CHAPTER I

AN OVERVIEW OF THE CLIMATE IN VIETNAM

1.1 Geography

Vietnam lies in the eastern part of Indochina, bounded by the South China Sea and the Gulf of Tonkin to the east and by the Truong Son mountain range to the west. Extending between latitudes 8-24^{o}N Vietnam is thus effectively entirely within the tropics. Its coastline stretches over 3,260 kilometres.

There are three distinct topographical regions: northern, central and southern. The northern region is characterized by mountainous or hilly terrain except for the Red River valley and the coastal plain. The major rivers, rising in the mountains to the west, flow through hilly terrain into narrow flood and coastal plains. The transition from mountains with steep slopes to narrow, low-lying plains can lead to rapid flows scouring the dykes and causing widespread destruction. The Red River is the principal river in this region. River systems in the central region are characterized by short streams with steep slopes, the average distance from the mountains to the coast being only 70 km. By contrast, the southern region which consists primarily of the Mekong River delta is an area of low, flat topography where numerous divergent flood channels are found. There are considerable areas of high land, particularly in the central highlands facing the South China Sea and in the northwest. Altitudes of 2,500-3,000 metres are reached in a few places in the mountains to the west.

1.2 Climate

Vietnam has a tropical monsoon type of climate with frequent tropical cyclones affecting the northern and central regions. They also occur in southern areas but less frequently. The seasonal distribution of rainfall is closely related to the monsoons. Rainfall intensity can be high, producing a rapid rate of runoff and serious flooding. Most of Vietnam experiences an annual rainfall of 1,800-2,500 mm, distributed unevenly through the year. Approximately 70 percent of the rainfall occurs during the main rainy season from May to September/October. The uneven distribution of rainfall is one of the main causes of river flooding. For the Mekong River, for example, the discharge during the rainy season is about 20 times greater than in the dry season.

Because of its low coastal topography, Vietnam is exposed to the high winds and storm surges brought by tropical cyclones. Furthermore, the whole country can be affected by the weather conditions over the ocean to the east. The northwest Pacific Ocean is the principal spawning ground for tropical cyclones which often track through the Philippines and then strike the Indochinese mainland through Vietnam.

1.3 The Monsoonal Regime

1.3.1 The Northeast (Winter) Monsoon

The northeast monsoon sets in about October, lasting until March. It brings two main air masses to continental Southeast Asia. The boundary between the dry, polar continental air and the tropical maritime air brought by the northeast trades forms part of the polar front which, in January, is close to 25^{o}N at sea level. The rainfall in Vietnam during the northeast monsoon is associated with disturbances travelling with the monsoon current, or to convergence within the monsoon currents, and is augmented locally by orographic lifting. In some coastal areas, such as Danang, the earlier part of the northeast monsoon gives the wettest months of the year. There, October is the wettest month with more than 500 mm.

Another feature of the northeast monsoon months is that they bring lower temperatures to the northern region. In mountainous areas it may drop as low as 4-5^{o}C, or even fall slightly below freezing. Frost and snow may result. Daily mean temperatures elsewhere in this region in winter may fall to 12-15^{o}C. These low temperatures reduce agricultural production, especially in the winter-spring crop season. If the daily mean temperature remains at these levels for 4-5 days young or just-transplanted paddy suffers injury. Rice productivity is then impaired.

This cooler weather is largely restricted to the northern region and the mountains. In central and southern regions there is no cooler season, the temperatures remaining high throughout the year. Northern parts are also subject to cloudy days and light rain (‘*crachin*’) during the northeast monsoon.

1.3.2 The Southwest (Summer) Monsoon

By May/June the southwest monsoon is well established over Vietnam and will persist until September/October. This is the main rainy season with falls on more than half the days. The heavy rains in May and June result from the convergence of a late season cold front from China and hot and humid southeasterly winds. In July the northeasterly winds have moved north to about 20^{o}N and the convergence of the southeasterly and southwesterly monsoon winds brings heavy rains. Sometimes tropical cyclones or other disturbances with very strong winds impact the northern and north central areas causing severe floods. Climate data show that August is the wettest month in the northern region.

Typically, the southwest monsoon winds also bring rain to the south central highlands to the west of the Truong Son range. After crossing the range the air, having lost its moisture, descends and becomes hot and dry. This brings dry weather to the central coastal area with high temperatures and low humidity. Maximum temperatures may reach 40-42^{o}C. In the central highlands and southern region the rainy season ends in October when the southwest winds weaken.

1.4 Tropical Cyclones[1]

Statistics for the 38 years from 1954 to 1991 (Tables 1.1-1.2) indicate that the only two months in which no tropical cyclones occurred were January and February. They are relatively infrequent in March, April, May and December. The main cyclone season in Vietnam therefore covers the six months from June to November in which 94 percent occurred in the years under review. Of the total of 225 the highest monthly frequency occurred in September and October, each accounting for 48 of that total. The average annual frequency during the 38 months was 5.9. Regionally, the peak occurrence was in the month of August for the north, October for central and November for the southern region. This shift from north to south is a common feature of the behaviour of Northwest Pacific tropical cyclones with their tendency to track northwards during the early part of the typhoon season and then progressively taking more westerly tracks from their point of generation as the season continues. Obviously there are many exceptions to this tendency. A partial explanation of this fact lies in the sea surface temperatures (SSTs) which decrease later in the season. With a threshold SST of approximately 26^{o}C needed for the generation of a typhoon, by September this is only found in those ocean areas further south where the SST remains around 25-28^{o}C throughout the year.

Tables 1.1 and 1.2 show the frequency of tropical cyclones in Vietnam during the years 1954-1991 by period and by region respectively.

