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PROPOSED AGROCLIMATIC ASSESSMENT MODELS FOR POLICY DECISION MAKING, ECONOMIC PLANNING AND RURAL DEVELOPMENT IN THE PHILIPPINES

Final Report

to

Philippine Atmospheric Geophysical and
Astronomical Services Administration (PAGASA)
Ministry of National Defense
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This project was sponsored by AID and conducted by the U.S. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, Assessment and Information Services Center (Center for Environmental Assessment Services)-Models Branch and University of Missouri-Columbia, Atmospheric Science Department in Columbia, Missouri under NOAA/AID PASA IND-0000-P-CC-1025-02 and UMC account code C-5-30339.

FORWARD

This report by Aida M. Jose, Science Research Supervisor II, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), describes agroclimatic assessment models developed for rainfed agriculture in the Philippines. These models can be used to implement a reliable, timely, yet inexpensive weather-based information system in the Philippines. Weather analysis and climatic impact assessments can help decision makers including managers, agronomists, economists, statisticians, agrometeorologists, and extension officials interpret and anticipate weather impacts on the agricultural sector. Specifically, the system will continuously monitor and assess the impact of weather (drought, flooding, typhoons, high winds, heat stress, etc.) on agriculture. Early warning of potential crop failure due to drought can be provided 30-60 days before crop harvest. This may represent a 3-6 month lead-time to develop strategies for improving food security. Agroclimatic/crop condition assessments can be provided during the crop growing season. These represent additional tools to complement and supplement other information sources used by statisticians to forecast crop production. Soil moisture estimates can be provided to the extension service. These agroclimatic models also offer potential long-term economic benefits related to agricultural planning and rural development, e.g., minimizing climate risk in land and water resource management.

The Bicol and Visayas (East, Central and West) Regions were chosen for this pilot study because weather and climate are major factors that help determine potential crop productivity and year-to-year variations in agricultural production levels. Also, this proposed weather assessment system complements ongoing or planned developmental projects involving rainfed agriculture and secondary food crops. The proposed agroclimatic assessment system is ready to be tested and evaluated. After successful testing, the system can be expanded to include other regions in the Philippines.

This work is the result of an intensive six week Orientation Program on Agroclimatic Models and Climate Impact Assessment Technology. The program was conducted in Columbia, Missouri, through the joint efforts of the NOAA/NESDIS Assessment and Information Services Center (AISC) - Models Branch and the Atmospheric Science Department, University of Missouri - Columbia. The project was sponsored by the Agency for International Development, Office of U.S. Foreign Disaster Assistance (AID/OFDA), Washington, D.C., as part of a NOAA/AID effort to transfer agroclimatic assessment technology to Southeast Asia. Individuals in these agencies making contributions to this study include: Dr. Wayne L. Decker, Dr. Andres C. Ravelo, Dr. Atanas V. Todorov, Ken Wherry, Judy Trujillo, Betty Whitmarsh and Jerry Wright of the University of Missouri - Columbia; Dr. Clarence M. Sakamoto, Rita Terry and Susan Conrad, NOAA/NESDIS/AISC-Models Branch, Columbia Missouri; and Alan Hankins, AID/ASIA/TR, Ron Pollock, US/AID Mission Manila (now located in India) and Paul Krumpe, AID/OFDA.

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CHAPTER I

INTRODUCTION

Agriculture is considered to be the economic lifeblood of the Philippines. About 50 percent of the working population is engaged in agriculture and 70 percent of the foreign exchange earnings result from export of agricultural products. Agriculture in the Philippines is most vulnerable to climate abnormalities such as occurrences of tropical cyclones, torrential rains causing floods, variability in the onset and termination of rainy seasons, drought and other severe weather hazards. Eighty-five percent of rice and corn production losses in the Bicol and Visayas Regions during the past 12 years (1968-1979) are attributed to tropical cyclones, floods and droughts. This does not include the losses due to weather-related incidences of pests and diseases. During the severe 1973 drought in the Visayas, total rice crop damage was estimated at about 61 million pesos. In the following year, 1974, flood damages to rice crop production amounted to about 56 million pesos. It is not uncommon for drought, floods, and tropical cyclone prone areas in the Philippines to experience yearly losses due to such hazards. It should be recognized, therefore, that economic security and even socio-political stability are subject to the effects of climatic variability.

Although many sectors of human activities are vulnerable to climatic variability, there is much that can be done to minimize the risk of climatic impact. If climatic factors are understood by national planners, this resource can be used to improve food security programs and can provide inexpensive input to short and long-term economic plans.

Short-term economic decisions at the national level can benefit by climatic information to avert or mitigate climatic impact. For example, real-time climatic data can be used as one input to forecast agricultural production.

Early warning of potential production shortfalls due to drought can be made a month or two prior to harvest. National level decision makers involved with economic planning, finance, marketing and travel can then develop alternative strategies and contingency plans to mitigate the potential climatic impact.

Short-term management decisions made by farmers can benefit from climate information. For example, weather advisories can provide farmers with recommended planting dates, irrigation scheduling, fertilizer and pesticide application and other field operations. Scarce and inexpensive resources can be more efficiently used according to current and expected climatic conditions.

Long-term economic plans to increase national food security through agricultural development can be improved with climatic information. Agroclimatic studies contribute to agricultural zoning, crop selection, optimum planting and harvest dates and other field operators that lead to increased productivity. Climatic risk can be assessed leading to alternative land management strategies which reduce climatic vulnerability. Such land utilization studies are of direct benefit to the farmer.

The main objective of this study is to provide a groundwork for developing a national program on agroclimatic assessments for policy decision making, economic planning and agricultural development in the Philippines. This study represents a "pilot project" focused on the Bicol and Visayas Regions to demonstrate the value of agroclimatic assessments and begin the process for a national program.

This report documents preliminary agroclimatic models and climatic impact assessment methods which after testing and evaluation can be used by managers to mitigate potential climate impact and reduce climatic vulnerability. Historic climatic data were used to develop three types of agroclimatic models for the Bicol and Visayas Regions of the Philippines. These include: 1) Drought/early

warning indices and agroclimatic/crop condition indices to provide relative crop yield information to support the crop production forecast problem, 2) statistical/crop yield models, and 3) procedures for estimating potential evapotranspiration and soil moisture. These assessment models are based on relationships which reflect the biological (or agronomic) response of the crop to moisture and temperature anomalies during the growing season, particularly during the critical flowering/reproductive crop stages.

Chapter II of this report provides agroclimatic background on the Bicol and Visayas Regions, describing the physical environment and agricultural practices. Chapter III presents the appropriate data bases and agroclimatic methods of analysis used in developing climate/crop index models and their applications in the formation of assessment procedures. Analytic results pertaining to potential evapotranspiration, soil moisture indices and climatic diagrams are discussed in Chapter IV. Results of climatic impact assessment modeling, including agroclimatic/crop conditions for rice and maize, statistical climate/crop yield forecast models for rice and soil moisture assessment procedures, are presented in Chapter V. This chapter also discusses the analytic steps in model development. Assessment procedures are described in Chapter VI. Recommendations for program implementation and future work in the Philippines are presented in Chapter VII; the different phases of implementation, the organizational flow, and the requirements and strategies of the proposed program are discussed.

CHAPTER II

AGROCLIMATIC BACKGROUND IN THE BICOL AND VISAYAS REGIONS

A. Physical Environment

1. Administrative Regions

The Philippines are divided into 12 administrative regions. Bicol and the three Visayas Regions (Eastern, Central and Western Visayas) are situated in the central part of the country (see Figure 2.1). Each region is composed of several provinces (Figure 2.2).

2. Geography and Topography

The Bicol Region includes three major islands; Luzon, Catanduanes and Masbate (Figure 2.2). It has a total land area of 17,592 square kilometers, extending from 11°50'N to 14°50'N and 122°15'E to 124°20'E. Mountain ranges, uplands and lowlands are found in this region (Figure 2.3).

The largest agricultural area is in the basin formed by the Bicol River and its main tributaries, the Sipocot and Libmanan Rivers. The basin contains 312,000 hectares and includes a broad plain bounded by volcanoes in the north and east and low sedimentary hills in the southwest. Forty-one percent of the basin consists of plains with a slope of less than 8°, 30 percent steep terrain with slopes exceeding 30°, 27 percent hilly areas with slopes of 8° - 30°, and 2 percent lakes and rivers. About 10 percent of the plains area is subjected to severe seasonal flooding and 35 percent slight to moderate seasonal flooding. The basin frequently experiences earthquakes of tectonic origin.

The Eastern Visayas Region contains two main islands, Samar and Leyte. It has a total land area of 20,560 square km, extending from 9°50'N to 12°40'N and 124°00'E to 125°50'E. Mountain ranges lie in a north-south direction on Leyte Island, with plains and lowlands in the northeast. Uplands and plateaus occupy most of Samar Island.

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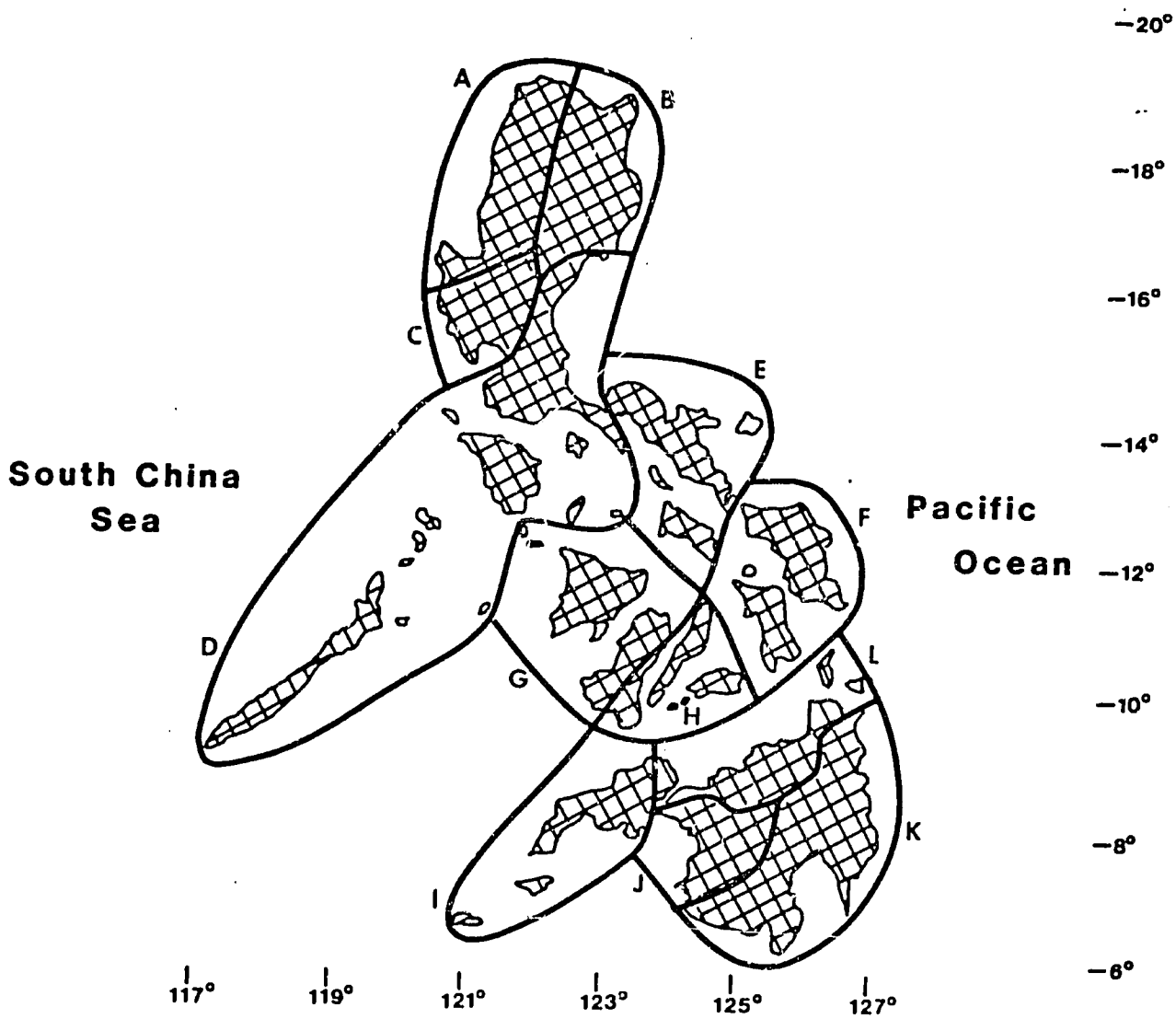
ADMINISTRATIVE REGIONS

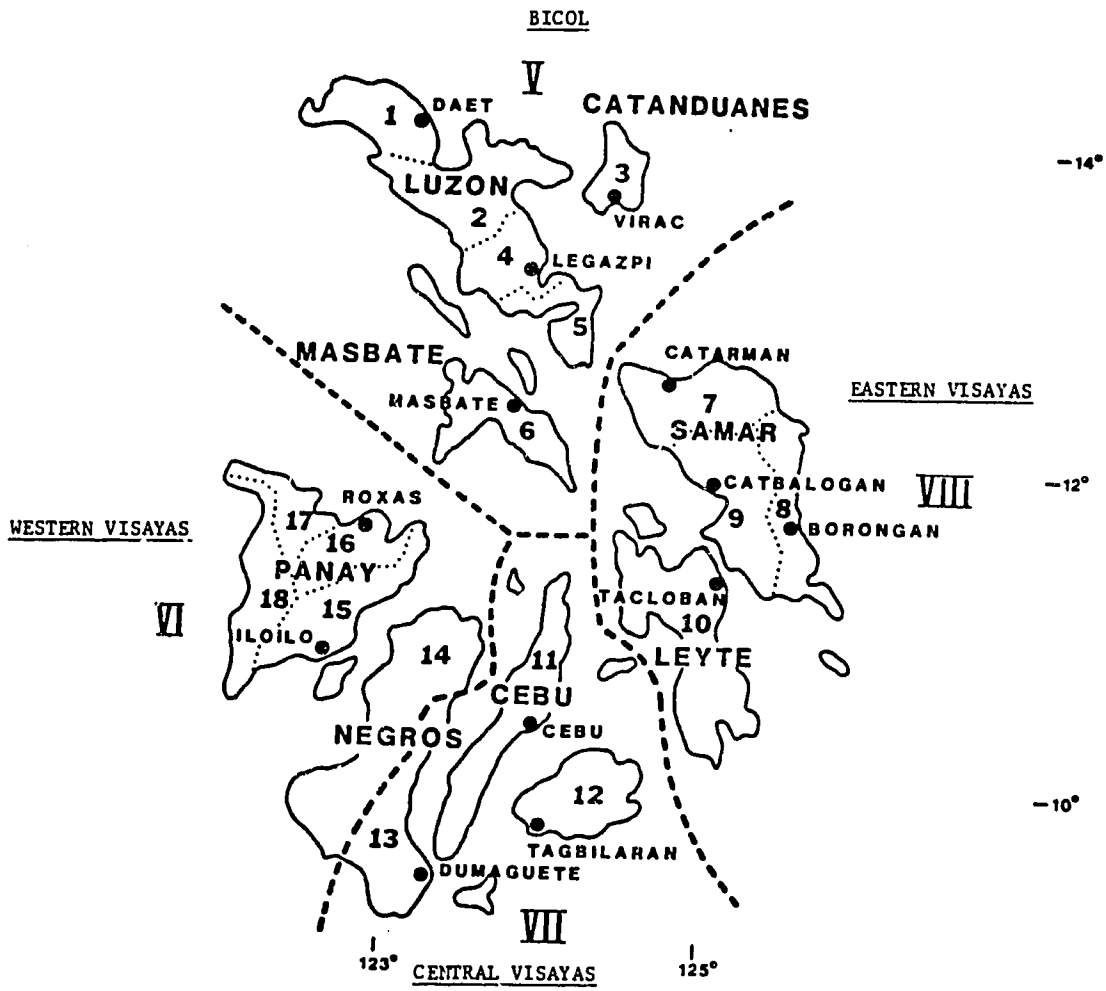


A ILICOS
B CAGAYAN VALLEY
C CENTRAL LUZON
D SOUTHERN TAGALOG
E BICOL
F EASTERN VISAYAS
G WESTERN VISAYAS
H CENTRAL VISAYAS
I WESTERN MINDANAO
J CENTRAL MINDANAO
K SOUTHERN MINDANAO
L NORTHERN MINDANAO

FIGURE 2.1 Administrative Regions in the Philippines.

PHILIPPINES

PROVINCES IN THE BICOL AND VISAYAS REGIONS



1. Camarines Norte	7. Northern Samar	13. Negros Oriental
2. Camarines Sur	8. Eastern Samar	14. Negros Occidental
3. Catanduanes	9. Western Samar	15. Iloilo
4. Albey	10. Leyte	16. Capiz
5. Sorsogon	11. Cebu	17. Aklan
6. Misbate	12. Bohol	18. Antique

FIGURE 2.2 Provinces in the Bicol and Visayas Regions.

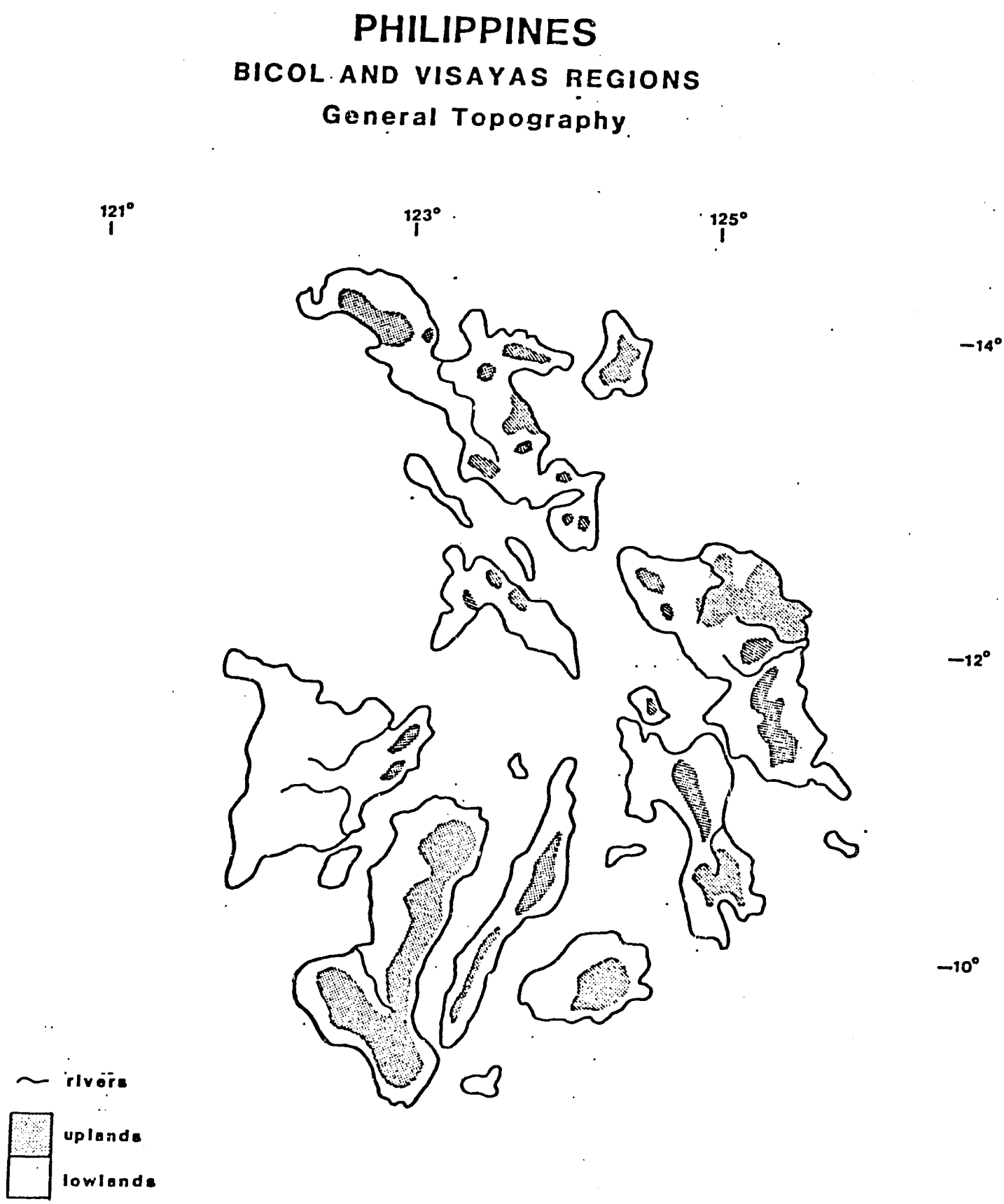


FIGURE 2.3 General Topography According to Uplands and Lowlands with Rivers in the Bicol and Visayas Regions.

The Central Visayas Region is comprised of two main islands, Cebu and Bohol. It has a total land area of 15,950 square km, extending from 9°05'N to 11°15'N and 122°25'E to 124°35'E. Mountain ranges oriented in a north-south direction are found in the western part, and in most of the Negros Oriental. The mountain ranges of Cebu Island run almost in a north-south direction and follow the contour of the island. There are also mountain ranges on the southern part of Bohol. The remaining regions are plains and uplands.

The Western Visayas Region is also comprised of two main islands, Panay and Western Negros. The total land area is about 20,223 square km, extending from 9°N to 12'N and 121°50'E to 123°30'E. Mountain ranges oriented in a north-south direction are found in the western part of Panay Island and also in the eastern part of the Negros Occidental. The remainder of the region contains plains and uplands.

3. Climate

Main Climatic Features

Rainfall in the Bicol Region is abundant as shown by the monthly and annual values in Table 2.1 for the 4 stations representing the area. It is the second wettest region in the Philippines. Rainfall is greatest in October, November and December (Figure 2.4) and the least in April. Masbate has the lowest annual average rainfall, 1,886 mm. The Bicol Region is affected by both the northeast and southwest monsoons.

