Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 70

Stabilization of Upland Agriculture under El Nino-induced Climatic Risks: Regional and Farm Level Risk Management and Coping Mechanisms in the Kedah-Perlis Region, Malaysia

Ariffin bin Tawang
Tengku Ariff bin Tengku Ahmad

United Nations

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

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Humid Tropics of Asia and the Pacific

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Jalan Merdeka 145, Bogor 16111
Indonesia

Published 2003
Printed in Indonesia

National Library: Cataloguing in Publication

Ariffin bin Tawang
Stabilization of Upland Agriculture under El Nino-induced Climatic Risks: Regional and Farm Level Risk Management and Coping Mechanisms in the Kedah-Perlis Region, Malaysia / Ariffin bin Tawang and Tengku Ariff bin Tengku Ahmad.
-- Bogor: CGPRT Centre, 2003.
xxii, 82 pp.; 25.5 cm. -- (Working paper series; No. 70)

Bibliography: 2 pp.
ISBN 979-9317-30-4

1. Agriculture -- Malaysia
I. Title II. Tengku Ariff bin Tengku Ahmad
III. Series

338.185 95

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Glossary of Acronyms

DID	Department of Irrigation and Drainage
DOA	Department of Agriculture
DOE	Department of the Environment
FELDA	Federal Land Development Authority
MADA	Agricultural Development Authority
MARDI	Malaysian Agricultural Research and Development Institute
MMS	Malaysian Meteorological Services
MPOB	Malaysian Palm Oil Board
TSP	Total Suspended Particulates

Foreword

The CGPRT Centre has successfully completed a three-year research project, "Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries (ELNINO)" (April 2000 – March 2003) in collaboration with five participating countries, Indonesia, Malaysia, Papua New Guinea, the Philippines and Thailand.

The impacts of El Nino-induced abnormal weather vary from country to country depending on its natural and socio-economic conditions. Thus, it is vitally important to examine carefully the outbreak and consequences of El Nino in each country at a local level to establish effective and practical mitigation measures against climatic risks. This volume, as research results of the second phase of the Malaysian country study of the ELNINO project, provides relevant policy recommendations based on rich and useful information derived from in-depth study by the national research team.

I thank Mr. Ariffin Tawang and Mr. Tengku Ariff Tengku for their sincere efforts. Their fruitful work is truly appreciated. This three-year, wide ranging research project could only be accomplished with the continuous and generous support from the Malaysia Agricultural Research and Development Institute (MARDI). Dr. Rogelio N. Concepcion, Bureau of Soils and Water Management, the Philippines Department of Agriculture, and Mr. Shigeki Yokoyama provided useful guidance at every stage of the study as the Regional Advisor and the Project Leader respectively. I extend thanks to Mr. Matthew Burrows for his English editing. Finally, I would like to express my sincere appreciation to the Japanese Government for its financial support of the project.

August 2003

Nobuyoshi Maeno
Director
CGPRT Centre

Acknowledgements

The study on “Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries” is sponsored by the UN-ESCAP CGPRT Centre, as part of a regional study involving selected Asia Pacific countries. The study comprises of two phases; the first concentrated on the national and macro analyses, while the second phase focuses on the effects, impacts and mitigating measures at the regional and farm levels. In this regard, we are very grateful to the CGPRT Centre for the opportunity given to us to participate in both phases of the study. We are indeed very honored to represent the country in conducting this study. For this, we appreciate the insight and contribution of Dr. Haruo Inagaki, former Director, and Dr. Nobuyoshi Maeno, the current Director of the CGPRT Centre. Their deep interest, dedication and leadership motivated us to undertake the study.

Special thanks are due to Dr. Saharan Haji Anang, the Director General of the Malaysian Agricultural Research and Development Institute (MARDI), Mr. Samion Haji Abdullah and Mr. Ahmad Tajuddin Zainuddin, the former and current Director of the Economics and Technology Management Research Centre, MARDI, respectively for allowing us to be involved in the study. Their understanding, support and encouragement are highly appreciated.

Our utmost gratitude is directed to the Project Leader, Mr. Shigeki Yokoyama, and Dr. Rogelio N. Concepcion, the Regional Advisor. Both of them were instrumental in developing the framework of the study as well as the continued advice and guidance to ensure the successful implementation of the study. Their untiring effort and persistence contributed significantly to the completion of the study. Similar gratitude and thanks are extended to the staff of the CGPRT Centre for all their support during the study.

There are many other individuals who contributed in one-way or another to this study. Most of the weather data was sourced from the Malaysian Meteorological Services. In this regard, we would like to express our special thanks to Mr. Azhar bin Ishak, the Meteorological Officer and his staff at the Climate Division. Special thanks are also due to the various department heads and their staff in Kedah who provided invaluable information during the conduct of the study. We would like to specifically express our gratitude to the Department of Irrigation and Drainage, Department of the Environment as well as the district offices of the Department of Agriculture, Department of Veterinary Services, and the Department of Fisheries.

Special thanks are due to the plantation managers and the individual farmers who were involved in the conduct of the various case studies. Their patience and their willingness to share information are highly appreciated. Definitely, this study would have not been able to achieve its objective without their kind cooperation and support.

In the Economic and Technology Management Research Centre, the contribution of our colleagues, Mr. Mohd Azwan Mohd Salleh and Mr. Suhaimi Talib were instrumental in data collection and assembly. Their untiring effort is very much appreciated. Finally, to Mrs. Norashikin Idris for her patience and dedication in typing the report.

MARDI, Serdang
August 2003

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Executive Summary

The first phase of the study focused on the effects and impacts of El Nino induced climatic change from a macro level perspective. The study measured the total economic losses among the three most important agricultural commodities in this country (oil palm, rubber and rice) during the 1980 to 1999 period which amounted to more than RM 3.3 billion. Similarly, the various risk management and mitigating measures in place have also been described. This study is an extension of the earlier study, with a focus on the impact of the El Nino induced weather changes at the regional and farm levels. This should be able to provide a complete continuum of the impacts and implications of El Nino from the national to the regional and farm levels. Hence, the general objective of the study is to determine the impact of El Nino induced climate variability on agriculture at the sub-national and farm level, and to identify appropriate mechanisms to mitigate the impact so as to ensure the stability of the agricultural contribution to the regional and farm economy.

In this study, the northwest region of Peninsular Malaysia was chosen as the region under study. It comprises of the states of Kedah and Perlis. The main climatic feature of the region is its distinctive two dry seasons and the resultant drought periods. The region is also an important agricultural and food producing area in the country and the agricultural sector is one of the important economic contributors to the region. Hence, it is expected that the El Nino induced climatic changes could result in significant impacts on the performance of the agricultural sector and the regional economy as a whole.

In the analyses of the climate change in the region, comparisons were made between the mean of the normal years, the El Nino years and the 1997/98 El Nino episode. As a whole, there were insignificant differences in the total amount of annual rainfall between normal and El Nino years. However, on a monthly basis, the region experienced significant rainfall deficit during the months of January to May, which coincided with the off-season paddy planting. During the 1997/98 El Nino episode, the situation worsened. Total annual rainfall registered a deficit of 9 per cent and 23 per cent respectively for Kedah and Perlis. The monthly deficits for the months of March to July 1997 were higher, where the state of Kedah received only two-thirds of its normal amount, and 73 per cent in Perlis. These rainfall patterns coincided with a similar reduction in the monthly rainy days registered in the region. In terms of temperature change, there were increased mean monthly temperatures for all months during the El Nino years in both the states of Kedah and Perlis. For all these months, the temperature increases were between 0.1 and 0.6^{o}C. The mean increase in temperature for Kedah and Perlis was 0.29^{o}C. During the El Nino episode of 1997/98, the monthly increases were more obvious. The increases ranged between 0.1 and 1.9^{o}C, with the mean at 0.9^{o}C in Kedah and between 0.1 and 2.4^{o}C, with a mean of 1.36^{o}C in Perlis. In line with the overall increase in mean monthly temperature, the mean monthly maximum and minimum temperatures also followed similar trends. For all months, in Kedah and Perlis, the maximum and minimum temperatures were higher during the El Nino years compared to that of normal years. The mean monthly increases in temperature during the 1997/98 El Nino were 1.09^{o}C and 1.6^{o}C for Kedah and Perlis respectively.

The mean daily increase in sunshine hours in all the El Nino years for Kedah and Perlis were 0.28 and 0.23 hours respectively. During the 1997 El Nino episode, the prolonged drought was accompanied by the formation of haze during the months of July to September. Whilst the ‘thickness’ of the haze was much less than that of other regions in the country, this phenomenon had, to some extent, influenced the degree of sunshine hours in the region. However, the data on sunshine hours indicated that the haze factor was overwhelmed by the long drought factor.

Hence, despite the haze formation, there were significant increases in daily sunshine hours for Kedah and Perlis, at 0.55 hours and 0.48 hours respectively. These increases were more than double the mean increase in daily sunshine hours registered in all the El Nino years. This indicates the severity of the 1997/98 El Nino episode.

During the prolonged drought period, solar radiation increases coinciding with the period of heavy haze reduced sunshine radiance, which actually resulted in a decrease in solar radiation. The mean solar radiation for the El Nino years in Kedah was 19.0 MJ and 18.2 MJ in Perlis, as compared to the mean radiation during normal years at 18.5 MJ and 17.8 MJ for both states respectively. During the 1997/98 El Nino episode, solar radiation was higher. The mean daily radiation increased to 19.6 MJ in Kedah and 19.3 MJ in Perlis. The northwest region of Peninsular Malaysia was the least affected, where the mean monthly TSP did not exceed 100 API (Air Pollution Index). However, readings of between 50 and 100 API, which is considered as moderate air quality, were observed for a number of months. In Kedah, these were the months of July to September 1997 and March to April 1998, while in Perlis the readings were observed in the months of July and September. Generally, during these months, the TSP value was double that of normal years.

In analyzing the impact of El Nino on commodities in the region, time series data for the period 1980 to 2000 was used. Similar methodologies as were used in the First Phase of the study were employed here. This includes the use of graphical presentation to visually analyze the correlation between the El Nino related weather variables and the performance of major commodities in the region. Through this approach, the observed relationships did not show any discernable positive pattern between crop performance and rainfall. There were cases of increases in yield when the rainfall dropped for all three commodities. This contradicts the findings at the country level where yield decreased with a decrease in rainfall. The relationship between air quality and yield performance in oil palm crops indicated some negative relationships, as expected. This was not so for rubber and paddy.

In the quantification of impact in terms of actual production loss due to weather variability, the five-year moving maximum was used. In the case of oil palm, the total loss as a result of weather variability amounted to an average of more than 14 per cent per year, with maximum yield loss as high as over 50 per cent. Throughout the 1980-2000 period, the losses due to this weather variability were estimated to be RM 281 million. For the 1997/98 El Nino, the losses were estimated at RM 113.2 million. The effects of El Nino alone, however, cannot be isolated from these losses since measurable variables of the El Nino phenomena could not be distinguished during El Nino and non-El Nino years. For rubber, the mean loss for the same period was about 15 per cent, with total economic losses valued at RM 858.7 million. The net loss from El Nino episodes was only 2.0 per cent, which is fairly insignificant. The impact on paddy production due to weather variability was 8.45 per cent, which is lower than that of oil palm and rubber. The loss due to climate variability amounts to RM 814 million for all years. The net loss due to El Nino alone was estimated at about 7 per cent in all the El Nino years. This is equivalent to economic losses of about RM 237.8 million.

For tobacco, the mean losses due to weather variability were fairly significant at about 16.5 per cent per year. As in the case of oil palm and rubber, there was little indication of the negative effects of El Nino on tobacco yield. Average yield lost during non-El Nino years was 19 per cent, while during the El Nino years, the loss actually went down to 11 per cent. For sugarcane, the mean annual loss due to climate variability was about 5 per cent, and net loss due to El Nino was only 1.3 per cent. Similarly, the measurement of impacts on fruits and vegetables, livestock and fisheries did not register any significant losses brought about by El Nino in this region.

To analyze the relationship between weather variables and the observed yields, a series of yield functions were estimated for oil palm, rubber, paddy and tobacco. The results of the analyses varied between crops. For oil palm, all the weather variables were consistent with the expectation of the rainfall variable. It might be the case that the timing of the rainfall did not coincide with the flowering and fruit bunch formation. None of the weather variables were significant in influencing the yield of rubber, except for total suspended particulates. For paddy, the estimates showed that except for suspended particulates, all the other variables were significant. However, sunshine hours and rainfall variables did not conform to the a priori expectation. Finally, the results of the tobacco yield function were poor in terms of statistical performance, where all the weather variables were not significant.

By using ‘case study approach’, several case studies were conducted to evaluate the impact of El Nino on individual farms. They were aimed at providing some quantitative assessment on the effects of El Nino at the farm level, as well as their coping mechanisms. Generally, for perennials such as oil palm, rubber and fruits, whilst there were reported cases of the negative impact of El Nino, especially with regard to crop growth and fruits, there were limited mitigating measures that had been introduced. On the oil palm estate, the impacts of El Nino were in the forms of water stress on young immature palms, disruption of the work schedule and the greater risks of ‘estate’ fires. On the rubber estate, El Nino contributed positively due to the increase in the number of tapping days, hence the resultant increase in yield and income. Other benefits included the reduction in the application of weedicides and fertilizers. Among the annuals, the most critical component was water availability. The continued availability of irrigation water, as was the case for most of the farms in the region, ensured continued farm production, with little impact on production. By virtue that the annuals are more flexible in terms of crop choice, the farmers are in a position to adjust their crop cycles.

The MADA Irrigation Scheme was used as a case study to evaluate the impact of El Nino at farm level. The major impacts faced by MADA were the huge disparity in rainfall distribution between months, which upset the crop calender, as well as the impact of total rainfall deficit in terms of water storage and withdrawal from the dam. Despite this, the difference in yield performance between El Nino and non-El Nino years was small and insignificant. The relatively small impacts were due to the various mitigating measures already in place, especially those related to water management within the irrigation scheme. The ability to reschedule water supply, the application of an efficient water control and management system, water recycling, water saving agronomic practices and overall efficiency in water use are some of the mitigating measures that have been successful in alleviating problems related to water availability.

The sugarcane plantation also benefited from the El Nino episodes. While there were negative impacts on yield level, this was compensated by an increase in sugar content. The most successful mitigating measure undertaken by the plantation in coping with drought was the construction of man-made lakes as a source of water supply. By using a mobile sprinkler system the effects of the prolonged drought period were drastically reduced.

In the case study on fruits, the major effects were on the young immature trees which died due to a lack of water. The high temperature and haze negatively affected the growth, pollination and fruit bearing with rampant incidences of fruit ‘abortion’. The mitigating measures were fairly limited, except the application of drip irrigation and the water ponding system to overcome problems associated with water stress. Similarly, the extensive usage of irrigation ensured the limited impact of El Nino on tobacco and vegetable farmers. Some measures in terms of adjustments to the production cycle, the choice of using shorter maturating vegetable types and the application of additional water conserving technology (such as mulching) drastically reduced the impact of El Nino on vegetable production.

For the poultry farms, the resultant heat and moisture stress resulted in an increase in the mortality rate among the young chicks. The introduction of automatic water mists and better ventilation in the housing minimized these effects. Similarly, there were also increases in health related problems, which resulted in an increase in the cost of medicine. A similar increase in mortality rate was also observed in fresh-water fish production. Additionally, the high temperatures resulted in slower growth of the fish due to reduced feed consumption.

The section on risk management strategy discusses the various mitigating measures and coping mechanisms already in place in the region to minimize the impact of El Nino. The role of Malaysian Meteorological Services in terms of providing timely meteorological information and forecasts, as well as advance warnings on the occurrence of adverse weather phenomena is well recognized. The highly successful water use management and conservation strategy practiced in the region was able to alleviate some of the problems associated with the water deficit situation. The improvement in irrigation efficiency by continuous improvement of irrigation infrastructures, and the enhancement of support services with improvements in storage, delivery and the distribution system had ensured an effective and efficient use of irrigated water, particularly in the MADA Irrigation Scheme. The indigenous capabilities in the area of water recycling activities and the implementation of water management and control systems had been successful in optimizing the use of the water resources and minimizing the wastage. Water ponding technology had been extensively used by the sugarcane plantation. The system was found to be very reliable, cheap and easy to maintain and had proven to be very practical as a water storage mechanism. In the area of science and technology, the widespread adoption of short maturating varieties and the continued screening of new varieties to suit different rice environments are crucial in ensuring a lesser water requirement and exposure to the drought period. The application of other water saving technologies, such as the use of dry rotovation, micro-irrigation systems, and re-circulating water systems ensured greater water savings. The role of the government in terms of the various policy measures has also been instrumental in alleviating some of the possible problems due to El Nino. The strategy to diversify sources of income among the resource poor farmers away from the agricultural sector reduced the risks brought about by El Nino. Direct income support and other supportive measures encouraged the farmers to diversify their sources of income. Finally, the recent initiative to develop an El Nino Action Plan that is based on a rainfall depletion indicator would ensure better uniformity, coordination and implementation of efforts to reduce the negative impacts of El Nino.

1. Introduction

The Malaysian climate has often been described as fairly stable and predictable. The advent of El Nino changed this, causing instability and abnormal climatic variations. These abnormal climatic conditions have consequently led to undesirable impacts on various sectors of the national economy. A study conducted by Tawang *et al*. (2002) showed that the losses in the agricultural sector alone, in Peninsular Malaysia, caused by El Nino, were at least RM 3.4 billion.

This study is an extension of the above earlier research with a focus on the impacts of the El Nino induced climate change at the regional and farm levels. In order to provide continuity and better understanding of this report, a brief summary of the findings from the earlier study is provided in the next section.

1.1 Stabilization of upland agriculture under El Nino induced climatic risk: impact assessment and mitigation measures in Malaysia

The study by Tawang *et al*. (2002) indicates that there was strong evidence of the negative effects of El Nino on Malaysian agriculture. The El Nino induced weather change resulted in prolonged dry seasons leading to severe drought and high temperatures. In addition, the large-scale burning of forests and plantations (during land clearing), which led to the formation of heavy haze engulfing the country during the El Nino period, further worsened the situation. These conditions not only imposed a variety of constraints on the economic activities of the country but also caused problems to the whole population at large. As such, El Nino resulted in serious implications on almost all economic sectors of the country, including the agricultural sector.

The economic analyses undertaken indicated that the total economic losses, resulting from the El Nino, accrued to the three most important agricultural commodities in the country, viz. oil palm, rubber and rice, during the 1980 to 1999 period amounted to more than RM 3.3 billion. Oil palm production was the hardest hit, with losses estimated at RM 2.65 billion, followed by rubber (RM 357 million) and rice (RM 218 million). These losses exclude the various secondary spin–off losses resulting from the loss of production value of other downstream activities. Results from the regression analyses supported the hypotheses that these losses were due to the El Nino episodes. Specifically for oil palm and rice, rainfall and total suspended particulates (as an indicator of air quality) were important variables that affected yield. However, similar analyses on the other sub sectors of the agricultural sector including tobacco, livestock, fisheries and fruits and vegetables did not show evidence of losses.

The report also highlighted the fact that as a whole, the impacts of El Nino on the agricultural sector were still relatively small when considering the output of the sector. This was due partly to the effectiveness of the mitigating measures already in place in the country. Early warnings and a forecast system based on the continuous monitoring of weather and climatic patterns and the availability of adequate infrastructure to ensure the efficient supply of irrigation water as well as the implementation of the various water conservation strategies helped to mitigate potentially more severe affects on crops. Provisions which provide stricter and stiffer penalties with regards to the maintenance of air quality and other action plans also contributed positively to this relatively marginal impact.

The report also provided some suggestions and recommendations on long-term strategies, especially in the area of increasing national capabilities for monitoring the development and evolution of El Nino, both for prediction and the introduction of mitigating measures. A recommendation was also put forward to strengthen and intensify research and development, particularly on precision farming, improvements in water saving technologies, development of drought resistant varieties and the development of expert systems. It was also recommended that these be undertaken parallel to the strengthening of other support-policies and initiatives including legislation and public awareness programs and education. The introduction of crop insurance and other financial strategies were also suggested. It was also recommended that an action plan to mitigate the effects of drought brought about by El Nino be developed. These strategies and recommendations should be able to enhance the mechanism to 'buffer' and insulate the impacts of El Nino, especially on the agricultural sector.

1.2 Scope and objectives of the study

The study by Tawang *et al*. (2002), though useful in providing an assessment on the extent of damage El Nino inflicted on the agricultural sector at the country level, was not sufficiently comprehensive to cover the depth of damage it caused at the micro level. This includes the extent of losses that had to be borne by the individual farmer and the extra economic costs that the farmer had to incur to mitigate and alleviate the negative impacts of the El Nino at the level of the farm. Information on these aspects would be important to formulate 'safety-net' measures that might be required to assist the farming community. This study was generally aimed at filling this information gap. In addition, this study would also assess the economic losses in the northwest region of Peninsular Malaysia, the region that is believed to be the hardest hit by the El Nino phenomena due to its high susceptibility to drought. As such, the study involved two levels. The first level concentrated on the impacts at the regional level comprising the states of Kedah and Perlis, while the second level of the study focused on the impacts at the farm level consisting of case studies of commodities involving a paddy irrigation scheme, an oil palm estate, a rubber smallholding, a sugarcane estate and individual fruit, vegetable and tobacco farms. Livestock and fisheries were also covered in the study.

Specifically, the objectives of the study are as follows:

a. To collect and analyze data on El Nino induced abnormal weather at the regional and farm levels.
b. To quantify the impacts of El Nino on the agricultural sector at the regional and farm levels.
c. To determine the socio-economic implications of El Nino with respect to regional and farm level food supply and food security, employment and farm incomes.
d. To assess the regional and farm level's mitigating measures, coping mechanisms and degree of preparedness to minimize the impact of El Nino

1.3 Organization of the report

This report is organized into eight chapters. This first chapter provides a brief summary of the findings of the first part of the study. The scope and objectives of the study are also highlighted in this chapter. Chapter 2 is devoted to the description of the study area. It deals with the rationale for choosing the northwest region as the study area. This is followed with a brief description of the region, particularly in terms of the socio-economic profile, agro-climatic characteristics, the natural resources, policy dimensions and the role of the relevant departments and institutions at the regional level. Chapter 3 provides a description of the changes in climate in terms of rainfall patterns, temperature, daily sunshine, solar radiation and air quality in the region. The resultant effects and impacts of El Nino induced climatic changes on the agricultural sector at the regional level are presented in Chapter 4, while the effects and impacts at the farm levels are discussed in Chapter 5. This chapter also highlights the various mitigating measures being adopted by the farmers. Chapter 6 is devoted to outlining the various management strategies and coping mechanisms already in place within the region. This includes the current climate monitoring and forecasting capabilities, water use management and conservation, the application of new technologies and other policy measures. This is followed by a conclusion of the report in the final chapter.

2. The Study Area

An earlier study by Tawang *et al*. (2002) clearly indicated that climate changes resulting from El Nino episodes had negatively affected a number of major commodities at the national level. As an extension of their previous study, which focussed mainly on national macro impacts, this study concentrates and investigates the impacts of the El Nino events at the regional and farm levels. For this purpose, the northwest region of Peninsular Malaysia was selected.

The rationale for selecting the northwest region as the study area is presented in the subsequent section of the chapter. In addition, this chapter provides a comprehensive profile of the region, including its socio economic profiles and resource endowments. Some policy aspects as well as the role of regional authorities and agencies, with regards to agricultural development in the region, are also described.

2.1 The selection criteria

The northwest region of Peninsular Malaysia was selected as the site for the study area based on the following considerations:

a. Drought prone area.
   This is the only region in the country which has a distinct and regular dry season, usually between the months of December and March. Hence, the incidence of long droughts during the dry season are quite prevalent in the area. Under such a situation, it is argued that the impact of the El Nino induced climate change, especially the prolonged dry period associated with El Nino, could lead to much longer drought periods in this region relative to other parts of the country. Theoretically, this should be the most badly affected region due to El Nino in the country.

b. Agricultural-based economies.
   This is a highly agricultural-based region, where the agricultural sector contributes about one-third of the GDP and almost half of the employment. Hence, any 'forces' that could influence the performance of the agricultural sector would have a significant impact on the economy and employment.

c. Low-income level.
   The Kedah-Perlis region is among the poorest regions in the country, where the per capita income is only about two-thirds of that of the national income. Being an agricultural-based region, most of the low-income population groups are directly associated with economic activities in the agricultural sector. Hence, any climate change or variation which affects the agricultural sector could result in grave economic and financial losses to the population.

d. Food producing region.
   This region is also the rice bowl of the country. It is responsible for about 40 per cent of total domestic rice production. At the same time, the region is also the main producing area of sugarcane, mango and rubber. These four commodities account for about 90 per cent of the total agricultural land in the region. Being a main supplier of food for the nation, any 'shocks' including negative climatic conditions such as El

Nino that could lead to shortfalls in food supply could potentially affect national food security. It is, therefore, critical that such potential effects on the region be studied.

e. Efficient water-use management.
There is a fairly high level of water-use efficiency in the region, particularly within the Muda Agricultural Development Authority (MADA) Irrigation Scheme and sugarcane plantations. This can provide a good example on how efficient water use management could help in ensuring minimal damage and economic losses from El Nino.

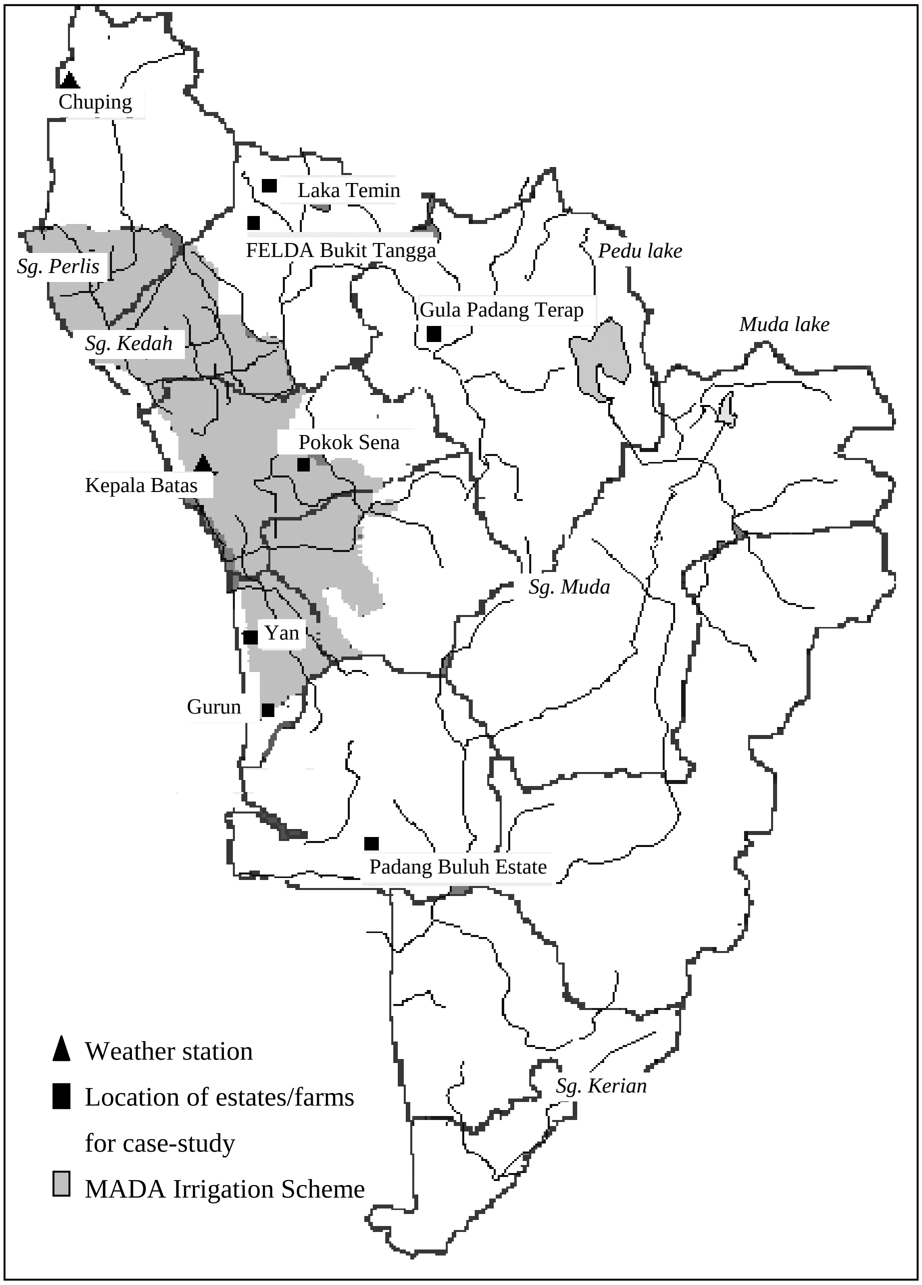
2.2 Profile of the study area

The region comprises of two states; the state of Kedah and Perlis. Kedah covers a land area of 949,891 hectares and is the eighth largest state in Malaysia, while the state of Perlis with 81,429 hectares is the smallest state. Together, they represent about 3 per cent of the total landmass of the country.

