Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 63

Stabilization of Upland Agriculture under El Nino-induced Climatic Risk: Impact Assessment and Mitigation Measures in Thailand

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Thamrong Mekhora

United Nations

The CGPRT Centre

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"CGPRT Centre Works Towards Reducing Poverty Through Enhancing Sustainable Agriculture in Asia and the Pacific Region"

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Foreword

El Nino-induced abnormal weather tends to be increasing in its frequency of occurrence, magnitude, duration and irregularity in recent years. Accordingly, it is urgent for rainfed upland agriculture, where most CGPRT crops are grown, to establish technological and institutional countermeasures to predict, avoid or minimize and recover from the damage caused by the abnormal weather, drought in particular. Responding to this vital need, the CGPRT Centre has been implementing a three-year research project, "Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries (ELNINO)", since April 2000 in collaboration with partners form five countries: Indonesia, Malaysia, Papua New Guinea, the Philippines and Thailand.

It is my pleasure to publish **Stabilization of Upland Agriculture under El Nino-induced Climatic Risk: Impact Assessment and Mitigation Measures in Thailand** as one of the results of the project. This volume covers various topics such as historical overview of El Nino-induced abnormal weather, its impacts on major commodities and mitigating measures. I believe the report will support the preparation of strategic proposals for technologies, farm management and administrative policies to stabilize upland crop production and the farm economy leading to sustainable rural development in the region.

I thank Ms. Bhibhatra Suwanabatr and Mr. Thamrong Mekhora for their earnest and fruitful work. This study could only be accomplished with the continuous support from Ministry of Agriculture and Cooperative of Thailand. Dr. Rogelio N. Concepcion, Bureau of Soils and Water Management, Department of Agriculture, the Philippines, and Mr. Shigeki Yokoyama provided useful comments and guidance at various stages of the study as the regional advisor and the project leader, respectively. I also thank Dr. Douglas R. Stoltz for his editing services throughout the publication of the report. Finally, I would like to express my sincere appreciation to the Government of Japan for its support in funding the project.

April 2002

Nobuyoshi Maeno
Director
CGPRT Centre

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This country report is part of the results of research project, “Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries (ELNINO).” The project covers five countries, Indonesia, Malaysia, Papua New Guinea and Thailand, with special focus on CGPRT crops. The country study of Thailand focuses on the El Nino effects on upland agriculture and policy and mitigation measures.

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The views in this technical paper are those of the author and do not necessary represent the policy of the organisation for which the author works.

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March 2002

Executive Summary

This study focuses on the impacts on areas vulnerable to El Nino in five provinces and five regions in Thailand. The findings indicate that events caused by El Nino-induced weather changes had some impacts on the stabilization of upland agriculture in those vulnerable areas. In general severe drought and a long period of water shortage were experienced in some of the vulnerable areas of the Northeast and the Central regions. Some areas had a decrease of corn yield, while others had a complete failure of field corn, sorghum, sugarcane, peanut and mungbean. The impacts of El Nino on social and economic conditions of Thailand's vulnerable areas included labour mobilization, and low purchasing power and loan repayment abilities of the farmers. For food security, more analysis is required at the farm level.

Although Thailand has no policies and measures for coping directly with events caused by El Nino, there are existing policies and measures that effectively cope with normal droughts and floods that frequently occur. These effective policies and measures are national risk awareness and warning, reforestation and afforestation, water resource management, crop diversification, mixed farm systems, integrated farming and self-sufficient farming.

For the future, policies and measures should be generated based on the following characteristics. They should increase the participation rate of any community and communal administrative organization concerned in cooperation. Moreover, they should be favorable to the stability and sustainability of on-farm productivity and the increase of the use of agricultural and forest by-products instead of fossil fuels. In addition, the policies should be favorable to the reinforcement of national food security and the betterment of physical, biological, economic, and social environments. The stability of bio-diversity, prevention of soil erosion and shallowness of water sources are also emphasized. The use of technologies should not only be suitable to the country's economic, social and environmental status, but also be self-sufficient and self-supportable. Finally, the policy should be clear-cut, concise, compact, flexible, practical, and useful.

1. Introduction

1.1 Background

El Nino, a natural phenomenon, has occurred for as long as a thousand years. It has been observed as early as the 1600s off the coast of Peru. At varying intervals, anomalously warm waters off the Peruvian coast appeared around Christmas and were dubbed El Nino, for the Christ child (http://www.coaps.fsu.edu/). Throughout the 1960s and 1970s, oceanographers referred to El Nino as the large-scale warming of the equatorial eastern and central Pacific. This anomalous warming was later shown to be associated with anomalies in the upper ocean thermal structure throughout the equatorial Pacific Ocean. At about same time, scientists realized that the Southern Oscillation was intimately related to the large-scale changes in the tropical Pacific Ocean. By the beginning of the 1980s, it became clear that the El Nino and Southern Oscillation are intimately related with the large-scale warming.

Over the past two decades, the term El Nino has become associated with social, economic and environmental crises in many parts of the world. In tropical regions El Nino events are associated with the occurrence of abnormal heat and long drought. Its prime causes are not only persistent rain and devastating flooding, but also the variations of the patterns of temperature, precipitation, and other changes of weather and climatic conditions. These include the frequency of tropical storms, unduly prolonged or shortened seasons, the occurrence of climate extremes and abnormal warming of offshore waters in some areas. Some consequences of the El Nino events may be beneficial to the stabilisation of upland agriculture and rural development. Others may have adverse effects on agricultural production, water supplies, floods and storms and other determinants of human well being and health. Loss of life and severe damage often accompanied in some areas.

All countries in the Asian monsoon region are vulnerable to El Nino-induced abnormal weather. Thailand, located in the most vulnerable area in the Southeast Asia and the Pacific sub-region, has conducted research, which includes the impacts of El Nino-induced abnormal weather on upland agriculture and the rural economy.

1.2 Objectives

The objectives of this study are to determine the impacts of El Nino-induced abnormal weather in Thailand in terms of the following:

- To study the historical events of abnormal weather.
- To study the extent of coverage of each event on vulnerable areas.
- To study the impacts on vulnerable areas (risks and opportunities) in terms of
  - Environmental conditions concerned and natural resources;
  - Agricultural production/output;
  - Social and economic impacts; and
  - Food security.
- To review and analyze the national coping mechanism and risk management strategies. In these cases, the efficiency of project implementation will be categorized as follows:
  - National risk management policy strategies
    - National awareness campaign
    - Technology interventions
    - Livelihood options

- Local initiatives
  - Indigenous technologies
  - Household risk management strategies
  - Communal risk mitigation systems
- Role of non-government organizations (NGOs).

1.3 Outline of the study

This study is described in five chapters. Chapter 1 presents the objectives of the study, general approach for this study and previous studies of El Nino effects in Thailand. Chapter 2 describes Thailand, including location and topography, climate, population, land use and forest, water resources, surface water, ground water, coastal areas, agriculture and the Thai economy. In Chapter 3, the historical events of abnormal weather are further detailed. The analysis includes El Nino induced weather changes, extent of coverage in each event on vulnerable areas and impacts of El Nino on vulnerable areas. Four impacts of El Nino are investigated in selected study areas. In Chapter 4, the analysis of national coping mechanisms is detailed. The focus is on their effectiveness when implemented. Chapter 5 includes conclusion of this study and policy recommendations of phase 1 of this study.

1.4 Effects of El Nino on Thailand

El Nino events have occurred several times throughout the twentieth century, but they were not well known or familiar in Thailand until 1988 and their effects have been studied since then. Muntana Brikshavana of the Analysis and Long-Range Forecast Sub-division, Climatologic Division, Meteorological Department, conducted the first study in July 1988 (Brikshavana 1988). The purpose of this study was to investigate the influence of El Nino events on rainfall patterns over Thailand. The analysis of data of monthly percentile rainfall indices was employed for evaluating the El Nino phenomena of the preceding, ongoing, and succeeding years with strong, moderate, and strong and moderate events. The results of the study indicated that there were no well-established relationships between the influence of the El Nino and the rainfall patterns over Thailand.

After that, the influence of El Nino events on temperature patterns over Thailand was studied. Muntana Brikshavana and Sudaporn Nimma of the Analysis and Long-Range Forecast Sub-division primarily conducted it in April 1993 (Brikshavana and Nimma 1993). Monthly average temperatures of the proceeding, ongoing, and succeeding years with strong and moderate El Nino events over the country were analyzed based on standardized indices. The findings indicated that above normal temperatures in the “winter and summer” seasons starting from November of the ongoing El Nino year to May of the succeeding year were associated with strong El Nino, as assured by 43 out of 47 synoptic stations or 90% of the cases. Thus, it may be concluded that there was a well-established relationship between the influence of the strong El Nino events and the monthly average surface temperatures of the winter and the summer over Thailand.

Impacts of El Nino in 1992 and 1997 were significant and had relationships with decrease in the average amounts of rainfall in each region and over the main river basins. This included the Chao Praya and the Mune-Chi river basins in the Central and the Northeast regions, respectively. The findings indicated that the El Nino situation was somewhat serious in some parts of Thailand.

2. Country Overview

2.1 Location and topography

Thailand is a tropical country in Southeast Asia, located in the central part of the Indochina peninsula. It lies between the latitudes of 15^0 27'N and 20^0 27'N and longitudes of 97^0 20'E and 105^0 37'E. The country shares its borders with four neighbouring countries: Myanmar (Burma), Laos, Cambodia, and Malaysia. The total length of Thailand's border is 5,326 kilometres. The country covers an area of 513,115 square kilometres, approximately the size of France or Texas.

Thailand can be divided into six physiographic regions based on topographic features: namely, the North, the West, the Northeast Plateau, the Central Plain, the East Coast, and the Peninsular South. The details of these features can be summarised as follows:

(1) The North is made up of hills, ridges and flat valleys. It provides the major catchment areas of headwaters of important rivers of Thailand including the Chao Phraya River.

(2) The West consists of a continuous cordillera with steep canyons and narrow valleys along the Myanmar border. This region is the origin of some major Asian rivers.

(3) The Northeast, or so-called "Northeast Plateau" or "Korat Plateau", covers nearly one-third of the country's areas. The plateau slopes gradually to the southeast from an elevation of about 150-200 meters along its western and northern boundaries to about 60 meters in the southeast. The region drains into the Mekong River through tributaries of the Mune River.

(4) The Central Plain is filled with alluvial soil, which is very suitable for growing rice. On the banks of the Chao Phraya River from Samut Prakan province through Nakhon Sawan province, the soils are all alluvium.

(5) The East Coast is made up of several small hills with a continuation of the Kampuchean mountain range. This region forms mountainous narrow coastal plains, streams and short rivers, and drains water trapped by hilly terraces through those tributaries to the Gulf of Thailand.

(6) The Peninsular South is a narrow land with mountain ranges running north to south and separating this region into the east and west coasts.

However, Thailand is officially and climatically divided into five regions, namely the North, the Central (in which the West is included), the East Coast, the Northeast and the South. Data are reported in accordance with either the physiographic regions or climatic regions.

2.2 Climate

The climatic conditions of Thailand are influenced by the Asian monsoon, which is characterized by two climate systems, the monsoon and tropical rainforest climate. During May to October, the country experiences a monsoon climate caused by the southwest wind bringing humid air from the Indian Ocean to both the upper mainland - the major area of the country - and the Peninsular South. This is easily recognizable by the six months of heavy rains or extremely wet weather throughout the country. During November to April, the country experiences a monsoon climate caused by the northeast wind carrying cool dry air from the northern part of Asia to both the upper mainland and the Peninsular South of the country. This can be easily recognized by the six months of cool, extremely dry weather in the affected area, especially the upper part of the country.

Passing over the South China Sea, the southeast wind humidity is greatly increased and the moisture transformed into rain that causes the Peninsular South, particularly the east coast,

to have six months of wet weather. Due to exposure to the southwest and northwest winds, the Peninsular South is characterized by wet weather throughout the year as three month precipitation of less than 1,000 mm has never occurred. There are many tropical rainforests with tropical evergreen species in this part of the country, whereas the upper part of the country is made up of dry and deciduous forests dominated by teak and dipterocarpus species. Mid-February to mid-May is the transitional period between the dry and wet seasons. During this period, coincidence with vernal equinox causes a hot and dry season almost throughout the country (Boonpragob 1996).

The climatic conditions of Thailand, especially in the upper part of the country, can be classified into 3 distinct seasons: the hot or dry season, the wet or rainy season, and the cool or winter season. However, the Peninsular South has only the hot and the wet seasons.

Normally, the temperature of the country ranges between 33 and 38ºC with a peak in April. The highest temperature during 1951-1980 was recorded at 44.5ºC. The lowest temperature of 10º C may occur in December and January, especially in the North and the Northeast (Rundel and Boonpragob 1995; TDRI 1987).

The annual average temperatures by regions during 1995-1999 adapted from the reports issued by the Department of Meteorology are given in Table 2.1.

Table 2.1 The annual average temperature (^{O}C) by region during 1995-1999.

Region	Extreme Low Temperature					Extreme High Temperature					Mean Annual Temperature				
	1995	1996	1997	1998	1999	1995	1996	1997	1998	1999	1995	1996	1997	1998	1999
The North	10.0	9.1	11.5	11.6	5.1	41.3	39.9	40.0	41.5	39.8	26.6	26.2	26.6	27.5	26.3
The Northeast	9.9	9.4	12.0	13.0	6.1	40.0	40.4	38.7	41.6	40.1	26.6	26.2	26.8	27.6	26.4
The West and Central	14.2	14.4	16.4	18.1	11.7	39.0	38.8	38.4	39.4	38.6	28.1	27.8	28.5	28.9	27.8
The East Coast	15.4	15.6	16.5	18.3	12.9	38.3	38.1	37.5	39.2	37.4	28.0	27.8	28.5	29.0	27.9
The Peninsular South	19.8	18.6	19.3	20.1	18.5	37.0	36.8	36.4	38.3	36.1	27.3	27.4	27.5	28.0	27.0

Source: Adapted from reports issued by the Department of Meteorology.

The annual average precipitation is 1,550 mm. However, annual precipitation exceeding 2,000 mm is common in the Peninsular South, and sometimes it reaches 4,000 mm on the Southeast coast (Rundel and Boonprabob 1995; TDRI 1987). The annual average rainfall by region during 1995-1999 adapted from the reports issued by the Department of Meteorology is given in Table 2.2.

Table 2.2 The annual average rainfall (mm) by region during 1995-1999.

Region	1995	1996	1997	1998	1999
The North	1,320.5	1,299.6	1,036.6	1,043.3	1,360.6
The Northeast	1,453.9	1,562.0	1,361.0	1,202.2	1,607.0
The West and Central	1,098.9	1,428.4	863.1	1,303.2	1,326.5
The East Coast	2,281.9	1,928.2	1,382.0	1,921.1	2,134.6
The peninsular South	2,373.5	2,519.1	2,303.6	2,358.1	2,745.0

Source: Adapted from data recorded by the Department of Meteorology.

2.3 Population

In accordance with a report issued by the Local Administration Department, the population of Thailand was about 48.8 million in 1982 and it increased to 61.7 million in 1999. Thus, the average population density increased from 95.2 persons per square kilometer in 1982 to 120.2 persons per square kilometer in 1999. Population growth rate has dropped from 2.4% in 1985 to 1.3% in 1999. Life expectancy is about 70 and 75 years of age for males and females, respectively in 1999.

2.4 Land use and forest

In 1995, the whole country was classified as 131,485.06 km^2 of forestland, 211,965.71 km^2 of farm holding land and 169,664.25 km^2 of unclassified land. There were 5,248,815 farms with an average farm size of 4.04 hectares as shown in Table

Table 2.3 Land utilization of Thailand by region in 1995.