Of the three Visayas regions, Eastern Visayas has the most abundant mean annual rainfall (Figure 2.5), more than double that of Central Visayas (Figure 2.5) and one-third greater than that of Western Visayas (Figure 2.4). The small amount of rainfall in Central Visayas during both the northeast and southwest monsoons is attributed to its leeward location. There is no pronounced rainy period in the 3 stations of Central Visayas; neither of them has a monthly rainfall in excess of 200 mm. Rainfall in Western Visayas is primarily influenced

Table 2.1 Mean Monthly and Annual Rainfall (mm) in Bicol and Visayas Regions (1951-80)

Region/Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
V. Bicol													
1. Daet	343	194	163	131	148	178	216	246	255	502	607	628	3610
2. Legaspi	324	201	205	168	198	215	246	276	242	311	494	539	3421
3. Virac	223	133	120	123	196	234	218	186	239	400	479	436	2988
4. Masbate	184	83	68	54	107	144	170	186	206	216	221	248	1886
VI. Western Visayas													
1. Iloilo	46	24	29	45	122	258	302	341	262	252	17[illegible]	101	1956
2. Roxas	109	53	70	54	140	259	259	237	238	332	244	188	2182
VII. Central Visayas													
1. Cebu	123	87	89	72	88	119	151	189	190	171	180	166	1625
2. Tagbilaran	111	88	81	66	82	143	124	110	128	177	196	113	1420
3. Dumaguete	81	70	60	39	77	133	144	112	130	169	170	118	1303
VIII. Eastern Visayas													
1. Catarman	414	247	212	158	143	187	198	159	202	369	507	509	3304
2. Borongan	601	419	315	270	326	223	220	216	193	297	587	691	4358
3. Tacloban	230	247	206	187	148	135	138	153	153	161	201	228	2186
4. Catalogan	261	191	209	160	166	140	182	261	234	264	277	295	2640

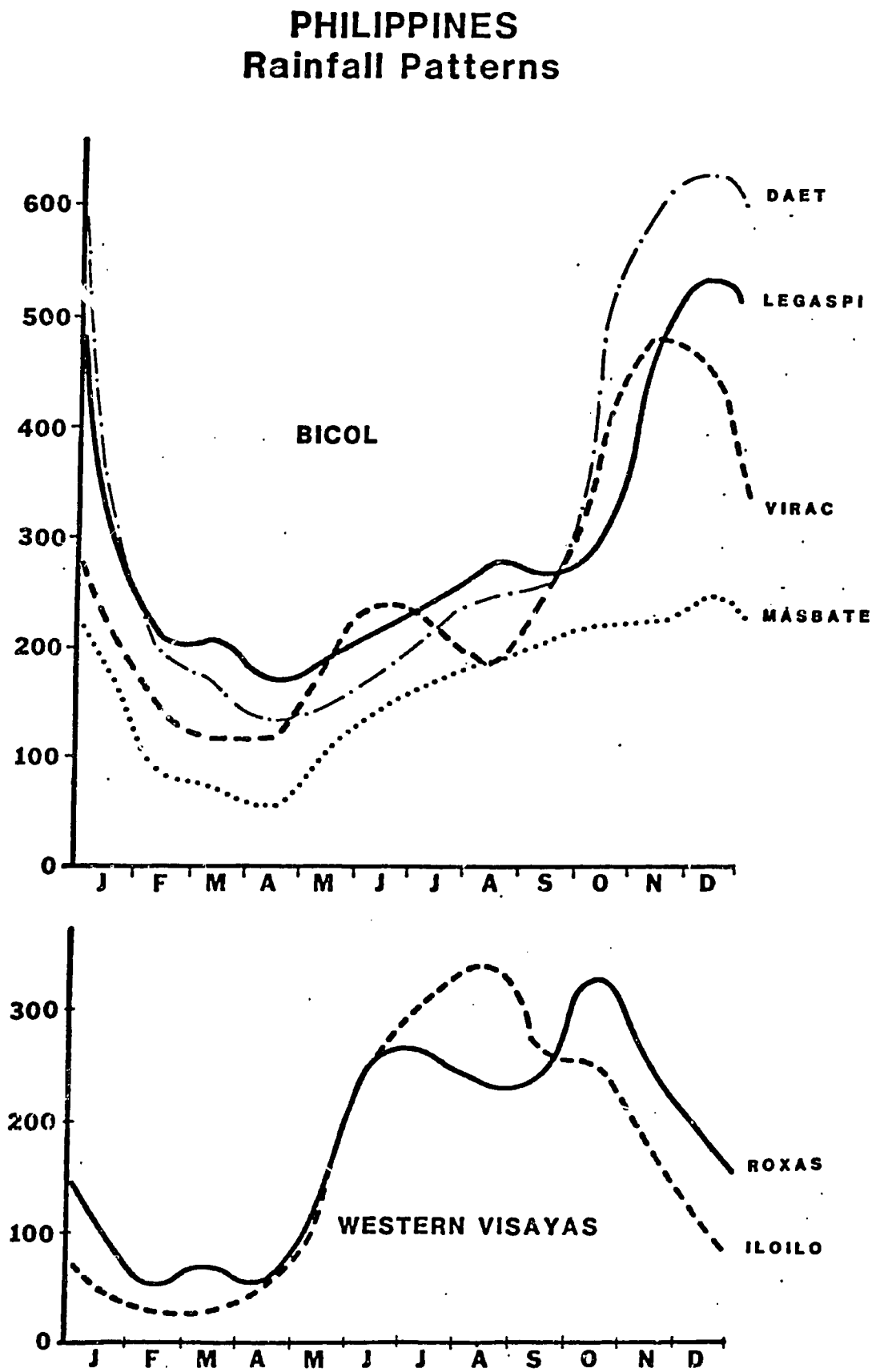


FIGURE 2.4 General Rainfall Patterns for Selected Locations in the Bicol and Western Visayas Regions.

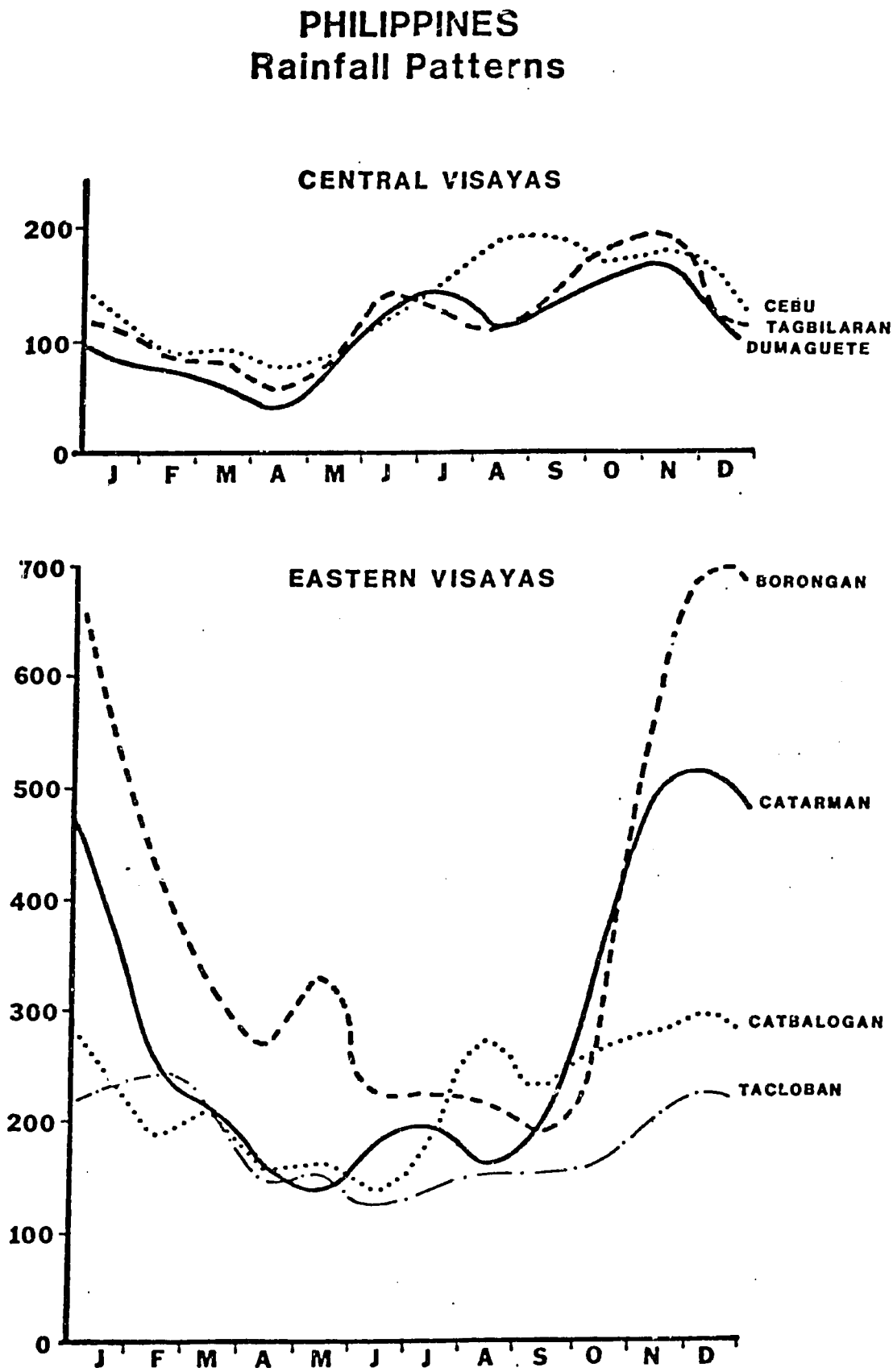


FIGURE 2.5 General Rainfall Patterns for Selected Locations in the Central Visayas and Eastern Visayas Regions.

by the southwest monsoon, hence the main rainy season is from June to October.

The average annual temperature of the 4 Bicol stations is 27.2°C (Table 2.2). The coldest month is January with an average of 25.6° and the warmest is June with 28.4°C, therefore the temperature range is quite small.

Like the Bicol Region, seasonal variations in temperature are quite small in the Visayas regions. In Eastern Visayas, the average temperature range from coldest (February) to warmest (August) is only 2.1°C from 25.8°C to 27.9°C. In Central Visayas the range is even smaller, 1.9°C. In Western Visayas the maximum average temperature is 28.8°C (May) and the minimum 26.1°C (January).

The relative humidity in Bicol Region is high and more or less homogeneous with an annual average of 82 percent. It varies between 80 and 84 percent and usually follows the monthly rainfall pattern (Table 2.3). Eastern Visayas with the largest amount of rainfall, is also the most humid region with an average annual relative humidity of 83 percent. The Central Visayas Region has a mean annual relative humidity of 80 percent, varying from 77 percent in April to 82 percent in October - December. The Western Visayas Region has a slightly lower mean annual relative humidity, or 78 percent; variation is from 74 percent in April to 82 percent in July - December.

Sunshine data are not available. However sunshine has an inverse relationship to cloudiness. Table 2.4 shows that during most of the months in Bicol Region the cloudiness is seven-tenths. Sunshine duration is therefore quite low during most of the year.

Factors Controlling Climate

The climate of the Bicol and Visayas Regions, like that of the Philippines, is controlled by several major factors: semi-permanent lows and anticyclones, prevailing air streams, tropical cyclones, the inter-tropical convergence zone, easterly waves, ocean currents, geographical setting and topography.

Table 2.2 - Mean Monthly and Annual Temperature (°C) in Bicol and Visayas Regions

Regions/Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
V. Bicol													
1. Daet	25.2	25.5	26.2	27.3	28.3	28.4	28.0	27.9	27.7	27.1	26.7	25.9	27.0
2. Legaspi	25.3	25.6	26.1	27.1	27.9	28.0	27.6	27.5	27.4	27.0	26.5	25.8	26.8
3. Virac	25.7	25.9	26.4	27.2	27.8	28.1	27.9	28.0	27.8	27.2	27.0	26.3	27.1
4. Masbate	26.3	26.4	27.4	28.6	29.3	29.1	28.6	28.4	28.4	28.1	27.6	26.8	27.9
VI. Western Visayas													
1. Iloilo	25.7	25.9	26.9	28.1	28.5	27.8	27.2	27.1	27.2	27.2	26.9	26.3	27.1
2. Roxas	26.4	26.5	27.2	28.5	29.0	28.5	28.1	28.1	28.1	27.8	27.6	26.9	27.7
VII. Central Visayas													
1. Cebu	26.7	26.7	26.8	27.5	27.9	28.0	28.0	27.8	27.5	27.6	27.4	27.0	27.4
2. Tagbilaran	25.8	25.9	26.5	27.5	28.2	28.0	27.8	28.0	28.0	27.5	27.1	26.7	27.2
3. Dumaguete	26.7	26.7	27.5	28.5	28.8	28.2	27.9	28 0	28.0	27.8	27.7	27.2	27.8
VIII. Eastern Visayas													
1. Catarman	25.1	25.2	25.7	26.5	27.4	27.5	27.4	27.6	27.4	26.8	26.2	25.7	26.5
2. Borongan	25.6	25.7	26.3	27.1	27.7	27.7	27.6	27.8	27.8	27.2	26.7	26.2	27.0
3. Tacloban	26.4	26.2	26.2	26.6	27.1	27.5	27.8	27.9	27.9	27.9	27.5	27.0	27.2
4. Catbalogan	26.5	26.3	26.4	26.9	27.6	28.1	28.3	28.3	28.1	27.9	27.6	26.9	27.4

Table 2.3 Mean Monthly and Annual Relative Humidity (%) in Bicol and Visayas Regions

Regions/Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
V. Bicol													
1. Daet	83	81	80	80	80	80	82	82	84	85	84	85	82
2. Legaspi	84	82	82	82	81	82	83	84	85	84	85	85	83
3. Virac	80	79	78	78	79	80	81	81	82	83	82	82	80
4. Masbate	83	82	80	78	78	80	82	82	83	83	84	85	82
VI. Western Visayas													
1. Iloilo	82	80	76	74	77	82	84	85	84	84	84	84	81
2. Roxas	79	78	77	74	76	79	80	80	80	80	80	80	76
VII. Central Visayas													
1. Cebu	79	78	77	75	75	76	77	79	81	81	81	81	78
2. Tagbilaran	83	82	80	77	79	81	81	80	81	83	84	84	81
3. Dumaguete	80	79	78	78	79	80	81	81	82	83	82	82	80
VIII. Eastern Visayas													
1. Catarman	86	85	84	83	83	84	83	82	83	86	87	88	84
2. Borongan	85	85	83	83	83	83	82	81	82	84	85	86	84
3. Tacloban	84	84	82	82	80	80	81	80	80	80	82	83	82
4. Catbalogan	82	82	81	80	78	78	79	80	80	81	82	83	81

Table 2.4 Mean Monthly and Annual Cloudiness (in tenths) in Bicol and Visayas Regions

Regions/Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
V. Bicol													
1. Daet	7	6	5	4	5	6	7	7	7	7	7	7	6
2. Legaspi	7	7	6	6	6	7	8	8	8	7	7	8	7
3. Virac	7	7	6	5	6	7	7	7	7	7	7	7	7
4. Masbate	7	6	6	5	6	7	8	8	8	7	7	7	7
VI. Western Visayas													
1. Iloilo	6	6	5	5	6	8	8	8	8	7	7	6	7
2. Roxas	6	6	5	4	5	7	7	7	7	7	6	7	6
VII. Central Visayas													
1. Cebu	7	7	6	7	7	7	7	8	8	8	7	8	7
2. Tagbilaran	7	7	6	5	7	8	8	8	8	8	7	7	7
3. Dumaguete	7	6	6	5	6	7	7	7	7	7	7	7	7
VIII. Eastern Visayas													
1. Catarman	6	6	5	4	4	6	6	7	7	6	6	6	5
2. Borongan	7	7	7	7	6	7	7	8	7	7	8	8	7
3. Tacloban	7	7	6	6	6	6	6	7	7	7	7	6	7
4. Catbalogan	6	6	6	6	5	6	6	7	7	7	7	7	6

During the winter and summer months semi-permanent cyclonic and anticyclonic pressure systems located south and north of the Philippines produce air streams and ocean currents which affect the climate of the Philippines. The three most important air streams affecting the area are: the northeast monsoon which prevails from October to March, the southwest monsoon from late May to early October, and the north Pacific trades generally dominant during April and early May.

Tropical cyclones contribute about 50 percent of the Philippine rainfall. A review of tropical cyclones from 1948 to 1977 shows the average annual frequency of 19.3 for tropical cyclones passing over the Philippines area of responsibility (Table 2.5). The number of occurrences is highly variable, ranging from 12 (1973) to 30 (1964). The tropical cyclone season is from June to December with a maximum in July, August and September; 45 percent occur in September, October and November (Table 2.6). According to the frequency of passage of the tropical cyclones, the Philippines have been divided into 12 zones (Figure 2.6). The frequency of passage at the different zones is shown in Table 2.7. Eastern Visayas appears to be most vulnerable; about 10-15 percent of all the tropical cyclones that cross the Philippine land area pass through this region. The other three regions are affected by 5-10 percent of all cyclones.

The climate of the Bicol and Visayas Regions are also influenced by the Intertropical Convergence Zone (ITCZ) and easterly waves. The ITCZ affects the area mainly during May, June and October. It is usually characterized by widespread cloudiness, precipitation and moderate to strong winds.

Climate Zoning

Several systems of climatic zoning have been adopted in the Philippines. The two most commonly used are the Coronas Classification and a modification to the Thornthwaite Classification by Mohr and Schmidt known also as zoning by the ratio of dry to wet months.

Table 2.5 Frequency of Tropical Cyclones in the Philippine Area of Responsibility From 1948 - 1977 (30 years)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (Annual)
1948	1	0	0	0	1	0	3	1	3	2	6	3	20
1949	1	0	0	0	0	2	5	2	4	3	3	2	22
1950	0	0	0	0	0	2	2	1	3	2	2	1	13
1951	0	0	0	1	0	1	1	4	2	1	1	2	13
1952	0	0	0	0	0	5	2	3	4	4	4	4	26
1953	1	1	0	0	1	2	0	5	2	2	3	2	19
1954	0	0	1	0	1	0	1	6	2	3	3	1	18
1955	1	1	0	1	0	0	2	3	1	4	1	1	15
1956	0	0	1	2	0	0	4	4	5	1	5	3	25
1957	2	0	0	1	0	2	1	2	3	3	1	0	15
1958	1	0	0	0	0	1	4	2	4	2	3	0	17
1959	0	1	1	0	0	0	1	4	2	4	3	2	18
1960	1	0	0	1	1	2	2	6	1	3	0	2	19
1961	1	1	1	0	1	3	4	4	4	1	1	2	23
1962	0	1	0	0	2	0	4	6	4	1	3	0	21
1963	0	0	0	0	1	3	4	2	3	1	0	2	16
1964	0	0	0	0	2	1	9	5	5	3	3	2	30
1965	2	1	1	0	2	2	6	2	3	1	1	0	21
1966	0	0	0	1	3	1	7	1	3	2	2	2	22
1967	0	1	1	1	1	2	4	5	0	2	3	1	21
1968	0	1	0	0	0	2	2	3	3	1	3	0	15
1969	0	0	0	1	1	0	4	2	4	1	2	0	15
1970	0	1	0	0	0	3	2	4	4	4	2	1	21
1971	1	0	1	3	3	2	5	2	3	5	2	0	27
1972	2	0	0	0	0	2	4	2	4	1	1	1	17
1973	0	0	0	0	0	1	2	3	2	3	1	0	12
1974	1	0	0	0	0	3	4	4	2	5	2	2	23
1975	1	0	0	0	0	0	1	3	3	3	2	1	14
1976	1	1	0	1	1	3	3	3	4	0	2	3	22
1977	1	0	0	0	1	1	4	2	4	2	2	2	19
Total	18	10	7	13	22	46	97	96	91	70	67	42	579
% Total	3.1	1.7	1.2	2.2	3.8	7.9	16.7	16.8	15.7	12.1	11.6	7.2	100%
Rank	9	11	12	10	8	6	1	2	3	4	5	7	
Average	0.6	0.33	0.23	0.43	0.73	1.53	3.23	3.2	3.1	2.33	2.2	1.4	19.3
Mode						2	2	2	4	1	2&3	2	15
Median						2	3	3	3	2	2	1	19

Table 2.6 Frequency of Tropical Cyclones Crossing the Philippines
From 1948 - 1977 (30 years)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1948							2	1	2	2	4	2	13
1949							1	1	2	2	3	2	11
1950								1	1	1	1	1	5
1951					1		1	1	3		1	1	8
1952						2	2	1	2	3	2	3	15
1953						2		3	1	2	2		10
1954			1		1			1		1	3	1	8
1955	1							2	1		1		5
1956				2			2	1	1	1	3	2	12
1957	1					2	1		3	1	1		9
1958									1	1	2		4
1959								1	1		2	2	6
1960				1	1	1		1	2	2			8
1961					1		1	2	1		1		6
1962					1		1	2	1		2		7
1963						2	1	1	1			1	6
1964						1	1	1	4	3	2	2	14
1965	1		1			2	2		1				7
1966					2		6	1		1	2	2	14
1967			1	1		1		2		1	2		8
1968							1	2	1		3		7
1969							2		1	1			4
1970						1	1	1	2	3	3		11
1971				1	3	2	4	1	1	4			16
1972	2					1	1		1	1	1	1	8
1973						1			1	3	1	0	6
1974						1	1	1	1	4	3	2	13
1975	1								1	2	1	1	6
1976					1	1		1				2	5
1977							2		3		1		6
Total	6	0	3	5	11	20	33	29	40	39	47	25	258
% of 258	2.3	0	1.2	1.9	4.3	7.8	12.8	11.2	15.5	15.1	19.2	9.7	100

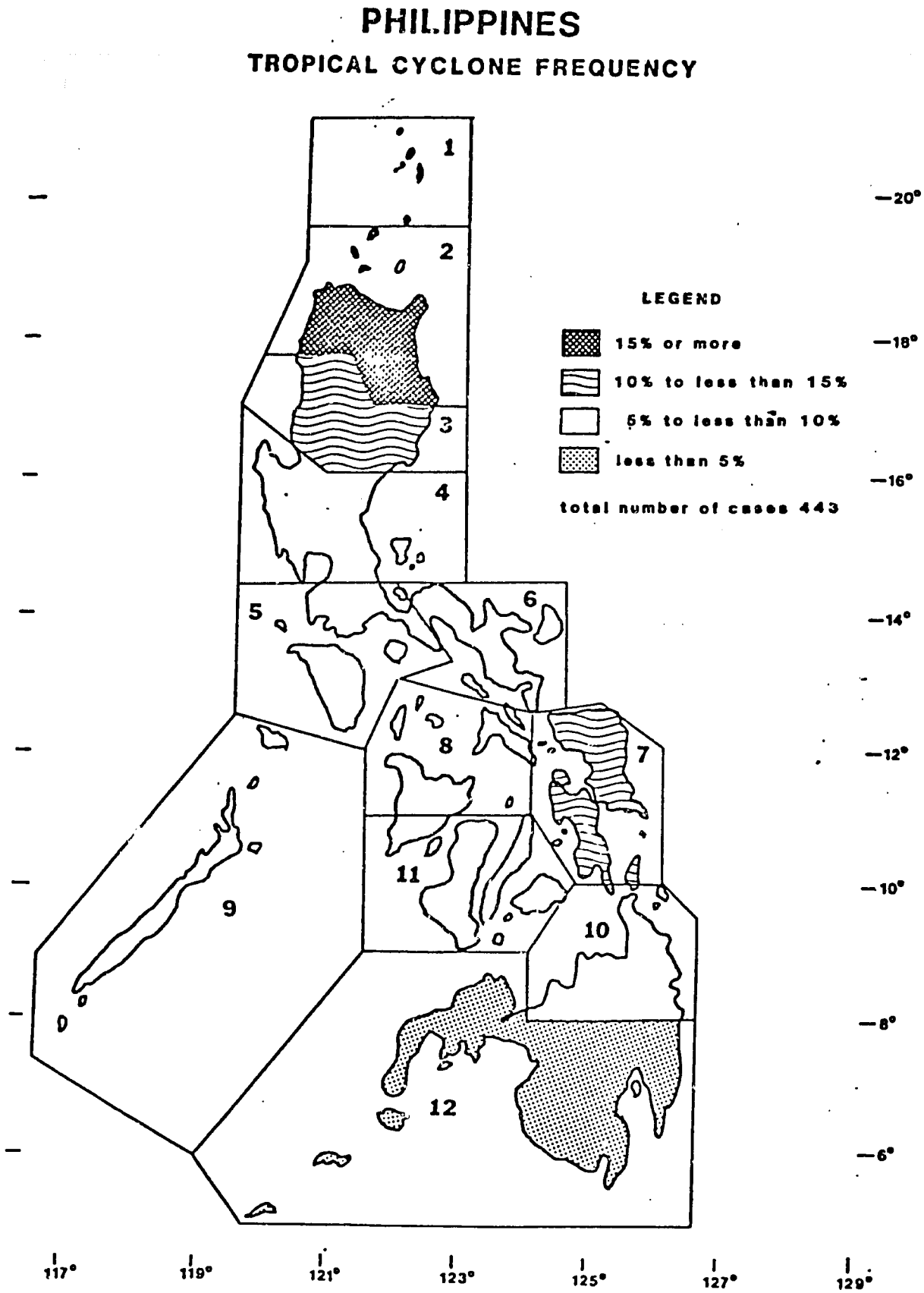


FIGURE 2.6 Tropical Cyclone Vulnerability by Reporting Zone in the Philippines Showing the Percent of all Tropical Cyclones Passing Through Each Zone.

