Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 75

Multilevel Impact Assessment and Coping Strategies against El Nino: Case of Food Crops in Indonesia

Bambang Irawan

United Nations

The CGPRT Centre

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Multilevel Impact Assessment and Coping Strategies against El Nino: Case of Food Crops in Indonesia

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

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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 and location to location depending on the 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 Indonesian country study of the ELNINO project, provides relevant policy recommendations based on rich and useful information derived from an in-depth study conducted in Lampung Province on Sumatra Island.

I thank Dr. Bambang Irawan for his sincere efforts. His fruitful work is truly appreciated. This three-year, wide ranging research project could only be accomplished with the continuous support from the Indonesian Agency for Agricultural Research and Development (IAARD) and the Indonesian Center for Agricultural Socio-Economic Research and Development (ICASERD).

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.

October 2003

Nobuyoshi Maeno
Director
CGPRT Centre

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The study entitled " Multilevel Impact Assessment and Coping Strategies against El Nino: Case of Food Crops in Indonesia" is the second phase of the El Nino study under the research project, "Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries" which was sponsored by the UNESCAP CGPRT Centre. This El Nino study was undertaken in five countries including Indonesia, Malaysia, the Philippines, Thailand and Papua New Guinea.

I am very grateful to the CGPRT Centre for providing the opportunity to my country to be one of the participants of the study. In this regard, I appreciate the contribution of Dr. Haruo Inagaki, former Director of the CGPRT Centre, for his deep interest and guidance in the preparation and implementation of the study. High appreciation is also due to Dr. Nobuyoshi Maeno, Director of the CGPRT Centre; his leadership motivated us to finalize the study with best efforts.

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October, 2003

Bambang Irawan
Indonesian Center for Agricultural Socio-Economic Research and Development
Agency for Agricultural Research and Development

Executive Summary

El Nino and La Nina: tendency of occurrence and impact on food production

El Nino events which occur for at least 4 months successively and have a high probability to induce drought and food crop failures, have shown an increase in their frequency during the last 25 years, from 3 events between 1925 and 1975, or once every 16 years, becoming 6 events during 1976-2000, or once every 4 years. El Nino magnitude, shown by extreme negative SOI, also inclined to increase, from averaging -14.7 between 1925-1975 to -17.5 between 1976 and 2000. Likewise, the duration of El Nino events has also increased from an average of 6 months during 1951-1975 to 9 months during 1976-2000. Most of the El Nino events occurred during the dry season, April - September. Such patterns of occurrence are disadvantageous for food production in Indonesia because during the dry season farmers usually suffer from water shortages and El Nino events usually lead to rainfall decreases. Consequently, El Nino is inclined to detrimentally affect water insufficiency problems faced by farmers.

Contrary to El Nino which causes rainfall decreases, La Nina events are usually followed by increases in rainfall. Most La Nina events occur during the wet season, primarily during November - February. La Nina events can actually result in positive impacts on food production due to the increase of water supply but can also be destructive due to floods and the increase of pest perturbations. The frequency of La Nina events has decreased from once every 8 years between 1925 and 1975 to once every 12 years during 1976-2000. Likewise, the duration of La Nina events has decreased from about 10 months in 1925-1975 to 7 months in 1976-2000, while La Nina magnitude, which is shown by extreme positive SOI, decreased from an average of 16.1 in 1926-1950 to 13.7 in 1976 - 2000.

The above discussion concludes that in the future, El Nino events will be a more serious climatic anomaly than La Nina, due to its increasing frequency, duration and magnitude. El Nino events that occurred from 1968 - 2000 (7 events) have, on average, caused food production losses of 3.06 per cent, whereas La Nina (5 events) resulted in food production increases of 0.64 per cent at the national level. Four provinces experienced significant decreases in food production (production losses of 5.4 per cent to 12.5 per cent) during El Nino events, they are the provinces of South Sumatera, Lampung, East Kalimantan and Irian Jaya. Five other provinces with food production quite sensitive to El Nino events (production losses of 3.2 to 4.9 per cent) are Riau, Jambi, West Java, Central Java and Yogyakarta. In general, there are two major factors that cause variations in production loss in the various provinces, i.e. geographical position of the province and social capacity in anticipating possible production decreases due to drought. Geographical position of the province determines the magnitude of the El Nino impact on rainfall decreases in the related province, whereas social capacity determines the magnitude of production loss which can be reduced through mitigation efforts performed by farmers.

Among the seven food crops which have been analyzed in this study (wetland rice, dryland rice, maize, cassava, groundnut, sweet potato, and soybean), maize production was the most sensitive to climatic anomalies events nationwide. On average, maize production increased by 9.5 per cent during La Nina but decreased by 10.6 per cent during El Nino. Production of wetland rice and cassava is least sensitive to El Nino, with production losses of only 2.2 per cent and 1.3 per cent respectively, while for other food crops the figures range from 2.9 per cent to 4.8 per cent. In general, there are three factors which determine the level of production loss caused by El Nino, they are: (1) Adaptability of the crop to water stress or drought situation, (2) Availability of an irrigation network for the cultivated crops, and (3) Cropping pattern applied by the farmer. Production loss will be higher for food crops which are usually cultivated during the dry season since El Nino events usually occur in this period.

Even though the rate of production decrease caused by El Nino was relatively low, the probability of production decreases of wetland rice was the highest among food crops cultivated by farmers. During seven El Nino events from 1968 to 2000, 69 per cent of wetland rice cultivated in 25 provinces was affected. Frequency in the cases of production decreases for wetland rice increased from 61 per cent for the period prior to 1985 to 75 per cent after 1985. This reveals that the probability of production decreases for wetland rice due to El Nino have been inclined to increase recently. This could be a result of the decreasing social capacity in anticipating any possible production decreases due to El Nino, and due to the increase in duration and magnitude of El Nino.

Basically, food production decreases result from a decline in harvest area and/or decreases in yield per hectare. During El Nino events, the probability of a decline in harvest area is generally higher than a reduction in yield, just the opposite of La Nina. This shows that the impact of El Nino on food production is more likely to be caused by reduced area, while a lower yield per hectare is the major constraint to production during La Nina. The lower yields during La Nina events are often the result of increases in pest perturbation associated with more rain.

Taking the case of the El Nino in 1997/1998, the province of Lampung showed that rainfall in the province decreased on average by 59 per cent in the dry season of 1997 and 21 per cent in the wet season of 1997/1998. In the dry season of 1998 and the wet season of 1998/1999 rainfall in Lampung increased as a result of La Nina. This case study also revealed that the El Nino event not only led to crop damage through its impacts on drought and water insufficiency, but also through its impacts on the increase of pest perturbation. Increasing pest perturbation, primarily locust and rat, primarily occurred during the wet season of 1997/1998, after a long period of drought in the dry season of 1997. Pest increases also occurred during the following two cultivation periods due to La Nina.

El Nino impacts on food area decline were greater in the dry season than in the wet season. During the El Nino episodes that occurred between 1975 and 2000, food crop area in Lampung decreased on average by 5.58 per cent in the wet season and 15.03 per cent in the dry season. Large area decline in the dry season generally occurs for food crops cultivated on dryland areas, such as dryland rice, maize, cassava, groundnut, sweet potato and soybean. The largest decrease in harvested area during El Nino events in the dry season was for dryland rice due to its high water requirement. Harvested area of soybean also declined steeply since soybean is very sensitive to water stress, whereas area decline of cassava was the lowest since cassava has a high adaptability to water availability.

To mitigate production loss due to El Nino-induced drought in 1997, earlier harvesting than usual was the most common measure employed by the farmers. By choosing this mitigation measure, indeed farmers obtained lower yields in terms of the grain, but the plant leaves could be utilized as feed for their livestock. Some farmers also tried to extract and pipe water from swamp areas located close to their wetland fields. Yet, despite the various efforts employed by the farmers, food production loss in the dry season was still very high, at 55 per cent and 41 per cent for maize cultivation on dryland and wetland respectively, 34 per cent for wetland rice, and 19 per cent for cassava.

The El Nino in 1997/1998 which also enveloped the wet season led to a delayed planting date 1 or 2 months later than usual. During the wet season of 1997/1998, pest perturbation, particularly locust, was more pronounced than drought disaster. To mitigate production loss caused by locust, earlier than normal harvesting was the most common practice employed by farmers. The application of more pesticides was also carried by some farmers. However, these various efforts were ineffective due to the very high locust population. Production loss due to locust attack in the wet season of 1997/1998, on average, was 35 - 36 per cent for maize which is usually cultivated on dryland areas, whereas for wetland rice it was around 39 - 58 per cent.

Although food production loss due to the 1997/1998 El Nino was very significant at the farm level, its impacts on household food security were not significant. Calorie intake of staple foods during El Nino was only 2 per cent lower than the usual consumption. Consumption shift from rice to dried cassava was the major strategy performed by farmers to overcome the shortfall in rice production. In addition to this strategy, some of the farmers also had to sell their jewelry, livestock or undertake off-farm working and borrow money from their neighbors to purchase rice. Some of the rice consumed during the El Nino of 1997/1998 also came from famine rice barns managed by farmer groups.

Governmental coping mechanisms

Based on the time frame, risk management strategies against climate variability can be grouped into three categories: (1) Ex-ante strategy or before the event, (2) Interactive strategy or during the event, and (3) Ex-post strategy or after the event. The primary goal of strategy (1) and (2) is to reduce possible losses caused by bad climate, while strategy (3) is more focused on recovering losses and other negative consequences induced. Those three strategies can be applied at multiple levels of analysis: farm level, household level, local community level, and national level.

At farm and household levels, interactive strategy is the most common performed strategy. Earlier harvesting to reduce production loss due to drought and increased pesticide use to anticipate pest increases caused by El Nino are examples of interactive strategy implementation. Experience in Lampung showed that this strategy was not effective because the drought and pest disturbance was very severe. However, these were the only mitigating measures that could be carried out by the farmers and they could not perform ex-ante strategies such as changing cultivation to a variety or crop tolerant to water stress; the unavailability of El Nino forecast information was the major cause of this.

Coping mechanisms implemented by the Indonesian government in anticipating El Nino are briefly described as follows:

A. Ex-ante strategy

- Rainfall forecasting by the Indonesian Bureau of Meteorology and Geophysics. Rainfall forecasting was conducted for the dry season and wet season in 102 rainfall zones in Indonesia. This information, however, could not quickly be obtained by farmers since there is no institutional mechanism for distributing the information to farmers. During the 1997/1998 El Nino, the additional problems of political and economic crisis contributed greatly to the late delivery of climatic information to farmers. To improve the dissemination system of climatic information, particularly those related to El Nino and La Nina, in 2000, climate task forces were established in every province and at the national level. These climate task forces involve multi-governmental institutions (Agriculture Office, Irrigation Office, Meteorological and Geophysics Agency, etc.) and its activities are coordinated by the provincial governor.
- Water pump program. This program was aimed to create new water sources whenever water shortages induced by El Nino occurred. The program was predominantly run on wetland areas located in the lowlands for two reasons: (1) Low investment is required and low risk of investment return, and (2) Most of the rice, a staple food for Indonesian people, is produced on wetland fields. The program, which involves support from the government’s budget for purchasing shallow tube, wells and water pumps, however, was not effective for creating new water sources for rice farming,

because during the occurrence of El Nino the volume of water which could be obtained was very limited. Technical mismanagement contributed also to the low effectiveness of the program in mitigating water shortages for rice farming during El Nino events.

- The establishment of famine rice barns is something carried out by the government to anticipate food insufficiency during a famine season caused by climate variability. This policy was initialized in 1999, after the occurrence of the food crisis in 1997/1998. The priority for the program was in poor areas which often had insufficient rice supply during famine seasons, such as in remote areas, usually in upland areas. For its implementation, the management of the rice barns was undertaken by Farmer Groups with a membership of 30 - 40 farmers per group.
- Development of tolerant-to-water-stress rice varieties. This strategy was undertaken to assist farmers in adapting cropping patterns in order to reduce possible production failure caused by drought. Nine tolerant-to-drought rice varieties have been launched by the government, yet their utilization by farmers is still very low. For example, during the El Nino event of 1997/1998, the application of tolerant-to-drought rice varieties in Java was only 1 - 2 per cent from total wetland rice area. Three contributing factors were: (1) Farmers had no knowledge when was the appropriate time to apply drought-tolerant-rice varieties, particularly during the El Nino event, because farmers' accessibility to the required climatic information was and is very limited, (2) Water-stress-tolerant rice varieties generally are less paletable than normal cooked rice, and (3) Seed producers were rather reluctant to produce drought-tolerant rice varieties due to their weak demand from the farmers.

B. Interactive strategies

- Distribution of seeds to farmers. This effort was mainly aimed at wetland rice cultivation in order to maintain food security. Seed distribution was carried out as an effort to help farmers conducting replanting. During the El Nino of 1997/1998, this effort did not succeed in reducing production loss of wetland rice in Lampung because of the very long drought and the increased attacks of locust and rat.
- Social Safety Net (SSN) Program. This program was initially established in 1998, due to the El Nino and economic crisis that occurred in 1997/1998. Rice production sharply decreased, which caused rice imports to rise to a level of 5.8 million tons or an increase of more than three times the previous year. Falling rice production, which was followed by price hikes due to the economic crisis, meant that some low income families could not afford rice at market price, about Rp 3,000 - Rp 4,000 per kilogram. To overcome this food problem, the government distributed subsidized rice at a price of Rp 1,000 per kilogram. The rice distribution program was conducted by BULOG (National Food Agency) in coordination with local governments.
- Utilization of swamp areas for rice cultivation. During El Nino events, which cause drastic decreases in rainfall, production of wetland and dryland rice usually decreases due to water shortages. However in swamp areas, rainfall decreases caused by El Nino enable the availability of more cultivable area for rice due to the excessive water, which usually occurs under normal climatic conditions to evaporate. This type of agricultural land is mostly located outside of Java, such as on Sumatera, Kalimantan and Sulawesi. In anticipating El Nino, which is again estimated to occur in 2003, the government has planned rice intensification programs in swamp areas totaling 350 thousand hectares.

C. Ex-post strategies

The primary impact of the El Nino event in 1997/1998 was radical production decreases of rice, which in turn, led to substantial increases in rice imports totaling 5.8 million tons in 1998. The increase in import volume caused the share of imported rice in the total national rice supply to increase from around 5 per cent in the previous year to 15 per cent in 1998. The increased dependence on imported rice is disadvantageous for national food security since the world price of rice is unstable and increased rice imports could waste foreign currency reserves, which had just been lowered due to the monetary crisis. In order to recover from the fall in rice production caused by El Nino, the Indonesian government carried out a rice intensification program named the Rice-IP 300 Program on particularly well-irrigated land. The program's goal was to increase cultivation intensity of wetland rice from twice per year to three times per year, by substituting non rice crops and fallow land with rice during the dry season. The implementation of this program increased wetland rice production in 1999 by as much as 3.78 per cent. However, the implementation of this program in several regions caused increases in the rice pest population during the following wet season, after the program had ended. The major cause was the extension of the pest's natural cycle which is usually cut off naturally when farmers cultivate rice only twice per year.

1. Introduction

1.1 Background

Since the 1980s, El Nino events, which cause abnormal weather changes, have been recognized as one of the causes of agricultural production failure. El Nino-related abnormal weather seriously disturbs the fundamental modes of crop cultivation and damages the production of food and other commodities in the affected areas. The El Nino phenomenon has tended to increase in its frequency of occurrence, magnitude, duration and irregularity in recent years and as such, is now one of the most dangerous factors in agricultural production. Accordingly, it is an urgent matter for agriculture, especially for rainfed upland agriculture, where most CGPRT crops are grown, to establish institutional countermeasures in order to minimize and recover from the damage caused by this weather anomaly.

Firstly, it is extremely important to elucidate the impacts of El Nino on food crop production, especially in vulnerable areas. Rural economic structure, infrastructure, resources and farming systems in the vulnerable areas are among the most important determinants of social potential to cope with the damage and will therefore be the main focus of the study. Secondly, it is important to clarify impacts on food security, mitigation strategies to cope with the damage at farm and household levels and factors or constraints related to the realization of these strategies. Depending upon the outcome of the analysis, strategic policies to overcome El Nino problems will be proposed.

This study is the second phase of the El Nino study which was undertaken by the CGPRT Centre in five vulnerable countries including Indonesia, Malaysia, the Philippines, Thailand and Papua New Guinea. The first phase of the study showed that the El Nino phenomenon has been increasing in its frequency of occurrence, magnitude and duration in recent years, which has led to substantial decreases in rainfall, irrigation water supply and food production at the national level. Experience from 1982/1983 and 1997/1998 showed that El Nino-related abnormal weather can lead to cultivatable area decline at the national level, ranging from 1 per cent to 38 per cent for various food crops cultivated in both the wet and dry season. In general, the impacts on food area are more severe in the dry season than the wet season, and most El Nino vulnerable areas are located in upland regions where most CGPRT crops are grown such as soybean, maize, groundnut and sweet potato.

El Nino, which is usually accompanied by a decrease in rainfall and temperature increases, can induce negative impacts at all levels of the farming system such as the farm level, household level and community level. Increasing production risk due to insufficient water supply is a common threat at the farm level while food security is an issue at household and community levels, representing social consequences that can be induced. Accordingly, impact analysis at various levels of the system is extremely important in order to develop appropriate strategies to handle the El Nino problem. Understanding the possible mitigation measures at each level of the system and the related constraints is also important for the development of an effective coping mechanism.

The first phase of the El Nino study in Indonesia, however, did not reveal the extent of El Nino impacts on production at the farm level, what efforts are undertaken by farmers to reduce possible production decline and what constraints are faced by farmers to implement efficient coping mechanisms. El Nino impacts on household food security, mitigation efforts applied by farmers to overcome their consumption problems and the role of local institutions or the local government in handling the consequences of El Nino were also neglected by the first phase of the study. Accordingly, the second phase will focus on these problems.

1.2 Objectives

In general, this study focuses on two subjects: (1) Impact assessment of El Nino at the farm level and household level, and (2) Assessment of coping mechanisms applied by farmers, the local community and the local government in particularly vulnerable areas to El Nino. More specifically the objectives of the study are:

- To elucidate El Nino impacts on decreases in rainfall and food production in selected vulnerable provinces.
- To elucidate El Nino impacts on farming activities including water insufficiency, crop perturbation and production decreases.
- To elucidate El Nino impacts on household consumption, primarily staple food consumption.
- To elucidate farmer's strategies in mitigating El Nino consequences both at farm and household levels, and constraints faced by farmers in implementing effective coping strategies.
- To elucidate the role of the local community and the local government in handling the consequences of El Nino, both at farm and household levels.

1.3 Study region

The first phase of the El Nino study revealed that food crop area decline due to the El Nino of 1997/1998 varied by province, ranging from 5,200 hectares to 231,000 hectares or from 0.7 to 19.2 per cent of the total food crop cultivation area in each province. Five provinces that experienced high food area losses (or area losses of more than 100,000 hectares) were Lampung, West Java, Central Java, East Java and South Sulawesi (Irawan, 2002). Among these provinces, the highest rate of area decline was observed in Lampung i.e. -18.4 per cent while other provinces ranged from -4.6 per cent to -9.2 per cent. Area decrease of each food crop (rice, maize, soybean, groundnut, sweet potato and cassava) in Lampung was also higher than the provincial average, both in acreage and percentage values. This means that the province of Lampung is the most sensitive region to El Nino, and accordingly, this study was conducted in Lampung.

Among the 10 districts of Lampung, the district of Lampung Tengah represents the main producer of food crops, contributing 33.4 per cent of total food crops cultivated in Lampung while the contribution of other districts ranges from 1 per cent to 22 per cent. During the El Nino of 1997/1998, most of the food area decline in Lampung was observed in Lampung Tengah, and therefore, this study was focused in Lampung Tengah. Four closely located villages of Kecamatan Gunung Sugih in the district of Lampung Tengah were selected as research sites, they are the villages of Binjai Agung, Kedatuan, Trimulyo and Tanjung Pandan. Most of the agricultural land in the four villages is dryland, rainfed or simple irrigated land. Dryland is non-irrigated land usually allocated for non-rice food crops, rainfed is non-irrigated land allocated for rice, and simple irrigated land is irrigated land with its main water source from small surrounding rivers.

1.4 Data collection and household sampling

Historical secondary data from various publications and official reports from local government institutions was the main data used for impact analysis of El Nino on rainfall, crop perturbation and food production loss at the provincial level. The main sources for the basic data were: (a) The Australian Bureau of Meteorology for Southern Oscillation Index (SOI) data, (b) Central Bureau of Statistics for food crop area, production and yield data, (c) The Office of

Public Work for rainfall data, (d) The Office of Protection of Food Crops and Horticulture for drought and pest disaster data, and (e) The Agricultural Agency for other related data.

Primary data, which was collected from farmers and stakeholders in the four selected villages, was the predominant data used for the impact analysis of the El Nino of 1997/1998 at farm and household levels, and the coping mechanisms applied by farmers and the local community. Household data was collected from 40 sample households, and was obtained from farmers who were capable of communicating well their experiences during the El Nino of 1997/1998. This criteria of household sampling was applied because it is not an easy task to explain accurately experiences that happened several years ago. The data collected consists of three classifications of information: (1) Climatic conditions and other related parameters during El Nino events, (2) Impact of El Nino on cultural practices, agricultural production and staple food consumption, and (3) Mitigation measures applied to reduce possible production failure and food problems induced by El Nino.

2. Impacts of El Nino and La Nina in Indonesia

Variability in production caused by climatic conditions is one of the major constraints in developing the agricultural sector. El Nino and La Nina represent abnormal climatic situations that can affect agricultural production through their impact on water availability and temperature changes. The impact, however, varies by region and depends on the severity of the phenomenon affecting the local climate and the social capacity in anticipating the damage to agricultural production. Variations in severity may also be found among the different crops cultivated because each crop has a different capacity in adapting to variability in climate.

Accordingly, it is extremely important to elucidate the long-term tendencies of abnormal weather change, or El Nino and La Nina cases, which includes frequency of occurrence, magnitude and duration of occurrence. It is also important to clarify how far the phenomenon influences food production failure nationwide, by province and by crop but primarily in Lampung, the province where micro analysis was conducted. Using Southern Oscillation Index (SOI) data published by the Australian Bureau of Meteorology, this section presents the tendencies of El Nino and La Nina events in the long-term, from 1875-2000. Also presented are the consequences on agricultural production, particularly for food crops between 1975 and 2000.

2.1 El Nino and La Nina: long-term patterns of occurrence, magnitude and duration

Meteorologically, the occurrence of El Nino and La Nina events are commonly measured by Southern Oscillation Index (SOI) and Sea Surface Temperature (SST) across the Pacific Ocean. Negative extreme values of SOI indicates El Nino events while La Nina events are indicated by positive extreme values of SOI. However, due to variations in timing and geographic patterns of warming, defining El Nino and La Nina events universally is difficult (World Meteorology Organization, 1999).

In Southeast Asia and Australia, SOI values are highly correlated with rainfall and accordingly, the SOI is known as a good indicator of rainfall (Podbury *et al*., 1998; Yoshino *et al*., 2000). The values of SOI during normal climate are around zero or range from negative 1 to positive 1. In cases of extreme negative SOI or El Nino events, rainfall drops significantly below the normal, in contrast to extreme positive SOI or La Nina events (Yoshino *et al*., 2000). Consequently, potential impacts of El Nino and La Nina on agricultural production through their effects on rainfall decreases or increases, highly depend on the abnormality of the SOI values. When SOI values are very low or less than -10, the possibility of severe rainfall decline due to El Nino occurs, while if SOI values are greater than 10, high rainfall increases might be induced by La Nina (Fox, 2000).

As such, the magnitude of El Nino or La Nina is quantitatively indicated by extreme negative or positive SOI values. However, decreases in rainfall due to El Nino or increases due to La Nina do not always significantly influence agricultural production if these climate anomalies occur for a relatively short duration. In general, El Nino or La Nina significantly influence food production if the events occur during four months successively, or in other words, they cover the entire cultivation period (around 100 days from planting until harvesting). If this happens, it can be very dangerous for farmers since the occurrence can destroy crops at all growth stages due to water shortage.

Using monthly SOI data from the Australian Bureau of Meteorology from January 1875 to September 2000, Table 2.1 shows El Nino and La Nina events that covered at least 4 months successively. It was assumed that the months covered by an El Nino event are those with a large negative SOI (less than the average monthly negative SOI during 1876-2000 subtracted by 0.5 its standard deviation). The same method was applied to identify La Nina episodes which are indicated by large positive SOI values. In general, months with SOI values less than -10.0 were included as El Nino episodes, while those with SOI values greater than 10.0 were included as La Nina episodes.

During the 1875-2000 period, 18 cases of El Nino and 15 cases of La Nina occurred (Table 2.1). The longest duration of El Nino occurred in 1940/41 covering 20 months, while for La Nina the longest period was 16 months, occurring twice, once in 1878/1879 and again in 1955/1956.

Table 2.1 Occurrence of El Nino and La Nina from 1875-2000

Climate anomaly	Year	Period of occurrence	Duration (months)	SOI value		
				Average	Minimum	Maximum
El Nino						
1	1877/88	06/77-03/78	10	-13.9	-21.1	-8.2
2	1882	06/82-09/82	4	-18.4	-25.6	-12.0
3	1888	03/88-07/88	5	-15.6	-23.6	-9.8
4	1896/97	05/96-05/97	13	-19.3	-42.2	-7.4
5	1905	02/05-07/05	6	-30.0	-42.6	-16.8
6	1911	06/11-10/11	5	-11.5	-12.8	-8.8
7	1912	02/12-05/12	4	-15.1	-21.1	-9.0
8	1914/15	06/14-05/15	12	-15.0	-21.6	-8.6
9	1923	07/23-11/23	5	-13.1	-18.5	-8.2
10	1940/41	03/40-10/41	20	-14.6	-29.4	-8.2
11	1965	06/65-11/65	6	-15.0	-22.6	-11.1
12	1972	05/72-10/72	6	-13.6	-18.6	-8.9
13	1977	05/77-12/77	8	-12.9	-17.7	-9.4
14	1982/83	06/82-04/83	11	-24.2	-33.3	-17.0
15	1987	02/87-09/87	8	-17.4	-24.4	-11.2
16	1991/92	09/91-04/92	8	-16.5	-25.4	-8.3
17	1994	03/94-12/94	10	-15.4	-22.8	-10.4
18	1997/98	03/97-04/98	14	-18.8	-28.5	-9.1
La Nina						
1	1878/79	07/78-10/79	16	15.0	8.1	22.6
2	1886/87	08/86-03/87	8	12.3	10.0	14.4
3	1889/90	11/89-03/90	5	18.2	11.0	23.0
4	1903/04	12/03-04/04	5	17.5	9.4	31.7
5	1906	08/06-11/06	4	16.2	9.1	21.7
6	1910	06/10-12/10	7	16.2	9.8	22.0
7	1917/18	02/17-02/18	13	21.2	10.0	34.8
8	1938	05/38-08/38	4	15.7	13.0	18.5
9	1950/51	02/50-01/51	12	16.5	7.6	26.9
10	1955/56	05/55-08/56	16	13.5	9.3	19.2
11	1970/71	09/70-04/71	8	16.3	10.3	22.6
12	1973/74	08/73-05/74	10	16.3	9.7	31.6
13	1975/76	06/75-03/76	10	16.9	11.8	22.5
14	1988/89	07/88-01/89	7	15.1	10.8	21.0
15	1998/99	06/98-01/99	8	12.2	9.8	15.6

Source: Australian Bureau of Meteorology. (http:/www.bom.gov.au/climatic/current/soihtm1.shtm1).

The frequency of El Nino occurrence has tended to increase since 1925; 1 case in 1926-1950, 2 cases in 1951-1975, and 6 cases in 1976-2000 (Table 2.2). Average SOI values for each El Nino case included in these 3 periods have also continuously decreased in value, increasing El Nino magnitude; -14.6 in 1926-1950, decreasing to -14.8 in 1951-1975 and decreasing further to -17.5 in 1976-2000. This reveals that El Nino events from 1925-2000 have inclined to increase both in occurrence and magnitude. Against exceptations, it seems that there was no increase in the duration of El Nino between the three periods. However, the long duration of El Nino in 1926-1950 is the result of a spectacular El Nino in 1940/1941, which lasted 20 months. Therefore, if the El Nino of 1940/1941 is removed from the average calculation for the 1926-1950 period, El Nino duration shows an increasing trend when observed over the long-term.

Table 2.2 Total number of cases of El Nino and La Nina events by period from 1875-2000

Event	Variable	Period 1875-1900	1901-1925	1926-1950	1951-1975	1976-2000	1875-2000
El Nino	Total number of cases	4	5	1	2	6	18
	Average duration (months)	8.0	6.4	20.0	6.0	9.3	8.4
	Average SOI	-16.8	-16.9	-14.6	-14.8	-17.5	-16.7
La Nina	Total number of cases	3	4	2	4	2	15
	Average duration (months)	9.7	7.3	8.0	11.2	7.5	8.9
	Average SOI	15.2	17.8	16.1	15.9	13.7	15.9

Source: Australian Bureau of Meteorology. (http:/www.bom.gov.au/climatic/current/soihtm1.shtm1).

It is clear that El Nino events have tended to increase in occurrence, magnitude and duration. However, there is no clear tendency for La Nina, both in occurrence and duration of episode. One clear pattern of La Nina is observed in terms of average SOI value or magnitude of event. The average SOI value of La Nina decreased from 16.1 in 1926-1950 to 15.9 in 1951-1975 and 13.7 in 1976-2000. This reveals that the magnitude of La Nina has tended to decrease although its occurrence and duration has not shown any consistent tendency in the long-term. In other words, possible damage to food crops caused by climatic variability expressed in terms of El Nino events or rainfall decline is more pronounced in the long-term than for La Nina events which are usually followed by rainfall increases.

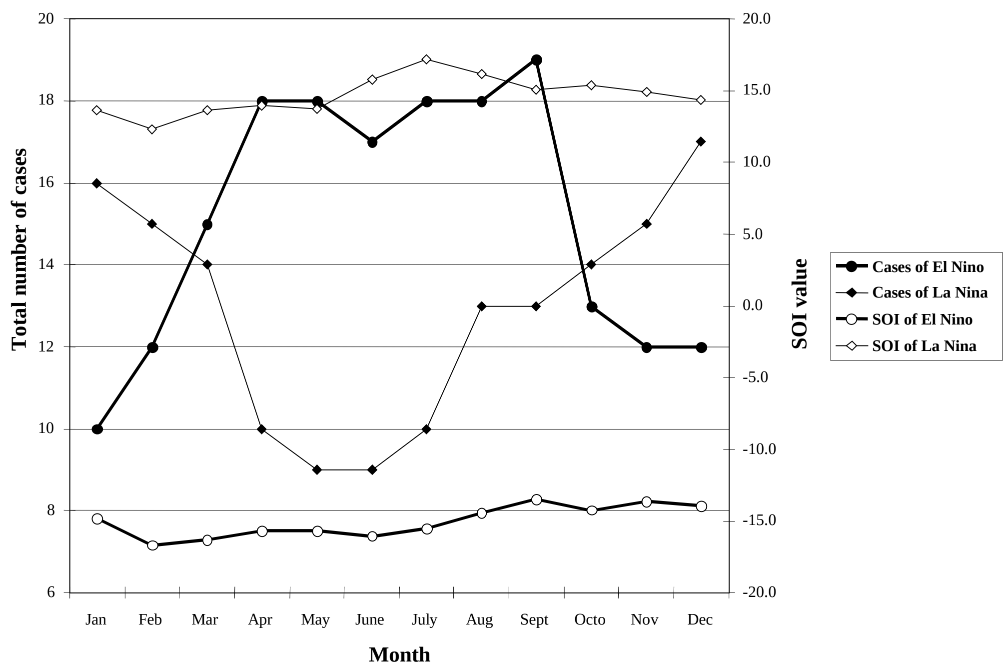
2.2 Time of occurrence of El Nino and La Nina

Crop damage due to water insufficiency is a common impact of El Nino, oppositely, La Nina usually leads to production failure through its impact on water excess or flood disaster. Damage to agricultural crops due to water stress or flood disasters are generally higher on younger crops than mature ones. Accordingly, impacts of El Nino on agricultural crops would be higher if these climatic anomalies occur during the vegetative stage or planting period, because the water requirement during this stage of crop growth is relatively high and young crops are generally less resistant to water stress and high temperatures. Thus, the potential damage to agricultural production caused by El Nino also depends on the date of occurrence, whether it occurs when the planted crop is still young or has reached maturity. In other words, the degree of damage to agricultural crops caused by El Nino depends on the cropping calendar applied by the farmer.

Food crops in Indonesia are generally cultivated in 2 cultivation periods, wet season and dry season. The planting date in the dry season usually starts in April/May whereas for the wet season in September/October. These cropping patterns show that April/May is a critical period of water supply for dry season cultivation and September/October is the critical period for wet season cultivation. Water stress induced by El Nino or flood disaster induced by La Nina, which occurs in these periods can lead to severe damage because crops are still young. In general, water shortage is the major cause of crop damage in the dry season, since rainfall in the dry season is already relatively low, on average around 30 - 40 per cent of the total rainfall in the wet season.

Figure 2.1 shows the number of El Nino events and La Nina events by month from 1875-2000. From the figure it is clear that most El Nino cases occur during April-September which is the cultivation period for the dry season when water shortages usually become the major problem for farmers. Thus, the occurrence of El Nino, which is usually followed by radical rainfall shortfalls increases the probability of crop damage due to water insufficiency, particularly for food crops cultivated in the dry season.

Figure 2.1 Total number of cases and SOI value by month of El Nino and La Nina events



Source: Australian Bureau of Meteorology. (http:/www.bom.gov.au/climatic/current/soihtm1.shtm1).

On the contrary, most La Nina events occurred during the cultivation period of the wet season, during November-February. La Nina usually causes rainfall to increase stimulating floods and increasing the pest population due to the increased humidity. This means that the occurrence of La Nina is also unfavorable, especially for food crops cultivated during the wet season due to the increase in pest attacks and flooding. Thus, both El Nino and La Nina are unfavorable for food production patterns in Indonesia. The occurrence of El Nino, generally April-September, can exaggerate water shortage problems during the planting period or younger stage of crop development in the dry season while La Nina, which usually occurs in November-February, enables pest increases and water excesses in the wet season, also primarily during the planting period.

2.3 Analytical method of studying the impacts of abnormal weather on agricultural production

Variability in agricultural production can be caused by prices, technology and the prevailing climatic condition. Weather fluctuations from year to year affect agricultural production both directly and indirectly through disease, pest, damage to infrastructure, etc. Weather can impact agricultural production at many levels of the production system such as harvesting, storage, etc. At the farm level, climatic variability impacts agricultural production through its affects on area planted/harvested and yield.

Since climatic variability is a function of time or year, evaluation of climatic impacts on agricultural production in a given region should be conducted using time series data analysis. Estimation of agricultural production loss due to climate variability of a given year can be carried out by comparing actual production with expected production. Deviation between both production figures reflects the production loss due to the influence of uncontrollable climatic factors on agricultural production activities. The deviation figure will become higher if extreme climatic conditions occur, which can cause negative impacts on agricultural production. Thus, the net impact of climatic anomalies on food production can be approached by comparing production deviation under normal climatic conditions to production deviation under abnormal climatic conditions, such as El Nino and La Nina.