Region	Total Land (km^2)	Forest Land (km^2)	Farm Holding Land (km^2)	Number of Farms	Farm Size (ha)	Unclassified Land (km^2)
The North	169,644.29	73,885.92	46,746.79	1,293,997	3.61	49,011.57
The Northeast	168,854.34	21,264.67	92,574.68	2,273,549	4.07	55,015.00
The Central	103,901.20	23,879.84	43,580.30	897,835	4.95	36,441.05
The South	70,715.19	12,454.63	29,063.94	801,434	3.63	29,196.63
Total	513,115.02	131,485.06	211,965.71	5,248,815	4.04	169,664.25

Source: Adapted from Department of Forestry (1999).

Note that: 1. Forest land is the land area still under forest cover.

2. Unclassified land is the balance of the area of land taken from total land minus forest land and farm holding land. It consists of degraded national forest reserves, swamps, sanitary district areas, municipal areas, railroads, highways, real estates, public areas, etc.

The country's forest area drastically decreased during the past three decades due to the increase of population, the demand for farmland expansion and the change in economic structure. Prior to 1960, more than 50% of the country was covered with forest. However, the forest area dropped to 26.6% and 25.3% in 1991 and 1998, respectively.

2.5 Water resources

TDRI (1987) estimated that Thailand receives about 800 billion cubic meters of rainwater annually. This amount comes from the average annual rainfall of 1,550 mm on the area of 513,115 square kilometers. Approximately 85% of this rainwater, except for the Peninsular South, falls during the rainy season from May to October.

Surface water is the most important water resource of the country. TDRI (1987) reported that the major river basins of the country are as follows:

- In the Central Plain, the Chao Phraya Basin is of the largest river basin. With its average annual runoff at the estuary of about 30,300 million cubic meters and its drainage area of about 178,000 square kilometers or about 35% of the country's area, this basin is the major source of agricultural produce.
- In the Northeast, the Mune Basin is the major river basin. It covers a drainage area of 119,570 square kilometers or approximately 23% of the country's area with an average annual runoff of about 28,580 million cubic meters.
- In the West, the Mae Klong Basin is the most important river basin of the region. It covers a drainage area of 33,000 square kilometers or approximately 6% of the country's area, with an average annual runoff of about 13,400 million cubic meters.
- In the East and the Peninsular South, there are small river basins in each region.

For ground water resources, ground water with varying quality and quantity is found throughout the country (TDRI 1987). It is not so important to agricultural production as the surface water is. Ground water is used for consumption in some areas.

2.6 Coastal areas

The country's coastal areas can be divided into the East Coast and the West Coast. The total length of their shorelines is approximately 2,614 km. Over 275 islands are found off both coasts (TDRI 1987).

The East Coast is on the Gulf of Thailand. It consists of the coasts of the East, the south of the Central Plain and the East of the Peninsular South. The total length of its shoreline is approximately 1,660 km, consisting of several coastal plains and many stretches of long sandy beach. This coastal area has been well developed with major industrial estates, ports and tourist resorts.

The West Coast is on the Andaman Sea, approximately 954 km long. It consists of an irregular shoreline, several mountainous areas and many estuaries.

2.7 Thai economy and agriculture

Aside from industrial and service sectors, agriculture has played a major role in the economy of Thailand. As classified by gross domestic product (GDP), it consists of four components: crops, livestock, fisheries, and forestry.

For several decades, agricultural development has been central to economic growth in Thailand, contributing to growth in employment and foreign exchange earnings, and to improvements in nutrition and the standard of living. In the 1990s, agriculture's contribution to the national GDP shrank to less than 15% (Table 2.4), and the agricultural sector accounted for just above 30% of export earnings. But agriculture employed nearly 60% of the total labour, force, and 41% of the land area was used for agricultural purposes (Agricultural Statistics of Thailand Crop Year 1995/96). As many as 40 million people, nearly two-thirds of the total population, depended on agriculture for a living. The very low share of agricultural product in GDP, combined with the very high share of the total population in the agricultural labour, indicates a very large difference in productivity between the agricultural and non-agricultural sectors. This also relates to the problem of income distribution.

Table 2.4 GDP of the agricultural sector, 1997-1999 at 1988 prices.

	Gross Domestic Product (million baht)			Growth Rate (%)		
Details	1997	1998	1999	1997	1998	1999
Agricultural sector	328,852	318,669	326,848	-0.67	-3.10	2.57
Crop	197,869	191,603	200,490	1.01	-3.17	4.64
Livestock	33,031	30,662	31,350	2.22	-7.17	2.24
Fishery	47,546	48,649	46,776	-4.90	2.32	-3.85
Forestry	4,550	3,345	3,424	-21.13	-26.48	2.36
Agricultural service	8,971	8,406	8,277	-2.31	-6.30	1.53
Simple processing	36,885	36,004	36,531	-2.71	-2.39	1.46
Non-agricultural sector	2,745,676	2,424,691	2,532,311	-1.54	-11.69	4.44
Total	3,074,528	2,743,360	2,859,159	-1.45	-10.77	4.22

Source: Office of the National Economic and Social Development Board, Office of the Prime Minister, Thailand.

Unlike other developing countries in Asia, Thailand has had food and agricultural surpluses for several decades. Although the average farm size is rather small (approximately four to five hectares - Agricultural Statistics of Thailand Crop Year 1995/96), exportable agricultural goods have been produced consistently with a mix of subsistence and commercial technology. Agricultural technology is based on small pieces of land, with human labor, light machinery, and draught animals as the principal sources of power. Some "improved" inputs such as high-yielding varieties, chemical fertilizers, insecticides and herbicides are also available in local markets. However, the yields of the major crops have remained stagnant and among the lowest in the world (Agricultural Statistics of Thailand Crop Year 1995/96).

Nevertheless, Thailand is a major exporter of rice, sugar, natural rubber, tapioca products, shrimp and prawns, chicken meat, and many varieties of vegetables and fruits. The export earnings from agriculture in 1995 were valued at more than 450 billion baht (Agricultural Statistics of Thailand Crop Year 1995/96). Rice, shrimp and natural rubber were among the top ten export commodities for Thailand in 1998 to 2000 (Table 2.5).

Table 2.5 Top ten export commodities for 1998-2000.

Rank	Commodity	Value (million US $)		
		1998	1999	2000
1	Computers and peripherals	320,525	304,982	344,048
2	Electrical circuits	93,833	111,767	179,302
3	Apparel	123,133	110,356	124,326
4	Vehicles and parts	68,348	91,954	122,445
5	Plastic pellets	40,786	46,025	73,975
6	TV sets and parts	58,058	47,233	71,877
7	Rice	86,803	73,812	65,516
8	Jewelry	57,350	59,820	66,730
9	Natural rubber	55,406	43,941	60,742
10	Frozen shrimp	58,343	48,348	60,270

Source: Department of Commercial Economics, Ministry of Commerce, Thailand.

Among the crops, rice has been the most important food for Thai people. During the crop years of 1995/1996 to 1998/1999, approximately 9.14 million hectares per year or about 17.8% of the country's area was used for rice production in the wet season. Over one million hectares or about 60% of the irrigated area was planted for the second rice crop. On average, the total paddy field area per annum was approximately 10.18 million hectares or 19.8% of the country's area. The annual rice production of Thailand was about 20-24 million tons, 75% of which was used for domestic consumption, the rest for export. The total farm value per annum during the crop years 1995/1996 to 1998/1999 was 128,899 million baht. The other important crops as classified by the total farm value are sugarcane, maize, soybean, mungbean, groundnut and sorghum, respectively. The data for each crop are presented in Table 2.6.

Table 2.6 Average production of important crops in Thailand during the crop years 1995/1996 to 1998/1999.

Crop	Planted Area ('000 ha)	Planted Area (%)*	Production ('000 tons)	Value (million baht)
Rice	10,179	19.8	22,678	128,899
- Rainy Season	9,136	17.8	18,187	105,073
- Dry Season	1,043	2.0	4,491	23,826
Sugarcane	969	1.9	52,893	23,230
Maize	1,390	2.7	4,284	17,135
Soybean	264	0.5	351	3,263
Mungbean	315	0.6	219	2,600
Groundnut	98	0.2	139	1,628
Sorghum	124	0.2	180	580
Cassava	1,187	2.3	16,870	16,136

* % of the country's area.
Source: Office of Agricultural Economics.

To counter the depression of world prices for agricultural produce during 1989-1992, the Royal Thai Government promoted the diversification of crops from rice- and cassava-domination to a diversified system, intensifying fruit plantations, vegetables, coffee, livestock, broilers, and aquaculture including fisheries products for export. To maintain and enhance the long-term economic viability of agricultural production as well as to reserve and to protect natural resources and ecosystems which are influenced by agricultural activities, sustainable agriculture by means of integrated agricultural production and self-sufficient agriculture have

been emphasized and promoted. In this case, various practical management strategies and technologies are effectively used to promote sustainability of farm productivity, conservation of agro-ecosystems, environment and natural resources. The strategy includes enhancing the quality and quantity of agricultural produce and agro-industrial products and protecting water quality and soil fertility. These measures are applied to farming systems, government policies, agricultural research and development, information systems, education and training, agricultural extension, and technology transfer.

One well-known project implemented since 1994 is a crop diversification and agricultural restructuring project (TDRI 1995). The Ministry of Agriculture and Cooperatives supported farmers wanting to change their farming system from rice and cassava to other commodities, including mixed farming, fruit trees, fast growing trees, dairy and cattle. Farm pond construction, seedlings, young fish and juvenile animals, appropriate technology and long-term and low interest loans have been supplied to farmers. The Division of Economic Project and Programme Evaluation of the Office of Agricultural Economics, the Ministry of Agriculture and Cooperative, conducted an on-going evaluation in 1999. The results indicate that farmers who received the loan to implement their mixed farming earned higher income from the new systems than from the previous mono-cropping system. The cash income was also high enough to return the loan back to the project (OAE 1999). The work involved was also much harder, because a fresh start had to be made every new cultivation season. With mixed farming, the daily cost of living was significantly reduced because various plants were used for family needs. There was a good flow of cash income all year round due to the varieties of products available for markets. The danger from using chemical products under the former monoculture system was greatly reduced.

2.8 Country development

Thailand has been structured in accordance with the National Economic and Social Development Plan (NESDP), a continuous series of five-year plans initially launched in 1961. Now (2000), the Eighth NESDP (1997-2001) is in effect and the ninth NESDP (2002-2006) has been prepared by the National Economic and Social Development Board (NESDB), the Office of the Prime Minister.

The development of human resources and the improvement of life quality, environment and natural resources as well as maintenance of the country's economic growth at a level proportional to the equal distribution of income and rural development were emphasized in the Seventh NESDP (1991-1996).

The Eighth NESDP (1997-2001) has the following objectives (NESDB 1996):

(1) To foster and develop the potentials of all Thais in terms of health, physical well-being, intellect, vocational skills and ability to adapt to changing social and economic conditions.
(2) To develop a stable society, strengthen family and community, support human development, improve quality of life and promote increasing community participation in national development.
(3) To promote stable and sustainable economic growth, and to empower the people to play a greater role in the development process and receive a fair share of the benefits of growth.
(4) To utilize, preserve and rehabilitate the environment and natural resources in such a way that they can play a major role in economic and social development and contribute to better quality of life for the Thai people.
(5) To reform the system of public administration so as to allow greater participation of non-governmental organizations, the private sector, communities and the general public in the process of national development.

To attain these objectives, the Eighth Plan sets the following development targets to be used as indicators of success:

(1) Increase in availability of good quality care and education for well-balanced early childhood development.
(2) Improvement of the quality of education at all levels; extension of basic education from six to nine years to all school-aged children; provision of continuing training for all schoolteachers; and working towards the further extension of basic education to 12 years.
(3) Upgrading the skills and basic knowledge of industrial workers, particularly in the 25-45 age group.
(4) Provision of opportunities for underprivileged groups to realize their full development potential, and increase in their access to basic social services.
(5) Reduction of the number of preventable accidents, particularly in the workplace, in traffic, the transport of toxic chemicals, and fires in high-rise buildings.
(6) Lowering the current account deficit to 3.4% of GDP by the last year of the Plan, while keeping the rate of inflation at not more than 4.5% per year, in order to safeguard economic stability.
(7) Increase in domestic savings to 10% of GDP by the last year of the Plan.
(8) Upgrading and expansion of infrastructure provision in the regions and rural areas.
(9) Reduction of the incidence of poverty to less than 10% of the total population by the last year of the Plan.
(10) Preservation and rehabilitation of forest areas to cover no less than 25% of the country, including not less than one million rai (160,000 ha) of mangrove forest, by the last year of the Plan.
(11) Increase in awareness of sustainable alternative agricultural methods, and increase in opportunities for their application.
(12) Promotion of investment in the rehabilitation and protection of urban, regional and rural environments.

To attain the objectives and targets concerning economic development of the country, the following strategy, one of the seven major development strategies, is proposed by the Eighth Plan. It is the Development of Economic Competitiveness to Support Human Development and Quality of Life Plan. This Plan aims at supporting stable and sustainable economic growth, restructuring production to adapt to changes in global markets and developing science and technology. It includes a foundation for sustainable development and undertaking area-based and community-based development, upgrading of infrastructure and promotion of higher productivity and better quality of life.

3. Impacts of El Nino-Induced Abnormal Weather in Thailand

3.1 Historical events of abnormal weather

Thailand has faced many forms of natural disaster mainly from flood and drought. The most important cause of flood disaster is an unduly long period of rain caused by tropical cyclone and typhoon with heavy rain and storm. The other causes may be surface water runoff from mountains and inundation caused by a tidal flow from the sea adding to the river water.

A further natural disaster is drought, a long period of dry weather or a serious shortage of rain due to an unseasonable rainy season. The drought brings water scarcity for consumption and agricultural production, a deficit of humidity and the water deficiency of surface soil. A decline in agricultural produce both in quantity and quality may occur to some extent in this period. In Thailand, there are two periods of marked drought. The first periodically occurs due to the untimely shortage of rain during the rainy season from late June to July. This period, which may be approximately one to two weeks, is so-called a "dry spell". The second is normally caused by a long shortage of rain for months during the dry season starting from November to April. During the drought periods, most canals and rivers run dry and agricultural production suffers from water scarcity in rainfed areas.

The Office of Environmental Policy and Planning (1996) reported that droughts normally occur in the lower part of the Northeast. Extreme nationwide droughts were recorded in 1919, 1945, 1946, 1972, 1977 and 1979. The last was the most extreme, nearly nationwide. It occurred from July to September, the middle of the rainy season, due to an unduly long drought. Severe degradation resulted not only in production of agricultural produce, industrial products, and water supply, but also in generating hydroelectric power.

The extreme droughts and floods that have occurred in Thailand are listed in Table 3.1.

Table 3.1 Extreme droughts and floods occurring in Thailand.