Table 2.7 Annual Frequency of Passage of Tropical Cyclone Centers Over Geographical Zone from 1948 - 1977 (30 years)

Year	1	2	3	4	Z 5	O 6	N 7	E 8	S 9	10	11	12
1948	1	1	7	0	2	0	2	2	1	0	0	0
1949	2	4	1	1	1	0	1	1	4	4	5	0
1950	1	0	2	1	0	1	0	0	1	1	1	0
1951	2	4	0	0	2	1	3	1	1	0	1	0
1952	2	4	1	1	5	3	5	2	1	1	1	0
1953	2	4	2	1	1	2	0	0	0	0	0	0
1954	1	2	2	0	0	0	1	0	3	3	4	0
1955	2	1	1	0	0	0	1	1	1	1	1	0
1956	2	2	5	2	2	2	3	2	1	0	0	0
1957	3	4	1	2	0	1	1	0	0	0	0	0
1958	0	0	1	0	1	0	2	2	1	1	0	1
1959	1	3	1	0	3	1	1	1	2	0	0	0
1960	1	1	1	4	3	4	1	0	1	1	1	0
1961	3	1	0	2	0	1	1	1	0	1	0	0
1962	2	1	1	2	3	2	3	2	1	1	1	0
1963	2	1	2	0	0	1	0	0	1	1	1	0
1964	2	5	2	5	0	4	1	2	0	1	0	0
1965	2	4	1	0	0	0	1	0	0	1	0	0
1966	4	3	4	0	3	2	3	2	0	0	0	0
1967	0	5	0	1	0	1	1	0	2	1	2	0
1968	1	3	0	1	0	0	1	0	2	1	2	0
1969	4	0	0	0	0	0	0	0	0	0	0	0
1970	1	1	2	2	2	2	2	2	2	1	2	1
1971	2	4	2	1	7	4	6	3	2	2	2	0
1972	0	0	1	3	1	2	3	2	1	1	1	0
1973	1	3	1	1	0	0	1	1	1	0	0	0
1974	1	5	4	3	1	1	2	2	1	0	0	0
1975	1	1	2	2	0	1	0	0	1	1	1	0
1976	1	1	2	1	0	1	0	0	0	1	1	0
1977	1	3	2	1	1	1	0	0	0	0	0	0
Total	48	71	51	37	38	38	46	29	31	25	27	2

The updated Coronas Classification system is based solely on rainfall characteristics because rainfall variation in the Philippines is largely due to the combined influence of topography and prevailing air streams with small temperature differences. The average monthly amounts of rainfall were used in dividing the area into four types (Figures 2.4, 2.5, 2.7a,b and 2.8).

Type I has two pronounced rainy seasons: one dry from November to April, the other wet during the rest of the year. The dry season lasts from 3 to 7 months. This type of climate is found in the western and southern parts of Panay Island and Negros Island of Western Visayas Region. Type II has no dry season, with a very pronounced rainy period from November to January. There is not a single dry month in the area of this type. The lowest monthly rainfall occurs at some locations in the spring and at other locations in the summer. This climate is experienced in the eastern and northern parts of Camarines Norte, Catanduanes, Sorsogon and the eastern parts of Camarines Sur and Albay. Type III or Intermediate A Type is relatively dry from January to April and relatively wet during the rest of the year. There is no pronounced rainy period, with a short dry season lasting only from one to three months. This type is intermediate between the preceding two, although it resembles the first type more closely since it has a short dry season. This climatic type is experienced in Panay Island, Eastern Negros Island including Siguijor Island and Central and Southern Cebu Island. Type IV or Intermediate B Type has more or less evenly distributed rainfall. This is also an intermediate type between the first and the second, but it resembles the second more closely since it has no dry season. The lowest rainfall occurs in spring although in some places it takes place in January. Areas of this type of climate are located in small portions of Western Samar, Western Leyte, Northern Cebu and Bohol Islands.

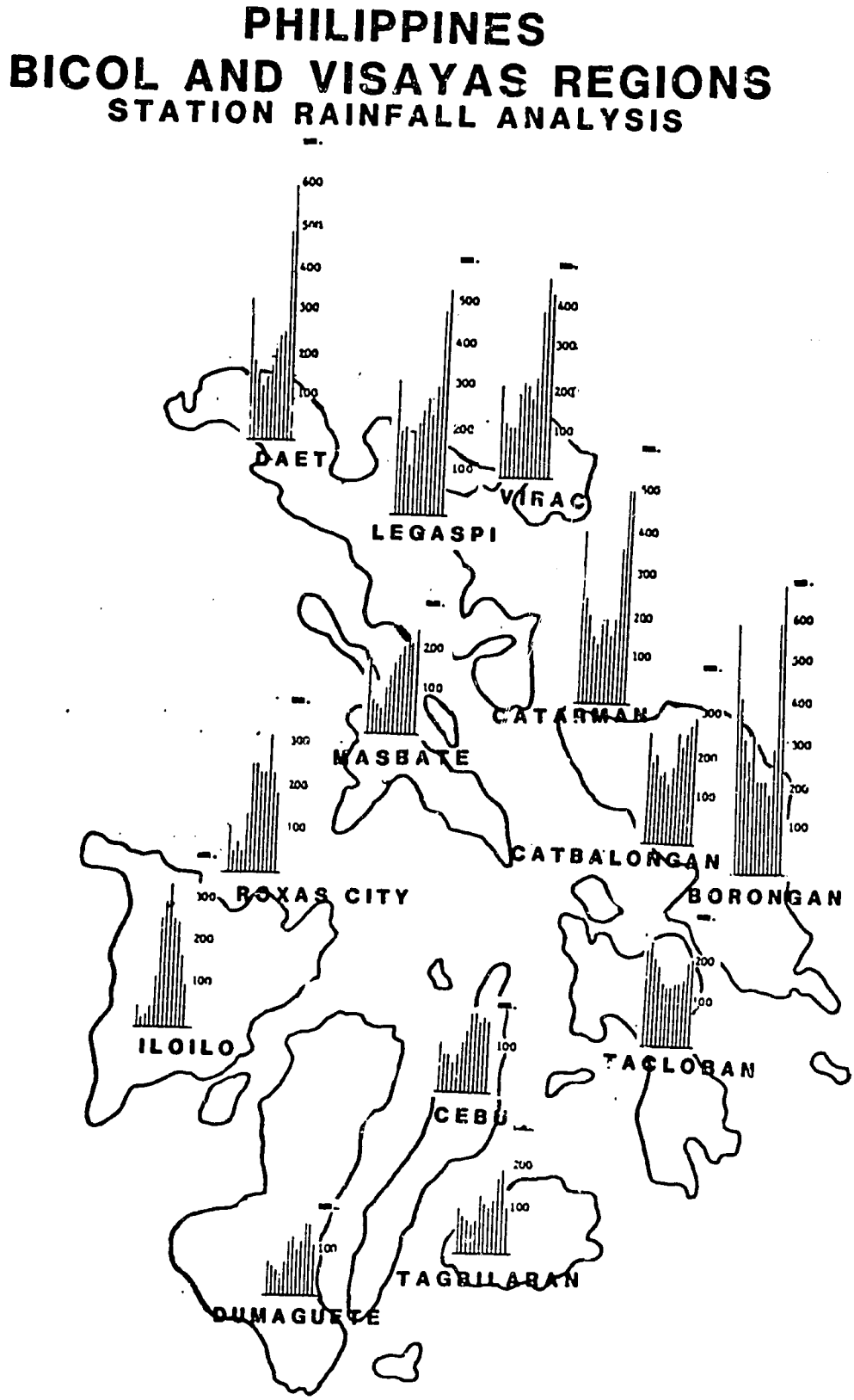


FIGURE 2.7a Station Rainfall Analysis in the Bicol and Visayas Regions.

PHILIPPINES

BICOL AND VISAYAS REGIONS

Mean Annual Rainfall

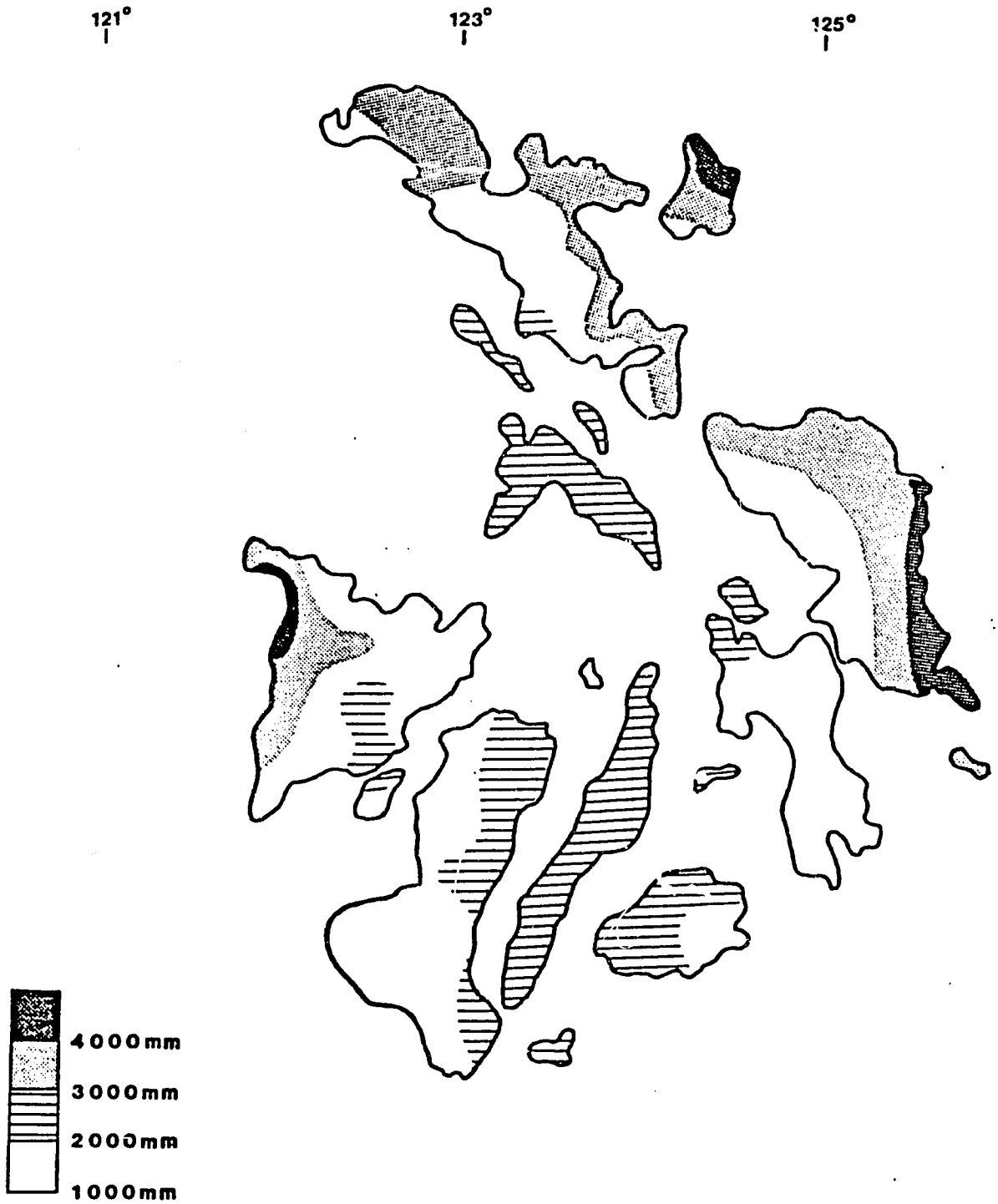


FIGURE 2.7b Mean Annual Rainfall Patterns (mm) in the Bicol and Visayas Regions.

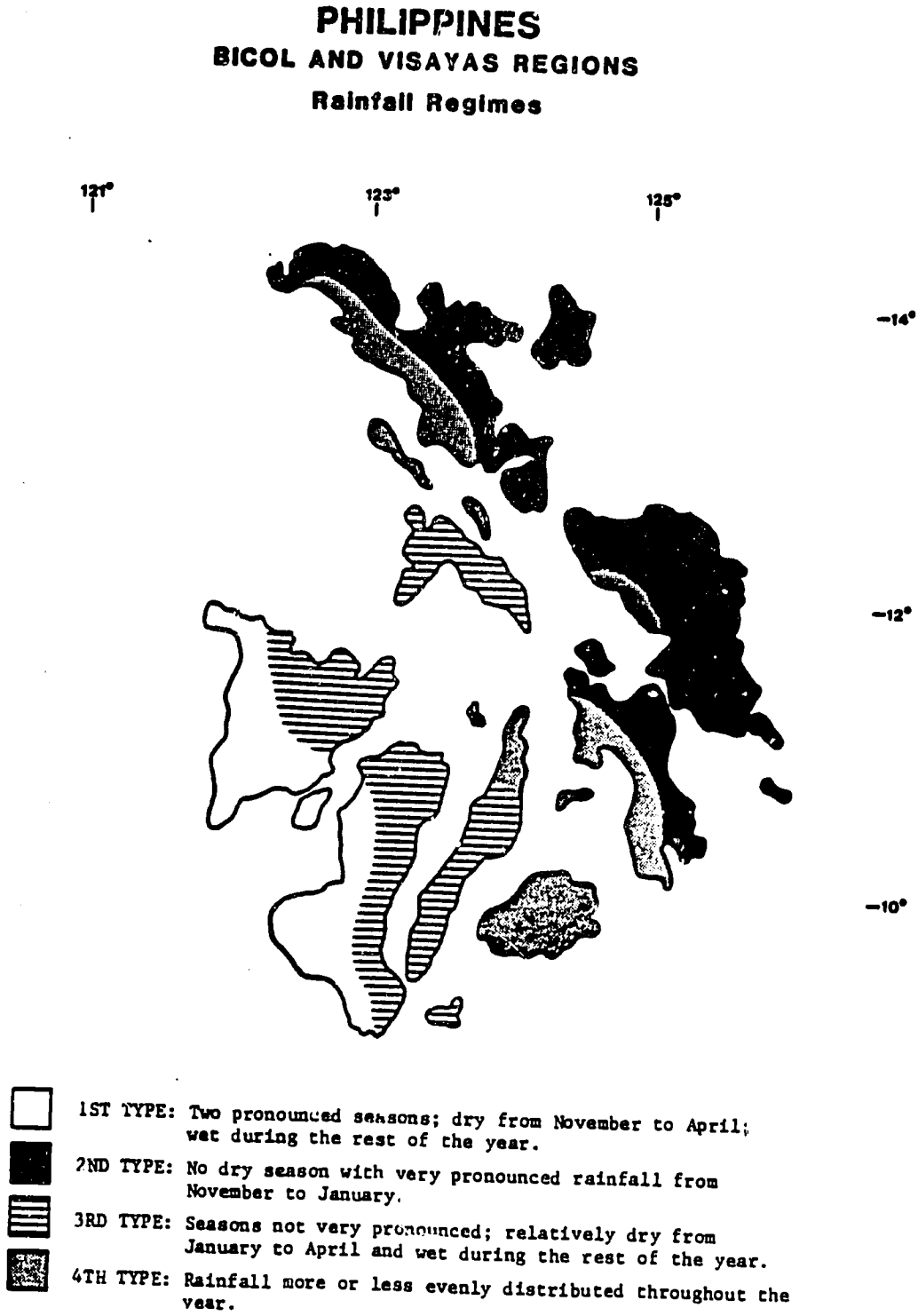


FIGURE 2.8 Rainfall Regimes in the Bicol and Visayas Regions According to the Updated Coronas Classification.

In contrast, zoning by the Mohr and Schmidt ratio method using dry months to wet months is an outgrowth of the work by Thornthwaite. A dry month is defined as one having less than 60 mm of rainfall while a wet month has more than 100 mm. To determine the type of climate, the ratio or quotient of the total number of dry months was computed. The border line between the various types lies at, $Q = 1.5a/(12 - 1.5a)$, where "a" is the number of dry months. The types of climates under this sytem with the corresponding Q-range values are:

TYPE	Q-RANGE
A	0 to less than 0.14
B	0.14 to less than 0.33
C	0.33 to less than 0.60
D	0.60 to less than 1.00
E	1.00 to less than 1.67
F	1.67 to less than 3.00
G	3.00 to less than 7.00
H	7.00 or more.

The mean monthly and annual amounts of rainfall in the Bicol and Visayas Regions based on 30-year observations (1951-1980) are shown in Figures 2.4, 2.5 and 2.7a,b, respectively. The amounts are influenced by the geographical setting, topography and exposure to the prevailing air stream. It is evident from these figures that annual rainfall amounts of more than 3,000 mm are experienced over the eastern section of Bicol Region and Samar Island and over western Panay Island. The maximum values exceed 4,000 mm. The eastern coastal areas receive more rainfall not only from the northeast monsoon but also from tropical cyclones and the associated intensification of the southwest monsoon reaching the area. Stations having annual amounts of less than 2,000 mm are primarily

located in valleys or plains or in places shielded from the dominant air streams by mountains or land masses, e.g., in Masbate or in the Central Visayas Region.

A closer examination of Figure 2.4 and 2.7a,b indicates the relationship between annual rainfall distribution and climatic zones in the Coronas Classification scheme.

B. Agriculture in the Bicol and Visayas Regions

Agriculture is the dominant sector of the Philippine economy. About 56 percent of the working population is engaged in agriculture and 70 percent of the foreign exchange earnings come from the export of agricultural products.

As of 1981, the land area of the Philippines utilized for agriculture was estimated at 12 million hectares. However, allowance must be made for areas reported twice because of more than one cropping a year. In 1981, 3,459,130 hectares were planted to rice (28% of the agricultural area); 3,238,690 hectares to corn (27%); 3,162,250 hectares to coconut (26%); 420,630 hectares to sugarcane (3.5%); and 230,140 hectares to abaca (2%). The rest was planted to other food and commercial crops (Table 2.8).

In the four regions under study, about 50 percent of the total land area is cultivated. Soils in plains and valleys are fertile due to the alluvial deposits of rivers and streams. Lowland soils are sometimes enriched by volcanic material, e.g., in the Bicol Plains and Negros Island.

Figure 2.9 gives a general view of land utilization and a possible indication of the characteristics of soils in the different parts of the Bicol and Visayas Regions.

1. Food and commercial crops

Rice and maize are the main subsistence crops, followed by rootcrops such as sweet potato, cassava, and gabi. Fruits and vegetables, dry beans and peas, and peanuts also contribute to the Filipino diet.

Table 2.8 Crops Grown in the Philippines (1981) and Percentage of Total Agricultural Land Area Utilized (Crop Area in Hectares)

FOOD CROPS			COMMERCIAL CROPS		
Name	Land Area	%	Name	Land Area	%
1. Rice	3,459,130	28	1. Coconut	3,162,250	26
2. Maize	3,238,690	27	2. Sugarcane	420,630	3.5
3. Fruits and Nuts	491,150	4	3. Abaca	230,140	2
4. Root crops	476,610	4	4. Tobacco	55,180	0.46
5. Vegetables	132,960	1.1	5. Rubber	53,880	0.45
6. Coffee	107,090	0.89	6. Cotton	9,140	0. 76
7. Drybeans and peas	68,600	0.57	7. Maguey	3,280	0.03
8. Peanuts	38,730	0.3	8. Castor bean	830	0.006
9. Citrus	25,150	0.2	9. Kapok	770	0.006
10. Other crops	-	1.408	10. Ramie	480	0.004

FIGURE 2.9 General Land Use in the Bicol and Visayas Regions.

Coconut, sugarcane, abaca and tobacco are the major commercial crops. Rubber, cotton and meguey are also produced in commercial quantities.

Rice Production

Data from the Bureau of Agricultural Economics (BAEcon) show that 42 percent of the more than 3 million hectares devoted to rice are irrigated; the rest is rainfed or upland rice. Whether rainfed, irrigated or upland, rice areas are mostly planted to only one crop each year. In some cases farmers plant another short season crop as secondary, but their numbers are small compared to the many who fallow the fields for the rest of the year. Thus the resources, both physical and socio-economic, are not utilized to the maximum. There is a great potential for crop diversification. Multiple cropping of both irrigated and rainfed areas can increase food production, improve the nutrition of the people, raise the living standard of the farmers by increasing their farm income, and eventually stabilize the economy of the country.

The reasons for the reluctance to maximize the use of available resources include: 1) commodity price fluctuations due to swings in supply and demand, 2) weather limitations and 3) lack of knowledge on the proper technology for planting more than one crop a year. Agriculture production is also constrained by low yields attributed to the use of low yielding varieties, poor land preparation, inadequate control of weeds, diseases and pests, poor fertilizer management and lack of irrigation water.

The answer to the need for better agricultural production demanded by population pressures lies in proper management of resources, introduction of new technology and working within the framework allowed by climatic factors. In response to these needs the Ministry of Agriculture has made some progress in encouraging farmers to improve agricultural practices, especially in rice production. Through the International Rice Research Institute located in Laguna

Province, development and introduction of improved or high-yielding varieties (HYVs) of rice have been made. Agricultural extension workers advise farmers on the use of fertilizers and pesticides. Irrigation facilities are being developed. Table 2.9 summarizes the use of high yielding varieties and ordinary (or traditional) varieties of rice for the whole country and for the regions under consideration. Self-sufficiency in this grain is one of the goals of the Ministry of Agriculture. However, typhoons and other weather calamities such as floods and droughts reduce the yield of standing crops.

Maize Production

Maize, like rice, is a main part of the diet for a large portion of the population. Maize is also used as a fodder crop. It is grown as a single crop or intercropped with coconut. Part of the crop is harvested as green maize for food. The use of new HYV's is becoming common. The cultivation of maize requires evenly distributed but not excessive rainfall; the main production areas are therefore in Central Visayas and other areas with Type III climatic zones.

Coconut Production

Coconut is grown chiefly for oil, a major export of the country. It is grown in monoculture or intercropped with abaca, maize, banana, fruit trees, sugarcane and various annual upland field crops.

Coconut beetle and the cadang-cadang disease affect the trees to a varying extent in different areas of the country. Generally no fertilizers are applied. Cultural practices are limited to removal of shrubs or tall grasses once or twice a year.

Although the Philippines is one of the world's major producers of coconut, the yields are low. Typhoons, other weather calamities and diseases also drastically reduce the yield.