2.2.1 The geographical location

The study area is located in northwest Peninsular Malaysia, situated at latitudes $5^o5'$ to $6^o40'$ and longitudes $100^o05'$ to $101^o08'$. The topography is quite varied, ranging from sparsely inhabited and heavily forested mountains, gently rolling hills, to a vast coastal plain where most of the economic activities take place. The coastal plain forms 15 per cent of the region while 40 per cent are steep highlands. The remaining 45 per cent consists of undulating and hilly areas. Most of the economic activities, including agriculture, are concentrated on the coastal plains. The eastern hills are devoted to rubber production and other less important activities, whilst the mountains are protected highlands. Within the plains lies the MADA Irrigation Scheme, the largest irrigation scheme in Malaysia. It covers the northwest of Kedah and a part of Perlis. With an area covering 97,000 hectares, the scheme represents almost 40 per cent of the total rice area in Peninsular Malaysia. The area is drained by four major river systems, which discharge into the Malacca Straits westwards. They are the Sungai Perlis, Sungai Kerian, Sungai Kedah and Sungai Muda (Figure 2.1).

Figure 2.1 The study area in the northwest region of Peninsular Malaysia



2.2.2 Geology and soil

The coastal plain is predominantly marine deposit and to a lesser extent riverine deposit, both of which are of the Quaternary period. The upland and highland areas are made of acid intrusive, metamorphic and, to a lesser extent, sedimentary rocks. In Kedah, a soil suitability study conducted in 1974 classified the land in the state into paddy land (15 per cent), Class 1 land (land which is very suitable for agriculture - 13.4 per cent), Class 5 land (soils which have very serious limitations and are deemed as not suitable for any agriculture - 43.4 per cent) and the remaining 27.2 per cent classified as land that can be used for cultivation with various agriculture inputs (Class 2 and Class 3 soil). Area under marginal soil (Class 4) is insignificant. In a similar soil study for Perlis, about 46 per cent of the land is classified paddy soils. Class 1 soils occupy only 6.8 per cent, whilst Class 3 soils occupy about 36 per cent. The rest are Class 5 soils, which have very serious limitations for agricultural development. There are no Class 2 and 4 soils in Perlis identified in the study.

2.2.3 Agro-climatic characteristics

The main climatic feature in this zone is the regular distinctive two dry seasons. The first dry season occurs during the period from December to March (Niewolt, 1982). Its duration may reach four months in the northern areas, decreasing to 1 to 2 months in the southern part of the region. In more interior locations, the dry season may last 3-4 months. The frequency of occurrence of at least one dry month (with an agricultural Rainfall Index below 40) between December and March is over 90 per cent of all the years on record. A second dry season occurs around June in the extreme north and south of the region. These dry seasons are usually associated with more sunshine, higher day and lower night temperatures and a lower relative humidity than during the rest of the year.

Like most parts of Peninsular Malaysia, the main rainy period is from September to November, while the secondary season is around April to May. The total annual rainfall received is between 2,200-2,500 mm. On the coastal plains, the mean annual air temperature is about 27^{o}C, with less than a 5^{o}C difference between the warmest and the coldest months.

Temperatures are uniformly high throughout the year. The mean annual range is small, from 26^{0}C to 28^{0}C, while the mean daily maximum and minimum temperatures vary between 31^{0}C to 34^{0}C and 21^{0}C to 24^{0}C respectively. Humidity is generally high, ranging from 72 per cent in February to a high of 87 per cent in October.

2.2.4 Natural resources

Land

Kedah and Perlis constitute about 7.7 per cent of the total land area in Peninsular Malaysia and account for 3.1 per cent of the land area of Malaysia. About 55 per cent of the area is currently being utilized for agricultural activities, while another 35 per cent is devoted to protected forests. For the period of 1966 to 1990, land area for agriculture increased at a rate of 1.17 per cent per annum, while that of non-agriculture (including forest) declined at about 1.06 per cent per annum. Urbanisation accounted for about 2 per cent of the land area. The urban sector has been rapidly expanding at about 2 per cent per annum due to significant increases in the urban population, industrialization and infrastructure development. The significantly higher percentage of land allocated for agricultural purposes at 55 per cent compared to the national average level of 35 per cent is shown in Table 2.1 and signifies the importance of agricultural activities in the region.

Table 2.1 Land use in the Kedah-Perlis region

Land use	Kedah	Perlis	The region	% of total area
Agricultural land	509,826	63,400	573,226	55.6
Steep land/forest	343,771	14,432	358,203	34.7
Grasslands/scrub forest	31,407	1,272	32,679	3.2
Swamps	14,817	-	14,817	1.4
Urban areas	21,379	2,325	23,704	2.3
Others	28,691	-	28,691	2.8
Total	949,891	81,429	1,031,320	100.0

Source: Kedah State Economic Planning Unit (2000). Perlis State Economic Planning Unit (2000).

Water resources

The region is served by three main rivers; the Kulim River, Muda River and Padang Terap River. Their hydrological cycle shows very high flow peaks in November and very low flows in the dry season. The means of the three main rivers' flow are 1,539 cu m/sec, 723 cu m/sec and 582 cu m/sec for the Kulim River, Muda River and Padang Terap River respectively (SEPU, 1994). All the rivers have significant upland catchments. In 1974-75, more than three-quarters of the land area in the region was utilised as water catchments areas. The area has since decreased due to agricultural development including logging activities.

Three dams serve the water supply in the region; the Pedu, Muda and Ahning dams. Together they have a total active storage capacity of 1,510 million cubic meters. The Pedu and Muda dams, which were constructed in 1969 and have a storage capacity of 1,050 million cubic meters and 160 million cubic meters respectively serve as the main source of water for the MADA Irrigation Scheme.

While there is abundant total annual rainfall, there are fairly frequent incidences of water shortages in the region, especially during the dry periods. The provision of irrigation through the MADA Irrigation Scheme has made it possible for double cropping and reduces the impact of drought on rice production. Rice areas outside the scheme, some of which are served with small irrigation schemes utilizing water from the Muda River and other smaller rivers, are more exposed to drought. Non-irrigated rice areas, which constitute about 38,600 hectares, are mostly single cropped. There is no paddy cultivation during the dry season. Instead, other cash crops such as tobacco, vegetables and watermelon are planted.

Ground water resources are limited in the region, both in terms of capacity and extent. While there exists some ground water, it is not economically utilised at present.

Water resource in MADA

The MADA Irrigation Scheme is the major rice bowl of the country, built in 1965 the introduction of the irrigation scheme made possible the double cropping of rice in the area. The scheme is irrigated by an extensive network of primary and secondary canals. The low canal density of about 10 meters per hectare in the earlier phase contributed to various problems in field water management and the inefficient use of irrigation water. Since 1979, MADA embarked on a program of tertiary canal development under the Muda II Project. The program greatly improved the efficiency and distribution of irrigation water in the scheme.

The water supply for MADA is obtained from four main sources, namely, direct rainfall on rice fields, dam release, uncontrolled river flow and recycled drainage water. Actual annual water supply from rain, uncontrolled flow and dam release is reported to be between 2.9 m and 4.1 m high (Lim and Tiak, 1997), which is equivalent to at least 3,000 million cubic meters for the entire area. Another source of water is from drainage recycling. Currently, approximately 115 million cubic meters of drainage water is being recycled annually.

MADA has also recently been given the responsibility of managing the Ahning reservoir, which provides an annual supply of about 43 million cubic meters, meant for domestic and industrial usage. Current domestic and industrial usage is only about 5-10 per cent of supply. As such, about 30 million cubic meters is currently available for agriculture. In future, water demand for domestic and industrial use in the state will definitely increase (Ismail *et al.*, 2002). In addition, there is also a request for MADA to supply domestic/industrial water to Penang and Langkawi. This being the case, water from the Ahning reservoir will not be available for agricultural use in the future. Another reservoir, called Beris, has been planned, and would be able to provide additional water supply to the region. In addition, there is another small reservoir in the state of Perlis, known as the Timah Tasok Dam, which is mainly used for domestic and industrial purposes.

The analyses by Ismail *et al.* (2002) also estimated that the actual water available for rice cultivation in the scheme is currently about 40 per cent of the total water source, and is expected to increase to 50 per cent and 60 per cent in 2010 and 2020 respectively.

Water source outside MADA

For areas outside MADA there are a number of small irrigation schemes under the jurisdiction of the Department of Irrigation and Drainage. These facilities provide irrigated water for double-cropped paddy cultivation outside the MADA areas, as well as for other cash crops such as vegetables and tobacco. Additionally, the usage of water from rivers or shallow wells by using mobile pumps is quite prominent among vegetable and fruit growers, both by the small and large farms. The Department of Agriculture has a fairly good stock of mobile pumps and tubes to be used in providing irrigated water to the farmers outside the MADA areas.

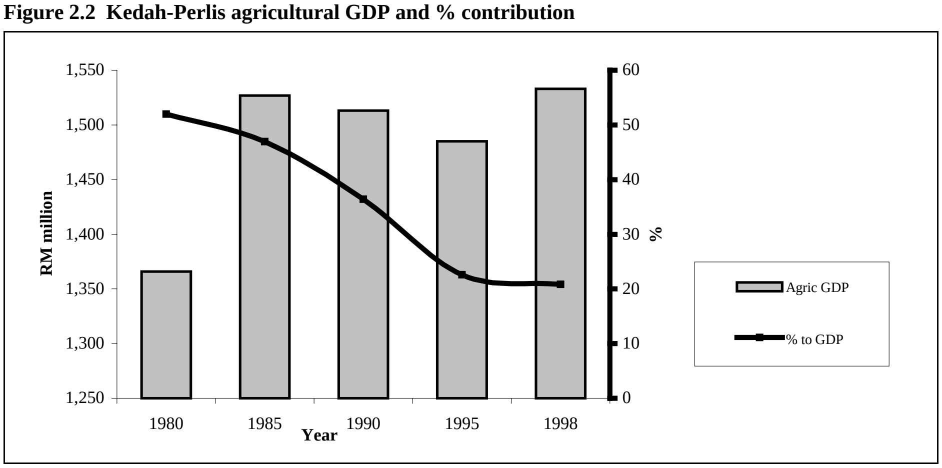
Farm labour

The total population in the region stands at 1.83 million with about 1.6 million in Kedah and 230,000 in Perlis. This constitutes about 8 per cent of the total population of Malaysia. The average annual population growth rate is 1.9 per cent for Kedah and 2.3 per cent for Perlis. The total labour force for all sectors is about 530,000 with about 243,000 directly involved in agriculture. The unemployment rate stands at about 2.2 per cent. About 80 per cent of the population are located in the rural areas.

2.2.5 The economy

The region's economy was previously dominated by the agricultural sector (including fisheries and forestry) which accounted for about 50 per cent of the Gross Domestic Product (GDP) in 1980. Since then, the percentage contribution of the sector to the regional economy had steadily declined to the current level of about 20 per cent. In terms of value, the agricultural sector's contribution to the economy has been maintained, at between RM 1.5 and RM1.6 billion since 1985 (Figure 2.2). This was due to the high growth in the manufacturing sector, especially in the state of Kedah.

Figure 2.2 Kedah-Perlis agricultural GDP and % contribution



Source: Kedah State Economic Planning Unit (2000), Perlis State Economic Planning Unit (2000 – Unpublished).

In 1998, the contribution from the agricultural sector was about 20.5 per cent, the equivalent of RM 1.5 billion from the region's total GDP of RM 7.3 billion (Table 2.2). The manufacturing sector contributed about one third to the regional GDP at RM 2.43 billion. Per capita GDP for Kedah and Perlis stood at RM 8,064 and RM 8,094 respectively. Compared with the national per capita income of RM 12,166, the per capita GDP for the region was only about 65 per cent of the national per capita level. Hence, regional average income could be considered low relative to the national average.

Total employment by major sectors is depicted in Table 2.3. The agricultural sector provided the most employment, accounting for almost half of the total employment in the region. A very large proportion of the population, particularly in the rural areas, depends on the agriculture sector for their livelihood. Given the relative importance of the agricultural sector to the overall economy and employment of the region, it is to be expected that the sector will continue to play a significant role in its future development.

Table 2.2 Gross Domestic Product in the Kedah-Perlis region (1998) (RM millions)

Sector	Kedah	Perlis	Total	Malaysia
Agriculture, forestry and fishery	1,322.0	211.2	1,533.2	17,415
Mining	10.4	2.1	12.5	14,425
Manufacturing	2,138.0	292.0	2,430.0	50,899
Transport and storage	392.0	56.4	448.4	14,873
Construction	244.0	46.3	290.3	7,333
Utilities	161.0	27.5	188.5	6,329
Wholesale and trade	472.0	97.6	569.6	28,565
Finance and insurance	648.0	91.2	739.2	23,346
Government services	807.0	148.6	955.6	13,278
Others	173.0	15.9	188.9	15,061
Total	6,368.0	988.8	7,356.8	182,221
Per capita GDP (RM)	8,064.0	8,094.0	8,079.0	12,166
Ratio to Malaysian average	0.66	0.67	0.66	

Note: US1.00 = RM3.80.
Source: Kedah State Economic Planning Unit, 2000.
Perlis State Economic Planning Unit, 2002.

Table 2.3 Employment by sector 1990

Sector	Kedah	Perlis	Total	% of total
Agriculture	218,200	24,500	242,700	45.8
Manufacturing	61,400	15,900	77,300	14.6
Transportation	13,400	2,400	15,800	3.0
Trade	71,400	700	72,100	13.6
Government services	72,000	11,300	83,300	15.7
Others	26,600	12,100	38,700	7.3
Total employment	463,000	66,900	529,900	100.0

Source: Kedah State Economic Planning Unit, 1996.
Perlis State Economic Planning Unit, 1997.

2.2.6 Land use

Within the agricultural sector, the most prominent commodities are rubber and rice, which together account for 81 per cent of total agricultural land. The land area under specific commodities is presented in Table 2.4.

Table 2.4 Land use in the Kedah-Perlis region by major commodities (1998) (ha)

Commodity	Kedah	Perlis	The region	% of total
Rubber	265,363	10,159	275,522	47.50
Paddy	143,905	48,111	19,216	33.10
Oil Palm	35,095	2	35,097	6.05
Tobacco	820	651	1,471	0.25
Sugarcane	12,051	8,255	20,306	3.50
Mixed horticulture and orchards	44,936	1,800	46,736	8.06
Coconut	2,142	531	2,673	0.46
Vegetable	1,124	227	1,351	0.23
Others	4,390	115	4,505	0.77
Total	509,826	69,851	579,677	100.00

Source: Kedah State Economic Planning Unit, 2000.
Perlis State Economic Planning Unit, 2000.

Rubber land, at 258,000 hectares, accounts for about half of the total agricultural land in the region. The smaller state of Perlis contributes less than 4 per cent to this total. About 23 per cent of the rubber area is under estates, while the remaining 77 per cent is under smallholders. Current rubber production is about 156,000 metric tons and this represents a one-third decline in production from its peak period at 233,000 metric tons in 1988. Many factors contributed to this decline. Some of the reasons are:

- Declining farmers' interests due to uncompetitive returns and labor-intensive operations. This resulted in a fairly high percentage of abandoned smallholder's farms.
- Continued re-allocation of resources, especially among the estate sectors, away from rubber cultivation.
- Continued diversification away from rubber to other more remunerative crops.
- High cost of production has exerted pressure on the income and returns on investment.
- Decline in replanting and new planting activities.
- Erosion of international competitiveness and comparative advantage in the production of natural rubber.

In contrast to rubber, the oil palm sub-sector recorded an impressive performance both in terms of area expansion and production. Oil palm production is concentrated solely in the state of Kedah, especially in southern Kedah due to the absence of distinct and long dry period as compared to that of the northern region. Since 1980, oil palm hectarage has been on the increase from only 8,900 hectares in 1980 to 52,500 in 1999, a growth of about 9.4 per cent per annum. Similarly, production has registered a steady increase from only 11,900 metric tons in 1980 to 128,700 tons in 1999, an increase of about 12.5 per cent per annum. The increase in land area as well as productivity (at about 3.2 per cent per annum) contributed to this significant increase during the last three decades.

The major issues which may hinder further growth of this sub-sector are due to the limited area that is suitable for oil palm production, since the crop cannot withstand the long annual dry period of 3-4 months as prevails in northern part of the region. Additionally, labor shortages (although not as acute as in the rubber sub-sector), rising production costs, declining prices and low productivity among smallholders could hamper the further expansion of this sub-sector.

The region is the largest producer of rice in the country producing about 40 per cent of the national total. Annually it produces about 800,000 metric tons of paddy. The MADA Irrigation Scheme covers an area of about 126,000 hectares, of which 97,000 hectares are cultivable paddy land. Additionally, there are about 16,800 ha of rice area outside the MADA Irrigation Scheme, which are served with small irrigation facilities, which enable it to be double-cropped too. These are called secondary or mini granary areas. The water source is mainly from the Muda River, which during severe droughts can result in limited access to water supply. There are a total of 22 secondary granaries in the region with a total area of about 9,150 hectares (Department of Agriculture, 2001). Another 20,500 hectares of rice area is not irrigated and these areas are more prone to droughts. The current total area under paddy is less than the total land use as in Table 2.4 due to the problem of idle paddy land especially in non-irrigated areas.

The region is the only producer of sugarcane in the country, with total area of about 20,000 hectares. There are only two sugarcane producers in the country, both of which are located within the region and operated on an estate basis. Total production is in the region of 400,000 metric tons annually. This contributes about 10 per cent of the total national requirement. Future expansion in area is no longer possible due to the limited area available suitable for sugarcane production.

Other minor crops are mango with a total area at 2,700 hectares, durians at 5,200 hectares, tobacco at 1,300 hectares and vegetables at 1,200 hectares. The area under mango has significantly expanded to the current level as compared to only about 100 hectares 20 years ago, representing a growth of about 6 per cent per annum since 1984. This is due to the suitability of the area for mango production coupled with strong market demand from both the local and overseas markets. The other important fruit is durian at about 5,200 hectares mostly in the state of Kedah. The hectarage of durian in the state of Perlis is negligible, due to the presence of long drought periods. The production of tobacco is dictated by the production quota given to the region. The area under tobacco cultivation is between 1,100 to 1,500 ha annually, almost equally shared by the two states, with annual production averaging about one million tons of cured leaves. Tobacco cultivation is mainly concentrated in rainfed areas and planted after the main rice season.

The land area for vegetable production is about 1,200 ha. Most of the producers are small farmers, and the farms are mostly irrigated using water from the surrounding rivers and ponds. Major vegetable types are chillies, cucumber and other leafy vegetables. Most are used for regional consumption. Vegetable is considered to be a lucrative cash crop, but the small domestic market in the region, plus the importation of cheaper vegetables from across the border from Thailand limits its expansion. There was a significant surge in vegetable production in 1997 (the El Nino year) and this was brought about by the intensive promotion by the government to encourage cash crop production when the country was faced with the economic recession in that year.

The livestock and fisheries sectors are basically not land-based activities. Nevertheless, the description of these two sectors is included in order to provide an overall status of major economic activities within the agricultural sector. Livestock is not very prominent in the region. There is limited scope for expansion of animal stocks due to limited grazing grounds. Total population of cattle was at about 97,700 heads in 1999 against the peak of 136,000 heads in 1995. The cattle-oil palm integration activities supported part of this population. Similarly, the number of buffalo has also significantly declined from 45,000 heads in 1980 to the current level of only 10,900 heads. Increased mechanisation in paddy cultivation and double cropping of paddy areas, especially within MADA has drastically reduced grazing areas for buffalo in the off-season. The goat population has remained steady in the last few years at between 30,000 – 40,000 heads. The sheep population at about 34,000 heads, however, has been on a slight increase due to some integration activities with the plantation crops. Dramatic progress is observed in the poultry sub-sector. There are at the moment about 7.3 million chickens against a mere 0.5 million a decade ago. High consumer demand and the move toward adopting commercialised production systems have contributed significantly to this expansion.

Total landed marine fish was 170,200 metric tons for the year 1999. Records show a 1.5 per cent growth rate per annum in marine landings since 1980. The depletion of coastal fishery resources is expected to consequently result in the decline in future marine fish landings. A fairly significant growth was registered for fresh water aquaculture, with current total production at about 1,100 metric tons, a more than 10 fold increase compared to ten years ago.

2.2.7 Demography of farms and the farmers

The agricultural sector in Malaysia can be distinctly divided into a more efficient export-oriented plantation sector and a traditional smallholder sector. The plantation sector is known for its high efficiency and productivity relative to the smallholder sector. It consists of the industrial crops, namely rubber, oil palm, sugarcane, coconut, cocoa and pineapple. The smallholder sector on the other hand mainly comprises of food crops such as rice, fruits and vegetables, together with tobacco as well as coconut and pineapple. The smallholder sector is known for its inefficiency and low productivity. In most cases, the farm holdings are small, highly fragmented and practising low technology farming. Farmers are aging with low educational levels. In the state of Kedah, the average farm size is 4.2 hectares. In the Kedah-Perlis region, smallholders dominate the agricultural sector. In the rubber sub-sector, the ratio of the area under smallholders to estates is 3:1 and for the oil palm the ratio is 1:4. Rice production is entirely under the smallholders. The situation is also similar for fruits, vegetables and tobacco.

Within the MADA area, the average farm size is 2.0 hectares per farm household, which is almost double that of the national average of 1.03 hectares. The increment is brought about primarily due to the reduction in the number of farmers involved in rice cultivation, which resulted in bigger holdings for the remaining farmers, either through land purchases or leases.

The average family size is 4.5. The average age of paddy farmers recorded in 1992 was 53.8 years old, ranging from 23 to 75 years old. Sixty-per cent of these farmers were 51 years or older (Tawang, 1996). The majority of the farmers have minimal primary school education.

2.2.8 Policy dimensions at regional level

The planning process

National planning and policy making is predominantly a federal matter. The key agency is the Economic Planning Unit (EPU) of the Prime Minister's Department, (Tawang, 1998). This is the agency responsible for the overall planning of the country including both long and medium term planners. The plans include the long term National Development Policies, 10-years Operational Perspective Plan, 5-years Malaysia National Operational Perspective Plans, Five-year Malaysia Development Plans and also other specific sectoral plans. The preparation of these plans, however, involves all the relevant agencies and departments.

As an example, in the preparation of a specific national policy such as the National Agricultural Policy, EPU will provide macro-perspectives especially on the development goals and directions, expected contribution between sectors, and some indications of resource allocation, especially the land resource. For agriculture, the Ministry of Agriculture coordinates the overall preparation of the policy documents. The plan then undergoes a series of processes for approval, from the Ministerial level and National Planning Council right up to the cabinet. Once approved, the plan is used as a basis for the development of various action plans by the respective departments and agencies.

At the state level, the plan is used as a basis for the development of state level development programs and projects. This is the responsibility of the State Economic Planning Unit, as the planning agency at the state level to ensure that the formulation of development plans and policy advice at the state level are in line with federal aspirations and plans.

Regional policy dimensions

The policies at the state and regional level follow closely to that of the federal or national policies. The national policies governing agricultural development are discussed in the earlier report (Tawang *et al*., 2002). Basically, they are formulated to fulfil the strategic needs of the sector including assuming safe levels of food security, income enhancement and poverty alleviation as well as to provide for rural employment.

Historically, in the 1960s, the policy direction was towards the objectives of providing employment and earn foreign exchange earnings. Import substitution was also a major policy goal. A very high emphasis was given on food security issues, where a 100 per cent self-sufficiency level (SSL) was targeted for domestic rice production. The launching of the first National Agricultural Policy (NAP) in 1984 shifted the policy, which then focused on enhancing productivity, efficiency and competitiveness. Rice production was also rationalized to 85 per cent of domestic consumption. In the mid 1980s and in 1990, with rapid expansion of the manufacturing and service sectors, coupled with problems within the agricultural sector, the relative importance of the sector declined. The second NAP was introduced in 1992, emphasizing the need to address productivity, efficiency and competitiveness in the context of sustainable development. Development efforts were concentrated on modernization and commercialisation. The SSL for rice was further reduced to 65 per cent in view of the continued constraints on the factors of production. The third review of NAP was undertaken in 1998, where the focus was on meeting national food requirements, enhancing competitiveness and profitability, enhanced integrated development, and adopting sustainable development.

State-level development plan

For the state of Kedah, the Kedah Development Action Plan covering the period 1991-2000 was formulated to guide the state's development efforts for the period. It provides a comprehensive, coordinated and continuous means of attaining economic goals for the state (SEPU, 1994). It outlines the state's objectives and strategies, provides sectoral development strategies and programmes, and identifies relevant supporting frameworks. The Plan also outlines the implementation strategy, institutional framework and financing and finally a list of the entire proposed development projects to be undertaken during the period.

In 2001, a new planning document, the Kedah Action Plan for the period up to 2010 was introduced. The overriding goal was to steer the Kedah state into a developed state. Particularly for agriculture, this sector has been identified as one of the prime movers to achieve the goal, with the overriding objective of income maximization through the optimal utilization of resources. One of the major strategies to achieve this objective is the introduction of the crop-zoning concept where the development of agricultural commodities is geared toward achieving competitive edge by exploiting the different and unique agro climatic characteristics of the state.

While similar documents for the state of Perlis are not available, a similar planning process as in the state of Kedah has also been undertaken. This is spearheaded by the State Economic Planning Unit and the relevant departments and agencies.

2.2.9 The role of state-level institutions

Government departments and institutions have been instrumental in facilitating and implementing agricultural development programmes in the region. The roles and functions of some of these departments and institutions was briefly described in the earlier report (Tawang *et al*., 2002). They are mostly involved in agricultural extension and development programmes, marketing, farmers' institutions, environmental monitoring and enforcement, support services and so on. This section further deliberates the functions of these selected departments and institutions within the region. However, the discussion is concentrated on highlighting their roles and functions in relation to their involvement in undertaking measures to address the effect of El Nino induced climate changes on the agricultural sector.

Department of Irrigation and Drainage (DID)

The DID's main objective is to provide services in irrigation development in the country, particularly for the paddy sector. It is the role of the department to provide irrigation and related infrastructure that is capable of supporting double cropping in both the main granary (MADA) and the mini or secondary granaries in the region. The department is also responsible to ensure effective and efficient management of irrigation water and facilities and improve the irrigation system and management through the practice of modern and appropriate technology. In this aspect it undertakes the continuous monitoring of rivers in terms of water height as indicators of water availability. Under a severe water deficiency situation the department is responsible to advise the state government on the next course of action through the State Natural Disaster Committee. The department is also entrusted to promote and support policy, legislative and institutional development related to irrigation. For the other commodities, the DID is responsible for providing technical assistance in infrastructure development related to irrigation, including areas zoned for commercial farming. Under an acute water shortage situation it provides support by pumping water from rivers to ensure sufficient irrigation water for the farmers, especially in secondary or mini irrigation schemes.

Since 2001, the department at the federal level has initiated a 'Drought Monitoring Programme'. The objective of the program is to disseminate online water resource status, aimed at providing early warnings on potential droughts. In this programme, the state department provides rainfall data as a basis to calculate water resource status. From the analysis, it is possible to calculate the deviation in water supply at the catchment areas against the long-term mean. This provides some indication of impending water shortages in a particular region. This information, in tables and maps, can be used by relevant government departments and agencies to introduce mitigating measures associated with water stress problems.

Department of the Environment (DOE)

As the guardian of Malaysia's environment, the department is responsible for the preservation of the environment, focussing on monitoring and ensuring the enforcement of the environmental laws and legislations. In line with this function, the department was the leading agency in handling the haze situation during the El Nino of 1997/98 by carrying out control procedures and prevention mechanisms, including the enforcement of the Environmental Quality Act and Haze Action Plan. The main activity during that period, especially during the peak of the haze episode, was to control open burning. This was carried out by routine inspections, quick responses to public complaints as well as responses to satellite information with regards to 'hot spots', which indicates where open burning is taking place. Depending on the seriousness of the burning, offenders could be advised to stop or control the burning, or be brought to a court of law if there was sufficient evidence.

Department of Agriculture (DOA)

The department could be considered as one of the closest government agencies to the farmers. It is the agency that is involved in extension activities, dissemination of new agricultural knowledge and technologies, provider of farm inputs in selected cases as well as other supportive functions. Other than the head office in the state capital, the department is well endowed with smaller offices in all of the districts in the state. It is manned by agricultural officers and agricultural technicians. In the last El Nino episode, the department played a prominent role especially in providing advice to farmers in managing their farms under severe drought conditions. In this respect, the department also provided more mobile pumps and pipes to help irrigated paddy farms and other crops outside the irrigation scheme. During the 1997/98 El Nino, a total of 1,300 hectares of paddy land was irrigated by this mechanism in the district of Baling, Kedah.

Malaysian Agriculture Research and Development Institute (MARDI)

As the premier research institution of the country, the institute is involved in research and development activities for agricultural commodities, except oil palm, rubber, cocoa and fisheries. Within the region, the institute has a primary research station for tropical fruits at Bukit Tangga, Kedah and a rice research station just across the southern border with the State of Penang. While the main objective of the establishment of these two stations is to serve the national interest, their location within the Kedah-Perlis region would benefit these two states more than the other regions due to the spill over effect of R&D activities conducted by these research stations.

a. Rice Research Station, Seberang Prai, Pulau Pinang.
   This is the primary rice research station in the country. Research activities began in 1972 with the objective of becoming a centre of excellence in paddy research able to provide new and appropriate technologies to the farmers. To date, the centre has released twenty-eight new paddy varieties, which have contributed to about 95 per cent of the total varieties used in paddy cultivation in the country. Almost all of these varieties are short-term maturation varieties, which is one aspect of a water saving strategy. In addition to its role in the development of new paddy varieties, the centre is also involved in conducting R&D on the efficient utilization of inputs, management of pests and disease, post harvest handling, mechanization and water management.