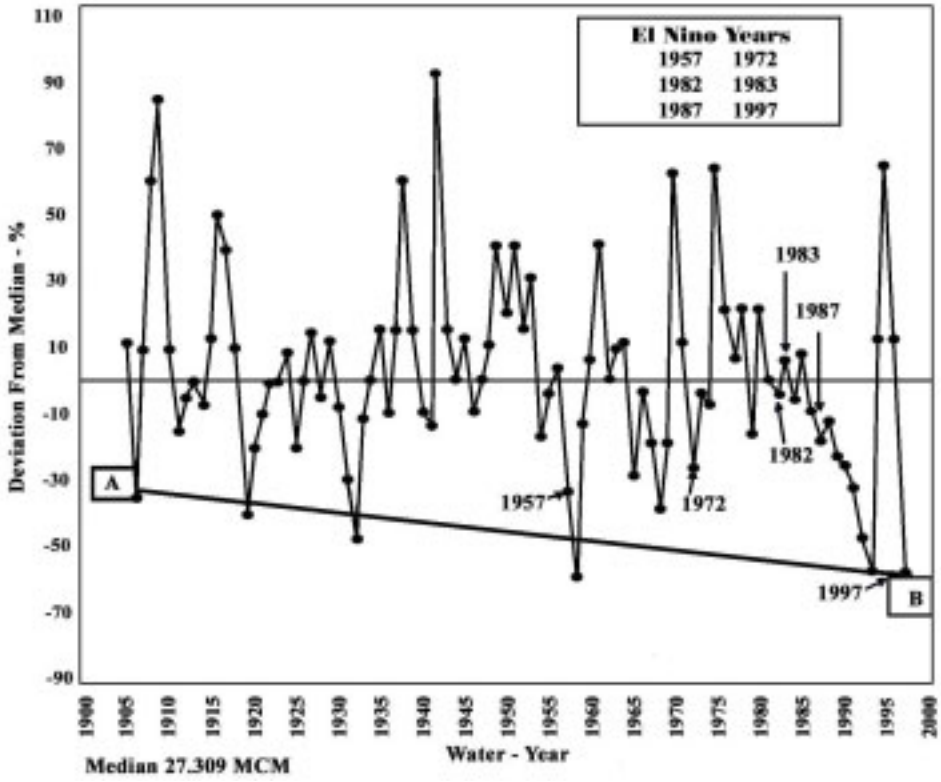
Year of Occurrence	
Drought	Flood
1919	1917
1945	1942
1946	1964
1972	1975
1977	1978
1979 *	1981
1998	1983
	1988
	1995

* The most extreme drought.
Source: Office of Environmental Policy and Planning.

TDRI and TEI (1993) pointed out that the El Nino affects the southwest monsoon wind, which is the source of rain for Thailand. Kanchanalak (1998) analyzed the deviation from median of surface water levels in the drainage basin of Chao Phraya River and its tributaries, which occupies about 152,000 km^2 or about 30% of the country's area. Analysis of data of annual means of surface water levels obtained from three gauging stations located at Chainat, Nakhon Sawan, and Bhumibol Dam in comparison with those of ongoing El Nino years, indicated that the annual means of surface water levels were below normal. This event

confirmed the severity of the El Nino events in effected years (Figure 3.1 and Figure 3.2). Furthermore, the annual means of surface water levels of the extreme drought years have tended to be continuously lower year by year as indicated by the AB line in Figure 3.2. If this situation continues, Thailand, in the near future, will be in great trouble of severe water shortage countrywide with a magnitude of more or less 70% below normal years or even greater as compared to the 55% in the year 1997.

Figure 3.1 Deviation from median of annual means of surface water levels in the Chao Phraya River basin and its tributaries measured at the gauging station of Bhumibol Dam, Tak Province.



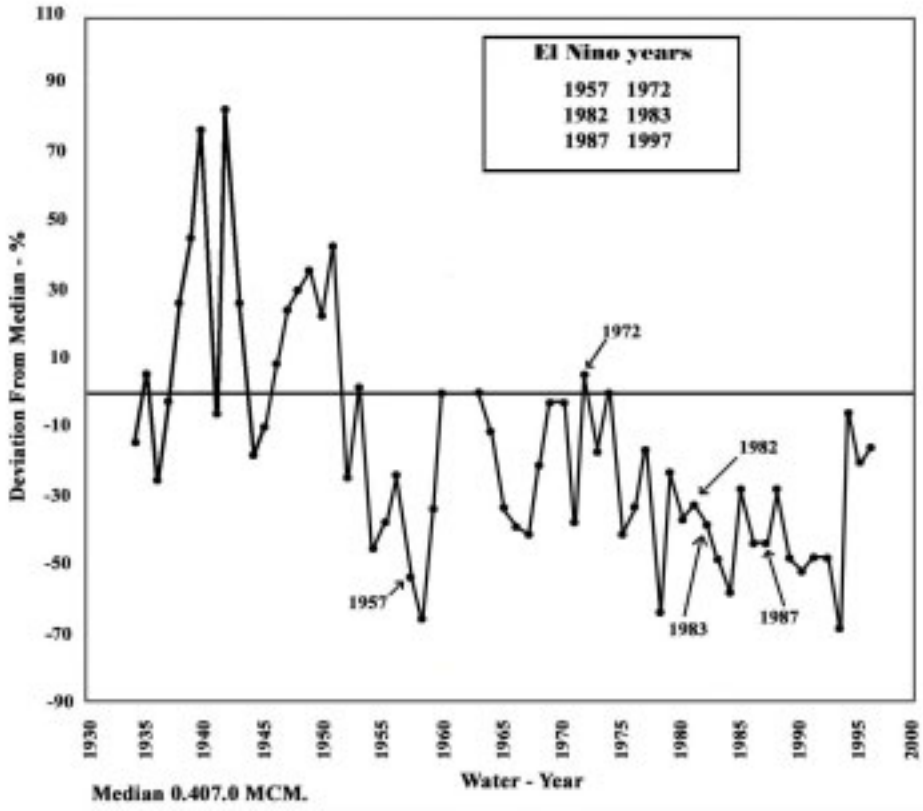
Source: Kanchanalak (1998).

3.2 El Nino-induced weather changes

The first sign of El Nino-induced weather changes was observed in May 1997 as strong warm weather. It intensified rapidly in June, remained at strength through April 1998 and declined abruptly in May 1998. After that it slowly strengthened to be a moderate event in October 1998 up to early 1999 (Meteorological Department 1999). The duration of these events was recorded as follows:

May to September, 1997 (rainy season): At the beginning of the rainy season, from May to June, drought occurred because of rainfall deficit throughout the country. However, the rainfall was close to normal in the second half of this season (July to September). It increased obviously during July to August, then again decreased in September, though it was considerably better than the beginning of the season (Table 3.2 and Figure 3.3).

Figure 3.2 Deviation from median of annual means of surface water levels in the Chao Phraya River basin and its tributaries measured at the gauging stations of Chainat and Nakhon Sawan Provinces.



Source: Kanchanalak (1998).

October 1997 to January 1998 (winter season): The average monthly temperature throughout this season was about 1º-2º C above normal in the first half and 1º-3º C in the second half. The average rainfall was below normal in this season in every region (Table 3.2 and Table 3.3.)

February to April 1998 (summer season): The average monthly temperature of this summer was not only about 1º-3ºC higher than normal but also higher than the 48-years' maximum temperatures that had ever been recorded during 1951-1998 in several provinces. Moreover, rainfall was lower than normal throughout the country (Table 3.3).

May to September 1998 (rainy season): This period was the declining stage of the El Nino. However, there were certain areas of the North and the Northeast that received below normal rainfall (Table 3.3 and Figure 3.2). The rest of the country experienced above normal rainfall. This evidence obviously contrasted to the 1997 rainy season rainfall patterns as illustrated in Table 3.2, Table 3.3, Figure 3.3 and Figure 3.4.

October 1998 to January 1999 (winter season): During this period, most of the upper part of the country experienced below normal rainfall, while the Peninsular south was covered with above normal rainfall (Table 3.3). The temperatures were warmer than the normal by 0.5º-2.0ºC. This was observed over most of the country, except for a small area in mid-Peninsular South where the temperature was cooler than the normal average recorded in December 1997 and January 1999.

February to April 1999 (summer season): In the summer, nearly all regions received above normal rainfall (Table 3.4). Most areas were 0.5º-2.0ºC warmer than normal in February and March and 0.5º-1.0ºC cooler than normal in April.

May to September 1999 (rainy season): The amount of rainfall was slightly below normal, however it was evenly distributed throughout the season. This resulted in drought in certain areas of the North and Northeast (Table 3.4 and Figure 3.5), but most crops were not affected.

It may be concluded that the amount of rainfall in all seasons during 1997-1998 was below normal, especially in the North and Northeast, along with persistently above normal temperatures almost throughout the period. The temperature became cooler than normal in April 1999, and the amount of rainfall was slightly below normal with even distribution in most regions from June to September 1999.

3.3 Extent of coverage of vulnerable areas in each event

3.3.1 Generally vulnerable areas

Vulnerable areas are sensitive areas that can be damaged by any adverse condition caused by certain natural phenomena, drought and flood. The degree and the extent of damage are topographically different from region to region and the severity of the natural disaster itself. Among the regions, either flood or drought always damages the Northeast. This is the result of the Northeast and Southwest Monsoons. Normally, this region faces long and heavy rains influenced by the Inter Tropical Convergence Zone (ITCZ), passing over this region during a period beginning from June to October (Figure 3.5). ITCZ is the so-called “Equatorial Trough” or “Monsoon Trough” (Figure 3.6). It is the cause of flooding in the Northeast region. At the same time, if a tropical cyclone is passing over this region, widespread flooding will result from long and heavy rains.

3.3.2 Identification of sensitivity of regions related to El Nino-induced weather changes

3.3.2.1 Selection of vulnerable provinces

The division of administrative regions helps identify regions sensitive to El Nino induced weather changes for this study. The Division of Climatic Regions covers five administrative regions, namely, the North, the Northeast, the East Coast, the Central (in which the West is included), and the South as illustrated in Figure 3.6. Each region consists of the provinces as follows:

- The North (15 provinces), including Chiang Rai, Chiang Mai, Mae Hong Son, Phayao, Nan, Phrae, Lamphun, Lampang, Uttaradit, Sukhothai, Phitsanulok, Phetchabun, Phichit, Kamphaeng Phet and Tak.
- The Northeast (19 provinces), including Loei, Nong Khai, Nong Bualampoo, Udon Thani, Sakon Nakhon, Nakhon Phanom, Mukdahan, Kalasin, Khon Kaen, Chaiyaphum, Maha Sarakham, Roi Et, Yasothon, Amnat Charoen, Si Sa Ket, Ubon Ratchathani, Surin, Buri Ram and Nakhon Ratchasima.
- The East (8 provinces), including Nakhon Nayok, Prachin Buri, Sa Kaew Chachoengsao, Chan Buri, Rayong, Chanthaburi and Trat.
- The Central (18 provinces), including Nakhon Sawan, Uthai Thani, Chai Nat, Lopburi, Saraburi, Ang Thong, Sing Buri, Phra Nakhon Si Ayutthaya, Suphan Buri, Kanchanaburi, Nakhon Pathom, Nonthburi, Pathum Thani, Bangkok Metropollitan, Samut Prakan, Samut Sakhon, Samut Songkhram and Ratchaburi.
- The South (16 provinces), including Phetchaburi, Prachuap Khiri Khan, Chumphon, Ranong, Surat Thani, Nakhon Si Thammarat, Krabi, Phangnga, Phuket, Trang, Phatthalung, Songkhla, Satun, Pattani, Yala and Narathiwat.

Table 3.2 Monthly and annual rainfall of Thailand in 1997.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	0.1	0.6	31.9	74.7	99.2	71.6	224.0	266.5	208.0	106.6	10.9	0.0	1,094.1
Depart * (mm)	-6.4	-8.3	+10.7	+9.4	-82.0	-87.1	+48.2	+45.8	-10.2	-25.0	-25.3	-7.1	-135.3
Depart * (%)	-99	-93	+51	+14	-45	-55	+27	+21	-5	-19	-70	-100	-11
The Northeast													
Amount (mm)	1.3	13.3	71.1	88.8	149.7	160.3	285.1	269.5	145.6	123.5	0.7	0.0	1,308.9
Depart * (mm)	-2.7	-2.4	+34.5	+3.8	-39.1	-55.4	+80.6	+12.1	-112.6	+9.0	-17.5	-2.6	-92.3
Depart * (%)	-68	-15	+94	+5	-21	-26	+39	+5	-44	+8	-96	-100	-7
The Central and the west													
Amount (mm)	0.6	4.5	32.1	52.5	90.6	55.7	127.3	159.7	282.3	157.4	26.7	0.2	989.5
Depart * (mm)	-6.9	-14.4	+1.1	-16.7	-72.7	-77.4	-14.0	-15.0	+19.1	-21.1	-17.6	-7.6	-243.3
Depart * (%)	91	-76	+4	-24	-45	-58	-10	-9	+7	-12	-40	-98	-20
The East													
Amount (mm)	10.6	38.7	82.1	97.1	145.9	144.7	330.1	261.3	327.0	175.5	45.9	4.9	1,661.2
Depart * (mm)	-4.9	+5.0	+27.9	+8.6	-81.9	-124.0	+73.5	-53.7	-8.5	-58.4	-28.2	-5.2	-252.6
Depart * (%)	32	+15	+51	+10	-36	-46	+29	-17	-3	-25	-38	-52	-13
The South (East Coast)													
Amount (mm)	14.2	54.9	20.7	60.6	65.0	106.3	126.2	262.2	190.0	209.4	289.5	283.8	1,682.8
Depart * (mm)	-59.1	+26.6	-18.0	-7.0	-82.6	+0.9	+9.6	+141.4	+45.5	-41.8	-102.5	+72.4	-14.6
Depart * (%)	-81	+94	-46	-10	-56	+1	+8	+117	+32	-17	-26	+34	-1
The South (West Coast)													
Amount (mm)	4.7	83.4	39.8	137.1	217.0	277.9	322.1	465.7	394.0	262.9	126.5	76.3	2,407.3
Depart * (mm)	-22.0	+60.6	-13.9	-15.0	-148.7	-51	-35.7	+94.9	-21.8	-88.4	-72.7	+15.8	-354.0
Depart * (%)	-82	+266	-26	-10	-41	-16	-10	+26	-5	-25	-37	+26	-12.0
Over the Country													
Amount (mm)	4.6	27.2	45.9	82.8	122.3	125.6	233.9	276.0	233.5	159.4	68.9	51.3	1,431.4
Depart * (mm)	-15.5	+7.7	+9.8	+1.1	-76.7	-64.6	+37.6	+37.2	-24.7	-28.2	-42.6	+6.5	147.4
Depart * (%)	-77	+40	+27.0	+1	-39	-34	+19	+16	-10	-15	-38	+15	9

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

* Departure from rainfall normal values which are from the 1961-1990 base period.