Table 2.9 Area Harvested of Irrigated and Rainfed Rice by Variety in the Philippines and the Bicol and Visayas Regions (Crop Year 1979, ha)

Location	IRRIGATED			RAINFED					Total Rainfed and Irrigated
				LOWLAND					
	HYV	Ordinary Varieties (OV)	Total	HYV	OV	Subtotal	Upland	Total	
1. Philippines	1,345,240	162,410	1,507,650	1,225,170	400,180	1,625,350	427,700	2,053,050	3,560,700
2. Bicol	134,500	6,250	140,750	114,400	10,160	124,550	28,290	152,850	293,600
3. Eastern Visayas	53,040	4,290	57,330	64,130	40,220	104,350	14,220	118,570	175,900
4. Central Visayas	21,270	3,440	24,710	35,400	13,510	48,910	2,280	51,190	75,900
5. Western Visayas	115,370	5,180	120,550	299,310	43,570	342,880	17,320	360,200	480,750

Sugarcane

Sugarcane can be grown in every province of the country, but it does not do well in a constantly rainy climate or in one with a long dry season without irrigation. Sugarcane thrives best in a sandy loam soil which is not too saturated or submerged during the rainy periods. Ideal conditions are found in Central Luzon and in the volcanic soil area of Western Negros Island.

Improved varieties suited for mill processing into granular sugar have been introduced.

Abaca

This crop is grown entirely for its yield of coarse fiber, a very good material for making cordage. It is also a major component for various cottage industry products. The principal regions for production are in southern Luzon (including the Bicol Area), Mindanao and the islands of Leyte, Masbate and Samar.

Most abaca is cultivated in monoculture. It is also grown as an intercrop under coconut trees. Problems in abaca cultivation include the occurrence of pests and diseases and degraded soil conditions in some areas. Fertilizers and chemicals for pest and disease control are seldom used. Cultivation usually includes the removal of shrubs and tall plants once a year.

Tobacco

Tobacco is grown throughout the country, but high quality tobacco is mostly grown in certain areas of the Cagayan Valley in Luzon. It is also produced in substantial amounts along the northwest coast of Luzon, Pangasinan Province and in parts of Cebu, Negros and Panay.

Cotton

Cotton is still mostly imported. In recent years efforts have been made to introduce long-fiber varieties and to study the areas with climate that will support the crop properly. Some areas of the Panay and Negros Islands have been found suitable, as well as other western coast areas of the Luzon and Mindanao.

Rubber

While rubber is considered a minor crop in the Philippines, it has an export potential and is rated as one of the most profitable agro-industrial ventures in this country. The Rubber Belt which can be developed is in the Mindanao Islands.

Fruits

Bananas are the main fruit in the diet of the Filipinos, and are now also cultivated quite extensively for export as well. Pineapples and mangoes are also cultivated for export. Numerous other fruits are also included in the Filipino diet.

2. Crop Regions

Bicol Region

The Bicol River Basin is one of the major agricultural areas in the Philippines. This region supports such food crops as rice, maize, fruit, nuts, rootcrops and vegetables (Figures 2.10 and 2.11). Commercial crops are coconut, abaca, sugarcane and tobacco. The land use for these crops is summarized in Table 2.10.

Climatic conditions allow the cultivation of a wide variety of crops. Major constraints are inadequate rainfall during the dry season and excessive cloudiness and typhoons during the wet season.

Rice is grown either in irrigated, rainfed or upland areas. In 1981, the irrigated harvested area was 161,430 hectares, the rainfed area 127,640 hectares and the upland area 18,860 hectares. Fifty percent of the area for lowland rice is irrigated. However, most of the existing irrigation systems need major improvements. The prospects for irrigating two rice crops per year on a large scale in the near future are quite favorable. The scope for rainfed upland crop cultivation is generally favorable.

PHILIPPINES

RICE AND CORN DISTRIBUTIONS

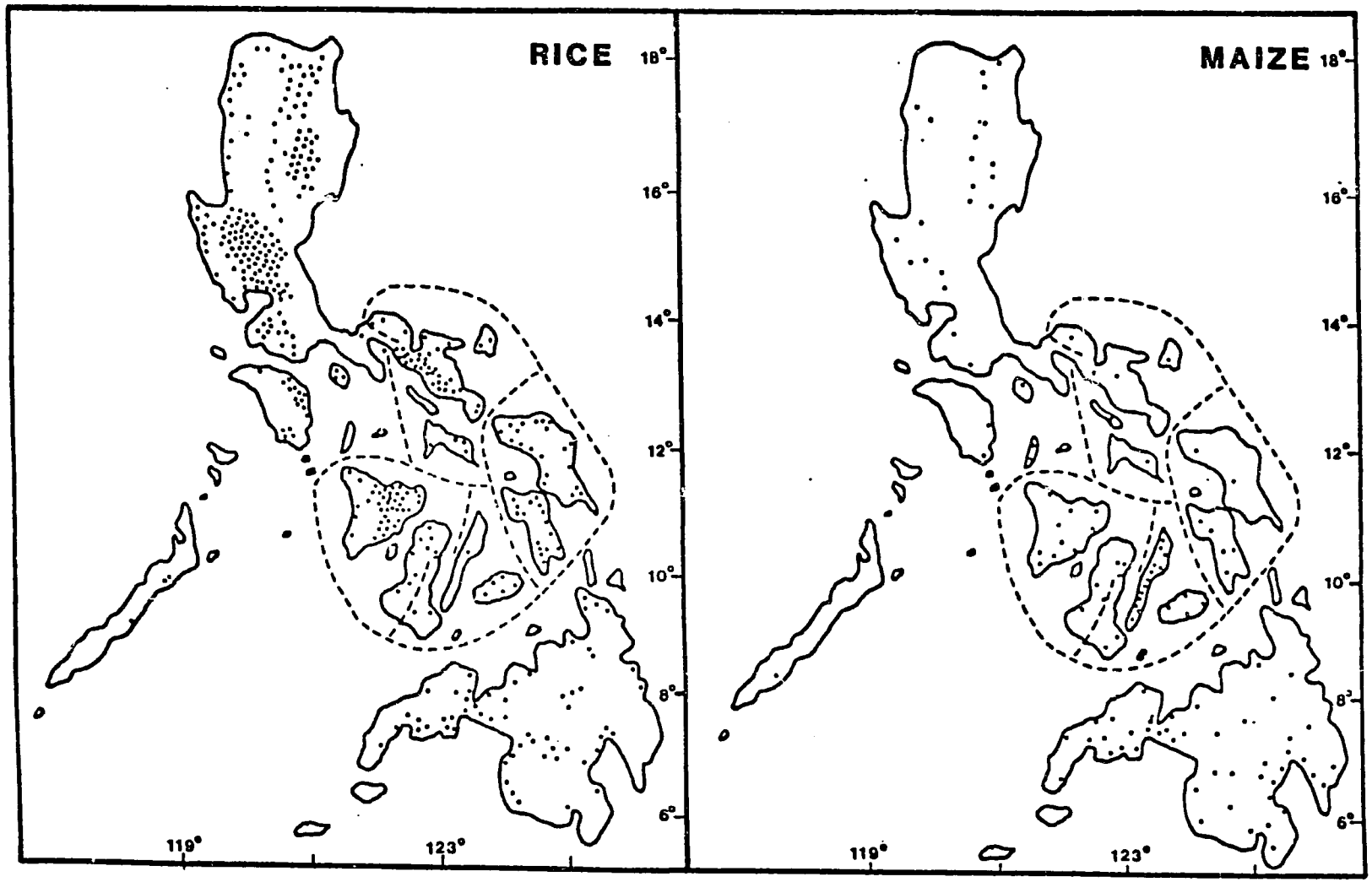


FIGURE 2.10 Distribution of Rice and Corn Grown in the Philippines.

PHILIPPINES

COCONUT AND SUGARCANE DISTRIBUTION

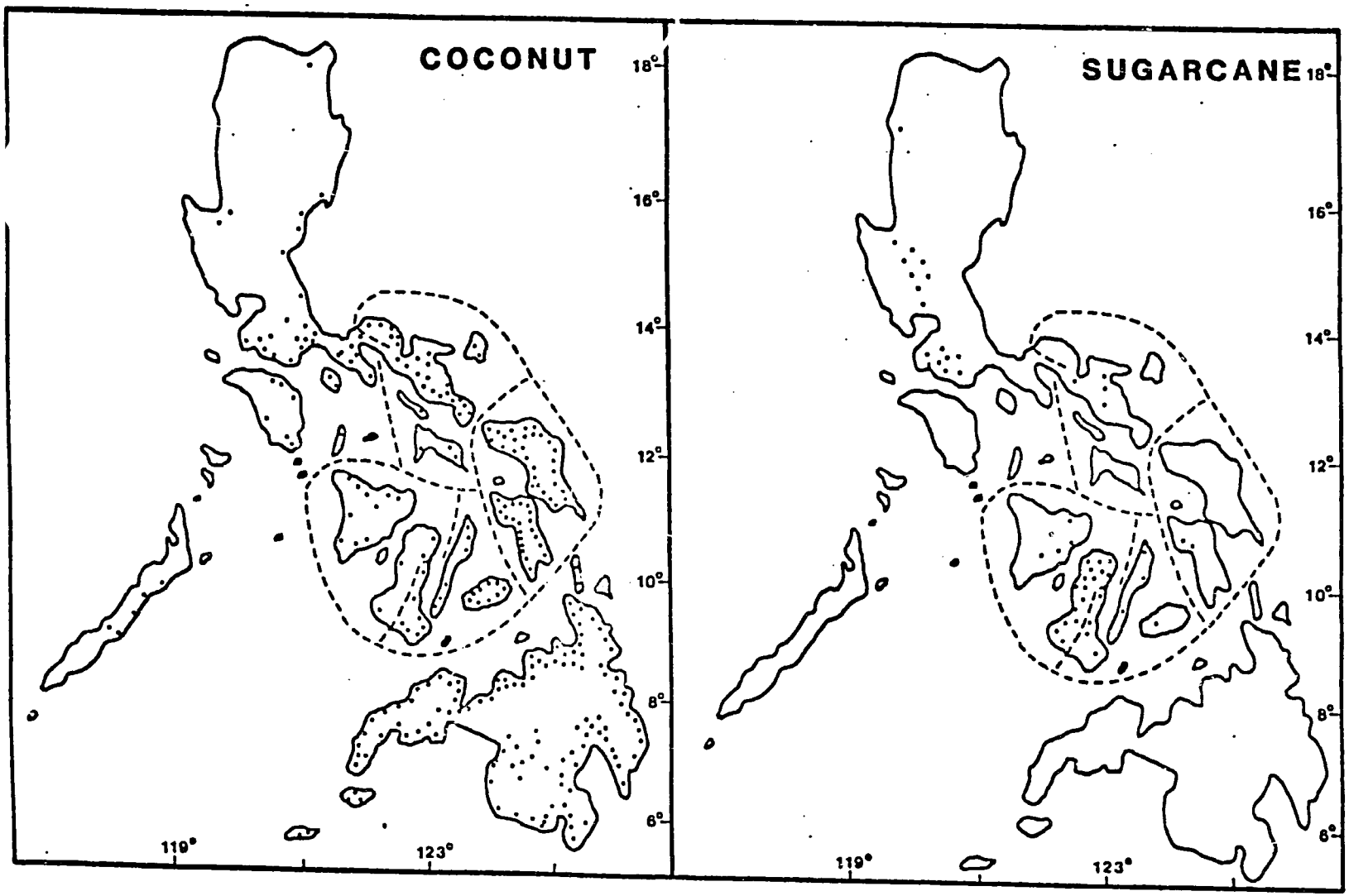


FIGURE 2.11 Distribution of Coconut and Sugarcane Grown in the Philippines.

Table 2.10 Crops Grown (1981) in Bicol Region and Percentage of Total Agricultural Land Area Utilized (Area in Hectares)

FOOD CROPS				COMMERCIAL CROPS		
	Name	Land Area	%		Name	Land Area	%
1.	Palay	307,930	28.6	1.	Coconut	353,470	32.8
	a) irrigated	(161,430)		2.	Abaca	96,100	8.9
	b) non-irrigated	(127,640)		3.	Sugarcane	9,410	0.87
	c) upland	(18,860)		4.	Tobacco and Others	-	0.06
2.	Maize	179,040	16.6				
3.	Rootcrops	77,070	7.2				
4.	Vegetables	29,090	2.8				
5.	Fruits and Nuts (except Citrus)	20,090	1.9				
6.	Citrus	3,290	.27				

Deep rooted crops can be grown in the dry season without moisture stress until the end of April on soils with a high water-holding capacity. Rainfed vegetables can be grown marginally on these soils in the dry season.

Inadequate drainage is a major problem for both rice and upland crop cultivation in large parts of the Bicol River Basin. Production inputs, levels of technology applied and yield range from low to moderate.

Visayas Regions

Some of the most important agricultural areas in the country are found in the Visayas Islands, particularly in the central plain of Panay, western plains of Negros and the northern plain of Leyte (Figures 2.10 and 2.11). Food crops grown in the Visayas Regions include rice, maize, fruits, rootcrops, vegetables, dry beans and peas, and citrus. The commercial crops are coconut, abaca, sugarcane, tobacco, cotton and maguey. The size of the areas planted to different crops (Table 2.11) depends mainly on the climatic conditions in each region. Central Visayas has a maize-coconut economy, Western Visayas mostly sugarcane and palay, and Eastern Visayas coconut, palay and maize.

Table 2.12 summarizes areas devoted to irrigated, rainfed and upland rice production.

Table 2.12 Rice areas in the Visayas

(harvested hectares)

Kind	Eastern Visayas	Central Visayas	Western Visayas
Irrigated	61,750	40,370	147,450
Rainfed	117,300	110,770	343,010
Upland	6,770	6,490	36,620

3. Crop Calendars

Crop calendars in the Philippines are generally determined by the rainfall pattern. Planting, particularly in Bicol and the Visayas Regions, is based on

Table 2.11 Crops Grown (1981) in Visayas Regions and Percentage of Total Agricultural Land Area Utilized (Area in Hectares)

CROPS	Eastern Visayas		Central Visayas		Western Visayas	
	Area	%	Area	%	Area	%
I. Food Crops						
1. Palay	185,820	19.9	157,630	16.79	527,080	50.3
2. Maize	187,840	20.1	470,870	50.15	73,610	7.0
3. Fruits and Nuts (except Citrus)	46,000	5	16,110	1.71	50,940	4.9
4. Citrus	280	.03	1,120	0.119	2,180	.21
5. Rootcrops	89,390	9.6	81,290	8.657	24,550	2.3
6. Vegetables	1,960	.2	6,360	.6773	11,590	1.11
7. Dry Beans and Peas	220	.02	1,530	.1629	20,710	2.0
8. Coffee	370	.04	1,190	.1267	4,730	0.45
9. Peanuts	2,540	.3	4,270	.4548	3,180	0.3
II. Commercial Crops						
1. Coconut	333,870	35.7	158,220	16.85	94,390	9.0
2. Sugarcane	18,910	2	36,550	3.89	228,280	21.8
3. Abaca	66,680	7.1	420	0.045	4,840	0.46
4. Tobacco	90	0.01	2,420	0.258	600	0.06
5. Cotton	-	-	-	-	1,130	0.11
6. Maquey	-	-	960	0.1	-	-
Total Area	934,370	100	938,940	100	1,047,810	100

the seasonal rainfall distribution. It was indicated earlier that four rainfall-based climatic zones are found in the area. There are also two to three climatic zones within a administrative region. Each zone has its own crop calendar. The crop calendars in the area under study are presented according to climatic zones and based on the information from the Bureau of Plant Industry, Ministry of Agriculture (Table 2.13).

4. Climatic Vulnerability of Agriculture

Of all elements affecting crop production in the Philippines, rainfall is the most important single factor. Although the distribution of rainfall is generally regular, deviations can occur. Often such deviations are greatly detrimental to crops. Especially harmful is a delay in the beginning of the rainy season or scanty rains during the season. The onset may also be too early, causing deviation from the planned agricultural activity. Prolonged or abrupt withdrawal of the rainy season also has an adverse effect on agriculture.

Records show that floods are in most cases caused by tropical cyclones associated with torrential rains and strong winds. Drought conditions are attributed to non-occurrence of the expected number of tropical cyclones. An example of this is the severe drought of 1973 when only 12 tropical cyclones occurred in the Philippines compared to the annual average of 19.

About 85 percent of reports from the Bicol and Visayas Regions during the past 12 years (1968-1979, Bureau of Agricultural Economics) attribute losses in rice and corn production to tropical cyclones, floods and droughts. This does not include losses due to weather-related occurrences of pests and diseases. During the severe drought in 1973 over the Visayas, the total rice crop damage was estimated at 61 million pesos. The following year flood damages to rice crop production amounted to about 56 million pesos.

Table 2.13 Tentative Crop Calendars in Bicol and Visayas Regions

Region	Climatic Zone	Crop	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bicol	II	Rice	Lowland 1st				//	////	~~////~~	~~——~~	00	0000	0000	00	
			Lowland 2nd	—0	00C0	0000	0000	00							
			Upland						////	////	////	00	//// 0000	~~////~~ 0000	~~////~~ 0000
		Maize	Dry Season			////	////	////	0000	0000	0000	00			
			Wet Season	////	////	//	0000	0000	0000						
		Soybean						////	////			0000	0000	00	
	IV	Rice	Lowland 1st					////	~~////~~	~~////~~	—0	0000	0000	0000	
			Lowland 2nd	~~////~~	0	0000	0000	0000							
			Upland				////	////	////	00	0000	0000	0000	////	~~////~~
		Maize	Dry Season	0000	0000	00									
			Wet Season				////	////	////	0000	0000	//// 0000	//// 00	////	0000
		Soybean						////	////			0000	0000	00	
		Sugarcane		////	ØØØØ	0000	0000	0000							////
	III	Rice	Lowland 1st						////	~~////~~	~~////~~	—0	0000	0000	0000
			Lowland 2nd	~~////~~		0000	0000	0000							
			Upland				////	////	////	00	0000	0000	0000	////	~~////~~
		Maize	Dry Season	0000	0000	0000	00								
			Wet Season				////	////	////	0000	0000	0000	//// 00	////	////
		Soybean						////	////			0000	0000	00	

Region	Climatic Zone	Crop	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eastern Visayas	II	Rice	Lowland 1st				//	/HH	HH	—	0000	0000	0000	00	
			Lowland 2nd	—0	0000	0000	0000						////	HH	HH
			Upland						////	////	////	00	0000	0000	0000
		Maize	Dry Season			////	////	////	0000	0000	0000	00			
			Wet Season	////	////	//	0000	0000	0000						
		Soybean						////	////			0000	0000	00	
	IV	Rice	Lowland 1st					////	HH	HH	—0	0000	0000	0000	
			Lowland 2nd	HH	—0	0000	0000	0000						////	HH
			Upland				////	////	////	00	0000	0000	0000		
		Maize	Dry Season	0000	0000	00						////	////	////	0000
			Wet Season				////	////	////	0000	0000	0000	00		
		Soybean						////	////			0000	0000	00	
		Sugarcane		////	ØØØØ	0000	0000	0000							////
Central Visayas	III	Rice	Lowland 1st						////	HH	HH	—0	0000	0000	0000
			Lowland 2nd	HH	—	0000	0000	0000						////	HH
			Upland				////	////	////	00	0000	0000	0000		
		Maize	Dry Season	0000	0000	0000	00						////	////	////
			Wet Season				////	////	////	0000	0000	0000	00		
		Soybean						////	////			0000	0000	00	
		Sugarcane		////	ØØØØ	0000	0000	0000							////
	IV	Rice	Lowland 1st					////	HH	HH	—0	0000	0000	0000	
			Lowland 2nd	HH	—0	0000	0000	0000						////	HH
			Upland				////	////	////	00	0000	0000	0000		
		Maize	Dry Season	0000	0000	00						////	////	////	0000
			Wet Season				////	////	////	0000	0000	0000			
		Soybean						////	////			000	0000	00	

Region	Climatic Zone	Crop	Season	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Western Visayas	I	Rice	Lowland 1st						////	~~////~~	~~////~~	—0	0000	0000	0000
			Lowland 2nd	—0	0000	0000	0000						////	~~////~~	~~////~~
			Upland				////	////	////	00	0000	0000	0000		
		Maize	Dry Season	////	0000	0000	0000	00							
			Wet Season					////	////		0000	0000	00	////	////
		Soybean						////	///!			0000	0000	00	
		Sugarcane		0000	0000	00					//	////	////	ØØØØ	0000
	III	Rice	Lowland 1st						////	~~////~~	~~////~~	—0	0000	0000	0000
			Lowland 2nd	~~////~~	——	0000	0000	0000						~~////~~	~~////~~
			Upland				////	////	////	00	0000	0000	0000		
		Maize	Dry Season	0000	0000	0000									
			Wet Season				////	////	////	0000	0000	0000	////	////	////
		Soybean						////	////			0000	0000	00	
		Sugarcane		////	ØØØØ	0000	0000	0000							////

LEGEND:

//// Planting
---- Transplanting
0000 Harvesting

CHAPTER III

METHODOLOGY AND ASSESSMENT TOOLS

This chapter describes the data bases and analysis techniques used to develop the agroclimatic models and their applications for assessment purposes in the Bicol and Visayas Regions.

A. Data

1. Meteorological Data

Meteorological data from 13 synoptic weather reporting stations located in the four regions were used as the primary data base. The data were available in decadal and monthly format, the period of record at each station was generally 1951-1980 and meteorological elements include rainfall, maximum and minimum temperature, dry and wet bulb temperature, dew point temperature, relative humidity, cloud cover and wind speed. At three of these locations, agrometeorological observations are maintained. In addition to the above meteorological elements, pan evaporation data were also available.

Table 3.1 shows basic agroclimatic data for each of the 13 synoptic stations. Figure 2.2 in Chapter II shows each station's location. The climatic zone refers to the Coronas Classification as indicated in Figure 2.8 of Chapter II. Other information in Table 3.1 include: 1) the station type, "A" for synoptic, 2) reporting frequency is daily "d", 3) the elevation (m), 4) mean annual rainfall (mm), 5) prevailing soil depth (cm), 6) provisions for future incorporation of soil water holding capacity information, and 7) peak sowing and harvesting months for the indicated rice and maize crops and 8) months used in calculating the various agroclimatic indices. This information will be extensively used in Chapter V.