A comparison of the above data for the frequency of tropical cyclones affecting Vietnam with statistics (not shown) for submerged rice fields, deaths, and the economic cost of the losses (Bureau of Hydrometeorology, 1980; and UN/DHA, 1994) reveals the linkage between tropical cyclones and natural disasters. The data also indicate that during the two decades of the 1960s and the 1970s there were five years in each of which more than eight tropical cyclones occurred, whereas the decade of the 1980s had only one such year. This suggests that tropical cyclone activity was high during the period 1960-1980, a tendency evident elsewhere in Southeast Asia, including Japan (Ohnishi 1994).

[1] It is important that the term **'typhoon'**, as used in this paper, be understood in its general context as a tropical cyclone. **'Tropical cyclone'** is the generic term for storms which form over tropical oceans from initial convective disturbances known as cloud clusters or mesoscale convective complexes. As they evolve into mature, intense storms they pass through four stages of intensity – (1) tropical depression (maximum wind speed less than 34 kt), (2) tropical storm (34-47 kt), (3) severe tropical storm (48-63 kt), (4) typhoon (greater than 64 kt). In this study the term typhoon is used to represent these storms regardless of their intensity, and to distinguish tropical cyclones from other types of disturbance. Thus **'typhoon season'** indicates the portion of the year in which these storms may occur, even though they are not all of typhoon strength. In the public mind the expression 'typhoon' has much greater impact than 'tropical cyclone'.

Table 1.1 Monthly frequency of tropical cyclones in Vietnam in 1954-1991 (38 years)

Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Aver per year
1954-59	0	0	0	1	1	4	3	9	5	5	2	1	33	5.5
1960-69	0	0	0	0	1	6	8	15	9	9	8	1	65	6.5
1970-79	0	0	0	0	-	6	7	11	10	10	10	4	63	6.3
1980-89	0	0	2	1	1	6	5	5	21	21	5	0	54	5.4
1990-91	0	0	1	0	0	0	1	2	3	3	2	0	10	5.0
TOTAL	0	0	3	2	3	22	24	42	48	48	27	6	225	5.9
Ave. per month	0.00	0.00	0.08	0.05	0.08	0.58	0.63	1.11	1.26	1.26	0.71	0.18	5.92	

Table 1.2 Monthly frequency of tropical cyclones which struck three regions in Vietnam (1954-1991, 38 years)

Regions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Northern	0	0	0	0	0	15	24	28	22	7	1	0	97
Central	0	0	0	1	2	0	0	14	23	35	6	0	81
Southern	0	0	3	1	1	7	0	0	3	6	20	6	47
TOTAL	0	0	3	2	3	22	24	42	48	48	27	6	225

1.5 The Variation of Temperature in Vietnam

In the southern and central regions of Vietnam air temperature remains high around the year. In general, the average daily maximum temperature in these areas is greater than 30^{o}C in every month; average daily minima are in the 20-25^{o}C range. In the north there is a definite cooler season when colder air from China intrudes. Frost and occasional snow only occur on the highest mountains in the north for a few days a year. In the south of Vietnam the lowlands are sheltered from any such outbreaks of colder northerly air and the dry season is warm to hot with much sunshine.

However, the temperature variations in the northern region (above latitude 20°N) are significant during the winter season and can have an appreciable effect on crop growth and quantity. The Red River delta in the northern region is one of the most important rice producing areas in Vietnam. Table 1.3 shows the monthly mean temperature in Hanoi for the six months November to April. The Standard Deviation (SD), representing the temperature fluctuations, is also shown. It may be seen that it is approximately 1°C in the first two and last two months, and 1.2-1.5°C in the other months of the winter-spring season.

Table 1.3 Monthly mean temperature (T) and standard deviation (SD) at Hanoi (°C)

	Months						Season
	Nov	Dec	Jan	Feb	Mar	Apr	
T	21.4	18.2	16.4	17.0	20.2	23.7	20.0
SD	1.05	1.07	1.25	1.46	1.04	0.95	0.69

CHAPTER II

THE EFFECT OF ENSO ON THE CLIMATE OF VIETNAM

2.1 ENSO and the Monsoons

During past El Nino (warm) and La Nina (cold) periods some striking weather events have occurred in Vietnam. In March 1982, during the El Nino precursor phase, heavy rainfall and severe flooding occurred in southern and central areas at a time of year normally part of the dry season. The year 1982 had, altogether, five storms and four tropical depressions whilst the continuing El Nino in 1983 included 7 storms and five tropical depressions. Tropical cyclones are rare in the south of Vietnam during El Nino periods but in November 1997 Typhoon Linda caused heavy loss of life and severe devastation. In the 1998 La Nina the southwest monsoon was replaced by northeasterlies a month earlier than usual, thereby curtailing the rainy season in northern and north central areas. Conversely, in the south and the central highlands the southwest monsoon continued for a month beyond its normal termination. The 1999 rainy season arrived earlier than usual.

2.2 The Impact of ENSO on Rainfall

A study was carried out as a means of determining the impact of ENSO (El Nino Southern Oscillation) on rainfall and stream flow and the consequent effect on rice production. The study covered the years 1970 to 1999 in the following agro-climatic zones:

- (i) Northwest of Bacbo
- (ii) Northeast of Bacbo
- (iii) Central Bacbo
- (iv) the Red River Delta
- (v) North Trung – Bo (Central region - North)
- (vi) South Trung – Bo
- (vii) Trung – Bo Plateau
- (viii) East Nam Bo
- (ix) Mekong Delta

The study revealed that there is a broad pattern of ENSO influences, apparently varying with latitude. For instance in the zones north of 20^{o}N where the terrain consists of mountains and the Red River delta, the frequency of tropical cyclones and rainfall amounts appear to be only marginally influenced by ENSO. Central areas are subject to a more significant impact. In the southern region where tropical cyclones are uncommon during El Nino periods they may, nonetheless, be unusually destructive when they do occur. For the purpose of the study the first four zones (i-iv) above were amalgamated and the following climatic zones were selected in order to examine the different impact of ENSO on each of them.