Table 3.3 Monthly and annual rainfall of Thailand in 1998.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	5.1	15.1	17.8	50.2	164.6	116.4	166.8	191.4	179.0	64.9	38.4	2.4	1,012.1
Depart * (mm)	-14	+6.2	-3.4	-15.1	-16.6	-42.3	9.0	-29.3	-39.2	-66.7	+2.2	-4.7	-219.3
Depart * (%)	-21	+70	-16	-23	-9	-27	5	-13	-18	-51	+6	-66	-18
The Northeast													
Amount (mm)	0.7	32.3	30.0	66.0	165.0	207.8	129.7	234.0	196.1	77.1	45.4	1.6	1,185.7
Depart * (mm)	-3.3	+16.6	-6.6	-19.0	-23.8	-7.9	-17.8	-23.4	-62.1	-37.4	+27.2	-1.0	-215.5
Depart * (%)	-83	+106	-18	-22	-13	-4	-37	-9	-24	-33	+149	-38	-15
The Central and the west													
Amount (mm)	13.3	15.8	5.8	47.8	168.9	145.1	195.8	208.3	244.4	199.9	47.9	2.1	1,295.2
Depart * (mm)	+5.8	-3.1	-25.2	-21.4	+5.6	+12.0	+54.5	+33.6	-18.8	+21.4	+3.6	-5.7	+62.4
Depart * (%)	+78	-16	-81	-31	+3	+9	+39	+19	-7	+12	+8	-73	+5
The East													
Amount (mm)	11.8	31.8	17.0	53.3	245.8	321.6	266.0	322.0	361.3	147.4	48.6	10.3	1,837.0
Depart * (mm)	-3.7	-1.9	-37.2	-35.2	+17.9	+52.9	+9.4	+6.8	+25.8	-86.5	-25.5	+0.2	-76.8
Depart * (%)	-24	-6	-69	-40	+8	+20	+4	+2	+8	-37	-34	+2	-4
The South (East Coast)													
Amount (mm)	32.7	2.7	13.8	15.8	97.6	130.3	137.9	166.9	200.2	337.6	285.1	275.2	1,695.8
Depart * (mm)	-40.6	-25.6	-24.9	-51.8	50.0	+24.9	+21.3	+46.1	+55.7	+86.4	-106.9	+63.8	-1.6
Depart * (%)	-55	-91	-64	-77	-34	+24	+18	+38	+39	+34	-27	+30	0
The South (West Coast)													
Amount (mm)	5.1	11.9	8.8	35.6	181.7	415.5	343.4	422.6	447.3	533.9	397.7	95.6	2,899.0
Depart * (mm)	-21.6	-10.9	-44.9	-116.5	-184.0	+86.6	-14.4	+51.8	-4.5	+182.6	+198.5	+35.1	+157.7
Depart * (%)	-81	-48	-84	-77	-50	+26	-4	+14	-1	+52	+100	+58	+6
Over the Country													
Amount (mm)	20.1	26.8	21.9	51.5	167.9	198.8	188.4	239.2	244.7	181.6	114.1	77.8	1,481.9
Depart * (mm)	0.0	+7.4	-14.2	-30.2	-31.1	+8.6	-7.9	+5.4	-13.6	-6.0	+2.6	+33.0	-96.9
Depart * (%)	0	+38	-39	-37	-16	+5	-4	+2	-5	-3	+2	+74	-6

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

* Departure from rainfall normal values which are from the 1961-1990 base period.

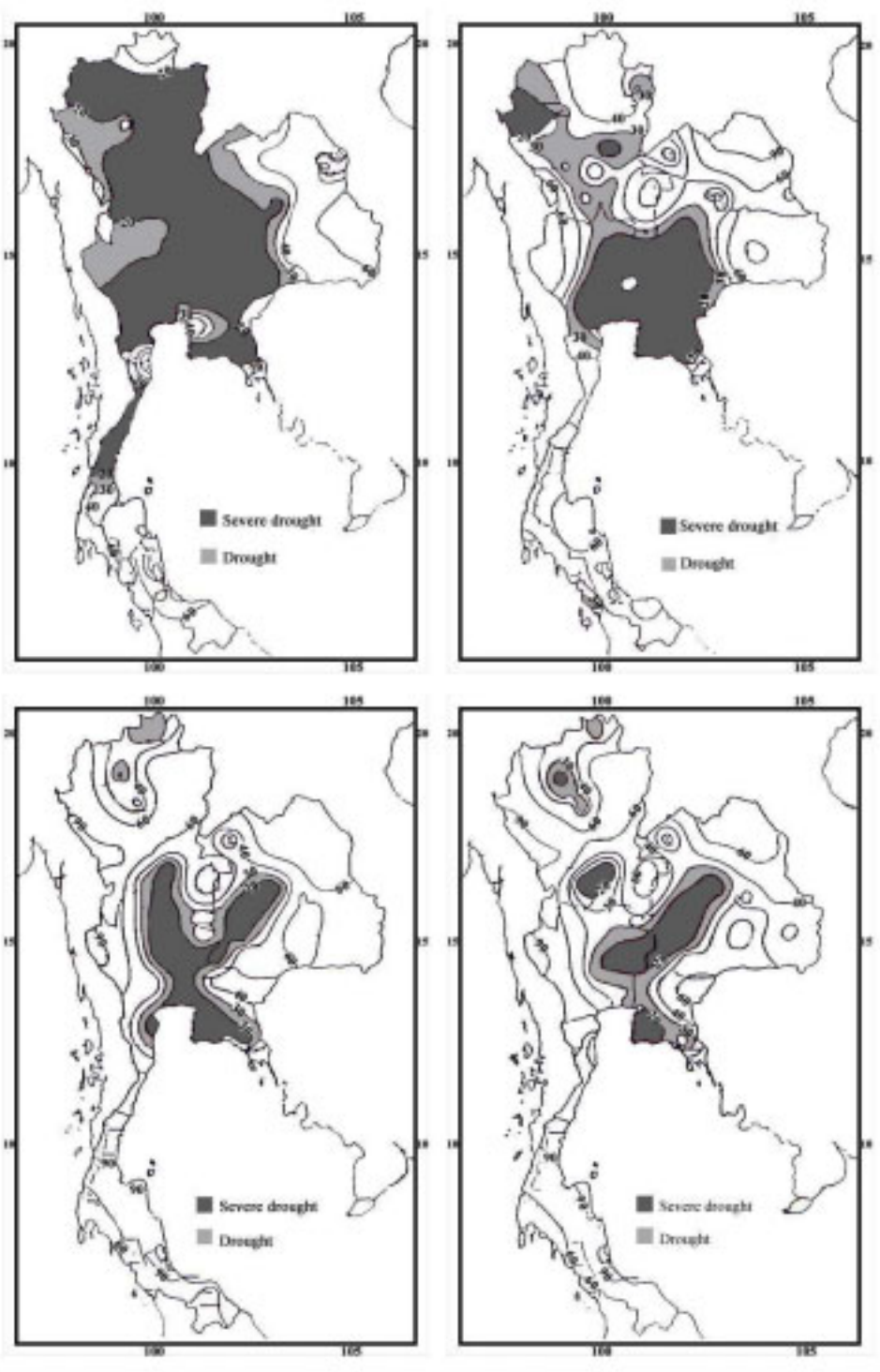
Table 3.4 Monthly and annual rainfall of Thailand in 1999.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	10.7	15.6	26.3	127.7	228.0	126.8	133.6	239.2	202.7	180.4	40.1	6.6	1337.7
Depart * (mm)	+4.2	+6.7	+5.1	+62.4	+46.8	-31.9	-42.2	+18.5	-15.3	+48.8	+3.9	-0..5	+106.3
Depart * (%)	+65	+75	+24	+96	+26	-20	-24	+8	-7	+37	+11	-7	+9
The Northeast													
Amount (mm)	2.4	1.7	66.7	150.6	260.9	223.6	257.3	165.7	251.2	122.9	32.9	0.9	1536.8
Depart * (mm)	-1.6	-14.0	-30.1	+65.6	+72.1	+7.9	52.8	-91.7	-7.0	+8.4	+3.9	-0.5	+135.6
Depart * (%)	-40	-89	-82	+77	+38	+4	+26	-36	-3	+7	+81	-65	+10
The Central and the west													
Amount (mm)	20.4	26.6	43.6	207.3	286.3	102.5	115.2	154.7	219.1	273.8	54.5	0.9	1504.9
Depart * (mm)	+12.9	+7.7	+12.6	+138.1	+123.0	-23.0	-26.4	-20.0	-44.1	+95.3	+10.2	-6.9	+272.1
Depart * (%)	+172	+41	+41	+200	+75	-23	-18	-11	-17	+53	+23	-88	+22
The East													
Amount (mm)	12.2	13.5	105.5	235.1	309.7	224.8	348.3	199.6	289.6	285.6	83.7	1.1	2108.7
Depart * (mm)	-3.3	-20.2	+51.3	146.6	+81.9	-43.9	+91.7	-115.6	45.9	+51.7	+9.6	-9	+194.9
Depart * (%)	-21	-60	+95	+166	+36	-16	+36	-37	-14	+22	+13	-89	+10
The South (East Coast)													
Amount (mm)	140.5	253.4	70.4	137.6	151.4	91.4	92.7	130.3	142.3	286.4	269.7	339.3	2105.4
Depart * (mm)	+65.1	+223.5	+29.9	+68.9	+6.2	-11.3	-16.8	+11.3	+2.2	+35.2	-122.3	+127.9	+408
Depart * (%)	+86	+747	+74	+100	+4	-11	-15	+9	+2	+14	-31	+60.5	+24
The South (West Coast)													
Amount (mm)	79.6	56.6	198.5	366.9	310.8	297.6	335.5	308.6	416.5	449.0	270.7	65.0	3155.3
Depart * (mm)	+52.9	+33.8	+144.8	+214.8	-54.9	-31.3	-22.4	-62.2	-35.3	+97.7	-122.3	+4.5	+414
Depart * (%)	+198	+148	+270	+141	-15	-10	-6	-17	-8	+27	+36	+7	+15
Over the Country													
Amount (mm)	36.4	53.4	71.3	181.7	250.0	169.5	201.7	197.5	238.7	237.9	+103.5	66.1	1807.7
Depart * (mm)	+16.6	+33.8	+32.1	+99.8	+50.6	-21.9	+4.2	-22.7	-21.2	+50.3	-8	+21.3	+228.9
Depart * (%)	+84	+172	+82	+122	+25	-11	+2	-10	-8	+27	-7	+48	+15

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

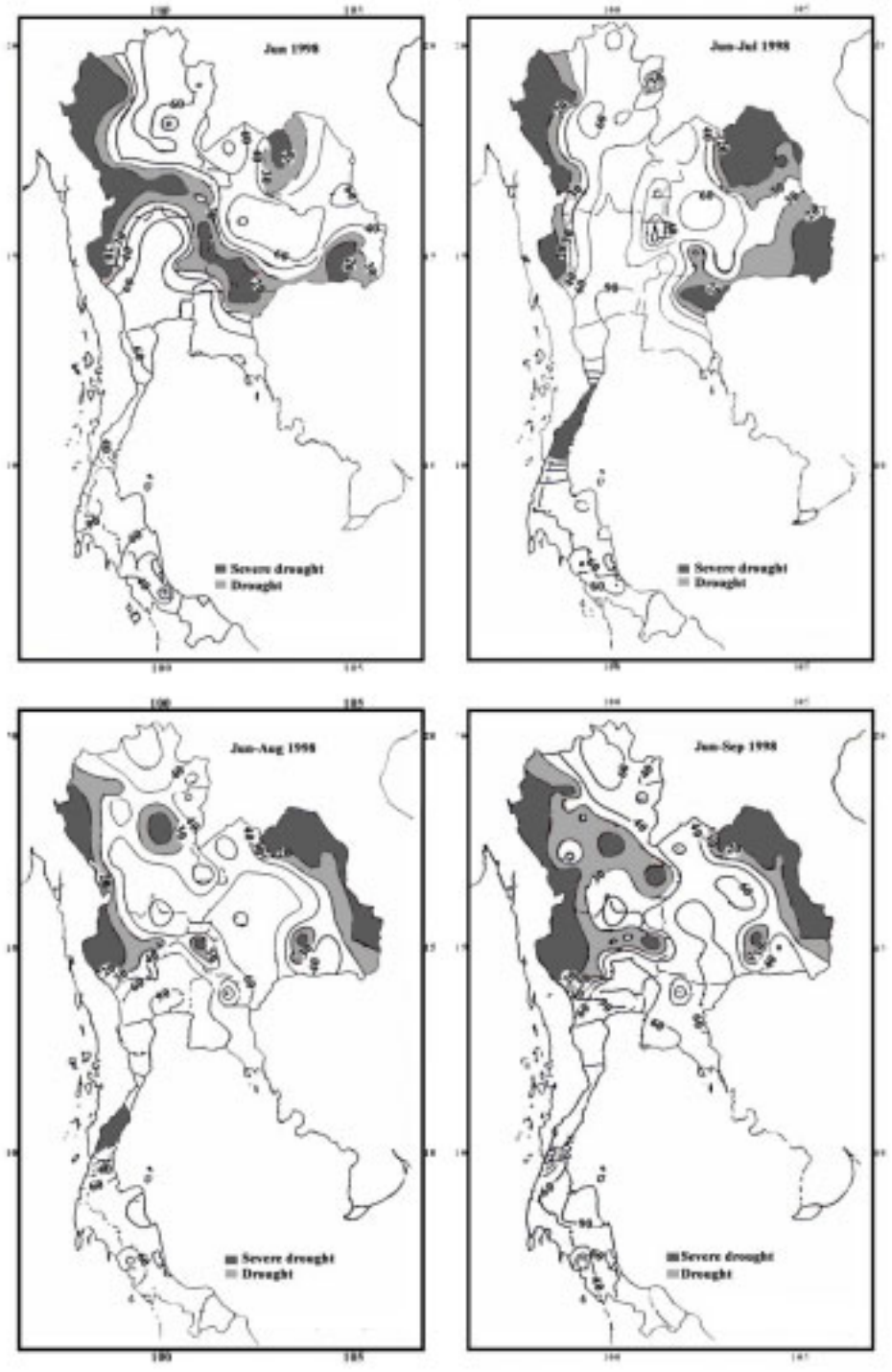
* Departure from rainfall normal values which are from the 1961-1990 base period.

Figure 3.3 GMI (Generalized Monsoon Index) percentile rank in June-September 1997.



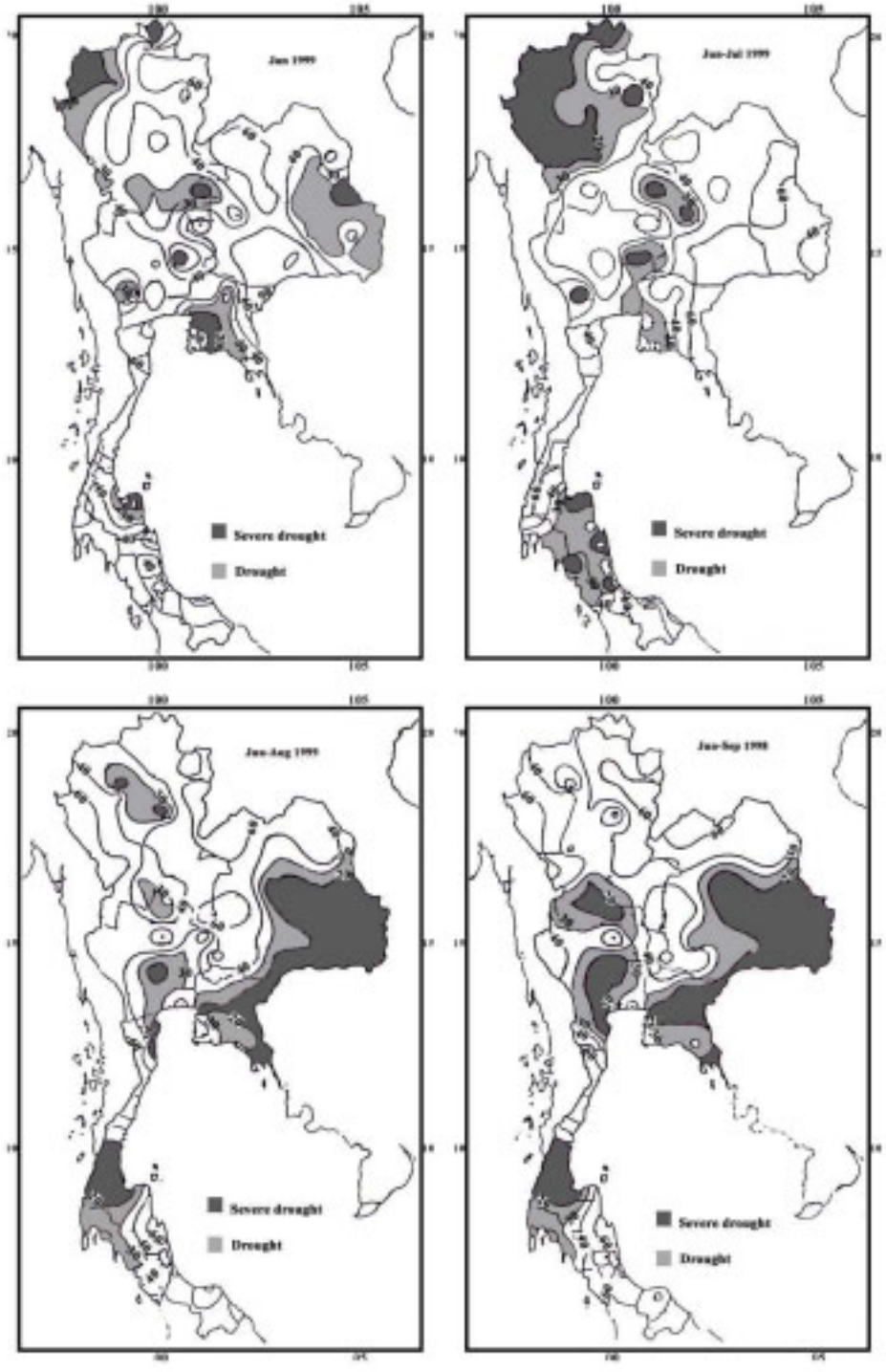
Source: Meteorological Department.