Table 3.1 Basic Agroclimatic Data in Bicol and Visayas Regions

Region and Province	Climatic Zone	STATION Name	Type	Reporting frequency	Elevation (m)	Mean Annual rainfall (mm)	Prevailing soil depth (cm)	Capacity of available water in the prevailing soils mm/1m soil	Peak sowing and harvesting months: RICE Low-land first crop	RICE Low-land second crop	RICE Up-land	MAIZE Dry season	MAIZE Wet season	MAIZE soy-bean	MAIZE sugar cane*	Months for calculating YMI and making assessments: RICE Low-land first crop	RICE Low-land second crop	RICE Up-land	MAIZE Dry season	MAIZE Wet season	MAIZE soy-bean	MAIZE sugar cane*	Months for calculating CMI
V. Bicol																							
1. Camarines Norte	2	Daet	A	d	10	3610	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
2. Albay	2	Legazpi	A	d	17	3421	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
3. Catanduanes	2	Virac	A	d	14	2988	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
4. Masbate	3	Masbate	A	d	10	1886	100	100	7-11	12-4	5-9	11-2	5-8	5-9	-	7-10	12-3	5-8	11-1	5-7	5-8	-	10-1
VIII. Eastern Visayas																							
1. Northeastern Samar	2	Catarman	A	d	4	3304	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
2. Eastern Samar	2	Borongan	A	d	6	4358	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
3. Western Samar	4	Catbalogan	A	d	3	2640	100	100	6-10	12-4	5-9	10-1	5-8	5-9	1-3	6-9	12-3	5-8	10-12	5-7	5-8	1-2	10-1
4. Leyte	2	Tacloban	A	d	16	2186	100	100	6-10	11-4	7-11	4-7	2-5	5-9	-	6-9	11-3	7-10	4-6	2-4	5-8	-	10-1
VII. Central Visayas																							
1. Negros Oriental	3	Dumaguete	A	d	5	1303	100	100	7-11	12-4	5-9	11-2	5-8	5-9	1-3	7-10	12-3	5-8	11-1	5-7	5-8	1-2	6-9
2. Cebu	3	Cebu	A	d	33	1625	100	100	7-11	12-4	5-9	11-2	5-8	5-9	1-3	7-10	12-3	5-8	11-1	5-7	5-8	1-2	6-9
3. Bohol	4	Tagbilaran	A	d	5	1420	75-100	100	6-10	12-4	5-9	10-1	5-8	5-9	1-3	6-9	12-3	5-8	10-12	5-7	5-8	1-2	6-9
VI. Western Visayas																							
1. Capiz	3	Roxas	A	d	2	2182	100	100	7-11	12-4	5-9	11-2	5-8	5-9	1-3	7-10	12-3	5-8	11-1	5-7	5-8	1-2	6-9
2. Iloilo	1	Iloilo	A	d	1	1956	100	100	7-11	11-3	5-9	12-3	5-8	5-9	9-1	7-10	11-2	5-8	12-2	5-7	5-8	9-12	6-9

*Crop calendar and assessment months for sugarcane are for periods longer than one year.

2. Agricultural Crop Statistics

Although a variety of crops are grown in the project regions as indicated in Chapter II, agricultural statistics from four primary economic crops were selected to investigate statistical climate/crop yield relationships. These crops include rice, maize, sugarcane and coconut. Data include area in hectares, production in metric tons and yield in metric tons per hectare for annual and/or seasonal time periods. Seasonal data were available for rice and maize, 1970-1978. Annual data were available for coconut and sugarcane. These data were obtained from BAEcon.

3. Episodic Event Data

Examination of historic records revealed that climatic anomalies are highly associated with crop failure. Some of these historic occurrences of crop failure (or damage) are indicated as episodic events in Table 3.2.

4. Capabilities and Limitations in the Data

The large spatial variability of rainfall within each region (e.g., Bicol) is of major concern. Usually two to three climatic regimes (Coronas Classification) exist in each region and the available 13 stations do not adequately represent each regime. It is necessary to add more stations to the analysis in the future.

Limitations in agricultural data can be attributed to the differences in data collection procedures over period of record. Changes in the crop reporting regions or areas during the period of record also occurred. An example is the Central Visayas Region which was formerly a component of the Eastern Visayas Region: crop/weather analysis can therefore not be included on data corresponding to those years when Central Visayas was still classified as Eastern Visayas.

Table 3.2 Summarized Episodic Event Data on Reported Climatic and Non-Climatic Factors Having Adverse Impact on Crop Conditions and Food Security in the Bicol and Visayas Regions.

YEAR	MONTH	EVENTS
1951	May	Typhoon and floods destroyed crops
	December	Typhoon crossed Visayas, destroyed crops and caused hundreds of casualties
1952	July	Typhoon Emma caused crop damages in the Visayas
	October	Typhoon Trix caused crop damage in Bicol and Visayas Regions
1956	December	Typhoon Polly caused considerable crop damages in Bicol Region
1957	November	Typhoon Kit destroyed crops in Bicol Region
1959	November	Typhoon Freda damaged crops in Bicol Region and neighboring provinces
	December	Typhoon Gilda caused flooding and strong winds destroyed crops in Bicol and Visayas Regions
	December-January 1960	Typhoon Harriet aggravated damages caused by "Gilda"
1960	June - October	Two typhoons caused damages to crops over Bicol and Visayas Regions
1962	May - November	Two typhoons crossed Visayas Regions causing floods and crop damages
1966	May	Typhoon Klaring caused heavy crop losses in Eastern Visayas and Bicol Regions
	December	Typhoon crossed the Visayas causing crop losses
1967	November	Typhoon crossed the Bicol Region, strong winds and torrential rains caused heavy damages to crops

1968	Early half of year	Drought over Central and Western Visayas caused damages to crops
		Incidence of pest and diseases reported to have caused considerable crop damages in Central and Western Visayas
1969		Drought over Bicol and Visayas Regions caused crop failures
		Incidences of pest and diseases reported to have caused crop damages in Western Visayas
1970	October	Destructive typhoons Sening and Tikang caused heavy losses to agricultural investments and casualities (more than 1,500 persons) in Bicol and Visayas Regions
1972	January	Floodings over Visayas during the early half of January
		Typhoon caused crop damages in Bicol Region during the second half of January
		Incidence of pest and diseases in Bicol Region
	Second half of year	Drought over Western Visayas caused crop failures
1973		Drought over Bicol and Visayas Regions caused heavy crop failures
1974-75		Heavy damage to crops reported due to incidence of pest and diseases in Eastern Visayas
1975		Drought experienced over Bicol and Visayas Regions. Crop damages reported
1976-77		Crop damage considerable in Bicol Region due to incidence of pest and disease
1978		Crop damages reported due to drought over Eastern and Central Visayas and the Bicol Regions

	September-October	Typhoons affected Bicol and Eastern Visayas Regions. Severe damages to crops due to floodings and strong winds
1978-79		Crop damages reported in Western and Eastern Visayas and Bicol Regions due to pest and diseases
1979	April	Typhoon Bekeng crossed Eastern Visayas and North of Central and Western Visayas Regions causing severe damages to crops
		Damages due to drought reported in Eastern and Central Visayas and the Bicol Region
1981	July	Typhoon caused crop damages in Bicol Region
	November	Typhoon caused heavy damages to crops in Bicol Region. Tidal waves swept over Eastern Camarines Province
	December	Typhoon caused crop damages in Bicol Region

As far as quality control of meteorological data from the 13 synoptic stations is concerned, standard procedures and guidelines were followed from the time of observation to the basic processing of such data from observations forms onto magnetic tapes. There are some missing data for certain elements, such as wind speed, for nearly all of the 13 synoptic stations during the 1950's. However, nearly 30 years of data provide generally stabilized climatological normals for most of the elements of the 13 stations.

B. Analytic Methods

1. Climatological Means

Monthly data available from each of the 13 weather stations were averaged to obtain the distribution of the monthly means. The northeast monsoon (October-January) is the primary source of rainfall for stations in the Bicol, Central Visayas and Eastern Visayas regions. On the other hand, stations in Western Visayas receive most of the rainfall during the southwest monsoon season (June-September).

2. Potential Evapotranspiration (PET)

Evapotranspiration (ET) is defined as the sum of the evaporation of water directly from the surface of water, soil and vegetation (dew) and the transpiration by plants. If soil water is not limiting, the evapotranspiration from a complete plant canopy is called the potential evapotranspiration (PET).

There have been many methods proposed for estimating PET from meteorological data. One of the simplest models is to approximate PET by 80 percent of pan evaporation (from U.S. Class A pan). Some of the other major methods include the following.

Penman Formula (1948)

Penman's method is derived from the physical laws governing the evapotranspiration process. The approach involves obtaining an empirical estimate of the transfer of mass (water vapor) from a wet surface and incorporating this estimate into an expression defining the surface energy budget. The Penman formula (Frere, 1972) for the rate of PET from an extensive and uniform wet surface can be written as:

$$PET = (mH + 0.66Ea)/(m + 0.66)$$

where: PET is the potential evapotranspiration (mm/day)

m is the slope of the saturation vapor pressure curve for water at mean air temperature in mb/°C,

H is the net radiation in evaporation equivalent of mm/day,

0.66 is the psychrometric constant in mm mb/°C, and

E_a is $0.26\ (e_s - e_a)\ (1 + 0.54\ U_2)$ in mm/day

with: e_s the saturation vapor pressure (mb) at the mean air temperature,

e_a the actual vapor pressure (mb), and

U_2 the mean wind speed at 2 meters in m/sec.

The main problem with the Penman method is that the data for net radiation, vapor pressure deficit, and wind speed are not available for most meteorological stations. Because of incomplete meteorological data at most weather stations, other empirical methods for estimating PET have also been proposed.

Modified Penman for the Philippines

Tamisin et al (1979) suggested the modified Penman as follows:

$$PET = (mH + sEa)/(mts)$$

where:

H = net radiation (mm/day) = $Q_t\ (1-r) - Qnl$,

Q_t = global radiation (mm/day) = $Qo\ (0.18 + 0.55\ n/N)$,

Q_{nl} = net longwave radiation = $T^4\ (0.56 - .098\sqrt{e_d}\ (0.1 + 0.9\ n/N)$ (mm/day),

r = reflection coefficients of the surface,

Q_o = extra-terrestrial radiation (mm/day),

σT^4 = Stefan - Boltzman equation,

n/N = percent of possible sunshine

m = slope of saturation vapor pressure (mm Hg/°T),

s = psychrometric constant (0.27),

E_a = aerodynamic term (mm/day),

= $(0.5 + 0.01\ U)\ 0.35\ (e_a - e_d)$,

U = windspeed at 2 meters above the surface (km/day),

e_a = saturation vapor pressure (mm),

e_d = actual vapor pressure (mm) = $e_a\ (RH/100)$, and

RH = relative humidity (%).

The following additional modifications were made for Philippine conditions:

1. Robertson (1971) recommended the use of $Q_t = Q_o\ [0.24 + 0.54\ n/N]$.

2. Change the expression $(0.5 + .01U)$ in the aerodynamic term to $(1.0 + .01U)$ to allow for the roughness factor.

3. In the net longwave radiation expression, change the term $(0.56 - 0.098\sqrt{e_d})$ to $(0.56 - 0.079\sqrt{e_d})$ to be more applicable for the humid tropics in light of results by Doorenbos and Pruitt (1977).

Thornthwaite Method

Thornthwaite (1948) derived an empirical relationship between PET and mean air temperature. PET is expressed as an exponential function of mean monthly air temperature or:

$$PET = 1.6\ (10\ T/I)^A$$

where: PET is the potential evapotranspiration (cm/month),

T is the mean air temperature (°C), normally a month,

I is a heat index which represents the sum of 12 monthly indices (i) and may vary from 0-160,

$$I = \sum_{i=1}^{n} (T_i/5)^{1.514}$$

A is a cubic function of I for a given location which may vary from 0-4.25 and is defined as:

$$A = 6.75 \times 10^{-7} I^3 - 7.71 \times 10^{-5} I^2 + 1.79 \times 10^{-2}\ I + 0.49$$

The values of PET are for a day length of 12 hours and a 30 day month; an adjustment must be made to estimate PET for a particular month and place.

This method has been used worldwide because only temperature and the local latitude are required for input. However, considerable criticism has been offered because the mean air temperature does not relate to the surface energy balance. Also, the method was designed only for making monthly PET estimates.

An adjustment for latitude is required for locations with daylengths different than 12 hours. This method has the great advantage of using only temperature and local latitude as input. However, there are certain shortcomings which are inherent in the method. Evaporation lags the annual maximum heating during the late spring and consequently is out of phase in the fall as well. Furthermore, application of the Thornthwaite concept to short-time periods leads to significant errors as a result of the often excessive variation in mean air

temperature during these periods. It has also been found that PET measurements based on short-term mean temperatures are unreliable. This failure is attributed to the fact that short-term mean temperature is not a suitable measure of net radiation. Success on a long-term basis is explained as being due to the fact that both evapotranspiration and mean temperature are similar functions of net radiation and are therefore autocorrelated over relatively long periods of time.

Hargreaves Method

Hargreaves (1977) developed an equation for comparing PET that corresponds well with standard Class A pan data and grass lysimeters. This can be written as:

$$PET = 0.0075 \times RSM \times T$$

where:

PET = potential evapotranspiration (mm/day),

RSM = solar radiation (mm/day), and

T = daily mean temperature (°F)

This method is quite simple. Measurements of temperature are usually available. If solar radiation is not available, it can be estimated from percentage of possible sunshine (S) and relative humidity (RH). It can also be estimated from the temperature diffference (TD, defined as the difference between maximum and minimum). These relationships include:

$$RSM = KS(RA)(S)$$

where:

RA = extraterrestrial radiation (mm/day)

KS = 0.055 + 0.00035 (100 - RH), and

S = percent possible sunshine.

The KS relation is for RH values greater than 40 percent, otherwise KS = 0.076 is recommended.

The equation to estimate solar radiation from the temperature difference (TD) can be written as:

$$RSM = KT(RA)(TD)$$

The value of KT is estimated by:

$$KT = 0.035\ (100-RH)^{1/3}$$

Evaluating Methods for Estimating PET

Potential evapotranspiration is one of the basic agroclimatic variables used in the study of soil moisture stress on crops. Several methods on estimating potential evapotranspiration were previously discussed. The question is now posed as to which method is most reliable and suitable for the Bicol and Visayas Regions.

In this study, monthly data from 13 primary stations representing the Bicol and Visayas Regions were used to estimate PET by Penman's, Hargreaves' and Thornthwaite's methods. Estimated values were compared and the sample means, variances and time series of individual monthly estimates were examined. One disadvantage common to all methods is that the baseline information on actual measurements of PET are not usually available to confirm the appropriate method. Also, data for the Penman method are not always available. Although some of these parameters can still be derived, this poses some limitations. Finally, some of the methods may be totally inappropriate for climatic conditions in Bicol and Visayas Regions.

Since actual measurements of PET are not available, definite conclusions cannot be made. However, some inferences can be drawn from the sensitivity of PET to the monthly rainfall variations. In this respect, crop calendar information can also be used to interpret PET (moisture demand) and rainfall (moisture supply) relationships. If crops are successfully grown in most years, rainfall

should generally exceed PET during the growing season. If estimated PET during the growing season is consistently larger than rainfall, the PET method is suspect for the region.

Despite these limitations, recommended procedures need to be developed for test and evaluation. The most "appropriate" method needs to be determined. Alternative methods or ways to adjust PET estimates to conform with the "appropriate" method are required. Interpolating PET to data sparse locations is important. Determining when PET normals can be used instead of individual monthly (or weekly, etc.) values is necessary. For example, if the variance of rainfall is much greater than the variance of PET, then possibly PET normals will suffice. These are some of the questions to be investigated.

A number of studies on estimating potential evapotranspiration were made in the Philippines, but the most important one which is relevant to the PET methods for Bicol and Visayas Regions is the one conducted by Tamisin et al (1979). Modifications were made to the original Penman's equation to make it more suitable for Philippine conditions in light of the results from Doorenbos and Pruitt (1977). Based on this generalized modified Penman's equation for Philippine conditions simple linear regressions for estimating PET for each particular area in the Philippines were developed. These results were also considered in the evaluation.

3. Soil Moisture Budgeting

Crop growth and development are influenced mainly by soil moisture, temperature and light intensity. Moisture sources are rainfall, water stored in the soil and irrigation. Precipitation recharges soil moisture in successive soil layers from the surface downwards. Precipitation in excess of that required to bring the crop root zone to water holding capacity is removed by

lateral run-off and percolation. Even without irrigation, crops are not seriously affected by short dry spells if there is sufficient soil moisture to support the demand for water. Thus, the soil moisture level may be as good or better an indicator of crop conditions as rainfall. Although soil moisture is difficult to measure directly in the field, estimates can be made using agroclimatic techniques. However, estimates should be viewed only as indices of soil moisture conditions. Simple water budgets based on gains and losses can provide useful information if capabilities and limitations are carefully considered. Two methods for estimating soil moisture are presented as follows:

One-Layer Water Balance Method

Thornthwaite's model is based on simple water balance equations for gains and losses within a single layer as follows:

$$S_i = S_{i-1} + P_i - PET_i\ (S_{i-1})/FC$$

where: S_i is the soil moisture estimate for the current period,

S_{i-1} is the soil moisture for the previous period,

P_i is the precipitation,

PET_i is potential evapotranspiration for the current period, and

FC is the field capacity of the soil.

Two-Layer Model

In contrast to the one-layer model, Palmer (1965) proposed a two-layer model which makes two assumptions:

1) The upper layer is equivalent to the plough layer and is assumed to hold about 2.5 cm of plant available water. The soil water (SS) in the surface layer is lost at a potential rate.

2) The underlying layer extends from the base of the plough layer to the depth of rooting for a particular crop. Soil water (SU) in the underlying layer is lost at the potential rate when the profile is at field capacity. The

available water in this layer depends on the depth of the root system and on the soil characteristics.

The soil moisture budget is:

$$S_i = SS_i + SU_i = SS_{i-1} + SU_{i-1} + P_i - AET_i - RO_i$$

where: SS_i and SU_i are the soil water in the surface and underlying layers, respectively,

i is the current time period and i-1 is the previous time period,

S_i is the soil water in both surface (SS_i) and underlying (SU_i) layers,

P_i is the rainfall received during the current time period,

AET_i is the actual water loss by evapotranspiration, and

RO_i is the runoff.

The actual water losses by evapotranspiration and runoff are estimated by:

a) If $P_i < PET_i$ then:

$$AET_i = P_i + LS_i + LU_i = P_i + \text{Minimum}\ (SS_{i-1},\ PET_i - P_i) + \text{Minimum}\ (SU_{i-1},\ (PET_i - P_i - LS_i)\ SU_{i-1}/(PAW_{max} - 2.5))$$

where:

LS_i and LU_i are the water losses from the surface and underlying layers in the current time period, respectively,

PET_i is the estimated potential evapotranspiration, and

PAW_{max} is the maximum possible plant available water in the total soil profile.

The runoff is zero for this case.

b) However, if $P_i > PET_i$ then:

$$AET_i = PET_i,$$

$$RO_i = P_i - AET_i - RE_i$$

where the soil water recharge (RE_i) is:

$$RE_i = \text{the minimum of } ((P_i - AET_i), (PAW_{max} - S_i))$$

The budget begins at a time when the soil moisture is at field capacity and water is lost from the upper layer first. Note that if SU_{i-1} is zero then the loss from the underlying layer (LU_i) is also zero. All units are in cm.

4. Crop Coefficients

Doorenbos and Pruitt (1977) defined the crop coefficient (KC) for a given crop as:

$$KC = AET_c/PET.$$

The crop coefficient relates to the evapotranspiration (AET_c) of a disease free crop grown in large fields under optimum soil water and fertility conditions achieving full production potential under the given environment. PET is the reference potential evapotranpsiration as defined in previous sections. Factors affecting the value of KC are mainly the crop characteristics, crop planting or sowing date, rate of crop development, length of growing season and the climatic conditions. Thus, crop coefficients are defined for each crop development stage. Usually the coefficients of a given crop are largest for the flowering/reproductive stage relative to the earlier stages, for example, planting and late early vegetative.

Some of the crop coefficients for selected crops as provided by Doorenbos and Pruitt are given in Table 3.3. These were determined from field experiments with lysimeters. Although the appropriate crop coefficients for environmental and cropping practices in the Bicol and Visayas Regions would have to be locally determined, the data in Table 3.3 can be carefully used in agroclimatic studies. The coefficients should be adjusted for local conditions, e.g., crop calendars and agricultural practices.

The KC can be used to estimate the crop water requirement for different crops at various stages of development by:

$$\text{Crop Water Requirement (CWR)} = AET_c = KC\ (PET).$$

Table 3.3 Crop Coefficients (kc)

CROP	Crop Development stages					Total growing period
	Initial	Crop development	Mid-season	Late season	At harvest	
Banana						
tropical	0.4 -0.5	0.7 -0.85	1.0 -1.1	0.9 -1.0	0.75-0.85	0.7 -0.8
subtropical	0.5 -0.65	0.8 -0.9	1.0 -1.2	1.0 -1.15	1.0 -1.15	0.85-0.95
Bean						
green	0.3 -0.4	0.65-0.75	0.95-1.05	0.9 -0.95	0.85-0.95	0.85-0.9
dry	0.3 -0.4	0.7 -0.8	1.05-1.2	0.65-0.75	0.25-0.3	0.7 -0.8
Cabbage	0.4 -0.5	0.7 -0.8	0.95-1.1	0.9 -1.0	0.8 -0.95	0.7 -0.8
Cotton	0.4 -0.5	0.7 -0.8	1.05-1.25	0.8 -0.9	0.65-0.7	0.8 -0.9
Grape	0.35-0.55	0.6 -0.8	0.7 -0.9	0.6 -0.8	0.55-0.7	0.55-0.75
Groundnut	0.4 -0.5	0.7 -0.8	0.95-1.1	0.75-0.85	0.55-0.6	0.75-0.8
Maize						
sweet	0.3 -0.5	0.7 -0.9	1.05-1.2	1.0 -1.15	0.95-1.1	0.8 -0.95
grain	0.3 -0.5*	0.7 -0.85*	1.05-1.2*	0.8 -0.95	0.55-0.6*	0.75-0.9*
Onion						
dry	0.4 -0.6	0.7 -0.8	0.95-1.1	0.85-0.9	0.75-0.85	0.8 -0.9
green	0.4 -0.6	0.6 -0.75	0.95-1.05	0.95-1.05	0.95-1.05	0.65-0.8
Pea, fresh	0.4 -0.5	0.7 -0.85	1.05-1.2	1.0 -1.15	0.95-1.1	0.8 -0.95
Pepper, fresh	0.3 -0.4	0.6 -0.75	0.95-1.1	0.85-1.0	0.8 -0.9	0.7 -0.8
Potato	0.4 -0.5	0.7 -0.8	1.05-1.2	0.85-0.95	0.7 -0.75	0.75-0.9
Rice	1.1 -1.15	1.1 -1.5	1.1 -1.3	0.95-1.05	0.95-1.05	1.05-1.2
Safflower	0.3 -0.4	0.7 -0.8	1.05-1.2	0.65-0.7	0.2 -0.25	0.65-0.7
Sorghum	0.3 -0.4	0.7 -0.75	1.0 -1.15	0.75-0.8	0.5 -0.55	0.75-0.85
Soybean	0.3 -0.4	0.7 -0.8	1.0 -1.15	0.7 -0.8	0.4 -0.5	0.75-0.9
Sugarbeet	0.4 -0.5	0.75-0.85	1.05-1.2	0.9 -1.0	0.6 -0.7	0.8 -0.9
Sugarcane	0.4 -0.5	0.7 -1.0	1.0 -1.3	0.75-0.8	0.5 -0.6	0.85-1.05
Sunflower	0.3 -0.4	0.7 -0.8	1.05-1.2	0.7 -0.8	0.35-0.45	0.75-0.85
Tobacco	0.3 -0.4	0.7 -0.8	1.0 -1.2	0.9 -1.0	0.75-0.85	0.85-0.95
Tomato	0.4 -0.5	0.7 -0.8	1.05-1.25	0.8 -0.95	0.6 -0.65	0.75-0.9
Watermelon	0.4 -0.5	0.7 -0.8	0.95-1.05	0.8 -0.9	0.65-0.75	0.75-0.85
Wheat	0.3 -0.4	0.7 -0.8	1.05-1.2	0.65-0.75	0.2 -0.25	0.8 -0.9
Alfalfa	0.3 -0.4				1.05-1.2	0.85-1.05
Citrus						
clean weeding						0.65-0.75
no weed control						0.85-0.9
Olive						0.4 -0.6

The CWR for each growth stage and the growing season of a particular crop can be estimated from historic meteorological data. The CWR can be compared with rainfall and soil moisture to determine the appropriate crops and planting dates that would minimize drought vulnerability. In contrast to this type of land use study, the CWR can be used in real-time applications such as irrigation advisories during the growing season.