A. Northern Vietnam – the coastal provinces in the Bac Bo region from Quang Ninh province to Ninh Binh province (north of 20^{o}N)

B. North Central Vietnam – the coastal provinces of the northern Trung Bo region from Thanh Hoa province to Thua Thien Hue province (from 17 - 20^{o}N)

C. South Central Vietnam – the coastal provinces of the southern Trung Bo region from Quang Nam province to Binh Thuang province (from 10.6 - 17^{o}N)

D. Southern Vietnam – the coastal provinces of Nam Bo region (south of 10.6^{o}N)

In the series of tables (2.1-2.5) rainfall, stream flow and crop production for summer and winter-spring plantings are presented for each of the four zones A, B, C and D. A single station is taken to represent each zone and annual rainfall is listed for El Nino years between 1963 and 1997 (to the extent that the data are available). The long-period average annual rainfall is given for comparison. Stream flow is represented by a coefficient of 1 as being the normal annual mean flow. Deviations from this norm are shown, shortfalls being less than 1 and excess flow as more than one. The rice production data show the difference from previous normal years in absolute units (area/hectares; production in metric tonnes); they are given only for El Nino years, no figures being presented for La Nina as significant differences have not been observed.

Table 2.1 El Nino impact in Northern Vietnam (Zone A)
Station*:* ***PHUHO***
Mean Annual rainfall: ***1756.2 mm*** (1963-1997)

El Nino Years	**Annual Rainfall**		**Deviation from normal**				
			Stream	**Summer-Autumn Season**		**Winter-Spring Season**	
	(in mm)	(*Percentage of normal)*	**Flow**	Area *(hectares)*	Production *(Mt. Tonne)*	Area *(hectares)*	Production *(Mt. Tonne)*
1963	1802.2	103	0.95				
1965	1593.1	91	0.98				
1969	1785.3	102	0.99				
1972	1652.9	94	0.99				
1976	1966.2	112					
1982	2035.8	116	1.00	*- 1*	+3	+2	
1987	1610.3	92	0.98	+23	+1	+1	+220
1991	1368.6	78	1.00	+15	+108	+0	+21
1994	1719.3	98	1.02	*- 120*	+8	+2	+40
1997	1693.8	96	1.03	+33	+56	+8	+173

Table 2.2 El Nino impact in North Central Vietnam (Zone B)
Station: ***VINH***
Mean Annual rainfall: ***2156.9 mm*** (1972-1997)

El Nino Years	**Annual Rainfall** (in mm)	(Percentage of normal)	**Deviation from normal** **Stream Flow**	**Summer-Autumn Season** Area (hectares)	Production (Mt. Tonne)	**Winter-Spring Season** Area (hectares)	Production (Mt. Tonne)
1972	1820.2	84	0.40	**Data not available**			
1976	1568.9	73					
1982	2535.6	117	0.47				
1987	1773.5	82	0.73				
1991	2606.5	121	0.84				
1994	2063.6	96	0.72				
1997	1587.2	74	0.80				

Table 2.3 El Nino impact in South Central Vietnam (Zone C)
Station: ***DANANG***
Mean Annual rainfall: ***2067.1 mm***

El Nino Years	**Annual Rainfall** (in mm)	(Percentage of normal)	**Deviation from normal** **Stream Flow**	**Summer-Autumn Season** Area (hectares)	Production (Mt. Tonne)	**Winter-Spring Season** Area (hectares)	Production Mt. Tonne)
1976	1932.1	92	0.57				
1982	1347.8	65	0.14	- 4	+61	- 2	+71
1987	1829.1	88	0.71	- 23	+64	- 2	+155
1991	2013.2	97	0.90	- 4	+56	+1	- 147
1994	2107.5	102	0.76	+7	+35	+2	- 60
1997	2369.3	115	0.95	- 11	+190	- 9	+46

Table 2.4 El Nino impact in Southern Vietnam (Zone D)
Station: ***HOCHIMINH***
Mean Annual rainfall: ***1922.1 mm*** (1963-1997)

El Nino Years	**Annual Rainfall**		*Deviation from normal*				
			Stream Flow	**Summer-Autumn Season**		**Winter-Spring Season**	
	(in mm)	*(Percentage of normal)*		Area *(hectares)*	Production *(Mt. Tonne)*	Area *(hectares)*	Production *(Mt. Tonne)*
1963	2407.2	125					
1965	1801.5	94					
1969	3381.8	176					
1972	1713.1	89					
1982	1853.3	96	1.05	- *17.0*	+525.5	+243	+15
1987	1772.1	92	0.96	- *64.7*		+25	+42
1991	1997.8	104	0.99	+09.0	+136.2	+340	+6
1994	1946.6	101	1.12	- *19.0*	+220.0	+200	+25
1997	1828.3	95	1.14	+48.0	+135.0	+500	+200

Table 2.5 La Nina impact in each of the four Zones A-D

La Nina Years	**Northern**			**North Central**			**South Central**			**Southern**		
	Annual Rainfall		Stream Flow	Annual Rainfall		Stream Flow	Annual Rainfall		Stream Flow	Annual Rainfall		Stream Flow
	In mm	*% of normal*	*Deviation from normal*	*In mm*	*% of normal*	*Deviation from normal*	*in mm*	*% of normal*	*Deviation from normal*	*in mm*	*% of normal*	*Deviation from normal*
1964	1951.6	111	1.00							2064.8		
1970	1798.4	102	1.00	2826.3	131					1661.6		
1971	2635.7	150	1.03	2349.9	109					1598.3		
1973	2163.1	123	1.03	3041.7	141					2178.0		
1975	2350.9	134	1.00	1681.4	78					2145.9		
1988	1266.2	72	0.99	1703.1	79	1.00	1758.7	85	1.00	17981.0		0.98
1995	1408.8	80	1.02	1733.0	80	1.24	2865.1	139	1.52	234.7		0.80
1998	975.4	55		2826.3	131		1275.9	62		1451.3		

Note: Mean annual rainfall at
(1) PHUHO *(Northern)* 1756.2 mm
(2) VINH *(North Central)* 2156.9 mm
(3) DANANG *(South Central)* 2067.1 mm
(4) LEIKU *(Southern)* 2891.2 mm

Some preliminary findings are listed below:

Rainfall

1. Rainfall in the Northern region (Zone A) for 10 El Nino years shows a deficit in six and an above normal amount in four. The lowest amount, in 1991, was 78 percent of normal whilst the highest recorded was 116 percent in 1982. El Nino thus shows no marked effect on Vietnamese rainfall in the area north of the 20^{o}N parallel of latitude.