Figure 3.4 GMI (Generalized Monsoon Index) percentile rank in June-September 1998.



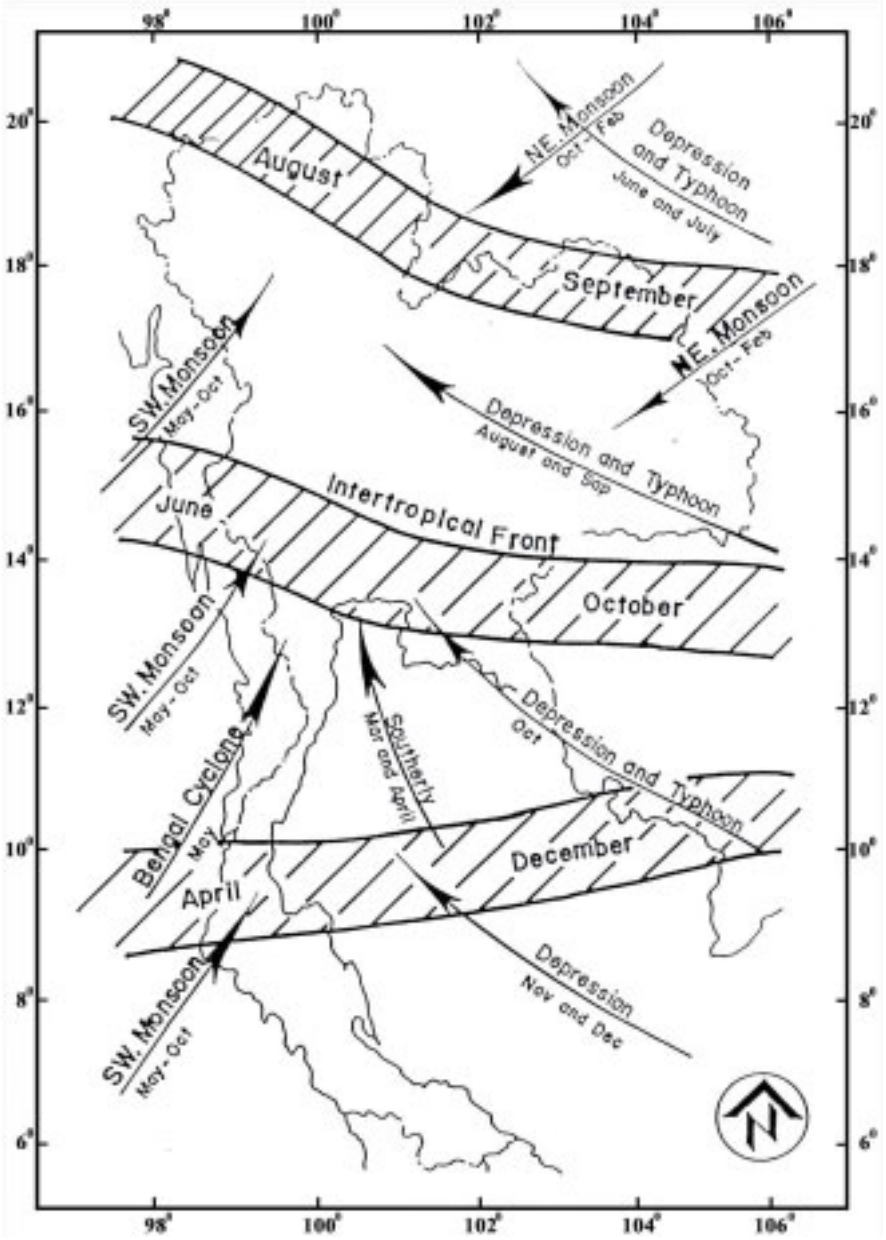
Source: Meteorological Department.

Figure 3.5 GMI (Generalized Monsoon Index) percentile rank in June-September 1999.



Source: Meteorological Department.

Figure 3.6 The pathways of Inter Tropical Convergence Zone (ITCZ) tropical cyclone over Thailand.



The selection of the most sensitive province as the vulnerable area of each region was based on the degree of drought severity related to El Nino-induced weather change. The decile range of the annual rainfall map of 1997 was used as the first indicative criteria in comparison with those of 1998 and 1999. The most sensitive province of each region with its agricultural produce damaged by drought was selected (Figure 3.7).

These five provinces selected are Phitsanulok of the North, Nakhon Ratchasima of the Northeast, Rayong of the East Coast, Nakhon Sawan of the Central and Phetchaburi of the South.

3.3.2.2 Selection of vulnerable districts

After the selection of the most sensitive province of each region, the following districts were selected as vulnerable areas of each province due to the extensive converge of upland crops in the area. They are:

- *Phitsanulok Province of the North*, consisting of
  - Wang Thong district
  - Promiram district
- *Nakhon Ratchasima Province of the Northeast*, consisting of
  - Wang Nam Kiew district
  - Pak Chong district
- *Rayong Province of the East Coast*, consisting of
  - Wang Chan district
  - Pattananikom district
  - Pluak Daeng district
- *Nakhon Sawan Province of the Central*, consisting of
  - Tak Fah district
  - Ta Tako district
  - Pisalee district
- *Phetchaburi Province of the South*, consisting of
  - Kaeng Krajan district
  - Ta Yang district
  - Cha Am district

All data for this research were acquired from interviewing the agricultural extension officers of the involved districts. Each district has a regional office, under the Department of Agricultural Extension, Ministry of Agriculture and Cooperatives. This office has agents who are responsible for local agricultural support to farmers in terms of technology transfer and data collection for policy planning, including disaster information from the villages. Each month, the agents have to visit farmers at the meeting points in order to transfer technology, observe farming areas and damage from natural disasters, and to collect yield data of major crops and livestock. Then, a report is made and sent to the centre every month in order to ask for assistance from the government. In addition, some data were also acquired from the Experiment and Research Station of the Department of Agriculture and from the author's observations.

3.4 Impacts of El Nino on vulnerable areas

Data of the impacts of El Nino on vulnerable areas were collected. They were then analyzed in the following terms: impacts on environment and natural resources; impacts on agricultural production/output; impacts on social and economic aspects; and impacts on food security. Results of each impact are summarised below.

3.4.1 Impacts on environment and natural resources

It may be concluded that El Nino had some impacts on the environment and natural resources of Thailand in 1997. Some districts of Nakhon Ratchasima Province: Wang Nam Kiew, and Pak Chong experienced severe drought and a rather long period of water scarcity and some Districts of Nahon Sawan Province: Ta Tako, and Pisalee experienced severe drought and a long period of water scarcity. All findings are arranged in tabular form (Table 3.5).

Table 3.5 Impacts of El Nino on the environment and natural resources of Thailand in 1997.

Region Province	Annual Rainfall (mm) Normal Year [1]	 1997	District	Impacts on Environment and Natural Resources	Mitigation Measures
North					
Phitsanulok	1,159.5	965.4	- Wang Thong	- None	These three districts are in irrigated areas
			- Wat Bode	- None	
			- Prompiram	- None	
Northeast					
Nakhon Ratchasima	1,079.9	624.0	- Wang Nam Kiew	- Broadly severe drought - A rather long period of water scarcity	- Operating Royal rain making
			- Pak Chong	- as above	- as above
East Coast					
Royong	1,797.0	892.1	- Wang Chan	- None	- has a 250 million m^3 reservoir
			- Pattananikom	- None	- has a 70 million m^3 reservoir
			- Pluak Daeng	- None	- has a 140 million m^3 reservoir
Central					
Nakhon Sawan	1,159.5	1,019.1	- Tak Fah	- None	- None
			- Ta Tako	- Broadly severe drought	- Operating Royal rain makings, but not successful due to very dry weather
				- A long period of water scarcity	- Supplying facilities for tube and shallow well construction
			- Pisa Lee	- as above	- as above
South					
Phetchaburi	1,136.9	994.6	- Kaeng Krajan	- None (Just only a very short period of modarate drought)	- None
			- Ta Yang	- as above	- as above
			- Cha Am	- as above	- as above (These three districts are in watershed and irrigated areas)

Note [1] = average 1994 – 1996.

3.4.2 Impacts on agricultural production/output

The 1997 El Nino had also some impacts on the agricultural production of Thailand and its output. In Nakhon Ratchasima Province, Wang Nam Kiew District had a decrease in corn yield with a loss of two million baht (production loss multiplied by market price). Moreover, Pak Chong District had a complete failure of field corn with a loss of 283 million baht. In Nakhon Sawan Province, Ta Tako district had a complete failure of corn and sorghum with losses of 25.3 and 8.9 million bath, respectively. In addition, Pisalee had a complete failure of corn, sugarcane, peanut and mungbean in some areas and the losses were 75.3, 10.4, 2.0, and 5.4 million baht, respectively. The details are presented in Table 3.6.

Table 3.6 Impacts of El Nino on the agricultural production/output of Thailand in 1997.

Region / Province / District / Crop	Area harvested (ha)		Yield[1] (t/ha)		Production (t)	
	Normal year[2]	1997	Normal year[2]	1997	Normal year[2]	1997
The Northeast						
Nakhon Ratchasima						
Wang Nam Kiew						
Corn	2,632	2,512	4.375	4.175	11,515	10,989
Pak Chong						
Corn	14,136	0	5.269	0.000	74,479	0
The Central						
Nakhon Sawan						
Ta Tako						
Corn	1,518	0	4.375	0.000	6,641	0
Sorghum	1,522	0	1.669	0.000	2,540	0
Pisalee						
Corn	15,003	10,475	4.375	3.055	65,638	45,828
Sugarcane	1,136	496	30.986	14.085	35,200	16,000
Peanut	40	40	3.125	0.000	125	0
Mungbean	648	328	0.938	0.475	608	308

Note [1] Estimated from planted area.
[2] means average 1994-1996.

The alleviation means illustrated in Table 3.6 were the factors that had been used as short-term and long-term measures to mitigate the adverse effects of abnormal weather. Royal rainmaking has been operated to relieve farmers' crops from agricultural drought since 1971. It could provide worthwhile results on the agricultural production when it is employed simultaneously with practicable water management of the three main water resources: the underground, the surface and the atmospheric.

The loans given by the Bank of Agriculture and Agricultural Cooperatives to its members for their new planting expenses relieved the effects of drought. After having failed at the early stage of the crop year, the farmers were able to grow some additional crops before the end of the season. Similar to the loan, supplying farmers with single-cross hybrid corn seed helped some farmers substitute for the failure crop. Drought-resistant crops such as mungbean and sesame could be promoted as a short-term alleviation only in the areas having enough soil moisture.

Constructing farm ponds to conserve water served for long-term alleviation. His Majesty the King remarked that farmers should devote 30% of any farm area to the farm pond. These are the practical elements of surface water management. Rehabilitating soil moisture and atmospheric relative humidity by promoting planting fruit trees, fuel wood and other trees as well as drilling shallow wells and tube wells in certain areas could serve for long-term alleviation. These can be used as the practical elements of underground and atmospheric water management.

3.4.3 Impacts on social and economic conditions

The impacts of El Nino on social and economic conditions of Thailand in 1997 were evidence in terms of labour mobilization and the farmers' repayment ability for their loans. Moreover, their purchasing power had also been weakened. These impacts were clear in Wang Nam Kiew Sub-District and Pak Chong District of Nakhon Ratchasima Province and in Ta Tako District and Pisalee District of Nakhon Sawan Province (Table 3.7).

Table 3.7 Impacts of El Nino on the social and economic conditions of Thailand in 1997.

Region Province District Crop	Production loss (%)[1] Area (ha.)	 Yield (t.)	Damage cost[2] (m. baht)	Mitigation measures
The Northeast				
Nakhon Ratchasima				
Wang Nam Kiew				
Corn	120	526	2.0	1. operating Royal rain making. 2. provision of the loan of 3.8 million baht for new planting.
Pak Chong				
Corn	14,136	74,479	283.0	1. operating Royal rain making. 2. supplying 21.5 tons of corn seeds to farmers.
The Central				
Nakhon Sawan				
Ta Tako				
Corn	1,518	6,641	25.3	1. operating Royal rain making.
Sorghum	1,522	2,540	8.9	2. promoting drought resistance crops such as mungbean and sesame. 3. supplying irrigation systems.
Pisalee				
Corn	4,528	19,810	75.3	1. promoting fruit trees, fuel wood and other trees in the area of 6,688 ha.
Sugarcane	640	16,000	10.4	
Peanut	40	125	2.0	2. constructing farm ponds in the total areas of 2,400 ha.
Mungbean	320	300	5.4	3. conditioning soil with polymers in 320 ha.

Note [1] Calculate from table 3.6, (normal-1997)/normal).
[2] Yields lost multiplied by its market prices.

3.4.4 Impacts on food security

Since El Nino had some impacts on agricultural production and its output and social and economic conditions of the vulnerable areas, some impacts on food security of those areas can be expected. Occurrence of labour mobilization, weakness of loan repayment and purchasing power seemed to support this expectation. Because Thailand is a food surplus country, the impacts on food security are not evident at the macro-level. At the farm level, more details are required; however, this study did not plan to observe farm data. The second phase will investigate this impact.