Currently, its gene bank has a collection of about 10,000 accessions, including the wild paddy. Based on this broad spectrum of rice germplasm, the centre is in a position to carry out breeding and selection programs for drought tolerant varieties when there is a need in the future.

b. Fruit Research Station, Bukit Tangga, Kedah.
This is the main research station for tropical fruits in the country. Established in 1986, the station conducts R&D activities mainly with regards to durian, mango, sapodilla and other tropical fruits. Research focus is in the areas of new varietal development, regulation of production, input utilization, management of pests and disease, plant architecture and mechanization, post harvest handling as well as water management.

There are also a few other federal and state government departments and agencies in the region which are also involved in agricultural development. However, their roles in addressing issues of El Nino and drought are quite limited. These include agencies such as the Veterinary Services Department, Farmers' Organisation Authority, Malaysian Rubber Board, Malaysian Palm Oil Board, Federal Marketing Authority and Aquaculture Bank and others.

3. The El Nino Events and Climatic Change

This chapter describes the changes El Nino events brought to the major weather variables such as rainfall, temperature, solar radiation and air quality in the study area. The relationships between the El Nino phenomena and these variables has been explained in earlier work by Tawang *et al*. (2002). While the earlier work described the relationship and the causal effects at the national level, the description and subsequent analyses in this chapter are specific to the study area in the northwest region of Peninsular Malaysia.

During the last 50 years, there were twelve incidences of a major El Nino event recorded in the country. Of these episodes, the worst and most severe was the 1997/98 episode, which began in March 1997 and ended in June 1998. This El Nino brought about prolonged dry weather and the subsequent incidence of severe haze, which led to a serious deterioration in air quality, caused by forest and plantation burning during the long drought period. The negative effects were thus not limited to the agricultural sector alone but also affected the whole population at large. During other El Nino episodes, the effect was relatively more severe in the states of Sabah and Sarawak (on the Borneo islands) due to their close proximity to the Equator as compared to the effects in Peninsular Malaysia. However, the severity of the 1997/98 episode led to extensive effects throughout the country. This resulted in massive water shortages in many states and the whole country was covered by thick haze. The other major El Nino events were the 1982/83 and the 1991/92 episodes. The severity of these two episodes was not very pronounced since there were no serious incidences of haze and water shortages when compared to that of the 1997/98 episode.

The subsequent discussion focuses on describing the climatic changes during El Nino episodes, especially the 1997/98 episode in the region. In describing the climate change, comparisons were made between normal years, El Nino years and the 1997/98 El Nino episode. The analyses cover the study area, i.e. the states of Kedah and Perlis. Climatic data for the analyses was obtained from two weather stations; the Kepala Batas weather station for the state of Kedah and the Chuping weather station for the state of Perlis. The exception is for the Total Suspended Particulate (TSP), where the Bayan Lepas weather station in the nearby state of Penang was used since the station has air quality records dating back to the 1980's.

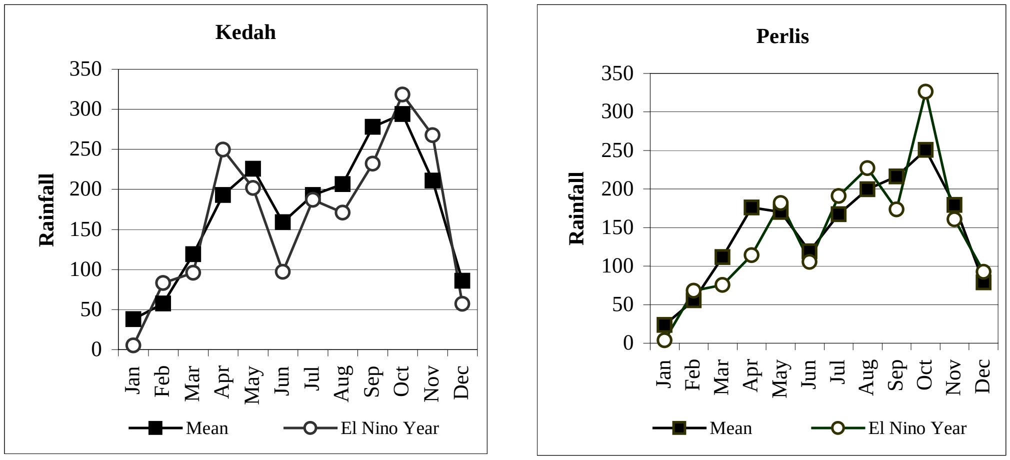
3.1 Effects on rainfall

Overall, there was an obvious impact on rainfall in the region, in terms of the distribution of monthly rainfall and monthly rainy days. Two analyses were made with regards to the rainfall pattern; one with respect to the changes in rainfall pattern (level and number of rainy days) between the normal years and the major El Nino years of 1981/82, 1991/92 and 1997/1998, and secondly between the mean of normal years and the El Nino of 1997/98. In this respect, normal years refer to non El Nino years.

3.1.1 The monthly rainfall level

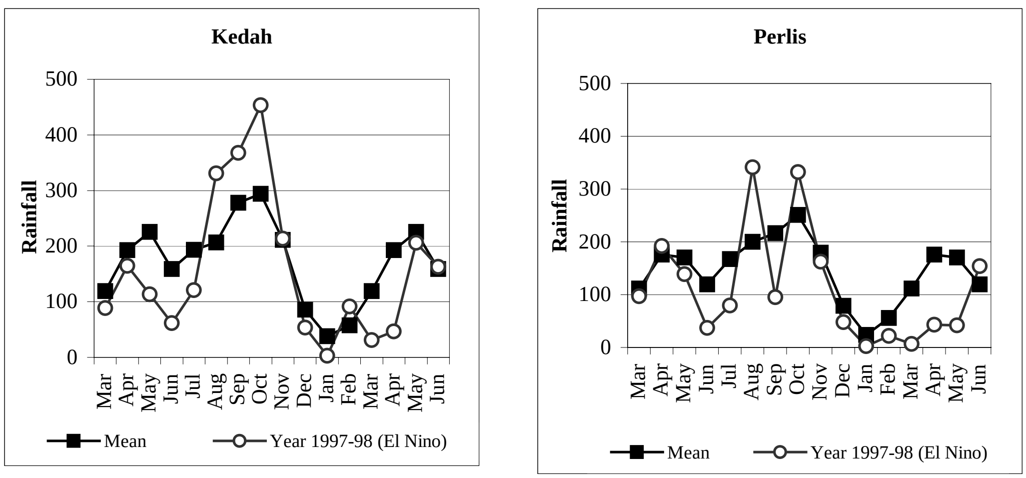
In the earlier report by Tawang *et al*. (2002), it was noted that there was generally little change in the total annual rainfall for the northwest region. This was reflected in the small differences in annual rainfall levels for the states of Kedah and Perlis, as indicated in Figure 3.1. The El Nino years registered an annual reduction in rainfall by only 54.3 mm. The total annual rainfall deficit during the El Nino years for Kedah was 94.3 mm, while Perlis registered a rainfall surplus of 367.4 mm.

Figure 3.1 Montly rainfall in Kedah and Perlis (mean and El Nino years)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.2 Monthly rainfall in Kedah and Perlis (mean and the 1997-98 El Nino)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Nevertheless, for the months of January to May, the two states experienced a fairly significant level of rainfall reduction, i.e. by more than 125 mm within the five-month period. March to May coincides with the off-season paddy-planting period where the availability of sufficient water in the field is critical. For the other months, the levels of rainfall in the El Nino years were much higher than the mean rainfall level. In the state of Kedah, the period of May to September showed a significant reduction in rainfall as well as in the months of January, March and December. For Perlis, the rain deficit months were the months of February to May, and August to October.

During the 1997/98 El Nino episode, which took place between March 1997 and June 1998, the impact on rainfall deficit was more obvious (Figure 3.2). Total rainfall during the period registered a deficit of 248 mm and 533 mm for the states of Kedah and Perlis respectively. This represents a percentage reduction of 9 per cent and 23 per cent respectively. Taking the period as a whole, the impact on rainfall deficit was not very significant, especially for the state of Kedah, closer observation indicates that the deficit in rainfall during the months of March to July 1997 was fairly significant. During this period, the state of Kedah received only about two-thirds of the amount of rainfall it normally receives. While for the state of Perlis it was about 73 per cent. What is critical, however, is the fact that the deficit occurred during the off-season paddy production period, where the need to have adequate water supply in a timely manner, both from irrigated or non-irrigated sources are of primary concern.

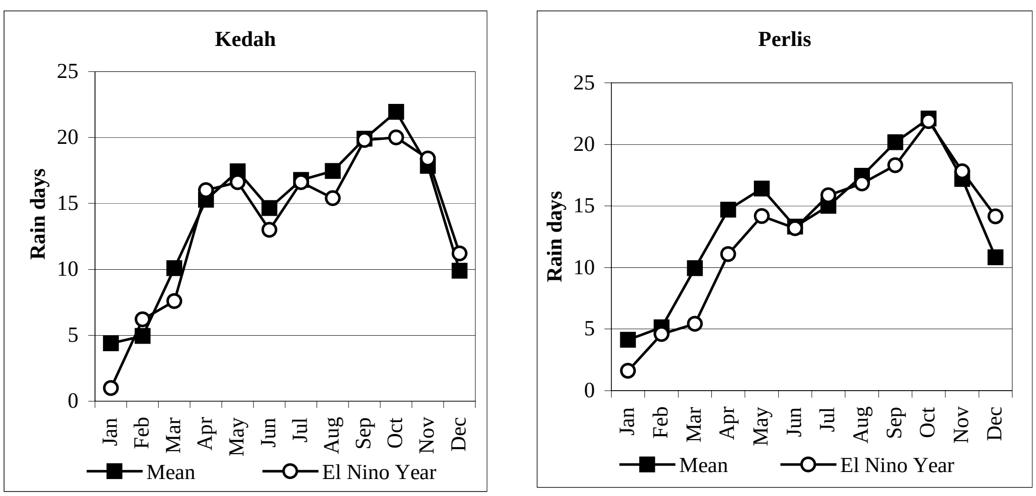
3.1.2 The monthly rainy days

The levels of monthly rainfall are dependent on the intensity and duration of the rains. The northwest region was noted as the region with the smallest differences in rainy days between El Nino and normal years, (Tawang *et al.*, 2002). This partly contributed to the relatively small differences in total rainfall in the region. The monthly rainy days are shown in Figure 3.3. Overall, there was a slight reduction in rainy days for most of the months, especially for the months of January to May. At the state level, the annual rainy days in the normal years exceeded that of the El Nino years by 8.8 days and 11.5 days for Kedah and Perlis respectively.

During the 1997/98 El Nino episode however, the difference in rainy days between this episode and the normal years was greater (Figure 3.4). During the episode, the reduction in the number of rainy days was fairly obvious when compared to the normal years for all the months in Kedah, except for the month of December. Similar trends were observed for Perlis, even though there were relatively more months that did not register reductions in rainy days.

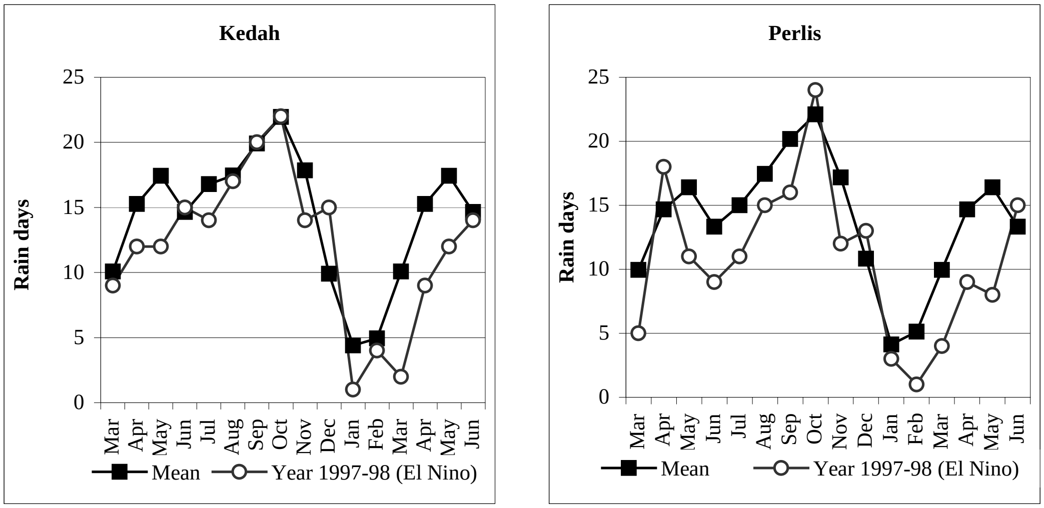
The resultant water stress due to a decrease in rainfall in the region negatively affects plant growth and hence, agricultural production in the region. Such impacts will be discussed later in this report.

Figure 3.3 Monthly rainy days in Kedah and Perlis (mean and El Nino years)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.4 Monthly rainy days in Kedah and Perlis (mean and the 1997-98 El Nino)



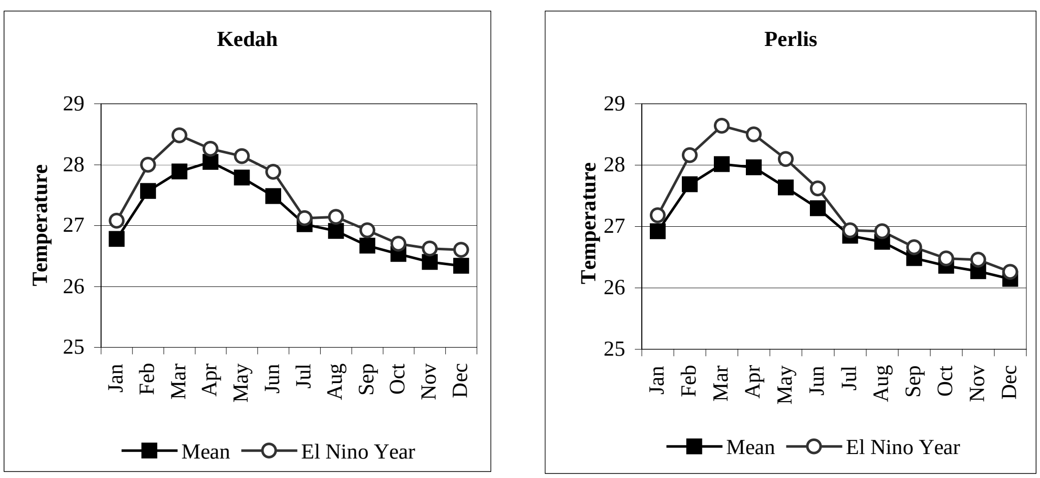
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

3.2 Effects on temperature

3.2.1 Mean temperature

The dry period brought about by the prolonged drought led to higher temperatures. This effect was very pronounced in the region. Data shows that there were increased mean monthly temperatures for all months during the El Nino years in both the states of Kedah and Perlis (Figure 3.5). For all of these months, the temperature increases were between 0.1 to 0.6^{o}C. The mean increase in temperature for Kedah and Perlis was 0.29^{o}C.

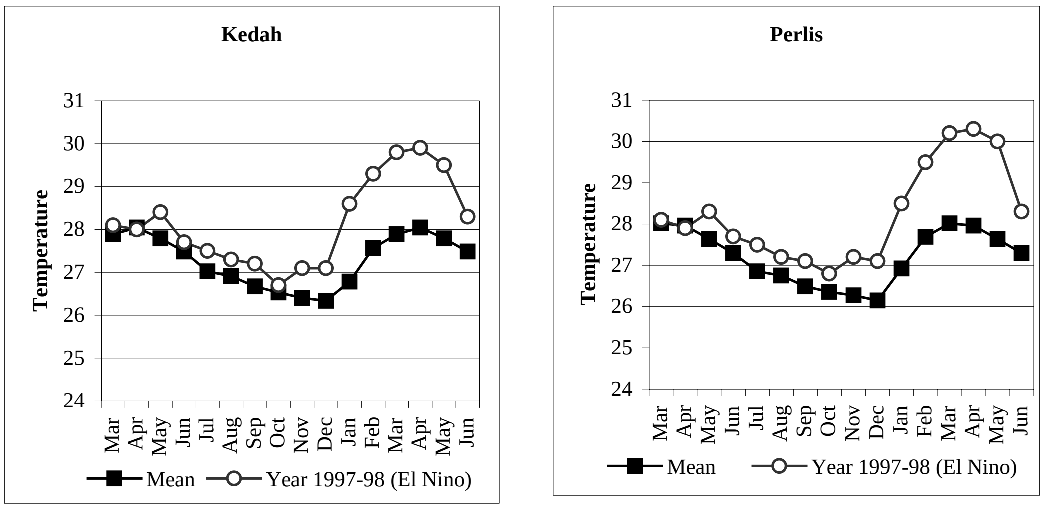
Figure 3.5 Monthly mean temperature in Kedah and Perlis (mean and El Nino years)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

During the El Nino episode of 1997/98, the monthly increase was more obvious (Fig. 3.6). The increases ranged between 0.1 and 1.9°C with the mean at 0.9°C in Kedah and between 0.1 to 2.4°C with a mean of 1.36°C in Perlis. Significant increases in temperature were noted in the months of February to May 1998, where the mean monthly increase ranged between 0.7°C to 1.9°C in Kedah, and 1.8°C to 2.4°C in Perlis. While such increases could partly be due to the general trend in global warming, the drastic increase was brought about primarily by the prolonged dry weather in the region.

Figure 3.6 Monthly mean temperature in Kedah and Perlis (mean and the 1997-98 El Nino)

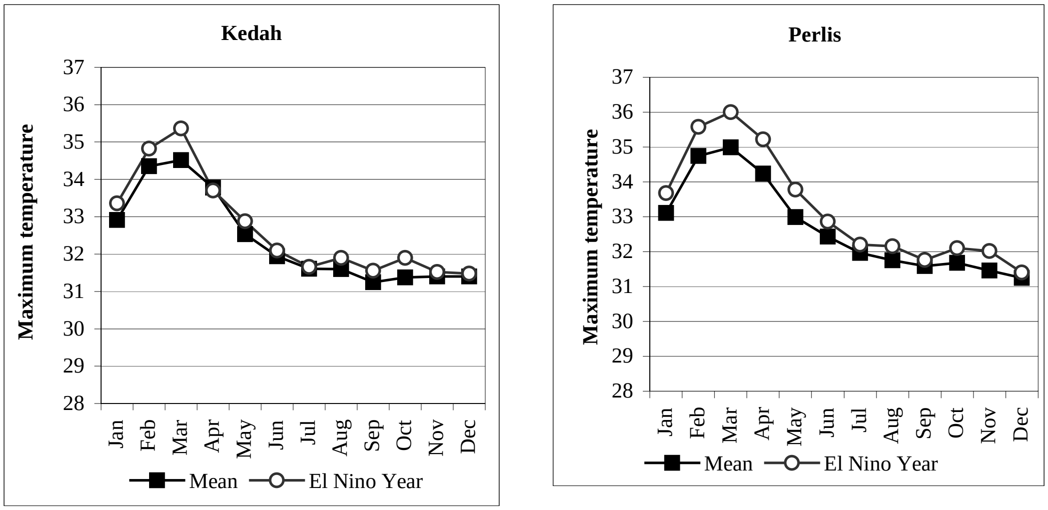


Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

3.2.2 Maximum and minimum temperature

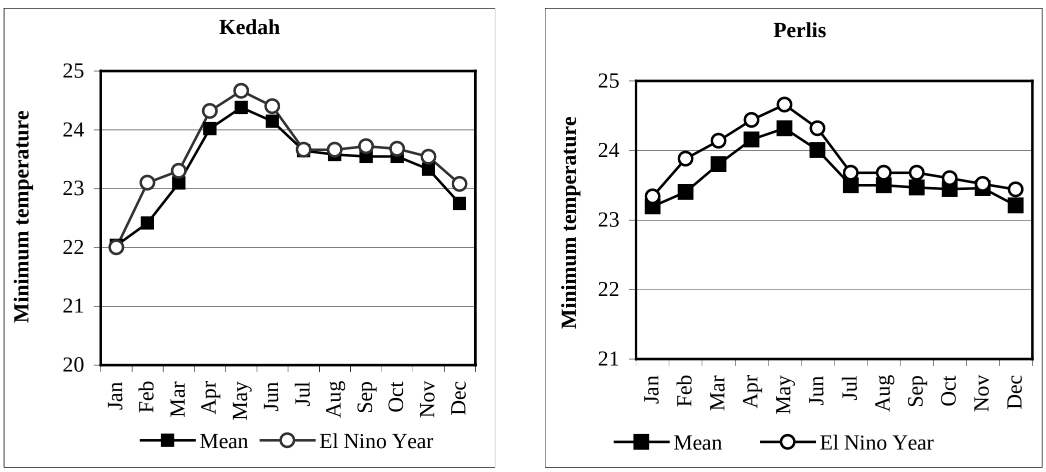
In line with the overall increase in mean monthly temperature, the mean monthly maximum and minimum temperatures also follow similar trends. For each month in Kedah and Perlis, the maximum and minimum temperatures were higher during the El Nino years compared to that of the normal years (Figure 3.7 and 3.8). The monthly increase in maximum temperature ranged between 0°C to 0.9°C in Kedah (mean increase of 0.32°C) and between 0°C to 0.6°C in Perlis (mean increase of 0.29°C). The mean monthly increase in temperature during the 1997/98 El Nino was 1.09°C and 1.6°C for Kedah and Perlis respectively. Figures 3.9 and 3.10 indicate the drastic increase in maximum temperature in the region. Such increases can be detrimental to the plants.

Figure 3.7 Monthly maximum temperature in Kedah and Perlis (mean and El Nino years)



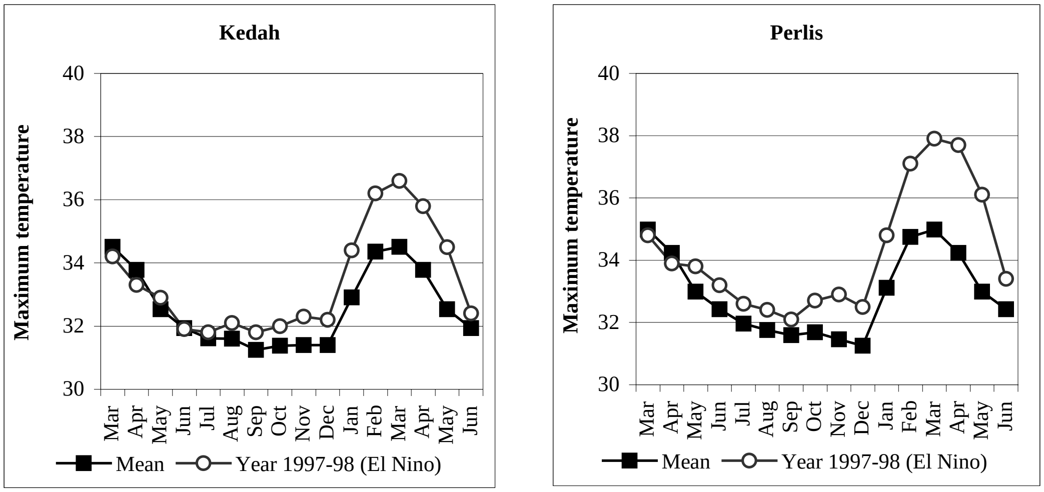
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.8 Monthly minimum temperature in Kedah and Perlis (mean and El Nino years)



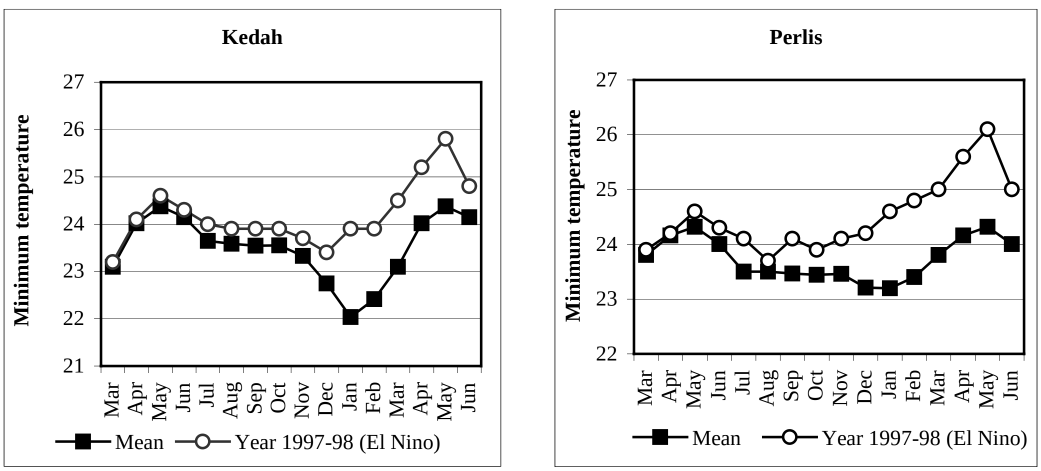
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.9 Monthly maximum temperature in Kedah and Perlis (mean and the 1997-98 El Nino)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.10 Monthly minimum temperature in Kedah and Perlis (mean and the 1997-98 El Nino)



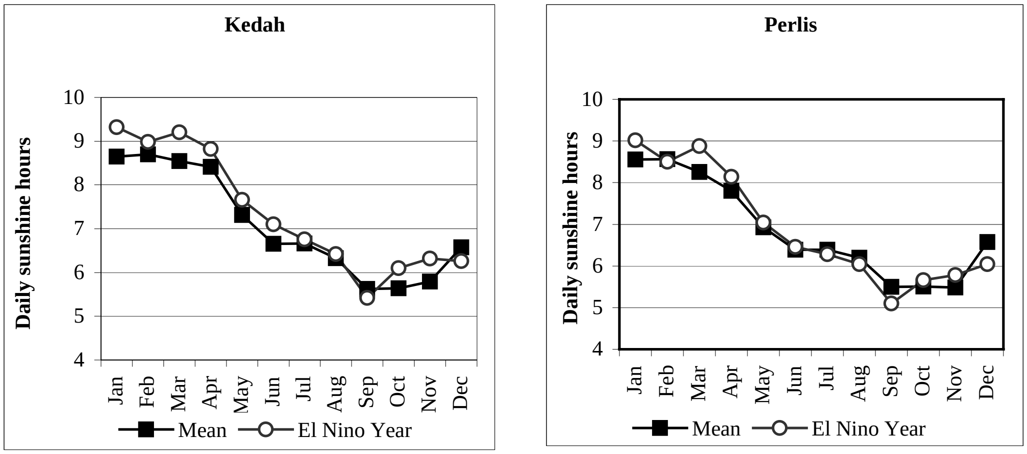
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

3.3 Effects on daily sunshine hours

The total sunshine hours and relatedly, the daily solar radiation are important factors affecting crop production since they influence the process of photosynthesis. During the prolonged dry season, there was an increase in sunshine hours. Although this can positively influence crop production, the formation of haze during El Nino years can block sunshine penetration, hence effectively reducing the daily sunshine hours.

The mean daily sunshine hours for Kedah and Perlis in the El Nino years is shown in Figure 3.11. The dry periods of December to March registered an increase in sunshine hours for both states. Overall, the mean daily increase in sunshine hours for Kedah and Perlis was 0.28 and 0.23 hours respectively.

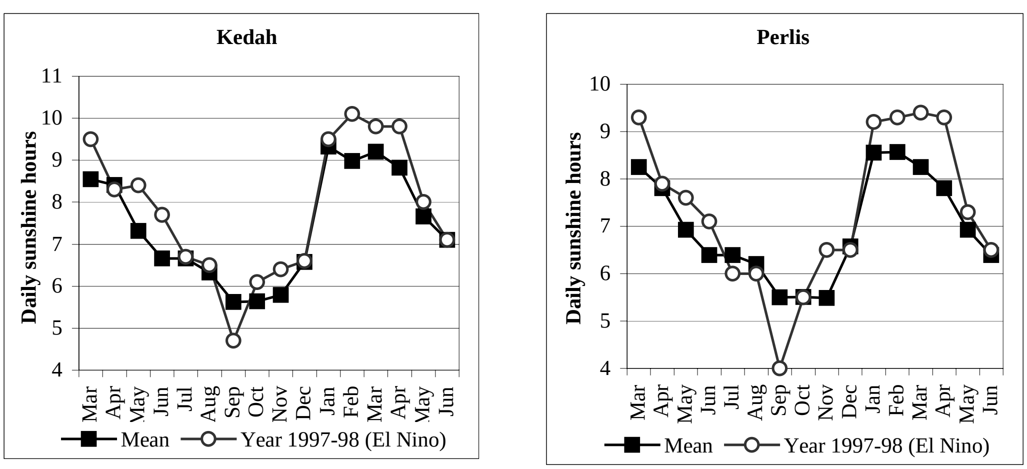
Figure 3.11 Monthly daily sunshine hours in Kedah and Perlis (mean and El Nino years)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

The mean daily sunshine hours during the 1997/1998 El Nino episode are shown in Figure 3.12. During the episode, the prolonged drought was accompanied by the formation of haze in the months of July to September. Whilst the 'thickness' of the haze was much less than that of the other regions in the country, this phenomenon, to some extent, influenced the degree of sunshine hours in the region. However, the data on sunshine hours indicates that the haze factor was overwhelmed by the long drought factor. Hence, inspite of haze formation, there were significant increases in daily sunshine hours for Kedah and Perlis, of 0.55 hours and 0.48 hours respectively. These increases were more than double the mean increase in daily sunshine hours registered in all the other El Nino years. This indicates the severity of the 1997/98 El Nino episode. There were, however, some months during this episode when the daily sunshine hours were lower than that of the mean sunshine hours of the normal years. Generally this took place between the months of July to September which coincided with the haze period. During the peak of the haze period, in the month of September, abnormal decreases in daily sunshine hours were observed. Daily sunshine hours were at the lowest levels during this period, falling to only 4 hours in Perlis and 4.7 hours in Kedah.