2. In the North Central area (Zone B) seven El Nino years are listed. Rainfall was below normal in five of them, sometimes substantially. In two of these years, 1976 and 1997, it was respectively only 73 and 74 percent of normal.

3. In South Central Vietnam (Zone C) the rainfall was below normal in four of the six El Nino years examined. Except in 1982 when it was only 65 percent of normal the deficits were small. For four of the six years (whether above or below) it was close to normal. These figures are, therefore, rather inconclusive.

4. Of the nine years compared for Southern Vietnam (Zone D) rainfall exceeded the average in four, being as high as 176 percent in 1969. The deficits in five of the years were mainly less than 10 percent. Here again it is difficult to attribute any great influence to El Nino.

5. The results of this study during La Nina years are very varied. Five out of eight years in Zone A recorded above average rainfall, with a peak 150 percent in 1971 and 134 percent in 1975. However, La Nina years 1988, 1995 and 1998 showed serious deficits, only 72, 80 and 55 percent respectively of normal amounts being recorded.

6. Zones B and C (Central Vietnam) are equally mixed, the years showing above average amounts as high as 141 percent (1973) whilst others are deficient by 20 – 30 percent. In 1998 Zone B was 31 percent above normal, but Zone C registered only 62 percent of normal.

7. Figures for Pleiku in the Southern region are discounted as being unrepresentative. Pleiku is in the Central Highlands (altitude perhaps about 2,000 m ?) where orographic effects could outweigh any La Nina influence.

8. A general comment must be made on the methods used for this attempt to detect ENSO influences on rainfall. Rainfall is subject to large differences over short distances. The use of data from one station as being representative of large geographical areas may not be valid. Some effort to estimate areal rainfall is necessary, or at least to compare the annual average with individual years at a selection of stations in each zone.

Stream flow

1. El Nino years do not show any great variation from normal for Northern Vietnam.
2. For the North and South Central regions stream flow is greatly below normal for all El Nino years. One notes in particular 1982 at Phuho where the coefficient is 0.14 (rainfall 65 percent of normal).
3. Stream flow data are given for only a few years for the Southern region. They appear to be close to normal for the five El Nino years between 1982 and 1997.

Crop production

1. The figures for crop production are incomplete. It is not fully clear, for example in Table 2.1, what the figure of +40 for 1994 represents. In general the figures appear to be positive with the exception of 1991 and 1994 for the South Central region. More information is needed if some idea of possible influence is to be obtained.

2.3 The Relationship between ENSO and Tropical Cyclone Frequency

In 1998 a state-of-the-art review published by the American Meteorological Society examined ENSO influences on tropical cyclone activity. It found a strong relationship between ENSO and longitudinal shifts in regions of cyclone development, the frequency and intensity of storms varying from region to region. In considering the tropical cyclones of the Northwest Pacific researchers have found evidence that these storms tend to northerly tracks during El Nino years and to more westerly tracks during La Nina periods.

The importance of such changes or variations to Vietnam is obvious. The study has therefore looked at the incidence of tropical cyclones and other disturbances under ENSO influences. Table 2.6 and 2.7 indicate the number of such storms during El Nino and La Nina years for northern, central and southern areas of Vietnam.

It will be recalled that examination of the 1954-1991 period (Chapter I) showed an annual average of 5.9 such storms. Table 2.6 covers 14 El Nino years,and gives a countrywide annual average of 5.3 for those years. Table 2.7 shows the average to be 8.3 for the La Nina years.

Table 2.6 Number of tropical cyclones (and other disturbances?) affecting different areas in Vietnam during *El Nino* periods

Year	Northern	Central	Southern	Whole Country
1951	2	3	0	5
1953	3	4	0	7
1957	0	2	0	2
1963	4	2	0	6
1965	4	3	1	8
1969	1	2	0	3
1972	1	5	1	7
1976	0	0	0	0
1982	2	3	0	5
1983	2	6	0	8
1987	1	5	0	6
1991	2	3	0	5
1993	3	5	0	8
1997	1	2	1	4
Average	**1.9**	**3.2**	**0.2**	**5.3**

Table 2.7 Number of tropical cyclones (and other disturbances?) affecting different areas in Vietnam during *La Nina* periods

Year	Northern	Central	Southern	Whole Country
1954	2	4	0	6
1955	3	2	0	5
1964	1	10	0	11
1967	2	4	0	6
1970	1	7	2	10
1971	1	8	0	9
1973	3	6	1	10
1974	2	6	1	9
1975	2	4	0	6
1985	1	6	3	10
1988	3	4	0	7
1996	3	6	1	10
Average	**2.0**	**5.6**	**0.7**	**8.3**

These figures suggest a small reduction in frequency for El Nino and a larger increase for La Nina and that, whether warm or cold events, ENSO will make a difference.

