchasing ability nor the access to credit. Although farmers are trained to use good seed, it is not practiced due to several reasons. Farmer's training programmes seem to be somewhat ineffective as growers continue to use highly toxic chemicals. Either the extension messages are not reaching small farmers at the field level, or the farmers disregard the advisory services and pay more attention to representatives of chemical companies that operate at the field level.

The overuse of agro-chemicals poses a serious health hazard to consumers as well as affecting the export of fresh vegetables. Other than the professional growers who produce crops under contract for export projects, most farmers are still ignorant of modern production technologies. Sometimes, for economic reasons, the level of input used is far below recommended levels and hence productivity suffers. Actual yields obtained are far below potential yields for most crops. Knowledge on the use of fertilizers, pesticides, weedicides and on irrigation frequencies and levels needs to be improved.

After harvest, most farmers are not aware of methods to prepare the produce in a presentable manner for better consumer appeal. Cleaning, grading, trimming etc. are not carried out systematically. Farmers lack knowledge on the use of growth regulators to increase yields, enhance quality of produce, hasten maturity, and harden produce for better shelf life.

Poor nursery management technologies result in production of low quality seedlings, which affects the performance of the crop in the field. Very few farmers have knowledge of protected cropping to produce crops free of agro-chemicals or raise off-season crops of high value vegetables. Most farmers lack knowledge of IPM technology and organic farming methods except in areas where pilot projects have been carried out.

5.3.3 Extension personnel

The field staff are mostly general purpose extension officers who, in addition to other crops, are expected to oversee the extension work for vegetables. Therefore, it is difficult to develop competence on such a large number of crops when an officer is expected to transfer technology on over 20 vegetable crops. Extension officers are also expected to have sufficient exposure to various disciplines including crop varieties, cultural practices to be followed, plant physiology, pre and post-harvest technology, processing, marketing etc. Unless more staff are deployed specifically for these major disciplines, it becomes impossible for a single officer to develop even a low level of competence to handle technology transfer programmes.

There are wide gaps between demonstration plots and on-farm yields in almost every crop which may be due to weak linkages among research, extension and farmers. Since there are a large number of vegetables produced, there is a justification to have a separate cadre of vegetable extension officers at field level.

5.3.4 Credit facilities

Contract farmers carry out vegetable production on a highly professional basis. Their inputs match the modern technologies they practice. Credit is an essential ingredient in developing such high levels of production. In some parts of the country credit is offered by middlemen, who also purchase the crops at prices decided by them. In most instances these traders exploit farmers. Since small farmers cannot offer security they are unable to obtain credit from agricultural banks. Group formation may help in obtaining such credit if some assistance is provided by the government.

5.3.5 Natural resources

Large areas of marginal land could be considered for development if irrigation facilities are available, in order to spread vegetable production into new areas. Marginal rice lands are not being considered for diversification into vegetable growing. While improvements in productivity can be brought about by the use of appropriate hybrid technology, some increase in cultivable area will be needed to raise production levels in order to meet future needs. Rainfall is a limiting factor in some parts of the country. Conservation techniques such as water harvesting and the use of other agronomic options to raise short-season crops in such constrained environments may be needed. Rehabilitation programmes to utilize problem soils for certain hardy vegetables would help to expand production further. Thailand has experience in land reclamation, especially conversion of submerged soils using the ditch and dyke system. Diversification and inter-cropping of such lands with vegetable crops could be considered to help alleviate hunger.

The problem of water quality has posed limitations in coastal and inland areas where salinity and alkalinity occur. Development of suitable crops for such environments is another area for exploration.

In peri-urban areas, the issues of water and atmospheric pollution are important. The use of water polluted with city and industrial wastes for vegetable growing poses a serious health hazard as vegetables are mostly consumed fresh. As urban population increases, peri-urban vegetable production should receive due recognition.

5.3.6 Socio-economic limitations

Vegetables are an essential component of the Thai diet, and in recent years per capita consumption has gone up steadily. However, certain sections of the population still consume vegetables in amounts less than the recommended per capita intake of 73 kg per year. As indicated earlier, the present per capita availability of vegetables is only 60 kg. Nutrition intervention programmes to reduce Vitamin A and iron deficiencies in school children need intensification to cover the deficient areas of the country.

Farmers are either ignorant of technologies or disregard advice against the use of dangerous pesticides and fungicides for which a nationwide mass media programme to educate people is required. The pesticide companies should also be urged to cooperate with the government in the education programme.

6 VEGETABLES AND FOOD SECURITY

6.1 ALLEVIATION OF SHORTAGE

In areas like hilltribe villages, where there is inadequate rice supply, potato is utilized as a staple food. Similarly, in the typhoon season on the distant islands of the South, long-keeping vegetables like pumpkin and wax gourd are consumed instead of rice, as food transport from the mainland is irregular.

6.2 NUTRITION SECURITY

Vegetarians, a minority group of health conscious people, consider vegetables as staples. When modern medicine cannot help, people suffering from particular cancers have been looking at the alternative systems of medicine and vegetarianism as a way of healing. Vegetables are rich sources of essential minerals and vitamins. Nutritional problems usually occur in rural school children, particularly in border areas. In these areas the School of Agriculture Lunch Project provides clean and nutritious meals to school children. Students and their parents are encouraged to grow vegetables in their school premises and the produce is used for preparing lunch. The project is not only aimed at alleviating nutritional problems in school children, but also at educating and creating awareness amongst children about vegetable production technologies, food preservation, processing and nutrition.

6.3 STABILITY OF SUPPLY

Long keeping vegetables such as potato, pumpkin, wax gourd, watermelon, onion, yam bean and sweet potato can be stored even in normal conditions. Fast-growing crops like *kangkong, pak choi*, Chinese kale and lettuce can ensure a stable and year round supply. In southern areas hit by typhoons, seeds of such fast growing vegetables are distributed for promoting home gardening so that a stable supply of vegetables is maintained in the diet.

The availability of indigenous vegetables ensures stability of food supply. Many of these, like torvum eggplant, are naturally available along roadsides and in waste places; *kangkong* or water mimosa are harvested from canals, and young shoots of *Coccinia* are available from fences and trees.

Some vegetables such as cabbage, Chinese cabbage, sweet pepper, spinach and head lettuce cannot be stored under room conditions. Due to the high cost of cold storage, they are promoted as a year-round product alternately in highland and lowland areas. The highland cabbage can supply lowland markets in the hot season. Garlic grown as a crop after rice in Chiangmai is supplied to the South. Year round cultivation of chili pepper in the central plain can be supplied to highland areas.

6.4 ACCESSIBILITY TO FOOD

Thai people have access to vegetables through several channels. A large number of indigenous vegetables exist in tropical rain forests along jungle tracks, roadside or in wasted areas as wild weeds. The local people living in these areas are usually aware of these vegetables and use them in their daily diets. Further research and documentation is needed to assess the nutritional significance of these indigenous vegetables.

Home gardens provide a supplementary source of essential nutrients in the family diet through products obtained from self-sustainable farming of vegetables grown in pots and school gardens. The group activities of 'Farm Housewife' include the preservation of vegetable as, fermented, pickled, dehydrated or dried, and sometimes canned products. These also play a role in vegetable supply.

Vegetable gardening for village markets is usually a larger enterprise than home gardening, with the purpose of providing vegetables for a community. This is commonly seen in the morning and afternoon markets of the communities in northern provinces. The availability of crop species varies according to seasons. Often, a middleman collects vegetables from communities for marketing in nearby towns.

The vegetable farms for market-oriented production are aimed to supply vegetables for the towns and cities, and the farms are usually near the populated centers. Many kinds of vegetables are grown at any one time. A new crop is planted immediately after harvest or sometimes before the standing crop is harvested, and most of the crops grown are fast growing.

Large-scale commercial farming, far from population centres, requires better transport facilities and information technologies, permitting the supply of vegetables not only in the region but also to export markets and food-processing plants. Big consumers or retailers normally have access to vegetables through wholesale markets. In Thailand, there is at least one big wholesale market in each region of the country.

6.5 SELF-SUSTAINABLE FARMING

"What's important for us is to have decent living and sufficient food to eat, as well as to maintain a self-sufficient economy. The key word 'sufficient' here implies that one should aim at becoming self-reliant. But to various economists, this line of thinking is considered to be obsolete because every economy needs to carry out trading activities under a market economy, not a self-sufficient economy - it is not attractive. However, Thailand is very fortunate and blessed because we can produce enough quantity to feed our people. Assuming that we can substitute the current market economy by a self-sufficient economy, if not entirely or by half, then at least one fourth, we will be sustained."

The above excerpts taken from His Majesty the King's Royal Speech delivered on the occasion of His Birthday Anniversary, 4 December 1997 illustrates the understanding of His Majesty in the true nature of the problem facing the Thai Society, one which is based on agriculture. His Majesty has stressed the idea of making things simple by taking into consideration the local environment and its natural state, in order to solve or alleviate the immediate problems. That is, leading a decent life and producing enough food to eat.

The impact resulting from the current national economic crisis not only leads Thai people to dramatically cut down their living expenses, but also to search for suitable and effective ways to live through the turmoil. The present situation illustrates the viability of His Majesty's approach to decent living or self-sufficient economy or self-reliant communal economy as being one of the appropriate and correct strategies to weather the present storm faced by the nation.