Figure 3.12 Monthly daily sunshine hours in Kedah and Perlis (mean and the 1997-98 El Nino)



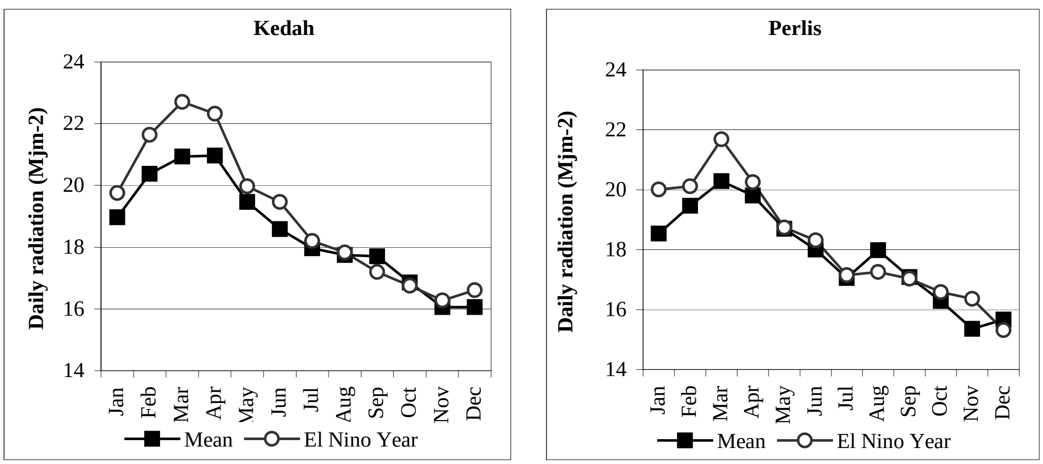
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

3.4 Effects on solar radiation

Solar radiation is closely related to the duration of sunshine. Therefore, during the prolonged drought period, solar radiation increases, while during the period of heavy haze, reduced sunshine radiance resulted in a decrease in solar radiation. Increased solar radiation positively affects crop development, which generally results in better yields. Figure 3.13 shows the monthly changes in daily radiation between the El Nino and normal years. The mean solar radiation for the El Nino years in Kedah was 19.0 MJ and 18.2 MJ in Perlis, compared to the mean radiation during normal years of 18.5 MJ and 17.8 MJ for both states respectively. Overall, except for the months of July to October in Kedah, and August, September and December in Perlis, all other months registered higher daily radiation in both states, with maximum readings at 22.7 MJ and 21.7 MJ in Kedah and Perlis respectively. Both of these readings were registered in the month of March, the peak of the drought period.

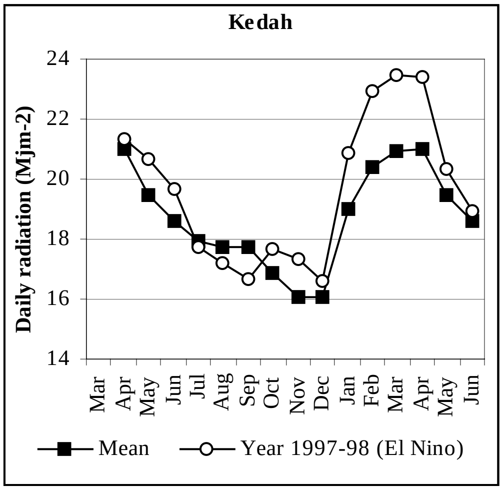
During the 1997/98 El Nino episode, solar radiation was higher. The mean daily radiation increased to 19.6 MJ in Kedah and 19.3 MJ in Perlis. Overall, except for the months of July to September, all other months during the episode registered increases compared to normal years. The maximum radiation registered was 23.5 MJ in Kedah and 23.1 MJ in Perlis, both in the month of March (Figure 3.14). As expected, the lower than normal solar radiation in the months of July to September coincided with the haze episode in the country.

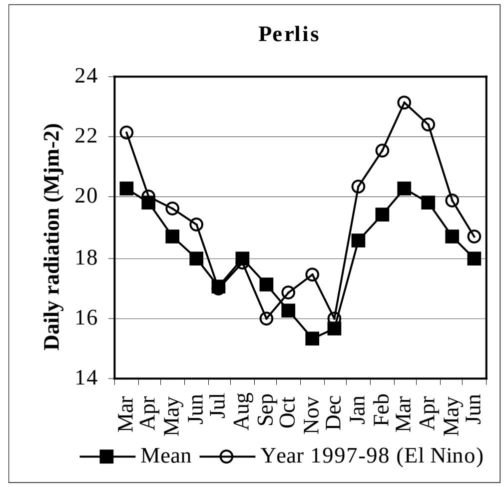
Figure 3.13 Monthly daily global radiation in Kedah and Perlis (mean and El Nino years)



Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

Figure 3.14 Monthly daily global radiation in Kedah and Perlis (mean and the 1997-98 El Nino)



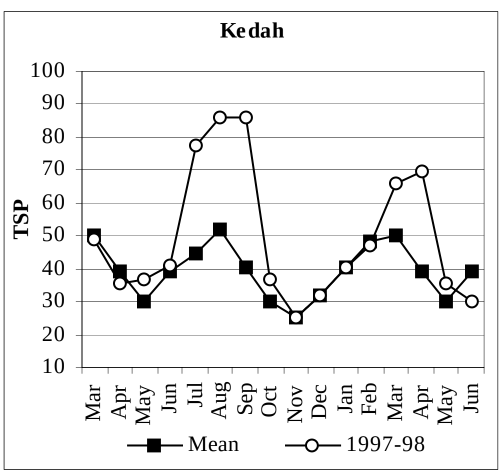


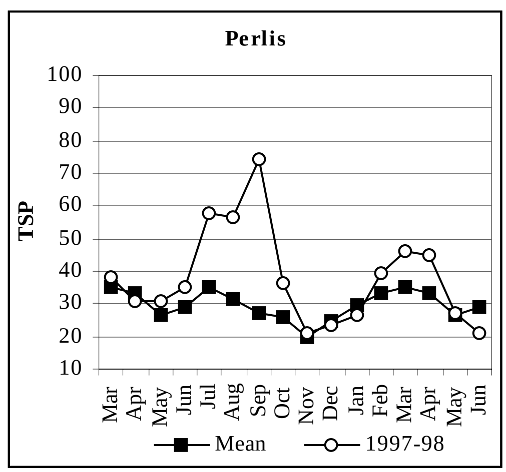
Source: Kepala Batas weather station, Kedah.
Chuping weather station, Perlis.

3.5 Effects on total suspended particulate (TSP)

Total suspended particulate refers to the tiny particulates suspended in the atmosphere. At high concentration, these particulates scatter and absorb sunlight resulting in diminished visibility thereby giving the atmosphere a characteristic opalescent appearance. This is used as a basis for Air Pollution Index (API). As was noted in the earlier study (Tawang *et al*., 2002), the northwest region of Peninsular Malaysia was the least affected, where the mean monthly TSP did not exceed 100. However, readings of between 50-100 (Figure 3.15), which is considered as moderate air quality, were observed for a number of months. In Kedah, these were the months of July to September 1997 and March to April 1998, while in Perlis the readings were observed in the months of July and September. Generally, during these months, the TSP value was double that of the normal years. The highest monthly TSP value recorded was in the month of September for both states (a similar trend for all the other parts of the country).

Figure 3.15 Monthly total suspended particulate (TSP) in Kedah and Perlis (mean and the 1997-98 El Nino)





Source: Bayan Lapas weather station, Penang.

4. The Regional Impacts

In this chapter, the impacts of El Nino on commodities in the northwest region of Peninsular Malaysia (the states of Kedah and Perlis) is quantitatively estimated. Time series data for the period 1980 to 2000 was used for this purpose. The first part of this section will further analyze the annual changes in major weather variables that were associated with the El Nino phenomena, namely rainfall, temperature and total suspended particulate (TSP), to reflect the changes that were brought about by the El Nino events. The relationships between the El Nino phenomena and these variables has been explained in the earlier work by Tawang *et al*. (2002). Additionally, the relationships of these variables and crop performance were also extensively elaborated in the work.

4.1 Methodology

In analysing the impacts of El Nino on crop performance, the variables that were associated with the El Nino phenomena were first plotted against the yield performances of the crops for the time period of 1980-1999. These plots were undertaken to visually analyze and observe, if indeed, any correlation existed between the El Nino related weather variables and the performance of crops such as oil palm, rubber and paddy.

Another simple analysis involved the calculation of means of the weather variables between the El Nino and the non-El Nino years to observe if there was any significant difference between the means of the two periods. If the weather variables themselves did not indicate any significant difference between the El Nino and the non-El Nino years, then it would be most likely that there would not be significant differences in crop performance during the El Nino years (EY) and the non-El Nino years (NEY).

In attempting to quantify the actual production loss due to weather variability, the five-year moving maximum outlined by Gommes (1998) was used. This method was similarly used by Tawang *et al*. (2002). In this method, the maximum average yield Y_m in a five-year interval from T_{t-2} to T_{t+2} was taken. The difference between Y_t of the year A_t was then expressed as a percentage loss of the achievable yield, should the weather conditions be as good as in the year where the maximum 5 year yield was achieved. The loss is thus equal to $(Y_m - Y_t)/Y_m$ expressed as a percentage.

A yield function was also estimated for oil palm, rubber, paddy and tobacco to analyze the relationships of the weather variables with the observed yields. Yield functions for other crops and commodities were not estimated due to the unavailability of yield data. In all the functions, yields of crops were hypothesised to be influenced by the weather-related variables consisting of mean annual daily temperature, mean annual daily sunshine hours, mean annual rainfall and the annual daily mean of the amount of total suspended particulates in the air. An intercept dummy variable was also introduced in the yield function to observe if indeed there exists significant differences in yield performance during EY and NEY.

The statistical model estimated was as follows:

$$CYt = f(Tt, St, Rt, TSPt, DUM)$$

where:

CYt	=	crop yield in year t,
Tt	=	mean annual daily temperature in year t,
St	=	mean annual daily sunshine hours in year t,

Rt = mean annual rainfall
TSPt = mean annual daily total suspended particulates in year t, and
DUM = dummy variable; where DUM = 1 for El Nino years and 0 otherwise

For oil palm, all the independent variables were lagged one year based on the assumption that the effects on the El Nino on yields of perennial crops would not be immediate but delayed. Based on a priori expectations, the relationships between yield and rainfall and sunshine hours were expected to be positive, while the relationships between crop yields and temperature and total suspended particulates were expected to be negative. A significant dummy variable showed that El Nino affected crop yields. A negative dummy was also expected. This would indicate a downward shift in the intercept of the yield function indicating that at all levels of the independent variables yields were lower during EY.

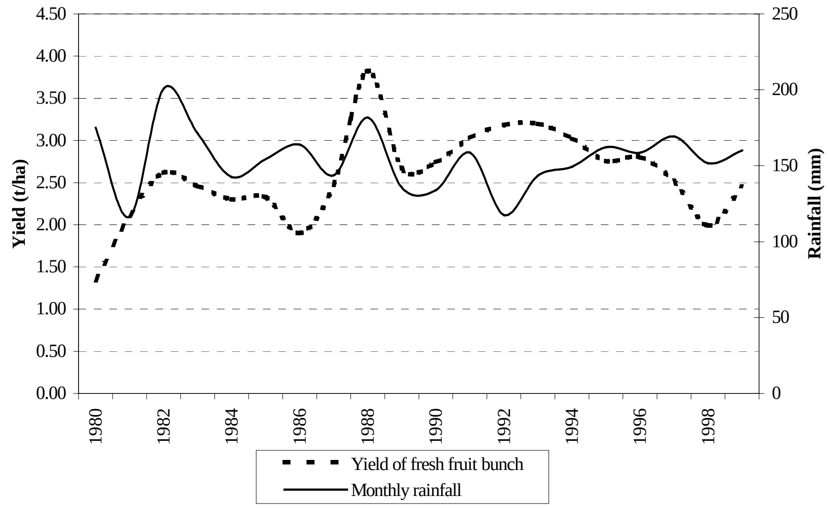
4.2 Relationships between crop performance and weather variables

4.2.1 Graphical disposition

Figures 4.1 to 4.3 show the graphical dispositions of the association between annual average rainfall and the yields of oil palm, rubber and paddy. Theoretically, water stress could negatively influence performance of crops. The relationship between rainfall and yield was almost always positive unless there were occurrences of severe rainfall resulting in flooding and damage to crops. Therefore, it follows that the higher the rainfall the higher the yield. As the rainfall graph indicates, there appeared to be very little positive relationship between rainfall and yield over the period of 1980 to 1999. For oil palm, they were many cases where the average yield moved in the opposite direction with mean annual rainfall.

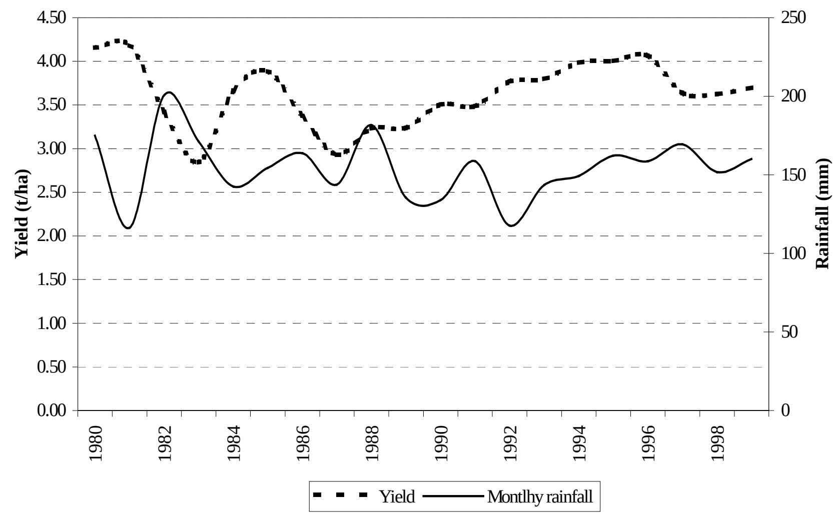
This situation was clear during the El Nino years of 1991 and 1992 where even as rainfall dropped from 158.7 mm to 117.6 mm, yield actually increased from 3.0 tons per hectare to 3.2 tons per hectare. Even if we assumed a lagged period of 1 to 2 years before the drought could affect the yield of the palms, yield levels remained stable in the subsequent two years. For paddy, the contrast was more obvious during the 1991/1992 period. While rainfall decreased by almost 26 per cent, yield of paddy increased from 3.5 tons per hectare to 3.8 tons per hectare (Figure 4.2). The case was also similar for rubber (Figure 4.3). These observed relationships were different when national data was used in the study by Tawang *et al*. (2002), where observed relationships showed discernable positive patterns between crop performance and rainfall.

Figure 4.1 Yield of oil palm and the rainfall pattern in Kedah and Perlis, 1980-1999



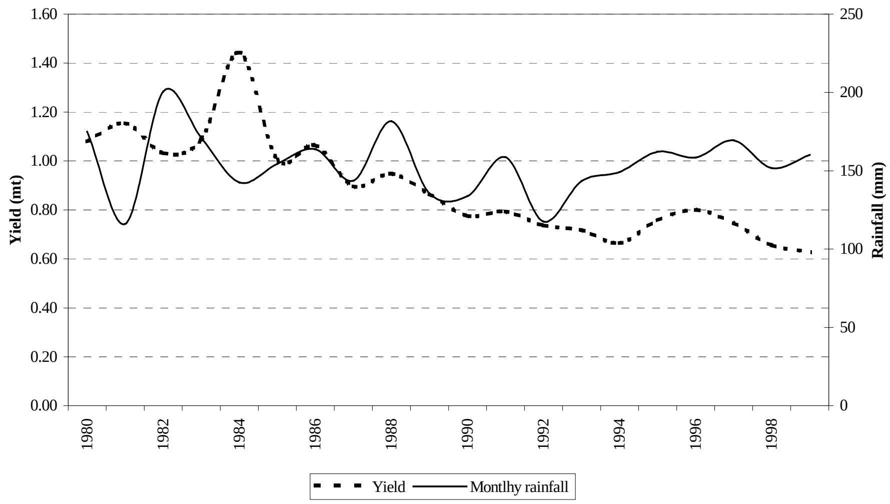
Source: Author's calculation.

Figure 4.2 Yield of paddy and the rainfall pattern in Kedah and Perlis, 1980-1999



Source: Author's calculation.

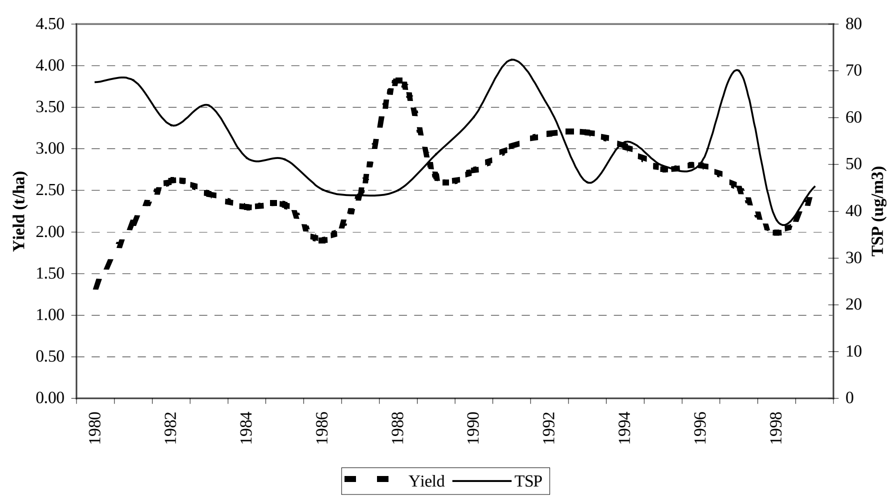
Figure 4.3 Yield of rubber and the rainfall pattern in Kedah and Perlis, 1980-1999



Source: Author's calculation.

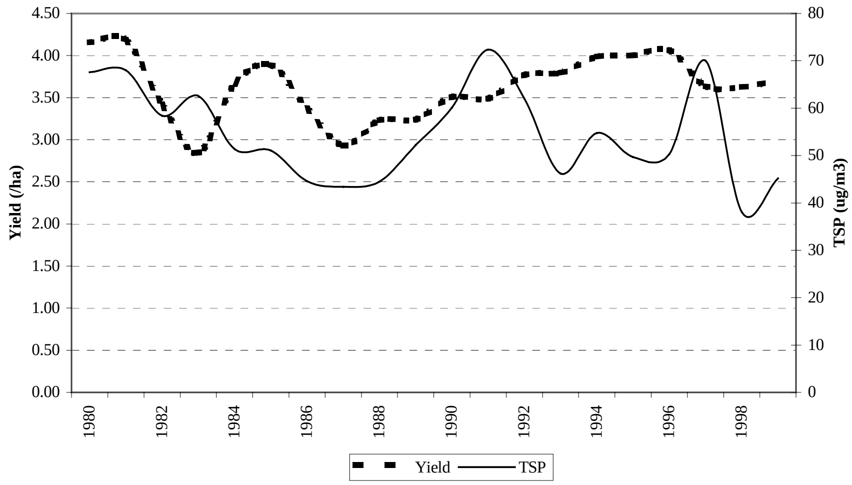
The relationships between total suspended particulate (TSP) and the yield performance of crops are shown in Figures 4.4 to 4.6. For oil palm, there appeared to be a negative relationship between yield and TSP. Generally, yield was higher when the TSP was low and vice-versa. This is consistent with the hypothesis that a higher TSP would result in lower yields due to the "disturbance" to the photosynthesis process from the suspended particles. However, the situation cannot be said for rubber and paddy where yields appeared higher during times of higher TSP and lower during times of lower TSP. (Figure 4.4 and 4.6).

Figure 4.4 Yield of oil palm and the TSP pattern in Kedah and Perlis, 1980-1999



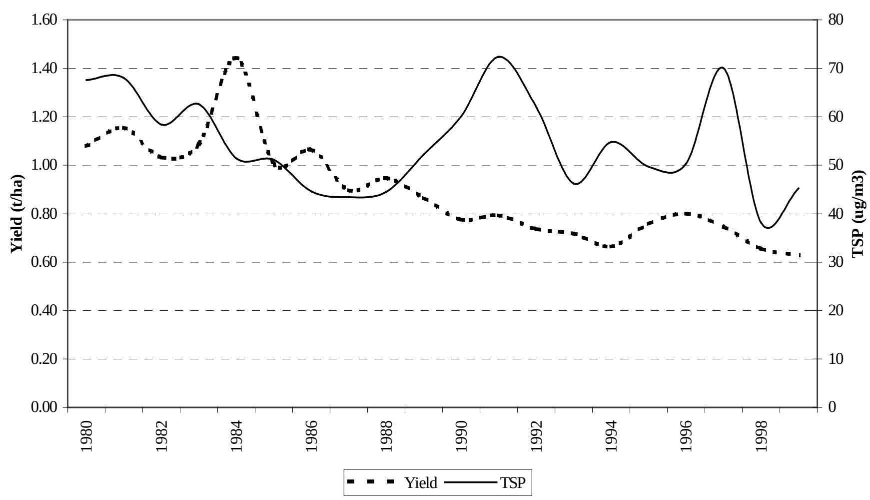
Source: Author's calculation.

Figure 4.5 Yield of paddy and the TSP pattern in Kedah and Perlis, 1980-1999



Source: Author's calculation.

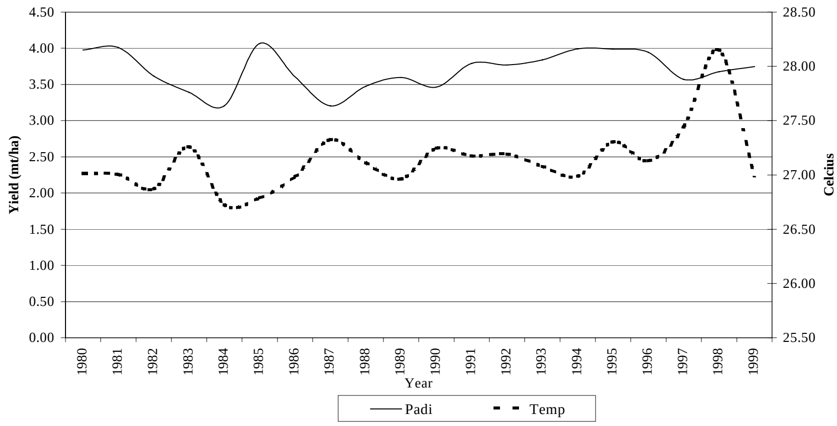
Figure 4.6 Yield of rubber and the TSP pattern in Kedah and Perlis, 1980-1999



Source: Author's calculation.

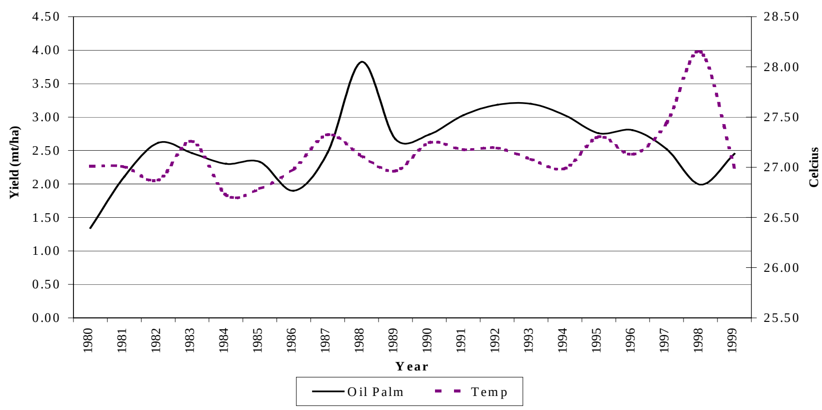
The patterns of association between temperature and yield of oil palm, rubber and paddy are shown in Figure 4.7 to 4.9. The figures show that there was no apparent relationship that could be concluded between temperature patterns and yields of paddy and rubber. There were periods when high temperatures with high yields were observed while there were also periods where yield declined with high temperatures. On the other hand, there seems to be some pattern of positive relationship between temperature and yields of oil palm. Observations in years with higher temperatures, in many cases, also registered higher yields. However, this was not the case for all the observations in the time series. It was the case that high temperatures could be associated with sunny days, thereby, increasing photosynthetic time and intensity that could lead to higher yields. Quantitative evidence of this relationship is further explored in subsequent sections.

Figure 4.7 Yield of paddy and mean annual temperature patterns in Kedah and Perlis, 1980-1999



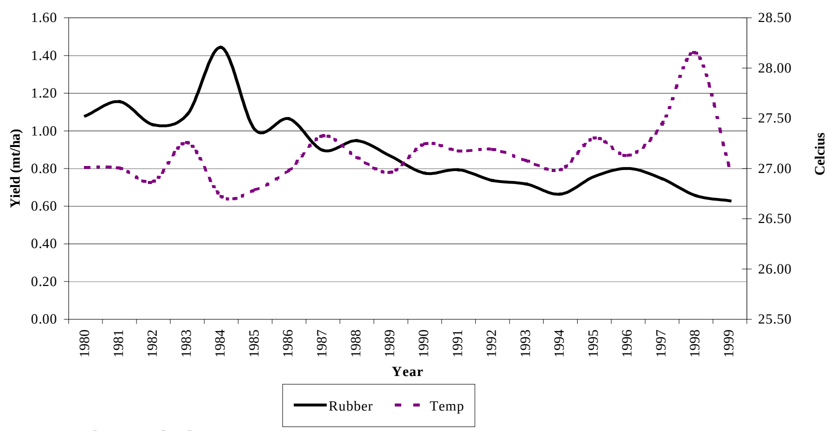
Source: Author's calculation.

Figure 4.8 Yield of oil palm and mean annual temperature patterns in Kedah and Perlis, 1980-1999



Source: Author's calculation.

Figure 4.9 Yield of rubber and mean annual temperature patterns in Kedah and Perlis, 1980-1999



Source: Author's calculation.

4.2.2 El Nino and non-El Nino years weather indicators

Tables 4.1, 4.2, 4.3 and 4.4 provide indicators of rainfall, TSP, temperature and sunshine hours for the period under study. The left column provides the observations for non-El Nino years (NEY) while the right column shows observations for El Nino years (EY). In Table 4.1 it can be seen that the difference in mean annual rainfall for the non-El Nino years was not significant This was in contrast with the El Nino phenomenon which was associated with dry spells and lower rainfall. It might be the case that there were distinct dry months in EY with very low rainfall but subsequently higher rainfall in the remaining months of the year to offset the periods of low rainfall. This being the situation, it is unlikely that the use of annual data could capture the effects of the El Nino phenomena. Unfortunately, monthly data on crop performance was not available and as such, analyses could only be carried out using annual data series. Under these constraints, the quantitative estimates need to be interpreted with caution as annual estimates of impacts might not reflect the actual effects of the El Nino phenomena per se. Nevertheless, the quantitative estimates of the effects could still be attributed to weather variability, though not necessarily of the El Nino.

Table 4.1 Mean monthly rainfall during El Nino and non-El Nino years in the Kedah-Perlis region, 1980-1999

Non-El Nino years		El Nino years	
Year	Mean rainfall	Year	Mean rainfall
1980	174.9	1982	200.7
1981	116.2	1983	171.2
1984	142.6	1991	158.7
1985	154.5	1992	117.6
1986	163.8	1997	169.4
1987	143.8	1998	151.7
1988	181.6		
1989	135.6		
1990	133.9		
1993	143.5		
1994	149.3		
1995	162.2		
1996	158.6		
1999	160.1		
Mean NEY	151.47	Mean EY	161.55

Source: Author's calculation.