5. Climatic Diagrams

The climatic diagram is a useful tool for investigating the availability of moisture of crops. It is a graphical plot of monthly, decadal, weekly or daily rainfall, soil moisture, PET, AET and other parameters such as pan evaporation. The crop coefficient could be used to adjust PET, thereby providing an estimate for the crop water requirement for each crop stage. The diagram can be based on data from a particular season or from climatic normals or both. For example, moisture supply and demand relationships can be monitored during the growing season by comparing real-time values to normal data. This can be an important tool for crop condition assessment. The diagram can also be used for integrated-area development projects such as land utilization including human settlement, cropping patterns, farming systems, irrigation requirements and others.

6. Derived Agroclimatic Indices

Agricultural drought indices are defined as derived numbers or classification identifiers which express the degree to which growing plants have been adversely affected by an abnormal moisture deficiency. The deficiency may result either from an unusually small moisture supply or an unusually large moisture demand. The sources of moisture supply are precipitation and water stored in the soil, while moisture depletion is caused by crop evapotranspiration. Potential evapotranspiration and soil moisture are some of the variables that can be used for calculating these indices.

This study examines six different agroclimatic indices: Yield Moisture Index (YMI), Generalized Monsoon Index (GMI), R-Index, Soil Moisture Index (SMI), Z-Index, and the Palmer Drought Index (PDI). These indices are used by the NOAA/Assessment and Information Services Center for drought early warning assessments. Details of each index follow.

Yield Moisture Index (YMI)

The Yield Moisture Index is defined as:

$$YMI_j = \sum_{i=1}^{N} P_i \, KC_{ij}$$

where:

YMI_j = the Yield Moisture Index for the jth crop (rice, maize, etc.),

P_i = the precipitation during the ith crop stage (1 = planting or transplanting, 2 = vegetative, 3 = flowering/reproductive etc.), and

KC_{ij} = the appropriate crop coefficient for the ith crop stage and jth crop (Doorenbos and Pruitt, 1977).

As discussed by Steyaert et al (1981), and Achutuni et al (1982), this drought index uses crop coefficients to weight rainfall during the growing season according to the relative water requirement between crop stages. For example, the crop coefficients for maize at planting and reproductive/flowering are about 0.35 and 1.05, respectively. Water is about three times more important during flowering than at planting. Thus, the YMI is based on objectively weighted rainfall and should represent an improvement over the use of cumulative rainfall during the growing season. The index can be calculated at the end of planting, vegetative, flowering and maturity crop stages. Assessments are made at the end of each stage. Usually water is beneficial to the crop at these times; however, caution must be exercised in the late maturity stages. If rainfall tends to adversely affect the crop during the final stages (grain drying), this stage should not be used in the YMI.

Generalized Monsoon Index (GMI)

The Generalized Monsoon Index was developed by Steyaert, Achutuni and Todorov (1981) to assess rainfed crops grown during monsoon. In a sense, it is a generalized YMI which is defined for the southwest and northeast monsoons.

The Generalized Monsoon Index for the Southwest monsoon (GMI_{SW}) is obtained by weighting June to September rainfall as follows:

$$GMI_{SW} = 0.15P_6 + 0.25P_7 + 0.40P_8 + 0.20P_9.$$

The Generalized Monsoon Index for the northeast monsoon period during October to January is defined as:

$$GMI_{NE} = 0.15P_{10} + 0.30P_{11} + 0.30P_{12} + 0.25P_1$$

where:

GMI_{SW} = the GMI for the southwest monsoon

GMI_{NE} = the GMI for the northeast monsoon and,

P_i = the rainfall in the ith month (i=1 for Jan, i=2 for Feb, etc.)

The rainfall is weighted such that 15 percent of the monsoon rainfall is assumed to precipitate during the first month (June/October), 25 percent during the second month (July/November) and so on. The index values are expressed in percentiles or as a percentage of normal for agroclimatic regions. The Generalized Monsoon Index provides information on rainfall conditions during the monsoon season and serves as a good indicator of potential irrigation supplies.

R-Index

The R-Index was developed by YAO (1969) and is defined as the ratio of AET to PET or:

$$R = AET/PET.$$

The index ranges from 0 to 1. Values near zero indicate extreme moisture stress while values near unity indicate no stress. The index can be used in crop condition assessments and also as a tool for land use studies. For example,

YAO (1973) used the R-Index to demonstrate that groundnuts could not be grown in Tanzania due to drought vulnerability. This simple agroclimatic analysis could have saved British investors several millions of U.S. dollars in 1948. Ravelo and Steyaert (1981) used the R-Index to estimate optimum crop calendars for Haiti and eliminate erroneous crop calendars cited in the literature.

Soil Moisture Index

Ravelo and Decker (1979) proposed a Soil Moisture Index (SMI) which is defined as:

$$SMI = PAW/PAW_{max}$$

where:

PAW is the plant available soil moisture, and

PAW_{max} is the maximum plant available soil moisture.

The SMI is defined for values ranging from zero to 1. The SMI has been used by AISC as a crop condition assessment tool.

The Z-Index

Monthly temperature and precipitation are used in an algorithm that derives the Z-Index, defined as:

$$Z = d\ (K)$$

where:

$$d = P - \hat{P}$$

is the observed precipitation while $\hat{P}$ is the "climatically appropriate" precipitation. $\hat{P}$ is further estimated by:

$$\hat{P} = \hat{ET} + \hat{R} + \hat{RO} - \hat{L}$$

Evapotranspiration (ET), recharge (R), runoff (RO), and Loss(L) are obtained by multiplying the potential value (PET, PR, PRO, PL) by the coefficients (A, B, C, D,) which are the ratio of average ET, R, RO or L by its average potential values, respectively; that is $A = \overline{ET}/\overline{PET}$, $B = \overline{R}/\overline{PR}$, $C = \overline{RO}/\overline{PRO}$, and $D = L/PL$. For example, to estimate ET, $ET = A(PET)$.

Palmer Drought Index

The Palmer Drought Index (PDI) is an important application of the Palmer two-layer soil moisture model (1965). This provides information on the duration and intensity of drought. The PDI is designed to monitor both dry and wet periods. The index values are scaled such that negative values indicate drought and positive values indicate wet conditions; an index value of zero indicates normal conditions. Table 3.4 shows the index categories for wet and dry periods.

Interpretation of Indices

Indices can be computed from historic data over a 15-30 year period and expressed in several forms: raw value, percent of normal and percentile. The indices must be tested and evaluated to determine how each should be interpreted and the potential for use as an operational index to monitor general agricultural conditions. The threshold values for the indices can be established by using available historic yield data and/or episodic event data These are used to identify the weather impact years and the critical values of the index associated with, for example, normal crops, moderate drought impact on crops (slightly below normal yields), drought impact on crops (reduced yields) and severe drought impact on crops (drastically reduced yields or crop failure). The index values for such years will be considered as a threshold value for each category.

Decisions should be made on which index or indices will be appropriate for an area of interest or for a particular purpose. Guidelines for determining the appropriate methods are discussed in following chapters. The assessment then can be made by calculating the indices using the observed weather data, interpreting the index values in terms of similar values in the historic record and evaluating the results along with other information. The indices are mainly

Table 3.4 Palmer Drought Index Classes for Wet and Dry Period

INDEX	CHARACTER OF RECENT WEATHER
> 4.00	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient drought
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
< -4.00	Extreme drought

useful in assessing drought impact on agricultural crops, not the flooding impact or crop conditions in irrigated areas. Drought causes physiologic damage to a crop. Excessive moisture due to flooding can cause physical and also physiologic damage. Thus, flooding is a more complex assessment problem. Also, wind damage is sometimes associated with floods.

C. Application of Agroclimatic Tools

These agroclimatic tools can be used to develop agroclimatic assessment models including: 1) drought early warning and crop condition assessment, 2) crop monitoring to determine irrigation scheduling requirements and 3) land and water resource management applications. Examples of these models and their applications are provided in this report.

CHAPTER IV

ANALYTIC RESULTS

A. Overview

Four major types of agroclimatic analyses for the Bicol and Visayas Regions were performed including: 1) investigating and evaluating various methods for estimating potential evapotranspiration, 2) estimating soil moisture and calculating the Palmer Drought Index, 3) developing historic/crop condition indices for use in assessments and 4) developing preliminary statistical climate/crop yield models for lowland rice and coconut for the Bicol and Visayas Regions, respectively. Discussion in this chapter focuses on PET results. The agroclimatic/crop condition indices and statistical modeling results are discussed in Chapter V.

1. Potential Evapotranspiration

The methods used for estimating PET discussed in Chapter III were applied to data sets from synoptic weather stations representing the Bicol and Visayas Regions; the main objective of this analysis was to determine which method was "appropriate" for estimating PET for these regions. Another objective was to determine if PET normals can be used instead of individual monthly values.

2. Soil Moisture, Z-Index and the PDI

The results of the PET analysis were used to estimate soil moisture using the Palmer two-layer model and then to calculate the Z-Index and Palmer Drought Index. The soil moisture estimates are integral to the assessment program. The Z-index depicts soil moisture anomalies in an area and appears to explain more variations on crop conditions. The PDI shows promise as a potential index for monitoring climatic conditions (both drought and flooding situations) at individual stations.

3. Agroclimatic/Crop Condition Indices

The indices used in the assessment study for Bicol and Visayas Regions were the Yield Moisture Index and the Generalized Monsoon Index. The Yield Moisture Indices for all of the 13 synoptic stations representing the regions were derived using monthly normal rainfall, crop coefficients and crop calendars. The Generalized Moisture Index was based on the summation of weighted monthly precipitation during the periods when the southwest and northwest monsoons were prevalant in the area.

4. Statistical Models

Preliminary statistical models which were developed relating historical crop yield and climatic conditions require test and evaluation, and these models should be used with caution.

B. PET Results

Potential evapotranspiration was estimated at all 13 stations by the Thornthwaite, Hargreaves and Penman methods. The monthly mean values of PET and rainfall are provided in a separate appendix. The example plot for Daet in Figure 4.1 illustrates this analysis. Some of the conclusions include:

1) In all cases, PET estimates by the Penman method are the lowest in magnitude while those from the Thornthwaite method are highest.
2) PET estimates for the wet months are lower than those during dry months.
3) In most cases the variability of Hargreaves estimates in relation to rainfall variability is similar to the Penman results.
4) The maximum PET by Thornthwaite lags the minimum rainfall for all cases and all climatic zones.
5) It is evident that Thornthwaite's PET estimates tend to follow temperature variations rather than rainfall which is understandable since the only inputs to Thornthwaite's method are temperature and latitude.

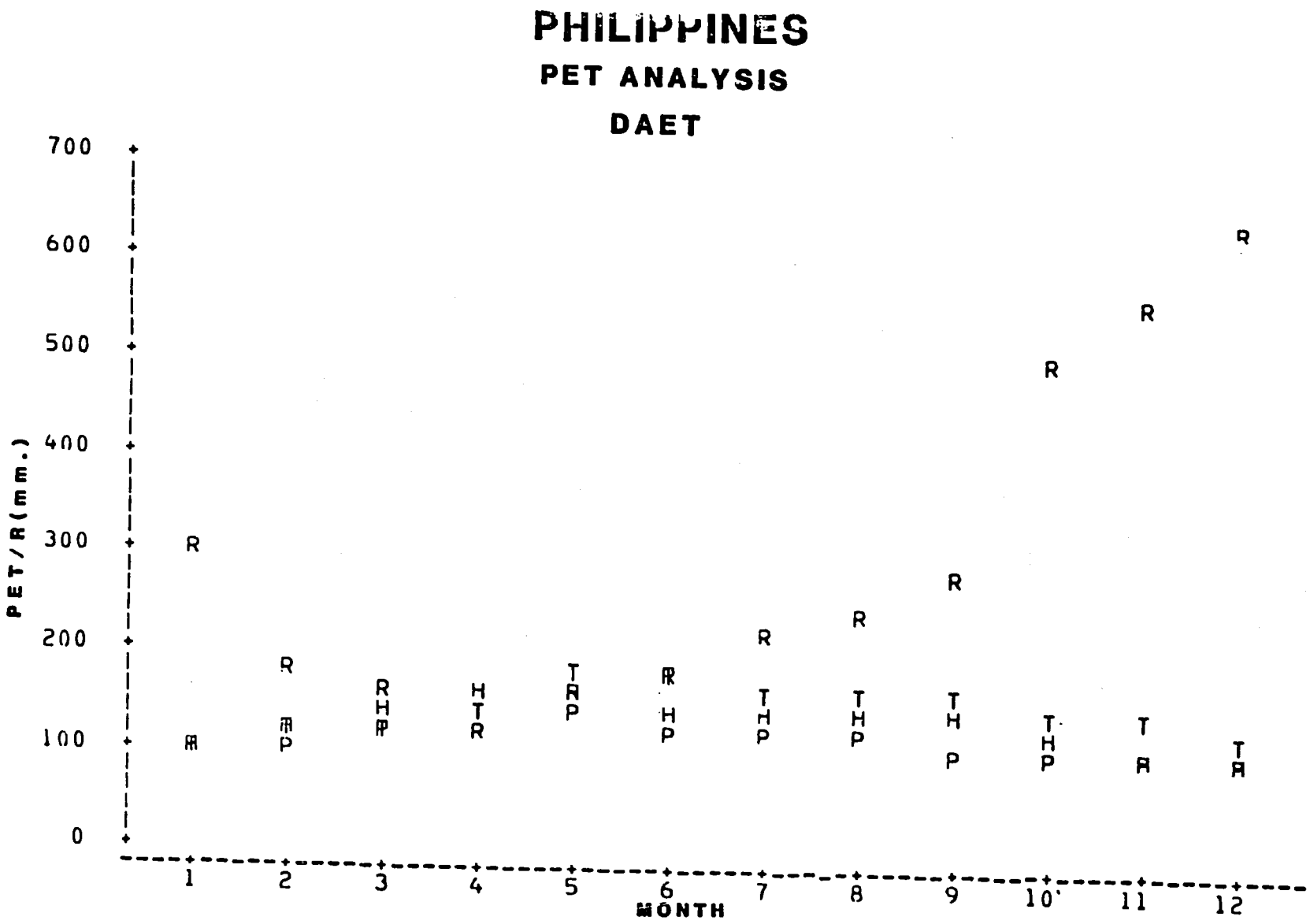


FIGURE 4.1 Potential Evapotranspiration Comparisons for Daet (P=Penman, T=Thornthwaite, H=Hargreaves and R=Rainfall).

6) In relatively dry areas such as those in climatic zones I and III, the monthly variability in PET is pronounced. Also, the PET estimates using Thornthwaite's method are larger in magnitude than Penman's or Hargreave's.

7) In all cases, the variability of monthly rainfall is very large compared to the variability of PET. For example, rainfall and PET statistics for Daet are shown in Table 4.1.

The question as to which of these three methods is most appropriate for operational use in the assessment program for the Bicol and Visayas Regions and whether monthly normal PET estimates can be used instead of actual monthly values will now be addressed.

First of all, pan evaporation data and basic information on actual potential evapotranspiration in any of the study areas is lacking for comparative purposes. For areas which have no dry months, like those belonging to Type II climatic zones, it is difficult to discern which of the three methods is most reliable as they are very close in magnitude. The variation between months is also small. However, an examination of PET estimates in areas with a distinct seasonal variation in rainfall, like those areas belonging to Types I and III climatic zones, shows a detectable sensitivity to rainfall variations. This is one of the key factors in determining the crop growing season. In this respect it appears that the Penman method followed by Hargreaves is more promising than Thornthwaite's, which is more sensitive to temperature variations.

Also, inferences from PET analysis for stations such as Dumaguete, which belong to Type III climate, suggest that Thornthwaite's method is not applicable for the Bicol and Visayas regions. For example, crops can generally be grown fairly well in Dumaguete. However, if we examine the graphical plot of rainfall

PHILIPPINES

PET AND RAINFALL STATISTICS

DAET

VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	VARIANCE
P1	20	306.5	136.4	63.0	570.5	18601.4
P2	20	177.1	114.6	31.0	403.9	13131.9
P3	20	157.5	107.6	40.7	415.2	11585.6
P4	20	123.7	80.8	19.0	294.9	6527.3
P5	20	158.1	143.8	1.0	472.7	20680.3
P6	20	183.5	104.5	49.2	451.1	10912.6
P7	20	212.4	97.1	57.8	480.7	9435.3
P8	20	242.5	138.4	69.1	569.0	19143.4
P9	20	270.8	89.5	126.6	415.8	8008.3
P10	20	505.7	179.8	287.2	931.9	32323.7
P11	20	565.1	296.3	233.5	1410.1	87806.8
P12	20	647.8	373.1	205.7	1480.1	139238.3
THORT1	20	109.2	9.1	83.8	122.5	83.4
THORT2	20	112.9	8.9	100.1	125.2	79.6
THORT3	20	126.0	8.8	110.0	137.8	77.5
THORT4	20	149.6	9.9	129.9	170.6	98.9
THORT5	20	172.2	13.3	141.8	198.0	177.7
THORT6	20	175.9	14.7	150.2	200.6	215.1
THORT7	20	165.0	9.5	148.0	185.1	90.2
THORT8	20	165.1	8.7	143.9	180.2	76.3
THORT9	20	157.4	8.7	137.8	170.7	76.0
THORT10	20	146.4	6.3	137.9	163.8	39.1
THORT11	20	137.6	9.1	120.7	152.7	82.1
THORT12	20	121.4	9.5	103.4	140.0	92.5
PENMAN1	20	94.2	8.0	83.1	111.2	63.2
PENMAN2	20	98.5	5.7	88.5	107.2	32.1
PENMAN3	20	121.8	7.4	110.6	137.1	54.3
PENMAN4	20	129.3	6.6	119.9	143.0	43.7
PENMAN5	20	133.7	8.4	111.9	153.7	71.2
PENMAN6	20	125.1	13.1	109.3	175.5	172.6
PENMAN7	20	121.6	10.7	109.3	155.9	115.0
PENMAN8	20	119.3	7.2	108.3	134.9	51.4
PENMAN9	20	108.1	5.8	98.1	120.0	33.9
PENMAN10	20	105.9	7.2	94.3	129.8	51.5
PENMAN11	20	97.6	9.5	83.0	115.4	90.4
PENMAN12	20	92.3	8.3	76.0	114.0	69.6
HARGRS1	20	104.7	7.7	90.9	120.2	59.4
HARGRS2	20	111.3	9.5	97.8	129.3	89.8
HARGRS3	20	142.9	8.3	128.0	158.7	68.3
HARGRS4	20	158.3	7.9	136.3	174.2	61.7
HARGRS5	20	165.1	12.6	141.6	189.3	157.6
HARGRS6	20	149.4	9.5	131.8	172.1	90.2
HARGRS7	20	143.0	8.0	124.4	155.5	64.4
HARGRS8	20	139.1	6.8	130.9	154.1	46.3
HARGRS9	20	131.6	5.7	122.7	143.1	32.5
HARGRS10	20	127.1	6.7	117.5	145.6	45.5
HARGRS11	20	109.4	6.3	100.8	118.8	39.5
HARGRS12	20	103.0	5.8	88.0	112.5	33.1

TABLE 4.1 Monthly PET (Thornthwaite, Penman and Hargreaves Methods) and Rainfall Statistics for Daet.

and PET for that station (Figure 4.2) it can be seen that at all times PET estimated by the Thornthwaite method exceeds available rainfall. This would certainly indicate that crops cannot be grown successfully in this area. The average annual PET values indicate that results from Penman's method were nearest the mean annual rainfall of Dumaguete. It is also apparent here, as in other areas investigated, that Penman's estimates respond well to rainfall both in time and in magnitude.

In addition, if we consider which of the three methods uses meteorological variables that determine potential evapotranspiration, the most "appropriate" method to be used should be that of Penman.

Since the variability of monthly PET estimates are quite small compared to the variability of monthly rainfall, normal monthly PET values can be used in estimating the soil moisture budget and in climatic diagrams.

C. Climatic Diagrams

Plots of the monthly normal PET values obtained by Penman's method, estimated actual evapotranspiration (AET) from the Palmer Soil Moisture Budget and mean rainfall at each of the 13 synoptic stations representing the Bicol and Visayas Regions are included in the Appendix. The climatic diagram for Daet is shown in Figure 4.3. These plots are referred to as climatic diagrams.

The climatic diagrams illustrate the general water supply (precipitation) and the water demand (AET); hence, general periods of water deficit or water surplus are indicated. This could be made more informative if mean soil moisture estimates are included. Such a diagram can also be made for any particular crop by using crop coefficients. This would be very useful in evaluating appropriate cropping patterns in an area. In order to make these user oriented, several variations could be made in the diagram presented including the time scale. It could be done on either a weekly, decadal or bi-monthly

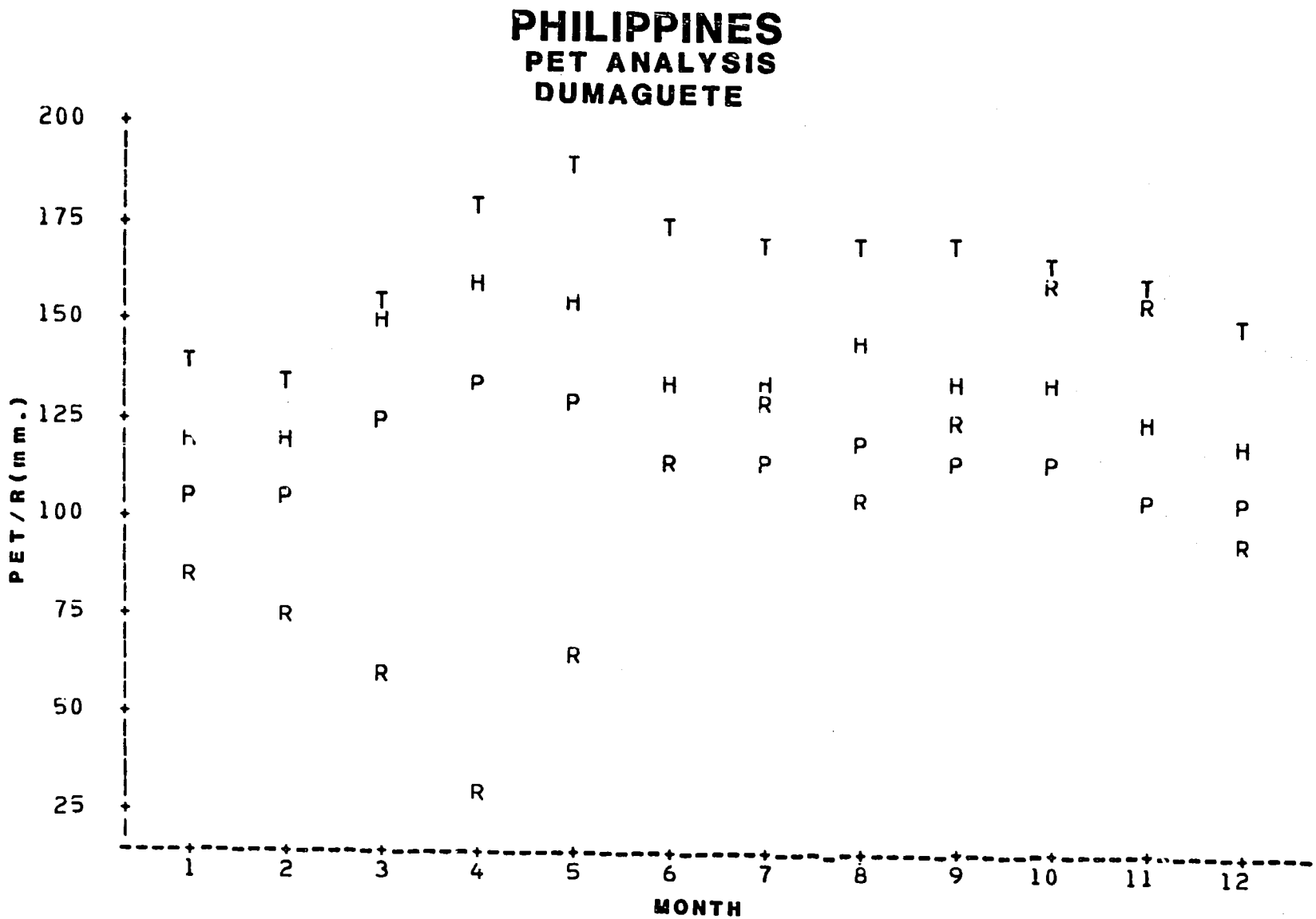


FIGURE 4.2 Potential Evapotranspiration Comparisons for Dumaguete (P=Penman, T=Thornthwaite, H=Hargreaves and R=Rainfall).