An effective and tangible representation of His Majesty's valuable concepts on decent living or self-sufficient economy can be seen from his New Theory, which is a concept aimed at assisting individual farmers possessing a small piece of land, in the proper management of the utilization of land and water for agricultural activities in order to create optimum benefits.

The key to the Theory is to maintain flexibility; that is, to adjust the land allocation ratio to suit the local conditions of the area. The area should consist of various farming activities carried out in an integrated manner, such as cultivation of vegetables, fruits, other plants, or rice farming, as well as constructing a pond to provide supplementary irrigation. The first priority is to produce enough for household consumption. After that, proceeds from the sales of surplus can be used to buy other necessary goods that the farmers are lacking or cannot produce by themselves.

The small piece of land is divided into four parts consisting of a pond to store water for cultivation as well for raising aquatic animals and plants; rice farming providing sufficient food for family consumption all year round; fruit and other perennial trees, vegetables, field crops, etc., from which farmers can sell the surplus from their own needs to the market; and space for housing, animal raising, and other purposes. The ultimate goal is to ensure that during the dry season a sufficient amount of water will be available for cultivation; farmers will have enough rice to eat all year round, and will become self-reliant economically.

7 FUTURE STRATEGIES

Keeping in view the importance of vegetables in both food and nutrition security, it becomes necessary for the nation to ensure sustainable vegetable production. Presently, the vegetable production is neither sufficient and stable in its supply nor adequate to meet nutritional standards. This is due to low crop productivity, inadequate water resources, erratic rains, and natural disasters such as typhoons and floods.

7.1 RESEARCH PRIORITIES

While area expansion may not be easily possible, it would not be difficult to increase crop productivity. Higher production can be obtained with the help of improved varieties and F1 hybrids, advanced agro-techniques, adequate water resources, water management and improved plant protection methods. In view of the fact that the national requirement for vegetables is likely to increase in the coming decades, to keep pace with the rising population, research priorities and programmes have to be reoriented and intensified, specifically with respect to need-based applied research. The varietal improvement should be targeted mainly towards breeding for resistance to diseases and insect pests, earliness and better keeping quality and transportability. Varieties have to be developed also for abiotic stresses, especially suitable for various agro-climatic conditions, like rainfed conditions, heat tolerance and problem soils (saline and alkaline). Early maturing varieties will fetch higher prices in the market than normal varieties, and in some cases these may escape the attack of a disease or insect. Efforts may be concentrated to identify genetic sources of resistance within both indigenous and exotic germplasm. Germs for disease resistance may be incorporated into the existing varieties through protoplast fusion/sotuatic hybridization, recombinant DNA technique and coat-protein in case of virus diseases. However, the development of transgenics should invariably be taken up under an appropriate regulatory system within the country. Breeding for heat tolerance in cabbage, cauliflower, onion, carrot, lettuce and tomato also needs to be emphasized.

7.2 GENETIC RESOURCES

It is essential to undertake collection, conservation, evaluation and documentation of the existing biodiversity of the common native vegetables before these are lost. Domestication, cultivation and improvement by conventional breeding methods is useful. A similar approach is required in the case of under-utilized vegetables, especially those which have a wide distribution in nature in the Southeast Asian region, like coccinia, bitter gourd, luffa, wax gourd, amaranthus, horseradish tree (*Moringa oleifera*). In addition, a genetic base could be enlarged through the introduction of germplasm particularly from Asian countries (Nath, Velayudhan and Singh, 1994).

7.3 F1 HYBRIDS

With the use of F1 hybrids, crop productivity can be increased manifold within a short period. Besides, hybrid cultivars have other useful attributes too, like disease resistance, earliness, better keeping quality and transportability. Development of F1 hybrids should receive priority in crop breeding programmes. It may include development and utilization of male sterility, genic (GMS) and Cytoplasmic (CMS) self-incompatibility and gametocide induced male sterility.

Hybrid cultivars require better production technology than common OP cultivars, which is necessary for exploitation of their maximum potential. Undoubtedly, seeds of hybrid cultivars are expensive, but provide at least two to three times higher economic returns from their yield and quality as compared to open pollinated cultivars. Besides, the cost of F1 hybrid seeds is only six to ten percent of the total production cost. By adopting improved methods of seed germination and raising seedlings often under protected environment, it has been possible to drastically reduce the seed rate per acre.

7.4 AGRO-TECHNOLOGIES

Priority may be given to develop appropriate and cost-effective agro-techniques, including bio-fertilizers, integrated nutrient management, water management etc. suitable to different agro-climatic and soil conditions and cropping systems in a few selected vegetables. The effort should be made in order to narrow down the existing wide gaps between farm yield and potential yield.

Raising seedlings in low polyethylene or netted tunnels, in polygreenhouses or in insect-proof net houses will be beneficial in obtaining healthy seedlings sufficient to maintain the desired plant density with almost negligible seedling mortality in the field. It will also help in raising an early crop. Protrays may also be used for sowing of seeds. Perhaps it may be worthwhile to develop greenhouse technology for growing vegetables under a protected environment, like polygreenhouse and insect-proof net house, with proper ventilation and air circulation but without cooling, similar to those used in Israel, Spain and other countries. Protected cultivation will be helpful in getting an early and off-season crop.

7.5 PESTICIDES

Farmers often indiscriminately use chemical pesticides to control diseases and insect pests in vegetable crops, resulting in environmental pollution and heavy residual toxicity most harmful to humans and animals. The multiplicity of diseases and insect pests in most of the vegetable crops makes it difficult to effectively control them. Integrated Pest Management (IPM), though useful in minimizing the use of chemicals, has unfortunately not proven its success in vegetable cultivation in the open in many developing countries because of small holdings, intensive cultivation, several crops grown in the same season, and numerous diseases and insect pests. Nevertheless, it may be useful to take up research on IPM using various methods including predators and parasites, bio-pesticides etc. in a few important vegetable crops. A bio-pesticide like Trichogramma is useful in controlling soil-born fungi like Pythium and Rhizoctonia in the nursery. Botanical or plant derived pesticides, like neemicide from neem, and a few others, have been found to be useful in controlling insect pests. Neem kernel extract has been reported to be effective against diamond back moth, which is a serious pest of cabbage, cauliflower and other crucifers in Asian countries, including Thailand. Trap crops are also useful in controlling this pest. Planting mustard around the cabbage field, or planting a few rows of it in between the rows of cabbage, minimizes the damage caused by the diamond back moth. Investigations on such aspects would prove useful.

7.6 ORGANIC FARMING

The recently launched organic farming project in Bangkok by His Majesty the King of Thailand is commendable. Organically grown vegetables have a great potential for export,

besides sale in domestic markets. However, many aspects of the organic farming system have to be studied in detail and standardized e.g. utilizing composts, greenhouse, oilcakes, bonemeal, vermiculture, bio-fertilizers (azetobacter and others), bio-pesticides etc. Besides, the cost-effectiveness of this system is equally important. In organic farming the general experience of farmers is that initially it takes at least three years to attain normal crops yields. Nevertheless, organic farming is a challenging venture.

7.7 POST-HARVEST HANDLING

Vegetables, being perishable, are subject to heavy losses after harvesting and during transportation. The post-harvest losses in vegetables are about 30 percent in Thailand. However, post-harvest handling of vegetables for processing and export by contract growers in commercial farms is better, with less wastages than in small-scale farming. Research on post-harvest technology may be focussed on physiological, pathological, entomological and engineering aspects, with a view to developing a package of practices to be adopted by small as well as large scale farmers. This technology should be simple, cost-effective, efficient on both small and large farms and dependable on different agro-climatic conditions.

7.8 STORAGE FACILITIES

Since most of the vegetables are perishable, cold storage facilities on farms and market outlets should be provided to reduce post-harvest losses. It will also enable the transportation of fresh vegetables from centres of excess production to deficit areas or to distant markets in large cities which have higher demands. Refrigerated vans for transport are necessary in such cases. The government should consider providing subsidies to farmers for cold storage and refrigerated vans, if possible. Furthermore, the public sector may encourage the formation of cooperative societies of farmers, preferably involving small farmers in contract farming. The cooperative society may also collect the vegetables from farms, grade them, store them in cold storages and transport them in refrigerated vans to market outlets in cities from where they may be sold directly without any involvement of wholesalers and middlemen. The cooperative society may establish a network of air-conditioned kiosks or shops in the city for selling vegetables at a pre-fixed price daily to consumers. It would ensure stability of supplies and prices of fresh vegetables of good quality, which will benefit both the growers and the consumers. To begin with, such a venture may be taken up in Bangkok and if successful, it may be adopted in other cities.

7.9 QUALITY SEEDS

Seed is the basic need for any crop production programme. In Thailand, vegetable seeds of both open pollinated varieties and hybrids are supplied (75 percent) by about 50 private seeds companies and only five percent is supplied by the public sector. The rest, 20 percent, is from seeds saved by farmers. All important aspects of seed technology require intensive studies. Standardization of seed production techniques, especially with respect to hybrid seed production, deserves special attention. Other studies may include advanced methods such as: electrophoresis, DNA makers, DNA-fingerprinting etc. for testing the genetic purity of parent, hybrid, and open pollinated varieties.