Table 4.2 Mean TSP during El Nino and non-El Nino years in the Kedah-Perlis region, 1980-1999

Non-El Nino years		El Nino years	
Year	TSP (ug/m^3)	Year	TSP (ug/m^3)
1980	67.6	1982	58.4
1981	68.0	1983	62.6
1984	51.4	1991	72.4
1985	51.1	1992	62.0
1986	44.6	1997	70.0
1987	43.4	1998	38.1
1988	44.5		
1989	52.2		
1990	60.1		
1993	46.2		
1994	54.8		
1995	49.7		
1996	50.3		
1999	45.2		
Mean NEY	52.08	Mean EY	60.58

Source: Author's calculation.

In contrast to annual rainfall means which show no significant difference between NEY and EY, TSP means show otherwise. The average of TSP readings for EY were much higher compared to NEY (Table 4.2). The difference between the means for both periods was 8.5. The mean for EY was therefore more than 15 per cent higher than NEY. Hence, differences in TSP readings between the EY and NEY were significant. Under these conditions, yield performance of crops as a result of influence by TSP, if any, could be captured by analysing the annual data series.

There were also observed differences for the average mean annual temperatures during EY and NEY. The average for EY was 27.37°C while that of NEY was lower at 27.04°C. This was in accordance with the original hypothesis that temperatures during EY were higher compared to that of NEY. However, though there was an observed difference, the difference was rather small. Nevertheless, certain crops are known to be very temperature sensitive which could influence performance from small changes in temperature.

Table 4.3 Mean annual temperature during El Nino and non-El Nino years in the Kedah-Perlis region, 1980-1999

NEY		EY	
Year	Temperature °C	Year	Temperature °C
1980	27.0	1982	26.9
1981	27.0	1983	27.3
1984	26.7	1991	27.2
1985	26.8	1992	27.2
1986	27.0	1997	27.4
1987	27.3	1998	28.2
1988	27.1		
1989	27.0		
1990	27.2		
1993	27.1		
1994	27.0		
1995	27.3		
1996	27.1		
1999	27.0		
Mean NEY	27.04	Mean EY	27.37

Source: Author's calculation.

There was also a slight difference in the average annual mean of daily sunshine hours between EY and NEY with the EY recording an average daily mean of sunshine hours of 7.06 hours while that of the NEY was 7.02 hours. Again, as was the case for temperature, the difference was rather small but nevertheless some crops can be sensitive to small changes in sunlight hours.

Table 4.4 Mean annual sunshine hours during El Nino and non-El Nino years in the Kedah-Perlis region, 1980-1999

NEY		EY	
Year	Sunshine (hours/day)	Year	Sunshine (hours/day)
1980	6.8	1982	7.1
1981	7.3	1983	7.0
1984	6.5	1991	6.9
1985	7.0	1992	7.1
1986	7.2	1997	7.1
1987	7.3	1998	7.2
1988	7.0		
1989	7.5		
1990	7.4		
1993	7.1		
1994	7.0		
1995	6.9		
1996	6.7		
1999	6.6		
Mean NEY	7.02	Mean EY	7.06

Source: Author's calculation.

4.3 Oil palm

To estimate the damage brought about by El Nino, the quantitative effects of weather variability on yields of oil palm are shown in Table 4.5. For the case of oil palm, the effects of El Nino are assumed to only impact yield one year after of the El Nino episode. Results from the table indicate that total loss as a result of weather variability amounted to an average of more than 14 per cent per year. The maximum yield loss as a result of this could be as high as over 50 per cent. Estimated losses throughout the period were RM 280 million.

To isolate the effects of El Nino from other weather-related variability, the average losses during EY were subtracted from the average losses from NEY. Results show that mean losses during EY for the 1980 to 1999 period were 10.0 per cent. However, mean losses for the NEY were higher at 16.02 per cent. This was suprising since the evaluation by Tawang *et al*. (2002) found that net losses from El Nino were about 7.5 per cent. Being an area where the intensity of El Nino was supposed to be the highest, the negative affects were expected to be more than the national level. It can be rationalized that since measurable weather variables of the El Nino phenomena could not be distinguished during EY and NEY as indicated in the preceding section, it would most likely be that the effects of El Nino per se cannot be isolated from losses resulting from other weather phenomena. However, estimates of losses due to weather variability of the El Nino of 1997-1998 alone were RM 113.2 million (Table 4.6).

Table 4.5 Estimated loss of oil palm yield due to weather variability in the Kedah-Perlis region, 1980-1999

Year	Yield (t/ha)	Five year moving maximum (t/ha)	Difference	% loss
1980	1.343	-	-	-
1981	2.110	2.615	0.505	19.31
1982	2.615	2.615	-	0.00
1983	2.460	2.615	0.155	EY 5.93
1984	2.301	2.615	0.314	EY 12.01
1985	2.329	2.471	0.142	5.75
1986	1.899	3.824	1.925	50.34
1987	2.471	3.824	1.353	35.38
1988	3.824	3.824	-	-
1989	2.670	3.824	1.154	30.18
1990	2.740	3.824	1.084	28.35
1991	3.027	3.198	0.171	5.35
1992	3.183	3.198	0.015	EY 0.47
1993	3.198	3.198	-	EY 0.00
1994	3.026	3.198	0.172	5.38
1995	2.757	3.198	0.44	13.76
1996	2.803	3.026	0.223	4.4
1997	2.519	2.803	0.284	10.1
1998	1.990	2.803	0.813	EY 29.01
1999	2.449	2.803	0.354	EY 12.63
Mean loss due to weather variability				14.13
Mean NEY				16.02
Mean EY				10.00
Net El Nino effect				(6.02)

Note: EY denotes El Nino affected years.
Source: Author’s calculation.

Table 4.6 Estimated loss of oil palm due to weather variability, 1980-1999

Year	Estimated % loss	Production	Potential production	Difference	Price per (RM/t)	Loss (RM)
1981	19.31	22,707	28,141.03	5,434	964	5,238,408.38
1982	0	30,658	30,658	0	829	0
1983	5.93	30,461	32,381.21	1,924	991	1,902,923.64
1984	12.01	31,705	36,032.5	4,328	1,407.5	6,090,961.45
1985	5.75	36,393	38,613.26	2,220	1,045.5	2,321,284.55
1986	50.34	36,230	72,956.1	36,726	578.5	21,246,049.7
1987	35.38	50,954	78,851.75	27,898	773	21,564,959.7
1988	0	86,142	86,142	0	1,029	0
1989	30.18	79,029	113,189.6	34,161	822	28,080,038.3
1990	28.35	80,282	112,047.5	31,765	700.5	22,251,699.8
1991	5.35	91,271	96,430.01	5,159	836.5	4,315,507.92
1992	0.47	101,424	101,902.9	479	916.5	438,952.026
1993	0	106,474	106,474	0	890	0
1994	5.38	102,817	108,663.1	5,846	1,283.5	7,503,435.14
1995	13.76	102,473	118,823.1	16,350	1,472.5	24,075,451.5
1996	4.4	110,890	115,993.7	5,104	1,191.5	6,081,086.97
1997	10.1	104,872	116,654.1	11,782	1,358	16,000,037.6
1998	29.01	90,209	127,074.8	36,864	2,337.5	86,169,196
1999	12.63	128,701	147,305.7	18,605	1,448.9	26,956,366.3
					Total loss	280,236,359

Source: Author's calculation.

4.4 Rubber

As with oil palm, the same analysis was conducted for rubber. Rubber performance varies substantially due to weather variability and could affect yields up to more than 30 per cent. However, the variability was not as wide as for oil palm and the mean loss for the period was almost similar to that of oil palm i.e. at 14.87 per cent (Table 4.7). Total loss was estimated to be 734,356 tons with a current value of RM 858.7 million (Table 4.8). Isolating the effects of other weather variability from El Nino showed that the net loss from El Nino was only about 2.0 per cent. This again, as in the case of oil palm, showed that the El Nino phenomena did not significantly affect yield performance of rubber in the region of Kedah-Perlis.

Table 4.7 Estimated loss of rubber yield in the Kedah-Perlis region due to weather variability

Year	Yield (t/ha)	Five year moving maximum (t/ha)	Difference	% loss
1980	1.079	-	-	-
1981	1.154	1.443	0.289	20.00
1982	1.032	1.443	0.411	[EY]28.48
1983	1.088	1.443	0.355	[EY]24.60
1984	1.443	-	-	0.00
1985	1.006	1.443	0.437	30.28
1986	1.064	1.443	0.379	26.26
1987	0.897	1.064	0.167	15.70
1988	0.947	1.064	0.117	11.00
1989	0.865	0.947	0.082	8.66
1990	0.775	0.947	0.172	18.16
1991	0.793	0.865	0.072	[EY]8.32
1992	0.737	0.793	0.056	[EY]7.06
1993	0.717	0.793	0.076	9.58
1994	0.664	0.800	0.136	17.00
1995	0.758	0.800	0.042	5.25
1996	0.800	0.800	-	-
1997	0.746	0.800	0.054	[EY]6.76
1998	0.656	0.800	0.144	[EY]18.00
1999	0.628	0.172	-	27.38
Mean loss due to weather variability				14.87
Mean NEY				13.49
Mean EY				15.53
Net El Nino effect				2.04

Note: EY denotes El Nino affected years.
Source: Author's calculation.

Table 4.8 Estimated loss of rubber due to weather variability

Year	% loss	Production (tons)	Potential production (tons)	Difference (tons)	Price (RM/t)	Loss (RM)
1980		215,028				
1981	20	230,247	287,808.8	57,561.75	-	-
1982	28.48	214,376	299,742.7	85,366.73	-	-
1983	24.6	230,827	306,136.6	75,309.6	-	-
1984	0	238,450.1	238,450.1	0	-	-
1985	30.28	206,393.5	296,032	89,638.49	1,283.9	115,086,851
1986	26.26	218,619.5	296,473.5	77,853.93	1,467.3	114,235,057
1987	15.7	223,790.6	265,469.3	41,678.68	1,751.4	72,996,034
1988	11	243,830.1	273,966.4	30,136.31	2,119.6	63,876,911
1989	8.66	223,206.5	244,368.8	21,162.34	1,793.5	37,954,660
1990	18.16	202,386.6	247,295.4	44,908.85	1,648.3	74,023,265
1991	8.32	204,606.1	223,174.2	18,568.1	1,706.4	31,684,594
1992	7.06	187,147.3	201,363.6	14,216.27	1,629.42	23,164,271
1993	9.58	189,867.9	209,984.5	20,116.51	1,588.3	31,951,047
1994	17	171,126.4	206,176.3	35,049.98	2,089.02	73,220,121
1995	5.25	192,214.9	202,865.4	10,650.43	2,735.46	29,133,825
1996	0	200,011.2	200,011.2	0	2,484.78	0
1997	6.76	191,518	205,403.3	13,885.26	1,940.4	26,942,959
1998	18	168,859	205,925.6	37,066.61	1,860.72	68,970,582
1999	27.4	162,121.9	223,308.4	61,186.49	1,559.76	95,436,259
					Total loss	858,676,435

Source: Author's calculation.

4.5 Paddy

As with the previous two crops, an analysis was also conducted for paddy yields in the Kedah-Perlis region. The results are exhibited in Table 4.9. The results indicate that the impacts of El Nino on paddy were more obvious. Total mean loss due to weather variability was 8.45 per cent, lower than that of oil palm and rubber. Total loss of production due to weather variability was estimated at 1.59 million tons during the period, averaging 83,743 tons per year (Table 4.10) valued at RM 814 million. Being a crop which is more water dependent, the lack of water during critical growth periods during the EY had obviously negative impacts on yield levels. The percentage losses were markedly higher for the EY compared to the NEY. Net losses as a result of El Nino were estimated to be about 7 per cent. The total loss in value terms due to the occurrence of El Nino episodes between 1980-1999 was RM 237.8 million (Table 4.11).

Table 4.9 Estimated loss of paddy yield in the Kedah-Perlis region due to weather variability

Year	Field (t/ha)	Five year moving maximum (t/ha)	Difference	% loss
1980	4.158	-	-	-
1981	4.184	4.184	-	0.00
1982	3.419	4.184	0.765	[EY]18.28
1983	2.844	4.184	1.34	[EY]32.03
1984	3.661	3.888	0.227	5.84
1985	3.888	3.888	-	-
1986	3.372	3.888	0.516	13.27
1987	2.932	3.888	0.956	24.59
1988	3.232	3.372	0.146	4.15
1989	3.238	3.506	0.268	7.64
1990	3.506	3.769	0.263	7.00
1991	3.487	3.796	0.282	[EY]7.48
1992	3.769	3.796	0.027	[EY]0.71
1993	3.796	4.003	0.207	5.17
1994	3.985	4.063	0.078	1.92
1995	4.003	4.063	0.060	1.48
1996	4.063	4.063	-	0.00
1997	3.638	4.063	0.425	[EY]10.46
1998	3.626	4.063	0.437	[EY]10.76
1999	3.700	4.063	0.363	9.81
Mean loss due to weather variability				8.45
Mean NEY				6.21
Mean EY				13.29
Net El Nino effect				7.08

Note: EY denotes El Nino affected years.
Source: Author's calculation.

Table 4.10 Estimated loss of paddy due to weather variability

Year	Production (tons)	% loss	Potential production (tons)	Difference (tons)	Price (RM/t)	Loss (RM)
1980	1,066,129	-	-	-	503	-
1981	1,069,706	0	1,069,706	0	n.a	n.a
1982	892,269	18.28	1,091,861	199,592.2	481	96,003,864
1983	645,536	32.03	949,736.6	304,200.6	489	148,754,117
1984	860,826	5.84	914,216.2	53,390.23	500	26,695,114
1985	965,724	0	965,724	0	488	0
1986	845,281	13.27	974,612	129,331	490	63,372,197
1987	736,938	24.59	977,241.7	240,303.7	490	117,748,835
1988	834,153	4.15	870,269.2	36,116.17	500	18,058,085
1989	862,300	7.64	933,629.3	71,329.28	500	35,664,638
1990	929,198	7	999,137.6	69,939.63	500	34,969,817
1991	869,919	7.48	940,249.7	70,330.68	500	35,165,338
1992	919,210	0.71	925,783.1	6,573.06	500	3,286,530
1993	950,972	5.17	1,002,818	51,845.67	500	25,922,837
1994	1,034,629	1.92	1,054,883	20,253.75	500	10,126,874
1995	1,035,698	1.48	1,051,257	15,558.6	536	8,339,408
1996	1,065,557	0	1,065,557	0	536	0
1997	941,658	10.46	1,051,662	110,003.8	536	58,962,051
1998	904,912	10.76	1,014,021	109,108.6	615	67,101,800
1999	949,150	9.81	1,052,389	103,239.4	618	63,801,949
					Total loss	813,973,457

Source: Author's calculation.

Table 4.11 Estimated net loss for paddy in the Kedah-Perlis region due to El Nino

Year	Estimated net loss (per cent)	Production ('000 tons)	Estimated production without El Nino (tons)	Difference ('000 tons)	Price/ton (RM/ton)	Loss (RM million)
1982	12.07	892	1,014	122	481	58.7
1983	25.82	646	871	255	489	124.7
1991	1.27	870	881	11	500	5.5
1992	(n.a)	919	(n.a)	(n.a)	500	-
1997	4.25	942	984	42	536	22.5
1998	4.55	905	948	3	615	26.5
					Total loss	237.8

n.a = not applicable.
Source: Author's calculation.

4.6 Tobacco

Table 4.12 shows the analysis for estimating the loss to tobacco yields due to variability in weather conditions. The difference due to this variability reached as high as 42.4 per cent. Mean loss was calculated at about 16.5 per cent. However, as the results show, there was very little indication of the negative effects of the El Nino on tobacco yields. Average yield loss during NEY was 19.02 per cent, while during EY the loss was significantly lower at 11.07 per cent (Table 4.12). As such, it can be safely concluded that the El Nino phenomenon was not a factor in influencing tobacco yields and that other weather and non-weather related factors were more important in influencing the yield level of tobacco.

These results were somewhat expected. Since most tobacco farmers practice irrigation in the cultivation of tobacco, any water deficiencies resulting from El Nino can easily be corrected. On the contrary, dry weather can have positive effects on the tobacco crop. Excess rainfall and water can result in green tobacco leaves that have less dry matter content. As a result, when these green leaves are cured, they not only weigh less, which leads to lower yields, but they are also of lower quality compared to cured leaves derived from green leaves with lesser water content. On the other hand, with less rainfall, the water content in green tobacco leaves is less and thus, when cured it results in a higher weight of cured leaves and also would most likely be of higher quality compared to the leaves with a higher moisture content.

Table 4.12 Estimated loss to tobacco yield in the Kedah-Perlis region due to weather variability

Year	Field (kg/ha)	Five year moving maximum (kg/ha)	Difference (kg/ha)	% loss
1980	700.5	-		
1981	578.4	1,004.3	425.9	42.4
1982	685.8	1,004.3	318.5	EY31.7
1983	1,004.3	1,004.3	0.0	EY0.0
1984	779.5	1,004.3	224.8	22.4
1985	864.8	1,004.3	139.5	13.9
1986	720.7	864.8	144.1	16.6
1987	658.1	1,172.4	514.3	43.9
1988	765.4	1,214.4	449.0	37.0
1989	1,172.4	1,214.4	42.0	3.5
1990	1,214.4	1,214.4	0.0	0.0
1991	1,116.8	1,214.4	97.6	EY8.0
1992	1,078.9	1,214.4	135.5	EY11.2
1993	1,158.4	1,214.4	0.0	0.0
1994	890.6	1,158.4	267.8	23.1
1995	975.0	1,158.4	183.4	15.8
1996	861.1	975.8	114.7	11.8
1997	897.3	975.8	78.5	EY8.0
1998	901.8	975.8	74.0	EY7.5
Mean loss due to weather variability				16.49
Mean loss during EY				11.07
Mean loss during NEY				19.20
Net loss due to El Nino				(8.13)

Note: EY denotes El Nino affected years.
Source: Author's calculation.

4.7 Other crops

The other crops and commodities that are included in the analyses are sugarcane, fruits and vegetables, livestock and fisheries. For many of the commodities mentioned, there is no regional production data to enable more accurate analyses of the impacts of El Nino on yield performance. In such cases, analyses on the variables that served as proxies to them were conducted. For example, in the case of fruits and vegetables, apart from the analysis on area data, analyses were also conducted on trade and price data. This was based on the rationale that if El Nino negatively influenced yields and production then total supply would fall driving prices up. Thus, during El Nino years, it is expected that annual prices of fruits and vegetables would be higher relative to that of normal years. Similarly, a shortfall in domestic supply due to the negative impacts of El Nino would lead to an increase in imports to bridge the gap between domestic demand and supply.

4.7.1 Sugarcane

For the analysis of losses to sugarcane production for the region, national data on production and yields was used. Considering that almost all of the sugar in Malaysia originates from this northwest region, the results of the analysis on national data would actually reflect the impacts on the region.

The losses due to weather variability and due to El Nino were estimated in Table 4.13. While yield losses due to weather variability estimated thus far were quite high, ranging from almost 17 per cent for tobacco to about 9 per cent for paddy, the average yield loss resulting from climatic variability for sugarcane was only 5 per cent. Calculations of mean loss of sugarcane yields during NEY and EY were at 5.0 and 6.3 per cent respectively, indicating the net loss resulting from El Nino was only 1.3 per cent. The analysis showed that El Nino had almost no effect on sugarcane yields. Technically, as the case study in the next chapter will prove, dry periods can actually be better for sugarcane. Although cane yield might decline with dry weather, sugar concentration in the canes, in reality, might be higher compared to canes grown under wet conditions.

Table 4.13 Estimated loss of sugarcane due to weather variability

Year	Yield (t/ha)	Five year moving maximum	Difference	% loss
1980	400	-		
1981	400	500	100	20.0
1982	500	500	-	-[EY]
1983	500	500	-	-[EY]
1984	500	530	30	5.7
1985	491	592	101	17.1
1986	530	592	62	10.5
1987	592	597	5	0.8
1988	544	603	-	-
1989	597	603	6	1.0
1990	603	603	-	-
1991	541	680	139	20.4[EY]
1992	561	680	119	17.5 [EY]
1993	680	680	-	-
1994	680	681	1	0.1
1995	680	681	1	0.1
1996	681	681	-	-
1997	681	681	-	-
1998	681	681	-	- [EY]
1999	681	681	-	- [EY]
2000	681			
Mean loss due to weather variability				5.4
Mean loss during non-El Nino years				5.0
Mean loss during EY				6.3
Net El Nino effect				1.3

Source: FAOSTATS.

4.7.2 Fruits and vegetables

Fruits

There is no regional production data for fruits and vegetables and as such, analyses conducted for fruits and vegetables focused on changes in area, price and also trade figures. For annuals, area data can to some extent reflect the affects of weather and climate. In view of the fact that annuals are short-term crops, their planted areas are not ‘locked-in’ and hence, annual changes can take place based on weather conditions and the production decision of farmers.

Table 4.14 shows the hectarage of major fruits in the region consisting of oranges, rambutan, duku, mangoesteen, banana, pineapple, watermelon, durian and mango.

Table 4.14 Area under selected fruits in the northwest region of Peninsular Malaysia, 1980-1999 **Unit : hectare**

Year	Oranges			Rambutan			Duku			Mangosteen		
	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total
1980	536	n.a	**536**	3,160	n.a	**3,160**	250	n.a	**250**	277	n.a	**277**
1981	524	n.a	**524**	3,105	n.a	**3,105**	250	n.a	**250**	272	n.a	**272**
1982	548	n.a	[EY]**548**	3,293	n.a	**3,293**	253	n.a	[EY]**253**	262	n.a	**262**
1983	570	n.a	[EY]**570**	3,616	n.a	**3,616**	249	n.a	[EY]**249**	270	n.a	**270**
1984	326	n.a	**326**	2,861	2.0	**2,863**	153	n.a	**153**	221	n.a	**221**
1985	335	n.a	**335**	2,871	5.0	**2,876**	144	n.a	**144**	225	n.a	**225**
1986	251	n.a	**251**	2,387	2.0	**2,389**	235	n.a	**235**	236	n.a	**236**
1987	271	16.0	**287**	2,521	4.0	**2,525**	361	n.a	**361**	279	n.a	**279**
1988	258	n.a	**258**	2,430	6.0	**2,436**	543	n.a	**543**	446	1.0	**447**
1989	327	10.0	**337**	2,849	30.0	**2,879**	712	n.a	**712**	496	15.0	**511**
1990	389	10.0	**399**	3,092	28.0	**3,120**	753	n.a	**753**	507	15.0	**522**
1991	461	10.0	[EY]**471**	3,233	22.0	[EY]**3,255**	802	n.a	[EY]**802**	527	15.0	**542**
1992	518	10.0	[EY]**528**	3,401	22.0	[EY]**3,423**	917	n.a	[EY]**917**	524	15.0	**539**
1993	535	10.0	**545**	3,514	36.0	**3,550**	1,022	n.a	**1,022**	524	16.0	**540**
1994	357	21.0	**378**	1,615	31.1	**1,646**	1,067	n.a	**1,067**	587	2.8	**590**
1995	378	19.0	**397**	1,739	31.1	**1,770**	1,187	n.a	**1,187**	604	2.8	**607**
1996	456	21.0	**477**	1,804	31.1	**1,835**	1,225	n.a	**1,225**	615	2.8	**618**
1997	669	22.0	[EY]**691**	1,843	31.3	[EY]**1,874**	1,289	n.a	[EY]**1,289**	638	2.8	**641**
1998	790	25.0	[EY]**815**	2,062	31.0	[EY]**2,093**	1,350	n.a	[EY]**1,350**	635	3.0	**638**
1999	849	64.0	**913**	2,115	45.0	**2,160**	1,047	n.a	**1,047**	648	5.0	**653**

EY = El Nino year.
Source: Department of Agriculture, Kedah-Perlis.

Continued ……………

Table 4.14 Area under selected fruits in the northwest region of Peninsular Malaysia, 1980-1999 (Continued) **Unit : hectare**

Year	Banana			Pineapple			Watermelon			Durian			Mangoes		
	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total
1980	970		**970**	46		**46**	50		**50**	3,698		**3,698**			
1981	530		**530**	24		**24**	76		**76**	3,495		**3,495**			
1982	599		**EY599**	24		**EY24**	82		**EY82**	3,733		**3,733**			
1983	680		**EY680**	22		**EY22**	231		**EY231**	3,788		**3,788**			
1984	944		**944**	59		**59**	102	40.0	**142**	3,007	10	**3,017**	911	202	**1,113**
1985	853	13	**866**	37		**37**	170	44.0	**214**	3,068	15	**3,083**	925	337	**1,262**
1986	1,095	9	**1,104**	32		**32**	301	16.0	**317**	2,456	21	**2,477**	753	291	**1,044**
1987	1,192	8	**1,200**	63		**63**	302	3.0	**305**	2,426	23	**2,449**	692	1,104	**1,796**
1988	2,065	7	**2,072**	58		**58**	307	61.0	**368**	3,332	40	**3,372**	575	1,210	**1,785**
1989	2,424	34	**2,458**	78	2.0	**80**	313	71.0	**384**	4,068	42	**4,110**	896	1,487	**2,383**
1990	2,920	34	**2,954**	85	2.0	**87**	639	75.0	**714**	4,381	37	**4,418**	915	1,667	**2,582**
1991	3,138	38	**EY3176**	87	2.0	**EY89**	1,021	141.0	**EY1,162**	4,663	38	**4,701**	919	1,500	**2,419**
1992	3,189	38	**EY3,227**	96	2.0	**EY98**	1,379	142.0	**EY1,521**	4,735	83	**4,818**	933	1,525	**2,458**
1993	3,501	101	**3,602**	115		**115**	1,437	143.0	**1,580**	5,207	42	**5,249**	924	1,588	**2,512**
1994	2,889	134	**3,023**	15		**15**	639	5.0	**644**	4,186	42	**4,228**	934	831	**1,765**
1995	3,088	135	**3,223**	10	3.0	**13**	761	33.0	**794**	4,416	42	**4,458**	1,295	875	**2,170**
1996	2,082	139	**2,221**	60	4.0	**64**	642	19.0	**661**	4,756	43	**4,799**	1,288	943	**2,231**
1997	2,085	142	**EY2,227**	110	4.0	**EY114**	744	50.2	**EY794**	4,956	52	**5,008**	1,286	1,096	**2,382**
1998	1,811	117	**EY1,928**	143		**EY143**	528	21.0	**EY549**	4,854	52	**4,906**	1,228	1,0,96	**2,324**
1999	1,783	117	**1,900**	143	1.0	**144**	471	101.0	**572**	5,154	83	**5,237**	1,534	1,161	**2,695**

EY = El Nino year.
Source: Department of Agriculture, Kedah-Perlis.

Most of these fruits are perennials and as such changes in area data cannot be associated with weather impacts. The annual fruit crops were only banana, pineapple and watermelon. In general, hectarage of all fruit types inducing both perennials and annuals showed an increasing trend. This was mainly due to increasing demand for fruits in Malaysia and in export markets and also due to the government's policy that encouraged fruit production.

As was mentioned earlier, there were no 'abnormal" area changes among the perennial fruits during the El Nino years as compared to the normal years. This observation was also true for the annual fruits where possible 'abnormal' changes in area could take place due to adverse weather conditions such as the El Nino. On the contrary, for watermelon, two of the highest total areas recorded in the time-series data analysed were both during El Nino years (in 1991 and 1992 at 162 and 1,521 hectares respectively). Again, as in the case of tobacco, it can be argued that water deficiencies can be corrected by farmers through irrigation and watering. Higher hectarage of watermelon during the El Nino years, on the other hand, could be due to the supply response to higher demand during these years of high temperatures, where the fruit is popularly served as a thirst-quencher. Hence, the interplay of market forces during El Nino periods could turn out favorably for the watermelon farmer.

Vegetables

Table 4.15 shows the area under selected vegetables in the northwest region of Peninsular Malaysia. As for fruits, the total hectarage of vegetables has also increased over the years in response to higher demand and favorable policies by the government. As with the fruit data, the vegetable area's data also did not show any significant and visibly distinct changes in area for any vegetable types. The changes in area are more likely due to market factors rather than climatic factors. Being annuals, if indeed El Nino had negative effects, it would have been reflected in the area data. Even the 'more water-sensitive' vegetable types such as spinach, watercress and brassica did not show any abnormal changes in area that could be associated with El Nino. In fact, during the most severe El Nino in 1997 and 1998, these crops registered the highest hectarage for the 1980-1999 period. Analysis of price and trade also revealed no irregular behavior in price movement and trade for vegetables during the El Nino years, indicating no 'supply-shocks' that are associated with El Nino. Hence, at the regional level, it can safely be concluded that El Nino did not affect vegetable cultivation.