But these differences are not uniform across the country. They may be summarized briefly as hereunder:

Years	**Northern**	**Central**	**Southern**	**Whole Country**
El Nino	1.9	3.2	0.2	5.3
La Nina	2.0	5.6	0.7	8.3

A number of conclusions may be drawn from the study of the influence of ENSO on the frequency of tropical cyclones (and other disturbances?) striking Vietnam:

1. It is seen that for Northern Vietnam the average annual frequency is approximately the same for El Nino and La Nina years.
2. For Central and Southern regions there are significant differences, La Nina years bringing more tropical cyclones (and other disturbances?). This is consonant with the trend, already mentioned, for typhoon tracks to be more northerly during El Nino periods.
3. Care is necessary to distinguish between the frequency of these storms and their intensity. Those occurring during El Nino years, although fewer, may be of higher intensity, thereby causing serious damage and loss of life. It was found that the highest wind speeds observed at coastal stations often occur during these years.
4. During La Nina years there is a 60 percent probability of nine or more tropical cyclones (and other disturbances?) affecting Vietnam. Sometimes several storms will follow each other in quick succession. Torrential rain over a period of days then causes severe floods, such as in 1964, 1970, 1971, 1996 and 1999, especially in the central region.
5. There is some evidence to suggest a possible increase in the number of storms affecting Vietnam not only during La Nina periods but also in succeeding years when La Nina is not immediately followed by an El Nino period.
6. Abnormal variations in frequency not associated with ENSO have been observed. There may be other factors affecting the tropical cyclone regime in Vietnam which are at present unknown. Further investigation of possible causes is needed.

2.4 ENSO Impact on Temperature

The monthly and seasonal (November-April) mean air temperatures in Hanoi were examined for ENSO events to determine whether they cause anomalies. The results of this investigation are shown in Tables 2.8 and 2.9.

Table 2.8 Monthly, seasonal mean anomalies, and standard deviation (SD) of air temperature at Hanoi during *El Nino* periods

Winter-Spring	Months						Season
	Nov	Dec	Jan	Feb	Mar	Apr	
1951-1952	0.3	0.9	0.8	1.3	2.6	1.0	1.2
1953-1954	0.7	0.0	3.2	1.6	- *2.1*	0.6	0.7
1957-1958	1.4	1.7	- *1.1*	- *1.0*	1.3	1.1	0.6
1963-1964	1.4	0.4	0.2	- *2.1*	0.4	1.6	0.3
1965-1966	0.9	- *0.8*	1.5	2.6	0.7	1.6	1.1
1969-1970	- *2.1*	- *0.9*	- *1.5*	2.0	- *2 .2*	- *1.0*	- *1.0*
1972-1973	- *0.5*	0.8	- *0.4*	3.7	2.4	1.3	1.2
1976-1977	- *2.8*	- *0.1*	- *3.4*	- *2.5*	0.5	0.2	- *1.4*
1982-1983	1.4	- *2.4*	- *2.5*	- *0.6*	- *1.5*	0.0	- *0.9*
1986-1987	0.0	1.0	2.6	3.3	2.8	0.3	1.7
1990-1991	1.4	1.5	1.1	2.0	1.3	- *0.3*	1.2
1991-1992	- *0.3*	1.2	- *0.6*	- *0.5*	- *0.4*	0.4	0.0
1993-1994	0.7	- *0.7*	1.4	1.9	- *1.8*	1.6	0.5
1997-1998	2.4	1.0	1.5	2.2	0.5	2.6	1.7
Average	0.35	0.26	0.20	0.99	0.32	0.79	0.49
SD	1.16	0.96	1.56	1.95	1.46	0.97	0.96

Table 2.9 Monthly, seasonal mean anomalies, and standard deviation (SD) of air temperature at Hanoi during *La Nina* periods

Winter-Spring	Months						Season
	Nov	Dec	Jan	Feb	Mar	Apr	
1949-1950	*- 0.9*	0.4	3.0	0.5	0.8	*- 0.4*	0.6
1954-1955	1.7	*- 1.9*	*- 2.1*	1.6	1.2	*- 0.6*	0.0
1955-1956	*- 1.8*	0.8	*- 0.8*	1.2	*- 0.2*	0.5	*-0.1*
1964-1965	*- 0.9*	*- 1.2*	1.3	2.6	*- 0.5*	1.0	0.4
1967-1968	0.1	*- 2.9*	0.8	*- 5.0*	*- 0.5*	*- 2.0*	*- 1.6*
1970-1971	*- 1.3*	*- 0.1*	*- 2.0*	*- 0.4*	*- 0.4*	0.5	*- 0.6*
1973-1974	*- 0.2*	*-1.3*	*- 0.7*	*- 1.4*	*- 2.0*	*- 0.8*	*- 1.1*
1974-1975	0.4	0.2	*- 0.2*	1.4	1.3	0.9	0.7
1975-1976	*- 1.4*	*- 3.0*	*- 0.6*	1.1	*- 0.9*	*- 1.4*	*- 1.0*
1984-1985	1.3	*- 1.0*	*- 2.4*	0.4	*- 2.9*	*- 1.7*	*- 1.1*
1988-1989	*- 0.4*	0.8	*- 1.3*	*- 0.3*	*- 0.3*	0.0	*- 0.3*
1996-1997	1.5	*- 0.2*	2.0	0.0	0.5	0.8	0.8
Average	*- 0.16*	*- 0.78*	*- 0.25*	0.14	*- 0.33*	*- 0.27*	*- 0.28*
SD	0.99	1.15	1.43	1.33	0.96	0.88	0.69

The data appearing in the above table show that the monthly and seasonal mean temperatures (for the winter-spring half of the year) are above normal during El Nino periods. The anomaly is even larger when the El Nino mean is compared to the mean during La Nina years. The difference is particularly marked during the second half of the winter-spring season (from February to April).

It may also be seen that there are considerable variations in the mean air temperature during El Nino years. The highest values are found to be for the seasons of 1951-2, 1953-4, 1965-6, 1972-3, 1986-7, 1990-1 and 1997-8, some of them being the highest on record. Conversely, lower values occurred in the seasons of 1969-70, 1976-7 and 1982-3. The standard deviation reaches its highest value in February. In general, it is close to that for mean values in non-ENSO years for the early and later months of the season but considerably higher in other months.

Table 2.9 shows that the monthly and seasonal mean anomalies of air temperature during La Nina periods vary much less than those for El Nino or normal years. Indeed, it is approximately equal to the mean value in two-thirds of La Nina years but lower for the rest. Amongst the La Nina years listed in Table 2.9 the coldest winter-spring seasons were in 1967-8, 1973-4, 1975-6 and 1984-5.