A few other techniques, like seed coating, pelleting, enhanced seeds, pre-germinated seeds, seed colouring etc., as well as methods of seed storage and packaging using different types of packing materials etc. may be worth investigating for their usefulness in the country.

Seed certification standards may be formulated which are to be followed by all seed producers. An independent seed certification agency/authority may be set up. It is always necessary to have an independent seed certification system separate from seed production agencies.

7.10 SEED MULTIPLICATION

The public sector may consider expansion of the present production of vegetable seeds, which is only five percent of the total seed requirement. Since there are already good infrastructure facilities available, it should not be difficult to organize large scale seed production within the country. This will also be useful in popularizing some of the good varieties already developed by government institutions among local farmers. Seed production for temperate vegetables (onion, carrot and crucifers) would, of course, be limited to the cooler regions of the country.

The public sector seed production will be helpful in import substitution to a great extent, save foreign exchange, provide gainful employment opportunities to young men and women in rural areas, especially in the case of labour intensive hybrid seed production, besides providing remunerative and stable income to small contract growers. The other advantage will be that farmers can depend on the performance of seeds of the varieties adapted to local agro-climatic conditions. It is also necessary to test the performance of imported varieties or hybrids in different agro-climatic conditions. Large quantities of seeds are allowed to be imported by the government. It will also be in the national interest to get the seeds of the best performing varieties or hybrids produced by foreign companies, into the country. The import substitution of vegetable seeds and their production in the country may be taken up in a phased manner.

7.11 EXPORT

The export of F1 hybrid vegetable seeds produced within the country by private seed companies may be encouraged in view of the fact that, it is not only remunerative to farmers, but also being labour intensive it generates employment opportunities in rural areas, besides bringing in much- needed valuable foreign exchange into the country. Similarly, export of both fresh and processed vegetables should be encouraged and expanded, if possible. The potential for the export of organically grown vegetables may be explored and encouraged in the future. The export of seeds, as well as of fresh and processed vegetables grown on commercial farms which adopt high standards of production and quality control, will prove helpful in upgrading the production technology and quality of local production.

7.12 MARKETING

The marketing of perishable vegetables is a difficult task in most of the developing countries. The main constraints are unstable supplies, uncertain demands, highly fluctuating prices, inadequate storage facilities, and problems in the long distance transportation of vegetables from production centres to distribution outlets in cities. Weather forecasting will be useful to farmers in vegetable growing regions, especially in those where weather is often uncertain such as in the more erratic southern and central regions. Similarly, market intelligence and forecasting is necessary to monitor demands, and thus help the farmers in efficient crop planning. A well-regulated marketing channel is required to avoid shortages, discourage hoarding, and to control prices in the market to a great extent. The market information

service, with the help of modern information technology, can be easily made available to farmers and planners. On the basis of the weather and market information available, the government may undertake crop planning region-wise, by convening regular meetings with extension and development staff before the start of each crop season. This planning would also be necessary to ensure adequate supply of seeds to farmers. In the absence of a database, crop planning may be difficult but, it would be useful for the national interest.

7.13 HUMAN RESOURCE DEVELOPMENT

Human resource development is an important foundation block for building any institution or programme. In the foregoing chapters, the relevance, importance and contribution of vegetables to food security have been discussed and highlighted. In order to maintain and improve upon activities of the vegetable sector, staff development in research, extension, and marketing will be essential. To ensure continued research, highly qualified personnel with M.S. and Ph.D. degrees in different disciplines, particularly breeding, agronomy, entomology, pathology, processing and biotechnology, are a pre-requisite to the success of research projects. To cater to the needs of the crop fields and farmers, well-trained officers would be required to train the middle-level technicians or extension workers with high school or agriculture diplomas, who, in turn, will train the farmers. Thus, an appropriate forward-looking human resource development strategy and plan need to be developed, looking into the foreseeable future and the requirement of the personnel at higher, middle and lower cadres covering all administrative regions of the country. This plan should take into consideration both the quality and quantity aspects of production to facilitate development of the vegetable sector in the country.

7.14 RESEARCH AND EXTENSION LINKAGE

On the one hand, there are significant gaps between potential yields and actual on-farm yields or between experimental plots and farmers fields which need to be bridged. On the other hand, problems emanating in the field should be identified by the extension officers and brought to the attention of the researchers for developing appropriate solutions. Hence, strenghtening of linkages between the institutions and officials of research and extension can ensure better results.

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APPENDICES

APPENDIX 1

MAJOR VEGETABLES IN THAILAND
KANGKONG (Ipomoea aquatica Forsskal.)

Kangkong is also known as water convonvulus, water spinach or morning glory. Generally, it is propagated by stem cuttings.

Figure 6. Kangkong: packed in plastic bag, tied in bundle

The total area under kangkong increased from 82 818 rai in 1994 to 117 996 rai in 1998. There are fluctuations in production from year to year. Floating kangkong occupies a total area of 45 633 rai with a production of 47 773 tons, while upland kangkong occupied an area of 72 363 rai with a production of 79 525 tons in 1998. Floating kangkong is mainly grown in Nonthaburi and Bangkok, whereas upland kangkong is widely grown throughout the country and is most common in the East.

The recommended cultivars are :

PICHIT NO.1: An upland type, with light green stems, long narrow upright leaves, and less stem-suckers: the time period from sowing to first harvest is 55 days.

BAI PHAI NO.5: Another upland type, with dark green leaves and stems, popularly known as the bamboo-leafed type.

Research should focus on cultural practices for the cooler areas and a breeding program which should concentrate on developing varieties with tolerance to low temperature.

LETTUCE *(Lactuca sativa L.)*

The total area under lettuce in 1994 was 20 640 rai and decreased by 23.09 percent in 1998, probably because of land pressure in peri-urban areas as planting areas near the cities are being progressively reduced. The growing area was 15 874 rai in 1998 with a production of 20 186 tons. Since it is a highly perishable product, it is mainly produced near big cities such as Nonthaburi, Bangkok, Samutsakhon and Pathumthani.

The recommended cultivars are :

GRAND RAPIDS: a loose-leaf cultivar, which is slow bolting, heat tolerant, and resistant to tip burn. The leaf is light green, ruffled and fluted. The crop matures in 40–45 days and is popular in Thai markets.

BLACK-SEEDED: it is also a loose-leaf type; the plant is large and vigorous; the leaves are light green, highly frilled, crisp, and suitable for decoration or for salads.

BALLADE: this is a round-headed type which has crisp and highly palatable leaves. The cultivar is quite heat tolerant and suitable for high rainfall areas and is best suited to the tropical monsoon season. The head weight averages 800 gm.

Post-harvest handling needs to be improved. Suitable packing of leaf lettuce may be in opentopped polythene bags which are put in crates or boxes. Cooling or packing with ice keeps it fresh for longer periods.

Future breeding work should focus on the improvement for heat-tolerant cultivars. There are no germplasm collections in Thailand. Local selection is carried out by agricultural universities and little activity is being handled by seed companies.

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

Figure 7. Chinese kale : young stage, tied in bunches

The area under Chinese kale in 1994 was 81 619 rai and has steadily increased during the last five-year period by 38.9 percent to reach 113 336 rai in 1998. Production areas are widely distributed in all regions of Thailand, with 31 524 rai in the Central region, 21 130 rai in the North, 15 894 rai in the East, 24 505 rai in the Northeast, 26 342 rai in the West and 7 095 rai in the South.

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 kale has a very short growing season. In general, the cultivars fall into three types:

BROAD LEAF: it is the old type of Chinese kale. 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.

Research should focus on optimizing cultural practices, in particular pest control using chemicals or bio-pesticides with less harmful residues. The development of integrated pest management (IPM) techniques against the diamond-back moth should be further pursued as this is the main production constraint faced by farmers.

The National Gene Bank, agricultural universities and seed companies have their own germplasm collections. Selection for narrow leaves and thick stems is a common objective.

PAK CHOI *(Brassica chinensis L. var.parachinensis* Bailey)

Figure 8. Pak choi, growing in nethouse

During the last five-year period the production area of pak choi has been steadily increasing. The planted area was 67 403 rai in 1994 with a 27.8 percent increase in 1998. The planted area in 1998 was 86 145 rai with a production of 146 668 tons. It is one of the main leafy vegetables of the Brassica group of crops in Thailand. It is currently being promoted to be grown under the insecticide-free program for healthy food due to its popularity. Pak choi is mainly cultivated in the Northeast (21 687 rai). North (20 799 rai) and West (14 451 rai). The provinces that have large-scale planted areas are Nakhonsawan, Lamphun, Nakhonratchasima, Nonthaburi and Pathumthani.

Pak choi is grown mainly from open-pollinated cultivars. These are:

NAN 60 (DOA): large plants with long petiole.

BANGLUANG 006 (DOA): the plant is large, stout, with a long petiole and less branching. The leaves are thick, green and oblong. It is suitable for any tropical climate and is both heat and disease tolerant.

KRUNG THEP 170 (Chia tai): the plant is vigorous, large, disease tolerant, bolt-resistant and has less branching. The leaves are large, green and slightly wavy.