The major problem in quantifying losses due to bad climate is how to estimate expected production. If climate variability is assumed as an exogenous factor in a production system, then expected production of a given region will be fully the function of prices and level of technology. Under this assumption, expected production will be able to be estimated using parameters of production functions calculated from time series data analysis. This type of approximation was used by Mukhopadhyay (1974) for the case in India.

Theoretically, the earlier mentioned estimation method is quite realistic to illustrate production fluctuations inter annually, but will require complex calculations, especially when the analyzed commodities and regions are great in number. A simpler method was proposed by UNDHA (1992) and IPCC (2001) which uses trend analysis of production. A similar method was also utilized by Gommes (1998) who estimated expected production based on a 7-year moving maximum production. Meanwhile, instead of a moving maximum production Yoshino *et al*. (2000) used 4-year mean production as the base in the estimation of expected production.

In this research, estimations of expected production for each year were conducted based on 3-year moving averages. A period of 3 years was chosen to avoid including the impacts of technological progress which is relatively fast, especially during the green revolution period. Therefore, losses due to El Nino events of a given year can be expressed as the following equation:

$$\text{Loss} = (P_m - P_t)/P_m \times 100$$

where: Loss = losses expressed as a percentage

P_m = 3-year moving average of food production

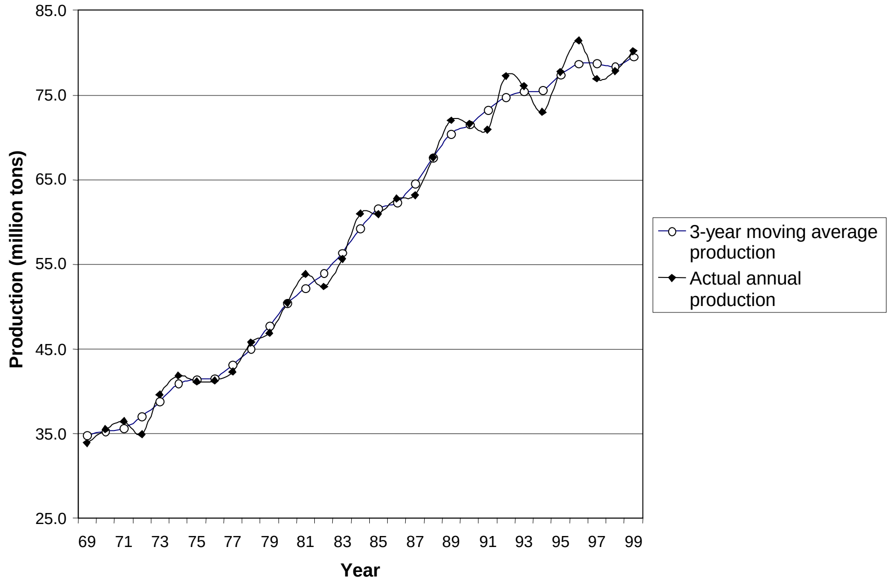
Pt = food production in year t

Estimations of losses due to El Nino were conducted using annual and monthly data from 1968-2000 which covered 7 food crops, i.e. wetland rice, dryland rice, maize, cassava, groundnut, sweet potato and soybean. Based on annual data, estimation of losses was conducted nationally, by province and by crop, and expressed in terms of production, harvested area and yield of food crop. Monthly data from 1975-2000 was especially useful in estimating food area losses by season (wet and dry season) in the province of Lampung. The sources for the basic data were the Indonesian Central Bureau of Statistics and the Central Bureau of Statistics of Lampung.

2.4 Impact on total food production nationally

Figure 2.2 shows the evolution of total food production (rice and other food crops) nationally from 1969-2000 which is expressed as values of the 3-year moving average and actual values. Deviation between the data indicates the variability of total food production due to climate variability. The deviation inclined to increase, which means that variability or uncertainty of total food production nationally has tended to increase. From 1969-1985 food production variability was 32.4 per cent, rising to 129.8 per cent for the 1985-1999 period, in other words, food production variability increased 4 fold. This reveals that food production uncertainty due to production failure during the most recent period was higher than in the past.

Figure 2.2 Evolution of 3-year moving average production and actual annual production of total foods in Indonesia, 1969-1999



Source: Author's calculation.

Food production failure may come from climatic anomalies which may lead to a lowering of the harvestable cultivation area and farming yield. During 1968-2000, there were 7 El Nino events, in 1972, 1977, 1982, 1987, 1991, 1994 and 1997, and 5 La Nina events in 1971, 1973, 1975, 1988 and 1998. The actual production of foods during El Nino events was generally lower than the 3-year moving average, which implies that El Nino tended to cause food production decreases nationally. The impact of La Nina on food production was inconsistent by events, the impacts were positive in 1971, 1973 and 1988 but negative in 1975 and 1998.

Table 2.3 shows that actual food production during normal climatic conditions from 1969-1999 was on average 0.84 per cent higher than the 3-year moving average or the expected production. The figure was however -3.06 per cent during El Nino events, implying that actual food production during the events was lower than expected production. In other words, net food production loss nationally due to El Nino was approximately 3.90 per cent. The impact of El Nino on total food production decline has tended to become more severe, from around 1.86-2.90 per cent during 1977-1987, rising to 2.28-3.45 per cent in 1991-1997.

Table 2.3 Impact of climate anomalies occurring from 1969-1999 on national food production

Year	Climate anomaly	Deviation from annual production and 3-year moving average production ('000 tons)	(Per cent)
1969		-863.6	-2.48
1970		215.3	0.61
1971	La	799.9	2.25
1972	El	-2057.7	-5.56
1973	La	833.0	2.15
1974		953.2	2.33
1975	La	-257.0	-0.62
1976		-314.0	-0.76
1977	El	-802.5	-1.86
1978		778.3	1.73
1979		-829.0	-1.74
1980		103.8	0.21
1981		1569.6	3.01
1982	El	-1564.9	-2.90
1983		-688.9	-1.22
1984		1808.3	3.05
1985		-640.1	-1.04
1986		488.7	0.78
1987	El	-1366.3	-2.12
1988	La	34.6	0.05
1989		1592.7	2.26
1990		100.9	0.14
1991	El	-2366.5	-3.23
1992		2541.7	3.40
1993		607.1	0.80
1994	El	-2609.6	-3.45
1995		372.0	0.48
1996		2710.3	3.44
1997	El	-1795.9	-2.28
1998	La	-476.7	-0.61
1999		687.8	0.86
Average	El Nino	-1794.8	-3.06
	La Nina	186.8	0.64
	Normal	589.2	0.84

Source: Author's calculation.

In contrast to the negative impacts induced by El Nino, La Ninas occurring between 1969 and 1999 tended to induce positive impacts on national food production. Actual food production during La Nina events was higher on average by 0.64 per cent than the expected production, which means that total food production tends to increase during La Nina episodes. The increases in food production were particularly high in 1971 and 1973 where actual production was around 2 per cent higher than expected production. However, during other La Nina cases, actual production was lower or only slightly higher than the expected production, implying that the positive impacts of La Nina on national food production are tending to become less.

Seven episodes of El Nino and 5 episodes of La Nina occurred between 1968 and 2000. During such occurrences some production in certain provinces decreased due to water shortages in El Nino events and due to water excesses in La Nina events. Food production in other provinces was not affected or so severely affected by the events and therefore, food production in other provinces did not decrease, or may have even increased due to technical progress. Increases in food production may also occur in provinces affected by El Nino/La Nina if the farmers adapt well or due to any positive impacts induced by the events. In the case of La Nina, for example, it is possible that some food production in affected provinces may increase due to greater water availability, this is possible primarily in provinces with low rainfall in normal years.

In total there were 7 food crops and 25 provinces analyzed in this nationwide analysis and accordingly, since 7 El Nino events occurred between 1968 and 2000, the total number of possible production fluctuations of all crops in all provinces was 1,225 cases. The question is, how many cases of reduced food production occurred during El Nino episodes, in other words, what is the probability of food production decreases during El Nino? The same question is also valid for the case of La Nina which covered, in total, 875 cases of production fluctuations of all cultivated crops in all provinces.

Table 2.4 shows the frequency of cases of food production decreases and increases during El Nino and La Nina years between 1968 and 2000. During El Nino events, 765 cases of reduced food production were observed, indicating that the probability of national food production decline due to El Nino was approximately 62.4 per cent while the probability of increased food production was 37.6 per cent. In contrast to the higher possibility of negative impacts induced by El Nino, La Nina tends to lead to a higher possibility of production increases. The total number of cases of production decline during La Nina was 428 or 49.0 per cent.

Table 2.4 The affect of El Nino and La Nina on national food production, 1968-2000

Climate anomaly	Period		
	1968-2000	Before 1985	After 1985
El Nino			
-Increased production	460	200	260
	(37.6)	(38.2)	(37.1)
-Decreased production	765	324	440
	(62.4)	(61.8)	(62.9)
La Nina			
-Increased production	445	272	173
	(51.0)	(52.0)	(49.4)
-Decreased production	428	251	177
	(49.0)	(48.0)	(50.6)

Note: In parentheses is percentage of total cases.
Source: Author’s calculation.

The frequency of reduced food production during El Nino events rose from 61.8 per cent before 1985 to 62.9 per cent after 1985. A similar trend was also observed for La Nina events, from 48.0 per cent to 50.6 per cent. This indicates that the probability of food production decline nationally due to El Nino and La Nina was more pronounced during the most recent period. The increase in magnitude and duration of El Nino and La Nina might be the major causes, while a decreasing social capacity in anticipating the event may also be to blame.

2.5 Impact on total food production by province

Climate anomalies such as El Nino and La Nina impact food production at different rates, whether geographically or by province. In general, variation in the magnitude of the impact may come from two major factors, i.e. (IPCC, 2001; Downing *et al*, 1999) (i) The magnitude of the impact of the climatic anomaly on local climate or local rainfall, and (ii) The farmer’s capability in preventing production loss caused by climatic anomalies in each region. The importance of both factors together means that a relatively high rainfall decrease in a certain area may not seriously affect food production if the lack of water can be mitigated by the farmers. On the contrary, a region that experiences a relatively low rainfall decrease may be seriously affected if the farmers have no or little capability in conducting the required adaptation or anticipation actions.

The data for 1968-2000 revealed that food production losses due to El Nino and La Nina varied by province. During El Nino events, food production decline occurred in all provinces except 4, i.e. North Sumatera, East Nusa Tenggara, Central Kalimantan and North Sulawesi, whereas during La Nina events, production losses occurred in only 10 provinces out of a total of 25 (Table 2.5). This indicates that El Nino's impact on food production covers a broader area and therefore, El Nino is a more serious threat to provincial food production than La Nina.

Regarding all El Nino cases from 1968-2000, most production losses occurred in 5 major provinces, i.e. Lampung, West Java, Central Java, East Java and South Sulawesi which are nationally major food producers with a production share of about 5 per cent or more to national food production. The average loss to food production in each of these five provinces was more than 150,000 tons per El Nino, while for other provinces it was less than 90,000 tons. Food production decline in these five provinces, excluding East Java, ranged between 3.2 per cent (West Java) and 7.5 per cent (Lampung).

In total, there are 4 provinces which are very sensitive to El Nino events (production decreases of more than 5 per cent), i.e. Irian Jaya, Lampung, South Sumatera and East Kalimantan. The moderately sensitive provinces (production decreases of 3-5 per cent) include Riau, Jambi, West Java, Central Java and Yogyakarta. Perhaps surprisingly, there were 3 provinces which experienced production increases.

Table 2.5 Average impact of climate anomaly on food production by province, 1968-2000

Province	Production share (%)	El Nino		La Nina	
		(Ton/event)	(%/event)	(Ton/event)	(%/event)
Aceh	2.0	-5,860	-0.5	-23,263	-2.2
North Sumatera	4.9	4,451	0.1	-9,461	-0.4
West Sumatera	2.4	-18,828	-1.3	-6,649	-0.5
Riau	0.7	-14,614	-3.2	-7,103	-1.8
Jambi	1.0	-25,079	-4.2	2,019	0.4
South Sumatera	2.5	-84,497	-5.4	73,942	5.6
Bengkulu	0.6	-2,465	-0.6	5,775	1.8
Lampung	4.8	-231,039	-7.5	46,010	1.9
West Java	18.2	-354,750	-3.2	-47,655	-0.5
Central Java	18.5	-543,776	-4.9	281,304	2.9
Yogyakarta	2.2	-51,789	-3.9	25,444	2.2
East Java	22.5	-227,787	-1.7	-40,621	-0.3
Bali	2.0	-14,886	-1.3	-19,339	-1.7
West Nusa Tenggara	2.0	-35,766	-2.9	-788	-0.1
East Nusa Tenggara	2.4	24,716	1.7	-33,467	-2.8
West Kalimantan	1.4	-3,845	-0.4	-19,906	-2.6
Central Kalimantan	0.5	4,336	1.3	-14,949	-5.3
South Kalimantan	1.6	-20,370	-2.1	-29,520	-3.8
East Kalimantan	0.5	-21,965	-7.3	-41,436	-7.7
North Sulawesi	1.0	195	0.0	-11,820	-2.3
Central Sulawesi	0.8	-12,605	-2.6	7,615	1.8
South Sulawesi	5.8	-159,927	-4.4	56,197	2.0
Southeast Sulawesi	0.7	-4,889	-1.1	2,811	0.7
Maluku	0.5	-311	-0.1	-12,033	-4.9
Irian Jaya	0.5	-37,360	-12.5	2,127	0.7

Note: El Nino years: 1972, 1977, 1982, 1987, 1991, 1994, 1997.
La Nina years: 1971, 1973, 1975, 1988, 1998.

Table 2.6 shows that the occurrence probability of production loss due to climatic anomalies varies from province to province. In general, South Sumatera, West Java, Central Java, West Nusa Tenggara, South Kalimatan, South Sulawesi, Southeast Sulawesi and Irian Jaya have a relatively high probability of food production decline as a result of climatic anomalies (El Nino and La Nina); the probability was more than 60 per cent. The probability of production loss of each province also varied by climatic anomaly. A high probability of production loss due to El Nino (more than 70 per cent) can be observed for South Sumatera, West Java, Central Java, West Nusa Tenggara, South Kalimantan, South Sulawesi and

Southeast Sulawesi. The highest probability of production loss caused by La Nina can be observed in Aceh, Riau, West Kalimantan and East Kalimantan.

Table 2.6 Percentage of total cases of food production loss from El Nino and La Nina by province

Province	El Nino	La Nina	El Nino and La Nina
Aceh	42.9	65.7	52.4
North Sumatera	59.2	34.3	48.8
West Sumatera	61.2	45.7	54.8
Riau	49.0	62.9	54.8
Jambi	65.3	42.9	56.0
South Sumatera	81.6	31.4	60.7
Bengkulu	53.1	48.6	51.2
Lampung	67.3	34.3	53.6
West Java	83.7	45.7	67.9
Central Java	89.8	25.7	63.1
Yogyakarta	59.2	45.7	53.6
East Java	63.3	48.6	57.1
Bali	55.1	54.3	54.8
West Nusa Tenggara	73.5	45.7	61.9
East Nusa Tenggara	44.9	45.7	45.2
West Kalimantan	57.1	62.9	59.5
Central Kalimantan	56.3	52.9	54.9
South Kalimantan	73.5	54.3	65.5
East Kalimantan	44.9	74.3	57.1
North Sulawesi	49.0	54.3	51.2
Central Sulawesi	59.2	54.3	57.1
South Sulawesi	71.4	45.7	60.7
Southeast Sulawesi	81.6	48.6	67.9
Maluku	55.1	42.9	50.0
Irian Jaya	63.3	58.8	61.4

Source: Author's calculation.

2.6 Impact on production by food crop

El Nino cases that occurred during the period of 1968-2000 resulted in production losses to all food crops but with different rates of loss (Table 2.7). On average, total food production loss per El Nino case was approximately 1.79 million tons. Quantitatively, production of wetland rice and maize suffered the highest loss, i.e. 781,000 tons and 601,000 tons respectively, whereas other food crops ranged between 20,000 tons and 182,000 tons. La Nina events were inconsistent by crop; there were positive impacts on the production of dryland rice, maize, groundnut and sweet potato, but negative impacts on the production of wetland rice, cassava and soybean.

Table 2.7 Impact of climatic anomaly on production by food crop, 1968-2000

Climatic anomaly	Food crop							
	All crops	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Quantity ('000 tons)								
El Nino	-1,794.8	-781.5	-63.3	-601.2	-182.3	-20.1	-94.2	-52.3
La Nina	186.8	-165.6	62.3	449.2	-227.7	10.8	58.1	-0.4
Percentage (%)								
El Nino	-3.06	-2.21	-2.91	-10.64	-1.30	-3.74	-4.50	-4.84
La Nina	0.64	-0.57	3.26	9.50	-1.74	2.49	2.66	-0.05

El Nino years: 1972, 1977, 1982, 1987, 1991, 1994, 1997.
La Nina years: 1971, 1973, 1975, 1988, 1998.
Source: Author's calculation.

Of all the food crops analyzed, maize was the most sensitive to El Nino with production decreasing by 10.6 per cent. Soybean, groundnut and sweet potato were moderately sensitive, with production decreases ranging from 3 per cent to 5 per cent. Encouragingly, wetland rice, dryland rice and cassava were relatively resistant to El Nino with production decreasing by only around 1 or 2 per cent.

Variation in the rate of production decrease by crop, in general, can be attributed to three factors:

(i) **Adaptability of the crop to a reduction in water supply due to El Nino.** To emphasize the role of this factor we can compare cassava loss to soybean loss. Due to its deep rooting system, cassava is relatively resistant to water insufficiency and temperature increases caused by El Nino. Therefore, the resultant impact on cassava production is the lowest, 1.30 per cent. This was the opposite for soybean which is sensitive to water supply and experienced quite a high production decrease of 4.84 per cent.

(ii) **Availability of an irrigation network**. This is shown by the lowest production losses for wetland rice compared to other food crop commodities, excluding cassava, since wetland rice is mostly cultivated on irrigated land while other food crops are cultivated on dry land.

(iii) **Cropping pattern applied by farmers**. El Nino events which cause drought and water insufficiency mostly occur during the dry season. As a consequence, the impact of El Nino is worse on crops cultivated in the dry season opposed to crops cultivated in the wet season. Among the commodities which are usually cultivated in dryland areas, dryland rice is the least common cultivated in the dry season. As a result, El Nino impacts on the production of dryland rice are relatively low compared to other food crops, despite its water requirement being relatively high.

Although the rate of production decrease of wetland rice due to El Nino was the lowest compared to other food crops, excluding cassava, the probability of the occurrence of production loss was actually the highest. For El Nino events of the said period, 69.1 per cent caused production losses to wetland rice, while for other food crops the percentage ranged between 58 per cent and 65 per cent (Table 2.8).

The highest percentage of cases of production decline due to La Nina also happened to be wetland rice, followed by soybean. This reveals that if El Nino or La Nina induced climatic anomalies occur, wetland rice has the highest probability of suffering production losses. This probability of production loss due to El Nino has inclined to increase over the period, from 61 per cent for El Nino events occurring before 1985 to 75 per cent for those occurring after 1985. The same trend can be seen for La Nina.

Table 2.8 Percentage of cases of production increases and production decreases during El Nino and La Nina events by commodity (%)

Climate anomaly	Period	Food crop						
		Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Production increase								
El Nino	1968-2000	30.9	38.3	34.9	42.3	41.7	39.4	35.6
	Before 1985	38.7	38.7	32.0	42.7	42.7	41.3	31.1
	After 1985	25.0	38.0	37.0	42.0	41.0	38.0	39.0
La Nina	1968-2000	44.0	59.2	63.2	45.6	56.0	47.2	41.5
	Before 1985	49.3	65.3	61.3	48.0	58.7	42.7	38.4
	After 1985	36.0	50.0	66.0	42.0	52.0	54.0	46.0
Production decrease								
El Nino	1968-2000	69.1	61.7	65.1	57.7	58.3	60.6	64.4
	Before 1985	61.3	61.3	68.0	57.3	57.3	58.7	68.9
	After 1985	75.0	62.0	63.0	58.0	59.0	62.0	61.0
La Nina	1968-2000	56.0	40.8	36.8	54.4	44.0	52.8	58.5
	Before 1985	50.7	34.7	38.7	52.0	41.3	57.3	61.6
	After 1985	64.0	50.0	34.0	58.0	48.0	46.0	54.0

El Nino years: 1972, 1977, 1982, 1987, 1991, 1994, 1997.
La Nina years: 1971, 1973, 1975, 1988, 1998.
Source: Author's calculation.

2.7 Impact on harvest area and yield by food crop

Changes in food production due to climatic anomalies are basically the result of changes in harvest area and productivity per hectare. Table 2.9 shows that during El Nino events, all food crop commodities experienced harvest area decline of about 0.25 per cent to 11.25 per cent, whereas productivity per hectare was not always affected. For each food crop, generally, decreases in harvest area were higher than decreases in productivity per hectare. This indicates that decreases in food production as a result of El Nino-induced drought were mainly due to a reduction in harvest area rather than lower farming productivity.

In the case of El Nino, reduced harvest area occurred for all food crops, but not all crops indicated a decrease in farming productivity, particularly wetland rice and sweet potato. Oppositely, during La Nina events, all crops displayed a decrease in productivity per hectare, but a reduction in harvest area did not occur for most crops with the exception of cassava and soybean. This reveals that El Nino and La Nina are inclined to cause negative impacts on food production through different mechanisms.

Analysis of the frequency of cases of increases or decreases of harvest area and productivity during climatic anomaly conditions showed similar results (Table 2.9). Cases of harvest area decline occurred more commonly during El Nino events (54.9 to 73.1 per cent by crop) than La Nina events (36.0 to 53.6 per cent by crop). However, cases of yield decrease were more common during La Nina events (49.6 to 67.2 per cent by crop) than El Nino events (43.4 to 56.4 per cent by crop). In other words, El Nino events tend to lead to decreases in harvest area, while La Nina events tend to lead to decreases in yield.

Table 2.9 Rate and frequency of decrease (or increase) of harvest area and yield by food crop during climatic anomaly events occurring between 1968 and 2000 (%)

Variable	Climate anomaly	Food crop						
		Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Rate of decrease or Increase (%)								
Harvest area	El Nino	-2.57	-3.03	-11.25	-0.25	-3.68	-4.83	-5.06
	La Nina	0.61	3.03	10.35	-2.12	4.06	3.71	-0.34
Yield per hectare	El Nino	0.37	0.33	-0.07	-0.51	-0.89	0.44	-0.99
	La Nina	-1.26	-0.31	-1.06	-0.39	-0.08	-1.82	-2.27
Frequency of cases (%)								
Harvest area	**El Nino**							
	-increasing	26.9	34.9	34.3	44.0	45.1	40.0	35.6
	-decreasing	73.1	65.1	65.7	56.0	54.9	60.0	64.4
	La Nina							
	-increasing	55.2	61.6	64.0	46.4	60.0	51.2	53.2
	-decreasing	44.8	38.4	36.0	53.6	40.0	48.8	46.8
Yield per hectare	**El Nino**							
	-increasing	56.6	53.1	50.3	49.7	44.0	56.0	50.6
	-decreasing	43.4	46.9	49.7	50.3	56.0	44.0	49.4
	La Nina							
	-increasing	32.8	50.4	43.2	45.6	46.4	36.8	39.5
	-decreasing	67.2	49.6	56.8	54.4	53.6	63.2	60.5

El Nino years: 1972, 1977, 1982, 1987, 1991, 1994, 1997.
La Nina years: 1971, 1973, 1975, 1988, 1998.
Source: Author's calculation.

It is interesting to note that the occurrence probability of harvest area decline for wetland rice during El Nino events was actually the highest (73.1 per cent), even though its magnitude of harvest area decline was the lowest (-2.57 per cent), with the exception of cassava. A similar trend phenomenon can also be seen for La Nina; frequency of yield decrease of wetland rice was the highest (67.2 per cent), indicating that the probability of yield decrease due to La Nina is particularly high for wetland rice. The two phenomena reveal that wetland rice is actually the most sensitive crop to the negative impacts induced by both El Nino (area decrease) and La Nina (yield decrease). Such a condition is understandable since the cultivation of wetland rice requires relatively high amounts of water, and therefore, if water shortages occur due to El Nino, it can lead to a high possibility of harvest failure. On the other hand, if rainfall increases due to La Nina, wetland rice cultivation becomes more sensitive to increases of pest perturbation which often accompany rainfall increases.

3. Performance of Food Crops in Lampung

3.1 Arable land for food crops

Excluding forest land, pasture, estate crops cultivated by enterprises and fish ponds, agricultural land, which is owned and cultivated by farmers can be grouped into two categories, i.e. wetland and dryland (Central Bureau of Statistics, 1999). Wetland represents agricultural land which is allocated especially to food crop cultivation, primarily wetland rice. Most of this type of agricultural land is located on flat areas and some may be irrigated land with the water supply coming from an irrigation network. In contrast, all dryland is non-irrigated with the water supply coming entirely from rainfall and is mostly located on non-flat areas. Dryland can be allocated to tree crop cultivation or food crop cultivation, generally, food crops that have a low water requirement or are relatively tolerant to water stress.

Table 3.1 Arable land for food crops in Lampung, 1990-2000

Year	Dryland (ha)		Food crops (ha)			Dryland and wetland for food crops (%)	
			Wetland				
	Tree crops	Food crops	Irrigated	Non-irrigated	Dryland and wetland	Irrigated	Non-irrigated
1990	512,238	202,075	135,291	88,039	425,405	31.8	68.2
1991	503,407	224,697	147,123	91,807	463,627	31.7	68.3
1992	498,561	261,149	145,138	111,926	518,213	28.0	72.0
1993	552,633	265,355	153,974	111,437	530,766	29.0	71.0
1994	535,083	273,943	161,829	119,572	555,344	29.1	70.9
1995	541,888	253,149	165,615	119,574	538,338	30.8	69.2
1996	538,153	242,011	165,932	121,656	529,599	31.3	68.7
1997	539,443	243,968	165,984	121,437	531,389	31.2	68.8
1998	533,713	245,990	163,366	119,967	529,323	30.9	69.1
1999	497,417	277,931	167,918	120,017	565,866	29.7	70.3
2000	507,036	336,579	171,257	117,355	625,191	27.4	72.6
Growth (%/year)	-0.01	5.60	2.43	3.12	4.05		

Source: Central Bureau of Statistics.

Table 3.1 shows that total arable land for food crop cultivation in Lampung was around 625 thousand hectares in 2000, the bulk of which being dryland with a coverage area of around 336 thousand hectares. This type of food crop area is generally considered risky for rice cultivation because, on one side, rice cultivation requires a high amount of continous water supply, and on the other side, water supply in dryland areas is uncontrollable due to its high dependency on rainfall as its water source. Consequently, the productivity of rice cultivated in wetland areas, or wetland rice, is generally much higher than dryland rice. The yield of wetland rice in Lampung ranged from 4.15 ton/ha to 4.38 ton/ha during 1990-2000, while dryland rice ranged from only 2.35 ton/ha to 2.39 ton/ha.

To reduce possible production failure of rice cultivation and other food crop cultivation, the development of irrigation is crucial. However, even though the development of irrigated land is so important for increasing food production, its annual growth is relatively low due to the high capital investment requirement. Annual growth of irrigated land was only 2.34 per cent per annum, while the growth rates of non-irrigated wetland and dryland areas were respectively 3.12 per cent per annum and 5.60 per cent per annum during 1990-2000 (Table 3.1). Consequently, the structure of arable land for food crops in Lampung tends to be dominated by non-irrigated land, its proportion to total arable land increased from 68.2 per cent in 1990 to 72.6 per cent in 2000.

Most rice production in Lampung comes from wetland rice cultivation, and accordingly, the availability of wetland area plays an important role for food security in the region. This land area consists of irrigated and non-irrigated land. In terms of water supply and investment patterns, irrigated land can be grouped into three categories, i.e. technical irrigated land, semi-technical irrigated land and simple irrigated land. Technical and semi-technical irrigated land is irrigated land with its water supply coming from water dams built by the government on big rivers, while the water supply for simple irrigated land generally comes from small rivers and most of the required investment comes from the village communities. Simple irrigated land generally has lower crop intensity than technical or semi-technical irrigated land. Around 83 per cent and 75 per cent respectively of technical and semi-technical irrigated land in Indonesia can be planted with rice 2-3 times per year, while for simple irrigated land and non-irrigated land the figures are only 57 per cent and 14 per cent (Irawan, 2002).

Table 3.2 Wetland area by irrigation status in Lampung, 1990 and 2000

Year	Irrigated land			Non-irrigated land		Total
	Technical	Semi-technical	Simple	Rainfed	Other	
Acreage (ha)						
1990	80,223	23,103	31,965	58,149	29,890	223,330
2000	99,717	28,782	42,758	79,406	37,318	288,612
Annual growth 1990-2000 (%/year)	2.28	3.49	3.08	3.96	6.16	2.64
Proportion (%)						
1990	35.9	10.3	14.3	26.0	13.4	100.0
2000	34.6	10.0	14.8	27.5	12.9	100.0

Source: Central Bureau of Statistics, Lampung.

Table 3.2 shows the structure of wetland area in Lampung by irrigation status. Total area of technical and semi-technical irrigated land accounted for 103 thousands hectares in 1990, rising to 128 thousand hectares by 2000. In other words, the annual growth of technical and semi-technical irrigated land was respectively 2.28 per cent per year and 3.49 per cent per year from 1990-2000. These growth rates were lower than that of non-irrigated land and simple irrigated land due to the high investment required for the construction of technical and semi-technical irrigated land. Consequently, the proportion of technical and semi-technical irrigated land decreased from 46.2 per cent of the total wetland area in 1990, to 44.6 per cent in 2000.

Around 75 per cent of the total wetland areas in Lampung are located in four districts, i.e. the districts of Lampung Selatan, Lampung Tengah, Tulang Bawang and Lampung Timur (Table 3.3). Total wetland area of the four districts is more than 50,000 hectares per district, while for other districts the figure is lower than 20,000 hectares excluding the district of Tanggamus. This reveals that the four districts are major producers of rice because most rice production is on wetland areas. The structure of wetland area, however, varies by district. Wetland areas in the districts of Lampung Selatan and Tulang Bawang are dominated by non-irrigated land, whereas, in contrast, irrigated land is very dominant in Lampung Tengah and Lampung Timur; the proportion of irrigated land in the two districts is more than 65 per cent of total wetland area.

Table 3.3 Wetland area (ha) by irrigation status and by district, Lampung, 2000

District	Irrigated land			Non-irrigated land		Total
	Technical	Semi-technical	Simple	Rainfed	Other	
Lampung Selatan	6,665	2,440	8,230	34,358	1,495	53,188
Lampung Tengah	35,522	4,356	7,205	9,255	1,700	58,038
Lampung Utara	6,014	420	2,797	1,031	1,193	11,455
Lampung Barat	1,275	741	8,218	5,943	23	16,200
Tanggamus	5,921	10,439	4,529	6,752	60	27,701
Tulang Bawang	11,387	6,422	1,375	6,288	25,379	50,851
Way Kanan	3,645	1,996	2,097	4,675	1,602	14,015
Bandar Lampung	0	500	49	493	0	1,042
Lampung Timur	26,223	1,468	8,258	10,611	6,497	53,057
Metro	3,065	0	0	0	0	3,065
Total	99,717	28,782	42,758	79,406	37,949	288,612
Proportion (%)						
Lampung Selatan	12.5	4.6	15.5	64.6	2.8	100
Lampung Tengah	61.2	7.5	12.4	15.9	2.9	100
Lampung Utara	52.5	3.7	24.4	9.0	10.4	100
Lampung Barat	7.9	4.6	50.7	36.7	0.1	100
Tanggamus	21.4	37.7	16.3	24.4	0.2	100
Tulang Bawang	22.4	12.6	2.7	12.4	49.9	100
Way Kanan	26.0	14.2	15.0	33.4	11.4	100
Bandar Lampung	0.0	48.0	4.7	47.3	0.0	100
Lampung Timur	49.4	2.8	15.6	20.0	12.2	100
Metro	100.0	0.0	0.0	0.0	0.0	100
Total	34.6	10.0	14.8	27.5	13.1	100

Source: Central Bureau of Statistics, Lampung.

3.2 Pattern of rainfall and food crop cultivation

Seasonal variation of production caused by climatic variability is a major characteristic of agricultural production. In tropical regions, where rainfall is relatively high and fluctuating, the production capacity of food crops or seasonal crops is highly affected by rainfall conditions. This influence of rainfall on food production generally varies by crop and the stage of growth of the crops cultivated. For example, rainfall influences rice cultivation more strongly than cassava cultivation because the water requirement of rice is much higher than for cassava. In general, the impact of rainfall deficits on young crops is also much higher than for mature crops since the adaptation capacity of young crops to water stress is lower than for mature crops.

The climatic situation also affects agricultural production through its impacts on increasing pest populations. Pest disaster can reduce quantity and quality of food products. In general, pest disasters have caused serious problems to farmers when rainfall is relatively high (Partridge and Mashum, 2002). Thus, the rainfall situation plays an important role in agricultural production through its direct impacts on water availability or through indirect impacts on increasing the occurrence of pest disasters.

Table 3.4 Average rainfall by season and by district, Lampung, 1977-2000

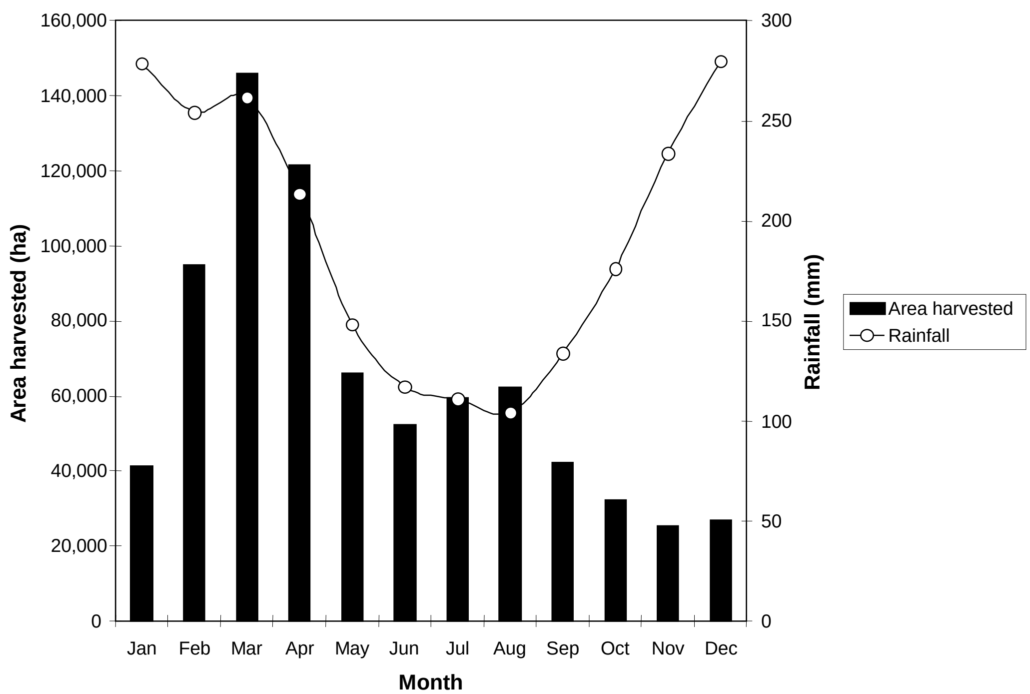
District	Average rainfall (mm)			Rainfall distribution (%)		
	Wet season	Dry season	Both seasons	Wet season	Dry season	Both seasons
Lampung Selatan	1,193	647	1,840	64.8	35.2	100
Tanggamus	1,272	780	2,052	62.0	38.0	100
Lampung Tengah	1,245	666	1,911	65.1	34.9	100
Lampung Utara	1,541	858	2,400	64.2	35.8	100
Tulang Bawang	1,273	578	1,851	68.8	31.2	100
Lampung Barat	1,751	1,059	2,810	62.3	37.7	100
Lampung Timur	1,560	755	2,315	67.4	32.6	100
Way Kanan	1,520	817	2,336	65.1	35.0	100

Source: Office of Public Works, Lampung Province.