Fluctuations in Rice Productivity

The analysis has shown that winter-spring mean air-temperatures in Hanoi (northern Vietnam) may vary considerably in El Nino years with warmer years occurring twice as frequently as colder ones. In La Nina years, on the other hand, mean air temperatures varied much less but with a tendency to be below normal.

In recent times the winter-spring crop has become the main crop of the year as it usually more productive with higher yields than given by the summer-autumn crop. Its productivity is mainly sensitive to temperature variations as the irrigation system is efficient. The yield is lower in years with higher than normal air temperatures in the mid-winter period (from December to February) than when mean temperature is below normal.

CHAPTER III

POTENTIAL APPLICATION OF ENSO FORECASTS IN VIETNAM

3.1 Current Status of Forecasting in Vietnam

3.1.1 Short- and Medium-Range Forecasts

It is one of the primary responsibilities of a National Meteorological and Hydrological Service (NMHS) to provide forecasts of future weather events and other information for the public and a variety of users. The forecasts are required to cover a range of time scales from a few hours (nowcasting), through short period forecasts for 2-3 days to extended period forecasts for a week or more. Long-range forecasts or outlooks for a month or a season are of considerable value to many users for reasons of safety, economy and efficient operations.

In Vietnam currently, short-range forecasts achieve an accuracy of 75-80 percent unless the weather is abnormal when difficulties can still reduce the level of accuracy substantially. Advisories and warnings of tropical storms and typhoons are issued 48 and 24 hours in advance respectively. Three to five day forecasts of heavy rain can only be made in quantitative terms – moderate (25 mm per day), heavy (50 mm per day) and very heavy (greater than 100 mm per day). Falls of 400-500 mm per day occasionally occur.

As medium-range forecasts are not quantitative they do not meet the needs of many users, and particularly for agriculture and for disaster preparedness and prevention. Heavy rains may cause the loss of thousands of hectares of winter rice through flooding. Forecasts of the arrival of winter cold fronts in the Red River Delta issued 5-10 days ahead have a probability of 80 percent. But medium-range forecasts do not predict long lasting warm spells in winter.

3.1.2 Long-Range Forecasts

Monthly forecasts of rain and temperature are made in quantitative terms, indicating the expected relationship to the climate normals, i.e. above, approximate to, or below average. But such a forecast is not adequate when, for example, above average rain is forecast and occurs but does not reflect amounts greatly above the expected level. The population is then left to face unexpected floods and danger. Equally important for many users is a knowledge that drought conditions are likely to prevail.

Seasonal forecasts are made for two seasons each year, the rainy season (May to October) and the dry season (November to April). These two seasons are the main crop seasons throughout the country. In northern areas the winter-spring crop season is dependent upon the winter monsoon weather and the summer-autumn crop on the summer monsoon weather. In the south of the country the winter-spring crop depends upon water not temperature, no cold fronts affecting that area. However, this season is also the dry season in the south; long-range forecasts which indicate whether the rainy season is expected to end early or late are therefore of the utmost importance for agricultural production in that area.

It would be very useful for all concerned in agriculture throughout the country to know whether, during the rainy season, any period of drought or rainfall deficit is probable. Unfortunately, the present limitations in the preparation of medium- and long-range forecasts preclude such information from being available.

The impact of this lack of adequately detailed long-range or seasonal forecasts may be illustrated by the catastrophic floods (more than 100-year floods) that affected Central Vietnam in late 1999. The long-range forecast covering the period 1-6 November 1999 predicted moderate-to-heavy rains with 10-day amounts of 100-200 mm, or slightly more in some areas. In fact, in many areas 1,500-2,000 mm of rain fell in the 6-day period. The severe floods that ensued caused massive loss of life and property damage. Just a month later in the first week of December Central Vietnam was again subjected to heavy rains and further severe flooding. On rivers from Binh Dinh Province to Quang Ngai Province flood levels were even higher than early November, surpassing the levels recorded in the historical 1964 floods. Once again the expected rainfall of 100-150 mm was greatly exceeded, amounts of 500-700 mm being recorded at many places whilst totals reached 1,500-1,800 mm in some areas.

These events clearly demonstrate that current long-range forecasts do not meet the user's requirements and are inadequate for effective disaster preparedness and prevention.

3.2 Prospects for the Application of El Nino and La Nina Forecasts

In Vietnam at present the technology and data available are inadequate for the preparation of effective long-range forecasts. Even though El Nino and La Nina have affected Vietnam they appear not to have received the attention they merit. For example, in 1997 and 1998 information and documents from the international media on the effects of El Nino phenomenon were assembled and comparisons made with actual data for other El Nino periods in 1982, 1987, etc. It was not, however, possible to incorporate such material usefully into the long-range forecast.

So far no systematic effort has been made in Vietnam to capitalize on the different weather patterns associated with ENSO when preparing long-range or seasonal forecasts. They should be part of the standard forecast practices and procedures.

Some of the ways in which the potential of ENSO forecasts could usefully be taken into account in the design and preparation of long-range forecasts would be through research into:

(a) rainfall behaviour in central Vietnam
(b) typhoon behaviour in central and southern Vietnam

(c) the influence of temperature on rice production in northern Vietnam during the winter-spring season
(d) water management for rice production in central Vietnam during the winter-spring season

There are, doubtless, many other features requiring study that would promote improvements in the availability and usefulness of long-range and seasonal forecasts in association with ENSO events.

3.2.1 Contingency Crop Planning

There are wide variations in rainfall distribution and amounts resulting from different factors. Amongst these, one may mention the dates of the onset and termination of the monsoons, the frequency of typhoons or other disturbances and the impact of dry spells. Such variations are potentially of use in evolving cropping patterns which can be related to ENSO climate behaviour. Agrometeorological research centres in Vietnam have proposed cropping patterns as part of studies executed under this project. The preliminary design is shown in Tables 3.1-3.5.