The potential to genetically improve pak choi using the variation in presently available cultivars seems to be limited. Germplasm collections are maintained by the universities and the Department of Agriculture. Breeding efforts are normally aimed at developing cultivars with thick leaves and petioles. Research work on integrated pest management is required. More research on organic farming and chemical-free production with the advantage of its fast growth, would promote pak choi production and consumption.

CABBAGE *(Brassica oleraceae L.var.capitata L.f.alba DC.)*

The planted area under cabbage in 1994 was 45 408 rai; it has been increased by 39.2 percent to reach 63 220 rai in 1998 with a production of 188 914 tons. Leading production regions were the north (164 232 tons) and the northeast (13 858 tons) in 1998. Provinces of high production are Nan, Payao, Maehongson, Tak and Phetchabun.

All cabbage seeds are imported from temperate countries. Most of them are hybrid seeds. Japanese seed companies are the leaders in the cabbage seed market. Recommended cultivars/hybrids are:

The 60-DAY NO.1 (Chia Tai): a uniform hybrid, highly heat-tolerant, flat-globe head shaped with an average head weight of 1.5–2.0 kg. It is a sweet-flavored hybrid with crispy leaves. The crop matures in 55–60 days after transplanting.

KY-CROSS (Japanese hybrid): it is widely cultivated as it is heat-tolerant. The head is a flat-globe with blue-green leaves and with an average weight of 1.6 kg. It is suitable for growing from the latter part of the rainy-season to the beginning of the cool season.

COPENHAGEN MARKET (Chia Tai, OP): the cultivar is best suited to the end of the monsoon or the beginning of the cool season. The round heads are compact, with thick leaves and are of bright greengrey colour. Maturity is 70–80 days after transplanting.

Cabbage will remain an important crop and production is expected to increase in the future. Heat-tolerant cultivars enable cultivation at lower elevations, but market gardening will continue to prevail in the highlands because of higher yield potential, better head quality and fewer disease and pest problems. Introduction of effective methods of integrated pest management (with emphasis on diamond back moth control) are much needed.

CUCUMBER (*Cucumis sativus L.*)

During the years 1994–1998, the area under mini cucumber increased whereas the area of long cucumber decreased. This is probably because the mini cucumber fetches a more attractive price. The total extent for all types of cucumber was 170 184 rai with a production of 303 853 tons in 1998. Cucumber occupies the fourth place in importance in Thailand, following chilli, baby corn and garlic. It is cultivated in every part of the country, with a major concentration in the Northeast - 17 838 rai with a production of 34 875 tons for mini cucumber and 21 315 rai with a production of 58 722 tons for long cucumber. The Western region is the second largest producer with an area of 37 294 rai and a production of 52 470 tons of the mini type; and 8 135 rai with a production of 16 153 tons of the long type.

Figure 9. Ditch-and-dyke : planting bed system, cucumber

The use of hybrid cucumber has been increasing during recent years. The contribution of F1 hybrids to increased productivity and uniform quality produce has been remarkable. The recommended cultivars/hybrids are :

BINGO (TSA): it is a mini cucumber cultivar that is very vigorous, with good branching and very high yield. Fruits are green at the shoulder and slender, with an average size of 4 × 12 cm. It is a very early cultivar that gives the first harvest in 32–33 days after planting.

LANNA (Eastwest): a mini cucumber cultivar that is vigorous with a high yield; fruits are whitish green, stout and have characteristic white spines.

MODEL 148 (Chia Tai): a mini cucumber type, with vigorous growth and high yield. The fruit is green, with an average size of 4 × 11 cm and weight of 100 gr. It has a long shelf-life; the first harvest is 30 days after sowing.

MUMMY (Chia Tai): it is a medium-long cucumber with uniform green fruits and high yield. It has a higher percentage of female flowers which set fruit on the lateral and main stems. Fruit size is 4 × 16 cm. with an average weight of 160 gr. the first harvest is 35 days after sowing.

NINJA (Chia Tai): this cultivar has a long type cucumber. Its popularity is due to the high yield and straight uniform fruit. The fruit set is on the lateral and main stems. The fruit is 5.5 × 22.5 cm. and 310 g in weight. Harvesting commences at 35 days after sowing.

Quality standards of cucumber will be elevated through the use of F1 hybrids as well as through the application of improved cultural practices. Better methods of irrigation and fertilizer application are currently being applied. Export of cucumbers should focus on processed products, mainly pickled cucumber in brine or vinegar. Important germplasm collections are available at Kasetsart University, Department of Agriculture and the National Gene Bank. Breeding work should focus on disease tolerance and long shelf-life of cucumbers.

YARD LONG BEAN (*Vigna sesquipedalis L.*)

Between the years 1994–1998, the planted areas have increased from 108 065 rai to 127 807 rai with a production of 173 779 tons. The crop is commercially cultivated as well as grown by home gardeners in every region. However, the major areas of cultivation are in the West (44 349 rai), the Northeast (22 732 rai) and the East (21 072 rai). The important provinces for yardlong bean production are Nakhonpathom, Petchaburi, Ratchaburi, Pathumthani and Nonthaburi.

Figure 10. Farm product : yardlong bean

Yard-long bean is a self-pollinating crop. Pure line cultivars are generally used as they maintain genetic purity over many generations. Farmers are, therefore, able to use their own seed. Recommended cultivars are:

BANGBUA THONG: a high yielding cultivar with long green pods, approximately 65–70 cm in length.

R W 24: this cultivar is well suited to the cool dry season. The seeds are half-white and half brownish-red. The pods are long and light green.

NEGRO: this cultivar has dark green pods with a purple tip. The pods are medium-long, and the texture is very firm. It grows well in any tropical climate. The seeds are black and hence the name of the cultivar.

GARLIC (*Allium sativum L.*)

Figure 11. Garlic : provincial market (NE)

The recorded area under garlic in 1994 was 154 391 rai and increased to 172 958 rai in 1998. Common garlic or the smallheaded type is widely grown while large-headed garlic is seldom cultivated probably due to progressive reduction in bulb size under local conditions and the consumer demand for the small type. In 1998, garlic was only second to chilli, with a production of 350 186 tons. For climatic reasons and availability of irrigation facilities, the cultivation is mainly confined to the North where the crop covers an area of 145 498 rai with a production of 305 938 tons and the Northeast which has only a limited area of about 15 163 rai under garlic with a production of 21 694 tons. Other regions shared small production areas with no production in the South in 1998. The important provinces for garlic production are Lamphun, Maehongson, Tak, Lampang, Chiang Mai and Sisaket.

Garlic is extremely variable in species with many distinct cultivars (clones) known in cultivation. Each region has its own cultivars. Thailand growers classify garlic cultivars into three groups. These are:

EARLY CULTIVAR GROUP:it is the smallest-headed type; maturity is about 75–90 days after planting. This cultivar is a native to Sisaket province.

MEDIUM-EARLY CULTIVAR GROUP: this is also a small-headed cultivar; maturity is about 90–120 days after planting. This cultivar is a native to Chiang Mai province.

LATE CULTIVAR GROUP: this is a large-headed type; maturity is about 150 days after planting. This cultivar is a native to China. This type needs a longer period of low temperature for bulbing, and the production is, therefore, very much limited under local conditions.

Research should emphasize on cultural practices for yield improvement and for good quality. Clonal selection could be carried out for virus eradication and for large-headed cultivars with

early maturity. Vegetatively propagated germplasm is maintained by the Department of Agriculture.

CHILLI (*Capsicum fruitescences L.*)

It is considered to be the most important vegetable crop in Thailand. In 1994, chilli covered an area of 254 246 rai which had increased to 435 194 rai in 1998 with a production of 441 033 tons. The Northern and Northeastern regions of the country continue to be the main producers of chilli. The major provinces of chilli cultivation are Nakhonsawan, Sukhothai, Tak, Nakhonratchasima, Ubonratchathani, and Nakhonphanom.

Figure 12. Chilli : green, bird pepper (white & red fruits)

There are no standard cultivars of chilli in Thailand. It is extremely difficult to maintain purity of any cultivar for a long time. The crop is mainly raised from farmer-saved seed. The three major cultivar groups of chillies grown in the country are:

BIRDS EYE CHILLI GROUP: it represents the most pungent chillies grown for the fresh market as well as for processing into dry chilli. The fruit size is rather small, 2–3.5 cm long. Popular names of this group are Jinda, Yodsoen, Huarea and Huaysithon.

BANG CHANG GROUP: the chillies of this group are characterized by a dark green type of hot pepper fruits highly adaptable to hot and humid areas. The fruit length reaches 5–10 cm. Popular names of this group are Mun-Banchang, Chee Fah, Mun-Phichai, Ban-Kham pepper and Red Pepper.

YUAK GROUP: the chillies of this group are yellow-green, waxy and mild flavored. The fruit lenght ranges from 15 to 20 cm. The group is represented by local selections known as Prik Yuak, Prik Nhum and several others.