Table 4.15 Area under selected vegetables in the northwest region of Peninsular Malaysia, 1980-1999 **Unit : hectare**

Year	Spinach			Watercress			Cabbage			Cucumber			Brassica			Long-Gourd			Brinjal			Long beans		
	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total	Kedah	Perlis	Total
1980	15	n.a	15	15	n.a	15	10	n.a	10	4	n.a	4	12	n.a	12	4	n.a	4	5	n.a	5	n.a	n.a	-
1981	11	n.a	11	10	n.a	10	n.a	n.a	-	11	n.a	11	10	n.a	10	3	n.a	3	4	n.a	4	n.a	n.a	-
1982	16	n.a	^{EY}16	17	n.a	^{EY}17	1	n.a	^{EY}1	11	n.a	^{EY}11	13	n.a	^{EY}13	7	n.a	^{EY}7	6	n.a	^{EY}6	n.a	n.a	-
1983	12	n.a	^{EY}12	14	n.a	^{EY}14	5	n.a	^{EY}5	26	n.a	^{EY}26	29	n.a	^{EY}29	10	n.a	^{EY}10	11	n.a	^{EY}11	n.a	n.a	-
1984	16	30	46	24	30	54	8	4	12	48	30	78	19	45	64	11	16	27	20	24	44	30	60	90
1985	32	26	58	37	25	62	12	3	15	49	13	62	24	40	64	29	6	35	21	10	31	n.a	na	-
1986	7	3	10	14	1	15	10	1	11	109	6	115	32	1	33	35	n.a	35	66	3	69	145	6	151
1987	23	1	24	53	n.a	53	13	na	13	84	14	98	16	n.a	16	26	2	28	32	7	39	88	13	101
1988	23	1	24	20	1	21	na	na	-	104	37	141	34	n.a	34	5	11	16	34	22	56	176	33	209
1989	39	5	44	52	3	55	16	na	16	229	41	270	40	5	45	18	31	49	101	39	140	244	50	294
1990	6	n.a	6	26	2	28	1	11	12	227	25	252	43	n.a	43	17	11	28	108	13	121	293	30	323
1991	10	3	^{EY}13	31	7	^{EY}38	n.a	61	^{EY}61	228	26	^{EY}254	53	n.a	^{EY}53	12	5	^{EY}17	151	16	167	^{EY}332	23	23
1992	16	2	^{EY}18	69	8	^{EY}77	4	34	^{EY}38	265	14	^{EY}279	56	n.a	^{EY}56	21	8	^{EY}29	125	9	134	^{EY}366	19	19
1993	13	4	17	63	6	69	4	4	8	343	21	364	74	n.a	74	45	14	59	141	14	155	400	28	428
1994	12	7	19	48	na	48	11	4	15	277	16	293	85	1	86	26	8	34	105	7	112	323	10	333
1995	21	5	26	65	2	67	17	3	20	287	21	308	122	8	130	36	11	47	84	21	105	274	17	291
1996	15	3	18	45	4	49	2	1	3	259	36	295	72	6	78	17	21	38	81	13	94	277	39	316
1997	45	13	^{EY}58	101	8	^{EY}109	5	1	^{EY}61	275	45	^{EY}320	92	18	^{EY}110	61	21	^{EY}82	121	25	146	^{EY}270	61	^{EY}331
1998	59	9	^{EY}68	92	n.a	^{EY}92	31	1	^{EY}32	187	35	^{EY}222	46	16	^{EY}62	34	10	^{EY}44	85	16	101	^{EY}200	28	^{EY}228
1999	61	7	68	100	n.a	100	28	6	34	190	82	272	48	15	63	38	6	44	82	82	164	170	12	182

EY = El Nino year.
Source: Department of Agriculture, Kedah-Perlis.

4.8 Livestock

As was rationalized in the national study on El Nino by Tawang *et al.* (2002), technically, dry periods would not have any direct affects on the performance of livestock. However, a number of analyses argue that the formation of haze as a result of prolonged dry periods, which led to low air quality, could cause respiratory problems in livestock, thus increasing mortality rates, especially among the more vulnerable small and young livestock, such as starter poultry. The study at the national level found no evidence of negative effects of El Nino on the production of livestock products. This includes poultry, beef, mutton, pork, milk and poultry eggs. Unfortunately, production data at the regional level is not available for these poultry products to enable similar analyses. However, livestock population data was available for a number of livestock.

For livestock, an analysis on the poultry population would serve as proxy to represent the whole of the livestock industry. This was based on the assumption that poultry, being a small non-ruminant, would be the most severely affected among the livestock species should there be any real effects of the El Nino on livestock. Other bigger livestock would be more tolerant to El Nino compared to poultry. Table 4.16 shows the time series data for the broiler-poultry population in the northwest region of Peninsular Malaysia for the period of 1980 - 2000 with EY denoting El Nino years.

The total broiler population has increased from a mere 4,500 heads in 1980 to more than 7 million heads in 2000. However, the population on a year-to-year basis is rather erratic in a number of observations. This includes the years of 1982 to 1983 where the population jumped from 36,035 heads to 164,527 heads; 1987 to 1988 where the population increased from about 470,00 heads to more than 780,00 heads; 1992 to 1993, from 536,380 to 2,211,048 and down again to 1,345,750 heads in 1994. The situation was also similar for 1996 to 1997 and 1999 to the year 2000. No plausible explanation could be found for these large variations in the year-to-year population. A probable reason could be the entry and exit of firms in and out of the industry due to failures and new ventures. Another reason could be the relocation of poultry firms to and from the region as the poultry industry consolidates itself towards better economies of scale to increase efficiency resulting from increasing intra-industry competition. Nevertheless, whatever the reasons, no discernable broiler-poultry population patterns could be associated with EY and NEY. Hence, similar to the findings at the national level, the regional level data also found no evidence of the negative effects of El Nino weather phenomena on poultry.

Table 4.16 Total broiler-poultry population in the northwest region of Peninsular Malaysia, 1980-2000

Year	Population ('000 heads)
1980	4.5
1981	3.0
1982	36.1 EY
1983	164.5
1984	41.5
1985	56.4
1986	49.4
1987	41.9
1988	468.4
1989	474.2
1990	784.3
1991	792.8 EY
1992	536.4 EY
1993	2,211.1
1994	1,325.8
1995	1,908.3
1996	3,808.3
1997	5,062.3 EY
1998	5,693.2 EY
1999	5,150.6
2000	7,328.6

Source: Department of Veterinary Services Malaysia.

4.9 Fisheries

It can be argued that fish capture and aquaculture production could be negatively effected by El Nino weather phenomena. In terms of fish captures, fisherman can be constrained by hazy conditions to go to sea, while for aquaculture, unhealthy conditions caused by high atmospheric pollution can also negatively affect aquaculture farmers. However, the study by Tawang *et al*. (2002) also found that there was no evidence that could link El Nino weather phenomena with fish captures and aquaculture performance. Nevertheless, analyses were conducted on the regional level data to investigate whether El Nino could affect fish capture and aquaculture production in the northwest region of Peninsular Malaysia.

Table 4.17 shows total fish landings in the states of Kedah and Perlis and the total for the region. Total fish landings in the time series data reached their peak at 201,711 metric tons in 1982 with a low of 88,015 metric tons in 1991.

Table 4.17 Marine fish landings in the northwest region of Peninsular Malaysia, 1980-2000

Year	Kedah	Perlis	Total
1980	99,500	26,732	126,232
1981	148,028	32,892	180,920
1982	161,418	40,293	EY 201,711
1983	148,072	41,770	EY 189,842
1984	114,993	33,540	148,533
1985	71,250	34,318	105,568
1986	75,992	29,065	105,057
1987	94,091	66,855	160,946
1988	72,775	40,731	113,506
1989	75,615	42,360	117,975
1990	86,408	46,206	132,614
1991	54,888	33,127	EY 88,015
1992	62,555	60,673	EY 123,228
1993	72,733	46,229	118,962
1994	72,633	36,691	109,324
1995	86,780	44,468	131,248
1996	76,269	44,763	121,032
1997	87,864	54,273	EY 142,137
1998	93,360	73,781	EY 167,141
1999	85,228	85,009	170,237
2000	76,735	57,168	133,903

Source: Ministry of Agriculture and Kedah Fisheries Department.

Both these years were El Nino affected years. Based on the observed fish-landing figures over the years, as with the case for livestock, it again cannot be established that El Nino negatively affected fish captures and landings. In fact, the highest records of fish capture were in 1982 and 1983, both of which were El Nino years. Even during the severe El Nino years of 1997 and 1998, fish landings, at 142,137 and 167,141 metric tons respectively were among the highest in the decade.

This simple observation of trend data in fish landings can quash any claims that El Nino could affect fish landings. The regional findings were the same as at the national level where Tawang *et al*. (2002) also could not find any linkages or association between the two variables.

Table 4.18 Loss due to weather variability in fresh water culture

Year	Yield (t/ha)	Five year moving maximum	Difference	% loss
1991	0.410	51.895	-	-
1992	0.395	1.895	1.500	9.16
1993	1.525	1.895	0.370	19.53
1994	1.435	2.050	0.615	30.00
1995	1.895	2.050	0.155	7.50
1996	2.050	2.050	0.0	0.00
1997	1.520	3.85	2.330	EY60.52
1998	1.845	4.505	2.660	EY59.05
1999	3.85	4.505	0.655	14.54
2000	4.505	4.505	-	-
Mean loss due to weather variability				33.79
Mean loss during NEY				14.51
Mean loss during EY				66.24
Net El Nino Effect				51.73

Source: Author's calculation.

Nevertheless, as has been argued, production data alone is not a good indicator to evaluate effects. Yield data would be needed to assess real damage caused by El Nino. Unfortunately yield data on aquaculture production at the regional level is only available from 1991 onwards. The application of the five-year moving maximum method in this case would be limited since less El Nino episodes could be reflected in this series of data. Therefore, the analysis using this method needs to be cautiously interpreted.

Total loss due to weather variability was quite high at almost 34 per cent (Table 4.18). Mean loss of yields during the non-El Nino years was estimated to be about 14.5 per cent while losses for El Nino years were at 66.24 per cent. Thus, the net loss from El Nino was about 52 per cent. This estimate was substantial compared to the estimated losses of the other commodities. The result was in contrast with the national results where there was no evidence of loss from El Nino.

4.10 The yield functions

Initial estimates of the yield functions through Ordinary Least Squares showed that the estimated equations contained auto-correlation and heteroskedasticity biasness. Subsequently, this biasness was corrected using the Newey-West HAC correction procedure. The use of this method substantially improved the statistical performance of the estimated equations in terms of the strength of the explanatory variables, a priori expectations and also significance of the estimated parameters.

4.10.1 Oil palm

Estimations for the oil palm yield function are as followings:

Dependent variable: YPOILt

Variable	Coefficient	Standard error	t-Statistic	Probability
$TEMP_{t-1}$	0.058059	0.085185	0.681566	0.5066
$SHINE_{t-1}$	0.408107	0.269894	1.512102	0.1527
$RAIN_{t-1}$	-0.006954	0.003490	-1.992505	0.0662*
$PART_{t-1}$	-0.006191	0.006498	-2.335751	0.0349**
DUM_{t-1}	-0.008983	0.274152	-0.032766	0.9747
R-SQUARE		0.332421		
ADJUSTED R-SQUARE		0.141684		

* = significant at the 10 per cent probability level.
** = significant at the 5 per cent probability level.

All the parameters of the above estimated equation were consistent with a priori expectations except for the variable rainfall. It was expected that higher rainfall would increase yield and lower rainfall be associated with lower yield. The results showed the opposite. It might be the case that the timing of the rainfall did not coincide with the flowering and the formation of fruit bunches. Heavy rainfall can cause abortion of flowers that can lower yields. Similarly, too heavy a rainfall might cause flooding and water logging in oil palm areas. Although oil palm is known to be tolerant of water, excessive water under the above conditions could negatively affect yields. The quantitative result was not different from the graphical disposition that was described early in the chapter, where it was also shown that rainfall seemed to move in the opposite direction to average yields. The variable, total suspended particulates (PART) was found to be significant at the 5 per cent probability level in affecting yields. The parameter estimate shows that more total suspended particulates negatively affect oil palm yield. This finding is similar to the study at the national level. The estimate also shows that the variable DUM was not significant in indicating that overall there was no difference in yield performance of oil palm during EY and NEY. This finding was consistent with the earlier analysis in estimating the loss in oil palm yields using the five-year moving maximum.

4.10.2 Rubber

The estimated yield function for rubber is as follows:

Dependent variable: YRUBt

Variable	Coefficient	Standard error	t-Statistic	Probability
TEMP	0.005417	0.083175	0.065125	0.9489
SHINE	-0.005368	0.291970	-0.018385	0.9856
RAIN	0.000932	0.002023	0.460819	0.6515
PART	-0.013949	0.003344	4.171375	0.0008***
DUM	-0.102361	0.062480	-1.638308	0.1222
R-SQUARE		0.427599		
ADJUSTED R-SQUARE		0.274959		

*** = significant at the 1 per cent probability level.

The previous estimates show that except for suspended particulates, all other variables were not significant in influencing average annual yield of rubber. The variable DUM was also not significant showing that the yield functions were similar during both EY and NEY. This was consistent with the findings earlier in the chapter where it was found that the net loss from El Nino was only about 2 per cent. The insignificant results of the equation for rubber could be somewhat expected since the rubber industry is currently faced with increasing economic constraints which are important variables that affect yield as opposed to weather variables. For example labour constraints, increasing costs of production and low prices of rubber have resulted in a sizeable area not being tapped, resulting in abandoned holdings. As such, El Nino was the least of the problems that rubber smallholders faced.

4.10.3 Paddy

The results of the estimated yield function for paddy are as follows:

Dependent variable: Paddy

Variable	Coefficient	Standard error	t-Statistic	Probability
TEMPt	0.322246	0.094277	3.418076	0.0038***
SHINEt	-0.665746	0.359349	-0.1852646	0.0837*
RAINt	-0.005852	0.002398	-0.2440780	0.0275**
PARTt	0.011347	0.009944	1.141112	0.2717
DUMt	-0.259838	0.143036	-1.658308	0.1012*
R-SQUARE		0.324033		
ADJUSTED R-SQUARE		0.143775		

*** = significant at the 1 per cent probability level
** = significant at the 5 per cent probability level
* = significant at the 10 per cent probability level

The above estimates show that almost all variables with the exception of suspended particulates were significant. However, it can be seen that there were two variables that did not conform to a priori expectations, i.e. sunshine hours and rainfall. It was expected for both these variables to have a positive relationship with yields. Nevertheless, the one-to-one variable relationships could sometimes not hold true for crops. The interplay and the combined influence of all the variables in affecting the overall biological process could be more dominant than the individual affect of a single variable itself. For example, temperature was known to have the greatest affects on crop performance when other climatic factors such as solar radiation and water were limited (Tawang *et al.*, 2002). As such, the inverse relationship of these two variables, although not consistent with a priori expectations, have plausible explanation and thus, the equation could be accepted. Furthermore, again as argued for the case of oil palm, excessive rains could cause flooding and damage part or the whole crop in a particular area. The intercept dummy variable was significant at the 10 per cent probability level showing that the intercept of the yield functions differed during the EY and NEY. The sign also followed a priori expectations showing that the intercept of the yield function was lower during EY. This indicates that the El Nino weather phenomena had negative effects on overall paddy yields. This finding was consistent with the findings using the five-year moving maximum earlier, where it was estimated that the negative net effects of the El Nino on losses to paddy yields were more than 7 per cent.

4.10.4 Tobacco

The estimated equation for tobacco yield is as follows:

Dependent variable: YTOBACCOt

Variable	Coefficient	Standard error	t-Statistic	Probability
TEMPt	-27.02634	84.86554	-0.318461	0.7545
SHINEt	310.8898	308.6331	1.007312	0.3298
RAINt	-2.332783	1.710328	-1.363939	0.1927
PARTt	-5.807681	4.816071	-1.205896	0.2465
DUMt	151.5913	74.69177	2.029558	0.0605*
R-SQUARE		0.296662		
ADJUSTED R-SQUARE		0.109106		

* = significant at the 10 per cent probability level

The tobacco yield function was poor in terms of its statistical performance. None of the variables except for the intercept dummy, were significant. However, the sign of the intercept dummy parameter was not consistent with a priori expectations. The equation suggested that the yield of tobacco performed better during years with El Nino. However, although this finding is inconsistent with the original hypothesis that El Nino negatively effects crop yields, this estimation was consistent with the earlier findings on tobacco. The earlier findings through the moving-maximum method also show that mean yields during EY were in fact better than NEY. The rationale for this for tobacco has already been presented.

4.11 Summary of impacts

The analyses conducted in this chapter show that the negative effects of the El Nino phenomena can not be generalized for all crops at all locations. Since the biological and physiological processes in crops are complex and vary widely between crops, their interactions between the climatic variables at different locations could also vary widely. The findings at the national and regional level studies show great differences in impacts. For example, analyses at the national level show high negative impacts of El Nino on oil palm yields but show no effects at the regional level. However, the results were consistent for paddy where it was shown that El

Nino had negative effects at both the regional and national levels. The level of intensity of loss due to the net effect of El Nino, however, at about 7 per cent, was much higher at the regional level compared to the national level (estimated at 1.15 per cent). This was expected since the northwest was the most susceptible region to El Nino compared to the rest of the country.

It was also observed that the use of individual weather variables to associate with yield might not be accurate since a combination of the weather variables could have a more dominant effect compared to the effect of a single variable itself. It is also difficult to associate deficiencies in annual weather-inputs with El Nino. In this case, it was of the timing of these weather inputs that actually influenced yields rather than the quantity of the inputs themselves. It was observed from this study that although El Nino could bring negative effects by delivering less weather input to crops e.g. water, the disruption in the timing of rainfall patterns due to El Nino was equally important if not more important in influencing yield performance of crops. This was clear for the case of paddy, where despite mean rainfall during EY being actually higher than that during NEY, paddy yield performance was, nevertheless, negatively affected by the El Nino phenomena.

In general, this study concludes that the only crop or commodity that was negatively affected by the El Nino phenomena in the northwest region of Peninsular Malaysia was paddy. The total net loss due to this was estimated to be close to RM 238 million. Although the analysis also showed that aquaculture production suffered net losses from El Nino, the evidence derived was not conclusive due to the short data period that was used in the analysis. This study found no conclusive evidence of the negative effects of El Nino on other crops and commodities in this region including oil palm, rubber, sugarcane, fruits and vegetables, livestock and also on capture fisheries. Nevertheless, this does not discount the probability of the negative impacts El Nino has on farms and farmers, on input use and profitability. This aspect will be dealt with in the next chapter.

5. Farm Level Impacts

This chapter is devoted to the assessment of the impact of El Nino on individual farms and the effects it has on the income and resources of the farmer. The evaluation of the impacts and effects was conducted using the 'case study approach' on the representative farms or estates of the major commodities in the region. These commodities include oil palm, rubber, sugarcane, tobacco, fruits, vegetables, poultry and aquaculture. An evaluation of the impacts' effects was also carried out for rice. However, it was based on the assessment of impacts on the MADA Irrigation Scheme. Admittedly, the case study approach faced some constraints especially when it involved the small farmers who usually did not keep farm records for this study to have a more quantitative evaluation. At best, the farmers could only provide a qualitative assessment by describing what had happened in the last El Nino episode in terms of climate change and its impacts on the farms and subsequently on the farmers themselves. Their recollection on the various mitigating measures undertaken to reduce the impacts of El Nino were recorded. For the industrial crops (oil palm, rubber and sugarcane) a few estates were selected for the case study. Better record keeping practices by the estates enabled this study to have better assessment on the impacts of El Nino on the performance of their estates. For both small farms and estates, the required information was obtained through personal interviews and primary data collection on the farms.

5.1 The oil palm case study

5.1.1 Introduction

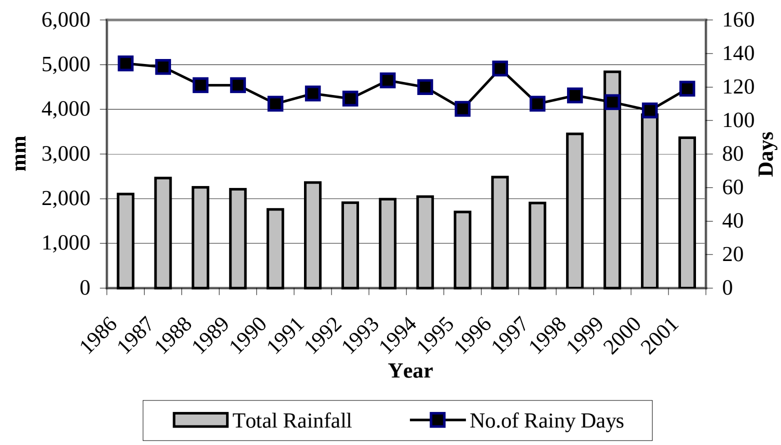
In the northwest region, oil palm cultivation is concentrated in the southern part of the state of Kedah, where the agro-climatic environment is more favourable for oil palm production. The northern part of the region is not suitable for oil palm cultivation. About 82 per cent or 43,000 hectares of the oil palm area in the region consist of estates, with the balance operated by small-scale farmers.

For the case study on oil palm, 'Ladang Padang Buluh" was chosen to be the representative estate for the region. Ladang Padang Buluh is an oil palm estate established in 1986. It is owned by Golden Hope Plantation, which is one of the major plantation houses in the country. The total area is 1,931 hectares, which is considered small by Malaysian standards. Currently, 1,321 hectares of the area are under mature palms, while the balance consist of immature palms that have yet to bear fruits. Headed by a manager, there are a total of 154 workers on the estate; 139 of them permanent employees and the balance contract workers. About 40 per cent of the workforce are foreign workers, in particular from Indonesia, Thailand and Bangladesh. Annual production is about 25,000 metric tons of fresh fruit bunch.

5.1.2 The El Nino episode

Records show that there were prolonged dry periods, especially in 1990 and 1997. A small weather station on the estate registered total rainfall at 1,762 mm and 1,906 mm respectively for these two years (Figure 5.1). This is well below the average annual rainfall level of 2,648 mm. Thus, the registered rainfall was 33 per cent (in 1990) and 28 per cent (in 1997) below the observed annual average. Similarly, the number of rainy days was also among the lowest in these years. A significant increase in the amount of rainfall for the years 1998 to 2000 could be associated with the La Nina episode that immediately followed El Nino.

Figure 5.1 Total rainfall and number of rainy days, 1986-2001, Ladang Padang Buluh



Source: Ladang Padang Buluh.

The water stress situation, especially in 1997, resulted in significant impacts on yield performance of the oil palm. Yield records between 1994 and 2001 indicated a dip in productivity for the years 1996 to 1998, with the yield in 1997 registering the lowest level (Table 5.1). While it was expected that the negative affects on yield for oil palm to be registered at least one year after of the El Nino episode, the immediate reduction in yield during the El Nino year itself was quite surprising. Additionally, the recovery in terms of productivity in 1999 is also unexpected since this was the year when the yield was expected to be negatively affected by El Nino. It is possible that the little changes in total rainfall during the 1997/98 El Nino, as indicated earlier, did not affect productivity. It is also possible that the significant increase in rainfall in late 1998 (after El Nino) and 1999 could contribute to the yield increment. The limited and insignificant impacts of El Nino on oil palm yield on this estate were consistent with the findings in the previous chapter, which assessed the impact at the regional level.

Table 5.1 Yield performance of oil palm, Ladang Padang Buluh, 1994-2001 (tons/ha)

Year	1994	1995	1996	1997	1998	1999	2000	2001
Yield	22.2	21.8	18.9	17.5	19.8	25.5	20.5	22.6

Source: Ladang Padang Buluh.

Although the effects of El Nino on oil palm yield on the estate were rather insignificant, there were other impacts. They include the following:

- The long drought negatively affected the growth of the young immature plants on the estate. Such stress was expected to affect the future development of the crop. However, since these crops were still immature, their subsequent affect on yield and productivity was still not known. While the estate's management were fully aware of the need to schedule the planting season so as to coincide with the rainy season, the long drought in the subsequent years resulted in many young immature plants dying. These need to be replanted resulting in the incurrence of additional costs and a delay in maturity.
- There was no negative affect on the income of the estate workers since the hot and dry period did not affect their work schedule. Furthermore, the workers are paid on a monthly basis. This was also true for some other workers who were paid based on tasks undertaken (harvesting, pesticide application, and others).
- There were a few cases of disruptions in the work schedule. For example, hot and dry weather with strong winds resulted in the rescheduling of chemical spraying activities.

- There was also an increase in risk of 'estate' fires. It required the estate's management to put extra effort in controlling the possible outbreaks of estate fires. In fact, the drought of 2002 resulted in estate fires affecting about 25 hectares of the plantation. However, fortunately no such incidences were recorded during the previous El Nino periods.

5.1.3 Mitigating measures

In general, there were limited mitigating measures that had been introduced to counter the impacts of El Nino induced climatic change for the oil palm sector. Whatever measures were introduced were primarily aimed at alleviating water stress on the young and immature plants so that their growth was not affected. It was also very fortunate that despite the long drought, the estate did not have problems with water availability since the Muda River that runs along the border of the estate was able to continuously supply water to the estate. The continued availability of this source of natural water made it possible for the estate to provide water for critical operations, notably watering of the young and immature oil palm trees in the field.

The estate had also ensured that all farm operations were planned based on historical rainfall patterns and distribution. This was the reason for the establishment of a weather station within the estate. The close monitoring of the rainfall pattern had strengthened the farm decision-making processes, especially with regards to new plantings, land clearing, pesticide spraying and fertilizer application. The adjustments to the schedule were made when climatic conditions were not conducive for certain farm operations. For instance, land clearing was undertaken only under dry field conditions to facilitate the movement of machinery, whilst new planting was always scheduled in the rainy season.

After the 1997/98 El Nino episode, the estate's management had taken up some remedial actions to reduce the potential impacts of future El Nino incidences. Among the major efforts undertaken was testing the feasibility of irrigation facilities to ensure the continued availability of moisture to immature trees. This was undertaken with the cooperation of the Malaysian Palm Oil Board (MPOB). If found to be feasible, such an approach would reduce significantly the impact of El Nino on the growth and productivity of oil palm trees.

5.2 The rubber case study

5.2.1 Introduction

This case study involved an organized land development scheme operated by the Federal Land Development Authority (FELDA). FELDA is a government agency which was responsible for developing hundreds of thousands of hectares of agricultural land, mostly in the 1970s and 1980s. The land was then allocated to the landless poor to provide employment and income. FELDA centrally managed these land development schemes.

The FELDA Bukit Tangga was established in 1977 as an organized rubber smallholder land scheme where each farmer was allocated 4 hectares of agricultural land to be planted with rubber, plus another quarter of a hectare for dwellings and a small orchard. In its initial stage, the government provided the necessary infrastructure, the rubber establishment costs as well as the operating costs. During the establishment stage, the settlers worked as labourers with fixed wages which were sufficient to cover their daily needs. When the rubber trees matured and started production, part of the revenue collected was deducted to cover some of the costs incurred during the establishment of the scheme, as well as some management costs. The total loan to each settler was calculated at about RM 40,000 with monthly deductions of about RM 230. With this amount, it would take about 15 years to settle the loan. The land and other properties (including the dwellings) would be given to the settler once the deduction was complete, but FELDA would continue to manage the operation of the scheme.

Over the years, this approach was changed whereby FELDA would manage the day-to-day operations of the whole scheme in the same mode as the management of an estate. The settlers were provided with some equity in the form of shares in return for their land holdings, which would be managed by FELDA management. The titles of the land were still with the settlers. Some of the settlers continued to work on the estate and be paid as any other worker, while the rest found employment outside the scheme. At the time of this study, FELDA Bukit Tangga estate had a total of 520 employees, 370 of them were former settlers of the scheme, while the rest were foreign workers from Thailand.

5.2.2 Impacts of El Nino

The economic life of a rubber tree is about 25 years but its yield level declines after the tenth tapping year. Since most of the rubber trees were planted in the 1980's, theoretically, the yield would naturally decline by the late 1990's onwards.

A summary of the performance of the estate is indicated in Table 5.2. Several deductions can be derived from the table:

- The highest yield level was achieved in the El Nino year of 1997. The increase could partly be due to the increase in the number of tapping days brought about by the long dry period in that year. From then onwards, the yield has steadily declined. It is highly probable that the impacts of El Nino came into affect only after the episode, lasting to the year 2000.

Table 5.2 Production and income performance by year

Year	Yield (kg/ha)	Production of natural rubber (tons)	Number of tapping days	Average income of tappers (RM)
1991	1,480	1,997	n.a	930
1992	1,582	2,297	n.a	1,000
1993	1,517	2,256	n.a	939
1994	1,689	2,506	270	1,581
1995	1,495	2,218	260	1,770
1996	1,632	2,439	243	1,765
1997	1,814	2,710	261	1,474
1998	1,447	2,154	248	1,190
1999	1,242	1,849	221	823
2000	1,094	1,629	222	830
2001	1,196	1,781	228	817

Source: FELDA Bukit Tangga.

- An increase in the number of tapping days meant an increase in working days for the rubber tappers. The longer dry season in 1997 allowed more tapping days, up to 261 days. This contributed to an increase in yield and production, as well as farm income. However, the increase in farm income did not necessarily parallel the increase in tapping days because of the changes in rubber prices over the years.
- The number of tapping days is dependent on the number of rainy days. The formation of haze, despite the health hazard that it could be associated with, had no influence on tapping days. In fact, some tappers considered the haze a blessing since it provided some cooling effects due to less penetration of the sunlight.
- Minimal application of weedicide necessary due to the drying up and dying of the crop. This reduced drastically the amount of weedicide used during the period, which resulted in some cost-savings.
- A delay in fertilizer application to avoid volatilisation lost during the hot period.
- Since rubber is a perennial crop, the El Nino episode had no bearing on the planted area, the same as for oil palm.