Table 3.1 Winter-spring rice crop season in *El Nino* years

Regions	Growing Duration *(days)*	Sowing Date	Flowering Date	Maturity Date
Lai Chau	160	25/XII	6/V	5/VI
Phu Ho	160	20/XII	2/V	3/VI
Bac Giang	160	19/XII	1/V	2/VI
Ha Noi	160	18/XII	30/IV	30/V
Vinh	160	17/XII	29/IV	18/V
Dong Ha	150	12/XII	17/IV	17/V
Nha Trang	135	5/XI	28/II	25/III
Can Tho	110	21/XII	10/III	10/IV
Bac Lieu	110	25/XII	15/III	15/IV

Table 3.2 Winter-spring rice crop season in *La Nina* years

Regions	Sowing Date	Flowering Date	Maturity Date
Lai Chau	5/XII	6/V	4/VI
Phu Ho	10/XII	30/IV	26/V
Bac Giang	9/XII	29/IV	27/V
Ha Noi	11/XII	28/IV	26/V
Vinh	20/XII	28/IV	24/V

Table 3.3 Crop season for early summer rice (summer-autumn) in central coastal provinces avoiding extreme climatic events (typhoons and floods)

Regions	Growing Duration (days)	Sowing Date	Flowering Date	Maturity Date
Dong Hoi	115-120	25/IV	31/VII	24/VIII
Dong Hu	115-120	23/IV	28/VII	21/VIII
Da Nang	100-110	20/IV	10/VII	5/VIII
Nha Trang	100-110	5/IV	20/VI	10/VII

Table 3.4 Crop season for summer rice in the northern provinces (from Ha Tinh Province northwards)

Regions	ENSO Event	Sowing Date	Flowering Date	Maturity Date
Lai Chau	El Nino La Nina	28/V 24/V	13/IX 9/IX	13/X 9/X
Lang Sinh	El Nino La Nina	17/V 20/V	30/IX 2/VIII	27/IX 30/IX
Phu Ho	El Nino La Nina	2/VI 4/VI	18/IX 20/IX	17/X 19/X
Bac Giang	El Nino La Nina	11/VI 12/VI	16/IX 17/IX	14/X 15/X
Ha Noi	El Nino La Nina	8/VI 6/VI	23/IX 21/IX	21/X 19/X
Vinh	El Nino La Nina	1/VI 4/VI	17/IX 20/IX	16/X 19/X

Table 3.5 Crop Seeding of Summer Rice in Rainfed Lands

Regions	Growing Duration (days)	ENSO Event	Sowing Date	Flowering Date	Maturity Date
Western Northern	110-120	El Nino La Nina	23/V 19/V	25/VIII 21VIII	23/IX 19/IX
Eastern Northern	110-120	El Nino La Nina	28/V 30/V	28/VII 23/VIII	28/IX 30/IX
Northern Midland					
Bac Giang	110-120	El Nino La Nina	9/VI 9/VI	10/IX 10/IX	9/X 9/X
Phu Tho		El Nino La Nina	2/VI 4/VI	4/IX 6/IX	2/X 4/X
North Central					
Vinh	100-110	El Nino La Nina	9/VVI 2/VI	31/VIII 24/VIII	29/IX 22/IX
Dong Ha	100-110	El Nino La Nina	15/VI 12/VI	10/IX 6/IX	7/X 3/X
South Central (Nha Trang)	100-110	El Nino La Nina	4/VIII 8/VIII	18/X 22/X	14/XI 18/XI
Mekong Delta (Can Tho)	100-110	El Nino La Nina	22/VI 25/VI	12/IX 15/IX	10/X 13/X
Central Highlands (Tay Nguyen)	100-110	El Nino La Nina	19/VI 23/VI	9/IX 13/I15X	7/X 11/X

3.2.2 The Influence of Air Temperature on Rice Production in the Winter-Spring Season in Northern Vietnam

As previously noted temperature variations have a significant impact upon rice production in northern Vietnam. Time-series data of winter-spring rice productivity for the period from 1976-1998 show a loss of about one tonne per hectare in some El Nino years. A potential loss of about 30 percent could be saved by appropriate use of El Nino forecasts. A change of rice variety or to other thermophilic crops such as carrots, potatoes, etc could, with market support, be of value to farmers in the northern region.

3.2.3 Water Management for Rice Production during the Winter-Spring Season in Central Vietnam

Below normal rainfall as a result of El Nino events causes a reduction in the water available in irrigation systems so that mild to severe drought occurs in some central and upland areas of central and southern Vietnam. The ENSO forecast could be used to manage water resources judiciously in order to prevent water stress at times of critical crop growth during the winter dry season.

Conversely, rainfall associated with La Nina may cause prolonged inundation, thus dislocating crop schedules during the winter season. La Nina forecasts could be used in the management of water resources to avoid disruption of the crop schedule.

3.2.4 ENSO Forecasts and Disaster Management

Typhoons account for about 80 percent of the disasters affecting Vietnam. Considerable interest has been focussed in recent years on tropical cyclone frequency, intensity and tracks during ENSO events in the different parts of the world exposed to these storms. Mention was made earlier in this study of El Nino influence on the tracks of tropical cyclones. For the typhoon area of the Northwest Pacific it has been shown that they tend to more northerly tracks during El Nino periods, whilst the tracks are more westerly under the influence of La Nina.

Possible changes in the frequency and intensity during ENSO events are other matters of critical importance having a direct bearing on the preparations made by countries in their disaster management plans. Determining vulnerability is hampered by the short period over which accurate records are available, making it different to analyse trends or the physical mechanisms responsible. For the time being a degree of caution is needed and hasty interpretation based on inadequate evidence should be avoided.