Anthracnose is a major disease that affects the ripe fruit and reduces marketability. Proper crop management, use of disease-free seed and prevention of its spread from affected plants by spot spraying can minimize losses. The major pests are thrips, aphids, mites, and the chilli pod borer. Production can be further developed if good cultivars are identified and quality seed is made available to traditional areas. Hybrid chilli has been only partially successful due to the high price of seed and low pungency. Germplasm collections are maintained by the National Gene Bank, universities, and the national agricultural research institutes. Ongoing breeding programs are mostly for yield, earliness, pungency, flavour and colour.

TOMATO (*Lycopersicun esculentum* Miller.)

Between the years 1994–1998 there was an increase in the planted area of table tomato by 18.1 percent. Processing tomato is grown once a year as a crop after rice, while the small-

fruited table tomato is grown year round. The total area of table tomato in 1998 was 24 273 rai with a production of 50 018 tons. The principal regions that cultivate table tomato are the West (8 118 rai), the North (8 032 rai) and the Northeast (5 467 rai). The provinces of large-scale production are Nongkhai, Sakhonnakhon, Nakhonphanom and Kalasin.

Figure 13. Seeda tomato : pink fruit, locally selected

In Thailand, farmers still use local cultivars (landraces), which are the small-fruited types such as Seeda, Seeda-Pakchong and also the selected lines Seedathip and L-22 which are well adapted to the rainy season. It may be expected that in the coming years landraces and local open pollinated cultivars will be replaced by F1 hybrid cultivars like Somtam (Eastwest, F1), S16 (TSA, F1), Valentine (Seminis, F1) and Seeda 013 (Chia Tai, F1). Table tomatoes of largefruited cultivars are mainly the processing types such as VF-134, Roma-VF, Lima-VF, Peto 4165 and Peto 4225.

Tomato breeders have accomplished a great deal in the past, including improvements in yield, disease resistance, adaptability to environments, processing quality, and others. However, Thailand needs more improvements of its own cultivars, especially the small-fruited type table tomato. The Germplasm collections are maintained by the universities in agriculture, the Department of Agriculture and local seed companies. Thailand exports large quantities of canned tomatoes and small quantities of fresh tomatoes to neighbouring countries.

ASPARAGUS (*Asparagus officinalis L.*)

The asparagus planting area decreased from 92 874 rai in 1994 to 46 897 rai in 1998, with a production of 31 763 tons. This was due to the reduction in demand from abroad. The production areas are mostly in the West (44 411 rai) and the Northeast (2 367 rai). The demand and price fluctuate from year to year. Provinces which predominate in cultivation are Ratchaburi, Prachuabkhirikan, Kanchanaburi and Nakhonpathom.

Most asparagus cultivars are being introduced by private companies. They have been selected for suitability to the tropics. They are recommended as being disease tolerant, with large tips, tender flesh, and good flavour. Such cultivars are grouped as follows:

OP-CULTIVARS: California 309, California 500 and Mary Washington.

F1 HYBRID CULTIVARS: Top A, Brock's Improved and Imperial (UC 157).

Asparagus is an important export vegetable (fresh green spears as well as frozen and canned white spears). There is a fluctuation in the production of asparagus for export due to world competition and the uncertain environment in world-trade agreements on tariffs. There is an

increasing interest in fresh asparagus locally rather than the processed product. There is a need for appropriate field maintenance of stems and crowns in relation to quality improvement of spears. The major challenge is to develop cultivars which are better adapted to Thailand's conditions. There are no germplasm collections in Thailand. Breeding work is mostly carried by academic institutions for the improvement of yield and quality.

OKRA (*Abelmoschus esculentus L.*)

Okra production has been encouraged since 1980 due to export demand. In 1998 the total area under okra was 5 112 rai with a production of 9 759 tons. Okra is mainly grown in the West (1 989 rai), Central region (1 472 rai) and the North (1 106 rai), within a distance of 200 km from Bangkok for convenient transportation. Provinces of major cultivation are Ratchaburi, Nakhonpathom, Suphanburi, Nonthaburi and Nakhonsawan.

Figure 14. Okra : harvesting

Five-ridged cultivars are the most acceptable type. They are represented by the following cultivars :

OP-CULTIVARS: OK No.5 (KU) - the cultivar is vigorous, high yielding, widely adaptable and tolerant to diseases. It is good for the fresh market as well as for processing into frozen okra.

F1 HYBRID CULTIVARS:

a) **Jubilee 047 (Chia Tai, F1)** - this highyielding cultivar produces dark green, five-ridged pods. The plant is strong with short internodes and good disease tolerance.

b) **Jackpot 039 (Chia Tai, F1)** - this cultivar is vigorous, disease and insect tolerant, and a prolific bearer with large pods which are light green in colour.

Figure 15. Okra: grading, plastic-box packing

Okra will remain an important export commodity as a fresh or frozen vegetable. The major export market is Japan. The production areas are confined to irrigated land where

transportation to collection points can be made within two hours after harvesting. Okra production improvement will greatly benefit from reducing the dependence on pesticides. Cultivars with resistance to important diseases and pests should be given priority when selecting for production. Germplasm collections are maintained by the National Gene Bank, Kasetsart University and the Department of Agriculture. Local okra landraces are at a great risk of genetic erosion because growers have switched to imported commercial hybrid cultivars.

BABY CORN (*Zea mays L.*)

From 1994 to 1998 the area under baby corn has increased by 64.9 percent. Baby corn planted area in 1998 was 173 832 rai with a production of 215 000 tons. The main areas of production are in the Western region (122 347 rai) and the Northern region (43 725 rai). The major provinces of baby corn production are Kanchanaburi, Nakhonpathom, Ratchaburi, Nakhonsawan and Nakhonratchasima. In the irrigated areas farmers can grow 3–4 crops a year, taking 60–70 days for each crop. The dehusked yield is 200 kg/rai. Ratio of husk-ear to dehusked-ear is 7:1.

Farmers can grow any type of corn (Zea mays) to produce baby corn. However, due to the problems of high seed cost and downy mildew susceptibility in other types, the downy mildew resistant field corn is used such as Rangsit 1 and Suwan 2. The sweet corn and its hybrids although having more attractive young cobs their seed prices are much higher. Such cultivars are Super Sweet (OP) and G. Baby 1127 (F1).

Thai exports of canned baby corn will remain stable even during the economic crisis. Asian markets can absorb baby corn products. Breeding of baby corn should focus on the high quality of young cobs and downy mildew resistant cultivars. Large germplasm collections of corn are maintained at the Kasetsart University, the Department of Agriculture and local seed companies.

WATERMELON (*Citrullus lanatus* Thunberg.)

Figure 16. Watermelon: piled under shade in the field

There was a decrease in the area under watermelon by 19.2 percent from 1994 to 1998. During this period, the area decreased from 187 993 rai to 151 883 rai with a production of 490 980 tons. The most important producing regions are the North (50 867 rai) and the northeast (45 156 rai), whereas the south and West have moderate production and the East and Central regions are producing the least. The major watermelon producing provinces in the country are Tak, Phayao, Sukhothai, Nakhonratchasima, Ubonratchathani, Nakhonphanom and Prachuabkhirikan.

Some cultivars grown in Thailand have been bred in the country and some others have been imported. Recommended cultivars are:

SUGAR BABY (OP): this cultivar is easy to grow as it is well adapted to local conditions. The fruits are round and very dark green. The flesh is deep red and sweet.

JINTARHA (KnownYou, F1): fruits are round and dragon-striped. The flesh is red, finely grained and firm.

TORPEDO (Known You, F1): fruits are oblong, dragon-striped, with a thin tough rind and good shipping quality; the flesh is red and crispy.

SWEET GIRL (Chia Tai, F1): it is the Charleston Grey type, with early maturity. The flesh is of bright crimson colour and very sweet. The thin but strong rind makes it durable for shipping.

BANPHAI (Chia Tai, F1): the plant is widely adapted with robust growth. The fruit is shortoblong, light green, with dark green stripes. The fruit weight is 2–4 kg. Maturity is 70–75 days.

The demand for watermelon cultivars in Thailand is for the small types which are ovoid to globular in shape and green-striped. They will also have to be hardy and fit for long-distance transportation. Watermelon is grown in sandy loam soils during dry weather as a crop after rice. There is a need for cultivars with compact plant type (short internodes), earliness and resistance to diseases such as fusarium wilt and anthracnose. Germplasm collections of watermelons are mainly maintained by seed companies.