Table 3.2 Monthly and annual rainfall of Thailand in 1997.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	0.1	0.6	31.9	74.7	99.2	71.6	224.0	266.5	208.0	106.6	10.9	0.0	1,094.1
Depart * (mm)	-6.4	-8.3	+10.7	+9.4	-82.0	-87.1	+48.2	+45.8	-10.2	-25.0	-25.3	-7.1	-135.3
Depart * (%)	-99	-93	+51	+14	-45	-55	+27	+21	-5	-19	-70	-100	-11
The Northeast													
Amount (mm)	1.3	13.3	71.1	88.8	149.7	160.3	285.1	269.5	145.6	123.5	0.7	0.0	1,308.9
Depart * (mm)	-2.7	-2.4	+34.5	+3.8	-39.1	-55.4	+80.6	+12.1	-112.6	+9.0	-17.5	-2.6	-92.3
Depart * (%)	-68	-15	+94	+5	-21	-26	+39	+5	-44	+8	-96	-100	-7
The Central and the west													
Amount (mm)	0.6	4.5	32.1	52.5	90.6	55.7	127.3	159.7	282.3	157.4	26.7	0.2	989.5
Depart * (mm)	-6.9	-14.4	+1.1	-16.7	-72.7	-77.4	-14.0	-15.0	+19.1	-21.1	-17.6	-7.6	-243.3
Depart * (%)	91	-76	+4	-24	-45	-58	-10	-9	+7	-12	-40	-98	-20
The East													
Amount (mm)	10.6	38.7	82.1	97.1	145.9	144.7	330.1	261.3	327.0	175.5	45.9	4.9	1,661.2
Depart * (mm)	-4.9	+5.0	+27.9	+8.6	-81.9	-124.0	+73.5	-53.7	-8.5	-58.4	-28.2	-5.2	-252.6
Depart * (%)	32	+15	+51	+10	-36	-46	+29	-17	-3	-25	-38	-52	-13
The South (East Coast)													
Amount (mm)	14.2	54.9	20.7	60.6	65.0	106.3	126.2	262.2	190.0	209.4	289.5	283.8	1,682.8
Depart * (mm)	-59.1	+26.6	-18.0	-7.0	-82.6	+0.9	+9.6	+141.4	+45.5	-41.8	-102.5	+72.4	-14.6
Depart * (%)	-81	+94	-46	-10	-56	+1	+8	+117	+32	-17	-26	+34	-1
The South (West Coast)													
Amount (mm)	4.7	83.4	39.8	137.1	217.0	277.9	322.1	465.7	394.0	262.9	126.5	76.3	2,407.3
Depart * (mm)	-22.0	+60.6	-13.9	-15.0	-148.7	-51	-35.7	+94.9	-21.8	-88.4	-72.7	+15.8	-354.0
Depart * (%)	-82	+266	-26	-10	-41	-16	-10	+26	-5	-25	-37	+26	-12.0
Over the Country													
Amount (mm)	4.6	27.2	45.9	82.8	122.3	125.6	233.9	276.0	233.5	159.4	68.9	51.3	1,431.4
Depart * (mm)	-15.5	+7.7	+9.8	+1.1	-76.7	-64.6	+37.6	+37.2	-24.7	-28.2	-42.6	+6.5	147.4
Depart * (%)	-77	+40	+27.0	+1	-39	-34	+19	+16	-10	-15	-38	+15	9

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

* Departure from rainfall normal values which are from the 1961-1990 base period.

Table 3.3 Monthly and annual rainfall of Thailand in 1998.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	5.1	15.1	17.8	50.2	164.6	116.4	166.8	191.4	179.0	64.9	38.4	2.4	1,012.1
Depart * (mm)	-14	+6.2	-3.4	-15.1	-16.6	-42.3	9.0	-29.3	-39.2	-66.7	+2.2	-4.7	-219.3
Depart * (%)	-21	+70	-16	-23	-9	-27	5	-13	-18	-51	+6	-66	-18
The Northeast													
Amount (mm)	0.7	32.3	30.0	66.0	165.0	207.8	129.7	234.0	196.1	77.1	45.4	1.6	1,185.7
Depart * (mm)	-3.3	+16.6	-6.6	-19.0	-23.8	-7.9	-17.8	-23.4	-62.1	-37.4	+27.2	-1.0	-215.5
Depart * (%)	-83	+106	-18	-22	-13	-4	-37	-9	-24	-33	+149	-38	-15
The Central and the west													
Amount (mm)	13.3	15.8	5.8	47.8	168.9	145.1	195.8	208.3	244.4	199.9	47.9	2.1	1,295.2
Depart * (mm)	+5.8	-3.1	-25.2	-21.4	+5.6	+12.0	+54.5	+33.6	-18.8	+21.4	+3.6	-5.7	+62.4
Depart * (%)	+78	-16	-81	-31	+3	+9	+39	+19	-7	+12	+8	-73	+5
The East													
Amount (mm)	11.8	31.8	17.0	53.3	245.8	321.6	266.0	322.0	361.3	147.4	48.6	10.3	1,837.0
Depart * (mm)	-3.7	-1.9	-37.2	-35.2	+17.9	+52.9	+9.4	+6.8	+25.8	-86.5	-25.5	+0.2	-76.8
Depart * (%)	-24	-6	-69	-40	+8	+20	+4	+2	+8	-37	-34	+2	-4
The South (East Coast)													
Amount (mm)	32.7	2.7	13.8	15.8	97.6	130.3	137.9	166.9	200.2	337.6	285.1	275.2	1,695.8
Depart * (mm)	-40.6	-25.6	-24.9	-51.8	50.0	+24.9	+21.3	+46.1	+55.7	+86.4	-106.9	+63.8	-1.6
Depart * (%)	-55	-91	-64	-77	-34	+24	+18	+38	+39	+34	-27	+30	0
The South (West Coast)													
Amount (mm)	5.1	11.9	8.8	35.6	181.7	415.5	343.4	422.6	447.3	533.9	397.7	95.6	2,899.0
Depart * (mm)	-21.6	-10.9	-44.9	-116.5	-184.0	+86.6	-14.4	+51.8	-4.5	+182.6	+198.5	+35.1	+157.7
Depart * (%)	-81	-48	-84	-77	-50	+26	-4	+14	-1	+52	+100	+58	+6
Over the Country													
Amount (mm)	20.1	26.8	21.9	51.5	167.9	198.8	188.4	239.2	244.7	181.6	114.1	77.8	1,481.9
Depart * (mm)	0.0	+7.4	-14.2	-30.2	-31.1	+8.6	-7.9	+5.4	-13.6	-6.0	+2.6	+33.0	-96.9
Depart * (%)	0	+38	-39	-37	-16	+5	-4	+2	-5	-3	+2	+74	-6

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

* Departure from rainfall normal values which are from the 1961-1990 base period.

Table 3.4 Monthly and annual rainfall of Thailand in 1999.

Region	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
The North													
Amount (mm)	10.7	15.6	26.3	127.7	228.0	126.8	133.6	239.2	202.7				
Depart * (mm)	+4.2	+6.7	+5.1	+62.4	+46.8	-31.9	-42.2	+18.5	-15.3				
Depart * (%)	+65	+75	+24	+96	+26	-20	-24	+8	-7				
The Northeast													
Amount (mm)	2.4	1.7	66.7	150.6	260.9	223.6	257.3	165.7	251.2				
Depart * (mm)	-1.6	-14.0	-30.1	+65.6	+72.1	+7.9	52.8	-91.7	-7.0				
Depart * (%)	-40	-89	-82	+77	+38	+4	+26	-36	-3				
The Central and the west													
Amount (mm)	20.4	26.6	43.6	207.3	286.3	102.5	115.2	154.7	219.1				
Depart * (mm)	+12.9	+7.7	+12.6	+138.1	+123.0	-23.0	-26.4	-20.0	-44.1				
Depart * (%)	+172	+41	+41	+200	+75	-23	-18	-11	-17				
The East													
Amount (mm)	12.2	13.5	105.5	235.1	309.7	224.8	348.3	199.6	289.6				
Depart * (mm)	-3.3	-20.2	+51.3	146.6	+81.9	-43.9	+91.7	-115.6	45.9				
Depart * (%)	-21	-60	+95	+166	+36	-16	+36	-37	-14				
The South (East Coast)													
Amount (mm)	140.5	253.4	70.4	137.6	151.4	91.4	92.7	130.3	142.3				
Depart * (mm)	+65.1	+223.5	+29.9	+68.9	+6.2	-11.3	-16.8	+11.3	+2.2				
Depart * (%)	+86	+747	+74	+100	+4	-11	-15	+9	+2				
The South (West Coast)													
Amount (mm)	79.6	56.6	198.5	366.9	310.8	297.6	335.5	308.6	416.5				
Depart * (mm)	+52.9	+33.8	+144.8	+214.8	-54.9	-31.3	-22.4	-62.2	-35.3				
Depart * (%)	+198	+148	+270	+141	-15	-10	-6	-17	-8				
Over the Country													
Amount (mm)	36.4	53.4	71.3	181.7	250.0	169.5	201.7	197.5	238.7				
Depart * (mm)	+16.6	+33.8	+32.1	+99.8	+50.6	-21.9	+4.2	-22.7	-21.2				
Depart * (%)	+84	+172	+82	+122	+25	-11	+2	-10	-8				

Source: Local Climate Sub-Division, Climatology Division, Meteorological Department.

- Departure from rainfall normal values which are from the 1961-1990 base period.

4. Assessment of National El Nino Coping Mechanisms

4.1 National risk management strategies

Since El Nino induced weather changes are quite new to Thailand, no policies and measures have been especially set up to cope with these events. Moreover, since Thailand is situated in a monsoon region, droughts and floods are normal. Many policies and measures could address these natural disasters, and thus may be used to alleviate the adversity of El Nino events.

4.1.1 National awareness campaigns

4.1.1.1 Campaigning through risk warning systems

Agricultural yield variations in Thailand, either favorable or unfavorable, are highly determined by climatic conditions including water runoff, surface water, and the ground water table, and particularly with the traditional cultural practices for rainfed agriculture. Adverse climate and weather can be a primary cause of crop failure and a decline in agricultural production and it can affect the national economy and the prosperity of the Thai population. Climate and weather forecasts are important as one of the risk warning systems, which can be used as a means of avoiding the undesirable effects. Mainly, the Department of Meteorology and the Department of Irrigation have made the risk warning systems.

The Department of Meteorology has issued not only climate and weather forecasts daily and weekly, but also the weather analysis and potential climatic impact assessments. The information users are among government agencies, policy decision-makers, economic analysts, agricultural scientists, agricultural officials and farmers. They use it for the development of strategies to mitigate the potential impact or to complement and supplement other information sources to make a forecast in crop production, especially in pre-harvest and post-harvest practices and to serve their individual needs. There are 62 synoptic stations, 28 agro-meteorological stations, and nine hydro-meteorological stations located at different elevations from 1 to 397 meters above mean sea level in 59 provinces throughout the country carrying out the climatic and weather data collection.

The forecasts are officially distributed to the public by broadcasting programmes through government radio and television stations. The weather analysis and potential climatic impact assessments are distributed to the public by technical documents, namely the “Report of Climatic Impact Assessment for Crops in Thailand”

Aside from the Department of Meteorology, the Department of Irrigation has made the other risk warnings. This department analyses data concerning the amount of water in the great dams. The warnings are publicized in timely manner to the farmers through government agencies, such as Regional Irrigation Offices, Regional Agricultural Centers, Regional Agricultural Extension Offices, Provincial Agricultural Offices, and District Agricultural Offices. Moreover, mass media such as newspapers, radio broadcasts, and television programs help distribute the information. Communication in the forms of seminar, training, visiting, as well as producing news, features and articles, have also been made regularly.

4.1.1.2 Campaigning for water source and forest awareness

First of all, it is important to that the greatest leaders campaigning for water sources and forest awareness in Thailand are His Majesty the King and Her Majesty the Queen.

His Majesty King Bhumibol Adulyadej remarked that "… If we inform the people about the profits of "The Forest of Three Forms" and that they can gain, they will keep such sources of their profits and harm nothing intentionally. If someone tries to deforest, they will do everything possible to protect the forest. This means that if we give people a chance to take suitable profits from the forest then we will have a large number of forest conservators" (Department of Forestry 1998).

"The Forest of Three Forms", explained by His Majesty at the Northern Regional Agricultural Center (Chiang Mai Province) on the February 26, 1981, means that the village supplies forest, the orchard forest and the firewood forest. These forests have given people the four major interests: logs and sawn-timber; fruits and greens; fuel wood and wood charcoal; and a means for conserving soil and water sources as well as retaining atmospheric relative humidity.

The achievement of campaigns for water source and forest awareness including the conservation of water sources and forests is significantly dependent on the virtues and the mentality of the people themselves. The people of the villages around that area should offer and participate both physicaly and psychologicaly. His Majesty remarked on January 24, 1977 that "… It is necessary to give the people the explanation that the amount of water in various natural sources is decreased because the area of forests or trees which are their water sources has been cleared through their ignorance of the facts…". Another remark on February 16, 1977 in Chiang Mai Province is that "… Nursery stations for the production of rapidly growing tree seedlings should be established so that those seedlings can be given free of charge to the people for planting in their fallow land. This helps them to be aware and to conserve natural environment…".

Her Majesty the Queen remarked that "… Someone has been exclusively absorbed in becoming a rich man within a short time because as a rich man he can gain everything he wants. Looking to a national forest reserve, he consents to pay a sum of money for employing poor to cut trees for export. The poor, who have been tricked by him, think that felling trees in a forest reserve is a good way to get rich quickly, that such forests give us nothing and prevent us from having farms. So I have made a note of His Majesty's remarks, which were expressed long ago, that the forest should be beneficial to our people. On the other hand a well-informed public should realize that national forest reserves provide benefits all of them …" (Department of Forestry 1998). Her Majesty remarked on August 28, 1998 that "… Forests have great advantages to our country as their humidity brings us the seasonal rain. They not only reserve water for us the year round as surface and underground water, but also give us many forest products, for example; medicinal herbs, mushrooms, honey, other forest products, etc…" (Department of Forestry 1999).

To make the campaigns for water source and forest awareness possible and practical and to attract people's attention nationwide, the Department of Forestry has issued policy and strategies concerned and conducted many important activities as follows:

- Amending the National Forestry Policy 1985 to become the National Forestry Policy 1998, which is under the consideration of the Committee on National Forestry Policy and the Cabinet;
- Initiating forest conservation and development strategies that have been used during the period of the Eighth National Economic and Social Development Plan (1997-2001);
- Producing public relations media in forms of video tape, TV spot and program, radio spot and program, poster, brochure, booklet, folder, etc.;
- Arranging mass media excursions on forestry affairs and activities concerned;
- Issuing news about forestry affairs;

- Arranging exhibitions;
- Sending mobile units to attract public's attention on water source and forest awareness in the targeted areas; and
- Giving lectures at schools and other academic institutes.

Frequently, His Majesty the King, Her Majesty the Queen and the royal family members participate in these activities. As a result now, more people realize the importance of water source and forest awareness. Many water sources and forests have been guarded and protected against deforesters to a greater extent. Many communal forests have also been established and continuously developed by their surrounding communities.

4.1.1.3 Restraining deforestation

The Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment (1998) reported that deforestation in Thailand came from three major causes: illegal entry to the forest area mainly for shifting cultivation; illegal felling of trees; and burning forest areas. The last is the most important in destroying the valuable trees and, also, creatures, conditions of soil, water sources, atmosphere and scenery of that forest area. Moreover, it is very difficult for the forest to recover once a forest fire has destroyed it.

The deforestation rate was the highest in 1978 and the lowest in 1998 at 1,159,650 ha or 2.26% and 58,769 ha or 0.11% of the country's forest area, respectively, (Table 4.1).

Table 4.1 Forest and deforested area during 1961-1998.

Year	Total Forest Area		Deforested Area	%
	Hectares	% of the country area	(ha/year)	Deforestation/year
1961	27,362,850	53.33	-	-
1973	22,170,700	43.21	432,679	0.84
1976	19,841,700	38.67	776,333	1.51
1978	17,522,400	34.15	1159,650	2.26
1982	15,660,000	30.52	465,600	0.91
1985	15,086,600	29.40	191,133	0.37
1988	14,380,300	28.03	235,433	0.46
1989	14,341,700	27.95	38,600	0.08
1991	13,669,800	26.64	335,950	0.66
1993	13,352,100	26.02	158,850	0.31
1995	13,148,506	25.62	101,797	0.20
1998	12,972,200	25.28	58,769	0.11

Source: Adapted from Office of Environmental Policy and Planning (1998).