The need for research programmes over both time and space, as well as into the dynamics involved, is urgent. Only the elucidation of numerous as yet unsolved problems will provide a sound basis on which efficient countermeasures against tropical cyclones can be planned and executed as part of disaster management programmes. In the meanwhile El Nino and La Nina forecasts that are capable of providing broad guidance are available and are valuable indicators of trends probable in some typhoon seasons. This information should be made full use of in all disaster preparations executed prior to the typhoon season.

CHAPTER IV

RECOMMENDATIONS

> ***"** El Nino has taught ……that large-scale variability such as El Nino is not a disaster, anomaly, or cruel twist of fate; it is how Earth works. To mature and live harmoniously in the Earth system, human culture must adapt to Earth's rhythms and use natural variability to its advantage. El Nino is an integral component of the El Nino – Southern Oscillation cycle that determines the character of a large portion of the Pacific Ocean and the meteorological character of much of the world.**"***
>
> (Richard Barber, quoted by Michael Glantz in **'Currents of Change, 1996'**)

4.1 Applied Research Efforts

The above quotation enshrines the main purpose of this chapter. We have already learned a great deal about ENSO; how can we now shape this knowledge so that it is used for the benefit of man? How can its promise be adapted to ensure that it gives us security and promotes economic progress? That is the challenge before us in seeking ways to apply growing climate forecast capabilities to the needs of the user. This chapter attempts to put forward a few pointers to the directions further work could take to reach this objective in Vietnam.

The present gap between the availability of long-range ENSO forecasts and their applications in Vietnam indicates the need for a new and much more concentrated programme of research. Two strategies are suggested to improve understanding of how ENSO impacts on socio-economic systems and to ensure that the full value of long-range ENSO forecasts is derived.

(i) Although a broad pattern of the ENSO impact on climate in Vietnam is discernible there are significant year-to-year variations in, for example, the incidence of typhoons, rainfall amounts and distribution, and temperature, associated with individual El Nino or La Nina events. A detailed investigation of the characteristics of individual events, such as their intensity, duration and spatial extent, as well as more detailed analyses of the regional characteristics of weather parameters, could provide better insight into the relationship between those weather parameters and ENSO. The Philippines and Indonesia have already undertaken considerable research on ENSO and its impact on local weather. There would be an obvious advantage for Vietnam if an institutional mechanism permitting an exchange of experience could be established. It would ensure capacity building of Vietnamese scientists.

(ii) There is a need to conduct research into the ways in which local farmers and other users cope with weather variations under the present institutional arrangements. There may be a need to reorientate climate research and current application strategies. Much work has been done in Australia on the application of ENSO forecasts. Although many features of the Australian climate differ from those in Vietnam, the principles and practice of climate forecast applications based on user needs may still be of value. Exploration of the Australian experience should assist Vietnam.

4.2 An Institutional Framework for Climate Forecast and Applications in Vietnam

Short- and medium-range forecasts are transmitted to user organizations as a standard procedure. Long-range forecasts are also transmitted routinely to users. Because long-range forecasts are probabilistic, based on ENSO forecasts, the end user may have difficulties in using the forecast information.

The absence of an intermediate mechanism which can interpret the ENSO forecast and convert it into locally usable information has proved to be a formidable barrier to the decision making progress at the user's end. The Extreme Climate Events (ECE) project endeavours to address this gap by identifying suitable institutional arrangements for the processing of ENSO forecast products and their conversion into usable information for delivery to end users. Appropriate research institutions should be selected, if a suitable agency already exists, or established to serve in this role as an intermediary. The ultimate recipients of the processed information would then be able to use it in making decisions affecting their future operations. It is further suggested that the intermediary could also undertake analyses of the consequences resulting from this process, taking into account different ENSO scenarios and their potential impact upon homogeneous micro-climatic zones.

4.3 Selection of Climatic Zones with High Sensitivity to ENSO Events

The societal benefits that could be derived from the application of ENSO forecasts is, perhaps, not well enough known at present in Vietnam. This fact may cause delays in setting up the type of mechanisms envisaged, or even engender opposition to them, especially where funding must first be secured. It will therefore be necessary to demonstrate the potential value of these benefits in ways which are convincing.

It is proposed, therefore, that climatic zones with a high sensitivity to ENSO events be selected. This would serve to overcome difficulties which might arise in areas in which the relationship between ENSO indices and local climate variables is not clear. The project should accordingly delimit specific climatic zones which are particularly sensitive to ENSO indices and in which the relationship between those indices and the variability of the local climate can be established. When this spatial selection has been carried out, the project should move on to the temporal selection of periods demanding priority attention. For example, the summer season is more sensitive to ENSO events than the dry (winter) season which is, by and large, protected by assured irrigation systems.

The definition of the climate sensitive zones, seasons and sectors would facilitate analyses of potential impacts and vulnerabilities on finer spatial scales for all sectors under different ENSO scenarios.

It is further recommended that when the proposed selection has been made, a pilot climate application project covering one province in each of the North Central and South Central Zones be taken up. It could later be expanded to cover other ENSO-sensitive provinces.

4.4 Incorporation of ENSO into the Current Long-Range Forecast System

Whilst research programmes aimed at increasing knowledge as recommended under 4.1 above should be undertaken urgently, it is further proposed that the Hydrometeorological Service of Vietnam should, concurrently devise a new strategy for the incorporation of ENSO into the present long-range forecast system. These forecasts should also ensure that the results of applied research are taken into account as they become available.

4.5 Conclusion

In concluding this paper a few remarks of a general nature should be made. The recommendations made in this chapter are phrased in broad, general terms. They might better be described as ideas. Thus they call for very careful consideration before work is done to develop the ideas into a programme that is both practical and productive. Some of the proposals will require the commital of substantial resources in terms of manpower and facilities; others could be implemented more easily.

The check list in the appendix to the document ‘*Understanding Extreme Climate Events in Vietnam*’ (not attached) provides a good starting point for the further development of the project but may require some selective amendment if a realistic programme is to emerge from the May 2000 Workshop.