5.2.3 Mitigating measures

In this case study, very limited mitigating measures were undertaken or planned for in response to the El Nino incidence. The FELDA management was of the opinion that there was little that could be done. There were some adjustments to the scheduling of fertilizer application to avoid volatilization lost due to the hot weather. More importantly was the fact that apparently the El Nino event had brought about more positive effects. This was in the form of increased tapping days, hence a similar increase in income for the farmers. There was definitely a decline in the yield after the El Nino episode because it was not possible to overcome the problem of water stress in rubber trees. Irrigating the rubber area was definitely not a viable option, especially when the crop was planted on undulating and hilly terrain.

5.3 The paddy case study

5.3.1 Introduction

As was mentioned earlier in the chapter, the paddy case study was undertaken on the Muda Irrigation Scheme Area which is managed by the Muda Agricultural Development Authority (MADA). This is the largest and the most important “granary-area” in the country. It is located in the northwest region of Peninsular Malaysia, covering the whole of the study area in the states of Kedah and Perlis. As was previously mentioned, it is the main rice bowl of the country with a total area of about 126,000 hectares under rice. The scheme contributes to about 40 per cent of the country’s total rice production. Almost all paddy fields in the area are served with a good irrigation system, making it possible for double cropping of rice in the area. The source of the irrigated water comes from three main reservoirs, namely Muda, Pedu and Ahning, with a total storage capacity of 1,485 million cubic metres and water catchment areas of 1,277 square kilometres.

As a whole, the area is a water-short region (Wong, 2002). This is partly due to the drought season which in this area usually takes place between the months of November to March. During this period, the monthly rainfall drops to only about 100 mm. The months of August and November are the rainy season, with average monthly rainfall between 200-300 mm.

5.3.2 The impacts of El Nino on water resources and the paddy crop

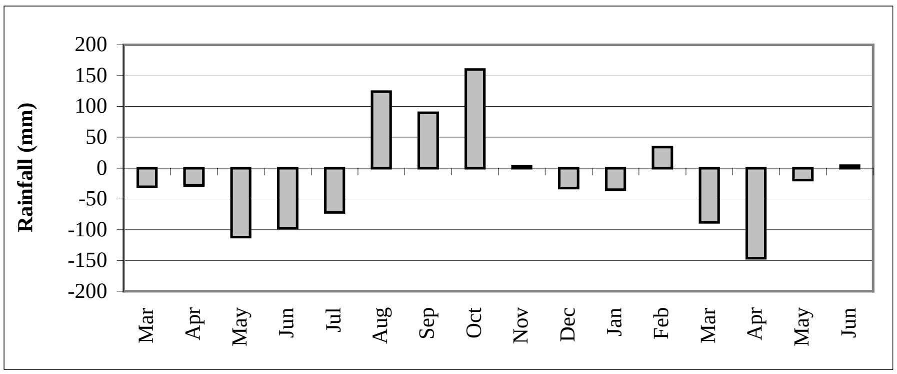
The El Nino episodes, characterized by lower rainfall, higher temperatures and poorer air quality due to haze, impacted paddy production in the area. These impacts are discussed below:

Rainfall patterns

The amount and timing of rainfall is always important to the MADA area. Despite the good irrigation infrastructure facilities, about 52 per cent of the total water requirement for paddy cultivation in the area is still derived from rainfall. The dams and reservoirs contribute another 30 per cent, followed by rivers and recycled water at 13 per cent and 5 per cent respectively. Shortages in rainfall affects all these sources of water supply to the paddy fields.

As was the case for the Kedah-Perlis region as indicated earlier, there was little disparity in terms of the total amount of rainfall registered during the El Nino years compared to that of normal years. The problem lies in the significant disparity in rainfall distribution between months. Figure 5.2 depicts the anomalies in terms of monthly rainfall distribution between the said periods. For almost all of the months during the period there were significant deviations in rainfall patterns. There was significantly less rain in the months of May, June and July. This period coincides with the planting and establishment stage of paddy plants in the MADA area. On the other hand, there was more rain than usual during the months of August, September and October. Such anomalies disrupt some of the on-farm operation activities. The less than normal rainfall at the beginning of the planting period for the off-season crop (March to May), where the amount of rainfall received was below normal, upsett the crop calender of the area. Similarly, the more than normal rainfall during the latter part of the period, which coincided with the harvesting period (July to October), compounded further the difficulties faced by the paddy farmers. Theoretically, without adequate mitigatory measures, this large deviation in rainfall pattern could result in negative impacts on paddy productivity in the area. Fortunately, such deviations in monthly rainfall distribution did not result in a significant change in paddy yield. This could be associated with the timely delivery of irrigated water from the reservoir.

Figure 5.2 Deviation in monthly rainfall distribution during the El Nino of 1997/98 in the MADA area

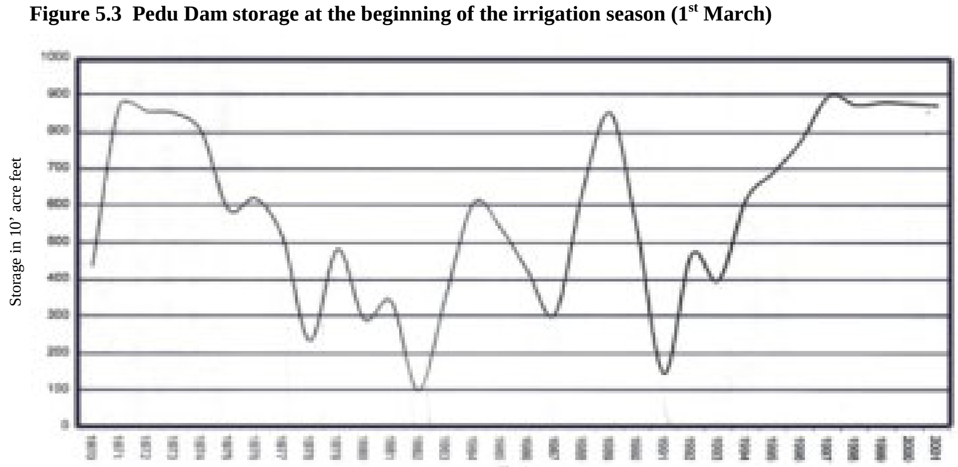


Source: MADA.

Water level in the dam

Figure 5.3 shows the corresponding low levels of water during El Nino years in the Pedu Dam, which is the main source of water supply to the MADA area. This is based on the level at the beginning of the irrigation season on the 1st March of each year. The El Nino years of 1977/78, 1982/83, 1986/87 and 1991/92 show low levels of water in the dam. During the more recent El Nino events of 1994/95 and 1997/98, the water levels were higher. This was partly due to the various water conservation measures instituted by MADA.

Figure 5.3 Pedu Dam storage at the beginning of the irrigation season (1st March)

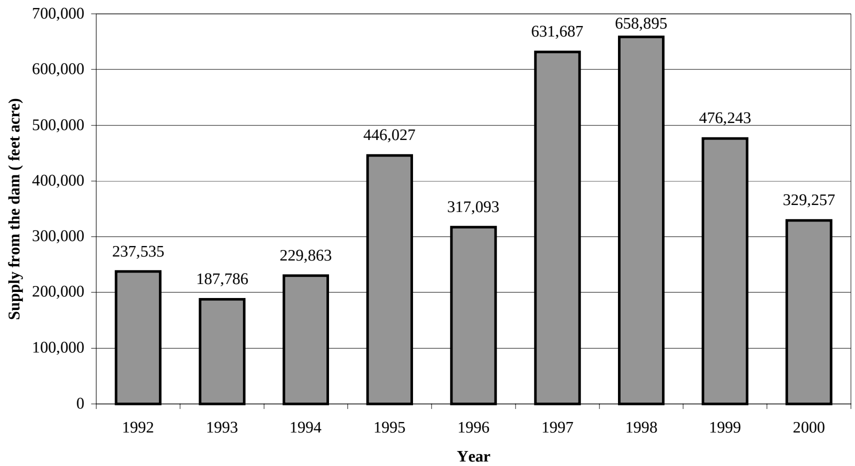


Source: MADA.

Level of water withdrawal from the dams

While the two most recent episodes of El Nino had a higher level of water in the dam, the droughts that were prevalent during these periods resulted in the high withdrawal levels of water from the reservoir to serve the irrigation needs. The resultant low rainfall in the areas, especially during the paddy planting stage, necessitated the increase in the amount of water released to the paddy farms. Such large releases of water from the dam to offset the low rainfall during the planting and establishment period is reflected in Figure 5.4. The levels of withdrawal amounted to 631,687 acre feet and 658,895 acre feet, which is more than double the withdrawal level in normal years.

Figure 5.4 The amount of water released from dams for first season crops



Source: MADA.

Changes in planted area, production and yield

Overall, there were no changes in planted area between El Nino and normal years (Table 5.3). However, there was disparity in terms of yield and the subsequent production levels between the El Nino and normal periods. It is apparent that during El Nino years, production and yield in the main season were higher than that of normal years. It was the opposite during the off-season. It could be that the longer day length and radiation increased the yield whilst the expected water stress was much reduced by the continued availability of irrigation water. The water situation in the off-season was more critical, as discussed earlier. The resultant water stress from El Nino obviously impacted yield performance. As a whole, however, the differences in yield between the El Nino and normal periods within the MADA area were small and insignificant. Hence, the intensity of production loss, quoted in a previous chapter at about 7 per cent, was mostly made up of paddy production outside the MADA area.

Table 5.3 Planted area, production and yield in MADA, 1980-1999

	Main season			Off season		
Year	Planted area (ha)	Production (mt)	Yield (kg/ha)	Planted area (ha)	Production (mt)	Yield (kg/ha)
1980	95,930	460,272	4,798	89,530	406,019	4,535
1981	95,840	446,039	4,654	90,200	397,692	4,409
1982	94,898	390,126	4,111	89,528	260,168	2,906
1983	95,208	371,406	3,901	89,220	262,307	2,940
1984	75,549	205,040	2,714	83,102	245,483	2,954
1985	95,470	388,372	4,068	90,686	312,595	3,447
1986	95,714	363,905	3,802	90,966	295,276	3,246
1987	95,944	373,222	3,890	88,956	203,620	2,289
1988	96,121	387,464	4,031	92,183	263,828	2,862
1989	97,029	371,621	3,830	92,447	300,730	3,253
1990	97,105	392,207	4,039	92,590	332,676	3,593
1991	97,120	429,562	4,423	92,528	323,200	3,493
1992	97,197	474,127	4,878	92,294	289,803	3,140
1993	96,603	422,542	4,374	92,719	365,498	3,942
1994	97,140	459,278	4,728	96,799	386,906	3,997
1995	96,734	479,704	4,959	97,078	382,487	3,940
1996	96,764	447,243	4,662	96,459	389,116	4,034
1997	94,405	390,247	4,048	96,427	363,530	3,770
1998	96,355	414,712	4,304	96,307	362,500	3,764
1999	96,320	391,444	4,064	96,307	403,815	4,193
Mean EY	95,864	411,697	4,278	92,717	310,251	3,336
Mean NEY	94,876	399,168	4,187	92,144	334,696	3,621

Source: Paddy Statistics (various issues).

Severity of crop damage

There have been no incidences of total crop damage due to drought ever registered in MADA. There have been two seasons in the history of MADA where there was no water schedule provided to the farmers. Those were in the years of 1987 and 1991 and due to a very low level of water storage in the reservoir. The farms, however, could still manage to generate a reasonable yield level due to the timely arrival of rain. This was not so for the paddy areas outside MADA where the number of paddy farms completely damaged due to drought was much higher (Table 5.4). All of this damage occurred during the dry season in areas where the irrigation water was insufficient to provide the necessary water supply. For the last 20 years, a total of 18,152 hectares of paddy land outside MADA has been seriously affected by droughts, even to the extent of total crop loss. The most severe cases were in 1990 (which was not an El Nino year) and 1998, where a total of 5,055 hectares and 4,390 hectares respectively of paddy land ended up with total loss. However, this represents only about 5–8 per cent of the total planted area outside MADA. In 1982, which was an El Nino year, a fairly significant area in MADA was damaged but its causes were not identified. It was suspected that the damage was also drought related. Other forms of damage that could be associated with climate change can not be established. Apparently, the incidences of pest and disease outbreaks, which can be linked to changes in climate, did not prevail within the MADA region, as well as for areas outside MADA. This kind of damage, which did not follow specific patterns, was small and insignificant. One exception was the very serious pest outbreak in 1989 that affected about 40 per cent of paddy areas in MADA. Though the outbreak was extensive, the degree of damage did not significantly reduce paddy production in the area.

Table 5.4 Crop damage in MADA and non MADA areas

	MADA									Non MADA								
Year	Planted	Drought	Flooding	Pests	Diseases	Wind	Other	Total	%	Planted	Drought	Flooding	Pests	Diseases	Wind	Other	Total	%
1980	185,466							0	0.00	71,141	1,274	40	353	3		3	1,673	2.35
1981	186,044							0	0.00	70,179	2,634	109	399	805		11	3,958	5.64
1982	184,426							1,951	1.06	68,136							18,930	27.78
1983	184,428							0	0.00	61,841							266	0.43
1984	158,651							877	0.55	61,791							115	0.19
1985	186,158							0	0.00	60,497	61		162	14			237	0.39
1986	186,680			6				6	0.00	60,119	7	193					200	0.33
1987	184,950							0	0.00	58,957	1,514	27					1,541	2.61
1988	188,341							0	0.00	62,727	8				12	29	49	0.08
1989	189,469		7,371	67,699	2,831			77,901	41.12	64,561	18	2,478	55				2,551	3.95
1990	189,695							0	0.00	61,228	5,055				65		5,120	8.36
1991	189,648		999					1,114	0.59	35,947	1,116						1,116	3.10
1992	189,491							0	0.00	82,436	324			35			359	0.44
1993	189,920							0	0.00	69,197	204						204	0.29
1994	193,939			38				38	0.02	65,718							0	0.00
1995	193,812							0	0.00	64,922							0	0.00
1996	193,223				108			108	0.06	69,005		216	1		1	10	228	0.33
1997	192,742		161					161	0.08	66,019	1,547	553	1		1		2,102	3.18
1998	192,662							0	0.00	84,360	4,390	21	299	79	1	1363	6,153	7.29
1999	192,627							0	0.00	63,894		54		1		18	73	0.11

Source: Paddy Statistics (various issues).

Burning of paddy stalks

At the peak of the haze episode, the government decided to ban all forms of open burning. This was for the purpose of limiting the further deterioration of the air quality in the region. The crops most affected by this ban were the paddy and sugarcane sub sector. In paddy farming, the burning of paddy stalks after the completion of harvesting was widely practiced. This is to facilitate land preparation, enhance the fertility level of the paddy land and is part of the practice for controlling pests and disease on the field. The ban resulted in severe dissatisfaction among the farmers. The ban, however, was lifted by the revised Environmental Quality Act (2000) and is now permitted provided that it is done in stages.

5.3.3 Mitigating measures

The planting of paddy in the MADA area depends greatly on rainfall in spite of the presence of irrigation facilities. In view of the fact that only about 30 per cent of the water requirement is met by irrigation, the region is very sensitive to changes in weather patterns. MADA has, therefore, instituted many water conservation measures to counter the effects of weather changes due to El Nino or otherwise. Wong (2002) outlines some of the mitigating measures undertaken by the authority to ensure the adequacy of irrigated water and its timely delivery to the paddy farmers in the MADA area, especially during the drought period. The measures undertaken include:

Re-scheduling of water supply

One of the major decisions MADA has to take during years when water levels in the dams are insufficient is whether or not to start irrigating the fields. For social and political reasons MADA found it prudent not to practice rotational irrigation. Once the authority decides to start irrigation, it is compelled to ensure the crop has sufficient water. Therefore, during the last 25 years, MADA has had to make the decision not to officially start off-season irrigation. This was during the El Nino years of 1978, 1987 and 1991. During these years, farmers were advised to withhold planting until there was sufficient rainfall. They were also advised to practice dry ploughing and dry direct seeding. In this way water was conserved and only supplementary irrigation was given during the season. The vast majority of farmers were able to successfully see the crop through although with reduced yields. On other occasions, MADA has delayed the start of the irrigation, as was evident in 2002 when the start of the off-season crop was delayed by 10 days in anticipation of rainfall. Simulations of the water supply situation in the dams show that with this delay, a total of 46,880 acre feet of water was saved.

Water control and management system

In response to critical water shortages experienced in the region, which are compounded by the El Nino phenomenon, MADA instituted a project to monitor rainfall and water conditions, water usage and maximize rainfall utilization. This took into account the fact that water released from the dams takes 2 to 3 days to reach its targeted destination in the fields. In the meantime, rain could have fallen and the released water would be wasted since there would already be sufficient rainwater in the field. This project involved the installation of 80 rainfall stations within the paddy areas as well as at the dam and catchments areas. In addition, 13 river stations were installed at rivers downstream of the dams. Data from these sites is transmitted in real time to the control centre at MADA headquarters. At the same time, readings of water levels in selected paddy fields in every irrigation block are transmitted to the centre weekly and computer calculations made daily on the water requirements of each block. Appropriate instructions are then made regarding dam water releases. Through this project, significant savings are made to water supplies. This system is being further refined and upgraded by increasing the number of monitoring stations.

Regulating ponds

These are planned to be constructed at a site between where the irrigation water is released from the dams and the destined fields. The justification for this is the long distance between the dams and the paddy fields. Water released from the dams will be diverted into these regulating ponds to minimize water wastage should rain fall from the time of dam release to the time it reaches its destination. Water from these regulating ponds could also be released to meet irrigation needs and avoid dam releases.

Recycling

Recycling of water from drains now contributes about 5 per cent of the total water requirement and this will further be enhanced as more sites are identified.

Water saving agronomic practices

Present water utilization by the paddy crop is high. The most wasteful practice is wet seeding whereby fields are flooded and then subsequently drained before seeding. Dry ploughing and dry seeding technology has been introduced and is being actively encouraged.

Water use efficiency

Present irrigation use efficiency has increased further through proper bund management, irrigation practices and the establishment of water user groups. Included in this category is the establishment of group farms and paddy estates.

Review of irrigation facilities

The present irrigation and drainage intensity in the Muda area is 11 meters per hectare in 70 per cent of the areas and 35 meters per hectare in the other 30 per cent. An ongoing project is being implemented to bring the entire area to 35 meters per hectare with tertiary irrigation facilities. MADA is presently reviewing this project to determine the actual intensity required in light of present attempts to encourage large-scale cultivation of paddy through group farms and paddy estates. However, research findings have indicated that increasing drainage intensity could result in a corresponding increase in water being wasted.

Cloud seeding

Cloud seeding has been carried out from time to time in response to critical water situations in the region. In the Muda area, several attempts have been made to encourage precipitation of rainfall over the catchment areas of the dams to help boost water levels. This has been met with mixed results. The exercise was very much dependent on the availability of suitable clouds over the targeted areas.

Research and Development

Research and development is ongoing whereby MARDI conducts rice breeding and selection programmes to ensure the availability of drought resistant and shorter-term varieties. In times of drought and acute water shortages, these varieties can be planted, as was the case in 1987. During that year, when water was not released from the dams, the variety IR42, which is shorter term and more suitable for the prevailing weather conditions, was distributed for planting.

5.4 The sugarcane case study

5.4.1 Introduction

The Kedah – Perlis region is the only region in the country where sugarcane is produced. This is the only area in the country that is suitable for sugarcane production since a 3-4 month dry period is a necessity for sugarcane production. There are only two major sugarcane estates in this region with a total hectarage of about 20,000 hectares. These estates have their own sugar refining mills.

For this study, the "Gula Padang Terap" plantation was chosen. The Gula Padang Terap plantation was established in 1973, and is now owned by a consortium comprising of Perbadanan Kemajuan Negeri Kedah (PKNK), which is the development corporation owned by the Kedah State Government, Perlis Plantation (the other sugarcane plantation and millers) and a private company. The plantation contributed to about 30 per cent of the total output of the mills. The remaining output was from the milling of raw sugar imported from Australia, Thailand, Indonesia and Brazil.

The total area under sugarcane on this estate is about 8,000 ha, from a total area of about 10,000 hectares. The balance of about 2,000 hectares is used for other agricultural commodities, recreation, milling, housing complex and so on. It employs about 2,000 farm workers, some of them being foreign labour from bordering Thailand. The number can increase to about 3,000 workers during the harvesting period. The plantation is supported by its own R&D activities, with a focus on varietal screening, fertilizer trials and pest and disease control.

5.4.2 The effects of El Nino

Generally, there is a five-year cycle of severe dryness in the region. In this regard, the El Nino of 1997/98 had already been expected and some mitigating measures had been put into place. To some extent, these measures were successful in alleviating some of the problems associated with long droughts, especially those related to crop growth and establishment. Hence, during almost 20 years in existence of sugarcane, the expected droughts have never been a primary consideration in determining the size of the area to be planted. Sugarcane production starts with the planting season between December and May, which also coincides with the harvesting season that spreads from December to March. The months of December to July or August are used for crop care, including the maintenance of ratoons.

The record on crop performance in terms of yield and sugar content is depicted in Table 5.5. The yield level ranges between the low 26 mt/ha in 1982 (which was one of the El Nino years) to as high as 52 mt/ha for the period 1990 and 1992. The yield levels during the worst El Nino episode in 1997 and 1998 were at 43 mt/ha and 46 mt/ha respectively, which are considered as a little lower than the average yield level on the plantation. The decrease in yield was brought about by the resultant water stress during the prolonged drought period, which had affected crop growth. The situation was further compounded during the El Nino 1997/98, where the very dry and hazy environment blocked sunlight penetration onto the crops, hence interfering with the photosynthesis process. The long dry season, however, was good for sugar formation. Hence, while yield declined, this was more than compensated by the increase in sugar content as reflected in the decrease in the TC/TS (tons cane/tons sugar) ratio, as can be seen in all El Nino years. The ratio refers to the recovery rate that indicates the unit amount of sugarcane required to produce one unit of sugar. In an ideal situation it is possible to achieve high yield as well as higher sugar content due to higher juice concentrate. This is achievable when there is sufficient water during the establishment and growing stage of the cane and followed by a long dry period during the maturity and harvesting stage. The periods 1988, 1990 and 1991 are examples of this. The year 1999 registered one of the highest yield levels for the plantation. It coincided with the La Nina (the reverse of El Nino) event of 1999, which brought lots of rain to the plantation. This resulted in very good crop growth and subsequently very high yield levels but the wet season resulted in a reduction of sugar content, which was among the lowest in the history of the plantation.

Table 5.5 Harvested area, yield and production of sugarcane on Gula Padang Terap estate, 1980-2001

Year	Harvested area (ha)	Average yield (TC/H)	Production of sugarcane (mt)	TC/TS
1980	3,951	40.03	158,174	21.15
1981	4,536	29.40	133,355	13.71
1982*	4,118	26.08	107,379	10.31
1983*	5,580	41.22	230,022	9.81
1984	5,792	39.02	226,000	9.17
1985	6,694	37.46	250,763	9.09
1986	7,271	44.09	320,575	8.80
1987	7,805	45.64	356,257	9.59
1988	7,876	51.44	405,152	10.14
1989	8,400	46.63	391,727	10.13
1990	8,429	52.32	440,996	10.21
1991	8,448	50.08	423,102	11.59
1992	8,638	52.54	453,806	10.31
1993	7,973	48.72	388,443	9.62
1994	8,136	49.19	400,218	11.19
1995	8,034	43.20	347,075	10.59
1996	7,953	45.73	363,728	10.43
1997	7,169	43.19	309,650	11.26
1998	7,285	46.55	339,134	11.36
1999	6,949	59.54	413,722	14.86
2000	6,847	45.04	308,407	11.71
2001	7,100	45.68	324,304	11.58

Source: Gula Padang Terap.

Some other effects faced by the plantation during previous El Nino periods were as follows:

i. Whilst it is a fairly common practise to irrigate the sugarcane plants, especially during the establishment stage, a lot more irrigation was needed during the long drought period. The first 3 months are critical for crop growth and a severe dry period during the growing stage (months 3 to 6) would negatively affect plant growth. Under normal conditions, the water requirement during the growth stage is supplied by rain, failing which some irrigation would be required. The increase in dependency on irrigated water could incur additional costs to the plantation. During the last El Nino period there were more areas that needed to be irrigated with greater frequency.

ii. There were observed increases in operational costs, especially for land preparation. The formation of hardpan made land preparation more difficult and required more tractor-hours.

iii. There were some cost savings during harvesting due to the easier operation as well as the decrease in weight of the sugarcane plants, which subsequently reduced the transportation costs of the sugarcane to the mills.

iv. During the peak of the haze period, the sugarcane plantation was also prohibited from carrying out open burning on the plantation. Such burning was commonly practised before the harvesting period for the purpose of facilitating the harvesting and transportation process, increasing the sugar content, as well as for the pest and diseases control mechanism. The ban on the burning of sugarcane leaves prior to harvesting badly affected the harvesting process, making the operation slower and more costly. The sugar content was also lowered. As was the case with paddy stalk burning, the ban was lifted through a similar revision of the Environmental Quality Act (2000) and the practice is now permitted on condition that the total burned area should not exceed 20 hectares per day.

5.4.3 Mitigating measures

The most important mitigating measure undertaken by the plantation in coping with the longer than normal droughts brought about by El Nino is to store sufficient water. This is done by constructing a number of small man-made lakes through the damming of small creeks in this hilly and undulating topography. Each ‘depression’, with a width of about 40 meters, costing between RM 4,000 – RM 5,000 each and requiring about 100 bulldozer hours, impounds the rain water during the rainy season, and stores it for the coming dry season. These sources of water supply, numbering about 200 ponds of different sizes, are sufficient to provide irrigated water for about four months. It is estimated that the total water holding capacity of these ponds on the estate is about 34 million cubic meters.

By using mobile sprinklers, almost all the areas on the plantation can be irrigated. Under very severe drought conditions there were cases where some of these ponds dried up but these were isolated cases. As a norm, irrigated water from these ponds is utilized from the month of January to March, which is normally the dry season. The months of April to June, which is the growing stage of the plant is normally the rainy season. The construction of new ponds and the continued maintenance of the existing ponds has been an ongoing activity by the plantation. The construction of new ponds is targeted in areas where there were incidences of limited water availability in the previous season. The efficiency of the system has ensured no drastic changes in the cropping schedule for the plantation during times of drought.

5.5 The case of fruit orchards

5.5.1 Introduction

The fruit orchard chosen for the study comprises a typical mixed-fruit farm with about one hectare of durian trees and 2 hectares of other fruit trees. The orchard was established in the early 1990s using new fruit clones. This was part of the ‘nucleus-estate’ approach adopted by the government, where farmers were grouped together in one area to facilitate the delivery of government support including technical advise, provision of inputs and credits, and marketing. This farm is one of the 82 farms on this nucleus-estate set-up. The choice of the new clones was based on the rationale that the new clones are better suited to this environment, against the more popular varieties which were known to result in poorer quality fruits under long drought periods.

5.5.2 Impacts of El Nino

Some of the effects of the previous drought periods, including the drought of 1997/98, on the fruit orchard are summarized as follows:

- During the drought of 1997/98, about 10-20 young immature durian trees died due to a lack of water. These plants would have to be replanted. The plants which were affected by canker (which is form of durian disease) were more prone this damage.
- The high mid-day temperatures that reached 42ºC had adverse affects on plant growth. It retarded growth of the fruit tree and affected fruit formation.
- The haze that occurred between February and September in the region, though on a much lower level than the rest of the country, affected productivity of the fruit trees. Since the plants rely on sunlight to produce fruit through photosynthesis, the decrease in sunlight intensity and duration during the haze period meant that the plants were less efficient in producing nutrients for growth, pollination and fruit bearing. The matured fruit trees have a cycle of between three to four months for pollination and fruit bearing. Hence, severe haze for two or three weeks is enough to disrupt the process. Theoretically, the presence of haze during the fruit bearing stage reduces the capacity of the plant to accumulate nutrients, hence reducing yield level.

The prolonged drought, coupled with the high temperatures caused young fruit trees to wilt and droop prematurely, a phenomenon called 'abortion'. Hardest hit would be the orchard, especially the durian orchard, which depends solely on rainfall as its main source of water. This resulted in a 20 per cent to 40 per cent decrease in fruit production on the farm. Without sufficient water, the fruits that survive the drought end up being smaller, lighter, with less flesh, drier texture and even lose some of their distinctive aroma. The decrease in production negatively affected farm income by similar percentages. With farm income estimated at about RM 7,500 per year from durian cultivation, the loss to farm income was in the range of RM 1,500 to RM 3,700.

5.5.3 Mitigating measures

The durian tree, in particular, is known to be very sensitive to drought. Hence, the most effective mitigating measure during the drought season is to ensure that farmers carry out extra watering and provide some form of shade for their young trees. Unfortunately, for some farmers, even their meagre water sources had dried up.

Some of the measures undertaken by the orchard grower to address the problems associated with droughts are:

- Application of drip irrigation systems in areas where there is a steady supply of water, mainly from nearby rivers and ponds. The system is cost-effective, with little wastage in water use and ensures healthy plant growth. It is mostly applied in new, more organized orchards and included as part of the technology package in fruit cultivation.
- Application of a water ponding system, where water is released around the plant to create a saturated condition around it. Some of the farmers did this manually during severe drought conditions.