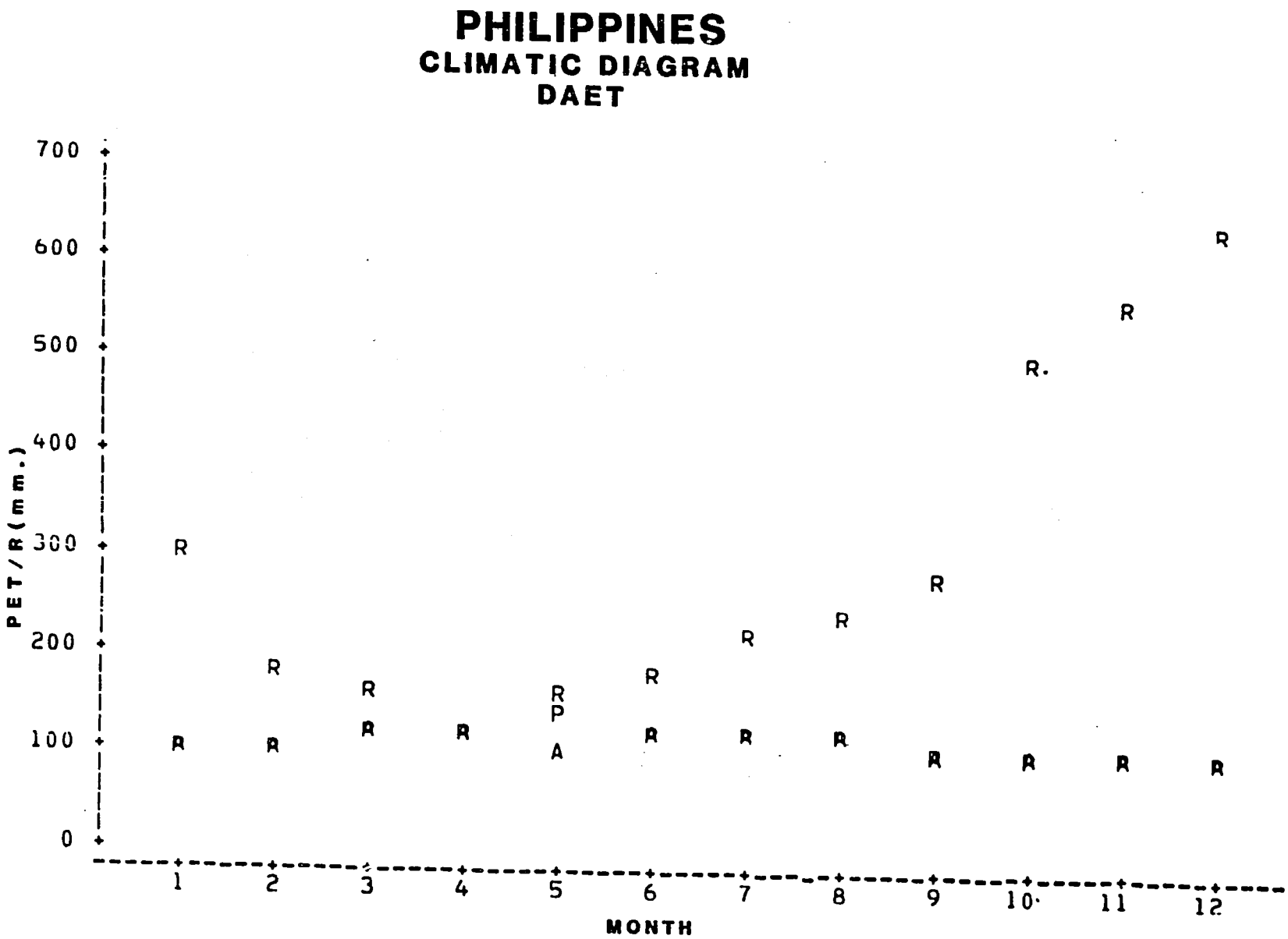


FIGURE 4.3 Climatic Diagram for Daet Showing Normal Precipitation (R), Potential Evapotranspiration (P) and Actual Evapotranspiration (A).

basis. This would depend on the assessment period that is being followed and the user's needs.

The climatic diagrams can be used along with other agroclimatic tools to assess climatic impact on crops or in land-use and water management studies. For example, the diagrams complement agroclimatic crop condition index models and statistical crop yield forecast models which are proposed for use in assessing climate impact on crops. There are also many different tools for application to land and water management problems. For example, the R-Index has been widely used in land suitability studies. The Moisture Availability Index (MAI) developed by Hargreaves has been used in land classification studies.

CHAPTER V

CLIMATIC IMPACT ASSESSMENT MODELING RESULTS

Climatic impact assessment models developed for Bicol and Visayas Regions include: 1) agroclimatic/crop condition indices for rice and maize, 2) statistical climatic/crop yield forecast models for paddy and annual coconut production and 3) soil moisture assessment procedures. These assessment models are based on relationships which reflect the biological (or agronomic) response of the crop to moisture and temperature anomalies during the growing season, particularly during the critical flowering/reproductive crop stages. These models would provide a firm foundation for assessing climatic impact on crops during the growing season. However, thorough testing and evaluation of these models should be done prior to making them operational.

This chapter includes information on the history of crop yield modeling, analytic steps for model development, discussion on the proposed assessment models for the Bicol and the Visayas Regions and suggestions for test and evaluation of the models.

A. Background

During the decade of the 1970's significant advances were made in the development and application of climatic impact assessment models for agriculture. The success of this applied model is associated with the increased availability of computers which permitted scientists to develop the models coupled with the critical need for climate impact information. Decision-makers, planners and economists have come to recognize that this approach can provide timely, reliable and yet inexpensive information concerning climatic impact on crop yields and agricultural production. It has become recognized that these models can supplement and complement other information sources, e.g., crop information

sources including farming and marketing reports, probability surveys involving area frame analysis, census, and demand side economic analysis to estimate production, among others.

Models are also being used to provide early warning of potentially disastrous food shortages resulting from severe drought. For example, the United Nations, Food and Agricultural Organization (UN/FAO) and the U.S. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service are two organizations involved in this type of effort. The NOAA program provides support to the Office of U.S. Foreign Disaster Assistance, Agency for International Development (AID/OFDA).

1. Types of Crop Yield Models

There are essentially three types of crop yield models: statistical climate/crop yield models, agroclimatic/crop condition index models and phenologic or "process" models.

The statistical model is based on multiple linear regression analysis using historic climatic data and crop yield. These models provide absolute yield forecasts. Statistical models have been developed or at least attempted for many regions in the world, particularly major grain producing areas. Some of the crops modeled include wheat, corn, barley, soybeans, sorghum/millet, rice, cotton, sunflower, flax, groundnuts, sesame, sugarcane, oil palm and others.

The second type of model is the agroclimatic/crop condition index based on historic climatic data. This approach has become increasingly popular for drought early warning assessments, to assess crop conditions and to obtain relative crop yield information. The index is based on an agroclimatic variable such as cumulative precipitation, PET, AET/PET, and/or soil moisture, which is directly associated with the year-to-year variations in crop yield. The index provides a measure of climatic impact on the crop, particularly in drought impact assessment.

The agroclimatic variable on which the index is based could be viewed as that predictor variable which would produce a statistically significant regression model, if reliable yield data were available. The choice of the proper agroclimatic variable can be determined by: 1) knowledge of those climatic conditions which determine yield in production regions where crops are rainfed, 2) information on the appropriate variables determined by regression analysis for similar regions and 3) episodic event data on the historical causes (both weather and non-weather factors) of crop failures or bumper crops. For example, published reports, newspaper articles, discussions with farmers and other sources of information can be used to assemble these qualitative accounts for many different years. Espisodic data can also be used to interpret or "calibrate" the indices for a particular region. For example, the index can be computed from 20-30 years of historic climatic data and plotted as a time-series. The values of the index are entirely relative and can be expressed in raw numbers, percent of normal, percent of some base year, percentiles, standard deviations, etc. Episodic reports on the failure of crops due to drought may suggest for example, that "historically crop failure is associated with index values which are below the 20th percentile or equivalently 60 percent of normal."

2. Applications

The statistical crop models and the agroclimatic/crop condition index models which were developed are primarily drought impact models. Excessive moisture or flooding conditions are usually quite difficult to model. However, a skilled analyst can use the models to provide very useful crop yield information. The capabilities (when the model works) of the model must be considered when interpreting the output of the model.

Statistical climate/crop yield models can be used for other applications. For example, long-term records of climatic data can be used to simulate yield beyond the period of record for observed yield data. Yield is an integrator of climate and the model converts climate data into simulated yield. Simulated yields can be used to determine the risk of crop failure, estimate probabilities of crop failure (2 or 3 consecutive years, etc.), estimate various probabilities for simultaneous crop failure in two or more regions and in the analysis of climatic trend. For example, an often overlooked fact is that trends in yield or production can also be associated with long-term trends in rainfall. Sometimes trend in yield due to climate trend can also be associated with trend in yield due to improved technology or decreased soil fertility.

Steyaert, Ravelo and Achutuni (1979) used a statistical crop yield model to investigate the vulnerability of maize to drought in Haiti due to soil erosion. They found that soil erosion (associated with deforestation) and the reduced water holding capacity of the soil resulted in increased vulnerability of corn to drought, i.e., shallow soils cannot store enough water to carry the crop through dry spells.

Crop yield models can be important tools for land use studies or analysis of impact of climatic change. (What happens to yield if rainfall decreases by 50 percent?) The models can increase awareness and knowledge about those climatic conditions which affect yield. Finally, the models can in some cases be used as a basis for farmers advisories, e.g., recommended planting date, irrigation scheduling and fertilizer applications (Steyaert et al, 1981).

B. Analytic Steps to Development of Statistical Models

Year-to-year changes in crop yield can be caused by weather events (typhoons, floods, etc.), climate (drought, anomalously "wet" years, low solar radiation, etc.), management decisions (planting date, weed and pest control,

water control, etc.), and/or technology (variety, fertilizers and pesticide applications, irrigation, etc.). These factors plus the soil determine the potential yield. Trends in yield can be associated with either changes in technology (e.g., increased technology impact each year), trend in climate or both.

The above factors suggest the need for several types of data bases: meteorological, crop statistics (area, yield and production), technology data and episodic data as previously described. Detailed information on crop calendars and agricultural practices are also necessary.

The first requirement is to assemble the available data and thoroughly perform quality control checks. The reliability and adequacy of meteorological and yield data must be determined.

The modeler must become very familiar with agricultural practices and the factors which cause yield variability. The candidate predictor variables, role of technology and significance of decadal, monthly or seasonal predictor variables must be determined.

In the traditional statistical climate/crop yield models, the basic predictor variables are monthly precipitation, temperature or derived indices (such as PET, YMI and GMI). If technology has caused a time trend in yield, a time (or year) term has traditionally been used as a surrogate variable for technology. The time trend variable can be included as a predictor variable in the model development.

Scatter diagrams and linear correlations are used to select preliminary predictor variables which must be statistically related to yield as well as biologically related to crop. Linear regression analysis is used to develop the model. The final models must be tested and evaluated for calibration and for further improvement.

Some of the advantages and disadvantages of statistical climate/crop yield models include:

Disadvantages

1. They use a fixed crop calendar, i.e., it is assumed that the crop stages occur at the same time each year. Therefore, if a delay in planting occurs, the model may not be able to respond.
2. Monthly data are often used. Crops are also responsive to more frequent changes in the weather or climate.
3. Shorter period weather phenomena, especially episodes such as extreme temperatures, high winds, floodings, or typhoons cannot be modeled well.
4. Episodes usually do not occur frequently enough to do a quantitative analysis.
5. Regression models tend to predict "close to the mean yield" and do not predict extremes very well. The models should not be used to predict independently outside of the range data used to build the model.
6. The models use a linear time trend as a surrogate to technology. If not objectively specified, the trend term can be very misleading in the development and use of the model. Linear trend is used because the technology data are generally not available or are of low quality. Furthermore no one has devised an operational statistical model based on combined weather and technology data.
7. Further climate/crop relationships may change from historical relationships used to develop the model. For example, varieties could change such as traditional varieties to high yielding varieties. The climatic responses could be different.

Advantages

1. These models are based on the statistical/agronomic/physical significance between the climatic data and crop yield data. Physical significance means that any weather or climatic variable used in the model has a high degree of biological relationship with known effect on the crop.

2. Models represent straightforward relationships that make minimal assumptions and permit the yield data and climatic data to define the model according to historical interrelationships. They make the maximum use of historical climate data and yield which is an integrator of climate.

3. The models are inexpensive to operate and can produce useful information, particularly if they are evaluated according to strengths and weaknesses along with other crop yield or crop condition forecast procedures, e.g., index models.

C. Agroclimatic/Crop Condition Indices

Agroclimatic crop condition indices based on the Generalized Monsoon Index (GMI) and Yield Moisture Index (YMI) were developed for assessing drought impact. The YMI for maize and rice and the GMI were calculated for each of the 13 synoptic stations representing the Bicol and Visayas Regions. Both indices will be used in preparing climatic impact assessments. Each index is described below.

The monthly rainfall data (P1=Jan, P2=Feb, etc.) for 1979 and the associated sample means from the period of record (NP1=Jan, NP2=Feb, etc.) at the meteorological stations for 1976 are indicated in Table 5.1. These data are also listed by station (1950-1981) and used to develop the agroclimatic indices.

PHILIPPINES

OBSERVED AND NORMAL PRECIPITATION (MM.) BY STATIONS

COUNTRY=PHILIPPINES YEAR=1976

REGION	STATION	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
BICOL	DAET	259	119	121	94	415	273	178	181	127	369	980
BICOL	LEGASPI	669	161	252	105	423	209	155	391	215	275	410
BICOL	MASBATE	139	88	98	36	300	201	100	181	148	94	218
BICOL	VIRAC	317	165	240	66	806	347	223	366	141	215	517
CENTRAL VISAYAS	CEBU	18	116	91	166	42	-1	32	164	275	214	175
CENTRAL VISAYAS	DUMAGUETE	146	44	60	29	72	133	111	62	103	211	259
CENTRAL VISAYAS	TAGBILARAN	122	81	56	64	68	173	52	153	82	126	215
EASTERN VISAYAS	BORONGAN											
EASTERN VISAYAS	CATARMAN	61T	37T	37T	10T	30T	27T	10T	13T	13T	20T	57T
EASTERN VISAYAS	CATBALOGAN	201	444	259	353	101	35	72	188	337	130	287
EASTERN VISAYAS	TACLOBAN	213	291	200	396	133	58	214	118	280	111	82
WESTERN VISAYAS	ILOILO	46	32	26	21	315	217	509	387	331	174	132
WESTERN VISAYAS	ROXAS CITY	33	26	30	13	165	141	144	299	138	237	367

REGION	P12	NP1	NP2	NP3	NP4	NP5	NP6	NP7	NP8	NP9	NP10	NP11	NP12
BICOL	1021	343	194	163	131	148	178	216	246	255	502	607	628
BICOL	845	324	201	205	168	198	215	246	276	242	311	494	539
BICOL	1036	184	83	68	54	107	144	171	186	205	216	221	248
BICOL	610	223	133	120	123	196	234	218	186	239	400	479	436
CENTRAL VISAYAS	190	123	87	89	72	88	119	151	189	190	171	180	166
CENTRAL VISAYAS	103	81	70	60	39	77	133	144	113	130	169	170	118
CENTRAL VISAYAS	131	111	88	81	66	82	143	124	110	128	177	196	113
EASTERN VISAYAS		601	419	315	270	326	223	220	216	193	297	587	691
EASTERN VISAYAS	91T	414	247	212	158	143	187	198	159	202	369	507	509
EASTERN VISAYAS	231	261	191	209	161	166	140	182	261	234	264	277	295
EASTERN VISAYAS	93	230	247	206	187	148	135	138	153	153	161	201	228
WESTERN VISAYAS	100	46	24	29	45	122	258	302	341	263	252	173	101
WESTERN VISAYAS	267	109	53	70	54	140	259	259	237	235	333	244	188

TABLE 5.1 Observed (P1,P2, etc.) and Normal (NP1,NP2, etc.) Station Rainfall (mm.) for 1976. Data are Similarly Listed for Other Years. Data are Also Listed by Individual Station and All Years in the Period of Record, 1951-1980.

1. Generalized Monsoon Indices

Two types of GMI's were developed; the GMI for the southwest monsoon and the GMI for the northeast monsoon. The southwest monsoon GMI is based on June through September monthly precipitation data. The weights for each month are 0.15 for June, 0.25 for July, 0.40 for August and 0.20 for September. The index is accumulated for each month. Assessments are made at the end of each month.

The northeast GMI is based on the monthly precipitation from October through January. The weights for each month are 0.15 for October, 0.30 for November, 0.30 for December and 0.25 for January. The index is similarly accumulated at the end of each month.

Table 5.2 shows the normal values, the percentages of normal and percentile ranking of the monthly accumulated GMI for each year at Daet. The GMI is expressed in millimeters at the end of each time period (GMI_P6, GMI6_7, GMI6_8, and GMI6_9) for the southwest monsoon GMI. The normal GMI values for each period represented by NGMI_P6 at the end of June, NGMI6_7 at the end of July, etc., are indicated. The percent normal GMI for each period is expressed as PNGMI_P6 for June, PNGMI6_7 for July and so forth, while the percentile variable is PLGMI_P6 for June, PLGMI6_7 for July, etc.

The GMI was expressed in percentiles at the end of each accumulation (end of June, end of July, etc.,). It was then plotted for each synoptic station as a time series for the period of record since 1951 (separate Appendix). For example, the GMI percentiles at the end of June, July, August and September for Cebu in the Central Visayas Region are shown in Figure 5.1. The GMI for each accumulation is below the 20th percentile during 1968 and 1972. This implies drought conditions during the growing seasons in these years. It is interesting to note that some of the features in the variations of the GMI's are common at a number of stations. This would also suggest the spatial extent of the climatic

G E N E R A L I Z E D M O N S O O N I N D E X
(S O U T H W E S T)

GMI COEFFICIENTS:

WEIGHT6 = .15 / JUNE
WEIGHT7 = .25 / JULY
WEIGHT8 = .40 / AUGUST
WEIGHT9 = .20 / SEPTEMBER

---------- COUNTRY=PHILIPPINES REGION=CENTRAL VISAYAS STATION=CEBU ----------

YEAR	GMI P6	NGMI P6	PNGMI6	PLGMI6	GMI67	NGMI67	PNGMI67	PLGMI67	GMI68	NGMI68	PNGMI68	PLGMI68	GMI69	NGMI69	PNGMI69	PLGMI69
1951	32	18	181	74	89	56	160	84	145	131	111	66	205	169	121	69
1952	38	18	211	88	113	56	204	96	286	131	215	96	334	169	198	96
1953	35	18	194	81	70	56	125	53	128	131	93	46	169	169	100	53
1954	35	18	196	81	91	56	164	89	172	131	131	79	247	169	146	93
1955	20	18	109	59	72	56	130	58	131	131	100	49	172	169	102	61
1956	38	18	211	88	93	56	163	93	186	131	142	89	209	169	124	73
1957	19	18	106	54	78	56	141	64	150	131	114	69	163	169	97	49
1958	8	18	42	34	42	56	75	38	112	131	85	36	128	169	76	26
1959	12	18	66	48	78	56	140	64	181	131	135	83	231	169	137	86
1960	32	18	176	74	84	56	152	76	162	131	123	73	218	169	129	81
1961	25	18	138	63	88	56	155	79	118	131	90	43	149	169	88	41
1962	27	18	148	68	79	56	143	69	212	131	162	93	240	169	142	89
1963	19	18	108	54	83	56	149	73	171	131	130	76	218	169	129	81
1964	27	18	150	68	89	56	161	84	116	131	85	39	149	169	98	41
1965	43	18	241	94	65	56	117	49	138	131	105	63	151	169	89	46
1966	2	18	10	11	17	56	30	21	86	131	66	19	125	169	74	19
1967	6	18	36	28	8	56	14	4	35	131	27	3	72	169	43	3
1968	1	18	5	6	15	56	27	16	79	131	60	16	103	169	61	6
1969	3	18	17	18	13	56	24	13	74	131	55	11	139	169	82	33
1970	12	18	66	48	42	56	75	38	195	131	141	86	216	169	128	76
1971	10	18	56	43	28	56	50	29	93	131	71	26	126	169	74	23
1972	3	18	14	18	9	56	15	9	68	131	52	6	109	169	64	9
1973	5	18	30	23	53	56	95	43	93	131	71	26	112	169	65	13
1974	8	18	47	34	17	56	30	21	134	131	102	54	171	169	101	56
1975	2	18	13	11	56	56	101	46	136	131	104	59	182	169	107	66
1976	0	18	-1	3	8	56	14	4	74	131	55	11	129	169	76	29
1977	9	18	53	39	25	56	45	26	93	131	71	26	119	169	70	16
1978	6	18	33	28	33	56	60	33	134	131	102	54	172	169	102	61
1979	43	18	242	94	72	56	130	58	110	131	84	33	145	169	86	36
1980	-	18	-	-	-	56	-	-	-	131	-	-	-	169	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5.2 Historical GMI (Southwest) Values for Cebu in Bicol Region.