Annual rainfall in Lampung varies by district, ranging from 1,840 mm/year to 2,810 mm/year (Table 3.4.). Three districts that have annual rainfall lower than 2,000 mm/year are the districts of Lampung Selatan, Lampung Tengah and Tulang Bawang, meaning that water availability in the three districts is relatively low compared to other districts. Most rain falls during the wet season, ranging from 62 per cent to 69 per cent of total annual rainfall by district. This imbalance in rainfall distribution is unfavorable for the continuity of food supply throughout the year because the capacity of food production during the dry season is relatively low due to water shortages. One of the consequences is that food prices during the dry season usually augment due to decreases in food supply. The opposite is observed during the wet season.

To stabilize food prices throughout the year or to reduce seasonal variation in food prices, particularly rice the staple food of most Indonesian people, the Indonesian government intervenes in the rice market through a buffer stock mechanism which is controlled by the National Food Agency, BULOG (Ellis, 1993). This policy, however, generates a substantial social cost to the country. Another strategy implemented is the development of irrigation networks which enable continuous water supply to farmer's fields in the dry season. However, as mentioned in section 3.1, the development of an irrigation network in Lampung is relatively limited and most arable land for food crops is non-irrigated, consequently, seasonal food production is highly dependent on seasonal rainfall distribution.

Figure 3.1 Average monthly rainfall and food crop area harvested in Lampung, average 1977-2000



Source: Office of Public Works and Central Bureau of Statistics, Lampung.

Figure 3.1 illustrates the relationship between monthly rainfall and monthly harvested area of food crops in Lampung. According to the Indonesian Agency for Meteorology and Geophysics, the wet season in Lampung occurs for 7 months from October to April, while the dry season from May to September. Based on the monthly rainfall distribution, farmers usually start to plant their wet season food crops in October/November and the harvesting period is therefore in January to May, depending on the cultivation period and planting date of the crops cultivated. Food crops harvested in the wet season account for 523 thousand hectares but only about 249 thousand hectares in the dry season, in other words, 67.7 per cent of the annual food area harvested comes from the wet season (Table 3.5). This pattern of seasonal food harvesting follows very closely the seasonal rainfall distribution (Table 3.4).

The rainfall situation also affects farmer choice of which food crop to cultivate. During the wet season when water is more available, most of the area harvested with food crops is utilized for rice because rice cultivation requires more water than other crops and the cultivation of rice is important to assure household food security. During the wet season, rice cultivation covers an average of 55.0 per cent of the total food area harvested, in other words, farmers tend to concentrate their farming on rice when water is available (Table 3.5). However, when water is less available during the dry season the farmers tend to diversify their crops to reduce the production risk. In the dry season, the share of rice decreases to 33.2 per cent of total area harvested because intensive rice cultivation during the dry season increases the risk of production failure due to water shortages, particularly for dryland rice which is cultivated on non-irrigated land. Oppositely, the share of other crops augments in the dry season because their water requirement is less than for rice, thus, production failure due to water insufficiency is relatively low.

Table 3.5 Average area harvested of food crops by season in Lampung, 1975-2000

Crop	Area harvested ('000 ha)			Percentage (%)		
	Wet season	Dry season	Both seasons	Wet season	Dry season	Both seasons
Wetland rice	164,127	82,346	246,472	31.4	33.1	31.9
Dryland rice	123,253	249	123,502	23.6	0.1	16.0
Maize	123,875	64,924	188,799	23.7	26.1	24.5
Cassava	55,166	71,619	126,785	10.6	28.8	16.4
Groundnut	6,514	3,547	10,062	1.2	1.4	1.3
Sweet potato	1,855	1,704	3,559	0.4	0.7	0.5
Soybean	47,957	24,543	72,500	9.2	9.9	9.4
All crops	522,746	248,932	771,678	100.0	100.0	100.0

Source: Office of Public Works and Central Bureau of Statistics, province of Lampung.

3.3 Role as national food producer

The province of Lampung is one of the major food producers in Indonesia, particularly for food crops cultivated in upland areas or dryland areas such as CGPRT crops. Production share of Lampung at the national level was about 12 per cent for dryland rice, 10 per cent for cassava, 8 per cent for maize and 7 per cent for soybean (Table 3.6). On Sumatera island, where Lampung is located, Lampung has an important role in maize and cassava production, contributing about 69 per cent and 66 per cent to total production. The province also has an important role in the production of soybean and dryland rice with a production share of 38 per cent and 30 per cent respectively.

Food production in Lampung increased, on average, by 5 to 16 per cent per annum during 1968-2000. A high rate of production growth, more than 10 per cent per year, was shown in the production of maize, cassava and soybean while the production growth of rice, the staple food of the population, was only 7.68 per cent for wetland rice and 2.88 per cent for dryland rice. The production growth of wetland rice was the most stable figure compared with other food crops, as indicated by the lowest coefficient of variation of growth of wetland rice production (129 per cent), whereas the coefficient of variation of other food crops ranged from 216 per cent to 613 per cent.

Table 3.6 Production of food crops in Lampung, 1968-2000 ('000 tons)

Year	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
1968	178.6	168.2	49.3	223.8	2.5	26.7	12.9
1969	169.5	110.2	45.7	295.3	1.9	19.5	6.4
1970	187.0	138.0	56.7	311.3	1.7	21.7	6.9
1971	231.0	150.8	111.4	388.1	2.5	29.7	10.1
1972	226.7	158.7	78.7	465.3	3.0	20.8	18.3
1973	258.8	158.3	115.0	734.2	3.6	23.2	35.0
1974	295.1	134.4	97.6	604.3	3.1	24.7	57.2
1975	384.3	148.6	32.0	654.7	4.9	23.8	35.1
1976	404.2	135.5	29.9	694.9	3.8	22.2	28.9
1977	408.6	173.3	49.4	786.4	3.5	23.5	27.3
1978	411.7	195.4	54.6	807.8	5.6	17.8	24.4
1979	424.5	176.3	77.3	901.7	6.3	20.0	31.4
1980	502.8	183.6	67.7	984.4	5.5	20.2	23.6
1981	596.4	187.5	87.6	822.0	6.5	16.4	29.4
1982	666.6	208.4	74.8	882.9	6.6	14.4	17.8
1983	745.8	214.9	131.2	827.3	6.2	19.3	13.2
1984	836.7	244.8	160.0	1,298.1	13.1	17.3	33.6
1985	823.8	214.5	261.4	929.0	10.8	16.7	74.0
1986	883.9	161.4	391.2	787.2	12.3	23.4	140.3
1987	1,002.5	242.0	342.5	1,361.8	12.1	23.1	117.7
1988	995.5	254.1	407.3	1,915.1	9.5	23.5	101.8
1989	1,034.0	249.4	454.3	2,072.8	12.8	30.3	99.6
1990	1,110.2	232.7	496.2	1,624.7	12.8	35.5	116.3
1991	1,088.6	239.0	415.5	1,828.2	9.1	43.0	89.0
1992	1,350.7	322.2	530.4	2,283.8	12.9	49.9	179.8
1993	1,355.4	291.5	579.1	2,894.3	12.1	49.1	126.2
1994	1,321.8	294.0	563.1	2,095.1	10.3	38.7	110.4
1995	1,572.0	371.7	843.2	2,267.7	20.5	56.8	183.6
1996	1,620.5	351.3	938.4	2,898.7	16.3	65.9	92.7
1997	1,442.2	311.5	1,080.7	1,609.7	10.1	34.8	31.9
1998	1,640.1	335.6	1,111.8	1,951.6	13.0	59.4	43.0
1999	1,547.9	253.6	1,176.3	2,936.3	7.5	49.1	53.9
2000	1,682.3	264.1	1,123.1	2,867.5	9.5	60.1	39.2
- Contribution to national production (%)	2.7	11.5	7.7	10.1	1.8	1.5	6.8
- Contribution to Sumatera production (%)	13.6	29.8	68.6	65.7	14.6	9.7	37.8
- Average growth (%/year)	7.68	2.88	15.52	11.52	9.42	5.48	15.63
- Coefficient of variation of growth (%)	127 (1.00)	613 (4.83)	216 (1.70)	232 (1.83)	386 (3.04)	455 (3.59)	354 (2.79)

Note: (1) Index of growth stability: Figure in parenthesis is a ratio of coefficient of variation of growth of wetland rice production.
Source: Central Bureau of Statistics, Indonesia, Compiled by UNESCAP CGPRT Centre.

The high uncertainty of production, related to climatic variability, may be the major cause of the low stability of production growth of other food crops compared to wetland rice because most food crops, excluding wetland rice, are cultivated in dryland areas where water availability is relatively limited.

Most production growth of food crops in Lampung is the result of area growth. Contribution of area growth compared with production growth ranges from 68 per cent to 100 per cent by crop and by period (Table 3.7). This reveals that the growth of food production in Lampung is highly dependent on the growth of the harvested area. Share of the area growth during 1985-2000 was higher than in 1970-85 for most food crops, implying that the role of area growth on production growth was more important during the most recent period.

Table 3.7 Growth of production, harvested area and yield of food crops in Lampung by period

Variable	Period	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Average growth (%/year)								
Production	1970-85	10.8	3.6	20.3	9.9	17.6	1.8	29.9
	1985-00	5.3	3.2	11.7	12.2	4.8	12.8	6.3
Area	1970-85	7.3	-0.2	13.6	8.0	13.9	-2.3	26.5
	1985-00	4.8	0.3	8.7	12.0	3.9	11.7	5.4
Yield	1970-85	3.4	3.7	6.7	1.9	3.7	4.0	3.4
	1985-00	0.5	2.8	3.0	0.2	0.9	1.1	1.0
Share of production growth (%)								
Yield	1970-85	32	104	33	19	21	228	11
	1985-00	9	89	25	2	18	9	15
Area	1970-85	68	-4	67	81	79	-128	89
	1985-00	91	11	75	98	82	91	85

Source: Author’s calculation.

4. Impacts of El Nino and La Nina in Lampung

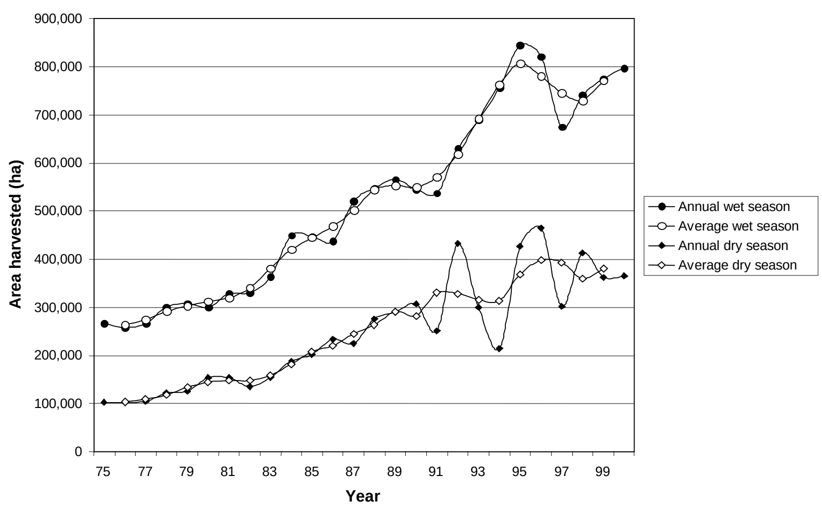
4.1 Impact on total food area by season

Section 2.1 revealed that the duration and months covered by El Nino events, which can be expressed in terms of extreme SOI values, vary year by year. Based on this information, the climatic situation of each season (El Nino or La Nina) can be defined for each year. In Lampung, the wet season covers the period of October to March and the dry season occurs from April to September. When an El Nino occurred for 14 months, for example the El Nino of 1997/1998 which covered the period of March 1997 to April 1998, both the wet season of 1997 (October 1997 to March 1998) and the dry season of 1997 (April 1997 to September 1997) were affected by the El Nino episode.

From 1975 to 2000, El Nino events affected 5 wet seasons (1977, 1982, 1986, 1991 and 1997) and 7 dry seasons (1977, 1982, 1987, 1991, 1993, 1994, and 1997). During the El Nino episodes the SOI values were extremely negative, ranging from - 10.5 to -18.5 in the wet season and from -10.3 to -17.6 in the dry season (Tables 4.1 and 4.2). In contrast, the SOI values were extremely positive during La Nina events, ranging from 10.3 to 13.7 (Tables 4.1 and 4.2). These La Nina episodes covered three periods of cultivation in the wet season, i.e. the wet seasons of 1988, 1998, 1999 and one period of cultivation in the dry season of 1998.

Figure 4.1 shows the harvested area of food crops in 1975-2000 during both the wet season and the dry season expressed in terms of the three-year-moving average and actual annual values. Deviation of harvested area between the two values can be assumed as the difference between expected harvested area and actual harvested area. The deviation can be caused by unexpected situations affecting harvested area, such as pest disaster, drought and flooding.

Figure 4.1 Three year moving average and actual annual harvested area of food crops by season in Lampung, 1975-2000



Source: Central Bureau of Statistics, Lampung.

Climate is one of the factors affecting harvested area. When the climate is normal, the difference between average area and actual area might be caused by the variability of non-climatic factors. Yet, when the climate is abnormal, the gap between average area and actual area may become lower or higher, depending on the impacts induced by the climatic abnormality on harvested area, whether it leads to positive or negative impacts.

From Figure 4.1 it is clear that a food crop's harvested area during the wet season is always higher than that of the dry season. This situation is primarily due to the higher water availability in the wet season. During normal climatic conditions, the difference between average area (or expected area) and actual area accounted for 7,813 ha or 1.29 per cent in the wet season, while the dry season figures were 18,974 ha or 5.86 per cent (Table 4.1 and Table 4.2). The larger deficits in the dry season indicate that the variability of harvested area, in other words risk of harvest failure, is higher in the dry season. Less water during the dry season is generally the major cause of area failure in the tropical region.

Table 4.1 Estimated loss of food crop area due to climatic variability during the wet season in Lampung, 1975-2000

Year	SOI value	Climatic situation	Harvested area during the wet season		Difference	
			Actual	Three year moving average	(ha)	(%)
1975/76	-0.2	N	257,926	263,681	-5,755	-2.2
1976/77	-11.8	EL	266,830	275,066	-8,236	-3.0
1977/78	-1.3	N	300,441	291,911	8,530	2.9
1978/99	-3.2	N	308,461	303,032	5,429	1.8
1979/80	-3.5	N	300,195	312,551	-12,356	-4.0
1980/81	2.8	N	328,998	319,913	9,085	2.8
1981/82	-16.9	EL	330,546	341,181	-10,635	-3.1
1982/83	1.6	N	363,999	381,392	-17,393	-4.6
1983/84	1.1	N	449,632	420,249	29,383	7.0
1984/85	-0.8	N	447,115	444,921	2,194	0.5
1985/86	-10.5	EL	438,015	468,472	-30,457	-6.5
1986/87	-3.1	N	520,286	502,156	18,130	3.6
1987/88	13.7	LA	548,167	544,647	3,520	0.6
1988/89	-4.1	N	565,487	553,129	12,358	2.2
1999/80	-2.5	N	545,733	549,721	-3,988	-0.7
1990/91	-15.9	EL	537,942	571,132	-33,190	-5.8
1991/92	-8.8	N	629,721	618,886	10,835	1.8
1992/93	-4.2	N	688,995	691,762	-2,767	-0.4
1993/94	-7.3	N	756,571	763,469	-6,898	-0.9
1994/95	2.0	N	844,841	807,524	37,317	4.6
1995/96	3.1	N	821,161	780,257	40,904	5.2
1996/97	-18.5	EL	674,768	745,537	-70,769	-9.5
1997/98	12.2	LA	740,681	730,225	10,456	1.4
1998/99	10.3	LA	775,226	771,136	4,090	0.5
Average	Normal years				7,813	1.24
	El Nino years				-30,657	-5.58
	La Nina years				6,022	0.87

Note: N=normal, El = El Nino, LA=La Nina.
Source: Central Bureau of Statistics, Lampung (area harvested); Australian Bureau of Meteorology (SOI).

During El Nino events, which are usually accompanied by a rainfall decrease, the actual harvested area was lower than the expected harvested area. This reveals that El Nino events lead to area loss of food crops cultivated. The loss is generally higher in the dry season because the decrease in water availability caused by El Nino is usually higher in the dry season (Irawan, 2002). Area loss due to El Nino in the wet season was 30,657 ha or 5.58 per cent, while for the dry season the figure was 46,180 ha or 15.03 per cent (Table 4.1 and Table 4.2).

Historically, area loss due to El Nino tends to increase in both the wet and dry seasons. In the dry season, the induced area loss ranged from 4.7 to 8.6 per cent for events occurring between 1975 and 1990. However, for events that occurred between 1990 and 2000, the figures ranged from 23.2 to 31.5 per cent, excluding the El Nino of 1993. An increase in area loss caused by El Nino was also observed for the wet season, from 3.0-6.5 per cent in 1975-1990 to 5.8-9.5 per cent in 1990-2000. The figures reveal that El Nino events tend to magnify impacts on food area losses, both for the wet season and dry season.

The increasing rate of area loss caused by recent El Nino events signifies that El Nino events are becoming more and more dangerous in terms of food security. Basically, this situation may be caused by two factors (UNDHA, 1992; IPCC, 2001): (i) The increase of duration and magnitude of El Nino that induces radical rainfall decreases, and (ii) Decreasing social capacity in anticipating or in reducing crop damage caused by water shortages induced by the events. This is clearly observed from the comparison between the El Nino of 1982/1983 and the El Nino of 1991/1992 or 1997/1998. Although both magnitude and duration of the El Nino of 1982/1983 were higher than that of 1991/1992 or similar compared with the El Nino of 1997/1998, food area loss in 1982 was lower, both for the wet season and the dry season (Table 4.1 and Table 4.2). This indicates that the social capacity to minimize food area loss caused by El Nino was better in 1982 than in 1991 or 1997.

In contrast to El Nino which induced area losses, La Nina tends to increase the food area harvested. This is particularly true for the dry season because during La Nina rainfall usually increases, thus reducing water problems which generally occur in the dry season. In the wet season, annual harvested area during La Nina was on average 0.87 per cent higher than the normal while for the dry season the figure was 15.01 per cent. This reveals that La Nina tends to induce positive impacts on harvested area in Lampung. This result is consistent with research carried out by Yoshino *et al.* (2000) which revealed that food crop production in Indonesia tends to increase during La Nina and decrease during El Nino events.

Table 4.2 Estimated loss of food crop area due to climatic variability during the dry season in Lampung, 1975-2000

Year	SOI value	Climatic situation	Harvested area during the dry season: Actual	Harvested area during the dry season: Three year moving average	Difference (ha)	Difference (%)
1976	-4.2	N	102,894	103,486	-593	-0.6
1977	-12.7	EL	104,704	109,872	-5,168	-4.7
1978	3.5	N	122,018	117,583	4,435	3.8
1979	-1.4	N	126,026	134,083	-8,057	-6.0
1980	-4.0	N	154,204	144,897	9,307	6.4
1981	4.8	N	154,461	148,021	6,440	4.4
1982	-15.7	EL	135,397	148,176	-12,779	-8.6
1983	-2.9	N	154,671	159,623	-4,952	-3.1
1984	-0.8	N	188,800	181,888	6,912	3.8
1985	1.1	N	202,192	208,526	-6,334	-3.0
1986	-0.3	N	234,587	220,559	14,028	6.4
1987	-17.6	EL	224,899	245,234	-20,335	-8.3
1988	6.4	N	276,217	263,818	12,399	4.7
1989	4.9	N	290,339	291,285	-946	-0.3
1990	1.2	N	307,298	283,103	24,195	8.5
1991	-10.3	EL	251,672	330,637	-78,965	-23.9
1992	-7.3	N	432,941	328,337	104,604	31.9
1993	-12.6	EL	300,397	316,171	-15,774	-5.0
1994	-15.6	EL	215,176	314,133	-98,957	-31.5
1995	-2.2	N	426,827	369,093	57,734	15.6
1996	6.6	N	465,277	398,165	67,112	16.9
1997	-17.5	EL	302,390	393,673	-91,283	-23.2
1998	9.2	LA	413,353	359,594	53,759	15.0
1999	4.5	N	363,038	380,520	-17,482	-4.6
Average	Normal years				18,974	5.86
	El Nino years				-46,180	-15.03
	La Nina years				53,759	15.01

Note: N = normal, El = El Nino, LA = La Nina.
Source: Central Bureau of Statistics, Lampung.

4.2 Frequency of area decrease by food crops and by season

In total, there were 5 El Nino and 3 La Nina episodes which covered wet seasons during 1975-2000 while the dry season statistics were 7 El Nino and 1 La Nina episode. During El Nino events, food crop area generally decreases due to water shortages, however, harvested area of some food crops may increase because of two possibilities: (i) Local climate of the region was not affected by the El Nino phenomena, and (ii) A shift in the cropping pattern applied by farmers in order to reduce possible production decline. For example, cassava can be substituted instead of maize since cassava is more tolerant to water stress. The two possibilities are also valid for La Nina. In addition, food crop area may also increase during La Nina events because more water is available as a result of more rainfall induced by the event. Decreases in food crop area can also occur during La Nina events caused by pest attacks which usually augment when rainfall increases.

Table 4.3. shows the frequency of cases of area increase and decrease by food crop and by season in Lampung during El Nino and La Nina episodes that occurred between 1975 and 2000. In general, the frequency of area decrease during El Nino was higher than that of La Nina, implying that the probability of food area decline is higher during El Nino events than La Nina events. The frequency of area decreases due to El Nino was higher for the dry season than the wet season, which signifies that the probability of food area decreases are particularly high during the dry season. In contrast, the probability of food area decline due to La Nina is higher during the wet season.

Among all food crops analyzed in this study, dryland rice and soybean are the most sensitive to El Nino episodes occurring in the wet season. The area of these two crops decreased in all El Nino events. A high water requirement is the main cause of area decline of dryland rice while high sensitivity to water stress is the main cause for soybean. In the dry season, cases of area decrease due to El Nino were relatively rare for wetland rice since this crop is usually only grown in the wet season, while the number of cases of area decline was still high for soybean.

Table 4.3 Frequency of cases of area increase and area decrease by food crop and by season during episodes of El Nino and La Nina in Lampung, 1975-2000

Season	Area change	Food crop						
		Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
El Nino	Increase	1	0	1	2	1	3	0
	Decrease	4	5	4	3	4	2	5
La Nina	Increase	3	2	2	1	2	1	1
	Decrease	0	1	1	2	1	2	2
Wet season (% case)								
El Nino	Increase	20	0	20	40	20	60	0
	Decrease	80	100	80	60	80	40	100
La Nina	Increase	100	67	67	33	67	33	33
	Decrease	0	33	33	67	33	67	67
Dry season (total cases)								
El Nino	Increase	1	2	0	1	1	1	0
	Decrease	6	5	7	6	6	6	7
La Nina	Increase	1	1	1	1	1	1	1
	Decrease	0	0	0	0	0	0	0
Dry season (% cases)								
El Nino	Increase	14	29	0	14	14	14	0
	Decrease	86	71	100	86	86	86	100
La Nina	Increase	100	100	100	100	100	100	100
	Decrease	0	0	0	0	0	0	0

Source: Author’s calculation.

4.3 Impact on harvested area by season and by food crop

Drought or water insufficiency due to a reduction in rainfall is a common impact of El Nino events. This impact may vary by period of cultivation, whether wet season or dry season, because El Nino impacts on rainfall are usually different by local climatic season in each region. The impacts may also vary by crop cultivated, depending on the adaptability of the crop to water stress or water insufficiency. If the crop cultivated is tolerant or highly adaptable to water stress one may expect a lower impact of El Nino on production and harvested area.

In general, rice cultivation is intolerant to water stress because of its high water requirement. Soybean is also intolerant to water stress despite the relatively low water requirement. In the case of soybean cropping, Rajit *et al*. (1991) revealed that an appropriate quantity and schedule of irrigation to farmers' fields is more important than the continuous high supply of water to assure optimal production of soybean because this crop is very sensitive to water supply, in other words, both excessive or insufficient water supply may reduce soybean production. For example, insufficient water supply at the flowering and pod formation stages can decrease soybean yield by about 40 per cent to 50 per cent. In contrast, cassava is very tolerant or very adaptable to water supply because with its deep root system, cassava can tolerate dry weather and water stress for a longer period (Falcon *et al*., 1984).

Table 4.4 shows that the actual harvested area was lower than the average area harvested for most food crops during El Nino events. This is particularly true for the dry season, when the reduction in rainfall is usually drastic with the onset of El Nino. From a total of 7 cases of El Nino in the dry season and 7 food crops being analyzed, only 4 cases showed higher actual area than the expected area, in other words, had positive affects on harvested area. They were wetland rice and cassava in 1977, groundnut in 1993, and dryland rice in 1994. The other 45 cases showed decreases in harvested area (92 per cent). Whereas for the wet season, the percentage was only 80 per cent. This helps to explain that the occurrence probability of food area decrease during El Nino events was higher in the dry season than in the wet season.

Table 4.4 Difference between expected harvested area and actual annual harvested area during El Nino and La Nina events by food crop and by season in Lampung, 1976-1999 (ha)

Year/season	Climate situation	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Wet season								
1977	EL	303	-3,234	-1,771	-1,875	-301	-284	-1,641
1982	EL	-1,638	-2,514	-7,467	1,172	899	-57	-1,030
1986	EL	-5,526	-19,286	1,560	-5,765	-784	80	-735
1988	LA	249	3,155	13,433	-6,918	-1,469	-112	-4,817
1991	EL	-17,175	-10,943	-4,045	5,477	-774	120	-5,850
1997	EL	-24,265	-10,665	-3,418	-15,618	-1,524	-232	-15,047
1998	LA	3,140	4,853	5,096	-8,898	128	-390	6,527
1999	LA	5,589	-3,329	-2,904	6,290	89	334	-1,979
Dry season								
1977	EL	202	-259	-2,558	4,331	-307	-49	-6,528
1982	EL	-2,787	-13	-6,314	-433	-707	-185	-2,341
1987	EL	-3,204	0	-2,717	-4,393	-514	-103	-9,404
1991	EL	-6,265	5	-23,295	-10,867	-1,338	-360	-36,845
1993	EL	-107	-21	-9,140	-4,247	66	-89	-2,235
1994	EL	-9,769	53	-38,688	-22,578	-3,153	-1,028	-23,795
1997	EL	-7,912	-22	-39,320	-32,529	-1,753	-1,678	-8,069
1998	LA	12,244	36	15,561	21,561	1,454	1,285	1,618

Note: El = El Nino, LA=La Nina.
Source: Central Bureau of Statistics, Lampung.

On average, decreases in harvested area during El Nino events ranged between 74 ha and 9,660 ha by food crop in the wet season, and between 37 ha and 17,433 ha in the dry season (Table 4.5). Wetland rice and dryland rice had the highest area decrease in the wet season (more than 9,000 ha) since the most common food crop cultivated by farmers in the wet season is rice. Meanwhile, when El Nino occurred in the dry season, maize, cassava and soybean were the food crops that were the most affected in terms of harvested area (more than 10,000 ha). Thus, the impacts of El Nino on food area differ according to season; during the wet season rice suffers the highest decrease in harvested area while in the dry season it is maize, cassava and soybean.

Table 4.5 Estimated loss of food crop area caused by El Nino and La Nina by crop and by season in Lampung, average during 1975-2000

Climate situation/season	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Wet season (ha)							
El Nino	-9,660	-9,329	-3,028	-3,322	-497	-74	-4,861
La Nina	2,992	1,560	5,208	-3,175	-417	-56	-90
Dry season (ha)							
El Nino	-4,263	-37	-17,433	-10,102	-1,101	-499	-12,745
La Nina	12,244	36	15,561	21,561	1,454	1,285	1,618
Wet season (%)							
El Nino	-6.0	-7.7	-2.7	-8.1	-8.0	-4.4	-12.2
La Nina	1.3	1.2	2.3	-5.5	-5.9	-2.6	-0.2
Dry season (%)							
El Nino	-5.4	-63.4	-27.7	-11.9	-29.8	-27.1	-37.7
La Nina	10.0	31.3	13.6	20.7	30.0	43.4	15.9

Source: Central Bureau of Statistics, Lampung.

In general, soybean is the most sensitive crop to El Nino. Area decreases of soybean were respectively 12.2 per cent in the wet season and 37.7 per cent in the dry season. For dryland rice, which is the most sensitive to El Nino occurring in the dry season, its economical impact can be ignored because cultivation of dryland rice is very rare. Other food crops sensitive to water stress caused by El Nino in the dry season are maize, sweet potato and groundnut, which all suffered area decreases in the dry season of more than 25 per cent. On the other hand, wetland rice and cassava are relatively tolerant to El Nino, their area decrease in the dry season being only 5.4 and 11.9 per cent respectively. The low area decrease of wetland rice was due to the availability of water supply from irrigation networks, while in the case of cassava it was due to its high tolerance to water stress.

Contrary to El Nino which causes decreases in harvested area, La Nina tends to increase harvested area. This is particularly true for dry season cultivation where harvested area of all food crops increased during La Nina events occurring during the dry season (Table 4.5). Increasing harvested area in the wet season during La Nina occurred for wetland rice, dryland rice and maize with increases of 2,992 ha, 1,560 ha and 5,208 ha respectively. The harvested area of other food crops such as cassava, groundnut, sweet potato and soybean decreased during La Nina occurring in the wet season.

Increasing harvested area during La Nina is possible because water insufficiency that is normal during the dry season and which can cause crop failure can often be reduced by the additional rainfall attributable to La Nina events. This is particularly true for food crops cultivated on non-irrigated land and dryland areas because the water supply on such agricultural land is highly dependent on rainfall. The same reason may also be valid for increasing harvested area of wetland rice, dryland rice and maize cultivated during the wet season. In addition to this factor, increasing harvested area of the three crops might also be caused by a cropping shift from other crops to these three crops. For example, the substitution of maize for cassava, groundnut, sweet potato or soybean is possible since most of these crops are cultivated on the same agricultural land. When water is more readily available due to La Nina, farmers prefers to cultivate maize than cassava because of its higher profitability. They also prefer to grow maize rather than soybean or groundnut because the latter two crops are more sensitive to pest attacks, which during the wet season or periods of high rainfall, usually increase.

4.4 Impact on yield

From an agronomic point of view, yield per hectare of food crops is a function of technology, such as the level of superior variety utilization, method of fertilizer application, land preparation method, technique of water utilization according to plantation requirements, etc. Yield of food crops can also be differentiated according to the level of land fertility and irrigation status of the cultivated land. In general, yield of food crops cultivated on irrigated land is higher than that cultivated on non-irrigated land, due to the controllable water supply to farmers' fields. Over the long-term, yield per hectare of food crops tends to increase due to technological progress. However, yield can still decrease if climate abnormalities occur which affect water availability at the farm level.

El Nino and La Nina are climatic abnormalities which affect water availability through their impacts on rainfall and accordingly, both events can disturb the yield of food crops cultivated. The impact is usually higher on crops cultivated on non-irrigated land because water supply and water availability on non-irrigated land highly depends on rainfall. Fortunately, water supply to irrigated land does not highly depend on the prevailing climatic conditions due to the presence of water reservoirs/dams which enable farmers to control the water supply to their cultivated field.

Due to the unavailability of seasonal and monthly data, impact analysis on yield of food crops was conducted based on annual data for 1968-2000. Using annual data, the definition of El Nino and La Nina episodes of certain years may differ slightly from the previous impact analysis on harvested area which was based on monthly data. This is because the coverage period of El Nino and La Nina events are not absolutely the same as the calendar year (i.e. January to December), however, the yield and production data was expressed in terms of calendar years. For example, the 1997/1998 El Nino covered a period of March 1997 to April 1998. In this case the El Nino was assumed to have occurred in 1997 because the number of months within 1997 covered by El Nino were more than in 1998.

Figure 4.2 Three year moving average and actual annual yields of wetland rice and dryland rice in Lampung, 1968-2000

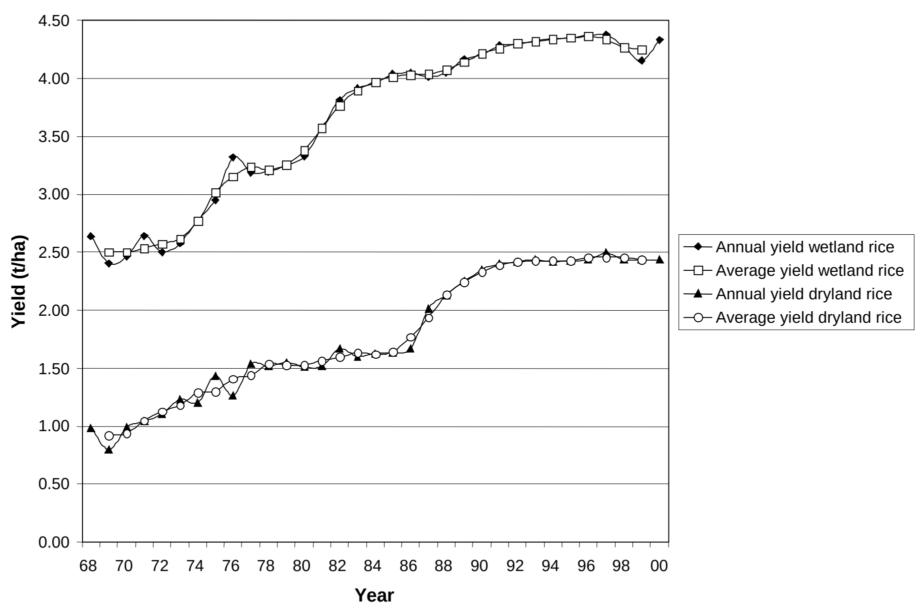


Figure 4.2 shows the evolution of yield of wetland rice and dryland rice expressed as a three year moving average and actual annual values. From this figure it is clear that the deviation of expected yield (average yield) from actual yield was very small, even during El Nino and La Nina events. This means that the variability in yield caused by climate and other factors was relatively small. This also reveals that the impact of El Nino and La Nina on the yield of both wetland and dryland rice was not significant.

On average, yield of wetland rice during El Nino events was 0.32 per cent lower than the expected yield while for La Nina the figure was 0.40 per cent (Table 4.6). Decreases in yield during El Nino episodes also occurred for groundnut (-1.63 per cent) and sweet potato (-1.27 per cent) while increasing yields were observed for dryland rice, maize, cassava and soybean with the rate of yield increase ranging from 0.55 to 1.92 per cent. During La Nina events, an increase in yield was observed for all food crops, excluding wetland rice, ranging from 0.47 to 2.25 per cent according to the crop. These figures reveal that both El Nino and La Nina events tend to increase yield of most food crops, excluding wetland rice, groundnut and sweet potato.