The major factors enhancing deforestation in Thailand are government policies, the commercial need of land and the increasing of population. The government policies include the National Forestry Policy, the National Land Policy, the Infrastructure Development Policy, the National Security Policy and the National Policy of the Export of Agricultural Commodities. These policies are not the direct cause of deforestation, but their limitations, inconsistent provisions and questionable procedures, including non-continuance of coordinated action among government agencies, have been considered causal to some extent. These factors initiate conflict on the application of forest resources and lands between certain government agencies, between some government agencies and people and among groups of people. Most opposition is linked to the problems of rights of tenancy, permanency and water source. This opposition is growing wider and stronger in some areas.

To address the problem of deforestation, the Department of Forestry launched many important policies concerning campaigns for water sources and forest awareness, for example:

- Initiating a master plan for national forest conserve management, which is not merely a site plan, but a practical plan with a manual for managing all living and nonliving components of national resources, including land utilization and occupation;

- Fixing boundary lines of national forest conserves quickly, suitably and clearly so that community areas are permanently excluded from them and all squatters will be prosecuted;
- Proclaiming boundary lines of national forest reserves and wildlife conservation areas so that community areas are excluded from them clearly and permanently in advance to avoid arguments and conflicts in the future;
- Promoting eco-tourism in the legally permitted areas to create and augment popular fronts of voluntary forest conservators;
- Managing water source areas so that people can live in harmony, peacefulness, and sufficiency by establishing conditions of using land and forest along with promoting occupations that favor the conservation of natural resources and environmental surroundings; and
- Establishing programs for promoting and extending forest rehabilitation and reforestation.

4.1.1.4 Reforestation and afforestation

In accordance with policies mentioned above, reforestation including partial afforestation, has been done annually. By the end of 1999, a total area of 8,878.60 square kilometers was already reforested and afforested. Contribution and cooperation of many public and private agencies had supported this task (Table 4.2).

Table 4.2 Annual reforestation and afforestation by objective.

	Reforested (and Afforested) Area (km^2)				
Item	Up to 1996	1997	1998	1999	Total
Afforestation by the Government budget	6,451.84	62.03	65.92	92.83	6,672.62
Concessionaire's reforestation	1,468.97	-	-	-	1,468.97
Reforestation by Forest Industry Organization (FIO)	270.25	-	-	59.24	329.49
Reforestation by Thai Plywood Co., Ltd.	11.74	7.01	6.19	6.94	31.88
Reforestation in accordance with the Ministry's Regulations	125.64	2.34	9.71	13.37	151.06
Reforestation by concessionaire's budget	208.69	6.51	8.98	0.40	224.58
Total	8,537.13	77.89	90.80	172.78	8,878.60

Source: Department of Forestry (2000).

His Majesty the King has paid considerable attention to reforestation and afforestation. In addition, a major public participation and cooperation afforestation project namely "Permanent Forests Afforested for Enhancement of His Majesty Prestige on the Occasion of the 50^{th} Anniversary of His Majesty's Throne Ascendancy" was implemented during 1994 to 1998. Its purpose was to increase the forest area to conserve water sources and retain atmospheric relative humidity as well as to campaign for enhancing water sources and forest awareness. A total area of 3,402.27 km^2 and a total distance of 49,700.48 km along roadsides fences, land boundaries, etc. were the results of the project: 2,317.84 km^2 within the bounds of conservation areas; and 1,084.43 km^2 and 49,700.48 km beyond the bounds of conservation areas (Table 4.3).

Furthermore, in 1998, a total area of 76.25 km^2 within the bounds of conservation forest was planted with tree seedlings for interposition and rehabilitation of that area.

Table 4.3 Afforestation under "Permanent Forests Afforested for the Enhancement of His Majesty's Prestige on the Occasion of the 50th Anniversary of His Majesty's Throne Ascendancy" project from 1994 to 1998.

Year	Within Bounds of Conservation Area	Beyond the Bounds of Conservation Area		Total	
	(km^2)	(km^2)	(km)*	(km^2)	(km)*
1994	178.05	280.67	11,409.89	458.72	11,409.89
1995	1,018.08	444.73	24,778.04	1,462.81	24,778.04
1996	855.65	206.29	8,766.56	1,061.94	8,766.56
1997	214.52	56.80	906.40	271.32	906.40
1998	51.54	95.94	3,839.59	147.48	3,839.59
Total	2,317.84	1,084.43	49,700.48	3,402.27	49,700.48

Remark: * Along roadsides, fences, land boundaries, etc.
Source: Department of Forestry (1999).

4.1.1.5 Proclaiming abrogation of forest concession countrywide

The Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment (1998) reported that deforestation resulting in the decrease of forest area in Thailand has continuously occurred. It has directly and indirectly affected economic, social, political and national security problems. In 1961, there was a total of 27,362,850 ha of forest area or 53.33% of the country's area, but in 1998, only 12,972,200 ha or 25.28% of the country's area remained under forest. Therefore, 14,390,650 ha or 28.05% of the forest area was cleared during a period of 37 years from 1961 to 1998 (Table 4.1). During 1989 to 1998, the deforested rate was somewhat slower than before. This might be as the result of the abrogation of forest concessions countrywide that has been enforced since 1989 in accordance with an order of the Ministry of Agriculture and Cooperatives dated January 17, 1989. The augmentation of additional forest reserves in many areas of the country has also been proclaimed since then.

4.1.1.6 Forest fire management

The occurrence of forest fires and the burned forest areas have been recorded since 1985 (Table 4.4). During the El Nino Years, the sea surface temperature (SST) measured in January was usually high. In 1998, one of the El Nino Years, the area burned by forest fire was greatest at 518 square kilometers, the frequency of fire occurrence was highest at 7,909 times, and the SST ran to an extreme of 3.56.

Table 4.4 Forest areas burned in Thailand, 1985-1999.

Year	Burned Area (km^2)	Frequency of Fire Occurrence	SST (Jan)
1985	80	2,563	-0.81
1986*	85	3,482	-0.67
1987*	90	4,414	1.30
1988	110	3,756	0.75
1989	114	3,722	-1.23
1990	118	3,688	-0.09
1991	124	4,411	0.28
1992*	158	4,684	1.65
1993*	123	4,263	0.12
1994	307	4,402	0.33
1995	239	5,252	0.98
1996	182	5,890	-0.39
1997	245	7,423	-0.62
1998*	518	7,909	3.56
1999	291	7,800	-0.94

Remark: * El Nino Year.
Source: Adapted from Nibhond Tangtham et al. (2000).

The activities for forest fire prevention and putting out forest fires in 1997-1999 are listed in Table 4.5. The media for forest fire protection campaigns were mobile units, mass media, notice boards, leaflets and posters, monographs, exhibitions, lectures and training. The operations for putting out forest fires consisted of surveying operational areas, preparing forest fire forces, preparing forest fire instruments and tracks, managing forest fire fuel, patrolling forest fire blazes and putting out forest fires.

Table 4.5 Activities for forest fire protection campaigns and putting out forest fires in 1997-1999.

Activity	Unit	Fiscal Year (October-September) 1997	1998	1999
Forest fire prevention campaigns through the following media:				
1. Mobile units	times	7,920	3,471	7,905
2. Mass media	times	1,583	1,712	2,688
3. Notice boards	boards	7,198	5,149	8,155
4. Leaflets, Posters	sheets	428,105	313,903	491,020
5. Monographs	books	199,439	140,470	257,021
6. Exhibitions	times	1,437	656	1,044
7. Lectures	times	3,169	2,207	3,272
8. Training	times	293	151	810
Operations for putting out forest fires:				
1. Surveying operation areas	km^2	28,608	26,572	47,179
2. Preparing forest fire forces	persons	*	2,898	4,035
3. Preparing forest fire instruments	units	236	198	269
4. Preparing forest fire tracks	meters	*	207,200	228,000
5. Managing forest fire fuel	km^2	*	69	84
6. Patrolling forest fire blazes	km^2	28,608	26,572	47,179
7. Putting out forest fires	times	7,423	7,909	7,800
	km^2	245	518	291

Remark: * No data available.

Source: 1997 Annual Report, Department of Forestry (1997); Office of Forest Fire Protection Task Force, Department of Forestry (2001).

The Department of Forestry has carried out forest fire management with two important indicators of success. The first is to control the burning areas to not more than 1% of the total of country's forest areas annually. The second is to decrease burnt forest area year after year. The Department of Forestry also sets up the major policies concerning forest fire management as follows:

- To eliminate forest fire in the important forests, parks and peat swamp forests by all means.
- To plan and train for distinguishing serious forest fires.

4.1.1.7 Minimization of dry season rice growing area with field crops cultivation displacement

In the drought in 1997, the annual average rainfall was much less than in a normal year. The water of 28 large reservoirs located throughout the country were largely gone in 1998. Thus, the government launched a measure to decrease the dry season rice area from 1.12 million ha to not more than 0.32 million ha. Farmers in some areas had to be prevented from cultivating in order to reserve water for consumption only. Others were recommended to cultivate any field crops which require less water and have drought resistant potential, including mungbean, soybean, green soybean, peanuts, field corn, baby corn, sorghum and vegetables, as early as possible after the harvest of early rainy season upland crops. Technologies, soil and water management knowledge, seeds and fertilizers were transferred and subsidized to rice farmers. Private companies were induced to guarantee prices of the proposed produce.

This measure did not meet its target. The farmers were not familiar with the other field crops. Moreover, the soil was not suitable for them. The price of rice also increased due to world demand. In response to the price incentive, the farmers kept growing rice and searched for additional ground water. Fortunately, the rains came early in 1998.

4.1.1.8 Well-planned irrigation management

The Office of Environmental Policy and Planning (1998) reported that at the end of the Fiscal Year 1998 Thailand had 731 large and medium irrigation projects, 8,234 small irrigation projects, and 20,006 mobile units for dredging rivers, canals, and other waterways. The total capacity of all reservoirs was 546,787 million cubic meters and the total irrigated area was 5,585,600 ha or about 26.35% of the area for agriculture (21,196,800 ha in 1995). It has been estimated that, in 2006, water requirements will increase in all of the country's activities. The total water requirements will be up to 70,494 million cubic meters, of which 61,746 million cubic meters or about 87.59% will be required by agricultural activities. Water scarcity will be a problem to some areas. Thus, preparation of well-planned irrigation management for the future is a must. The polices are focusing on:

- New irrigation methods and facilities to handle the various problems that can occur;
- User participation in order to determine the rights and the priority of water use; and
- Water pricing to minimize water usage and maximize water use efficiency. The World Bank (1993) has estimated that, if the water price is raised by 10%, water requirements for consumption, the industrial sector, and agricultural production will decrease by 2-4, 4-10, and 4-15%, respectively.

4.1.2 Technology interventions

4.1.2.1 Water source development

The purpose of water source development is to supply water to respond to the requirements of consumption, irrigation, and industrial sectors. Additional purposes are to conserve water sources, to generate electricity, to prevent and attenuate floods, to drain surplus water from cultivated areas and to leach acidic soils, and to conserve soil and to treat wastewater. The Department of Irrigation has conducted most water source development projects, which are mainly of reservoir construction that can be classified into three levels:

- Large-sized projects: the capacity of any reservoir constructed in this level is at least 100 million cubic meters that enables irrigation of at least 12,800 ha of farming area. Up to now, more than 100 such projects have been established and are under operation.
- Medium-sized projects: each reservoir constructed has a capacity not larger than 100 million cubic meters, which enables irrigation of less than 12,800 ha of farming area. Up to now, more than 500 such projects have been finished and are under operation.
- Small-sized projects: any reservoir constructed at this level has low capacity. These projects are mainly used for water consumption and are only used for supplying water to household gardens to produce greens in the surrounding communities. Now, more than 8,000 projects have been finished throughout the country.

Along with the construction of reservoirs, irrigation systems are also developed. They include water damming up, water irrigation, water drainage, attenuation of brine content, water management of acidic soil, construction of farm ponds, and dredging of waterways, marshes and swamps. Farm ponds are constructed to retain water for farming purposes especially in the outer areas, where there is no irrigation. In addition, all responsibilities of dredging waterways, marshes, and swamps have been transferred from the Department of Irrigation to the communal administrative organizations concerned since March 24, 1998.

4.1.2.2 Royal rainmaking

After visiting people throughout the country since the early part of the throne ascendancy, His Majesty the King Bhumibol Adulyadej realized the long drought problem and its effects on farmers' production. The agricultural drought has tended to occur more frequently and seriously year after year. To alleviate this problem, His Majesty the King decided to support research on and the practice of artificial rain enhancement, as well as planned water management of the three main resources: the underground, the surface, and the atmosphere.

The first sky experiment of royal rainmaking was accomplished in 1969, and was employed to relieve farmers' crops from drought in 1971. After that it has operated continuously every year. In 1975, the Royal Thai Government issued a decree to set up "The Royal Rainmaking Research and Development Institute" in the Ministry of Agriculture and Cooperatives.

The royal rainmaking activities of Thailand have been reported annually to the World Meteorological Organization (WMO) since 1982. Technology transfer and academic assistance on rainmaking have been made worldwide.

In 1986, His Majesty the King expressed the precepts of royal rainmaking to the staff of the Royal Rainmaking Research and Development Institute and U.S. rainmaking specialists in three important remarks:

- Royal rainmaking is to be developed more scientifically;
- Royal rainmaking is an important factor for the whole water resource management of the country; and
- Royal rainmaking can be accomplished satisfactorily only if there is good coordination and cooperation among the agencies concerned.

Moreover, the development of royal rainmaking as mentioned above should be accomplished step by step, economically, and self-sufficiently.

In 1992, by Cabinet resolution, the Royal Rainmaking Research and Development Institute was united with the Agricultural Aviation Division of the Ministry of Agriculture and Cooperatives to become "The Bureau of Royal Rainmaking and Agricultural Aviation" in order to enhance its operational efficiency. Its main duties are to provide artificial rain enhancement to serve farmers and general water users by means of increasing the water level of ponds, reservoirs, and dams in the agricultural production areas and also developing rainmaking technologies. Moreover, it provides aviation and communication services to support agricultural tasks. Finally, it encourages cooperation among the agencies concerned and conducts the special tasks appointed.

Royal rainmaking in Thailand has been developed effectively and quite rapidly. The area under royal rainmaking operation has been extended year after year and also the rainmaking working groups have increased as well. In 1971, there was only one working group with a budget of 1.962 million baht to conduct artificial rain enhancement to alleviate agricultural drought despite a total number of 119 workdays. Now, there are nine working groups with an annual budget of more than 220 million baht and the total number of workdays has been extended to more than 1,700, or approximately 190 workdays per group. In case of emergency and necessity, private aircraft will be hired to enhance rainmaking operations. The plan of aircraft application for royal rainmaking in 2001 has already been scheduled as illustrated in Table 4.6.

Table 4.6 Plan of aircraft application for royal rainmaking in 2001.

Operation Base	Period of Operation											
	Jan	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1. Chiang Mai	CASA 1512, 1513, 1535			KING AIR 2011 (Moved from Nakhon Sawan)								
1.1 Phare					CASA 1534, 1536 (Moved from Nakhon Sawan)							
2. Nakhon Sawan**	KING AIR 2011											
	CASA 1534, 1536											
2.1 Phitasanulok*	CASA		2 BT 67									
	1531											
	1532											
	1533											
2.2 Lop Buri					2 BT 67 (Moved from Phitsanulok)							
3. Khon Kaen			1 CN235 AND 2 NORMAT (NAVY)									
4. Nakhon Ratchasima*			KING AIR 2012, CASA 1531, 1532, 1533 (Moved from Phitsanulok)									
5. Rayong*		2 BT 67										
5.1 Chanthaburi		CARAVAN 1911, 1912, 1913, 1914										
5.2 Prachin Buri						CARAVAN 1911, 1912, 1913, 1914 (Moved from Chanthaburi)						
6. Prachuap Khiri Khan*		CARAVAN 1915, 1916, 1917										
		CARAVAN 1918 (From Fishery Task Force)										

Scheduled on January 5, 2001 by Sommart Daengjai, the Bureau of Royal Rainmaking and Agricultural Aviation, Ministry of Agriculture and Cooperatives.
* Included in the vulnerable areas studied.