APPENDIX 2

UNDER-UTILIZED VEGETABLES IN THAILAND

It is estimated that about 1 000 plant species have been used as food in Southeast Asia. At least 500 species are of indigenous vegetation and primitive cultivars (Siemonsma and Piluek, 1994). Some species are moving closer to human habitats and being cultivated in home gardens or mixed with field crops to obtain a more reliable supply for home consumption. It is necessary to explore the possibilities of exploiting newer plant species of cultivated crops to meet food requirements. Some indigenous species of under-utilized vegetables in Thailand are shown in the table below:

Some indigenous/under-utilized vegetables in Thailand		
English Name	**Scientific Name**	**Thai Name**
Cucurbitaceae		
Coccinia	*Cocinia grandis* Voiht	Phak tamlueng
Smooth luffa	*Luffa cylindrica* Roem	Buap hom
Bird bitter gourd	*Momordica charantia L.*	Mara khinok
Spiny gourd	*Momordica cocbincbinensis* Spreng	Fak khaao
Snake gourd	*Trichosantbes anguina L.*	Buap nguu
Solanaceae		
Nightshade	*Solanum trilobatum L.*	Ma waeng bruea
Torvum eggplant	*Solanum torvum* Swartz	Ma khua phuang
Hairy eggplant	*Solanum ferox L.*	Ma-uk
Leguminosae		
Water mimosa	*Neptunia oleracea* Lour.	Phak krachet
Nitta tree	*Parkia speciosa* Hassk	Sator
Nitta tree	*Parkia timonana* Morr.	Riang
Ipil-ipil (Lead tree)	*Leucaena leucocephala* de Wit	Kra thin Thai
Djenkol tree	*Archidendron jiringa* Nielsen	Cha niang
Siamense cassia	*Cassia siamea* Britt	Kheelek
Hyacinth bean	*Dolichos lablab L.*	Thua paep
Winged bean	*Psophocarpus tetragonolobus DC.*	Thua phuu
Sesban tree	*Sesbania grandiflora* Desv.	Khae baan
Sesbania	*Sesbania javanica* Mig.	Sano kin dok
Zingiberaceae		
Kamfer	*Boesenbergia pandurata* Holtt.	Kra chaai
Curcuma	*Curcuma parviflora* Wall	Krachieo
Zingiber	*Zingiber zerumbet* Smith	Ka thue
Others		
Indian thrumpet flower	*Oroxylum indicum* Vent.	Phe kaa
Asiatic pennywort	*Centella asiatica* Urban	Boa bok
Piper	*Piper sarmenosum* Roxb.	Chaa phlu
Colubrina	*Colubrina longipes* Back.	Khan zong
Hog plum	*Spondias pinnata* Kurz.	Ma kok
Paco (fern)	*Diplazium esculentum S.W.*	Phak kuut
Melientha	*Melientha suavis* Pierre	Pak waan
Hourseradish tree	*Moringa oleifera* Lamk.	Ma rum
Telosma	*Telosma minor* Craib	Salit
Awl tree	*Morinda citrifolia* L.	Yo baan
Rat-tailed Radish	*Raphanus sativus var caudatus*	Phak kheel huut

COCCINIA *(Coccinia grandis* Voiht.)

Market gardening is mainly in Nakhonsawan province, but it is extensively used in home gardening nationwide. There is no statistical data of production or scientific studies on the crop in Thailand. However, leaves and young shoots of coccinia are regularly offered for sale at local markets as well as supermarkets. No distinct cultivars are classified. The wild and cultivated forms are sometimes described as cultivars.

Figure 17. Coccinia: cultivation

Young shoots 40–50 cm long are harvested, bundled, packed in plastic bags or in bamboo baskets with banana leaves underneath for maintaining humidity, and shipped to wholesale markets from where they are distributed to retail markets in small bundles. Young shoots and leaves of coccinia are rich in Vitamin A. It is consumed as a fried, blanched or boiled vegetable for rice dishes, noodles or soups. It is a very popular green vegetable in Thailand. Young fruits are sometimes used in soups and curries. Ripe fruits are sweet and can be eaten, but this is rarely done. There is no germplasm collection or breeding work in Thailand. Due to its high nutritive value and economic potential, breeding work should be undertaken.

Figure 18. Coccinia : retailing bundle, pack

BIRD BITTER GOURD (*Momordica charantia L.*)

Commercial cultivation is in Phitsanulok and it is also grown in home gardens nationwide. No production data is available. First harvest according to local growers is 45 days after sowing. Harvesting continues for 1 year. Two forms are locally described. The elongated fruit-type is a wild form and the stout fruit-type is an indigenous cultivar often grown in home gardens.

Fruit at the green mature stage is harvested, packed in plastic bags with ventilation holes and marketed locally. Sometimes it is offered for sale to a specialized consumer market as an indigenous medicine. Young fruits are consumed as a vegetable similar to balsam pear. It is supposed to have medicinal properties with potential for reducing diabetes. The seed is reported to contain MAP 30 (momordica anti-HIV protein, 30 KD molecular weight).

Research should emphasize its potential as a health food vegetable and as a medicinal plant. Breeding for less bitterness can increase the crop's popularity.

Figure 19. Bird bitter gourd : local market, in bunches

SPINY GOURD *(Momordica cochinchinensis* Spreng.)

The fruit of spiny gourd is usually collected from fence climbers or from wild plants. It is found seasonally in local markets. Statistical data is lacking. There is very little information on genetic variations, and no cultivar selection has been reported. Germplasm collections are made by villagers with home gardens.

Figure 20. Spiny gourd : seasonally marketed

***T*ORVUM EGGPLANT *(Solanum torvum* Swartz.)**

Figure 21. Torvum eggplant : local market

Small-scale production is in Central Thailand and the East. No statistical data is available. It is usually cultivated in small-scale gardens or home gardens. However, it is always available in markets year round. There is large variability within the species but no distinguished cultivated types are identified or recommended as commercial cultivars. Germplasm collections are maintained by Kasetsart University. Breeding for spineless plant types is conducted at the Lopburi Experimental Station, KU Research and Development Institute.

Figure 22. Boat sprinkler : for watering in ditch-and-dyke system, eggplant

HAIRY EGGPLANT (*Solanum ferox L.*)

In Thailand, hairy eggplant is a home garden crop; however, in some cases the fruits are collected from the wild. At local vegetable markets in Thailand, the fruits of the plant are commonly offered for sale. No statistics are available on production and sales. The wild and cultivated forms are described as cultivars. The species will remain a commercially minor vegetable in Thailand, unless more attention is given to the crop and its cultivation is expanded. A breeding program should focus on the development of spineless cultivars. Germplasm collections are maintained by home gardeners in all regions of the country.

HYACINTH BEAN (*Dolichos lablab L.*)

Hyacinth bean is usually grown in Northern Thailand in home gardens, often seen climbing on fences. Plants do not tolerate brackish (saline) water, or waterlogging; they prefer sandy soils if fertile alluvial soil is not available. The local landrace found commonly in markets is a ‘purple pod’ cultivar. Pods are flat, curved and purple, with 3–4 ovoid seeds. It's drought resistance, and its suitability for a wide range of soils gives it a place in home gardens as a fence climber in Northern villages of Thailand. No attempts have been made to collect germplasm or to breed hyacinth bean. Research work should focus on cultivation methods and selection for market quality produce.

WATER MIMOSA (*Neptunia oleracea* Lour.)

Figure 23. Water mimosa : in bundle

It is locally grown and is marketed mostly in lowland provinces such as Nonthaburi, Nakhon-pathom and Ratchaburi. No data on production and trade are available. There are no records on variability of the cultivated form. Only the local selections are grown. It is a nutritious and palatable vegetable. Research should focus on the improvement of cultivation methods and cultivar selection. No work has been undertaken on germplasm collections and breeding.

SIAMEA CASSIA (*Cassia siamea* Britt.)

It is widely cultivated as fence tree or in home gardens in all regions of the country. Statistical data on production is not available. The wild and cultivated forms are described as cultivars. The cultivated forms may be distinguished by leaf size and the wild forms by the bitter taste of the leaves. The young shoots and young inflorescences are bundled and sold in markets as a vegetable. The young leaves have a bitter taste and flower buds are also edible. It is an interesting vegetable due to its high Vitamin A content. It is still a minor vegetable but it will remain important for a typical Thai dish known as 'kaeng kheelek'. Its medicinal properties may promote further consumption as a vegetable. Research should concentrate on commercial cultivation and selection for less bitterness or a bitter free cultivar. Germplasm collections are maintained by the Royal Forestry Department.

SESBAN TREE (*Sesbania grandiflora* Desv.)

Commercial cultivation is currently on a small-scale near big cities such as Bangkok, Nonthaburi, Suphanburi and Nakhonsawan. In home gardens, it is grown as a living fence. Young shoots and flowers are the main products. Production figures have never been recorded as it still remains as a minor vegetable. Two cultivated forms are distinguished in Thailand, based on the flower colour. These are the 'red flower' and 'white flower' forms. The white-flower form is more common in the markets.

Figure 24. Flowers of sesban tree : white form

Young shoots and leaves are blanched and eaten with chilli paste 'nam prik kapi' or 'nam prik plaa raa'. After removal of the bitter stamens, young flowers are an ingredient of sour curry soups such as 'kaeng som'. They are also fried with pork or shrimps or mixed with flour and fried. It is a nutritive vegetable due to its high Ca and Vitamin A content. The sesban tree will remain a minor vegetable in the market. It can be promoted as a vegetable tree in the programmes on 'Agriculture for Life' during the economic crisis, as it is fast-growing and it can provide a year-round supply.

NITTA TREE (*Parkia speciosa* Hassk.)

Its production is mainly in the Southern provinces of the country such as Phuket, Trang, Phang-nga, Krabi and Suratthani. Flowering starts from February and pods can be marketed in May. Individual tree yields vary from 200–500 pods/year. The commercial product from the Nitta tree is locally important and always fetches a good price. It often seems to be in short supply, and prices increase sharply in times of scarcity.