The results indicated above, however, seem unrealistic, particularly for El Nino cases. During La Nina events, yield of food crops might increase since the water supply to farmers' fields usually increases from the increased rainfall induced by the event. Negative impacts of La Nina on the yield of wetland rice are also possible due to a swollen pest population induced by higher humidity and lower temperatures. It is difficult however, to explain why yield increased during El Nino events or when water was less available to farmers. This is particularly true for soybean and dryland rice because these two crops are intolerant to water stress.

Inaccurate yield data is a potential reason because the yield data published by the Central Bureau of Statistics is sampled data which is generally sampled in major food producing regions. When an El Nino event occurs and part of the cultivated area is affected by drought, yield sampling can only be executed in non-affected areas. These areas are generally good because when drought disaster hits, farmers tend to concentrate and to intensify their farming activities on the non-affected areas. Consequently, the yield obtained by a farmer during an El Nino episode might be higher than usual but only in non-affected areas.

Table 4.6 Deviation of annual yield from the three year moving average by food crop during El Nino and La Nina events in Lampung (percentage)

Year	Abnormal climate	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
1972	EL	-2.75	-1.70	-0.78	-1.93	-2.59	-7.60	-8.61
1977	EL	-1.41	6.79	5.04	-0.60	-7.72	2.02	6.77
1982	EL	1.25	4.47	-2.94	3.60	-0.23	-1.60	2.45
1987	EL	-0.60	4.04	-0.40	2.63	-3.17	-1.20	4.67
1992	EL	-0.12	0.09	0.92	-1.24	-1.59	-1.07	-2.23
1993	EL	0.09	0.41	0.80	5.74	3.58	-1.43	0.59
1994	EL	0.05	-0.32	-1.41	-3.61	-6.74	1.17	0.61
1997	EL	0.94	1.54	8.75	-0.15	5.45	-0.49	0.09
1971	LA	4.16	-0.38	18.77	5.78	3.07	11.36	3.75
1973	LA	-1.59	4.37	-5.78	1.29	4.96	-4.86	-3.44
1975	LA	-2.12	10.31	-6.07	-3.28	3.09	2.54	-0.14
1988	LA	-0.61	-0.03	-1.47	-0.89	-0.46	-4.28	1.77
1998	LA	0.06	-0.67	-0.22	0.10	-4.58	-1.20	-0.96
Average	El Nino	-0.32	1.92	1.25	0.55	-1.63	-1.27	0.54
	La Nina	-0.40	2.25	0.84	0.47	1.31	0.74	1.06
Total positive cases	El Nino	4	6	4	3	2	6	2
	La Nina	2	2	1	3	3	2	2
Mean of deviation (%)	El Nino	0.58	2.89	3.88	3.99	4.52	2.53	1.60
	La Nina	2.11	7.34	18.77	2.39	3.22	3.63	1.59
Total negative cases	El Nino	4	2	4	5	6	2	6
	La Nina	3	3	4	2	2	3	3
Mean of deviation (%)	El Nino	-1.22	-1.01	-1.38	-1.51	-3.67	-5.42	-2.23
	La Nina	-1.66	-0.29	-2.75	-1.44	-2.52	-1.51	-3.44

Table 4.6 shows that El Nino and La Nina produced inconsistent impacts on the yield of food crops, both positive and negative. For example, El Nino events in 1972, 1977, 1987 and 1992 resulted in negative impacts on yield of wetland rice but in 1982, 1993, 1994 and 1997 led to positive impacts (yield increases). Inconsistent impacts, positive and negative, were also observed for other food crops analyzed and for La Nina.

During La Nina events, the number of cases of negative impacts on wetland rice, dryland rice and maize were respectively 3, 3 and 4 cases while for positive impacts the figures were respectively 2 cases, 2 cases and 1 case. The higher number of negative cases indicates that the probability of decreasing yield was higher than the probability of increasing yield, in other words, La Nina events tend to decrease yield of wetland rice, dryland rice and maize. The number of cases of negative and positive impacts were similar during El Nino events, particularly for wetland rice and maize. This reveals that the probability of decreasing yield of wetland rice and maize is higher during events of La Nina than El Nino, or in other words, the impact of La Nina on yield of these two crops were more dangerous than that of El Nino. The situation was, however, the reverse for cassava, groundnut and soybean. The number of negative cases was much higher in El Nino episodes while both positive and negative cases were relatively similar in La Nina episodes, implying that the probability of yield decreases of cassava, groundnut and soybean is higher during El Nino events than La Nina events.

4.5 Impact on production by food crop

The impact on production is basically the result of impacts on harvested area and impacts on yield per hectare. Accordingly, the impact on production of each crop highly depends on the degree of impact on harvested area and yield per hectare. If the impact on harvested area and yield per hectare are relatively high, we might expect a high impact on production and vice versa. In the case of very high negative impacts on harvested area, we might also expect a high negative impact on production, even if impacts on yield per hectare are very low, or even positive.

Due to the unavailability of seasonal and monthly data, impact analysis on food production was conducted based on annual data from 1968 to 2000. Table 4.7 shows that El Nino events occurring from 1968 to 2000, in general, caused production decreases of all food crops analyzed. On average, El Nino caused the highest fall in production for soybean, which was 11.87 per cent. The second group of food crops which experienced rather high production decreases (5.47-7.63 per cent) was maize, groundnut and sweet potato. While a rather low production decrease occurred for cassava (3.17 per cent), with the lowest being dryland rice (1.61 per cent) and wetland rice (1.00 per cent).

Table 4.7 Deviation of actual annual production from the three year moving average by food crop during El Nino and La Nina events in Lampung, 1968-2000

Year	Abnormal climate	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
Quantity (ton)								
1972	EL	-12,098	2,774	-23,006	-63,884	-39	-3,797	-2,845
1977	EL	440	5,253	4,726	23,341	-761	2,340	390
1982	EL	-2,984	4,821	-23,090	38,848	179	-2,269	-2,313
1987	EL	41,850	-10,501	-37,883	7,049	846	-239	-2,228
1992	EL	85,786	-22,022	22,035	-51,649	1,505	2,577	48,116
1993	EL	12,806	18,921	21,608	469,904	355	3,194	-12,588
1994	EL	-94,618	-25,084	-98,727	-323,940	-4,002	-9,514	-29,670
1997	EL	-125,403	-21,307	37,052	-543,645	-3,066	-18,550	-23,970
1971	LA	16,070	1,613	29,122	-102	96	5,678	-1,641
1973	LA	-1,437	7,822	17,894	132,881	379	311	-1,853
1975	LA	23,094	9,144	-21,198	3,409	950	204	-5,320
1988	LA	-15,144	5,599	5,975	131,911	-2,012	-2,122	-4,573
1998	LA	96,718	35,376	-11,106	-214,273	2,830	11,624	83
Average	**El Nino**	**-11,778**	**-5,893**	**-12,161**	**-55,497**	**-623**	**-3,282**	**-3,139**
	La Nina	**7,289**	**4,788**	**9,983**	**67,505**	**-49**	**1,436**	**-803**
Percentage (%)								
1972	EL	-5.1	1.8	-22.6	-12.1	-1.3	-15.4	-13.5
1977	EL	0.1	3.1	10.6	3.1	-17.7	11.0	1.5
1982	EL	-0.4	2.4	-23.6	4.6	2.8	-13.6	-11.5
1987	EL	4.4	-4.2	-10.0	0.5	7.5	-1.0	-1.9
1992	EL	6.8	-8.7	4.3	-2.2	13.2	5.4	3.5
1993	EL	1.0	6.9	3.9	19.4	3.0	7.0	-9.1
1994	EL	-6.7	-7.9	-14.9	-13.4	-28.0	-19.7	-21.2
1997	EL	-8.0	-6.4	3.6	-25.2	-23.4	-34.7	-42.9
1971	LA	7.5	1.1	35.4	0.0	4.0	23.6	-14.0
1973	LA	-0.6	5.2	18.4	22.1	11.7	1.4	-5.0
1975	LA	6.4	6.6	-39.9	0.5	24.3	0.9	-13.2
1988	LA	-1.5	2.3	1.5	7.4	-17.6	-8.3	-4.3
1998	LA	6.3	11.8	-1.0	-9.9	27.8	24.3	0.2
Average	**El Nino**	**-1.00**	**-1.61**	**-6.09**	**-3.17**	**-5.47**	**-7.63**	**-11.87**
	La Nina	**2.24**	**2.67**	**2.99**	**5.61**	**4.15**	**4.88**	**-2.93**

In contradiction to the negative impacts on food production induced by El Nino, La Nina tends to increase food production; excluding soybean since this crop is very sensitive to water supply. Positive impacts of La Nina on food production are generally higher on food crops predominantly cultivated by farmers in dry areas in the dry season, such as maize, cassava, groundnut and sweet potato. On average, production increases during La Nina events ranged between 2.99 per cent and 5.61 per cent (Table 4.7). Whereas for wetland and dryland rice, production increases were 2.24 per cent and 2.67 per cent respectively. The greater impact of La Nina on dryland rice production is basically because dryland rice is cultivated on non-irrigated land and on this type of agricultural land water is less available and consequently, if La Nina occurs inducing rainfall, then the problem of water insufficiency faced by farmers is reduced.

5. El Nino 1997/1998: Impact Analysis and Mitigation Measures in Lampung

The El Nino of 1997/1998 was recognized as one of the biggest events of the century seriously disturbing the fundamental modes of crop cultivation and damaging the production of foods and other commodities in affected areas. The negative impacts on production of food crops are generally worse for upland areas and on non-irrigated land where most CGPRT crops are grown. Accordingly, it is a most urgent subject for agriculture, especially for rainfed upland agriculture, to establish institutional countermeasures in order to minimize and recover from the damage.

This chapter is devoted to analyzing the impacts of the 1997/1998 El Nino particularly for the province of Lampung. Experience indicates that Lampung is one of the most sensitive provinces to El Nino in Indonesia with total food production loss averaging 7.5 per cent, more than double production loss nationwide. The analysis covers two levels: (i) Aggregate analysis at a provincial level for Lampung, and (ii) Analysis at the household level of selected villages. Impact on rainfall and related crop perturbation induced by El Nino was the main focus of the analysis at the provincial level, while the analysis at the household level focused on aspects of change of cropping patterns, loss of production and yield, impacts on staple food consumption, and coping strategies applied by farmers to minimize any consequences induced.

5.1 Impact on rainfall

Meteorologically, El Nino is shown by a large negative SOI (Southern Oscillation Index), which is usually followed by a decrease in rainfall. To understand the impact of El Nino on rainfall in Lampung, daily rainfall data from 1977-2000 was collected from Dinas Pengairan Pekerjaan Umum, Propinsi Lampung (Public Works). In total, 75 rainfall stations exist in Lampung but only 46 data sets could be analyzed due to incomplete data, particularly for new stations built during the last five years. The rainfall stations included were distributed in 8 districts of Lampung with 3-12 stations per district.

The analysis of El Nino impacts on rainfall was carried out by comparing seasonal rainfall (dry season and wet season) in 1997 and 1998 with the average rainfall figure for each station, expressed as a percentage. The period of analyzed data of average rainfall was different for some stations due to incomplete data, but at least 10 years data covering 1990-2000 was used. In general, the dry season in Lampung occurs between April and September and the wet season from October - March. Following this rainfall pattern, the wet season of 1996/1997 covered the period of October 1996 - March 1997, and the dry season of 1997 covered the period of April 1997 - September 1997.

Figure 5.1 shows the evolution of SOI values, average rainfall and actual rainfall in Lampung for April 1996 - March 2000. From this figure it is clear that large negative SOI values occurred from March 1997 until April 1998, ranging from -8.5 to -28.5, indicating the occurrence the El Nino of 1997/1998. In other words, the El Nino event covered some months within the wet season of 1996/1997 (Febuary 1997 and March 1997), and all months within the dry season of 1997 and wet season 1997/1998.

After large negative SOI values up to April 1998, large positive SOI values (more than 10.0) were registered from June 1998 until January 1999 indicating that this period was affected by a La Nina event. In other words, the La Nina event covered the dry season of 1998 and some months of the 1998/1999 wet season (October 1998 through January 1999). This also reveals that the severe El Nino of 1997/1998 was followed by La Nina.

In the case of an El Nino event, rainfall in Lampung tends to decrease compared with the average. However, despite the El Nino of 1997/1998 starting in March 1997 rainfall decline in Lampung began in February 1997 (Figure 5.2). From Figure 5.2 it is clear that the highest percentage of rainfall decrease primarily occurred during June to November 1997, with rainfall decreases of more than 40 per cent below the long-term average. A moderate rate of rainfall decrease, (between 20 per cent and 40 per cent) occurred in March, April and December 1997 while low rates of rainfall decrease (less than 10 per cent) occurred from January - April 1998. After such time, rainfall in Lampung increased significantly to more than 20 per cent above average, particularly May - August 1998 due the La Nina episode. Again, a time delay between the rainfall changes in accordance with SOI fluctuation was observed, large positive SOI values started in June 1998 but the significant rainfall increase began in May 1998.

Figure 5.1 Relation between Southern Oscillation Index (SOI) and rainfall in Lampung, April 1996 - March 2000

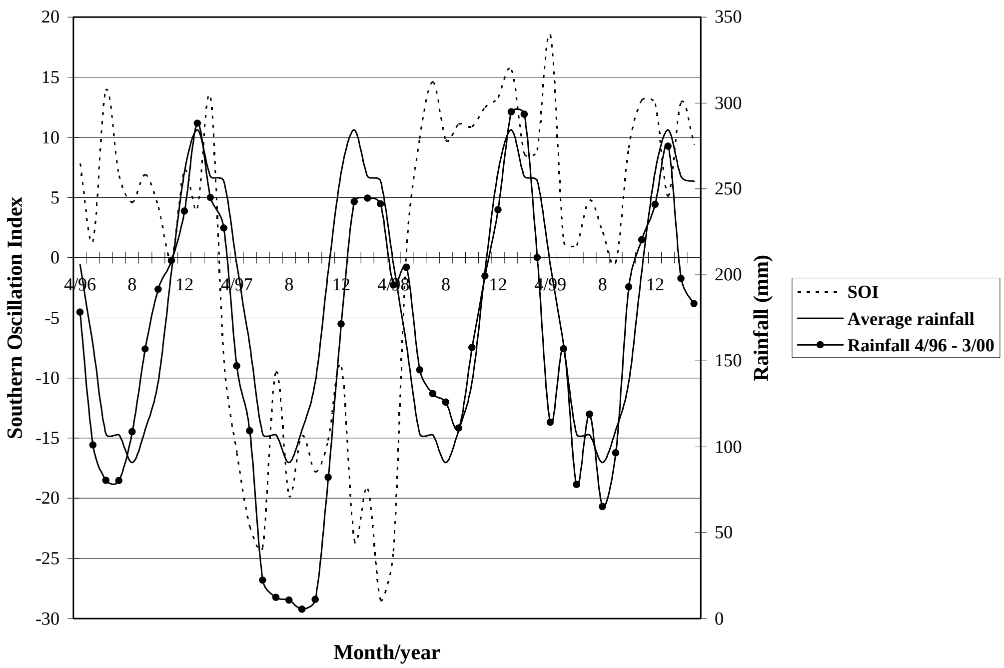


Figure 5.2 Deviation of monthly rainfall compared with average rainfall in Lampung, April 1996 - March 2000

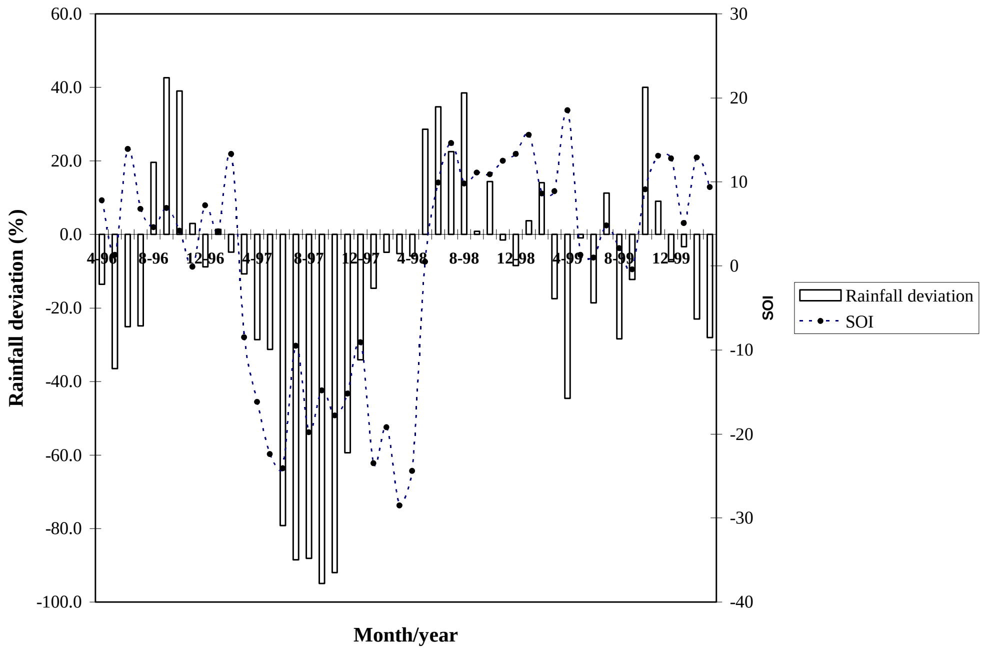


Table 5.1 shows rainfall statistics for 1997 and 1998, and average rainfall by station and by season in Lampung. The greatest rainfall decrease was registered in the 1997 dry season, as was observed at all stations analyzed, with rainfall decreases ranging from -41.1 to -82.5 per cent (Table 5.1). On average, of all stations analyzed, rainfall decrease was higher in the 1997 dry season (-59.1 per cent) than in the wet season of 1998 (-28.1 per cent) despite the negative SOI values being higher during the 1998 wet season. These results are consistent with results obtained in previous work by Yoshino *et al*. (2000). This implies that El Nino's impacts on rainfall not only depend on magnitude (indicated by large negative SOI) but are also influenced by the date of occurrence, whether wet season or dry season. The effects also depend on how long the El Nino lasts. This was shown by the relatively stable rainfall during the wet season of 1996/1997 (rainfall change of only 1 per cent) even though the El Nino event covered two months out of the six included in the 1996/1997 wet season.

The high rainfall decrease in the 1997 dry season (more than 60 per cent) was observed predominantly in three districts of Lampung, namely, Lampung Selatan, Tanggamus and Lampung Barat (Table 5.2). A similar situation also occurred in the 1998 wet season. This reveals that reduced rainfall induced by El Nino tends to be concentrated in certain regions with specific geographic characteristics. Table 5.2 shows that rainfall decreases were relatively high in regions with high altitude or in other words, the higher the altitude of a region, the higher the decrease in rainfall caused by El Nino. Regions of higher altitude are generally dryland or upland regions where most CGPRT crops are grown.

Table 5.1 Rainfall decrease due to the El Nino of 1997/1998 by rainfall station and by season in Lampung

Station	Altitude	Average rainfall (mm)			Rainfall decrease compared with average rainfall (%)					
					1997			1998		
	(m)	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons
Bendungan Argoguruh	52	1,332	581	1,912	-10.8	-45.2	-21.2	-35.6	46.7	-10.6
Gunung Batu	300	1,207	637	1,844	-7.7	-57.3	-24.8	-34.6	-1.1	-23.0
Jati Baru/T. Bintang	65	1,074	724	1,798	27.2	-55.1	-5.9	-25.1	37.8	0.3
Sukajaya-Kedondong	157	1,116	547	1,662	-8.7	-68.3	-28.3	-36.3	-18.8	-30.6
Ketibung	35	1,375	722	2,096	-10.4	-60.6	-27.7	-32.0	31.1	-10.3
Penengahan	45	1,057	673	1,730	0.1	-74.7	-29.1	-39.8	-3.6	-25.7
Air Naningan	385	1,233	866	2,099	-7.5	-73.3	-34.7	-5.7	25.2	7.0
Banjar Agung	165	1,086	577	1,663	-7.9	-63.9	-27.3	-51.8	-29.1	-43.9
Banyuwangi/Suko	120	1,268	685	1,953	1.5	-69.6	-23.4	-36.1	39.6	-9.5
Gisting	560	1,243	967	2,209	12.2	-65.8	-21.9	-5.9	-21.7	-12.8
Gunung Sari	720	1,533	843	2,377	3.1	-71.4	-23.3	-29.2	25.0	-10.0
Kunyir	435	1,394	751	2,145	9.3	-69.8	-18.4	-22.5	18.6	-8.1
Pematang Nebak	430	1,033	587	1,619	23.4	-51.6	-3.7	-22.7	-2.5	-15.4
Pringsewu	100	1,193	638	1,831	2.0	-66.2	-21.8	-26.5	47.7	-0.6
Wonosobo/S. Betik	30	1,116	770	1,886	16.8	-73.3	-20.0	-0.9	-18.9	-8.3
Srikaton/Srikuncoro	30	1,387	1,087	2,474	-10.9	-82.1	-42.2	-22.7	-14.2	-19.0
Way Harong Toto	370	1,558	865	2,423	1.1	-51.9	-17.8	-12.2	23.9	0.7
Wonokriyo/G. Rejo	65	1,218	722	1,940	-1.4	-59.6	-23.0	-30.5	21.7	-11.1
Metro DPU	58	960	495	1,454	4.4	-46.1	-12.8	-13.0	44.5	6.6
Bumi Kencana	48	1,167	752	1,919	5.9	-44.2	-13.7	-12.9	45.9	10.1
Komering Putih	40	1,271	611	1,883	4.2	-56.2	-15.4	-16.7	34.2	-0.2
Negeri Kepayungan	115	1,273	628	1,901	-7.7	-35.4	-16.9	-20.5	37.4	-1.4
Sindang Asri	120	1,554	844	2,398	-4.6	-55.8	-22.6	-30.7	6.3	-17.7

Note:
(1) Average rainfall in 1980-2000.
(2) Wet season 1997 = (October 1996 - March 1997); Dry season 1997 = (April 1997 - September 1997).
Source : Dinas Pengairan PU. Propinsi Lampung.

Continued …………

Table 5.1 Rainfall decrease due to the El Nino of 1997/1998 by rainfall station and by season in Lampung (continued)

Station	Altitude	Average rainfall (mm)			Rainfall decrease compared with average rainfall (%)					
					1997			1998		
	(m)	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons
Bukit Kemuning	310	1,273	752	2,024	8.4	-45.4	-11.6	-11.2	37.0	6.7
Gedung R.S. Utara	46	1,391	731	2,123	-7.0	-57.6	-24.4	-18.8	33.7	-0.7
Ketapang	50	1,972	1,208	3,180	-13.6	-77.6	-38.0	-30.8	-10.0	-22.9
Kotabumi	40	1,153	514	1,667	12.6	-44.2	-4.9	-25.6	56.9	-0.2
Pekurun	70	1,919	1,087	3,006	-21.8	-52.9	-33.0	-40.9	-9.0	-29.4
Daya Murni	25	1,193	616	1,808	2.5	-61.4	-19.2	-32.6	44.1	-6.5
Gedung Ratu	12	1,253	577	1,830	12.3	-43.4	-5.3	-57.2	16.7	-33.9
Menggala	15	1,372	587	1,959	3.4	-42.7	-10.4	-24.7	94.3	11.0
Purwajaya Unit I	30	1,700	665	2,365	-0.8	-45.4	-13.3	-51.2	33.7	-27.3
Sidoharjo G. Aji	9	846	447	1,294	5.5	-64.8	-18.8	-43.6	43.8	-13.4
Air Itam	806	1,596	985	2,582	-3.3	-52.9	-22.2	-22.0	12.0	-9.0
Bungin	810	1,550	987	2,537	-11.2	-71.7	-34.7	-22.6	26.1	-3.7
Dusun Kenali	820	1,780	1,108	2,887	9.2	-64.3	-19.0	-41.9	-17.7	-32.6
Gedung Cahya.K.	12	2,416	1,643	4,059	-8.8	-74.2	-35.3	-46.7	-8.6	-31.3
Kebun Tebu	825	1,610	926	2,536	-2.0	-61.4	-23.7	-22.3	-9.9	-17.8
Rawa Bebek	812	1,916	914	2,830	-22.4	-82.5	-41.8	-40.9	19.3	-21.4
Sekincau	1,000	1,388	852	2,240	17.6	-58.1	-11.2	-16.8	37.3	3.8
Reno Basuki	20	1,449	703	2,152	3.3	-46.1	-12.8	-34.2	34.1	-11.8
Sukadana	23	1,792	784	2,577	-1.5	-41.1	-13.5	-23.1	49.5	-1.0
Way Jepara	22	1,439	777	2,216	3.2	-61.9	-19.6	-50.4	34.9	-20.5
Baradatu	120	1,003	482	1,485	-3.5	-52.5	-19.4	-15.1	21.4	-3.3
Blambangan Umpu	110	1,758	920	2,678	11.3	-67.8	-15.9	-30.2	7.6	-17.2
Tahmi Lumut	275	1,799	1,048	2,846	17.4	-53.3	-8.6	-26.3	3.9	-15.2
	Average	**1,396**	**780**	**2,176**	**1.0**	**-59.1**	**-20.7**	**-28.1**	**20.2**	**-11.5**

Note:
(1) Average rainfall in 1980-2000.
(2) Wet season 1997 = (October 1996 - March 1997); Dry season 1997 = (April 1997 - September 1997).
Source: Dinas Pengairan PU. Propinsi Lampung.

Table 5.2 Rainfall decreases due to the El Nino of 1997/1998 by district and by altitude in Lampung

District or altitude	Average rainfall (mm)			Rainfall decrease compared with average rainfall (%)					
				1997			1998		
	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons	Wet season	Dry season	All seasons
District									
Lampung Selatan	1,193	647	1,840	-1.7	-60.2	-22.8	-33.9	15.4	-16.7
Tanggamus	1,272	780	2,052	3.5	-66.5	-23.1	-22.2	9.6	-10.9
Lampung Tengah	1,245	666	1,911	0.5	-47.5	-16.3	-18.8	33.7	-0.5
Lampung Utara	1,541	858	2,400	-4.3	-55.6	-22.4	-25.5	21.7	-9.3
Tulang Bawang	1,273	578	1,851	4.6	-51.5	-13.4	-41.9	46.5	-14.0
Lampung Barat	1,751	1,059	2,810	-3.0	-66.4	-26.9	-30.5	8.3	-16.0
Lampung Timur	1,560	755	2,315	1.7	-49.7	-15.3	-35.9	39.5	-11.1
Way Kanan	1,520	817	2,336	8.4	-57.9	-14.6	-23.9	11.0	-11.9
Altitude									
<200	1,358	735	2,093	-0.1	-57.7	-20.5	-30.9	24.2	-12.3
200-600 m	1,342	809	2,151	7.1	-58.6	-17.7	-17.7	10.4	-7.5
>600 m	1,625	945	2,570	-1.3	-66.0	-25.1	-28.0	13.1	-13.0

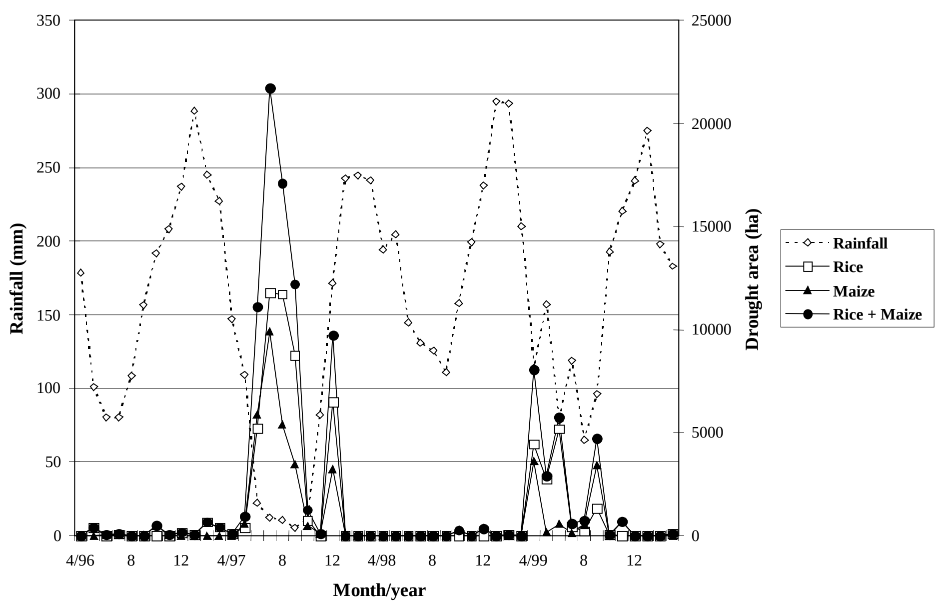
Note:
(1) Average rainfall in 1980-2000.
(2) Wet season 1997 = (October 1996 - March 1997); Dry season 1997 = (April 1997 - September 1997).
Source: Dinas Pengairan PU. Propinsi Lampung.

5.2 Impact on drought disaster

Drought or water insufficiency due to rainfall decreases is a common impact of El Nino. Balai Proteksi Tanaman Pangan dan Hortikultura in the province of Lampung (Office for the Protection of Food crops and Hortuculture) is the agricultural institution which monitors the area of food crops that suffer from drought, pests, floods and other natural disasters. All information appertaining to drought and pest attacks is compiled and presented in "Laporan Musiman" or seasonal report. However, not all food crops are monitored. Rice and maize are the major concern for drought cases, while for pest cases the report also covers soybean.

Figure 5.3 shows the evolution of rainfall and area affected by drought for rice and maize in Lampung for April 1996 - March 2000. From this figure it is clear that a large area was affected by drought between May 1997 and January 1998 when rainfall drastically dropped. This was the occurrence period of the El Nino of 1997/1998, which covered 14 months from Febuary 1997 to April 1998. Due to water insufficiency, the area of rice and maize affected by drought began augmenting in May 1997, reaching maximum values in July and August 1997 and ending in October/November 1997.

Figure 5.3 Monthly rainfall and area of rice and maize affected by drought in Lampung, April 1996 - March 2000



No drought was reported in October and November of 1997 because rice and maize grown in the dry season has normally been harvested by this time. Drought cases rose again in December 1997 after farmers had planted their wet season crop of 1997/1998, which is generally planted after harvesting the dry season crop.

During the 48 months from April 1996 - March 2000, or 8 periods of cultivation, the area of rice and maize affected by drought was respectively 61,621 ha and 39,454 ha, or about 101,000 ha in total (Table 5.3). About 74 per cent of all drought cases were recorded between May 1997 and April 1998, during the El Nino of 1997/1998. This indicates that El Nino tends to cause drought disaster due to water insufficiency. Monthly rainfall during this period decreased by about 50 per cent compared with the average rainfall over a long period. Large rainfall decreases were observed, particularly from June-October 1997 (dry season) where the monthly rainfall was only 6-22 mm per month or an 80-95 per cent decrease compared with the average.

Most drought cases in 1997/1998 occurred in the 1997 dry season both for rice and maize. The coverage area of rice farming during the 1997 dry season affected by drought was 37,967 ha while the figure was 25,209 ha for maize farming. Drought also occurred in the 1997/1998 wet season but to a lesser degree, covering 7,251 ha of rice farming and 3,856 ha of maize farming. Thus, the total area of rice and maize affected by drought induced by the El Nino in 1997/1998 was 45,218 ha and 29,065 ha respectively.

Table 5.3 Seasonal area affected of rice and maize by drought in Lampung, dry season 1996 to wet season 1999

Area	Season							
	Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
Area affected by drought (ha)								
Rice	485	1,308	37,967	7,251	10	61	14,393	146
Maize	100	523	25,209	3,856	0	637	8,425	704
Total	585	1,831	63,176	11,107	10	698	22,818	850
Area completely damaged by drought								
a. Coverage area (ha)								
Rice	176	419	9,750	307	0	5	1,493	3
Maize	19	10	12,650	502	0	270	170	0
Total	195	429	22,400	809	0	275	1,663	3
b. Percentage of total area affected (%)								
Rice	36.3	32.0	25.7	4.2	0.0	8.2	10.4	2.1
Maize	19.0	1.9	50.2	13.0	0.0	42.4	2.0	0.0
Total	33.3	23.4	35.5	7.3	0.0	39.4	7.3	0.4

Note:
(1) Wet 1996/97: Wet season 1997 (October 1996 to March 1997).
(2) Dry 1997: Dry season 1997 (April 1997 to September 1997).
Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

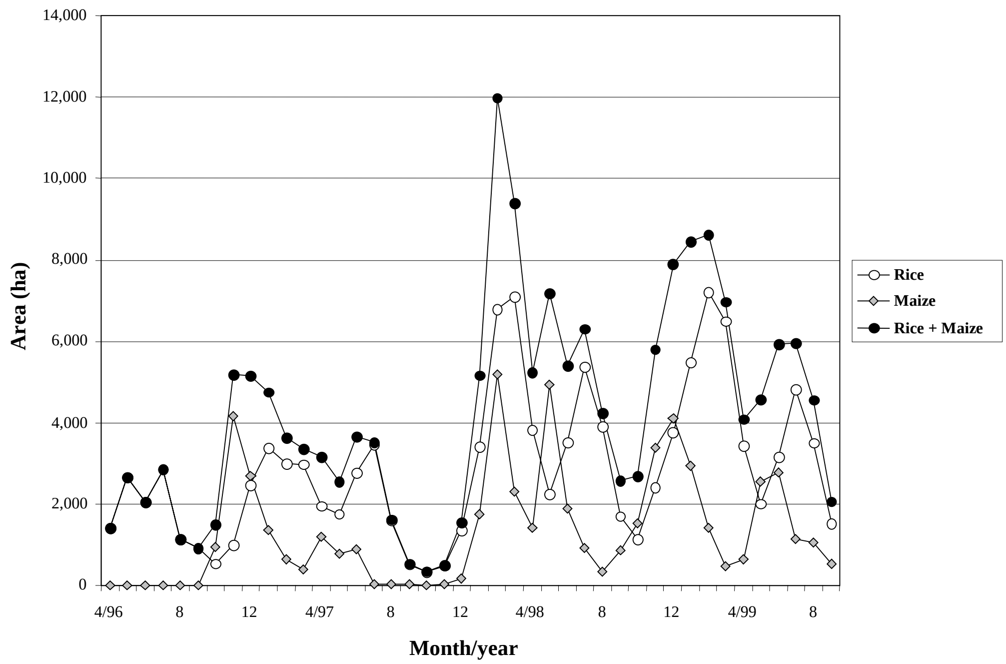
Although the coverage area affected by drought was higher for rice farming than maize farming, the area completely destroyed by drought (or ‘puso’ area) was higher for maize farming. In the 1997 dry season, the ‘puso’ area of maize was 12,650 ha or 50.2 per cent of the total area affected, while for rice it was 9,750 ha or 25.7 per cent. The higher rate or percentage of ‘puso’ area of maize compared with rice indicates that maize farming in Lampung was more sensitive to drought disaster than rice farming. This is because most rice farming in Lampung is wetland rice farming which is cultivated on irrigated land (sawah land) while maize farming is generally cultivated in dryland areas. In general, water is more readily available on irrigated land so it is reasonable to assume that drought impacts would be lower for rice farming than maize farming.