5.6 The case of the tobacco farm

5.6.1 Introduction

The case chosen for tobacco involved a large-scale tobacco production system, with a farm size of about 140 hectares supported by 170 farm labourers. This is also a very highly commercialised operation, with a specific production quota given by the government. There were a number of years when the quota was not achieved, and generally all were due to changes in weather. There was too little rain (hence upsetting the irrigation schedule), or too much rain that resulted in the flooding of the farms. The farms were organized in segments, with each segment occupying an area of 14 hectares planted with 250,000 tobacco plants. The average yield was about 1,500 kg/ha and each crop cycle was about 70 days. Three crop cycles were operated in a year.

The changes in planted area and productivity since 1990 is shown in Table 5.6. The peak periods in terms of planted area and production levels were during the period 1993 to 1997, where planted area fluctuated between 100 and 115 hectares, with the production level at between 126 to 136 metric tons of cured leaves. Since then, there was a significant reduction in terms of planted area and production from 1998 onwards. The lowest level was in 2000 and it was due to a severe flood that year. The El Nino period of 1992/93 and 1997/98 did not result in a significant change in productivity, raging between 1,200 kg to 1,300 kg per hectare. This was attributed to the massive investment in irrigation facilities provided to the farm.

Table 5.6 Planted area, production and yield of tobacco, 1990-2001

Year	Planted area (ha)	Production of cured leaf (kg)	Average cured (kg/ha)
1990	97.8	127,220	1,300.8
1991	83.1	99,797	1,200.9
1992	97.0	126,132	1,300.3
1993	117.6	152,897	1,300.1
1994	110.5	143,683	1,300.3
1995	101.9	132,561	1,300.9
1996	109.9	142,891	1,300.2
1997	114.0	136,916	1,201.0
1998	77.1	92,622	1,201.3
1999	51.9	62,337	1,201.1
2000	16.4	16,454	1,003.3
2001	72.3	94,000	1,300.1

Source: Farm record (unpublished).

5.6.2 Impacts of El Nino

Water availability is a prerequisite for tobacco production and this accounts for part of the cost component in tobacco production. Under very severe droughts, without irrigation, the farm experienced achieving a yield level of only 500 kg/ha. This was only about 40 per cent of the average yield and therefore, the farmers incurred heavy economic losses. This problem is quite prevalent among tobacco growers in Malaysia.

5.6.3 Mitigating measures

In view of the importance of ensuring sufficient water supply to the farm, the farmers invested quite heavily in irrigation equipment and facilities. The farms were equipped with a ‘rain-gun’, water pumps and pump houses, and an extensive networking of irrigation piping for a sprinkler system. The operation of the irrigation water constituted the major production cost of the farms. With the initial investment of between RM 7,500 to RM 12,000 per hectare for a sprinkler system, and RM 1,500 per hectare for the ‘rain-gun’ system, the capital outlays for irrigation purposes are quite substantial. Recently, there have been some attempts to shift to drip irrigation by using drip-tape. Under this system, there is a saving in water use by as much as 50 per cent. The system could also serve for fertigation purposes. The overhead cost is fairly high, at about RM 15,000 per hectare. The water supply for the farm is from a nearby river, which has not yet failed to deliver an adequate water supply to the farm, except during a very severe drought episode. Additionally, the ongoing advisory services from the relevant agencies, including R&D, have enabled the farm to adopt some of the new technologies that are appropriate under drought-prone conditions. Of particular importance was the adoption of technologies with regards to different irrigation systems, varieties and good agronomic practices.

5.7 Vegetable farmer

5.7.1 Introduction

Vegetable production is normally operated by small farmers, with farm sizes below 0.5 hectares. They are operated on a mixed-crop basis, comprising a whole range of vegetable types, mainly for the surrounding markets. The case chosen for this study was a farm of about 1.12 hectares. This is considered large by industry standards. The farm comprises of two separate parcels and both are fully irrigated; the first by sourcing its water supply from the nearby river, while the other parcel derives its water supply from the nearby springs. In some areas where irrigation was not possible, manual watering was practiced but this is limited to very small farms and during the growing stage of vegetable production.

5.7.2 Impacts of El Nino

The farmers did not face severe water shortages on their vegetable farms. On-farm irrigation was still available even during the 1997/98 El Nino episode. The negative impact was more from the combined effects of high temperatures and haze conditions. Some of the impacts obtained from the study are as follows:

- Slower growth observed on spinach, which resulted in a delay of harvest from the normal 25 days to 35 days.
- A general decline in production was also observed by the farmer. While the farmer normally harvested about 6,000 kg of vegetable products for each crop cycle, the volume decreased to 3,900 – 4,000 kg during the peak of the haze period. This was a reduction of about one third from what the farmer used to produce. However, the decrease in supply had been compensated with a slight increase in market price.
- There were more disease incidences prevalent during the hot and dry period. The farmers claimed that chilli plants were more susceptible to virus attacks during this period. Additionally, pest problems were intensified. As a result, more plant protection measures were needed and this increased the cost of production.
- There was some deterioration in the quality of selected vegetables. The reduction in solar radiation due to the formation of haze was suspected to result in the leaves of some brassica becoming more elongated. This negatively influenced quality and therefore market price.

5.7.3 Mitigating measures

Some of the mitigating measures undertaken were as follows:

- Since most vegetable types planted were of a short maturation cycle, the farmer adjusted the production cycle so that it could mitigate the effects brought about by water stress, hot temperatures and haze. Particularly for 1997, the choice of vegetable types differed slightly from what the farmer normally produced. Instead, the focus was on planting very short maturating vegetable types, such as brassica and spinach, both with a life-cycle of 30 and 25 days respectively, instead of the longer maturing types so as to reduce the risks. Through this approach, other risks such as the ones associated with increased pests and disease could also be minimized.
- A greater adoption of water conserving technology, such as the application of mulching in order to reduce water stress and alleviate the high temperatures which are detrimental to plant growth and development. The introduction of drip irrigation under plastic mulching made it possible to save water. Through this mechanism, moisture from the irrigation water is trapped under the plastic mulching and not evaporated as is the case without the plastic mulching.
- The introduction of a netted structure, which was a part of the controlled production system. The structure was originally designed to reduce the impact of rainfall during the wet season. In the dry season, the structure, with sufficient ventilation, was able to provide shade, hence lowering the temperature.
- There is strong possibility that a very severe and prolonged drought could even affect the availability of the existing water sources. In some cases, farmers utilised ground water as an additional source of water supply for his farm.

5.8 The case of the poultry farm

5.8.1 Introduction

The poultry farm chosen in this study was a small family-based farm, with annual production of about 35,000 broilers, on five cycles. Each cycle lasts about 42 days. This is a conventional production system, as is practised by almost all small poultry rearers in the region. The farm was established in 1987 and the farmer had good experience in dealing with the negative impacts of drought on poultry rearing, especially the long drought of 1997/98.

5.8.2 Impacts of El Nino

- The heat and moisture stress resulted in production losses due to slower body growth. For this particular farm, however, the effect of drought was not so much on water availability, but more so on the high temperature within the poultry housing which negatively affected the growth and operation costs. These effects were brought about by the following factors:
  a. There was an increase in health related problems in the birds due to their higher sensitivity to climate change and the resultant heat stress. There were more cases of pest and disease problems during the El Nino period. Hence, the cost of medicine increased from the normal level at RM 0.16 to RM 0.20 per bird, to that of about RM 0.25. This eroded the profit margin of the farm. Additionally, the farmer also claimed that the poultry were fed with food supplements in order to 'cool' down the body temperature.
  b. An increase in the mortality rate among the young chicks. Under normal conditions, the mortality rate ranges from 300 to 320 heads per cycle (about 4.3 per cent), but this increased two-fold to 600 to 700 heads, an equivalent of an 8 – 9 per cent mortality rate. That represented a large economic loss to the farmers.

5.8.3 Mitigating measures

The level of mitigating measures undertaken by the farmer depended upon the intensity and duration of the drought period. In a very severe and prolonged drought period accompanied by high temperatures, the farmer would ensure that the temperature within the house remains bearable to the broilers. The housing was fitted with automatic water mists. The duration of the spray for each cycle was fifteen minutes for the chicks and forty-five minutes for the broilers of age 30 days and above. The measure was effective in reducing the temperature of the housing. Improved ventilation systems further contributed to improving the environment within the housing.

5.9 The case of the aquaculture farm

5.9.1 Introduction

On the chosen farm, the farmer operated six ponds, each of size 100 feet by 200 feet. He had been in the business since 1990 and employed four permanent workers to support the operation. Five of the ponds were used for the rearing of catfish and the balance for the rearing of carp. Each pond was supplied with about 100,000 fish fries, most of which were imported from Thailand at a cost of about RM 0.04/fry. Daily harvest was about 150 – 180 kg, priced at RM 4.00/kg.

5.9.2 Impacts of El Nino

Water availability to the pond and the increase in water temperature were the two main problems faced by fish breaders during the El Nino episode. These two contributed negatively to the aquaculture operation and products of the farm due to the following reasons:

- The relatively higher temperature resulted in slower growth of the fish. The catfish, which normally could be harvested after 2.5 months, required an additional half a month in order to attain the standard size.
- The rate of mortality was higher, at about 30 per cent compared to the normal rate of between 10 per cent and 15 per cent. This was especially so for the catfish. The mortality rate for the carp was about 15 per cent, which is still higher than the normal rate of between 5 and 10 per cent.
- The increase in water temperature affected fish feeding. When the temperature of the water was higher, the fish became less active and avoided the water surface. Consequently, less food was consumed by the fish, resulting in feed wastage. It was estimated that, while in normal weather about 100 kg of feed per pond is required, the requirement was reduced to about 80 kg in the hot season. This had subsequently resulted in slower fish growth.
- The water supply for the pond was derived from a MADA irrigation canal. Hence, the depleted water volume or the delay in the release of water by the MADA authority during the drought period could upset the production schedule. Acidic build-up as well as poor oxidation could erode the water quality in the pond and affect the productivity of the farm.

5.9.3 Mitigating measures

In view of the importance of ensuring adequate water availability to the pond, as well as to avoid too high a water temperature during the growing stage of the fresh water fish, the operation schedule was planned so as to avoid the peak dry season. Since there are only three production cycles per pond per year, during the peak of the drought period (January to March) there was limited rearing of fish. Ponds were allowed to dry up and the farmer concentrated on the maintenance and upgrading of the ponds. Currently, this is seen to be the only effective mechanism to overcome problems associated with aquaculture production in the region. The farmers also outsourced new water supplies to ensure a continuous supply of water to the pond and not to be too dependent on the water source from the irrigation canal. Deep wells operated by pumps were introduced. Although this was not operated in a big way, it helped in alleviating the problem of water sourcing during a very dry period. The construction of some physical shades to reduce the water temperature is not only expensive but is also found to be impracticle. The planting of trees around the pond helps reduce water temperature but the dead leaves which fall into the pond would cause some level of fermentations and change the acidic level of the pond, hence reducing the water quality. It would also make fish harvesting more difficult.

6. Risk Management Strategy

The previous two chapters have extensively elaborated on the effects and impacts of El Nino induced climate change on agricultural development in the study area. As a whole, the impacts on agricultural production, both at the regional and farm levels, have not been very significant compared to other regions and also at the national level. Total economic losses due to El Nino events were only registered for paddy production. At the country level, for the three main agricultural products namely oil palm, rubber and paddy, the losses were estimated to be about RM 3.3 billion, (Tawang *et al*., 2002). The major contributor to that loss at the national level was from oil palm. The fact that the area under oil palm within the region under study was small is likely to be the explanation for this relatively small regional loss. However, another more important reason could be due to the effectiveness of the various risk management and coping strategies already in place which successfully alleviated the potential impacts of El Nino induced climate change on the agricultural sector in the region. In this chapter, these risk management and coping strategies adopted at the regional level are highlighted. Most of these strategies are in line with the approaches adopted by the country as were discussed in the previous study.

6.1 Regional climate monitoring and forecasting

Malaysian Meteorological Services (MMS) is the main agency that is responsible for climate monitoring and forecasting in the country. The agency provides a whole range of meteorological services, including weather surveillance. The department operates a network of observation stations to support the monitoring of weather conditions and seismic activity in the country. Within the region, there are two main meteorological observation stations, one in Kepala Batas in Kedah, and the other in Chuping, Perlis. Additionally, there are 24 other smaller stations that collect basic meteorological data such as rainfall, temperature and humidity. As part of its function, MMS issues routinely and timely meteorological information and forecasts to the relevant departments and authorities, as well as to the public at large. It also provides advance warnings on the occurrence of adverse weather phenomena in the region. The major 'clients' are the government departments and agencies involved in handling natural disasters and mitigation measures, agricultural development and the monitoring of environmental quality in the region.

With its active participation in international programmes as part of its international obligation in the field of meteorology and seismology, MMS has enhanced its capability in forecasting and predicting climatic variations. These capabilities have been utilized and extended to the regional and state levels so that mitigating measures can be put into place. Within this region, MMS has a good network and linkages especially with the state's Department of Irrigation and Drainage, Department of the Environment, Department of Agriculture as well as the MADA authority.

6.2 Water use management and conservation

Efficient water management practices are a critical factor to enhance crop productivity. The objective of good irrigation water management is to make water a stable input for agricultural productivity. This can be realized through the provision of a dependable irrigation water supply. Relative to the other agricultural regions in the country, the Kedah-Pelis region is one of the good examples of how good water use management can contribute positively to the efficient uses of the resource. The region successfully alleviated some of the problems associated with El Nino, particularly the prolonged drought in the region. This is especially so for paddy cultivation where such practices contributed significantly in sustaining the region as the main rice-bowl of the country. This is inspite of the fact that the irrigation infrastructure facilities, which include irrigation canals, are generally less superior in terms of canal density per hectare compared to the other newer, more modern setups in other granaries. This was made possible due to the various measures being undertaken in managing water resources in the region. Some of these measures are presented below.

6.2.1 Improvement in irrigation efficiency

Within the agricultural sector, and especially in the major irrigation schemes, the efforts to ensure the efficient and judicious use of irrigated water, especially during the time of rainfall deficit have been an ongoing affair. Several measures have been taken within the irrigation schemes to continue upgrading water-use efficiency within the irrigation schemes and avoid unnecessary wastage. Low (1996) indicated some of these efforts as listed below:

a The continued improvements to irrigation infrastructure by embarking on extensive development of tertiary infrastructures and ancillaries. This also involves the upgrading and improvement of major drainage systems to ensure the more efficient and timely distribution of irrigated water. Additionally, water conservation strategies that involve the rehabilitation of waterways and replacement of old control structures were also implemented.

b Enhancment of the management support services in irrigation schemes with total improvement in storage, delivery and distribution systems, collector drain systems and trunk drainage systems. Specific activities undertaken by the authority involved the following water management initiatives:

- Upgrading the in-storage system which involves the continuous maintenance of reservoirs and the development of 'supportive dams' as alternative water sources during the drought period.
- Enhancing the delivery system to ensure timely delivery of water supply. This involves the installation of intake structures to collect run-off and the installation of booster pumps to support the gravity flow when the water level is insufficient.
- Intensifying the distribution system through the continuous upgrading of tertiary canals supported by mobile pump units.
- Establishing a collector drain system as a water conservation measure by utilizing field, tertiary, and secondary drains and national depressions and swamps.

With the systems in place, they ensure the effective and efficient use of irrigated water in order to sustain agricultural production, even during times of water deficit.

6.2.2 Water recycling technology

As part of a water conservation strategy, water-recycling activities were introduced within the MADA Irrigation Scheme. With this approach, water demand from the dam for rice cultivation can be reduced. Using this technology, excess drainage water from rice fields is captured and the water in the drainage canal is pumped back into irrigation canals for reuse by using one or a series of pumps. Previously, this excess water was channelled into the sea. Currently, there are 22 pump houses and 685 mobile pumps in place for this purpose. About 5 per cent of the total water requirement in the scheme is from this source. The quality of the recycled water is comparable to that of original irrigation water. In fact there were cases of yield improvements due to the usage of recycled water (Sani *et al*, 1992). In the long run, as water use efficiency increases, the amount of water available for recycle purposes will decline.

6.2.3 Water management and control scheme

This was briefly discussed in an earlier chapter.The water management and control scheme was operationalized in 1998 in the MADA Irrigation Scheme with the purpose of optimizing the limited amount of stored water and other resources through accurate and timely assessments of the supply and demand of water (Low,1996). It is a decision making tool capable of real time reporting of rainfall distribution and strategic water levels in the dam and the irrigation canals. The major component of the system is the mainframe computer as host for all data processing and a central depository. Sixty-seven telemetric rainfall stations and computer terminals are linked to the host computer with VHF radio channels for voice communication.

The control centre collects large amounts of data, which are processed and transmitted to gate operators to ensure the timely and accurate delivery of water with minimum wastage. An indigenous system, called the Telemetry System, utilizes the information on rainfall and water levels at the dam to determine the right outflow of irrigated water to the farms. Basically, the system computes daily water demand for each irrigation block and subsequently indicates the amount of discharge required. At the moment, this is one of the important tools that is able to precisely and timely determine the amount of water to be released from the dam, almost on a day-to-day basis.This information is used in deciding the reduction of down releases from the dam to the irrigation canals, reallocation of water within the scheme and the drawing up of an irrigation schedule. The committee, comprising of the management of the irrigation schemes, farmers' associations and other relevant government agencies finalize the water availability schedule, which is then printed and distributed widely within the scheme. The committee is empowered to make 'critical' decisions, such as the cancellation of the whole 1978 off season planting, enforcement of the water supply cut-off date and so on (Low,1996).

6.2.4 Water ponding system

A simple, indigenous technology on water management is widely practiced on the sugarcane plantations. This was partly discussed in an earlier chapter. Since all of the sugar plantations are located in the drought prone areas in the northwest of Peninsular Malaysia, where severe droughts occurre almost routinely every four to five years, all the plantations are equipped with irrigation systems. The water sources are derived from the many small and scattered man-made lakes, made possible by damming up small creeks in this hilly and undulating topography. The storage water is sufficient to irrigate the field by using mobile sprinkler systems. The system was found to be very reliable, cheap and easy to maintain. When the need arises, more 'lakes' can always be constructed.

6.2.5 New water sources

The expected increase in demand for water, be it for household consumption, industrial or agricultural purposes prompted the need to exploit new water sources. At the same time there is a need to ensure the current water availability is protected and used judiciously. While the region as a whole receives an abundant quantity of water, as reflected by its total annual precipitation as compared to its demand, the uneven distribution of rainfall occurrence in both time and space results in fluctuations of river flows over a wide range. The provision of dams and reservoirs, including inter-basin transfer and pumping stations, has enhanced water resource supply to meet the irrigation demand. The construction of new dams would further ease the water stress situation in the region. As a long-term plan, there are strong commitments by the state government to protect the current water catchments areas. The construction of new dams and reservoirs are also on the development agenda in order to meet the increasing demand for water for all the economic sectors in the future.

6.2.6 Other short-term measures

Provision of small mobile pumps

Government agencies such as the Department of Agriculture maintain stocks of small irrigation tools and implements to be distributed or lent to affected farmers during a drought. These tools, in the form of small water pumps, irrigation tubes and others, are very helpful to the affected small farmers. These tools are used to irrigate water from either the rivers or ponds to their farms. These have been extensively used, especially in areas outside the MADA area, mainly for the annual crops such as vegetables, paddy and tobacco. The stocks of these irrigation implements have been on the increase, making it possible to cover a wider area and a greater number of farmers. These approaches have been helpful in alleviating some of the water problems faced by the small farmers especially during times of severe drought.

Cloud seeding

The use of cloud seeding equipment fitted into an aircraft for ‘rain-making’ purposes is another short-term measure. The agency responsible for conducting the activity is the Malaysian Meteorological Services, with the main purpose of making rain, especially in the water catchment areas.

These operations have been routinely carried out, especially when the water level in the dams has reached alarming levels. In the Kedah-Perlis region, the exercises were carried out in the Pedu and Muda reservoir areas, for the purpose of expediting rain formation in the area, hence filling up the reservoir from the resultant rains. The approach was also adopted in situations when the haze level was too ‘thick’, therefore, the resultant rain was used to ‘wash’ the haze down.

6.3 Science and technology

The development of new technologies and innovations through research and development activities have also been successful in mitigating some of the negative effects and impacts of El Nino induced climate change on agricultural commodities. The prominent achievements are as follows:

a The development of short maturating varieties.
Malaysia has been successful in developing a number of short maturating rice varieties. These varieties are grown extensively in almost all the rice growing areas. With a short maturation period of between 115 to 135 days, water requirements are less compared to the earlier long maturing varieties. A shorter rice season also means a less risky venture due to a shorter exposure to environmental hazards, be it in the form of drought or flood. The latest variety introduced to the farmers has a maturation period of only 100 days.

b The development of drought resistant paddy varieties.
MARDI keeps a gene bank where genetic resources of various genetic diversity are obtained for breeding. The collection, preservation and maintenance of a broad spectrum of rice germplasm, currently totaling about 10,000 accessions, are used as the source of breeding activities, including the development of drought tolerant varieties. Through the ongoing rice varietal development program, the breeding and selection of new varieties with the objective of developing high yielding varieties to suit different rice environments has been carried out.

c Water saving technologies.
New technology in water management can be a powerful tool to conserve irrigation water. Given that irrigated agriculture is the major water consumer in the country, a

small percentage reduction in irrigation water use could result in large savings in terms of water quantity. In this respect, new and improved procedures for on-farm water management have been formulated and developed. To minimize water use at the farm level, improved cultural practices have been introduced. These cultural practices could optimize water use efficiency while reducing water losses and wastage. Among the technology that has been adopted to reduce water usage is:

- The adoption of dry rotovation together with direct seeding in paddy production, thus dispensing with irrigation techniques which waste water resources, such as the deliberate drainage of paddy fields for sowing soon after the completion of pre-saturation.
- The use of micro-irrigation systems such as drip or trickle irrigation in fruit, vegetable and flower production. Such systems could reduce water usage by as much as half the conventional sprinkler system, hence reducing the water requirement as well as the energy required to pump water.
- The use of 're-circulating systems' in aquaculture and livestock farms where water is recycled for use after being filtered and treated in water treatment plants.
- Application of an automated water delivery system to ensure precise and efficient water use.

6.4 Farm management practices

Some of the crop management practices adopted by the farmers to mitigate the effects of El Nino were discussed in the respective case studies. Following are some additional practices adopted by some farmers in the region:

- The pruning of oil palm fronds and branches to reduce water loss. This was conducted fairly routinely by some farms and estates during severe drought periods.
- The placement of organic mulches such as the frond piles in the inter rows for the purpose of trapping moisture, hence reducing moisture loss. The practice was used especially on short-term crops such as vegetables and fruits.
- The construction of some kind of small-scale "water trap" mechanism to catch water during low rainfall periods.
- The introduction of short-term drought tolerant crops in areas where there is very limited water supply, especially during long droughts. Cassava is one crop that has been used for this purpose.
- Decrease the stocking rate of fresh water fish in ponds in order to reduce acidity.

6.5 Other policy measures

6.5.1 Economic diversification and income support programs

There is a need to diversify the sources of income among the resource poor farmers away from the agricultural sector. An over dependence on the agricultural sector, especially in the sector where the farmers are more exposed to the risks brought about by El Nino induced climate change need to be avoided. Currently, the poverty level is the highest in the agricultural sector, where about one quarter of all rice farmers and one-fifth of rubber tappers are within the poverty group. In this respect, current efforts by the government to diversify and improve the farmers' incomes by the introduction of specific income enhancement programs are commendable. Under the current 'Development Program for the Poorest', farmers are provided with direct income support as well as financial and other supportive measures to encourage their involvement into economic other than agriculture. The small farmers are also encouraged to seek employment in other economic sectors, notably in the manufacturing and services sector within their vicinity. Additionally, the introduction of the Micro Credit Scheme opened up new avenues for income earning opportunities among these resource poor farmers.

6.5.2 Introduction of El Nino/Drought Action Plan

Whilst drought incidence is not one of the major disasters facing the agricultural sector, the development of a drought action plan would be helpful in times of severe drought incidences. The current initiative by the government to develop the El Nino Action Plan is commendable and very timely. This effort should be able to establish the mechanisms to ensure better coordination and implementation of efforts to reduce the potential negative impacts of El Nino. The proposed action plan was based on the rainfall depletion indicator as a basis to indicate the severity of the impending drought period. Based on these severity levels for the different crop types, sets of actions to be taken by respective authorities and agencies are identified. Once adopted, the action plan should be able to coordinate and streamline the mitigating efforts among the relevant departments and agencies. An operation or control centre to process information and coordinate mitigating operations could be established when the drought situation reaches critical levels.

6.5.3 Contingency aid schemes for affected farmers

The previous El Nino episode caused adverse effects on some segments of the farming community. For example, the total loss experienced by some paddy farmers, although on a small scale, warrant the introduction of some contingency plans. A government-sponsored scheme to provide some aid to the affected farmers so as to protect their livelihood and welfare during such episodes is already in place, especially for those involved in natural disasters. The planned crop insurance scheme, for small farmers, should be able to provide some level of income-security to them in the event of crop disasters and failures. Provisions of soft loans and extending loan payback periods have been practiced in the past but they cover mainly the farmers who are affected by floods. Similar provisions could be extended to farmers affected by severe drought.

7. Conclusions

This study has highlighted the various effects and impacts of El Nino induced climatic change, specifically on the agricultural sector in the northwest region of Peninsular Malaysia. As was the case at the country level, the changes in climatic variables recorded in the region were a decrease in total rainfall, higher monthly deviation in rainfall, significantly higher temperatures and a deterioration in air quality. Greater climatic variation during the 1997/98 El Nino confirms the established fact that the episode was the most severe among all the other El Nino episodes beforehand. This was reflected by a significant decrease in rainfall and air quality, and a greater increase in daily temperatures compared to the earlier El Nino episodes. This study also made quantitative assessments on the effects of El Nino on the agricultural sector. Contrary to what was expected, the impacts were relatively milder within the region. Whilst the overall effect of climate variability on the production of major economic commodities was quite substantial, the direct losses due to the occurrence of El Nino over the past 20 years were only registered in paddy production with economic losses of about RM 237.8 million. Similar losses were not experienced by rubber and oil palm. The assessment at the farm level yielded similar results. In fact, there were cases on individual farms and estates, such as in rubber and sugarcane production, where El Nino incidences resulted in positive impacts in terms of farm outputs. Similarly, while some farmers indicated some levels of economic losses due to El Nino, the degree of loss was generally minimal and still within tolerable levels. In general, these findings indicate that there were large differences between the impacts at the national and regional levels. Whilst the national level impact on economic losses for oil palm, rubber and paddy were fairly significant at RM 3.3 billion for the last twenty years, the regional total for similar commodities was only at about RM 238 million, which was totally from paddy. Furthermore, these losses were suspected to come from the paddy areas outside MADA irrigation scheme.

There are strong possibilities that the introduction and subsequent application of the various mitigating measures were successful in minimizing the El Nino induced climate change, especially within the MADA irrigation area, sugarcane plantations and tobacco farms. In addition, since the occurrence of drought in the region is fairly normal every year, the farmers are better prepared to face the phenomena compared to other farmers in other regions. Hence, the effects have been kept to a minimum.

There are definitely lessons that can be learned from the successful application of the various mitigating measures undertaken in the region. For one, the high level of ingenuity in government agencies and farm operators, especially those involved in water management is highly commendable. The establishment of the various indigenous technology in managing the irrigation water such as the use of recycled irrigated water, water control management systems, water ponding technology and other water saving technology clearly indicates their applicability and should be replicated at least to the other regions of the country. Additionally, the support provided by the relevant departments and authorities was instrumental in making sure the region did not face serious water problems during the previous El Nino episodes.

Despite these successes, efforts to further improve and strengthen the existing mitigating mechanisms must be pursued continuously, especially with regards to water resources. With the increasing demand on water resources from domestic and industrial uses, which will always be given higher priority over that of irrigation water, the challenge to ensure the continued availability and accessibility of adequate water to the agricultural sector will be greater in the future. In light of this, more efficient methods than what are being practiced now must be generated, new sources of water supply must be exploited, and new and more water saving technologies must be made available. All these require the collective efforts of all; the government to ensure appropriate policy directions, the various departments and agencies to ensure the continued generation and adoption of the best management practices of water resources and the better understanding of water and soil relationships, and the estate management and the farmers to ensure that agricultural production can continue, even with less water resources on hand.

Admittedly, the region is fairly comfortable with regard to its capacity to manage water resources efficiently as indicated from the study. However, the same cannot hold true with regards to the issue of high temperatures and thick haze formation that were known to also effect productivity in agricultural sector. These issues have not yet been given similar emphasis as that of the water issue and this must be rectified. Granted that their impacts have been negligible, as was also indicated in this study but this might not be so in the future. The sharing of knowledge, especially in these areas, is definitely a good starting point and must be encouraged.

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CGPRT CENTRE
Publication Section

Editor: Matthew L. Burrows

Production: Agustina Mardyanti
S. Tayanih (Yayan)

Distribution: Fetty Prihastini

Printer: SMK. Grafika Desa Putera

ISBN 979-9317-30-4

The CGPRT Centre
Working Paper Series, August 2003