Figure 25. Fruits of nitta tree : in bunches

The three forms of *P. speciosa* in Thailand have been named as follows:

i. 'sator kaw' which is the most popular one; the seeds are small and have a strong odour with a rather sweet taste;
ii. 'sator dan', with larger and harder seeds which have a stronger odour and taste than 'sator kaw';
iii. 'sator tae', which is not really suitable for consumption because of the very hard seeds.

The seeds of *P. speciosa* are one of the most relished native vegetables in spite of their strong smell (sometimes called "stink beans") if not properly heated. Fresh seeds, young or ripe are eaten raw, cooked or roasted as a side dish with rice. Germplasm collections are known to exist at the Southern Horticultural Experimental Station of the Department of Agriculture. No breeding work has been undertaken.

BASILS (*Ocimum spp.*)

Figure 26. Sweet basil : on ditch-and-dyke system

Commercial production is mainly in the Central plain, and the predominant provinces where it is grown are Pathumthani. Nakhonpathom and Ratchaburi. Production data is not available. Three commercial species of basils are cultivated in Thailand. These are:

***O. basilicum* L.** 'Sweet Basil' which is mild in flavour. Fresh young shoots are served with fried roll-noodles, or as a typical hot and sour chopped meat salad called "larp". It is also an ingredient of green curry soup.

***O. americanum* L.** 'Hoary (white) Basil' is also mild in flavour with a particular fragrance. Young leaves are served as a fresh vegetable in vermicelli known as 'khanom cheen'. It is also used in Thai mixed vegetable soups called 'kaeng liang'. The seeds are used in desserts and are included in slimming diets because the leaves swell when placed in liquid.

***O. gratissimum* L.** 'Shrubby Basil' is a large leafy basil, not widely used; it is commonly used in a meat soup of the northeastern style of cooking.

Basil will remain the most popular traditional vegetable in Thailand. It is an important condiment in Thai dishes, with the additional advantage that it is easy to grow and is easily maintained. Germplasm collections are maintained by villagers and the National Gene Bank. Selection and breeding work has been carried out on the basis of leaf colour and inflorescence characteristics, but aiming at their essential oil content rather than selection for their quality as a vegetable.

ERYNGO *(Eryngium foetidum L.)*

It is generally cultivated under shade in small-scale commercial gardens. Nakhonsawan has the largest production area. No production data is available. There is no information available on variability within the species. Research should focus on cultivation methods to improve the quality of the vegetable. No breeding work is being carried out at present.

Figure 27. Eryngo : in bundles

MALABAR NIGHTSHADE *(Basella alba L.)*

Malabar nightshade is now cultivated throughout the country but no production data is available. It is a small-scale production vegetable and is usually grown with other greens in market gardens or in backyard plots.
There are three main types, which are sometimes considered distinct species, and can be distinguished as follows:

i. The most common type has dark green, ovate or nearly round leaves (synonym *B. alba).*
ii. A second type which is less popular, is often planted as an ornamental. It has red ovate or nearly round leaves and red stems (synonym *B. rubra).*
iii. The third type has heartshaped, dark green leaves (synonym *B. cordifolia).*

Figure 28. Malabar nightshade : in home garden

Shoots of 15–25 cm long are cut, bundled and sold at local markets. Leaves can be kept for one week in the refrigerator. It contains a wide range of Vitamin A (1 686-6 390 IU). Young shoots make an excellent, succulent, slightly mucilaginous ingredient in stews or soups.

Malabar nightshade is a very productive leaf vegetable, suitable for both home and market gardens in lowland areas. An important advantage of this leafy vegetable is its remarkable resistance to diseases and pests. The recommended cultivation method for the market should be by sowing seeds at a high density, which will help plants to grow without support. No germplasm collections and breeding programs have been reported, and only the local types are maintained by villagers.

HORSERADISH TREE *(Moringa oleifera Lamk.)*

Trees are usually planted in home gardens or to mark boundaries. There are no commercial plantings in Thailand. The fruits are a common product in local markets. Yields are low during the first two years, but from the third year onwards, individual tree yields of 600 or more fruits can be harvested for 10–15 years. No production figures are recorded.

Figure 29. Horseradish tree : in home garden

A number of forms are distinguished in Thailand, based on the size and the shape of the fruits. Distinction of cultivars has not yet been formally carried out. The horseraddish tree is certainly under-exploited at present. Its numerous uses as a vegetable, seed oil, gum, hedge tree, ornamental and medicinal plant, and its easy propagation and cultivation justify more intensive research into its biological and economic potential. Research should aim for cultivation in agro-forestry systems, as a component in the 'edible forest'. Germplasm exist in natural stands and maintenance of long, large fruited types is usually practiced.

MELIENTHA (*Melientha suavis* Pierre)

Cultivation on a commercial scale is done in Northern Thailand, where intercropping in fruit orchards is practiced. For this purpose, seedlings can be obtained from commercial nurseries in the area. However, no production data is available.

Figure 30. Melientha : in curry soup

The species is distinguished by the size of the fruits which are ellipsoid and 2.3–3 cm long. It has a high nutrition value and deserves to be studied to encourage its wider use and cultivation. Research on cultivation in agroforestry systems should be undertaken to exploit its potential. Only natural stands are available as germplasm.

ZUEK (*Albizia lebbeck* Benth.)

Figure 31. Zuek : young shoots, at local market

It is expected to be widely accepted as a newly recommended vegetable tree in rural agriculture. There is no statistical data on production. Little variability of *A. lebbeck* has been described, differences may be mainly in leaf size and colour. Distinction of cultivars would be preferable, but no improvement work has been attempted. Zuek is considered a good vegetable, and deserves more research attention in cultivation. It may have the best potential for somewhat drier climates. Research on cultivation methods and post-harvest should be carried out to obtain more information for its wider use. Analysis on nutritive values is also needed. Germplasm collections are maintained by Kasetsart University and the Royal Forestry Department. No breeding work has been undertaken.

APPENDIX 3

NUTRIENT CONTENT OF SELECTED VEGETABLES IN THAILAND

(Mean value per 100 g edible portion)

Vegetable	Moisture (gm)	Calorie (gm)	Fat (gm)	CHO		Protein (mg)	Ca (mg)	P (mg)	Fe (I.U.)	Vitamins				C (mg)
				NFE (gm)	CF (gm)					A (mg)	B1 (mg)	B2 (mg)	Niacin (mg)	
Leafy Vegetable														
Amaranth	82.1	50	0.7	8.2	1.5	6	535	75	2.2	11 090	0.01	0.32	1.5	55
Chinese celery	90.9	27	0.6	4.6	1.4	2.2	326	51	15.3	2 685	0.08	0.12	0.6	49
Chrysanthemum	93.5	18	0.4	2.6	0.7	2.3	78	30	9.4	4 850	0.08	0.18	0.6	17
Coriander	86.8	40	0.6	8	1.1	2.7	167	122	3.2	6 800	0.12	0.32	1.6	193
Kang Kong	90	29	0.5	4.2	1.1	3.9	60	66	5.6	4 475	0.09	0.25	1.2	59
Lettuce	93	23	0.4	4.6	0.5	1.2	83	34	5.4	2 855	0.06	0.12	0.4	21
Spinach	84.5	46	1.1	7.2	1.4	4.7	320	81	31.3	12 860	0.01	0.37	1.9	120
Sweet basil	85.4	44	4	5.5	2.5	3.3	336	Tr	22	20 712	0.15	0.22	0.8	3
White basil	89.9	30	1	2.3	2.6	2.9	140	40	17.2	26 000	0.12	0.28	0.6	3
Cucurbit														
Bitter gourd	93.4	22	0.4	4.6	0.9	0.9	32	32	0.9	335	0.06	0.03	0.3	55
Bottle gourd	94.8	17	0.1	4	0.4	0.6	19	16	0.4	20	0.04	0.03	0.4	10
Cucumber	95.7	14	0.1	3.2	0.3	0.6	17	18	0.3	Tr	0.03	0.04	0.2	11
Pumpkin	89.6	34	0.4	7.3	0.7	1.9	19	35	0.5	1 065	0.08	0.07	0.9	18
Ridged gourd	95.4	18	0.1	3.7	-	0.5	40	40	1.6	56	0.07	-	-	-
Smooth luffa	93.9	21	0.2	4.9	0.5	0.6	16	24	0.6	45	0.04	0.02	0.3	7
Snake gourd	95.2	16	Tr	4	0.5	0.6	23	15	0.3	235	0.02	0.03	0.3	12
Wax gourd	95.6	15	0.2	3.5	0.7	0.4	18	17	0.2	0	0.05	0.06	0.3	22
Cole Crop														
Cabbage	92.4	24	0.2	5.4	0.8	1.3	49	29	0.4	130	0.05	0.05	0.3	47
Cauliflower	91	27	0.2	5.2	1	2.7	25	56	1.1	60	0.11	0.1	0.7	78
Chinese cabbage	93.1	21	0.3	3.9	0.7	1.8	147	33	4.4	3 600	0.07	0.13	1	74
Chinese kale	86.9	40	0.7	7.2	0.9	3.6	203	63	1	6 500	0.2	0.31	1.7	92
Kohlrabi	90.3	29	0.1	0.1	1	2	41	51	0.5	20	0.06	0.04	0.3	66