5.3 Impact on pest disaster

Figure 5.4 shows that the area of rice and maize affected by pests sharply decreased in July-December 1997, the dry season. The increase in pest attacks was observed in January 1998 reaching a maximum in Febuary 1998 when the total area affected by pests of rice and maize was around 12,000 ha or 3.3 times higher than that in February 1997 (before the El Nino event).

The high pest disturbance continued throughout 1998 and reached a second maximum in Febuary 1999, covering around 8,600 ha or 2.3 times higher than the area affected in Febuary 1997. Pest attacks tended to decrease in the subsequent months.

Figure 5.4 Area of rice and maize affected by pests and drought in Lampung, April 1996 - September 1999



The evolution of rice and maize affected by pests as shown in Figure 5.4 indicates that during the long drought period during the 1997 dry season pest disturbance sharply decreased. However, after that period and during the 1997/1998 wet season, pest attacks tended to increase radically. The increase in pest attacks occurred during 3 planting periods; the wet season of 1997/1998, dry season of 1998 and wet season of 1998/1999. The total area affected by pests for each season was respectively 19,505 ha, 25,544 ha and 26,562 ha for rice farming and 9,351 ha, 10,380 ha, 13,853 ha for maize farming (Table 5.4). Soybean also suffered from increasing pest attacks but over a smaller area, ranging from 1,026 ha to 1,523 ha per season.

Table 5.4 Area of rice and maize affected by locusts, rats and all pests in Lampung, dry season 1996 - wet season 1999/2000

Pest	Season							
	Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
Rice area affected (ha)								
Locust	94	3	80	2,962	4,960	397	296	220
Rat	5,041	1,725	2,661	676	4,903	8,664	7,341	3,484
All pests	11,464	13,154	10,966	19,505	25,544	26,562	19,114	15,758
Rice area completely destroyed or 'puso' (ha)								
Locust	0	0	0	2	458	274	67	35
Rat	335	1	7	0	789	496	1,705	232
All pests	354	85	17	13	1,595	789	1,957	306
Percentage of area destroyed/area affected (%)								
Locust	0.0	0.0	0.0	0.1	9.2	69.0	22.6	15.9
Rat	6.6	0.1	0.3	0.0	16.1	5.7	23.2	6.7
All pests	3.1	0.6	0.2	0.1	6.2	3.0	10.2	1.9
Maize area affected (ha)								
Locust	118	257	29	2,568	8,270	654	1,594	1,137
Rat	1,474	146	424	13	473	2,792	2,475	131
All pests	2,740	14,255	2,974	9,351	10,380	13,853	5,870	3,750
Maize area completely destroyed or 'puso' (ha)								
Locust	8	45	0	532	2,658	305	486	443
Rat	42	0	2	0	15	134	246	0
All pests	50	1,492	12	532	2,719	768	786	457
Percentage of area destroyed/area affected (%)								
Locust	6.8	17.5	0.0	20.7	32.1	46.6	30.5	39.0
Rat	2.8	0.0	0.5	0.0	3.2	4.8	9.9	0.0
All pests	1.8	10.5	0.4	5.7	26.2	5.5	13.4	12.2

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, propinsi Lampung. Laporan Musiman.

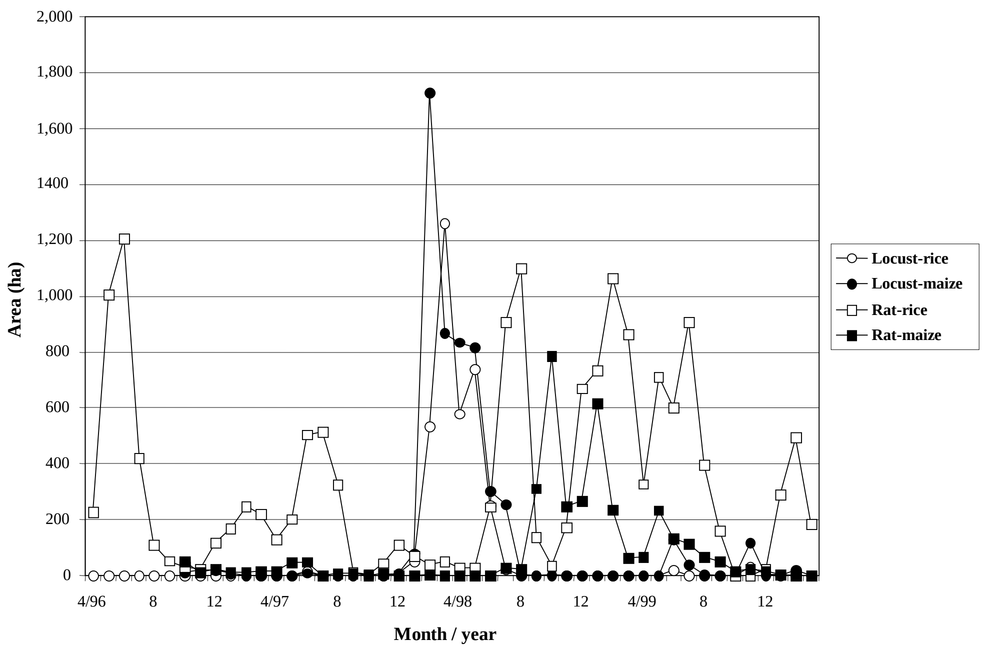
In general, a greater number of pest attacks occur when rainfall increases or during La Nina episodes (Partridge and Mashum, 2002). Usually, more pest attacks occur in the wet season or after the cultivation period in the dry season, particularly after a long period of drought during the dry season (Fagi and Manwan, 1992). From Table 5.4 it is clear that the highest pest perturbation occurred during the 1998 dry season and wet season due to La Nina, which covered both seasons of cultivation. However, radical increases in pest attacks, in particularly from locusts, also occurred during the 1997/1998 wet season, just at the onset of El Nino. This reveals that more pests are not always associated with just La Nina but also with El Nino events occurring predominantly in the wet season.

Among the 38 pests to rice cultivation and 28 pests to maize farming, locust and rat are the two main pests which experienced a steep increase in the population. In addition to these two pests, the population of brown plant hopper also frequently increases after a long drought induced by El Nino (Anonymous, 2003). In the case of Lampung, a high increase in locust attacks especially in the wet season, affected a rice area of about 3,000 ha or more than 30 times larger than the situation in the three previous seasons. Locust attacks augmented in the 1998 dry season with an affected area of 4,960 ha, steeply decreasing the following season. A similar pattern of locust attacks also occurred for maize cultivation. Figure 5.5 shows that a very large area suffered from locust attacks, particularly in Febuary 1998 for maize and in March 1998 for rice.

The evolution of rat attacks was different to that of locust increases. The area affected by rat attacks occurred later than for locust, commencing in June 1998 during the dry season (Table 5.4). Total rice area affected by rat infestation in the 1998 dry season was around 4,900 ha or 3 times higher than situation in the previous wet season. The high level of rat attacks continued until the 1999 dry season, encompassing 3 seasons of rice cultivation, one season more than in the case of locusts. As indicated in Table 5.4, seasonal patterns of rat attacks were relatively similar for both rice and maize cultivations; the high increase in rat attacks occurring in the 1998 dry season.

In general, rat attacks caused more crop damage to rice than maize, the opposite to locusts. During 3 cultivation periods of rice (wet season of 1997/1998 to the wet season of 1998/1999), when the increase in pest attacks occurred, total rice area completely destroyed (or 'puso' area) due to locusts was 734 ha or 8.8 per cent of the area affected by locusts, while, in the case of rats it was 1,285 ha or 9.2 per cent. In the case of maize, locust attacks caused 'puso' area of 3,495 ha or 30.4 per cent of area affected, while for rats it was only 149 ha or 4.5 per cent.

Figure 5.5 Area of rice and maize affected by locust and rat in Lampung Tengah, April 1996 - March 2000



5.4 Structure of crop damage caused by climate anomalies in 1997 and 1998 to rice and maize cultivation

The two previous sections concluded that the increasing food crop damage due to climatic anomalies was not only caused by El Nino but also by La Nina. El Nino induced crop damage in the dry season of 1997 and wet season of 1997/1998 while La Nina affected the 1998 dry season and following wet season. The two sections also revealed that the El Nino of 1997/1998 not only led to drought disaster due to rainfall decreases but also stimulated the occurrence of pest disaster. In other words, the El Nino event caused two negative impacts on farming activities: (a) Drought disaster as a direct impact of El Nino, which caused decreases in water availability due to a lack of rainfall, and (b) An increase in pest attacks after a long drought during the El Nino period as an indirect impact. The question then, is: Which one had a greater negative impact on food production? The question should be clarified to enable policy makers to formulate effective and efficient mitigation efforts for future El Nino events.

Figure 5.6 Total area of rice and maize affected by drought and pest attacks in Lampung, April 1996 – September 1999

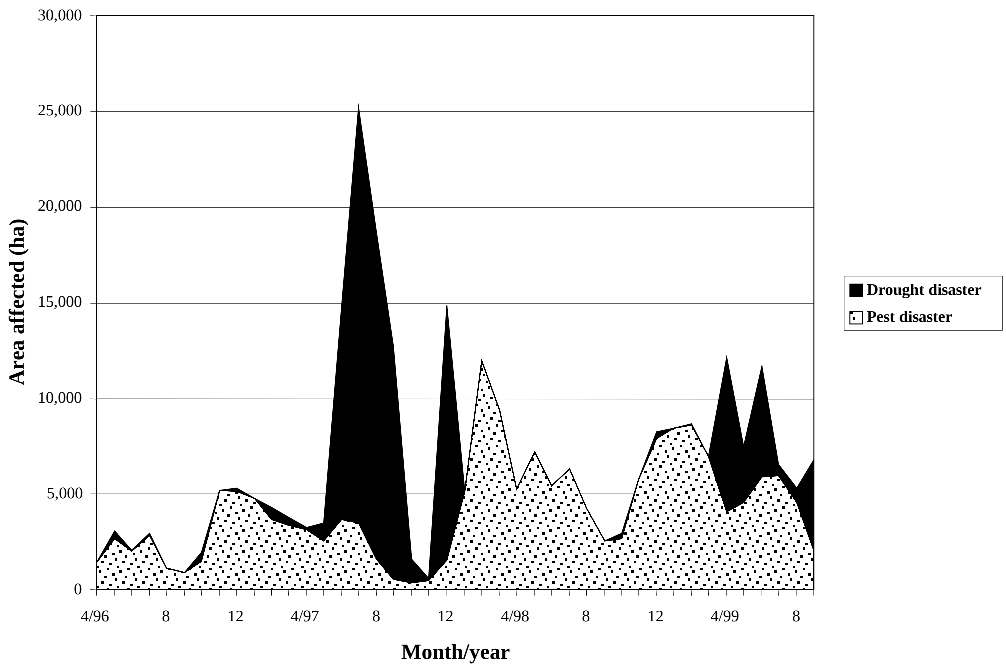


Figure 5.6 shows the monthly evolution of total area of rice and maize affected by drought and pests in Lampung for April 1996 - September 1999. From this figure it is clear that an increase in drought and pest cases occurred during the El Nino event (March 1997 - April 1998) and after the El Nino event, due to the La Nina episode that followed. In the period of September 1996 - March 1997 or before the El Nino, the maximum monthly area affected by drought and pests was only around 5,000 ha. This maximum augmented radically to 25,000 ha in July/August 1997 or during the El Nino event due predominantly to drought. In the months that followed, the maximum affected area was still high compared to the situation before, ranging from 8,000 ha to 15,000 ha per month due to increasing pest disasters occurring until the wet season of 1998/1999. These evolutions of drought and pest cases reveal that the impacts of El Nino remain, mainly through pest increases, even after the event has ended.

Table 5.5 shows a breakdown of rice crop damage caused by the El Nino of 1997/1998 through its direct impacts (drought), indirect impacts (pest increase), and due to the La Nina of 1998/1999. The El Nino covered two periods of cultivation, the 1997 dry season and the following wet season, while La Nina covered a period from the 1998 dry season and including the wet season proceeding.

Table 5.5 Breakdown of rice crop damage caused by the El Nino of 1997/1998 and the La Nina of 1998/1999 in Lampung

Variable	Season				
	Dry 1997 (El Nino)	Wet 1997/98 (El Nino)	Dry 1998 (La Nina)	Wet 1998/99 (La Nina)	All seasons
Area affected (ha)	48,933	26,756	25,554	26,623	127,866
1. Drought	37,967	7,251	10	61	45,289
2. Pest	10,966	19,505	25,544	26,562	82,577
-Locust	80	2,962	4,960	397	8,399
-Rat	2,661	676	4,903	8,664	16,904
Share (%)					
1. Drought	77.6	27.1	0.0	0.2	35.4
2. Pest	22.4	72.9	100.0	99.8	64.6
-Locust	0.2	11.1	19.4	1.5	6.6
-Rat	5.4	2.5	19.2	32.5	13.2
Area totally destroyed (ha)	9,767	320	1595	794	12,476
1. Drought	9,750	307	0	5	10,062
2. Pest	17	13	1,595	789	2,414
-Locust	0	2	458	274	734
-Rat	7	0	789	496	1,292
Share (%)					
1. Drought	99.8	95.9	0.0	0.6	80.7
2. Pest	0.2	4.1	100.0	99.4	19.3
-Locust	0.0	0.6	28.7	34.5	5.9
-Rat	0.1	0.0	49.5	62.5	10.4
Percentage of area totally destroyed compared with area affected (%)					
1. Drought	25.7	4.2	0.0	8.2	24.0
2. Pest	0.2	0.1	6.2	3.0	7.3
-Locust	0.0	0.1	9.2	69.0	12.8
-Rat	0.3	0.0	16.1	5.7	0.0

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman.

The total rice area affected by drought and pests in the dry season of 1997 until the wet season of 1998/1999 was about 128,000 ha; about 59 per cent caused by the El Nino of 1997/1998 (38.2 per cent in the 1997 dry season and 20.9 per cent in the 1997/1998 wet season) and 41 per cent caused by the La Nina of 1998/1999. During the dry season of 1997, drought was the major problem to rice farmers, contributing 77.6 per cent of the total area affected by drought and pests. However, pest attacks became the major rice crop agitation during the 1997/1998 wet season due to El Nino and during the 1998 dry season and following wet season due to La Nina..

Although the occurrence of pest disasters (3 cultivation periods) was more intensive than that of drought disaster (1 cultivation period), drought was the major cause of rice crop damage. During the four cultivation periods covered by El Nino and La Nina, about 80.7 per cent of the total rice area completely destroyed was because of drought disaster. This means that coping mechanisms to reduce possible area losses due to drought are more difficult to realize than that due to pest attacks.

Table 5.6 Structure of maize crop damage caused by the El Nino of 1997/1998 and the La Nina of 1998/1999 in Lampung

Variable	Season				
	Dry 1997 (El Nino)	Wet 1997/98 (El Nino)	Dry 1998 (La Nina)	Wet 1998/99 (La Nina)	All seasons
Area affected (ha)	28,183	13,207	10,380	14,490	66,260
1. Drought	25,209	3,856	0	637	29,702
2. Pest	2,974	9,351	10,380	13,853	36,558
-Locust	29	2,568	8,270	654	11,521
-Rat	424	13	473	2,792	3,702
Share (%)					
1. Drought	89.4	29.2	0.0	4.4	44.8
2. Pest	10.6	70.8	100.0	95.6	55.2
-Locust	0.1	19.4	79.7	4.5	17.4
-Rat	1.5	0.1	4.6	19.3	5.6
Area totally destroyed (ha)	12,662	1,034	2,719	1,038	17,453
1. Drought	12,650	502	0	270	13,422
2. Pest	12	532	2,719	768	4,031
-Locust	0	532	2,658	305	3,495
-Rat	2	0	15	134	151
Share (%)					
1. Drought	99.9	48.5	0.0	26.0	76.9
2. Pest	0.1	51.5	100.0	74.0	23.1
-Locust	0.0	51.5	97.8	29.4	20.0
-Rat	0.0	0.0	0.6	12.9	0.9
Percentage of area totally destroyed compared with area affected (%)					
1. Drought	50.2	13.0	0.0	42.4	30.0
2. Pest	0.4	5.7	26.2	5.5	26.0
-Locust	0.0	20.7	32.1	46.6	1.1
-Rat	0.5	0.0	3.2	4.8	0.0

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman.

Drought was also a major cause of production decreases in maize farming during the El Nino event, even though maize area affected by pests was greater than the area affected by drought (Table 5.6). In total, drought contributed around 77 per cent of total ‘puso’ area, affecting 17,453 ha. Harvest failure as a result of drought mainly occurred during the 1997 dry season and the wet season of 1997/1998 (during the El Nino event), while for pest cases it was predominantly during the 1998 dry season and following wet season (La Nina). The pattern of harvest failure of maize by period of cultivation as a result of drought and pests was similar to that of rice. High rainfall decreases in the 1997 dry season (59 per cent) and during the wet season of 1997/1998 (28 per cent) were the major cause of harvest failure during the two seasons of cultivation in 1997-1998.

In the case of maize farming, the increase in the locust population stimulated by El Nino was the major cause of harvest failure resulting from pests, contributing around 87 per cent of the ‘puso’ area resulting from pests or 20 per cent of total area completely destroyed. The situation was different for rice; rat was the most significant pest during La Nina events, contributing about 53 per cent of ‘puso’ area as a result of pests or 10 per cent of the total area completely destroyed, and it’s occurrence was particularly severe in the dry season of 1998 and wet season of 1998/1999 (Table 5.5). The different patterns of pest disasters between rice and maize, for period of occurrence and degree of impact on area damaged was due to three factors: (1) The increase in the locust population was earlier than the rat population. Drastic increases of locust numbers started in January 1998 during the wet season while for rats it began in June 1998 during the dry season. (2) The increasing locust population started in dryland areas where most maize is grown, then moved to wetland areas. However, rat population increases started in sawah land or irrigated land where most rice is grown, then moved to dryland areas. In other words, there was a spatial movement of the rat population from wetland areas to dryland areas, while locusts moved from dryland areas to wetland areas. (3) A combination of the two previous factors led to increasing maize crop damage due to locust starting in the wet season of 1997/1998 but in the case of rice, increasing crop damage caused by rats started in the 1998 dry season.

5.5 Impact analysis at the farm and household level

In upland areas where irrigated land is relatively limited, such as at the research sites, rainfall is the major water source for food crop farming activities. Accordingly, El Nino events which lead to rainfall decreases and temperature increases have significant impacts on agriculture production. In general, the impact is not only determined by the magnitude of the negative climate induced, but also by the mitigation efforts applied by farmers. Risk management strategies, based on their time frame, can be grouped into three categories (Malton, 1991; Downing *et al.*, 1999): (1) Ex ante strategy, e.g. grain stocks for risk management at a household level, (2) Interactive strategy, e.g. change crop by replanting for risk management at a farm level, and (3) Ex-post strategy, e.g. local non farm work for risk management at a household level.

The following description reveals how seriously the El Nino of 1997/1998 caused negative impacts for farmers and the mitigation efforts applied by the farmers. The analysis focuses on two levels or scopes of risk management, i.e. farm level and household level. Analysis at farm level covered aspects of cultural practices, crop perturbation induced by unfavorable weather, and quantification of impacts on production losses. While the analysis at household level focuses on household consumption, particularly for staple foods.

5.5.1 Land holdings and cultivation period shift during the El Nino of 1997/1998

Agricultural land for plantation purposes in general could be specified as wetland or irrigated land, and dryland or non irrigated land. Based on the pattern of its utilization, dryland can be further classified as dryland allocated for food crops (usually called *tegalan*), dryland allocated for perennial crops (called *kebun*) and home yard. In terms of water source and investment budget, irrigated land can also be grouped into three categories, i.e. technical irrigated land, semi-technical irrigated land and simple irrigated land (Bottema, 1995).

Technical and semi-technical irrigated land are categories of irrigated land with water supply coming from water dams built by the government on big rivers, while water supply for simple irrigated land generally comes from small rivers and most of its required investment budget comes from the village community. Simple irrigated land generally has less water availability and water continuity, and consequently, lower crop intensity than technical or semi-technical irrigated land.

Most farmers at the research site worked dryland, contributing 70.6 per cent of total land holdings (Table 5.7). Only farmers in the village of Tanjung Pandan owned more irrigated land than dryland with a composition of 57 per cent for irrigated land and 43 per cent for dryland. All irrigated land owned by the farmers is simple irrigated. Water availability of such irrigated land, even more so for dryland, is fully dependant on rainfall, although water continuity on simple irrigated land is generally better than dryland.

In dryland areas, the planting date for the wet season is highly dependant on the occurrence of the first rainfall of the season. Based on their experience, most farmers concurred that the wet season at the research site usually occurs in Oct/Nov-Mar/Apr and the dry season in Apr/May-Sep/Oct (Table 5.8).

Table 5.7 Number of farm households and average size of land holding at the research sites

Village	Number of farmers	Land holdings (ha/household)			Percentage (%)	
		Wetland	Dryland	Total	Wetland	Dryland
Binjai Agung	18	0.25	1.25	1.50	15.8	84.2
Kedatuan	5	0.61	1.55	2.16	29.3	70.7
Tanjung Pandan	9	0.62	0.48	1.10	57.0	43.0
Trimulyo	8	0.41	1.22	1.63	29.3	70.7
All villages	40	0.41	1.11	1.52	29.4	70.6

Source: Survey data.

Other than an induced longer dry season, the El Nino of 1997/1998 also caused a shift in the wet season and dry season. Under normal climatic conditions the wet season usually starts in October/November, but due to the El Nino of 1997/1998 the wet season began in December/January.

Table 5.8 Pattern of wet/dry season as per farmer recall at the research sites

Pattern	Wet season (month)		Dry season (month)		Number of farmers		Total number of months	
	Beginning	End	Beginning	End	Total farmers	Percentage (%)	Wet season	Dry season
Normal climate								
1	October	March	April	September	14	35.0	6	6
2	October	April	May	September	16	40.0	7	5
3	November	March	April	October	2	5.0	5	7
4	November	April	May	October	8	20.0	6	6
1997/98								
5	Nov-1997	Mar-1998	Apr-1997	Oct-1997	7	17.5	5	7
6	Dec-1997	Mar-1998	Apr-1997	Nov-1997	11	27.5	4	8
7	Dec-1997	Apr-1998	May-1997	Nov-1997	8	20.0	5	7
8	Jan-1998	Apr-1998	May-1997	Dec-1997	14	35.0	4	8

Source: Survey data.

Table 5.9 Planting dates of rice, maize and cassava in the wet season

Month (week)	Normal wet season			Wet season 1997/98		
	Rice	Maize	Cassava	Rice	Maize	Cassava
Number of farmers						
September (week 3-4)	0	6	3	0	0	0
October (week 1-4)	4	9	5	1	1	1
November (week 1-4)	13	7	4	1	7	3
December (week 1-4)	5	0	0	4	9	8
January (week 1-4)	0	0	0	14	5	0
February (week 1-4)	0	0	0	2	0	0
Total	22	22	12	22	22	12
Percentage of farmers (%)						
September (week 3-4)	0.0	27.3	25.0	0.0	0.0	0.0
October (week 1-4)	18.2	40.9	41.7	4.5	4.5	8.3
November (week 1-4)	59.1	31.8	33.3	4.5	31.8	25.0
December (week 1-4)	22.7	0.0	0.0	18.2	40.9	66.7
January (week 1-4)	0.0	0.0	0.0	63.6	22.7	0.0
February (week 1-4)	0.0	0.0	0.0	9.1	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Survey data.

At the research sites, rice, maize and cassava are the main food crops cultivated by farmers. Rice is usually grown in wetland areas, particularly during the wet season, whereas maize and cassava are usually cultivated in dryland areas under mixed cropping systems. Due to the lower water requirement or higher tolerance to water restriction, maize and cassava are usually planted earlier than rice. Under normal climatic conditions, these crops are normally planted in October/November, but during the 1997/1998 El Nino event farmers could only start to plant in November/December because of the delay of the rainy season. A delay of the planting date also happened for rice, from November/December under normal climatic conditions to December/January in the El Nino of 1997/1998 (Table 5.9).

5.5.2 Drought disaster; coping strategies and production loss

Drought disaster is the most frequently reported impact of El Nino. To understand the influence of El Nino on the incidence of drought, qualitative information was collected from farmer respondents. The two main categories of the collected information were the magnitude of the drought in 1997/1998 compared to normal conditions, and farmers' efforts to mitigate the drought problems.

Farmers at the research sites generally own more than one plot of agricultural land, wet or dry. Of all the farmer respondents, in total there were 57 dryland plots and 41 wetland plots. Of the total plots, around 95 per cent suffered from serious drought during the dry season in 1997 (Table 5.10). However, in the wet season of 1997/1998, the area affected by serious drought was relatively low, less than 15 per cent, both on a plot and area basis. This reveals that the increase in drought cases induced by El Nino only actually occurred during the dry season which in 1997/1998 lasted 7 or 8 months, from April/May 1997 until November/December 1997.

Drought during the dry season in 1997 not only affected the dryland, but also wet or irrigated land. The occurrence of drought on irrigated land was caused by the fact that water sources for simple irrigated land, generally small rivers, ran dry.

Table 5.10 Area affected by drought and by season in 1997/1998 at the research sites

Land type	Degree of attack	Dry season 1997				Wet season 1997/98			
		Total plots affected		Total area affected		Total plots affected		Total area affected	
		Field	Percentage (%)	Area (ha)	Percentage (%)	Field	Percentage (%)	Area (ha)	Percentage (%)
Dryland	High	55	96	43.3	98	3	5	2.0	5
Dryland	Medium	2	4	0.9	2	8	14	3.5	8
Dryland	Low	0	0	0.0	0	17	30	13.1	30
Dryland	None	0	0	0.0	0	29	51	25.6	58
Wetland	High	39	95	15.8	95	3	7	1.8	11
Wetland	Medium	2	5	0.8	5	5	12	2.0	12
Wetland	Low	0	0	0.0	0	9	22	3.6	22
Wetland	None	0	0	0.0	0	24	59	9.3	56

Note: High/Medium/Low degree compared with usual scenario.
Source: Survey data.

Replacing crops with crops resistant to water stress was a strategy applied by farmers to lower production risks brought about by water restrictions. This strategy is usually applied by farmers in anticipating predictable water stress situations, such as during the dry season. In the dry season, when water availability is lower than in the wet season, farmers usually cultivate relatively resistant-to-water-stress crops or varieties. In general, however, farmers did not realize that the dry season in 1997 would be worse than usual. They only knew that there was a delay of the wet season, therefore the planting date should be postponed. This condition made farmers not shift their cropping pattern to the high-tolerant-to-water-stress crops during this El Nino episode; instead they applied the usual cropping pattern, with delayed planting and early harvest (Table 5.11).

Table 5.11 Number of farmers applying various mitigation methods during the El Nino of 1997/1998

Method	Size of land holding (ha)				
	0.50-1.00	1.25-1.50	1.75-2.00	2.25-3.50	All size
Total no. of farmers	15	10	9	6	40
Number of farmers					
Replace cropping pattern with drought tolerant crop	0	0	0	0	0
Delay planting date	12	6	4	4	26
Replanting	1	0	0	1	2
Reduce crop intensity	1	1	0	1	3
Hire water pump	2	0	1	0	3
Buy water	0	0	0	0	0
Early harvesting	8	3	4	2	17
Percentage of farmers (%)					
Replace cropping pattern with drought tolerant crop	0	0	0	0	0
Delay planting date	80	60	44	67	65
Replanting	7	0	0	17	5
Reduce crop intensity	7	10	0	17	8
Hire water pump	13	0	11	0	8
Buy water	0	0	0	0	0
Early harvesting	53	30	44	33	43

Source: Survey data.

Even though various mitigation efforts were implemented, they were unable to reduce production loss significantly. Table 5.12 shows food crop yield during the dry season in 1997 compared to normal conditions. From the table it is clear that yield loss in the dry season of 1997 was relatively high for maize, 55 per cent for dryland maize and 41 per cent for wetland maize. Yield loss for wetland rice was also high, around 34 per cent, whereas cassava, which is more tolerant to water restrictions had the lowest loss, at around 19 per cent.

Table 5.12 Crop cultivated and production loss due to drought in the dry season of 1997

Land type	Pattern	Crop		Coverage area		Number of farmers		Yield (kg/ha)		Yield loss
		Normal	1997	(ha)	(%)	Total	(%)	Normal	1997	(%)
Dryland	1	Maize	Maize	1.5	3	3	8	2,470	1,105	55
	2	Cassava	Cassava	35.5	80	32	82	11,800	9,548	19
	3	Fallow	Fallow	7.2	16	4	10	-	-	-
Wetland	1	Maize	Maize	1.5	9	2	6	3,690	2,180	41
	2	Maize	-	2.1	13	5	16	2,283	-	100
	3	Rice	Rice	2.8	17	3	10	3,733	2,467	34
	4	Rice	-	6.9	42	13	42	3,996	-	100
	5	Fallow	Fallow	3.2	19	8	26	-	-	-

Source: Survey data.

5.5.3 Pest disaster; coping strategies and production loss

Besides drought, El Nino also stimulates increases in the size of pest populations. This began in February/March 1998 (the final stage of the El Nino in 1997/1998). From a crop schedule point of view, February/March is the beginning of the wet season cropping period and accordingly, increases in pest attacks mainly transpired during the wet season in 1997/1998.

Table 5.13 shows the statistics of the pest attacks during the El Nino episode. There were 3 types of major pest at the research sites, they were locust, rat and snail, the most serious being locust. Rice and maize were the major crops attacked by locust, while cassava suffered no significant perturbation increase.

Table 5.13 Number of farmers affected by pest disasters by crop during 1997/1998 at the research sites

		Number of farmers			Percentage (%)		
Crop	Variable	Locust	Rat	Snail	Locust	Rat	Snail
Rice	**Total number of farmers**	31	31	31	100.0	100.0	100.0
	Occurrence						
	-Yes	29	7	3	93.5	22.6	9.7
	-No	2	24	28	6.5	77.4	90.3
	Date of occurrence						
	-Dry season 1997	0	3	0	0.0	9.7	0.0
	-Wet season 1997/98	29	4	3	93.5	12.9	9.7
	Attack period						
	-Vegetative stage	3	1	3	9.7	3.2	9.7
	-Flowering stage	3	1	0	9.7	3.2	0.0
	-Generative stage	26	5	0	83.9	16.1	0.0
Maize	**Total number of farmers**	40	40	40	100.0	100.0	100.0
	Occurrence						
	-Yes	31	0	0	77.5	0.0	0.0
	-No	9	40	40	22.5	100.0	100.0
	Date of occurrence						
	-Dry season 1997	0	0	0	0.0	0.0	0.0
	-Wet season 1997/98	31	0	0	77.5	0.0	0.0
	Attack period						
	-Vegetative stage	3	0	0	7.5	0.0	0.0
	-Flowering stage	2	0	0	5.0	0.0	0.0
	-Generative stage	26	0	0	65.0	0.0	0.0
Cassava	**Total number of farmers**	34	34	34	100.0	100.0	100.0
	Occurrence						
	-Yes	3	0	0	8.8	0.0	0.0
	-No	28	34	34	82.4	100.0	100.0
	Date of occurrence						
	-Dry season 1997	0	0	0	0.0	0.0	0.0
	-Wet season 1997/98	3	0	0	8.8	0.0	0.0
	Attack period						
	-Vegetative stage	2	0	0	5.9	0.0	0.0
	-Flowering stage	0	0	0	0.0	0.0	0.0
	-Generative stage	1	0	0	2.9	0.0	0.0

Source: Survey data.

The increase in locust attacks mainly occurred when maize and rice were at their generative stage, 1-2 months after being planted. The percentage of plots affected by locust attacks were 67 and 76 per cent for dryland and wetland plots respectively (Table 5.14). This reveals that locust attacks during El Nino were well spread in all four villages analyzed. The increase in locust attacks predominantly happened during the 1998 wet season, whereas in the dry season of 1997 only about 5 per cent of wetland plots were affected by pest increases.

Table 5.14 Area affected by locusts in the dry season of 1997 and the wet season of 1997/1998 at the research sites

		Dry season 1997				Wet season 1997/98			
		Total fields affected		Total area affected		Total fields affected		Total area affected	
Land type	Degree of attack	Field	(%)	Area (ha)	(%)	Field	(%)	Area (ha)	Percentage (%)
Dryland	High	0	0	0.0	0	38	67	30.4	69
Dryland	Medium	0	0	0.0	0	8	14	4.8	11
Dryland	Low	9	16	7.7	17	6	11	4.3	10
Dryland	None	48	84	36.5	83	5	9	4.8	11
Wetland	High	2	5	1.3	8	31	76	13.4	81
Wetland	Medium	2	5	0.8	5	5	12	1.5	9
Wetland	Low	3	7	1.8	11	0	0	0.0	0
Wetland	None	34	83	12.8	77	5	12	1.7	10

Note: High/Medium/Low degree compared with usual case.
Source: Survey data.

To cope with the locust problem, early harvesting was the most common measure undertaken by farmers (65 per cent of the respondents). This was mainly carried out by farmers with a high intensity of locust perturbation, after they had predicted that the cultivation would not be able to give the expected output. By implementing this strategy, indeed farmers lost grain production of rice and maize, yet they still could utilize the leaves as livestock feed. Actually, during the wet season in 1997/1998, livestock feed became a problem as a result of harvest failure which happened in the dry season of 1997 induced by prolonged drought.

Table 5.15 Number of farmers applying mitigation methods against pest disasters during the El Nino of 1997/1998

	Land holding (ha)				
Method	0.50-1.00	1.25-1.50	1.75-2.00	2.25-3.50	All sizes
Total no. of farmers	15	10	9	6	40
Number of farmers					
Increase pesticide application	5	3	7	2	17
Replace seed with pest tolerant variety	0	0	0	0	0
Early harvesting	10	6	4	6	26
Percentage of farmers (%)					
Increase pesticide application	33	30	78	33	43
Replace seed with pest tolerant variety	0	0	0	0	0
Early harvesting	67	60	44	100	65

Source: Survey data.

About 43 per cent of farmers tried to cope with locust attacks by applying pesticides (Table 5.15). This was mainly undertaken by farmers with low pest attack intensity or if the cultivated crop had reached its flowering or generative stage. In general, this method was used by farmers who had cultivated earlier, around November/December 1997. However, due to the very high population of locusts and its continuous increase, the strategy was unable to reduce production loss significantly.

Table 5.16 shows the yield of rice and maize produced in the wet season of 1997/1998 under abnormal climatic conditions. From this table it is clear that yield loss of rice was higher than that of maize. Under normal climatic conditions, wetland rice in the wet season can produce 5.0-6.6 tons of rice per hectare, but in the wet season of 1997/1998 yield was only 2.3-3.7 tons per hectare, a decrease 44-58 per cent. Whereas for maize, yield decrease was around 35-36 per cent from about 3.5 tons to 2.2-2.3 tons per hectare.

Table 5.16 Crops cultivated and yield loss due to pests in the wet season of 1997/1998

Land type	Pattern	Crop		Coverage area		Number of farmers		Yield (kg/ha)		Yield loss
		Normal	1997/98	(ha)	(%)	Total	(%)	Normal	1997/98	(%)
Dryland	1	Maize	Maize	1.5	3	3	8	3,527	2,278	35
	2	Maize	Maize	35.5	80	32	82	3,514	2,250	36
	3	Maize	Maize	7.2	16	4	10	3,523	2,297	35
Wetland	1	Rice	Rice	1.5	9	2	6	6,140	3,460	44
	2	Rice	Rice	2.1	13	5	16	5,000	2,317	54
	3	Rice	Rice	2.8	17	3	10	6,667	2,800	58
	4	Rice	Rice	6.9	42	13	42	5,281	2,946	44
	5	Rice	Rice	3.2	19	8	26	6,050	3,717	39

Source: Survey data.