4.1.2.3 Introduction of micro-irrigation system

The Department of Irrigation (1996) first introduced the micro-irrigation system to the farmers, at two locations of the Northeast as a five-year pilot project from 1994 to 1998. This was to encourage farmers to use water more efficiently and to modernize on-farm water management. Drip lines, mini-sprinklers, and micro-sprinklers were employed and 36 farmers participated in this project in a total area of 48.6 ha. Because of the satisfactory results, this project has been extended into the other 19 provinces of the Northeast from 1996 to 2001 in an area of 640 ha.

4.1.3 Livelihood options

4.1.3.1 Conversion of field crops to orchards

Since field crops are frequently damaged by the long drought, they should be converted into orchards. Fruit trees have deep root systems; they can use underground water at a deeper level than the field crops. When drip irrigation is applied, the water can be used economically and farmers can save themselves a larger amount of water and expenses compared to planting of field crops. Instead of seasonal or annual planting as in growing field crops, a single planting is enough for growing fruit trees. For two or more years after planting fruit trees, intercropping with either vegetables or drought resistant rapidly growing field crops is possible. Conversion of field crops to orchards has been done in many areas. For example, under the crop diversification and agricultural restructuring project (TDRI 1995), rice and cassava areas of 0.3 million hectares have been converted to orchards.

4.1.3.2 Promotion of sustainable agriculture

Sustainable agriculture consists of farming systems that are economically viable both at the farm and national levels, environmentally sound, socially acceptable, and politically supportable. This includes consideration of agro-ecosystems, natural resource management, environmental conservation, optimum agricultural production systems, production diversification and equity, poverty eradication, and food security.

Integrated farming systems are viable options of sustainable agriculture and suitable for socio-economic, climatic and soil conditions in Thailand. This farming emphasizes complementary animal husbandry and growing plants such that part of the plant products or waste can be used for animal feed and waste from animals becomes plant food. Farm productivity also increases within farm and indigenous flora and fauna are preserved. The country has set the target of four million hectares. It is now gradually developing. Its success depends largely on the intellectual ability of the farmers themselves and their ability to endure more hardship during the transitional process.

4.1.3.3 Augmentation of self-sufficient agriculture

Briefly speaking, self-sufficient agriculture is a practical method for agricultural production. A farmer who occupies a small piece of farmland of about 15 rai or 2.4 ha is able to operate this system. Theoretically, a field should be divided into four categories. The first five rai are used for paddy. Another five rai are used for orchard or field crops. The third three rai are used for a 4-meter deep farm pond. The last two rai are allocated for a house, a kitchen garden, and the other purposes such as for vegetable plots, poultry, livestock, milk production and others.

In principle, agricultural production on a farm of that size should be self-sufficient. First of all, a farmer must produce rice as the staple food in an amount sufficient for consumption by his family all year round. The orchard or fruit trees and field crops will provide the major farm income. The farm pond will prevent his farm from water scarcity during the dry season or a dry-spell period. The kitchen garden, including vegetable plots, poultry, livestock, and milk production will save him money and give him extra farm income all year round. Self-sufficient

agriculture is now widely practiced by the farmers throughout the country promoted under the cooperation of the government agencies concerned. A recent study indicates that successful farmers earn additional net income from their farms by more than 100% and decrease the cost of food consumption by 35% (MOAC 2001).

4.2 Local initiatives

4.2.1 Employment of indigenous technology

4.2.1.1 Construction of sandbag dikes

The local people now can dam up streams for farm irrigation in the dry season. Many sandbag dikes were constructed by communities in various areas, for example in Rayong Province. However, the number of such dikes is not available.

4.2.1.2 Construction of tube wells

The Office of Environmental Policy and Planning (1998) reported that many tube wells have been constructed by certain government agencies to improve water supply conditions.

The Department of Mineral Resources, Ministry of Industry has constructed tube wells to provide water sources for the extension of accelerated rural water supply systems throughout the country since 1992. The target of this project is that 70% of all villages will be equipped with a water supply system by the end of 2001. By 1998, the Department of Mineral Resources had constructed 3,808 tube wells in 1,000 villages of 70 provinces.

By 1998, the Office of Accelerated Rural Development, Ministry of the Interior, had constructed 1,023 tube wells for the provision of household water in 75 provinces. Moreover, 150 shallow tube wells which are not deeper than 30 meters have been constructed to fulfill the requirements of agricultural production.

Aside from the government agencies mentioned above, the Department of Public Works, Ministry of the Interior, and the Department of Health, Ministry of Public Health have constructed tube wells to provide water supply systems for each school and village located in remote areas. However, the number of constructed tube wells is not mentioned in the report.

4.2.1.3 Construction of tubing irrigation system

To save water used in irrigation for farming purposes as much as possible and to simultaneously modernize the water management system, the Department of Irrigation has constructed many tubing irrigation systems. They covered a total area of 8,000 ha from 1997 to 2000 as a pilot project in the Northeast, the Central, and the East Coast.

4.2.2 Household risk management strategies

4.2.2.1 Construction of farm ponds, shallow wells and tube wells

To provide for crops planted in the areas that have a high underground water table, some farmers have constructed personal farm ponds, shallow wells, and tube wells so that they can pump water for irrigating their crops. However, the exact numbers are not available.

4.2.2.2 Cultivation of drought resistant varieties

To save water used in growing crops, the areas planted with second rice or dry season rice have been reduced to some extent, replaced with field crops of drought resistant varieties or crops with lower water requirements. These crops are mungbean, soybean, sorghum, corn, vegetables, etc. The exact area of second rice that has been replaced with field crops of drought resistant varieties is not available.

4.2.3 Communal risk mitigation system

4.2.3.1 Communal forest development project

The Department of Forestry has implemented the Communal Forest Development Project since 1984. Its activities include publicizing the importance of communal forest development, establishing groups of people in the targeted villages, training officials and people, and conducting case studies. Now the total number of villages that have been promoted is 12,572 and the total area that has been afforested is 32,776 ha (Table 4.7). Since 1997, the project has been extended from a one-year project to be a three-year project. The first year was a period for studying and doing many important activities such as establishment of a database, compilation of information concerned and preparation of communal readiness for the project. The preparation included promotion of communal participation in resource management and evaluation, provision of demonstration plots and other activities supporting the project. The second and the third year are a period of doing activities to enhance and reinforce the strength of the villages being promoted as well as to prepare tree seedlings for the extension of communal afforestation.

Table 4.7 Number of villages promoted under Communal Forest Development Project and the area afforested from 1984 to 1998.

Year	Villages Promoted	Area Afforested (ha)
1984-1986	6,920	5,536
1987-1991	1,952	15,352
1992-1996	3,000	7,888
1997-1998	700	4,000
Total	12,572	32,776

Source: Department of Forestry (1999).

4.2.3.2 Conversion of agricultural residues into compost instead of burning

Even though burning agricultural residues is good for eradication of some plant diseases, it increases the amount of atmospheric carbon dioxide that finally results in global warming. Making compost is a better alternative for agricultural residue management. This is because compost can be used as a fertilizer as well as mulching material to prevent evaporation of water from soil and either sunburn or freezing of roots.

4.3 Roles of NGOs

Non-governmental agencies (NGOs) in Thailand concerned with El Nino are rare. The NGOs that work in the areas concerning El Nino in Thailand are the Asian Disaster Preparedness Center (ADPC) and Thailand Development Research Institute (TDRI).

4.3.1 ADPC

The Asian Disaster Preparedness Center (ADPC) was founded in 1986 as one of the international agencies of the Asian Institute of Technology (AIT). It has been separated from under AIT and registered as a foundation since 1999.

ADPC has a vision of disaster prevention and reduction to increase safety for people (communities and societies) of countries in the Asia and Pacific region and to meet sustainable development. It facilitates regional cooperation. It makes the flow of information and experience exchange possible among those countries by establishing networks of experts, universities, and academic institutes working with disaster management training. For those countries, it not only advises on ways to develop policy and potential to reduce natural and man-made disasters, but it also plays a major role as the center of information, research, disaster management syllabus formation, academic training and seminars nationally and internationally.

During the last decade, ADPC participated with many agencies of the Royal Thai Government (RTG) in the area of disaster management as follows:

- Provided experts for the "Needs Assessment Study for Improvement of Early Warning Systems and Disaster Relief Coordination" project run by the Office of the National Economic and Social Development Commission in 1990.
- Studied "Strengthening Disaster Management Strategies in Thailand" in 1994 by the cooperation with the Office of the National Economic and Social Development commission and UNDP;
- Cooperated with the Department of East Asian Affairs, Ministry of Foreign Affairs, which had been working for the promotion of disaster management in the ASEAN Regional Forum (ARF) in 1997; and
- Cooperated with GTZ (Deutsche Gesellschaft fur Technische Zusammenarbeit) in studying on the "Role and Functions of Accelerated Rural Development (ARD) Field Operations Center in Disaster Management in Thailand" for the Office of Accelerated Rural Development, Ministry of the Interior, during 1997-1998.

ADPC has carried many projects concerning disaster mitigation, disaster management, and El Nino induced weather change. One of them is the "Understanding Extreme Climate Events in Southeast Asia Project", a project that ran during 2000-2001. The project was concerned with the recording of data and policies of southeast Asian countries including Thailand about their extreme climate events caused by El Nino and La Nina. The information obtained was used for forecasting weather and analyzing weather conditions and their effects on certain communities to make them better understood and to prepare communities to handle the problems caused by El Nino and La Nina induced weather changes.

4.3.2 TDRI

The Thailand Development Research Institute (TDRI) was established in 1984. Its main purposes are to conduct policy research and to disseminate the findings to the public and private sectors. TDRI is Thailand's first policy research institute. It was conceived, created and registered as a non-profit, non-governmental foundation, and recognized as such by the Royal Thai Government. TDRI provides technical and policy analysis that supports the formulation of policies with long-term implications for sustaining social and economic development in Thailand.

Usually, the research work of TDRI is funded not only by its research users but also various local and foreign donors. TDRI was initially funded by the following fundamental supporters: the National Economic and Social Development Board (NESDB), the Department of Technical and Economic Cooperation (DTEC), the Canadian International Development Agency (CIDA), and the United States Agency for International Development (USAID).

To meet its objectives, six research programs and a non-program research project were established. Each was staffed with highly qualified scientists and policy analysts. The six programs are: Human Resource and Social Development, International Economic Relations, Macroeconomic Policy, Natural Resources and Environment, Science and Technology Development; and Sectoral Economics.

A Council of Trustees and a Board of Directors govern TDRI. The President as the Chief Executive of the Institute is responsible to the Council and the Board for decisions on institute finances, operations, and directions.

The findings of TDRI's research work that have been used in this study are the "Thailand Natural Resources Profile" (TDRI 1987), and the "Preparation of a National Strategy on Global Climate Change: Thailand" (TDRE and TEI 1993). The first was done by TDRI itself, and the latter was done in cooperation with the Thailand Environment Institute (TEI).

5. Conclusions and Policy Recommendations

5.1 Conclusions

El Nino events in Thailand were not well known until 1988 and the effects of El Nino have been studied since then. The findings indicate that there were no well-established relationships between the influence of the El Nino and the rainfall patterns over Thailand, but there was a well-established relationship between the influence of the strong El Nino events and the monthly mean average temperatures of the winter and the summer. Fortunately, this situation was not so serious. This study focused on the impacts on vulnerable areas of five provinces in five regions of Thailand. The findings indicate that events caused by El Nino-induced weather changes had some impacts on the stabilization of upland agriculture in those vulnerable areas. Although Thailand has no policies and measures for coping directly with events caused by El Nino, there are existing policies and measures effectively coping with normal droughts and floods that frequently occur.

The field data and information analysis indicate four impacts as follows.

- El Nino had some impacts on the environment and natural resources of Thailand. In general, severe drought and a long period of water shortage were experienced by some vulnerable areas of the Northeast and the Central.
- El Nino had some impacts on the agricultural production of Thailand. Some vulnerable areas of the Northeast and the Central had a decrease of corn yield. Some areas had a complete failure of field corn, sorghum, sugarcane, peanut and mungbean.
- The impacts of El Nino on the social and economic conditions of Thailand's vulnerable areas were an occurrence of labour mobilization, weakness in purchasing power and loan repayment abilities of the farmers.
- The impacts on food security require more analysis on the farm level.

5.2 Recommendations

5.2.1 Recommendations for existing policies

Some existing policies and measures to address the drought problems are able to cope with the undesirable situations and the adversity caused by the occurrence of El Nino events. They should be enhanced and strengthened further. The details are as follows.

To improve national risk awareness and warning, the government should continually pay attention to risk warning systems. Broadcast programmes through government radio and television stations should reach every village. Moreover, more research and facilities should be established for improved climatic prediction.

Restraining deforestation, reforestation and afforestation should be enhanced in terms of:

- defining boundary lines of national forest conservation and wildlife conservation areas so that the community areas are permanently excluded from them;
- encouraging private agencies to contribute to and cooperate in reforestation and its maintenance;
- promoting eco-tourism in the legally permitted areas;
- strongly supporting forest fire prevention measures; and
- supporting and subsidising village and communal forest and farm reforestation.

For water resource management, the policy should be enhanced in terms of:

- replacing dry season rice in water shortage areas with field crops, vegetables, flowering and ornamental plants;
- registering all activities using irrigation water;
- introducing micro-irrigation systems to stimulate farmers to use water for agriculture more efficiently;
- maintaining and developing rainmaking measures; and
- emphasising small scale water resource development, especially at the farm level.

For agricultural production, the policies and measures should be enhanced in terms of:

- crop diversification, mixed farming systems, integrated farming and self-sufficient farming for small farmers, that is environmentally sound and socially acceptance;
- indigenous flora and fauna protection;
- soil fertility improvement and soil degradation prevention;
- research and experimentation on field crops which require less water than the traditional crops; and
- off-farm training.

5.2.2 Recommendations for new policies

As a matter of fact, El Nino induced weather changes have some effects on Thailand, especially on the agricultural production side. However, Thailand does not face food security problems even at low productivity. When taking the amount of rainfall and its distribution into consideration, there is a need for water management to conserve and wisely use water for better irrigation in some regions. Instead of being lost by deep percolation and running into the sea, water runoff should be dammed up as reserves. All water users should be well informed to appreciate the true importance of water upon their lives and to recognize the ways to make use of the limited amount of water more efficiently. Thus, it would be better to make preparations and to enhance the people's awareness and maximize their ability to prevent natural disasters and mitigate their effects by means of effective policies. The abrogation of forest concessions nationwide, reforestation, forest rehabilitation, afforestation, communal forest promotion, rainmaking, planting fruit trees, conservation and development of soil and water sources are factors that should be established as national policies. These policies should have the following characteristics as for as possible:

(1) favour the increased participation of any community and communal administrative organizations concerned;
(2) favour the stability and sustainability of on-farm productivity;
(3) favour an increase in the use of agricultural and forest by-products instead of fossil fuels;
(4) favour the reinforcement of national food security;
(5) favour the betterment of physical, biological, economic, and social environments;
(6) favour the stability of bio-diversity;
(7) favour the prevention of soil erosion and the preservation of water sources;
(8) favour the increase of natural enemies of pests and the decrease of plant pests as well;
(9) favour the use of technologies those are not only suitable to the country's economic, social and environmental status but also self-sufficient and self-supportable.
(10) be policies that are clear-cut, concise, compact, flexible, practical, and useful.

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