Legume														
Snap bean	90.5	34	0.1	6.8	1	2	72	38	0.8	525	0.07	0.1	0.7	15
Edible podded pea	81.9	57	0.3	13	1.2	3.3	76	45	1.4	305	0.14	0.09	0.9	77
Hyacinth bean	87.8	47	0.5	7.9	1.7	3	5	47	1	460	0.08	0.08	1.1	13
Yardlong bean	88.1	38	0.2	8.2	1.5	2.8	42	46	0.9	570	0.12	0.13	1.2	22
Winged bean	90.7	29	0.3	5.6	1.3	2.8	64	36	0.1	545	0.24	0.09	1.2	15
Salanaceous fruit														
Chili	72.2	62	2.2	9	1.4	4.8	65	89	2.3	7 010	0.31	0.25	1.8	69
Garden eggplant	92.5	24	0.2	5.7	0.8	1	30	27	0.6	130	0.1	0.05	0.6	5
Sweet pepper (green)	93.3	23	0.2	5.4	1.5	0.7	12	18	0.4	260	0.05	0.03	0.5	84
Hot pepper (green)	89.6	35	0.5	7.5	2.3	1.8	15	42	1.6	895	0.08	0.08	0.9	122
Torvum eggplant	81.9	47	0.6	7.5	6.1	2.8	158	110	7.1	554	0.17	0.06	2.6	4
Tomato (red)	93.5	22	0.2	4.7	0.5	1.1	13	27	0.5	900	0.06	0.04	0.7	23
Root, bulb and tuber														
Carrot	85.1	55	0.4	12.4	0.9	1.3	60	28	1.7	18 520	0.04	0.04	0.6	9
Chinese radish	93.5	21	0.1	5.3	0.60.6	32	21	0.6	Tr	0.02	0.03	0.3	25	
Garlic	80.3	68	0.6	15.8	20	2.6	94	53	2.2	1 430	0.09	0.1	0.8	33
Ginger	90.3	37	0.9	6.9	1	1.1	32	29	3	0	0.04	005	0.6	4
Potato	79.8	76	0.1	17.1	0.5	2.1	7	53	0.6	Tr	0.1	0.04	1.5	20
Shallot (green)	89.4	36	0.2	8.2	1.2	1.5	51	36	1	2 000	0.05	0.05	0.4	32
Sweet Potato (yellow)	65	136	0.4	32.3	0.7	1.1	57	52	0.7	900	0.1	0.04	0.6	35
Taro	77.5	85	0.2	19.1	0.4	2.4	32	64	0.8	Tr	0.18	0.04	0.9	10
Yam (Dioscorea)	75.8	94	0.3	21.1	0.7	2.2	22	30	1.2	140	0.04	0.02	0.6	22
Yam bean	89.5	39	0.2	8.9	0.5	1.1	14	15	0.4	Tr	0.05	0.02	0.2	14
Others														
Okra	89.1	34	0.1	8.2	0.7	1.8	120	49	0	240	0	0.09	0.8	17
Rosell (young leaves)	86.6	46	0.3	9.4	1.3	1.4	151	59	1	10 833	0.1	0.24	1.8	18
Indigenous Vegetable English (Thai) Name														
Asiatic penny wort (Boa bok)	44	86	0.9	7.1	2.6	1.8	146	30	3.9	10 962	0.24	0.09	0.8	4
Awl tree (Yo bean leaves)	77.3	105	7.8	3.8	4	5	469	Tr	1.4	43 333	0.3	0.14	7.2	3
Acacia shoot (cha-om)	79.7	57	0.6	3.5	5.7	9.5	58	80	4.1	10 066	0.35	0.24	8.5	58

Coccinia (Phak Tamlueng/young shoot)	90.7	35	0.4	4.5	1	3.3	126	30	4.6	18 608	0.17	0.13	3.8	34
Hairy eggplant (Ma-Uk)	83.4	53	0.8	9.5	3.6	1.9	26	41	0.8	1 806	0.07	0.05	4.9	3
Ipil-ipil (Kra thin Thai)	80.7	62	0.9	5	3.8	8.4	137	11	9.2	7 883	0.33	0.09	5.4	8
Neem tree (Sadao)	59.4	129	1	22.9	6.2	7.1	510	80	17.1	-	-	-	1.4	-
Nitta tree (Sator)	70.7	150	8.1	11.4	0.5	8	76	83	0.7	734	0.11	0.01	1	6
Pepperminth (Sara Nae)	83	57	0.6	8	2.4	4.8	200	80	15.6	2 700	-	-	0.4	-
Piper (Chaa Phluu)	69.5	101	2.5	14.2	4.6	5.4	601	30	7.6	8 824	0.13	0.11	16.2	10
Sesban shoot (Khae baan)	74.4	97	2.6	10.1	2.7	8.3	365	40	41	12 466	0.28	0.33	2	19
Sesbania (Sano kin dok)	86	40	0.4	5.6	3.9	3.6	51	56	8.2	3 338	0.26	0.4	2.8	24
Siamese cassia (Kheelek leaves)	57.8	157	1.9	27.3	3.7	7.7	156	190	5.8	7 625	0.04	0.69	1.3	11
Telosma (Salit flower)	80.5	72	1.1	10.6	1.6	5	70	90	1	3 150	0.1	0.12	1.5	45
Horse-radish	73.8	8.9	0.4	22.2	0.9	2.6	32	43	0.8	95	0.05	0.09	0.8	223

Source: MPH, 1970

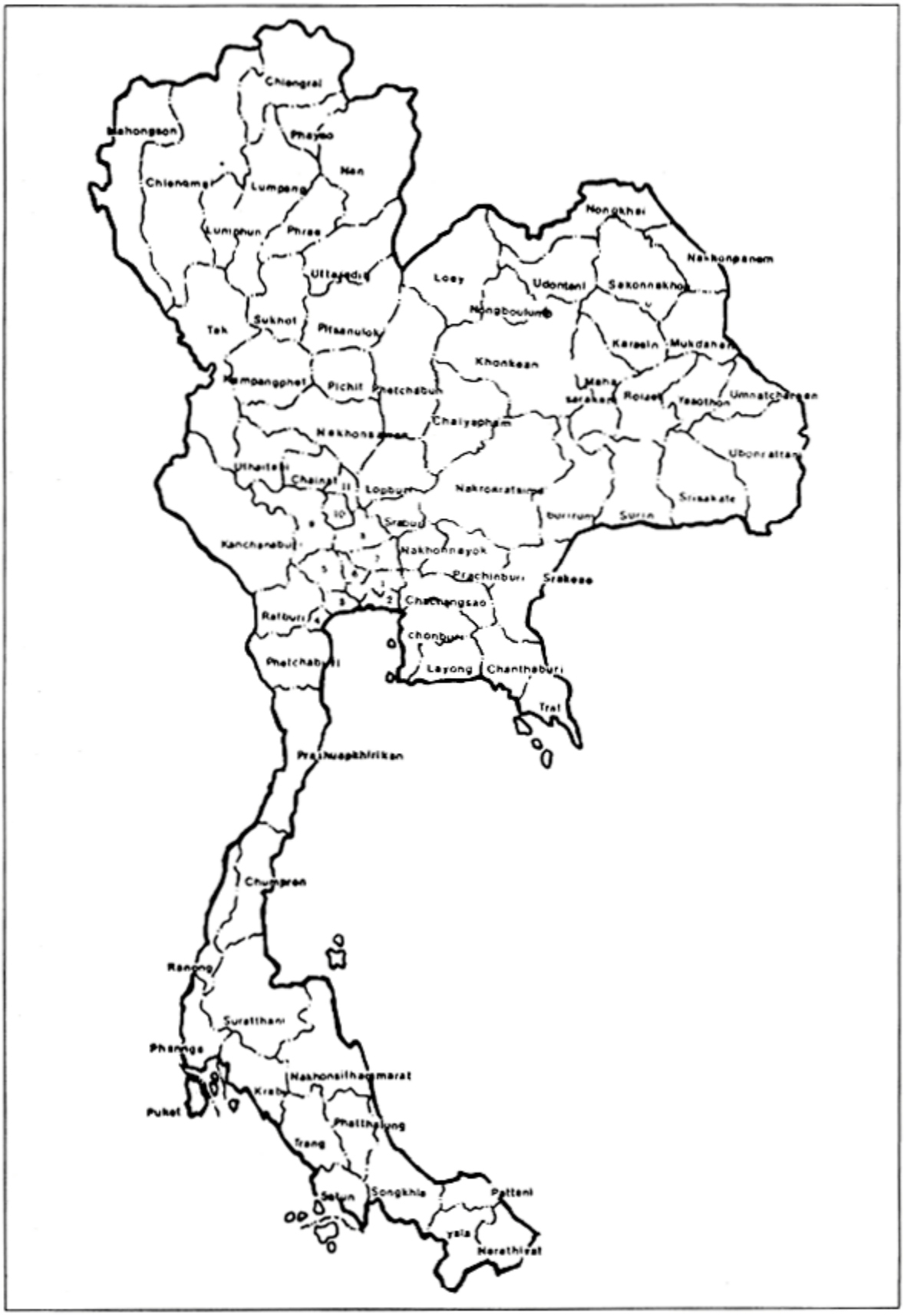

Figure 32. Map of Thailand