5.5.4 Household food security and coping strategies for maintaining staple food consumption

Food security is one of the main focuses of agricultural development in Indonesia. El Nino, which induces abnormal weather change can influence household food security through its impact on food production failure. In upland areas, which are generally located in remote areas, rice production is relatively low due to the lack of suitable agricultural land and the low rate of technology adoption. Accordingly, food problems arise frequently in upland areas particularly when problems with local food production occur due to weather variability. To anticipate the uncertainty within food production, the two strategies usually carried out by farmers are: (1) Maintaining a sufficient stock of rice, and (2) Combining rice consumption with other complementary staple foods.

In the research area, dried cassava has a function as a complementary staple food to rice, the main staple food. After being processed into traditional meal called "oyek", dried cassava can be stored for long periods, about 8 to 10 months, without any significant quality degradation. The product also has a high energy content, about 2,200 cal/kg, while the energy content of rice is 3,600 cal/kg. In times of rice scarcity, farmers usually consume the product in combination with rice.

The proportion of rice and oyek consumed usually varies depending upon the food cropping pattern applied by the farmer. During the wet season, when most farmers cultivate rice, the consumption of oyek is usually low but it increases during the dry season due to low rice production. Under normal conditions, average rice consumption per household per week is 10 kg during the dry season and 11 kg during the wet season, while consumption of oyek is respectively 1.2 kg and 0.6 kg (Table 5.17). More than 75 per cent of the consumed rice comes from the farmers own production, while the level of self production of dried cassava is only around 10 per cent since the cultivation of cassava is generally market orientated, particularly local tapioca factories.

Table 5.17 Staple food consumption per week per household

Staple food	Normal climate		El Nino 1997/98		Change	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Consumption (kg)						
- Rice	10.0	11.0	7.5	8.0	-2.5	-3.0
- Dried cassava	1.2	0.6	5.0	5.1	3.8	4.5
Self production (%)						
- Rice	75.0	78.1	55.0	62.5	-20.0	-15.6
- Dried cassava	15.0	5.0	32.0	29.5	17.0	24.5
Calory intake (cal)						
- Rice	36,000	39,600	27,000	28,800	-9,000	-10,800
- Dried cassava	2,640	1,320	11,000	11,220	8,360	9,910
- Total	38,640	40,920	38,000	40,020	-640	-900

Source: Survey data.

Due to the El Nino of 1997/1998, which induced drought and pest increases, rice production decreased significantly. This situation led in turn, to decreases in rice consumption to 7.5 kg per household per week in the dry season of 1997 and 8.0 kg during the wet season of 1997/1998. On the contrary, consumption of dried cassava increased sharply to around 5 kg per household per week, 4-8 times higher then previously. The level of self production of rice also fell to 55 per cent in the dry season and 63 per cent in the wet season, while self production of dried cassava rose to 30 per cent for both seasons.

Although the change in staple food consumption occurred during the El Nino event, its impact on household calory intake was not significant. Compared with normal consumption, the decrease in calory intake was only 2 per cent for both the dry season and the wet season. Assuming that rice and cassava consumption contributes 63 per cent of total calory intake in rural areas (SUSENAS, 1999), the figure indicates that the El Nino of 1997/1998 had no significant impacts on food security at the household level.

As previously mentioned, the level of self production for rice consumption decreased during the El Nino event. This means that more rice had to be purchased by farmers to maintain their consumption requirement, in other words, an additional food consumption budget had to be provided. In general, animal selling, particularly chicken and sheep, was the most common method used; 47.5 per cent of the total respondents applied this coping strategy (Table 5.18). Other ways are to borrow money from neighbors, sell jewelry, and off farm working amongst others.

Table 5.18 Frequency of farmers by strategy applied for maintaining food consumption during El Nino 1997/1998

Strategy	Dry season		Wet season		All	
	Frequency	%	Frequency	%	Frequency	%
a. Animal selling	14	35.0	5	12.5	19	47.5
b. Jewelry selling	3	7.5	0	0.0	3	7.5
c. Selling of electronic goods	0	0.0	0	0.0	0	0.0
d. Borrow from neighbour	5	12.5	1	2.5	6	15.0
e. Borrow from local institution	0	0.0	0	0.0	0	0.0
f. Off-farm working	2	5.0	0	0.0	2	5.0
g .Others	3	7.5	0	0.0	3	7.5

Source: Survey data.

6. Government Coping Mechanisms against El Nino

Institutional preparedness represents mitigating measures required to reduce the adverse impacts of climate variability such as El Nino events. In accordance with its time frame of activities, coping mechanisms against climate variability can be grouped into three categories (Malton, 1991; Downing *et al*., 1999), i.e.: (1) Ex ante strategies or activities which are executed before the event, (2) Interactive strategies or activities which are executed during the event, and (3) Ex post strategies or activities which are conducted after the event. In fact, several coping mechanisms have been established by the Indonesian government. Some of the coping mechanisms were updated after the big El Nino of 1997/1998, which induced a food crisis nationwide. The following description is devoted to identifying major coping mechanisms undertaken by government institutions.

6.1 Climate forecasting and the establishment of a climate task force

The El Nino of 1997/1998 was the biggest one of the century. No El Nino event in history has been given the international attention of the 1997/1998 El Nino (Fox, 2000). This El Nino was well predicted in advance of its onset and considerable attention was given to its likely severity and potential impacts. Its course was monitored closely and information was widely available through international electronic data.

The information was, however, not available to farmers in Indonesia. This may be due to two factors: (1) There was no institutional mechanism that could rapidly distribute El Nino information to the farmers, (2) After the general election, which was held in May 1997, political issues in Indonesia became more important and more focused away from agriculture. Since mid 1997 Indonesia has suffered from an economic crisis due to the drop of the rupiah's value. Both conditions ensured any information conveyed by mass media was more focused on political and economical issues, primarily sectors other than agriculture. In Indonesia, the main agency responsible for the monitoring and forecasting of climatic variability is the Bureau of Meteorology and Geophysics (BMG). The BMG issues rainfall forecasts which are published in monthly climate reports. Indonesia is classified into 102 rainfall zones with differences in seasonal period, duration of wet season and dry season, magnitude of rainfall and temperature. The rainfall forecast of each rainfall zone is published by season, one season before the forecast season. During the El Nino of 1997/1998, the information was, however, not available to farmers who had to determine their own particular planting strategies when facing a lack of good rain.

The mechanism of dissemination of climate information, however, has been improved in recent years. In anticipating the impact of El Nino in 2002, a climate task force was established in each province. The task force involves BMG, local agricultural agencies and other related government institutions. The task force was also established at the national level with three main activities: (1) Disseminating rainfall and El Nino forecasts to farmers, (2) Mapping vulnerable regions to drought, and (3) Preparing anticipation programs to drought and other agronomic perturbation induced by El Nino. An earlier planting date in the wet season represents the main strategy suggested for farmers to avoid food production loss in the dry season due to a prolonged dry season during El Nino events. In the case of Lampung, subsidized rice seeds and shallow tube well construction were also prepared by the local government.

6.2 Social Safety Net (SSN) program

The El Nino of 1997/1998 caused decreased production for most food commodities nationwide. Reduced rice production coinciding with the economic crisis led to the food crisis where rice prices rose by 300 per cent. The crisis affected food security in rural areas through unemployment and the consequent decline in household income and access to food. In urban areas, the crisis also interfered with food security through increased migration to urban areas, which in turn led to increased competition for jobs and depressed wages. Moreover, as most migrants were landless and had little savings and assets, their susceptibility to food shortages became even more pronounced.

The Social Safety Net (SSN) was initiated to overcome the effects of the economic crisis and food crisis induced by El Nino. Generally, SSN policy was intended to improve and speed up the ability to overcome the effects of the crisis, especially for people in villages and small towns who were worst hit. One of the priorities of the SSN program was improving food security through securing the supply of basic staples at affordable prices (Sumodiningrat, 1999). Among other means, this was achieved through subsidizing the rice price.

The program involved BULOG (national food agency) in distributing subsidized rice to the needy household markets through a mechanism called ‘special market operation’. Under this program, BULOG provided 10 kg of rice per household per month at Rp 1,000 per kg to registered needy households. For this purpose, needy households had to be registered through their village organization or other local agencies. The government made an initial estimation of the number of the most needy households in every province in Indonesia and set its target at 7.35 million households, but this estimation was raised to 16.8 million households as the program expanded (Fox, 2000).

6.3 Establishment of famine rice barns

As a result of El Nino together with the economic crisis, Indonesia suffered from a food crisis in 1997/1998, which is shown by the increase in imported rice from 1.5 million tons in 1997 to 5.8 million tons in 1998. The crisis caused a staple food problem, particularly in upland areas which are generally remote areas. In such areas, farmers can only grow one rice crop in the wet season with productivity per hectare of about 2-3 tons. This production pattern results in the discontinuity of rice supply, which is often the main problem regarding food security in upland areas, especially by the end of the dry season which occurs from May - September.

The establishment of famine rice barns is a method carried out by the government to mitigate food insufficiency during a famine season. This policy has been in realization since 1999, after the occurrence of the food crisis in 1997/1998. The priority was poor areas which often have insufficient rice supply during famine seasons, usually remote, upland areas. Management of the rice barns was carried out by Farmer Groups each with a membership of about 30 - 40 farmers per group.

In the research area, famine rice barns had actually been built by local farmers since 1989. The famine rice barn tradition was initiated by transmigrants coming from Java who have settled since the 1970’s. Therefore, the government’s role in the development of rice barns was just to upgrade existing ones, by offering supporting funds of 4 - 5 million rupiahs per barn.

In accordance with the agreement between the members of the Farmer Group, every farmer stores about 1 quintal of rice per hectare after harvesting in the wet season. With a membership of 30-40 farmers per group, every year around 3-12 tons of rice for each Farmer Group is stored depending on its membership size and the sawah areas owned. The rice can be utilized for various purposes, such as:

(1) Loaned to farmers who need rice for household consumption or farming capital. In this case, member and non-member farmers have the same opportunity to borrow rice from

the barn. In other words, farmers with no contribution to the total stored rice are also able to borrow rice for their household needs. The borrowed rice then should be reimbursed without interest after the rice harvest the following year.

(2) Maintenance of the irrigation network. Rice allocation for repairing the irrigation network is usually carried out by the end of the dry season approaching the wet season planting time. In this period, around October - November, the stored rice is distributed to all members of the Farmer Group. However, prior to that, some of the rice is allocated for repairing the irrigation network. The amount of rice sold for this purpose is adjusted to the required fund.

(3) In the case of rice shortages caused by harvest failure, the stored rice is loaned to members of the Farmer Group and farmers around. In the case of the El Nino of 1997/1998, which caused rice harvest failure in both the wet and dry season, every household received loaned rice according to the number of household members, around 80 kg on average, or approximately 10-20 per cent of the total required rice per household per year.

In the research villages there were 11 units of famine rice barns with a storage capacity of 5-15 tons of rice. Most of the barns were built by the village community and only one barn was built using government aid managed by the Agricultural Office of Lampung. Six barns were built in 1990-1999 and four barns were built between 1999-2002 by local communities. The increasing rate of rice barn construction during the last period shows that the existence of famine rice barns are required by local communities.

6.4 Water pump program

Water insufficiency as a result of a drop in rainfall is a common impact induced by El Nino and can cause significant impacts on food crop production, particularly for crops that require relatively high amounts of water, such as rice. To reduce the probability of production failure from water insufficiency, additional water sources are required to support the existing irrigation. Construction of shallow tube wells is one method carried out by the local government of Lampung to overcome water problems which generally occur during the dry season.

In general, agricultural land for food crops can be grouped into irrigated land which is generally located in lowland areas, and non-irrigated land located in upland areas. The development of water pumps in Lampung was emphasized on irrigated land based on two considerations: (1) Investment for constructing pump irrigation on non-irrigated land, which is generally located in upland areas, is relatively high, and the return on the investment in terms of increased food production is relatively low considering that crop intensity and rice productivity on drylands is relatively low. (2) Technically, the development of water pumps is easier on irrigated land than on non-irrigated land. The impact of the investment on the increase of rice production is also relatively high, particularly for dry season rice when there are often water insufficiencies.

During 1998-2000, the local government of Lampung distributed aid for the construction of shallow tube wells and water pumps to farmers. The aid covered 69 units of shallow tube wells and 155 units of water pumps. During the period, 9 water catchments and 12 deep tube wells were also constructed, but in 2001 the policy was withdrawn since it was judged to be inefficient in overcoming the lack of water needed for irrigation. Therefore, since 2001, the program has been more focused on the construction of shallow tube wells with irrigated land as the target. In 2001, as many as 437 shallow tube wells were constructed, supported by 102 water pumps.

The support fund for the water pump program was distributed through Farmers' Groups, with each group receiving one water pump (5.5 HP) and 5 shallow tube wells constructed on different farmer's lands. Overall maintenance and operational costs, and also the arrangement of pump utilization among the farmers is performed by the Farmer Groups themselves. Using this formula, it was expected that the construction of shallow tube wells would be able to irrigate around 4-5 ha of rice in the dry season at target locations. In reality, these pumps are not always utilized for rice farming, but also for secondary crops such as maize and soybean or vegetable crops such as chili. Replacement of the target crop may occur because of two factors, which are:

(1) Volume of water supplied through the pump is not sufficient to irrigate rice which has a relatively higher water demand than the other crops. This condition may be the result of the smallness of the pump or limited water availability.

(2) Farmers who use the pump have to pay a rental cost to the Farmer Group which in turn, is allocated as a maintenance cost. If the rental cost is assumed too expensive, then its utilization for rice is estimated as unprofitable. In this case, generally, farmers will produce higher value crops, such as vegetable crops.

6.5 Rice intensification program

Experience during the El Nino in 1997/1998 showed that the climatic anomaly can lead to a substantial decrease in rice production and cause problems to food security. The El Nino which covered the dry season of 1997, reduced rice production during May – December 1997 by around 1.73 million tons (Irawan, 2002). Afterwards, due to El Nino coupled with the economic crisis which caused radical increases in input prices, rice production during the period of January – April 1998 decreased by around 4.38 million tons. In total, the decrease in rice production during May 1997 – April 1998, or during the occurrence of El Nino 1997/1998, was 6.11 million tons.

The radical decrease in rice production caused rice imports to soar from about 1 – 1.5 million tons per year to 5.8 million tons in 1998. The rapid rise in rice imports was disadvantageous for three reasons: (1) High rice importation could wipe out the country's foreign currency reserves which had just decreased in value due to the economic crisis, (2) Rice supply in the world market is unstable and as a consequence, instability of the national rice supply would also increase in accordance with the dependence upon imported rice, and (3) Indonesia is the largest rice importing country in the world market and any changes in volume of Indonesia's imports significantly affects world rice prices. Accordingly, increasing rice imports would require the further allocation of foreign currency reserves of the country due to the increasing rice price.

In order to recover rice production loss caused by El Nino, or to reduce rice importation, the Indonesian government executed a rice intensification program called Rice IP-300. Basically, the program is aimed at increasing the intensity of wetland rice cultivation, particularly that of irrigated land, from rice cropping twice per year to three times a year, which technically could be achieved three ways: (1) Utilization of fallow land during the dry season, (2) Earlier planting date than usual and application of rice varieties with a shorter-cultivation-period so that the cultivation period of each cultivation season could be reduced, and (3) Encourage farmers to cultivate two rice croppings during the dry season, by replacing other food crops which are usually cultivated in the dry season.

The key for the success of the program is the arrangement of a cultivation schedule appropriate to the schedule of water availability. In addition to the utilization of shorter-cultivation-period rice varieties such as Way Apo Baru, the program also applies minimum tillage of land preparation and the arrangement of the irrigation schedule in a strict way. The program was mainly executed in regions with good irrigated land in order to reduce the possibility of production failure due to water insufficiency. The program's participant farmers receive support in terms of seeds and intensive technical guidance from the Regional Agricultural Office and the Regional Assessment Institute of Agricultural Technology (BPTP). The Local government and the Irrigation Office of the Ministry of Public Works are also directly involved in the implementation of the program to ensure that the irrigation schedule is suited to the crops' requirements.

It was estimated that 800 thousand hectares of irrigated wetland area was available for the implementation of the Rice IP-300 program (Anonymous, 2003). However, not all of the areas took part in the program due to the expensive institutional cost and supporting cost to the farmers. As a result of the implementation of the program, rice production in 1999 increased by around 3.77 per cent, from 46.43 million tons in 1998 to 48.18 million tons in 1999, mainly due to increasing the harvest area by 3.16 per cent. However, various studies reveal that the increase in rice production in 1999 was not only the result of the implementation of the program but also from the occurrence of La Nina, which brought more available water. Yet, besides its positive impacts on rice production, implementation of the program in several regions has increased the population of certain pests of the rice crop. This is because the cutting of the pests' lifecycle, which naturally occurs when farmers grow other crops than rice during the dry season, no longer occurs due to the intensive nature of the new cropping system.

In addition to the implementation of the Rice IP-300 program, the utilization of swamp wetland areas is an anticipation strategy planned by the government to recover possible production losses due to the El Nino which was predicted to occur in 2003. When El Nino occurs, negative impacts on food production usually happen in dryland areas and on irrigated land due to the decrease in water supply caused by rainfall deficits. Whereas, in swamp wetland areas, El Nino can result in positive impacts as water log is reduced. In total, nationwide, 350 thousand hectares of swamp wetland areas are available, located mainly off Java, such as on the islands of Kalimantan, Sumatera and Sulawesi.

6.6 Development of tolerant rice varieties to drought

Due to its important role in food security, labor opportunities and GDP of the agricultural sector, increasing rise production is a major concern of the Indonesian government. During the last 40 years, the government has launched 124 improved varieties of wetland rice in order to increase rice production (Irawan *et al.*, 2002; Sunihardi and Hermanto, 2000). Physiological characteristics of the improved varieties are generally different according to their development period, and depends on agronomical problems faced by farmers at the time. In general, the development of rice and other food crop varieties was carried out in order to reach 3 goals (Oka, 1997): (1) To increase yield per hectare, (2) To reduce cropping period, and (3) To obtained varieties resistant to biotic/abiotic perturbation.

In general, the daily water requirement of each rice variety is not significantly different, however, the cultivation period of rice varieties used is very influential in determining the amount of water consumption per period of cultivation. For that reason, to reduce water consumption, particularly during drought conditions induced by El Nino, the application of varieties with a short cultivation period (110 – 120 days) and tolerant to drought is important to reduce possible production failure due to water stress. Since 1990, the government has launched 9 wetland rice varieties which are tolerant to drought with relatively short cultivation periods (Table 6.1). Moreover, some of these varieties are also cultivatable in dryland areas where water is usually less available than on irrigated land.

Table 6.1 Wetland rice varieties tolerant to drought developed by the Indonesian Agency for Agricultural Research and Development

Variety	Cultivation period (days)	Taste of cooked rice	Biotic tolerancy	Abiotic tolerancy
Towuti	115	good	Wck 2,3 and HDB	drought tolerant and dryland
Gajahmungkur	110	poor	Blas	drought tolerant and dryland
Silugonggo	85	moderate	Blas	drought tolerant and dryland
Jatiluhur	115	poor	Blas	dryland
Kalimutu	100	moderate	Blas	drought tolerant and dryland
IR3234-27-51	80	poor	Blas	drought tolerant
PR36-1-1-2	80	poor	HDB	drought tolerant
Dodokan	100	good	Wck 1,2 and HDB	drought tolerant
Jangkok	100	poor	Wck 1,2 and HDB	drought tolerant

Source: Anonymous, 2003.

Although various drought resistant and less water requiring wetland rice varieties have been developed by the government, their application by farmers is very limited; even during El Nino episodes. For example, the application of rice varieties resistant to drought and with a short period of cultivation during the El Nino event of 1997/1998 in West Java was only 0.54 per cent (dry season 1997) and 2.15 per cent (wet season 1997/1998) of total wetland rice area, while for Central Java and East Java the figures were 0.50 – 0.72 per cent for the dry season in 1997 and 0.47 – 0.77 per cent for the wet season of 1997/1998 (Irawan *et al.,* 2002). In general, 3 major constraints exist which cause the low adoption rate of drought resistant rice varieties by farmers: (1) Rice varieties with a short period of cultivation and resistance to drought generally do not taste good when cooked, (2) The occurrence of El Nino is unpredictable due to its high irregularity, consequently, farmers do not know when they should utilize drought tolerant varieties, and (3) Seed production and the distribution of drought resistant varieties is very limited since seed producers are reluctant to produce seeds with uncertain and low demand.

The above description reveals that the adaptation process to drought situations brought about by El Nino is not sufficient if only to be taken through the development of rice varieties which are tolerant to water stress. This effort should also be supported by other means to produce and distribute the seeds to farmers. This means that accurate forecasting of El Nino and dissemination of the information to farmers before the event occurs is the main initial step to be taken to motivate farmers in utilizing water-stress-tolerant rice varieties, in other words, to enlarge the market of the varieties. In addition to this, in order to facilitate the distribution of the seeds to farmers, the government should give support to seed producers and distributors.

7. Conclusions

Most El Nino events occur in the dry season whereas La Nina occurs in the wet season. These climatic anomalies can be disadvantageous for food crop production through drought, flooding or increases of pest perturbation. El Nino events, which are usually followed by a rainfall decrease, cause water constraints that must be faced by farmers, whereas La Nina events, which are followed by rainfall increases can result in crop damage in the wet season due to increases of pest perturbation or flooding.

Experience during 1968-2000 reveals that national food production on average, decreased by 3.06 per cent during the 7 El Nino events that occurred in the period. La Nina events resulted in food production increases of 0.64 per cent. Food production decreases during El Nino episodes are generally more likely to result in decreases in harvest area rather than decreases of yield per hectare, just the opposite of La Nina events. Production decreases induced by El Nino are generally higher for food crops cultivated in dryland areas such as CGPRT crops, rather than wetland rice due to the availability of irrigation water in wetland areas. Among the food crops cultivated in dryland areas, maize and soybean are the most sensitive to El Nino events, whereas cassava is the most insensitive due to the high adaptability of cassava to water stress.

Although the rate of production decrease of wetland rice was the lowest (about 2 per cent) compared to other food crops, excluding cassava, the probability of the occurrence of wetland rice production decreases due to El Nino was the highest. The probability of losses to production has increased more and more recently, which could indicate that the social capacity in anticipating El Nino events is becoming weaker and weaker. It also reveals that El Nino is inclined to become a more serious threat to food security. Experience in Lampung shows that El Nino does not only lead to food crop damage through drought, but also through increases of pest perturbation, primarily locust and rat. This reveals that El Nino anticipation efforts should not only be focused on increasing adaptability to drought, but also to certain pest types of which the population usually increases after a long period of drought in the dry season. To reduce possible production decreases due to drought and pest disaster, various efforts have been performed by farmers but these efforts are not very effective. Production losses due to drought and pest increases induced by the El Nino of 1997/1998 at the farm level were around 30 - 50 per cent for maize, 40 - 60 per cent for wetland rice and about 20 per cent for cassava.

Various coping mechanisms against El Nino events have been conducted by the government. In general, the strategies can be grouped into three categories, i.e. ex-ante strategy (before the event), interactive strategy (during the event) and ex-post strategy (after the event). Some of the efforts executed by the government were quite effective in lowering the negative impacts of El Nino and related consequences induced, some others were less effective. Generally, efforts to reduce the negative impacts on food production through the required adaptation process were the most difficult to implement. Two major factors which could be the cause are: (1) Forecasting and dissemination of climatic information to farmers is inefficient and inaccurate, and (2) Effective farming technology to reduce production loss which is economically acceptable for farmers has not yet been found.

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Appendix 4.1 Monthly Southern Oscillation Index (SOI), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	-4.9	5.3	11.6	14.4	6	15.5	21.1	20.7	22.5	17.7	13.8	19.5
1976	11.8	12.9	13.2	1.2	2.1	0.2	-12.8	-12.1	-13	3	9.8	-3
1977	-4	7.7	-9.5	-9.6	-11.4	-17.7	-14.7	-12.1	-9.4	-12.9	-14.6	-10.6
1978	-3	-24.4	-5.8	-7.9	16.3	5.8	6.1	1.4	0.8	-6.2	-2	-0.9
1979	-4	6.7	-3	-5.5	3.6	5.8	-8.2	-5	1.4	-2.5	-4.7	-7.5
1980	3.2	1.1	-8.5	-12.9	-3.5	-4.7	-1.7	1.4	-5.2	-1.9	-3.4	-0.9
1981	2.7	-3.2	-16.6	-5.5	7.6	11.5	9.4	5.9	7.5	-5	2.6	4.7
1982	9.4	0.6	2.4	-3.8	-8.2	-20.1	-19.3	-23.6	-21.4	-20.2	-31.1	-21.3
1983	-30.6	-33.3	-28	-17	6	-3.1	-7.6	0.1	9.9	4.2	-0.7	0.1
1984	1.3	5.8	-5.8	2	-0.3	-8.7	2.2	2.7	2	-5	3.9	-1.4
1985	-3.5	6.7	-2	14.4	2.8	-9.6	-2.3	8.5	0.2	-5.6	-1.4	2.1
1986	8	-10.7	0.8	1.2	-6.6	10.7	2.2	-7.6	-5.2	6.1	-13.9	-13.6
1987	-6.3	-12.6	-16.6	-24.4	-21.6	-20.1	-18.6	-14	-11.2	-5.6	-1.4	-4.5
1988	-1.1	-5	2.4	-1.3	10	-3.9	11.3	14.9	20.1	14.6	21	10.8
1989	13.2	9.1	6.7	21	14.7	7.4	9.4	-6.3	5.7	7.3	-2	-5
1990	-1.1	-17.3	-8.5	-0.5	13.1	1	5.5	-5	-7.6	1.8	-5.3	-2.4
1991	5.1	0.6	-10.6	-12.9	-19.3	-5.5	-1.7	-7.6	-16.6	-12.9	-7.3	-16.7
1992	-25.4	-9.3	-24.2	-18.7	0.5	-12.8	-6.9	1.4	0.8	-17.2	-7.3	-5.5
1993	-8.2	-7.9	-8.5	-21.1	-8.2	-16	-10.8	-14	-7.6	-13.5	0.6	1.6
1994	-1.6	0.6	-10.6	-22.8	-13	-10.4	-18	-17.2	-17.2	-14.1	-7.3	-11.6
1995	-4	-2.7	3.5	-16.2	-9	-1.5	4.2	0.8	3.2	-1.3	1.3	-5.5
1996	8.4	1.1	6.2	7.8	1.3	13.9	6.8	4.6	6.9	4.2	-0.1	7.2
1997	4.1	13.3	-8.5	-16.2	-22.4	-24.1	-9.5	-19.8	-14.8	-17.8	-15.2	-9.1
1998	-23.5	-19.2	-28.5	-24.4	0.5	9.9	14.6	9.8	11.1	10.9	12.5	13.3
1999	15.6	8.6	8.9	18.5	1.3	1	4.8	2.1	-0.4	9.1	13.1	12.8
2000	5.1	12.9	9.4	16.8	3.6	-5.5	-3.7	5.3	9.9			

Source: Australian Bureau of Meteorology.

Appendix 4.2 Wetland rice area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	1,463	3,401	15,022	33,027	25,256	12,560	7,427	11,041	7,077	6,030	4,773	3,110
1976	2,166	2,791	6,800	28,552	29,150	19,887	9,549	1,397	2,289	9,242	6,922	2,973
1977	2,390	1,385	4,606	25,975	42,055	16,274	7,814	1,143	3,880	11,270	7,439	3,879
1978	1,041	701	8,021	24,792	45,563	15,000	9,559	3,098	4,945	9,161	7,614	3,497
1979	1,217	30	7,027	34,146	38,326	28,511	3,841	104	1,765	6,728	8,074	5,099
1980	2,291	440	10,434	40,384	40,129	19,408	5,661	10,465	10,415	5,806	6,050	4,398
1981	2,028	2,280	15,385	48,663	30,651	16,405	5,351	20,228	10,703	5,357	7,705	7,645
1982	3,096	5,026	20,240	46,492	28,113	16,806	18,254	20,361	6,735	3,932	3,097	2,655
1983	650	5,449	39,303	36,748	23,209	23,689	17,599	22,542	10,013	6,082	3,837	1,366
1984	819	15,005	34,338	50,179	26,656	16,176	16,289	24,270	7,445	5,944	8,135	5,867
1985	2,105	9,914	24,602	58,101	39,352	17,350	10,873	13,501	7,409	8,616	7,317	4,930
1986	3,865	2,473	18,228	48,979	54,238	19,381	9,430	19,812	13,534	11,483	7,815	9,012
1987	5,322	6,900	20,736	65,798	44,764	15,961	12,685	12,780	14,501	12,763	8,448	9,009
1988	1,391	2,527	20,570	77,911	45,414	18,917	9,333	21,215	27,339	9,178	10,278	1,555
1989	1,110	8,024	48,857	69,331	29,469	16,442	11,856	26,774	16,618	12,018	4,318	3,447
1990	2,551	11,580	49,968	67,553	36,253	14,979	14,627	24,209	17,462	14,543	7,533	2,804
1991	1,734	9,883	47,233	77,898	24,086	13,448	9,897	42,079	15,441	9,526	1,864	919
1992	542	16,065	96,210	63,974	28,252	12,162	33,359	33,639	16,534	7,480	3,133	2,924
1993	6,226	38,058	90,406	51,932	16,557	12,811	37,643	25,144	13,666	8,002	8,003	4,914
1994	3,567	29,004	72,843	68,968	36,415	15,653	30,607	27,147	10,256	4,164	4,494	1,329
1995	5,157	24,492	76,887	109,460	34,456	12,877	26,845	35,018	17,952	13,046	3,444	1,625
1996	11,026	52,330	71,311	77,222	31,015	13,886	41,558	33,395	13,965	10,678	7,863	6,693
1997	10,767	28,776	47,478	79,541	34,353	15,473	30,482	41,254	21,263	7,582	4,543	7,696
1998	2,911	9,613	54,015	87,164	58,237	36,842	21,291	37,125	41,862	17,431	8,209	9,307
1999	5,860	29,318	82,862	93,234	40,555	19,927	32,967	41,135	22,592	12,606	6,634	4,963
2000	5,983	29,982	84,740	95,407	41,474	20,378	33,714	42,067	23,104	12,892	6,784	5,075

Source: Central Bureau of Statistics, Lampung.

Appendix 4.3 Dryland rice area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	1,519	15,975	52,086	30,048	3,644	233	98	0	3	1	10	123
1976	1,341	19,740	51,922	30,077	3,008	567	541	0	0	0	0	137
1977	734	11,633	67,260	31,294	1,914	0	0	0	0	0	0	0
1978	5	3,034	31,610	82,719	10,115	1,233	0	0	0	10	90	0
1979	2,241	14,507	48,846	40,075	7,230	707	35	0	0	0	40	0
1980	4,290	14,856	59,214	34,751	6,883	598	1,045	0	0	0	14	0
1981	1,396	11,973	68,502	32,504	8,277	669	11	0	12	0	0	15
1982	3,060	21,359	68,950	27,388	4,088	71	0	0	0	0	41	0
1983	124	857	35,405	85,374	12,184	107	58	0	26	0	0	0
1984	13	19,702	100,689	26,866	2,905	70	0	0	0	2	0	0
1985	381	22,631	73,283	32,754	2,485	0	0	0	0	0	0	0
1986	6,467	30,252	43,453	16,588	48	0	0	0	0	0	0	0
1987	3,885	36,908	56,486	21,999	663	0	0	0	0	0	0	0
1988	434	7,028	74,140	34,983	2,548	5	0	0	0	0	0	0
1989	625	29,287	66,361	11,912	685	0	0	0	0	0	0	1,975
1990	1,273	32,538	54,747	10,429	0	0	0	0	0	0	0	0
1991	1,099	35,490	45,029	16,656	1,342	37	8	1	0	0	0	0
1992	0	29,190	82,701	20,387	871	0	0	1	0	3	0	0
1993	3,210	56,879	53,612	5,839	161	2	0	4	4	3	2	0
1994	2,151	38,775	65,359	14,147	910	65	0	0	0	0	18	68
1995	110	23,185	93,224	29,929	6,575	81	0	0	0	0	0	0
1996	13,587	71,439	51,022	7,851	312	37	2	0	0	0	0	0
1997	10,271	49,875	55,896	8,590	247	0	0	0	0	0	0	0
1998	0	4,616	64,281	65,977	2,630	0	64	0	0	0	0	0
1999	3,699	41,851	67,634	20,928	1,432	26	8	1	0	0	2	8
2000	3,646	51,251	66,663	20,627	1,411	25	8	1	0	0	2	8

Source: Central Bureau of Statistics, Lampung.

Appendix 4.4 Maize area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	8,027	3,461	2,366	2,720	1,533	2,346	2,174	2,343	733	334	675	1,840
1976	5,044	3,927	3,176	1,638	2,068	1,148	2,931	1,533	271	142	1,238	4,198
1977	3,803	4,200	2,380	4,749	1,532	4,359	2,174	3,968	1,449	642	347	121
1978	379	7,736	17,338	2,108	264	2,532	4,672	4,913	2,913	1,202	261	801
1979	9,723	9,440	5,162	4,790	4,319	2,197	6,736	5,661	755	4,276	261	5,131
1980	8,368	9,059	4,850	3,375	2,179	4,253	7,557	4,433	798	4,574	1,130	1,331
1981	6,489	15,663	7,201	4,820	467	1,912	3,908	10,977	4,436	4,623	386	3,449
1982	8,359	11,259	5,950	5,011	3,020	3,193	6,803	5,602	2,318	915	92	859
1983	3,486	18,487	23,853	3,025	1,448	9,133	10,443	8,286	3,687	840	151	933
1984	19,111	29,390	7,054	986	9,937	5,996	7,706	6,174	4,222	648	724	3,885
1985	24,244	17,746	8,675	10,611	7,303	6,238	12,042	11,304	5,258	5,166	6,599	17,894
1986	22,094	23,371	12,247	11,252	10,036	15,683	21,305	10,622	3,760	4,341	9,511	14,327
1987	31,443	26,770	12,987	16,597	11,716	10,356	20,624	24,183	7,036	1,002	1,015	1,999
1988	14,151	40,194	37,261	26,011	10,962	10,972	18,314	17,535	11,663	2,679	1,782	4,031
1989	14,990	48,586	23,575	15,027	15,551	11,205	22,009	16,642	9,300	7,164	8,114	15,020
1990	22,742	50,824	23,844	20,875	16,600	23,313	14,406	14,220	9,840	11,059	6,333	12,509
1991	21,711	43,538	26,308	19,628	12,086	18,660	22,078	11,732	6,822	4,013	2,392	849
1992	1,557	63,797	27,341	4,071	15,093	25,941	35,201	25,928	16,073	6,739	8,200	3,623
1993	22,857	67,007	26,239	26,507	20,744	22,182	6,389	10,151	14,418	9,158	11,724	15,451
1994	25,122	80,046	27,556	25,980	23,251	25,970	21,455	9,631	5,192	1,069	3,457	852
1995	5,122	63,125	97,879	26,885	10,732	16,324	49,213	42,319	26,942	8,424	5,557	11,156
1996	69,067	63,495	22,235	20,588	28,818	28,029	48,906	46,640	26,347	14,572	17,353	17,214
1997	158	27,859	118,449	69,489	11,784	16,982	39,232	36,222	8,725	5,502	1,655	259
1998	68,379	62,902	32,846	27,660	31,365	44,311	32,731	27,281	25,809	17,198	10,526	16,574
1999	34,780	85,515	59,517	33,944	24,561	36,600	39,181	31,606	18,334	11,457	10,005	11,378
2000	36,825	90,543	63,017	35,940	26,006	38,752	41,485	33,465	19,412	12,131	10,593	12,047

Source: Central Bureau of Statistics, Lampung.

Appendix 4.5 Cassava area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	2,984	3,021	3,427	2,053	3,942	6,363	11,458	12,535	7,097	4,523	2,050	1,170
1976	3,026	3,064	3,475	2,082	3,998	6,453	11,620	12,710	7,197	4,587	2,088	1,194
1977	2,607	2,214	1,319	3,461	4,828	5,453	8,971	12,151	10,059	8,498	5,450	6,476
1978	2,937	2,919	3,557	3,108	6,735	4,034	10,798	11,528	10,765	7,926	6,560	3,244
1979	5,874	2,633	3,142	5,715	4,584	3,324	8,542	15,197	11,346	10,733	5,679	4,461
1980	2,377	2,691	2,384	2,751	2,849	4,050	13,898	16,149	19,988	9,991	6,238	6,169
1981	2,057	3,896	4,283	5,356	4,096	4,362	6,983	14,170	14,638	8,009	6,136	2,850
1982	3,578	4,623	4,122	3,880	3,001	5,025	7,250	17,432	16,380	8,183	5,008	1,782
1983	1,194	1,218	2,879	3,144	5,410	7,047	8,592	13,907	17,742	11,834	5,887	2,622
1984	5,311	7,574	4,772	6,255	7,539	12,235	14,045	21,105	18,647	11,349	4,904	4,271
1985	5,787	5,606	4,603	3,294	6,593	5395	9,103	8,534	13,742	7,071	5,993	3,683
1986	3,390	2,593	2,994	4,747	7,111	7,272	7,495	7,994	6,581	6,598	4,280	4,004
1987	2,143	3,486	5,640	9,527	10,881	10,555	14,961	11,284	13,993	12,056	5,993	5,303
1988	5,325	4,267	4,064	7,038	10,360	16,953	21,013	25,714	21,951	15,242	10,035	9,452
1989	7,571	9,739	11,013	14,805	16,044	15,364	15,179	17,689	21,280	17,036	10,972	5,655
1990	8,553	8,350	6,667	8,673	15,055	6,530	11,220	12,160	9,863	18,267	9,749	11,987
1991	4,619	11,277	6,686	8,600	12,677	11,696	16,677	11,857	12,891	16,525	22,006	8,976
1992	6,878	3,723	7,747	4,474	6,487	11,541	21,976	27,605	25,366	32,045	21,016	9,212
1993	12,510	12,550	11,142	13,493	13,978	20,120	21,415	29,183	23,489	24,276	21,626	10,907
1994	10,647	23,938	20,914	21,392	12,529	8,689	23,475	14,147	13,638	12,324	8,477	5,252
1995	5,045	5,245	25,103	12,689	8,123	15,392	18,954	20045	28,568	22,738	18,850	12,310
1996	20,755	22,498	20,014	22,048	15,888	15,727	17,722	29,040	34,141	26,965	19,925	12,694
1997	10,029	10,635	10,924	8,844	10,235	8,930	12,243	18,769	14,849	17,419	13,122	7,862
1998	5,411	4,253	6,703	10,234	9,398	13,119	13,742	17,088	24,289	28,648	22,120	19,740
1999	8,648	10,662	11,836	11,346	11,323	11,518	16,605	18,520	18,986	21,029	16,558	10,610
2000	8,297	10,228	11,355	10,885	10,863	11,050	15,931	17,767	18,214	20,175	15,885	10,179

Source: Central Bureau of Statistics, Lampung.

Appendix 4.6 Groundnut area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	1,377	876	750	697	907	554	490	477	245	156	247	165
1976	976	615	664	481	1,016	273	331	388	88	128	339	247
1977	1,218	780	531	629	429	609	449	372	302	121	55	16
1978	48	1,502	1,648	455	528	1,090	607	572	440	317	64	30
1979	1,342	2,282	568	397	616	718	795	601	234	33	94	503
1980	780	1,128	609	289	422	755	483	222	192	302	265	167
1981	443	1,145	1,388	289	395	423	421	504	554	429	252	593
1982	1,716	1,178	600	1,191	855	437	457	631	302	151	51	53
1983	214	875	2,294	297	363	1,131	1,480	709	45	66	12	345
1984	3,030	4,119	648	238	1,693	1,516	510	837	406	118	73	324
1985	1,880	2,052	936	813	1,511	788	760	434	367	586	352	990
1986	1,610	1,389	1,028	982	2,053	839	696	648	420	510	474	1,359
1987	4,523	1,294	696	1,997	1,103	562	1,010	595	371	95	343	219
1988	909	2,593	947	1,231	537	872	745	897	188	238	121	512
1989	1,474	2,287	738	1,129	1,441	1,342	897	861	376	224	507	1,569
1990	1,664	1,401	761	1,472	493	945	849	754	1,163	466	172	1,117
1991	1,185	1,518	796	587	666	886	1,172	646	629	235	81	59
1992	757	2,124	814	609	1,511	1,046	1,030	1,177	364	477	1,076	1,012
1993	2,348	1,988	636	627	568	813	1,292	706	480	732	342	288
1994	1,727	1,971	1,076	566	1,020	1,094	1,262	586	269	127	88	15
1995	317	2,422	1,750	408	669	1,069	2,280	2,579	1,400	1,857	496	1,700
1996	2,983	1,690	1,274	905	1,048	635	1,896	1,691	668	283	671	780
1997	866	1,161	995	580	612	813	1,656	1,110	300	270	97	82
1998	19	746	2,561	847	366	1,552	1,767	1,045	1,236	893	584	774
1999	1,368	1,687	1,165	752	789	1,009	1,468	1,084	694	539	369	568
2000	1,269	1,565	1,981	698	732	936	1,362	1,006	643	500	342	527

Source: Central Bureau of Statistics, Lampung.

Appendix 4.7 Sweet potato area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	165	198	232	343	352	324	218	236	165	132	95	71
1976	138	208	195	466	311	272	258	186	193	113	104	111
1977	212	210	296	260	434	414	204	313	155	167	96	39
1978	90	177	331	237	223	153	210	230	220	342	83	45
1979	178	191	294	169	162	151	442	343	344	70	87	73
1980	130	294	161	174	174	257	398	189	112	232	101	132
1981	140	188	358	335	134	85	110	89	200	112	87	134
1982	296	178	256	158	86	155	127	175	125	84	96	24
1983	65	211	352	231	193	137	194	347	272	174	80	17
1984	53	220	187	129	145	213	212	166	157	120	89	271
1985	120	184	163	206	161	163	200	170	153	200	90	160
1986	237	215	326	223	171	158	172	186	179	197	183	221
1987	254	250	275	222	170	252	219	274	308	83	118	52
1988	80	226	219	371	138	160	232	309	340	175	125	98
1989	217	165	257	274	151	238	389	301	312	193	107	158
1990	297	399	447	229	335	218	411	240	396	421	177	229
1991	292	349	313	323	457	453	363	576	514	155	161	96
1992	154	456	431	419	317	312	460	670	436	574	462	333
1993	465	558	524	313	396	319	554	407	402	676	303	207
1994	229	597	492	295	586	382	541	381	221	153	107	28
1995	119	411	639	333	287	380	571	782	756	991	275	521
1996	654	767	657	425	347	273	662	958	544	596	449	386
1997	409	360	438	374	318	349	546	513	169	54	93	29
1998	34	209	471	529	184	641	542	703	1208	810	580	404
1999	393	597	632	463	491	482	671	725	626	579	345	288
2000	392	594	629	461	489	480	669	723	624	578	344	288

Source: Central Bureau of Statistics, Lampung.

Appendix 4.8 Soybean area per month in Lampung (ha), 1975-2000

Year	January	February	March	April	May	June	July	August	September	October	November	December
1975	8,601	699	3,030	8,151	506	2,047	6,166	909	206	1,423	990	3,845
1976	6,971	668	1,980	6,919	163	511	5,837	552	263	2,462	1,625	6,911
1977	3,486	588	1,465	7,729	747	368	5,244	1,081	108	96	155	0
1978	1,948	2,909	6,088	406	2,561	2,566	4,266	8,936	744	165	93	1,097
1979	6,827	1,968	2,159	3,272	122	3,279	4,735	896	90	33	1,523	10,666
1980	228	958	6,458	1,356	133	3,025	8,082	297	134	3,527	831	2,428
1981	2,537	8,690	8,206	313	378	4,216	5,313	1,349	4,858	104	375	1,385
1982	6,088	6,447	629	2,658	1,449	460	1,174	1,907	1,441	133	38	729
1983	164	6,135	4,212	237	186	3,279	3,260	645	139	127	119	193
1984	10,549	4,068	315	1,840	9,685	1,406	4,233	3,305	373	165	1,307	10,502
1985	10,700	3,708	6,901	10,929	6,999	9,848	14,641	1,273	252	720	9,270	12,539
1986	7,835	1,116	10,283	16,671	12,013	14,104	13,905	3,564	740	8,750	14,292	16,187
1987	20,296	12,028	7,019	19,140	11,670	7,012	14,008	8,931	2,791	303	953	4,591
1988	16,335	7,875	2,407	25,444	5,447	8,950	13,192	9,360	1,244	1,211	822	8,099
1989	24,517	7,777	3,434	20,600	5,784	8,089	13,071	4,570	1,424	360	8,044	13,910
1990	4,626	6,313	6,335	11,916	4,125	9,860	7,890	9,422	3,081	2,502	7,325	47,892
1991	8,405	5,774	12,553	12,605	6,454	12,905	8,981	11,231	6,866	2,474	370	510
1992	3,087	37,582	6,277	529	20,622	23,670	9,878	16,590	5,399	8,412	16,372	36,635
1993	10,202	9,964	8,164	19,125	14,082	12,881	6,158	3,867	5,297	13,416	15,508	6,217
1994	19,073	18,770	7,503	5,882	24,218	17,199	4,395	2,779	5,738	961	454	19
1995	2,356	38,681	30,170	6,562	19,697	30,474	10,758	10,811	9,961	3,538	1,770	12,775
1996	25,764	6,085	4,535	3,507	10,672	8,740	9,673	11,225	1,902	1,602	2,799	2,819
1997	8,000	4,508	2,157	1,505	3,055	2,683	4,728	1,742	1,855	373	74	20
1998	33	4,339	13,131	2,204	1,191	8,757	4,055	2,678	2,063	790	361	1,825
1999	2,994	3,427	2,989	1,938	2,820	3,654	2,249	2,027	1,279	860	1,028	2,454
2000	2,004	2,293	2,000	1,297	1,887	2,445	1,505	1,357	856	576	688	1,642

Source: Central Bureau of Statistics, Lampung.

Appendix 4.9 Annual harvested area of food crops in Lampung (ha), 1968-2000

Year	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
1968	67,705	170,417	62,214	26,442	4,223	5,256	21,904
1969	70,532	138,908	57,730	34,696	3,525	4,130	14,749
1970	75,890	139,768	63,839	34,347	2,930	4,189	11,845
1971	87,424	144,673	76,836	36,068	3,863	4,422	15,610
1972	90,579	143,138	59,425	43,507	4,617	3,341	28,318
1973	100,438	128,414	93,541	65,188	5,140	3,202	42,370
1974	106,360	111,831	71,722	53,013	4,708	2,632	52,327
1975	130,187	103,740	28,552	60,623	6,942	2,531	36,573
1976	121,717	107,332	27,314	61,494	5,546	2,555	34,862
1977	128,111	112,834	39,724	71,487	5,511	2,800	30,867
1978	128,872	128,816	45,119	74,111	7,301	2,341	31,779
1979	130,665	113,681	58,428	81,230	8,180	2,503	37,614
1980	151,049	121,651	51,879	89,488	5,586	2,353	29,443
1981	167,055	123,359	64,300	76,820	6,829	1,970	37,715
1982	174,807	124,956	53,381	80,264	7,622	1,760	23,153
1983	190,487	134,135	83,772	81,476	7,831	2,273	18,696
1984	211,123	150,247	95,833	118,007	13,512	1,962	47,748
1985	204,070	131,534	133,080	79,404	11,469	1,970	87,780
1986	218,250	96,808	188,549	65,059	12,008	2,468	139,460
1987	249,667	119,941	165,728	105,822	12,808	2,477	108,742
1988	245,628	119,138	195,555	151,414	9,790	2,473	100,386
1989	248,264	110,845	207,183	162,347	12,845	2,762	111,580
1990	264,062	98,987	226,565	127,074	12,363	3,799	121,287
1991	254,008	99,662	189,817	144,487	8,460	4,052	89,128
1992	314,274	133,153	233,564	178,070	11,997	5,024	185,052
1993	313,362	119,716	252,827	214,689	10,820	5,124	124,881
1994	304,447	121,493	249,581	175,422	9,801	4,012	106,991
1995	361,259	153,104	363,678	193,062	16,947	6,065	177,553
1996	370,942	144,250	403,264	257,417	14,524	6,718	89,323
1997	329,208	124,879	359,058	143,861	8,542	3,652	30,700
1998	384,007	137,568	374,840	174,745	12,390	6,315	41,427
1999	372,710	104,189	399,827	264,178	6,956	5,107	50,472
2000	388,383	108,496	382,401	258,029	9,163	6,266	42,066

Source: Central Bureau of Statistics, Lampung.

Appendix 4.10 Annual yield of food crops in Lampung (tons/ha), 1968-2000

Year	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
1968	2.64	0.99	0.79	8.47	0.60	5.08	0.59
1969	2.40	0.79	0.79	8.51	0.54	4.72	0.44
1970	2.46	0.99	0.89	9.06	0.59	5.17	0.58
1971	2.64	1.04	1.45	10.76	0.65	6.72	0.65
1972	2.50	1.11	1.32	10.70	0.65	6.22	0.65
1973	2.58	1.23	1.23	11.26	0.70	7.26	0.83
1974	2.77	1.20	1.36	11.40	0.66	9.40	1.09
1975	2.95	1.43	1.12	10.80	0.70	9.40	0.96
1976	3.32	1.26	1.10	11.30	0.68	8.70	0.83
1977	3.19	1.54	1.24	11.00	0.64	8.40	0.88
1978	3.19	1.52	1.21	10.90	0.77	7.60	0.77
1979	3.25	1.55	1.32	11.10	0.77	8.00	0.84
1980	3.33	1.51	1.30	11.00	0.98	8.60	0.80
1981	3.57	1.52	1.36	10.70	0.94	8.30	0.78
1982	3.81	1.67	1.40	11.00	0.87	8.20	0.77
1983	3.92	1.60	1.57	10.15	0.79	8.50	0.70
1984	3.96	1.63	1.67	11.00	0.97	8.80	0.70
1985	4.04	1.63	1.96	11.70	0.94	8.50	0.84
1986	4.05	1.67	2.07	12.10	1.02	9.50	1.01
1987	4.02	2.02	2.07	12.87	0.95	9.34	1.08
1988	4.05	2.13	2.08	12.65	0.97	9.52	1.01
1989	4.16	2.25	2.19	12.77	1.00	10.98	0.89
1990	4.20	2.35	2.19	12.79	1.04	9.34	0.96
1991	4.29	2.40	2.19	12.65	1.08	10.60	1.00
1992	4.30	2.42	2.27	12.83	1.07	9.93	0.97
1993	4.33	2.43	2.29	13.48	1.12	9.58	1.01
1994	4.34	2.42	2.26	11.94	1.05	9.64	1.03
1995	4.35	2.43	2.32	11.75	1.21	9.37	1.03
1996	4.37	2.44	2.33	11.26	1.12	9.81	1.04
1997	4.38	2.49	3.01	11.19	1.18	9.54	1.04
1998	4.27	2.44	2.97	11.17	1.05	9.41	1.04
1999	4.15	2.43	2.94	11.12	1.07	9.62	1.07
2000	4.33	2.43	2.94	11.11	1.04	9.59	0.93

Source: Central Bureau of Statistics, Lampung.

Appendix 4.11 Annual production of food crops in Lampung (tons), 1968-2000

Year	Wetland rice	Dryland rice	Maize	Cassava	Groundnut	Sweet potato	Soybean
1968	178,629	168,184	49,345	223,834	2,542	26,712	12,929
1969	169,474	110,246	45,667	295,347	1,903	19,487	6,439
1970	186,998	138,027	56,681	311,266	1,741	21,650	6,867
1971	230,967	150,778	111,350	388,141	2,520	29,736	10,111
1972	226,726	158,689	78,654	465,322	3,011	20,789	18,279
1973	258,780	158,278	114,975	734,156	3,618	23,232	34,983
1974	295,145	134,400	97,614	604,348	3,088	24,741	57,246
1975	384,307	148,643	31,978	654,728	4,852	23,791	35,110
1976	404,187	135,453	29,936	694,882	3,766	22,229	28,935
1977	408,605	173,313	49,377	786,357	3,538	23,520	27,256
1978	411,702	195,414	54,639	807,810	5,593	17,792	24,406
1979	424,499	176,319	77,300	901,653	6,266	20,024	31,445
1980	502,824	183,571	67,650	984,368	5,480	20,236	23,643
1981	596,427	187,506	87,641	821,974	6,453	16,351	29,418
1982	666,628	208,427	74,787	882,904	6,601	14,432	17,828
1983	745,781	214,884	131,204	827,290	6,211	19,320	13,177
1984	836,680	244,752	160,041	1,298,077	13,080	17,266	33,615
1985	823,770	214,532	261,369	929,027	10,804	16,745	73,999
1986	883,891	261,379	391,239	787,214	12,272	23,446	140,297
1987	1,002,483	241,978	342,467	1,361,750	12,130	23,137	117,698
1988	995,526	254,081	407,344	1,915,140	9,450	23,545	101,783
1989	1,034,001	249,386	454,296	2,072,796	12,806	30,318	99,586
1990	1,110,246	232,666	496,234	1,624,714	12,806	35,498	116,287
1991	1,088,578	238,966	415,531	1,828,196	9,137	42,957	89,035
1992	1,350,692	232,176	530,388	2,283,774	12,888	49,878	179,793
1993	1,355,447	291,453	579,141	2,894,298	12,123	49,067	126,204
1994	1,321,784	293,967	563,069	2,095,109	10,294	38,675	110,380
1995	1,571,975	371,734	843,177	2,267,741	20,470	56,824	183,566
1996	1,620,487	351,253	938,395	2,898,667	16,314	65,915	92,730
1997	1,442,193	311,463	1,080,691	1,609,661	10,061	34,843	31,914
1998	1,640,107	335,593	1,111,832	1,951,590	13,007	59,422	43,008
1999	1,547,867	253,596	1,176,291	2,936,338	7,464	49,129	53,854
2000	1,682,337	264,079	1,123,112	2,867,476	9,530	60,066	39,248

Source: Central Bureau of Statistics, Lampung.

Appendix 5.1A Average rainfall by station and by district in Lampung (mm/month)

Rainfall station	Altitude (m)	District	Month												Data period
			1	2	3	4	5	6	7	8	9	10	11	12	
Bendungan Dam Argoguruh	52	Lampung Selatan	289	301	247	142	122	68	97	58	94	99	159	236	1980-2000
Gunung Batu	300	Lampung Selatan	241	263	243	170	133	90	74	91	80	83	146	231	1977-2000
Jati Baru/Tanjung Bintang	65	Lampung Selatan	224	251	206	213	151	102	85	80	93	91	144	157	1977-2000
Sukajaya-Kedondong	157	Lampung Selatan	278	207	194	107	106	64	105	99	65	80	176	181	1977-2000
Ketibung	35	Lampung Selatan	346	295	240	205	137	114	91	87	89	120	161	213	1986-2000
Penengahan/Pesuruhan	45	Lampung Selatan	226	206	183	139	141	92	147	87	67	100	128	214	1977-2000
Air Naningan	385	Tanggamus	290	240	231	248	197	130	104	74	113	115	132	225	1977-2000
Banjar Agung	165	Tanggamus	257	228	184	150	111	86	90	71	69	88	126	203	1977-2000
Banyuwangi/Sukoharjo	120	Tanggamus	242	258	267	197	135	80	110	70	92	112	166	225	1977-2000
Gisting	560	Tanggamus	260	181	231	201	174	127	158	152	155	156	204	212	1977-2000
Gunung Sari	720	Tanggamus	323	235	276	213	200	114	96	87	133	170	244	286	1977-2000
Kunyir	435	Tanggamus	325	264	264	204	146	103	107	75	116	97	187	257	1977-2000
Pematang Nebak	430	Tanggamus	269	192	137	117	108	84	85	66	127	98	118	219	1977-2000
Pringsewu	100	Tanggamus	290	236	239	160	142	84	69	87	96	84	155	188	1977-2000
Wonosobo/siring Betik	30	Tanggamus	197	173	148	129	111	84	126	165	156	151	194	254	1986-2000
Srikaton/Srikuncoro	30	Tanggamus	250	178	188	199	170	119	141	191	267	271	261	239	1977-2000
Way Harong Toto Margo	370	Tanggamus	367	339	295	230	186	124	109	86	130	131	195	231	1977-2000
Wonokriyo/Gedung Rejo	65	Tanggamus	267	259	244	175	155	114	103	75	101	92	132	223	1977-2000
Metro DPU	58	Lampung Tengah	226	209	168	210	96	45	50	42	52	67	99	191	1981-2000
Bumi Kencana	48	Lampung Tengah	264	212	231	191	124	98	132	118	89	84	159	217	1976-2000
Komering Putih	40	Lampung Tengah	265	250	260	205	142	68	58	65	72	73	171	252	1984-2000
Negeri Kepayungan	115	Lampung Tengah	263	251	233	195	125	105	90	53	60	107	171	247	1986-2000
Sindang Asri/Kalirejo	120	Lampung Tengah	343	306	237	232	192	133	115	75	96	144	225	299	1986-2000

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1A Average rainfall by station and by district in Lampung (mm/month), (continued)

Rainfall station	Altitude (m)	District	Month												Data period
			1	2	3	4	5	6	7	8	9	10	11	12	
Bukit Kemuning	310	Lampung Utara	290	227	205	212	191	93	82	99	74	110	184	257	1984-2000
Gedung Raja Sungkai Utara	46	Lampung Utara	280	239	284	188	161	85	126	92	79	143	196	250	1984-2000
Ketapang	50	Lampung Utara	335	333	335	256	239	226	133	200	154	245	337	387	1977-2000
Kotabumi	40	Lampung Utara	210	237	228	157	96	60	67	62	71	105	159	214	1977-2000
Pekurun	70	Lampung Utara	419	361	337	284	212	183	163	102	143	159	272	370	1977-2000
Daya Murni	25	Tulang Bawang	264	188	286	204	114	82	116	56	44	73	145	238	1977-2000
Gedung Ratu	12	Tulang Bawang	263	193	251	178	138	42	69	81	69	116	167	263	1977-2000
Menggala	15	Tulang Bawang	208	358	245	181	93	73	87	61	92	102	185	274	1977-2000
Purwajaya Unit I Mesuji	30	Tulang Bawang	297	299	303	223	123	71	87	71	91	213	298	290	1977-2000
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	152	124	156	129	80	66	77	44	51	75	139	201	1977-2000
Air Itam	806	Lampung Barat	294	236	303	254	229	132	127	97	146	199	278	286	1977-2000
Bungin	810	Lampung Barat	270	272	275	278	200	117	123	94	174	181	253	299	1977-2000
Dusun Kenali	820	Lampung Barat	366	261	288	241	245	177	119	118	209	246	304	315	1977-2000
Gedung Cahya Kuningan	12	Lampung Barat	378	454	531	480	303	228	177	212	243	253	380	420	1977-2000
Kebun Tebu/Purajaya	825	Lampung Barat	285	257	308	228	195	149	120	83	151	187	256	317	1977-2000
Rawa Bebek	812	Lampung Barat	344	301	345	258	184	135	113	71	152	247	296	384	1990-2000
Sekincau	1000	Lampung Barat	223	216	208	184	186	128	103	105	146	227	249	265	1984-2000
Reno Basuki-Rumbia	20	Lampung Timur	266	309	290	157	168	119	106	77	76	131	202	251	1984-2000
Sukadana	23	Lampung Timur	422	361	323	237	161	117	120	61	89	112	227	348	1984-2000
Way Jepara	22	Lampung Timur	363	319	252	214	146	123	119	100	75	97	181	227	1984-2000
Baradatu	120	Way Kanan	175	183	196	165	90	49	70	53	55	71	174	204	1986-2000
Blambangan Umpu	110	Way Kanan	316	315	245	210	205	140	128	103	133	267	294	321	1977-2000
Tahmi Lumut	275	Way Kanan	351	258	371	329	249	117	142	85	126	170	276	373	1977-2000

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.1B Monthly rainfall by station in Lampung, 1996 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bendungan Dam Argoguruh	52	Lampung Selatan	382	334	224	66	34	27	11	103	184	127	111	184
Gunung Batu	300	Lampung Selatan	267	277	364	244	50	83	60	96	118	152	103	210
Jati Baru/Tanjung Bintang	65	Lampung Selatan	289	303	220	163	73	54	10	106	135	278	199	147
Sukajaya-Kedondong	157	Lampung Selatan	228	194	66	130	94	10	24	65	115	221	109	64
Ketibung	35	Lampung Selatan	261	326	243	129	111	120	48	111	124	153	179	167
Penengahan/Pesuruhan	45	Lampung Selatan	242	148	180	105	42	46	63	56	88	125	192	229
Air Naningan	385	Tanggamus	543	494	278	226	123	131	46	88	144	155	182	181
Banjar Agung	165	Tanggamus	121	214	164	74	78	71	46	69	92	97	167	145
Banyuwangi/Sukoharjo	120	Tanggamus	169	331	155	189	104	35	113	109	120	197	158	145
Gisting	560	Tanggamus	534	376	231	376	160	18	200	140	283	325	226	196
Gunung Sari	720	Tanggamus	386	381	212	172	65	45	79	163	173	233	230	263
Kunyir	435	Tanggamus	113	123	220	237	164	83	115	89	183	142	150	400
Pematang Nebak	430	Tanggamus	121	130	122	80	31	34	50	164	152	162	188	259
Pringsewu	100	Tanggamus	310	231	234	180	128	126	55	97	101	197	136	290
Wonosobo/siring Betik	30	Tanggamus	150	173	165	106	165	55	120	235	225	345	235	235
Srikaton/Srikuncoro	30	Tanggamus	308	341	193	240	54	154	110	146	251	236	224	213
Way Harong Toto Margo	370	Tanggamus	308	494	293	100	80	118	59	80	178	191	172	257
Wonokriyo/Gedung Rejo	65	Tanggamus	233	328	246	147	66	98	35	125	154	156	136	180
Metro DPU	58	Lampung Tengah	362	294	256	103	105	29	11	69	180	85	111	135
Bumi Kencana	48	Lampung Tengah	190	327	334	151	76	107	97	72	117	179	161	195
Komering Putih	40	Lampung Tengah	337	295	295	195	72	70	50	78	125	100	180	271
Negeri Kepayungan/Segala Mider	115	Lampung Tengah	275	541	118	136	125	58	58	63	153	146	172	209
Sindang Asri/Kalirejo	120	Lampung Tengah	234	348	295	122	128	129	47	121	130	155	270	257

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1B Monthly rainfall by station in Lampung, 1996 (mm/month), (continued)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bukit Kemuning	310	Lampung Utara	216	135	281	218	93	62	23	77	93	148	166	235
Gedung Raja Sungkai Utara	46	Lampung Utara	204	189	479	225	108	37	18	118	184	190	192	197
Ketapang	50	Lampung Utara	189	143	201	103	75	74	68	143	188	218	318	316
Kotabumi	40	Lampung Utara	114	224	210	132	41	112	87	83	93	100	299	194
Pekurun	70	Lampung Utara	223	248	271	208	44	72	125	120	134	174	233	254
Daya Murni	25	Tulang Bawang	143	62	158	206	59	84	87	30	175	147	113	211
Gedung Ratu	12	Tulang Bawang	225	183	154	49	71	84	132	173	179	220	160	245
Menggala	15	Tulang Bawang	126	237	458	128	133	114	105	102	179	185	146	261
Purwajaya Unit I Mesuji	30	Tulang Bawang	76	166	62	176	84	66	44	85	131	250	266	216
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	156	134	103	85	96	68	40	78	153	114	182	202
Air Itam	806	Lampung Barat	274	199	160	209	165	29	152	101	88	219	273	255
Bungin	810	Lampung Barat	289	439	36	296	105	56	139	193	210	142	240	299
Dusun Kenali	820	Lampung Barat	379	319	362	433	106	121	126	205	217	372	301	316
Gedung Cahya Kuningan	12	Lampung Barat	480	346	428	259	198	189	168	210	310	385	310	373
Kebun Tebu/Purajaya	825	Lampung Barat	483	531	262	160	159	20	136	50	118	256	293	247
Rawa Bebek	812	Lampung Barat	318	341	353	285	78	55	118	131	195	179	276	312
Sekincau	1000	Lampung Barat	296	382	282	325	92	53	133	120	332	195	371	327
Reno Basuki-Rumbia/Riksobinangun	20	Lampung Timur	304	336	220	144	86	116	52	86	148	159	251	236
Sukadana	23	Lampung Timur	365	597	155	65	82	133	60	171	186	218	215	271
Way Jepara	22	Lampung Timur	379	263	344	154	126	120	75	75	78	220	182	240
Baradatu	120	Way Kanan	262	142	206	129	171	73	60	20	95	140	146	203
Blambangan Umpu	110	Way Kanan	415	346	217	275	146	64	120	54	153	255	394	312
Tahmi Lumut	275	Way Kanan	323	374	305	265	200	204	120	130	51	173	270	357

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.1C Monthly rainfall by station in Lampung, 1997 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bendungan Dam Argoguruh	52	Lampung Selatan	296	234	236	187	103	12	16	0	0	0	39	97
Gunung Batu	300	Lampung Selatan	239	192	218	151	121	0	0	0	0	70	23	71
Jati Baru/Tanjung Bintang	65	Lampung Selatan	420	188	134	171	154	0	0	0	0	0	64	57
Sukajaya-Kedondong	157	Lampung Selatan	239	241	146	92	39	32	11	0	0	15	34	89
Ketibung	35	Lampung Selatan	276	220	237	85	85	15	9	0	91	2	26	87
Penengahan/Pesuruhan	45	Lampung Selatan	158	180	175	108	35	18	10	0	0	0	24	92
Air Naningan	385	Tanggamus	337	126	158	106	90	26	10	0	0	0	90	277
Banjar Agung	165	Tanggamus	282	161	148	63	119	15	8	0	3	13	48	77
Banyuwangi/Sukoharjo	120	Tanggamus	276	237	277	100	82	16	0	5	5	12	114	178
Gisting	560	Tanggamus	229	217	203	66	38	77	58	92	0	65	181	245
Gunung Sari	720	Tanggamus	296	348	211	131	86	0	0	9	15	17	33	281
Kunyir	435	Tanggamus	294	260	278	114	103	0	0	0	10	5	68	166
Pematang Nebak	430	Tanggamus	293	171	202	162	56	63	3	0	0	4	122	129
Pringsewu	100	Tanggamus	211	195	186	110	62	10	33	1	0	3	43	29
Wonosobo/siring Betik	30	Tanggamus	222	145	121	78	40	62	20	0	5	10	233	267
Srikaton/Srikuncoro	30	Tanggamus	241	142	181	91	60	28	8	5	2	28	90	198
Way Harong Toto Margo	370	Tanggamus	317	372	267	201	161	10	26	18	0	8	102	262
Wonokriyo/Gedung Rejo	65	Tanggamus	267	214	248	146	146	0	0	0	0	16	29	98
Metro DPU	58	Lampung Tengah	259	207	205	153	96	10	8	0	0	0	30	190
Bumi Kencana	48	Lampung Tengah	252	219	231	239	161	5	14	0	0	12	72	231
Komering Putih	40	Lampung Tengah	200	295	279	144	74	50	0	0	0	0	200	143
Negeri Kepayungan/Segala Mider	115	Lampung Tengah	219	286	145	187	156	47	6	11	0	0	117	210
Sindang Asri/Kalirejo	120	Lampung Tengah	344	207	250	164	113	30	6	60	0	0	118	155

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1C Monthly rainfall by station in Lampung, 1997 (mm/month), (continued)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bukit Kemuning	310	Lampung Utara	284	251	296	191	201	8	5	0	6	0	129	231
Gedung Raja Sungkai Utara	46	Lampung Utara	231	259	226	105	136	25	0	44	0	0	105	203
Ketapang	50	Lampung Utara	338	273	240	124	146	0	0	0	0	12	161	275
Kotabumi	40	Lampung Utara	244	222	240	164	90	19	15	0	0	24	68	103
Pekurun	70	Lampung Utara	321	257	262	158	159	61	72	38	24	49	63	129
Daya Murni	25	Tulang Bawang	297	225	231	128	87	23	0	0	0	0	70	129
Gedung Ratu	12	Tulang Bawang	342	272	167	163	107	14	43	0	0	3	18	14
Menggala	15	Tulang Bawang	318	227	281	195	92	50	0	0	0	13	95	184
Purwajaya Unit I Mesuji	30	Tulang Bawang	362	301	292	209	102	47	5	0	0	0	13	150
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	108	190	98	88	65	5	0	0	0	0	0	23
Air Itam	806	Lampung Barat	267	286	243	177	182	26	17	36	26	16	131	208
Bungin	810	Lampung Barat	255	257	184	117	135	21	0	0	8	12	69	297
Dusun Kenali	820	Lampung Barat	333	329	293	168	82	22	50	68	6	15	78	214
Gedung Cahya Kuningan	12	Lampung Barat	367	400	370	258	165	0	0	0	0	0	99	177
Kebun Tebu/Purajaya	825	Lampung Barat	287	258	237	227	105	19	0	6	0	0	94	303
Rawa Bebek	812	Lampung Barat	260	243	218	93	32	35	0	0	0	0	54	175
Sekincau	1000	Lampung Barat	227	288	225	166	140	6	15	21	11	27	145	299
Reno Basuki-Rumbia/Riksobinangun	20	Lampung Timur	298	306	248	191	130	24	34	0	0	0	26	97
Sukadana	23	Lampung Timur	405	376	282	242	159	28	33	0	0	0	81	194
Way Jepara	22	Lampung Timur	341	251	252	57	181	59	0	0	0	0	17	61
Baradatu	120	Way Kanan	193	140	146	61	57	10	29	28	44	32	75	244
Blambangan Umpu	110	Way Kanan	549	206	240	179	90	2	4	21	0	0	170	295
Tahmi Lumut	275	Way Kanan	465	399	448	256	200	0	0	33	0	26	118	249

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.1D Monthly rainfall by station in Lampung, 1998 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bendungan Dam Argoguruh	52	Lampung Selatan	260	212	249	167	181	128	139	175	62	52	173	292
Gunung Batu	300	Lampung Selatan	162	198	266	169	141	102	56	113	50	26	41	61
Jati Baru/Tanjung Bintang	65	Lampung Selatan	196	299	189	196	212	186	149	182	74	64	166	181
Sukajaya-Kedondong	157	Lampung Selatan	206	160	207	126	103	51	45	58	61	60	94	78
Ketibung	35	Lampung Selatan	249	331	240	190	208	185	87	112	165	143	94	136
Penengahan/Pesuruhan	45	Lampung Selatan	140	197	184	131	130	135	103	95	56	75	113	83
Air Naningan	385	Tanggamus	273	258	263	251	285	234	117	93	104	94	271	241
Banjar Agung	165	Tanggamus	180	117	89	96	110	44	45	88	26	73	69	95
Banyuwangi/Sukoharjo	120	Tanggamus	139	126	242	186	272	144	83	171	101	169	237	137
Gisting	560	Tanggamus	231	240	209	179	185	120	44	105	124	195	216	201
Gunung Sari	720	Tanggamus	240	288	227	291	218	187	92	40	226	255	144	169
Kunyir	435	Tanggamus	295	225	321	262	160	98	140	111	120	181	193	146
Pematang Nebak	430	Tanggamus	176	163	204	150	112	82	67	50	111	53	80	117
Pringsewu	100	Tanggamus	310	218	273	159	182	222	76	228	76	90	109	316
Wonosobo/siring Betik	30	Tanggamus	260	213	122	105	166	71	93	55	134	194	125	95
Srikaton/Srikuncoro	30	Tanggamus	275	239	243	247	264	92	90	167	74	151	171	363
Way Harong Toto Margo	370	Tanggamus	362	327	306	253	289	107	188	96	139	133	167	260
Wonokriyo/Gedung Rejo	65	Tanggamus	189	264	251	157	192	167	126	168	69	81	145	223
Metro DPU	58	Lampung Tengah	211	225	179	217	214	126	47	69	42	39	89	109
Bumi Kencana	48	Lampung Tengah	224	264	213	206	240	157	164	176	154	152	229	415
Komering Putih	40	Lampung Tengah	234	208	274	186	228	137	127	102	40	89	100	293
Negeri Kepayungan/Segala Mider	115	Lampung Tengah	195	246	245	160	139	95	145	150	176	205	242	234
Sindang Asri/Kalirejo	120	Lampung Tengah	259	251	294	164	212	107	109	215	90	358	183	238

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1D Monthly rainfall by station in Lampung, 1998 (mm/month), (continued)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bukit Kemuning	310	Lampung Utara	282	262	226	213	218	214	195	98	92	124	153	369
Gedung Raja Sungkai Utara	46	Lampung Utara	272	254	296	203	270	128	156	106	116	205	129	172
Ketapang	50	Lampung Utara	356	296	264	150	249	169	203	128	188	344	411	435
Kotabumi	40	Lampung Utara	227	209	227	139	172	117	169	121	92	210	176	241
Pekurun	70	Lampung Utara	290	313	290	244	209	130	191	124	91	185	243	378
Daya Murni	25	Tulang Bawang	68	237	301	222	165	141	130	162	68	182	252	337
Gedung Ratu	12	Tulang Bawang	111	130	260	164	212	88	55	104	50	203	162	112
Menggala	15	Tulang Bawang	196	318	227	204	284	159	217	132	145	228	331	320
Purwajaya Unit I Mesuji	30	Tulang Bawang	176	296	194	188	153	99	131	104	214	152	362	265
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	143	145	166	75	142	65	155	130	76	45	129	203
Air Itam	806	Lampung Barat	298	257	335	291	244	169	105	147	147	282	150	394
Bungin	810	Lampung Barat	317	219	286	249	260	217	175	211	132	305	253	229
Dusun Kenali	820	Lampung Barat	224	237	266	159	108	250	191	133	71	93	229	299
Gedung Cahya Kuningan	12	Lampung Barat	388	314	310	340	341	193	241	215	171	323	457	463
Kebun Tebu/Purajaya	825	Lampung Barat	387	278	190	166	144	142	191	103	88	173	157	193
Rawa Bebek	812	Lampung Barat	286	349	269	248	273	196	164	133	77	110	92	200
Sekincau	1000	Lampung Barat	271	228	185	144	262	262	206	147	150	184	435	399
Reno Basuki-Rumbia/Riksobinangun	20	Lampung Timur	177	337	317	179	164	157	163	93	188	200	226	206
Sukadana	23	Lampung Timur	394	331	380	273	299	199	143	143	118	264	481	305
Way Jepara	22	Lampung Timur	190	299	147	210	295	117	169	152	105	141	115	179
Baradatu	120	Way Kanan	180	166	154	185	166	73	66	42	53	113	95	183
Blambangan Umpu	110	Way Kanan	279	289	194	172	154	182	127	103	252	118	243	214
Tahmi Lumut	275	Way Kanan	380	221	331	258	181	215	152	141	142	139	439	365

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.1E Monthly rainfall by station in Lampung, 1999 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bendungan Dam Argoguruh	52	Lampung Selatan	275	334	280	130	124	51	122	65	62	214	250	248
Gunung Batu	300	Lampung Selatan	203	156	59	33	95	22	66	40	72	241	166	170
Jati Baru/Tanjung Bintang	65	Lampung Selatan	170	344	118	33	199	70	30	82	88	185	175	124
Sukajaya-Kedondong	157	Lampung Selatan	177	170	35	34	61	36	54	30	72	182	150	239
Ketibung	35	Lampung Selatan	165	388	146	31	169	114	107	35	71	161	184	135
Penengahan/Pesuruhan	45	Lampung Selatan	130	130	108	20	123	52	173	23	31	183	103	80
Air Naningan	385	Tanggamus	262	290	201	66	217	56	129	63	73	183	138	370
Banjar Agung	165	Tanggamus	205	179	63	55	59	54	38	46	32	88	57	193
Banyuwangi/Sukoharjo	120	Tanggamus	290	254	303	136	47	95	161	34	78	184	104	201
Gisting	560	Tanggamus	358	348	136	78	176	177	705	57	42	169	289	397
Gunung Sari	720	Tanggamus	242	253	155	108	191	62	67	40	21	128	229	264
Kunyir	435	Tanggamus	314	395	432	232	231	111	195	156	288	252	292	173
Pematang Nebak	430	Tanggamus	247	256	100	111	63	50	68	91	107	199	171	264
Pringsewu	100	Tanggamus	288	247	244	89	170	56	110	103	62	90	112	312
Wonosobo/siring Betik	30	Tanggamus	143	155	102	61	134	182	46	62	232	206	224	103
Srikaton/Srikuncoro	30	Tanggamus	246	149	361	278	239	45	198	324	373	270	387	243
Way Harong Toto Margo	370	Tanggamus	392	318	258	69	174	43	118	146	105	288	214	311
Wonokriyo/Gedung Rejo	65	Tanggamus	311	256	149	84	171	26	84	38	73	186	93	186
Metro DPU	58	Lampung Tengah	170	137	108	51	20	60	45	32	105	115	30	98
Bumi Kencana	48	Lampung Tengah	383	284	198	117	164	52	82	64	42	41	295	320
Komering Putih	40	Lampung Tengah	216	178	112	120	126	40	124	21	63	179	264	372
Negeri Kepayungan/Segala Mider	115	Lampung Tengah	317	232	196	220	65	63	151	30	92	255	114	210
Sindang Asri/Kalirejo	120	Lampung Tengah	273	326	335	147	243	108	70	125	80	216	227	233

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1E Monthly rainfall by station in Lampung, 1999 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bukit Kemuning	310	Lampung Utara	534	496	125	104	226	103	53	94	123	128	203	315
Gedung Raja Sungkai Utara	46	Lampung Utara	350	258	181	48	122	101	276	43	90	249	262	237
Ketapang	50	Lampung Utara	491	509	188	116	77	87	82	82	77	289	214	214
Kotabumi	40	Lampung Utara	278	480	155	98	139	125	60	42	63	75	228	183
Pekurun	70	Lampung Utara	561	777	308	81	127	240	175	74	247	202	211	312
Daya Murni	25	Tulang Bawang	542	314	372	188	189	80	168	50	52	111	272	259
Gedung Ratu	12	Tulang Bawang	155	158	90	80	160	56	147	186	63	220	232	315
Menggala	15	Tulang Bawang	416	192	87	52	106	30	183	27	36	163	312	206
Purwajaya Unit I Mesuji	30	Tulang Bawang	440	121	137	61	50	109	64	18	40	218	310	266
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	101	101	102	26	26	34	44	79	123	145	245	333
Air Itam	806	Lampung Barat	182	189	164	142	447	136	144	62	67	222	275	220
Bungin	810	Lampung Barat	262	198	322	134	100	86	93	38	269	280	308	218
Dusun Kenali	820	Lampung Barat	207	89	90	124	264	37	69	41	42	271	244	157
Gedung Cahya Kuningan	12	Lampung Barat	261	438	249	290	381	295	80	136	253	303	344	368
Kebun Tebu/Purajaya	825	Lampung Barat	179	161	248	105	21	34	14	37	57	70	204	211
Rawa Bebek	812	Lampung Barat	242	148	277	315	337	145	55	20	133	237	267	205
Sekincau	1000	Lampung Barat	188	235	253	138	341	115	64	19	93	226	226	208
Reno Basuki-Rumbia/Riksobinangun	20	Lampung Timur	491	519	361	119	115	92	99	60	70	250	296	313
Sukadana	23	Lampung Timur	512	825	321	187	233	76	259	28	119	182	227	348
Way Jepara	22	Lampung Timur	342	388	363	184	49	183	95	31	25	236	131	244
Baradatu	120	Way Kanan	158	280	256	115	34	19	120	65	25	61	371	239
Blambangan Umpu	110	Way Kanan	393	416	377	64	120	62	64	30	84	269	243	187
Tahmi Lumut	275	Way Kanan	506	435	443	180	323	155	122	30	24	259	250	283

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.1F Monthly rainfall by station in Lampung, 2000 (mm/month)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bendungan Dam Argoguruh	52	Lampung Selatan	226	165	235	168	123	164	97	63	49	140	99	115
Gunung Batu	300	Lampung Selatan	280	195	160	115	76	127	99	35	44	71	289	167
Jati Baru/Tanjung Bintang	65	Lampung Selatan	225	163	43	103	162	191	63	155	52	57	267	214
Sukajaya-Kedondong	157	Lampung Selatan	191	83	46	85	35	87	65	51	70	96	129	147
Ketibung	35	Lampung Selatan	283	181	166	297	138	182	84	23	122	246	269	104
Penengahan/Pesuruhan	45	Lampung Selatan	105	118	174	41	68	43	129	67	27	74	140	89
Air Naningan	385	Tanggamus	428	308	296	351	311	350	230	42	54	175	255	417
Banjar Agung	165	Tanggamus	91	41	85	48	49	41	60	42	20	46	101	135
Banyuwangi/Sukoharjo	120	Tanggamus	120	110	169	246	43	49	122	83	93	196	184	152
Gisting	560	Tanggamus	250	365	85	164	120	136	170	177	83	288	243	382
Gunung Sari	720	Tanggamus	266	145	103	122	150	115	95	84	86	92	437	282
Kunyir	435	Tanggamus	531	155	141	224	156	267	300	90	241	260	591	476
Pematang Nebak	430	Tanggamus	348	170	100	55	70	103	28	65	92	237	188	145
Pringsewu	100	Tanggamus	225	126	199	257	46	106	96	70	35	106	241	162
Wonosobo/siring Betik	30	Tanggamus	183	54	72	53	92	65	173	30	165	294	375	291
Srikaton/Srikuncoro	30	Tanggamus	113	53	62	103	107	150	132	109	305	266	393	260
Way Harong Toto Margo	370	Tanggamus	356	289	168	290	46	88	179	33	117	254	386	462
Wonokriyo/Gedung Rejo	65	Tanggamus	233	133	45	185	41	82	125	55	30	148	236	148
Metro DPU	58	Lampung Tengah	149	125	175	107	41	104	80	73	79	202	106	253
Bumi Kencana	48	Lampung Tengah	332	253	244	206	128	98	119	64	50	84	159	317
Komering Putih	40	Lampung Tengah	360	187	163	412	48	63	90	42	119	200	176	237
Negeri Kepayungan/Segala Mider	115	Lampung Tengah	202	200	180	221	49	100	88	65	135	144	263	253
Sindang Asri/Kalirejo	120	Lampung Tengah	166	236	290	167	154	181	164	23	129	207	334	296

Source: Dinas Pengairan PU. Propinsi Lampung.

Continued ……………..

Appendix 5.1F Monthly rainfall by station in Lampung, 2000 (mm/month), (continued)

Rainfall station	Altitude (m)	District	Month											
			1	2	3	4	5	6	7	8	9	10	11	12
Bukit Kemuning	310	Lampung Utara	437	264	73	121	385	93	108	545	81	251	457	336
Gedung Raja Sungkai Utara	46	Lampung Utara	244	234	137	258	90	227	81	76	88	170	368	244
Ketapang	50	Lampung Utara	252	224	211	208	112	108	125	243	119	250	407	343
Kotabumi	40	Lampung Utara	126	202	232	136	60	69	54	75	29	96	163	336
Pekurun	70	Lampung Utara	261	351	306	107	93	110	280	131	139	67	226	386
Daya Murni	25	Tulang Bawang	278	150	178	148	67	159	96	52	87	140	142	220
Gedung Ratu	12	Tulang Bawang	394	138	52	166	112	51	74	77	112	91	221	302
Menggala	15	Tulang Bawang	224	221	271	270	94	131	125	64	87	224	359	350
Purwajaya Unit I Mesuji	30	Tulang Bawang	490	284	69	114	105	64	172	89	66	82	365	275
Sidoharjo Gedung Aji Mesuji	9	Tulang Bawang	224	84	109	167	133	103	132	99	44	235	387	334
Air Itam	806	Lampung Barat	185	169	189	327	166	125	132	124	76	164	315	259
Bungin	810	Lampung Barat	63	505	192	518	164	244	185	62	254	391	416	340
Dusun Kenali	820	Lampung Barat	151	137	101	232	180	248	61	87	75	130	362	222
Gedung Cahya Kuningan	12	Lampung Barat	391	426	420	363	369	481	126	181	96	412	419	324
Kebun Tebu/Purajaya	825	Lampung Barat	93	132	243	124	162	157	176	36	365	272	390	254
Rawa Bebek	812	Lampung Barat	228	85	422	486	146	109	73	182	162	253	295	248
Sekincau	1000	Lampung Barat	193	186	107	306	273	379	178	244	88	188	432	266
Reno Basuki-Rumbia/Riksobinangun	20	Lampung Timur	356	107	433	259	279	263	95	66	144	117	228	321
Sukadana	23	Lampung Timur	457	262	493	175	182	369	132	72	48	289	522	272
Way Jepara	22	Lampung Timur	364	239	300	196	60	291	293	61	42	97	181	227
Baradatu	120	Way Kanan	178	362	168	302	112	51	62	62	44	132	177	271
Blambangan Umpu	110	Way Kanan	659	363	65	115	109	76	69	58	86	113	123	340
Tahmi Lumut	275	Way Kanan	734	128	253	408	143	247	184	50	93	106	532	113

Source: Dinas Pengairan PU. Propinsi Lampung.

Appendix 5.2A Rice area affected by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
1	Anjing tanah	0	0	0	39	0	0	0	0
2	Babi	0	65	23	80	0	125	26	155
3	Belalang	94	3	80	2,962	4,960	397	296	220
4	Bercak daun coklat	0	0	0	0	0	0	254	195
5	Blast	0	0	0	0	724	354	23	513
6	Burung	8	45	63	288	80	79	349	319
7	Busuk pelepah	0	0	0	0	0	21	0	0
8	Cercospora oryzae	49	157	177	182	294	346	203	396
9	Gajah	17	7	0	7	213	29	0	37
10	Ganjur	103	138	29	31	66	70	28	25
11	Hama putih palsu	1,587	3,434	2,372	4,474	2,528	4,093	2,598	3,550
12	Helminthosporium oryzae	75	146	304	845	318	506	0	0
13	Hispa	34	13	0	0	0	0	0	0
14	Keong mas	0	79	177	67	672	700	372	240
15	Kepik hjau	0	0	0	0	0	5	0	0
16	Kepinding tanah	16	13	14	18	471	604	276	85
17	Lalat hydrellia	232	1,314	851	2,203	847	2,649	749	1,635
18	Orong-orong	1	0	0	0	5	176	6	8
19	Parnara	5	0	5	0	0	0	0	0
20	Penggerek batang	886	829	948	1,217	2,987	1,914	2,148	1,526
21	Pilopidas	0	0	0	0	0	0	0	7
22	Pyricularia oryzae	469	1,219	938	2,207	0	0	93	0
23	Rhizoctonia oryzae	1,223	2,048	835	1,293	1,803	2243	753	690
24	Rhizoctonia solani	0	0	0	0	0	0	0	0
25	Siput murbei	392	0	0	0	0	0	0	0
26	Thrips	9	278	1	67	1	65	0	35
27	Tikus	5,041	1,725	2,661	676	4903	8,664	7,341	3,484
28	Tungro	27	3	24	234	485	132	765	504
29	Ulat daun	0	0	21	191	2	3	19	10
30	Ulat grayak	173	289	228	803	204	510	625	377
31	Ulat jengkal	0	0	0	5	0	0	0	0
32	Ulat tanah	0	0	0	12	0	0	0	0
33	Ulat tanduk	0	0	0	0	0	0	0	19
34	Uret	0	0	0	8	0	15	0	0
35	Walang sangit	947	949	941	659	1,881	1,906	1,739	1,272
36	Wereng coklat	38	2	23	859	1,776	149	165	116
37	Wereng hijau	0	0	0	0	0	1	0	0
38	Xanthomonas oryzae	38	398	251	78	324	797	287	340
	Total	11,464	13,154	10,966	19,505	25,544	26,562	19,114	15,758

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.2B Rice area completely damaged by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
1	Anjing tanah	0	0	0	0	0	0	0	0
2	Babi	0	0	0	0	0	0	0	0
3	Belalang	0	0	0	2	458	274	67	35
4	Bercak daun coklat	0	0	0	0	0	0	0	0
5	Blast	0	0	0	0	0	1	0	0
6	Burung	0	0	0	0	0	0	0	0
7	Busuk pelepah	0	0	0	0	0	0	0	0
8	Cercospora oryzae	0	0	0	0	0	0	0	0
9	Gajah	17	7	0	0	60	15	7	38
10	Ganjur	0	0	0	0	0	0	0	0
11	Hama putih palsu	0	0	0	0	0	0	0	0
12	Helminthosporium oryzae	0	0	0	0	0	0	0	0
13	Hispa	0	0	0	0	0	0	0	0
14	Keong mas	0	0	0	0	2	0	0	1
15	Kepik hjau	0	0	0	0	0	0	0	0
16	Kepinding tanah	0	0	0	0	16	0	0	0
17	Lalat hydrellia	0	0	0	0	0	0	0	0
18	Orong-orong	0	0	0	0	0	2	0	0
19	Parnara	0	0	0	0	0	0	0	0
20	Penggerek batang	0	0	0	0	22	1	0	0
21	Pilopidas	0	0	0	0	0	0	0	0
22	Pyricularia oryzae	0	77	0	9	0	0	6	0
23	Rhizoctonia oryzae	0	0	0	0	0	0	0	0
24	Rhizoctonia solani	0	0	0	0	0	0	0	0
25	Siput murbei	0	0	0	0	0	0	0	0
26	Thrips	0	0	0	0	0	0	0	0
27	Tikus	335	1	7	0	789	496	1,705	232
28	Tungro	0	0	10	0	201	0	169	0
29	Ulat daun	0	0	0	0	0	0	0	0
30	Ulat grayak	2	0	0	0	0	0	0	0
31	Ulat jengkal	0	0	0	0	0	0	0	0
32	Ulat tanah	0	0	0	0	0	0	0	0
33	Ulat tanduk	0	0	0	0	0	0	0	0
34	Uret	0	0	0	0	0	0	0	0
35	Walang sangit	0	0	0	0	16	0	0	0
36	Wereng coklat	0	0	0	2	31	0	3	0
37	Wereng hijau	0	0	0	0	0	0	0	0
38	Xanthomonas oryzae	0	0	0	0	0	0	0	0
Total		354	85	17	13	1,595	789	1,957	306

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.3A Maize area affected by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	**Wet 1996/97**	**Dry 1997**	**Wet 1997/98**	**Dry 1998**	**Wet 1998/99**	**Dry 1999**	**Wet 1999/00**
1	Aphis	0	250	0	0	0	16	0	0
2	Babi	16	0	0	0	0	62	17	0
3	Belalang	118	257	29	2,568	8,270	654	1,594	1,137
4	Bercak daun	0	94	6	0	0	241	0	0
5	Bulai	50	11,111	989	0	27	5,798	123	419
6	Busuk akar	0	0	0	0	0	3	0	0
7	Busuk batang	0	0	0	0	0	12	11	0
8	Busuk tongkol	0	0	23	12	0	2	0	3
9	Cercospora	0	0	0	0	0	0	135	22
10	Gajah	6	0	0	0	46	184	54	35
11	Hawar daun	0	44	19	0	0	0	0	0
12	Hawar pelepah	0	1,476	1,072	3,574	781	3,288	793	1,514
13	Helminthosporium	0	0	0	23	14	0	4	0
14	Jamur upas	0	0	7	0	0	15	0	0
15	Karat daun	28	73	45	113	330	368	366	174
16	Kumbang tanah kuning	0	9	17	1	0	0	0	0
17	Kutu daun	0	0	0	81	0	0	0	16
18	Lalat bibit	70	174	58	100	24	68	2	110
19	Penggerek batang	69	98	13	26	40	53	65	11
20	Penggerek tongkol	43	332	8	2437	117	95	98	9
21	Rhizoctonia	851	0	0	0	0	0	0	0
22	Tikus	1,474	146	424	13	473	2,792	2,475	131
23	Ulat daun	0	9	0	31	65	25	24	82
24	Ulat grayak	9	162	16	324	186	170	90	87
25	Ulat jengkal	0	0	0	0	7	7	2	0
26	Ulat tanah	6	4	0	3	0	0	13	0
27	Valanga	0	0	0	0	0	0	4	0
28	Wereng	0	15	248	45	0	0	0	0
Total		2740	14,255	2,974	9,351	10,380	13,853	5,870	3,750

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.3B Maize area completely damaged by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
1	Aphis	0	0	0	0	0	0	0	0
2	Babi	0	0	0	0	0	0	0	0
3	Belalang	8	45	0	532	2,658	305	486	443
4	Bercak daun	0	0	0	0	0	0	0	0
5	Bulai	0	1,447	10	0	0	248	0	4
6	Busuk akar	0	0	0	0	0	0	0	0
7	Busuk batang	0	0	0	0	0	0	0	0
8	Busuk tongkol	0	0	0	0	0	0	0	0
9	Cercospora	0	0	0	0	0	0	0	0
10	Gajah	0	0	0	0	46	81	54	10
11	Hawar daun	0	0	0	0	0	0	0	0
12	Hawar pelepah	0	0	0	0	0	0	0	0
13	Helminthosporium	0	0	0	0	0	0	0	0
14	Jamur upas	0	0	0	0	0	0	0	0
15	Karat daun	0	0	0	0	0	0	0	0
16	Kumbang tanah kuning	0	0	0	0	0	0	0	0
17	Kutu daun	0	0	0	0	0	0	0	0
18	Lalat bibit	0	0	0	0	0	0	0	0
19	Penggerek batang	0	0	0	0	0	0	0	0
20	Penggerek tongkol	0	0	0	0	0	0	0	0
21	Rhizoctonia	0	0	0	0	0	0	0	0
22	Tikus	42	0	2	0	15	134	246	0
23	Ulat daun	0	0	0	0	0	0	0	0
24	Ulat grayak	0	0	0	0	0	0	0	0
25	Ulat jengkal	0	0	0	0	0	0	0	0
26	Ulat tanah	0	0	0	0	0	0	0	0
27	Valanga	0	0	0	0	0	0	0	0
28	Wereng	0	0	0	0	0	0	0	0
	Total	50	1492	12	532	2719	768	786	457

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.4A Soybean area affected by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	**Wet 1996/97**	**Dry 1997**	**Wet 1997/98**	**Dry 1998**	**Wet 1998/99**	**Dry 1999**	**Wet 1999/00**
1	Aphis	39	186	92	0	56	88	0	0
2	Belalang	9	13	23	90	112	0	10	10
3	Gajah	0	0	0	0	50	0	0	0
4	Hawar	0	0	0	4	11	45	34	0
5	Helminthosporium	0	0	0	0	0	0	0	0
6	Karat daun	0	0	0	0	15	4	15	0
7	Kepik hijau	11	2	3	14	32	15	7	0
8	Kumbang daun	0	0	22	48	33	136	3	10
9	Kumbang tanah kuning	0	8	8	14	11	52	17	3
10	Kutu daun	0	0	0	90	0	2	68	14
11	Lalat bibit	0	0	0	0	0	0	75	0
12	Lalat kacang	13	76	19	25	43	41	110	5
13	Penggerek batang	0	3	94	0	0	38	30	2
14	Penggerek polong	46	81	0	85	124	38	155	41
15	Penggerek pucuk	4	2	8	0	2	0	3	0
16	Penggulung daun	85	132	152	166	185	193	339	58
17	Pengisap polong	2	1	10	23	57	42	27	4
18	Rhizoctonia	0	0	36	0	0	0	0	0
19	Rispo	1	0	0	0	0	0	0	0
20	Tikus	30	2	2	0	54	84	72	0
21	Ulat buah	6	14	24	396	16	38	32	23
22	Ulat daun	0	61	0	0	22	0	3	4
23	Ulat grayak	127	0	62	242	70	75	146	98
24	Ulat jengkal	97	160	80	325	144	115	192	21
25	Virus mozaik	0	0	0	1	37	20	10	0
Total		470	741	635	1523	1074	1026	1348	293

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.4B Soybean area completely damaged by pest in Lampung, dry season 1996 - wet season 1999/2000

No.	Pest	Season							
		Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
1	Aphis	0	0	0	0	0	0	0	0
2	Belalang	0	0	0	0	2	0	1	0
3	Gajah	0	0	0	0	50	0	0	0
4	Hawar	0	0	0	0	0	0	0	0
5	Helminthosporium	0	0	0	0	0	0	0	0
6	Karat daun	0	0	0	0	0	0	0	0
7	Kepik hijau	0	0	0	0	0	0	0	0
8	Kumbang daun	0	0	0	0	0	0	0	0
9	Kumbang tanah kuning	0	0	0	0	0	0	0	0
10	Kutu daun	0	0	0	0	0	0	0	0
11	Lalat bibit	0	0	0	0	0	0	0	0
12	Lalat kacang	0	0	0	0	0	0	0	0
13	Penggerek batang	0	0	0	0	0	0	0	0
14	Penggerek polong	0	0	0	0	1	0	0	0
15	Penggerek pucuk	0	0	0	0	0	0	0	0
16	Penggulung daun	0	0	0	0	0	0	0	0
17	Pengisap polong	0	0	0	0	0	0	0	0
18	Rhizoctonia	0	0	0	0	0	0	0	0
19	Rispo	0	0	0	0	0	0	0	0
20	Tikus	0	0	0	0	0	4	0	0
21	Ulat buah	0	0	0	0	0	0	0	0
22	Ulat daun	0	0	0	0	0	0	0	0
23	Ulat grayak	0	0	0	0	0	0	0	0
24	Ulat jengkal	0	0	0	25	0	0	0	0
25	Virus mozaik	0	0	0	0	0	0	0	0
Total		0	0	0	25	53	4	1	0

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.

Appendix 5.5A Rice area affected by pest in Lampung Tengah by season

Pest	Pest category	Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
Bercak coklat	Mn	0	0	0	0	0	62	65	65
Blast	Mn	0	0	0	0	452	80	0	293
Burung	Mn	0	0	20	100	0	0	0	0
Cercospora oryzae	Mn	0	0	0	0	0	0	0	67
Gajah	Mn	17	7	0	7	37	29	0	0
Ganjur	Mn	71	15	5	0	53	40	9	5
Helminthosporium	Mn	0	0	0	407	68	0	0	0
Keong mas	Mn	188	7	119	33	205	320	85	29
Thrips	Mn	0	260	0	66	0	62	0	15
Ulat grayak	Mn	90	14	0	438	15	11	41	50
Wereng coklat	Mn	34	0	23	323	890	79	126	72
Belalang	Mj	0	0	16	1,857	1,596	0	21	43
Hama putih palsu	Mj	1,015	1,715	1,096	2,101	873	2,062	614	1,415
Lalat hydrella	Mj	61	927	360	803	212	1,876	299	1,072
Penggerek batang	Mj	642	281	452	481	1,482	481	560	179
Pyricularia oryzae	Mj	380	1,056	842	1671	0	0	30	0
Rhizoctonia oryzae	Mj	1,133	1,712	792	1,219	1,454	0	518	667
Tikus	Mj	3,025	817	1,697	323	2,449	3,542	3,110	996
Walang sangit	Mj	716	432	564	256	905	740	421	80
Major pest (Mj)		6,972	6,940	5,819	8,711	8,971	8,701	5,573	4452
Minor pest (Mn)		400	303	167	1,374	1,720	683	326	596
Total		7,372	7,243	5,986	10,085	10,691	9,384	5,899	5,048

Note:
(1) Major pest: if proportion of area affected (in per cent) is higher than 100/number of pests.
(2) Wet 1996/97: wet season 1997 (October 1996 to March 1997).
(3) Dry 1997: dry season 1997 (April 1997 to September 1997).

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/00.

Appendix 5.5B Maize area affected by pest in Lampung Tengah by season

Pest	Pest category	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99	Dry 1999	Wet 1999/00
Aphis	Mn	0	0	0	0	16	0	0
Bercak daun	Mn	66	0	0	0	2	0	0
Busuk batang	Mn	0	0	0	0	2	11	0
Busuk tongkol	Mn	0	23	12	0	0	0	3
Cercospora	Mn	0	0	0	0	0	132	22
Gajah	Mn	0	0	0	21	184	0	0
Helminthosporium	Mn	0	0	0	0	0	4	0
Lalat bibit	Mn	91	40	28	18	26	0	61
Penggerek batang	Mn	97	13	2	32	15	0	0
Ulat daun	Mn	9	0	0	18	6	0	0
Ulat grayak	Mn	95	0	274	6	14	10	74
Wereng	Mn	15	0	0	0	0	0	0
Belalang	Mj	64	10	2,688	2,219	5	173	142
Bulai	Mj	6,066	922	0	13	4,482	0	129
Hawar daun	Mj	1,395	997	3,273	754	2,961	692	1,442
Penggerek tongkol	Mj	267	8	2,115	49	22	16	5
Tikus	Mj	128	131	13	363	2,217	671	64
Major pest (Mj)		7,920	2,068	8,089	3,398	9,687	1,552	1,782
Minor pest (Mn)		373	76	316	95	265	157	160
Total		8,293	2,144	8,405	3,493	9,952	1,709	1,942

Note:
(1) Major pest: if proportion of area affected (in per cent) is higher than 100/number of pests.
(2) Wet 1996/97: wet season 1997 (October 1996 to March 1997).
(3) Dry 1997: dry season 1997 (April 1997 to September 1997).

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996/97 - musim tanam 1999/00.

Appendix 5.5C Soybean area affected by pest in Lampung Tengah by season

Pest	Pest category	Dry 1996	Wet 1996/97	Dry 1997	Wet 1997/98	Dry 1998	Wet 1998/99
Belalang	Mn	0	13	7	90	21	0
Hawar	Mn	6	0	0	0	11	27
Kepik	Mn	11	0	3	0	0	14
Kumbang daun	Mn	0	0	4	0	6	27
Kumbang tanah kuning	Mn	0	0	0	1	1	0
Kutu daun	Mn	0	0	0	0	0	26
Lalat kacang	Mn	17	31	14	10	20	30
Penggerek batang	Mn	0	3	0	0	0	38
Pengisap polong	Mn	2	0	0	0	25	4
Rhizoctonia	Mn	0	0	36	4	0	0
Tikus	Mn	30	2	2	0	25	84
Ulat buah	Mn	0	10	24	100	5	4
Virus	Mn	0	0	0	0	0	15
Aphis	Mj	34	141	92	2	26	0
Penggerek polong	Mj	41	54	86	37	53	12
Penggulung daun	Mj	53	80	124	142	111	112
Ulat grayak	Mj	102	41	43	134	55	57
Ulat jengkal	Mj	89	125	67	135	56	32
Major pest (Mj)		319	441	412	450	301	213
Minor pest (Mn)		66	59	90	205	114	269
Total		385	500	502	655	415	482

Note:
(1) Major pest: if proportion of area affected (in per cent) is higher than 100/number of pests.
(2) Wet 1996/1997: wet season 1997 (October 1996 to March 1997).
(3) Dry 1997: dry season 1997 (April 1997 to September 1997).

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1998/99.

Appendix 5.6 Area affected by locust and rat of rice, maize and soybean cultivations in Lampung Tengah, April 1996 - March 2000

Year	Month	Locust (ha)			Rat (ha)		
		Rice	Maize	Soybean	Rice	Maize	Soybean
1996	April	0	n.a	0	229	n.a	0
	May	0	n.a	0	1007	n.a	2
	June	0	n.a	0	1206	n.a	10
	July	0	n.a	0	420	n.a	12
	August	0	n.a	0	109	n.a	1
	September	0	n.a	0	54	n.a	5
	October	0	14	9	33	51	2
	November	0	20	4	26	13	0
	December	0	21	0	118	23	0
1997	January	0	9	0	170	13	0
	Febuary	0	0	0	249	12	0
	March	0	0	0	221	16	0
	April	0	0	0	131	17	0
	May	0	0	0	203	47	0
	June	16	10	0	505	49	2
	July	0	0	0	516	0	0
	August	0	0	0	328	9	0
	September	0	0	7	14	9	0
	October	0	0	0	6	2	0
	November	0	0	0	46	7	0
	December	8	10	10	110	0	0
1998	January	52	81	80	72	0	0
	Febuary	536	1730	0	39	4	0
	March	1261	867	0	50	0	0
	April	580	836	15	28	0	0
	May	740	819	6	27	0	0
	June	252	303	0	246	0	3
	July	24	256	0	909	27	0
	August	0	5	0	1100	23	0
	September	0	0	0	139	313	22
	October	0	4	0	36	786	22
	November	0	1	0	172	248	41
	December	0	0	0	670	268	5
1999	January	0	0	0	735	616	16
	Febuary	0	0	0	1065	236	0
	March	0	0	0	864	63	0
	April	0	0.25	n.a	329	68	n.a
	May	0	0	n.a	711	234	n.a
	June	19	130	n.a	602	136	n.a
	July	2	39	n.a	909	113	n.a
	August	0	4	n.a	397	68	n.a
	September	0	0	n.a	162	52	n.a
	October	0	0	n.a	0	17	n.a
	November	33	119	n.a	0	25	n.a
	December	5	1	n.a	25	17	n.a
2000	January	5	2	n.a	291	5	n.a
	Febuary	0	20	n.a	494	0	n.a
	March	0	0	n.a	186	0	n.a

Note: n.a = data not available.

Source: Balai Proteksi Tanaman Pangan dan Hortikultura, Propinsi Lampung. Laporan Musiman, musim tanam 1996 - musim tanam 1999/2000.