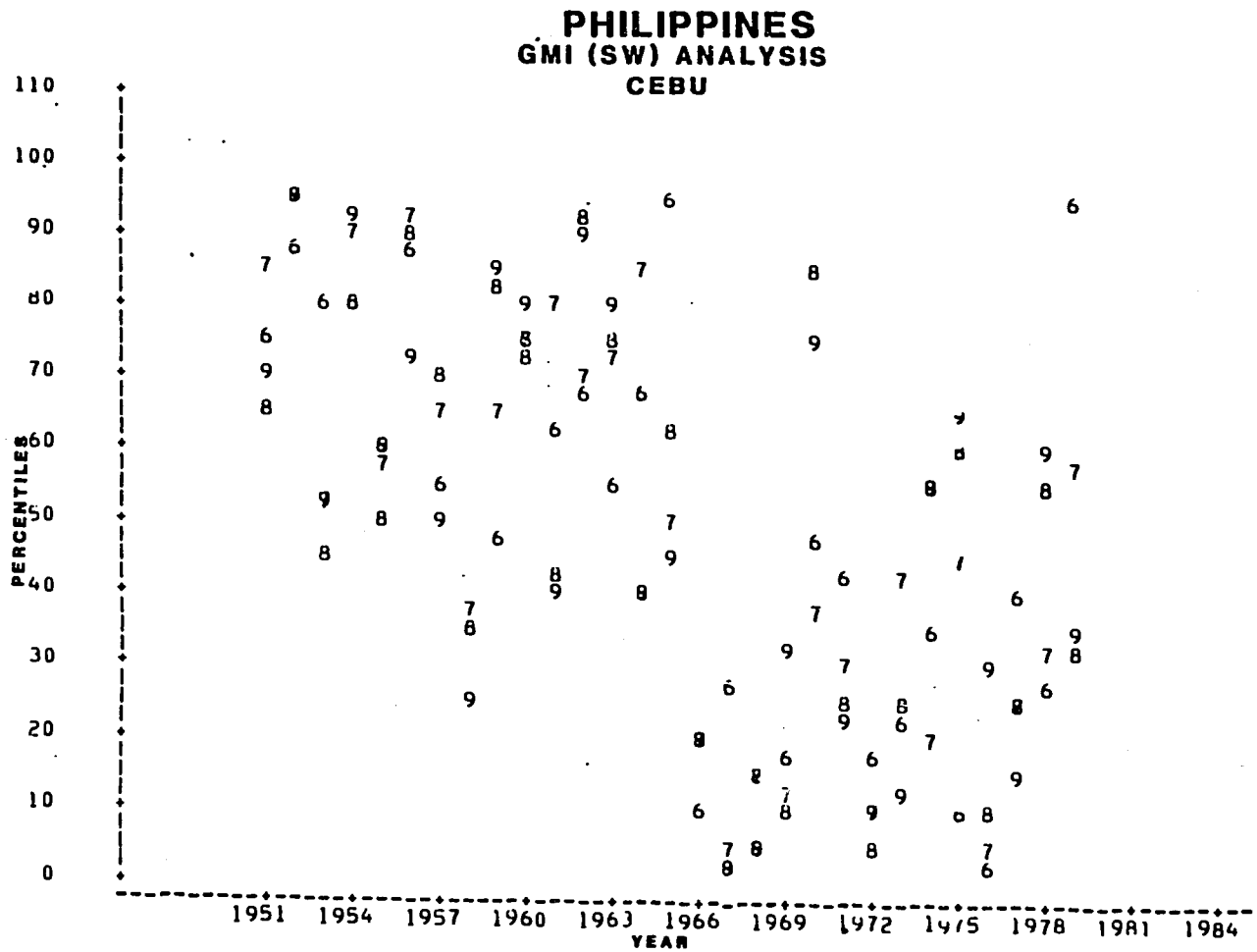


FIGURE 5.1 GMI (Southwest) Percentile Ranks for Cebu in Central Visayas where "6" is the GMI in Percentiles at the end of June , "7" is the GMI Percentiles at the end of July, "8" is the GMI Percentiles at the end of August, and "9" is the GMI Percentiles at the end of September.

event. Episodic event data can be used to verify these conditions and possibly interpret the index according to crop impact. The GMI is primarily designed to assess drought impact. However, GMI values above the 80-90th percentiles may be indicative of flooding conditions. These also need to be verified.

The preliminary criteria for the critical thresholds to interpret the GMI could be: 1) 90-100th percentile range for possible excessive moisture; 2) 60-90th percentile range for possible above normal crops, 3) 40-60th percentile range for normal crops, 4) 30-40th percentile range for moderate drought impact on crops, 5) 20-30th percentile range for drought impact on crops and 6) somewhere in the 0-20th percentile range for severe drought impact indicating crop failure.

2. Yield Moisture Index (YMI)

The YMI was determined for maize and rice using crop calendar information, estimated crop coefficients and monthly rainfall data from the 13 synoptic weather stations in the Bicol and Visayas Regions. YMI for other crops can also be computed, particularly those susceptible to drought. AISC has usually defined the YMI for short-cycle crops such as rice, maize, beans, sorghum and millet that are vulnerable to drought. Long-cycle, drought resistant crops such as cassava and cow peas are not easily assessed by this index technique.

The YMI is analogous to the GMI; however, the YMI is crop specific whereas the GMI pertains to general crop conditions for crops planted at the beginning of the southwest or northeast monsoons and dependent on the monsoon for growing season rainfall.

3. YMI/Maize

The YMI for maize was defined by the estimated crop coefficient at each crop stage and the corresponding monthly precipitation. The cropping calendars in the Bicol and Visayas Regions, discussed earlier, are determined from agroclimat-

ic zones. There are four agroclimatic zones in the study area, hence there are four crop calendars for maize for each dry and wet season crop. The preliminary crop coefficients for each crop stage are 0.65 for planting, 1.05 for vegetative growth and 0.75 for flowering/reproductive (Table 5.3a). The YMI is accumulated at the end of each stage. Results of the computations for each of the 13 synoptic stations are shown in the Appendix. Table 5.3b shows the YMI for maize at Cebu (1951-1979). The index is expressed in millimeters at the end of planting (YMI_5), vegetative (YMI_6) and flowering (YMI_7). "Normal" (or sample mean) values of the YMI determined from the period of record at each station are indicated, e.g., NYMI_5 at planting. The percent of normal values (PNYMI_5 at the end of planting, etc.) are indicated. The percentile value for each crop stage are provided (e.g., PLYMI_5 for planting). The index value and its relationship to potential drought impact on the crop becomes more reliable at the end of flowering.

In the percentile ranking graphical plot, for example in Cebu (Figure 5.2) for wet season maize, the months considered for YMI computations are May (planting), June (vegetative growth) and July (flowering/reproductive growth). These are plotted as 5, 6, and 7, respectively. In 1969 and 1972, the accumulated percentile ranking at all levels (5,6, and 7) are below 20th percentile. These suggest drought conditions during those years for the wet season maize in Cebu.

4. YMI/Rice

An approach similar to YMI/Maize was used in the determination of YMI/Rice. The computation was mainly based on the crop coefficents at different growth stages and cropping calendars at respective stations. The crop coefficients used for rice at the planting stage is 0.85, vegetative growth 0.95, flowering/reproductive stage 1.05, and maturity stage 0.95 (Table 5.3a). The

Table 5.3a: Estimated Crop Coefficients Used in Defining the Yield Moisture Index for Rice and Maize Crops in the Bicol and Visayas Regions.

CROP	SEASON	CROP COEFFICIENTS (KC)				
		PLANTING	VEGETATIVE	LATE VEGETATIVE	FLOWERING	MATURITY
RICE	LOWLAND FIRST	.85(T)	.95	———	1.05	.95
RICE	LOWLAND SECOND	.85(T)	.95	1.05	.95	.90
RICE	UPLAND	.85	.95	———	1.05	.95
MAIZE	DRY	.65	1.05	———	.75	———
MAIZE	WET	.65	1.05	———	.75	———

T=Transplanting

Y I E L D M O I S T U R E I N D E X

CROP COEFFICIENTS:

KC5 = .65/ PLANTING /MAY
KC6 = 1.05/ VEGETATION /JUNE
KC7 = .75/ FLOWERING /JULY

---- COUNTRY=PHILIPPINES REGION=CENTRAL VISAYAS STATION=CEBU CROP=MAIZE SEASON=WET ----

YEAR	YMI_5	NYMI_5	PNYMI_5	PLYMI_5	YMI_6	NYMI_6	PNYMI_6	PLYMI_6	YMI_7	NYMI_7	PNYMI_7	PLYMI_7
1951	152	57	267	93	378	182	208	86	547	295	185	89
1952	132	57	232	89	397	182	218	93	624	295	211	96
1953	76	57	133	69	318	182	174	76	424	295	144	73
1954	79	57	138	73	324	182	178	83	492	295	167	83
1955	55	57	97	59	192	182	105	59	349	295	118	56
1956	173	57	303	96	436	182	240	96	604	295	204	93
1957	14	57	24	16	147	182	80	49	324	295	110	49
1958	92	57	161	83	145	182	79	46	249	295	84	43
1959	69	57	120	63	151	182	83	53	349	295	118	53
1960	37	57	64	43	257	182	141	69	416	295	141	69
1961	83	57	146	76	256	182	141	66	446	295	151	76
1962	54	57	95	56	240	182	132	63	398	295	135	66
1963	53	57	93	49	188	182	103	56	378	295	128	59
1964	123	57	215	86	311	182	171	73	498	295	169	86
1965	21	57	37	29	323	182	177	79	388	295	131	63
1966	52	57	90	46	64	182	35	23	109	295	37	23
1967	35	57	61	39	80	182	44	29	84	295	28	16
1968	19	57	32	26	24	182	13	6	67	295	23	13
1969	9	57	17	13	31	182	17	16	61	295	21	9
1970	15	57	26	19	98	182	54	36	189	295	64	39
1971	54	57	94	53	125	182	68	43	178	295	60	33
1972	9	57	16	9	27	182	15	9	47	295	16	3
1973	75	57	131	66	112	182	61	39	254	295	86	46
1974	15	57	26	23	74	182	40	26	99	295	33	19
1975	6	57	10	3	21	182	12	3	184	295	62	36
1976	27	57	48	33	28	182	15	13	52	295	18	6
1977	30	57	53	36	97	182	53	33	144	295	49	29
1978	6	57	10	6	47	182	26	19	128	295	43	26
1979	91	57	160	79	394	182	216	89	481	295	163	79
1980	-	57	-	-	-	182	-	-	-	295	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5.3b Historical Yield Moisture Index Analysis for the Dry Season Maize Crop at Cebu in Central Visayas Region.

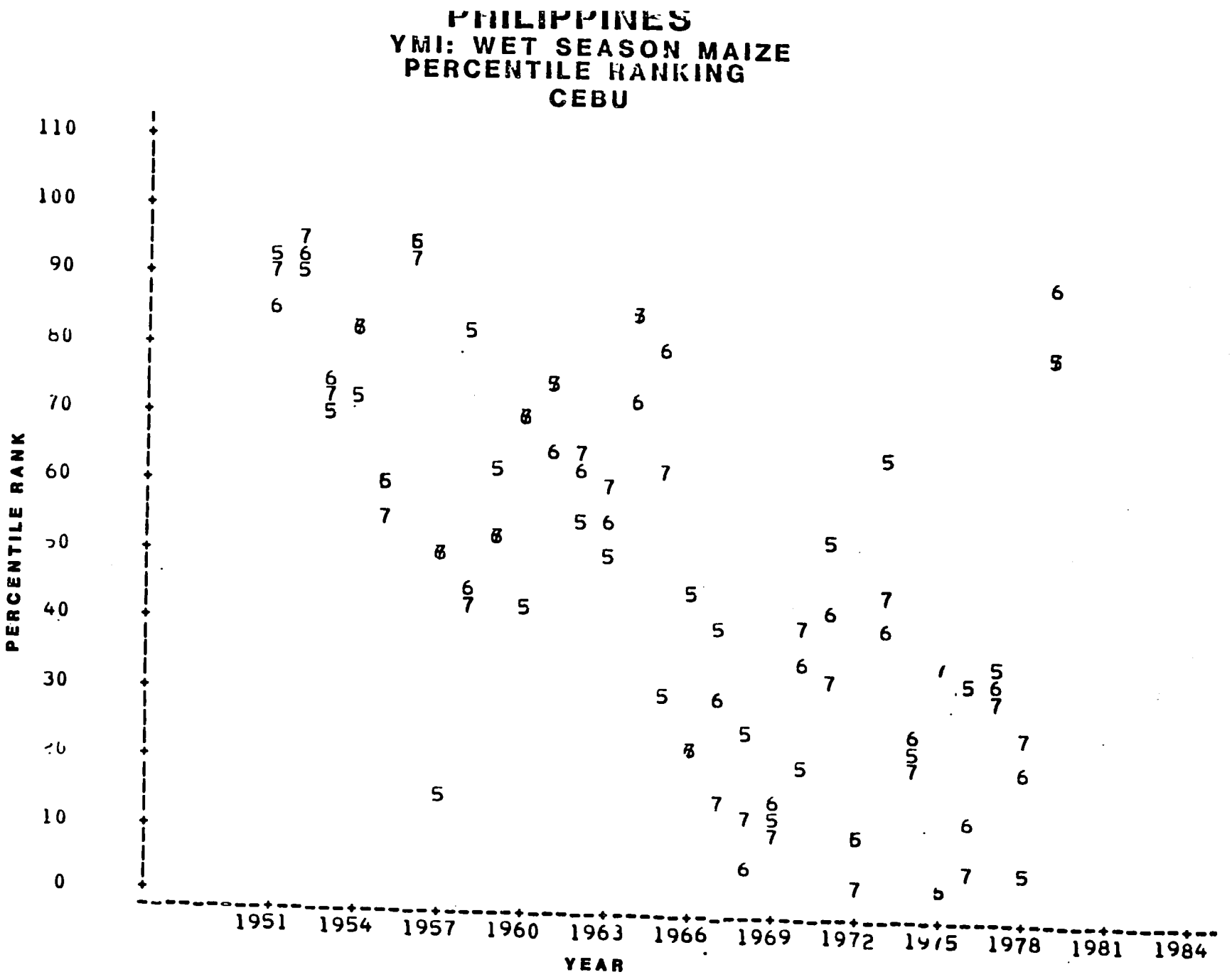


FIGURE 5.2 Historical Percentile Rankings of Wet Season Maize in Cebu (Rankings: 4=April, 5=May and 6=June).

results of the YMI computations for each of the 13 stations are shown in the Appendix. Table 5.4 and Figure 5.3 show the YMI computations and the YMI plotted in percentiles, respectively, for the lowland first rice crop at Daet in the Bicol region. Table 5.5 shows the YMI for this crop at all stations during 1975.

In the YMI lowland first rice crop (Table 5.4) the YMI at end of planting (June) is presented as YMI_6; end of vegetative growth YMI_7, etc.; normal YMI at end of planting NYMI_6; end of vegetative growth NYMI_6 etc.; percentage of normal YMI at end of each stage is presented as PNYMI_(6,7,8 or 9); and percentile ranking YMI at the end of each stage is presented as PLYMI_(6,7,8 or 9). Essentially the analysis and evaluation of the YMI/Rice is the same as for YMI/Maize.

D. Soil Moisture Assessments

The Palmer two-layer soil moisture budget model was used to estimate soil moisture at the 13 stations in the study area. The Penman method was used to estimate normal PET for input in the monthly soil moisture budget. The Appendix contains the results of this analysis and Table 5.6 shows the soil moisture budget for Daet.

The R-Index (AET/PET), Soil Moisture Index (SMI) and the Palmer Drought Index (PDI) were also calculated at these 13 stations in the Philippines. However, test and evaluation must be performed. Specifically, this analysis assumes a maximum available water capacity (AWC) of 100.4 mm in the soil profile. The implications must be carefully evaluated. Figure 5.4 shows the PDI for Daet.

E. Statistical Climate/Crop Yield Forecast Models

Preliminary statistical climate/crop yield models were developed for the first and second lowland paddy crops in the Bicol Region of the Philippines. These models require testing prior to operational use. Testing should include

Y I E L D M O I S T U R E I N D E X

CROP COEFFICIENTS:

KC6	=	.85/	PLANTING	/JUNE
KC7	=	.95/	VEGETATION	/JULY
KC8	=	1.05/	FLOWERING	/AUGUST
KC9	=	.95/	MATURITY	/SEPTEMBER

---- COUNTRY=PHILIPPINES REGION=BICOL STATION=DAET CROP=RICE SEASON=LOWLAND FIRST -----

YEAR	YMI 6	NYMI 6	PNYMI 6	PLYMI 6	YMI 7	NYMI 7	PNYMI 7	PLYMI 7	YMI 8	NYMI 8	PNYMI 8	PLYMI 8	YMI 9	NYMI 9	PNYMI 9	PLYMI 9
1951	122	151	81	42	381	356	107	60	585	615	95	42	834	857	97	53
1952	152	151	101	64	346	356	97	35	696	615	113	74	970	857	113	71
1953	195	151	130	71	355	356	100	42	545	615	89	32	640	857	75	10
1954	139	151	92	53	351	356	99	39	614	615	100	53	775	857	90	35
1955	68	151	45	14	274	356	77	21	630	615	102	64	836	857	98	57
1956	225	151	149	82	400	356	112	64	648	615	105	67	936	857	109	64
1957	53	151	35	10	356	356	100	46	626	615	102	57	759	857	89	28
1958	89	151	59	24	144	356	40	3	580	615	94	39	821	857	96	42
1959	118	151	78	35	269	356	76	17	380	615	62	7	506	857	59	3
1960	224	151	148	78	358	356	100	49	550	615	90	35	946	857	110	67
1961	42	151	28	3	203	356	57	10	504	615	82	17	839	857	98	60
1962	130	151	86	49	462	356	130	85	768	615	125	85	1130	857	132	89
1963	212	151	141	74	451	356	126	82	1048	615	171	96	1372	857	160	96
1964	383	151	254	96	593	356	157	96	803	615	131	89	1085	857	127	85
1965	121	151	80	39	320	356	90	32	699	615	114	78	974	857	114	74
1966	111	151	74	32	425	356	119	74	626	615	102	60	990	857	115	82
1967	111	151	73	28	215	356	50	14	535	615	87	28	829	857	97	49
1968	84	151	56	21	153	356	43	7	327	615	53	3	528	857	62	7
1969	76	151	50	17	292	356	82	24	415	615	68	10	653	857	76	14
1970	129	151	86	46	358	356	100	53	917	615	149	92	1211	857	141	92
1971	300	151	199	92	520	356	146	92	593	615	96	49	717	857	84	21
1972	140	151	93	57	294	356	82	28	496	615	81	14	762	857	89	32
1973	154	151	102	67	403	356	113	71	675	615	110	71	983	857	115	78
1974	272	151	180	89	436	356	122	78	531	615	86	24	729	857	85	24
1975	146	151	97	60	358	356	101	57	509	615	83	21	783	857	91	39
1976	232	151	154	85	401	356	113	67	591	615	96	46	712	857	83	17
1977	43	151	29	7	500	356	140	89	700	615	114	82	823	857	96	46
1978	-	151	-	-	-	356	-	-	-	615	-	-	-	857	-	-
1979	-	151	-	-	-	356	-	-	-	615	-	-	-	857	-	-
1980	-	151	-	-	-	356	-	-	-	615	-	-	-	857	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5.4 Historical Yield Moisture Index Analysis for the Lowland First Rice Crop at Daet in Bicol.

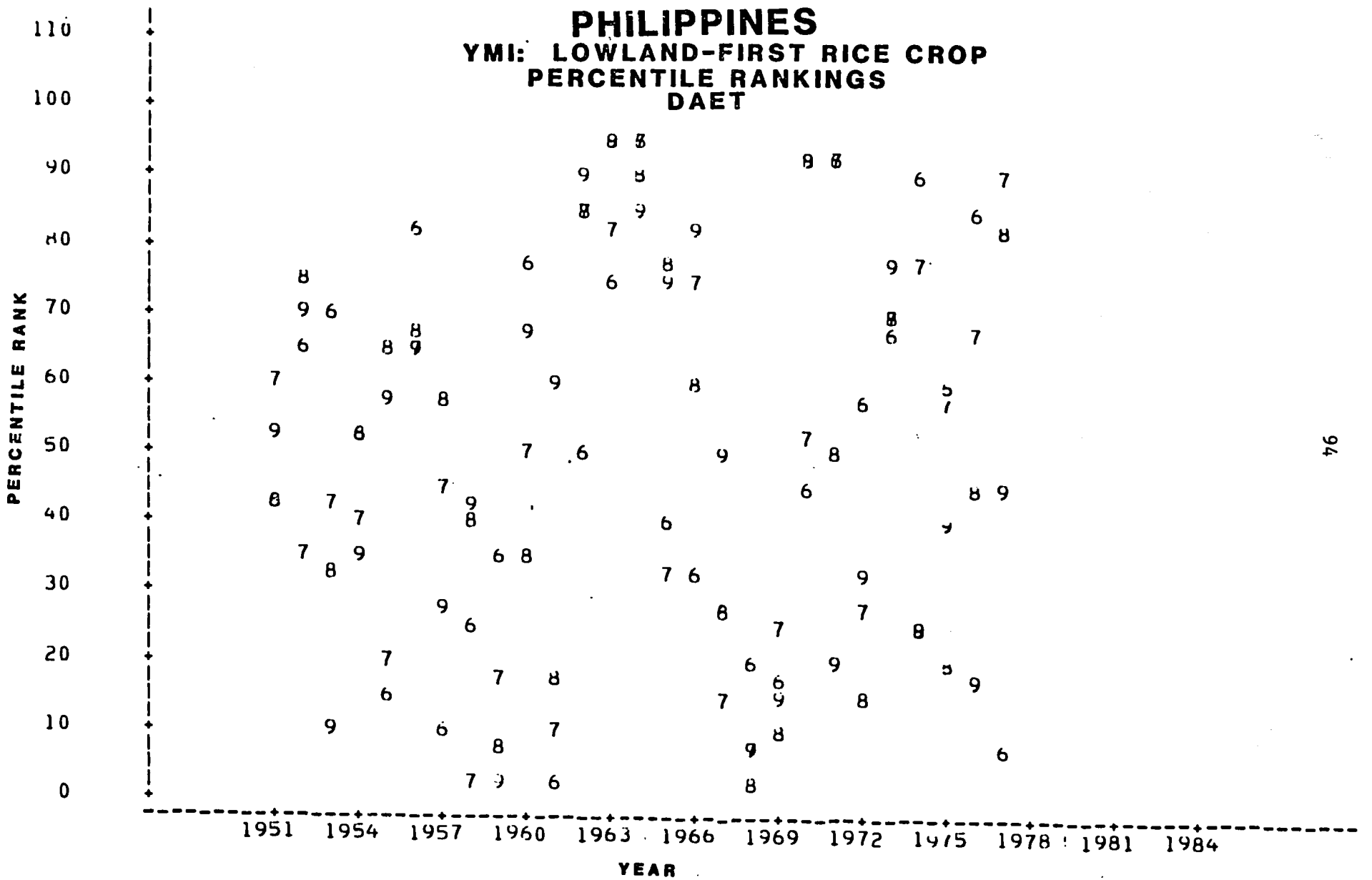


FIGURE 5.3 Historical Percentile Rankings of Lowland First Rice Crop YMI at Daet in Bicol Region (Rankings: 6=June, 7=July, 8=August and 9=September)

Y I E L D M O I S T U R E I N D E X

CROP COEFFICIENTS:

KC7	=	.85/	PLANTING	/JULY
KC8	=	.95/	VEGETATION	/AUGUST
KC9	=	1.05/	FLOWERING	/SEPTEMBER
KC10	=	.95/	MATURITY	/OCTOBER

---------- YEAR=1975 COUNTRY=PHILIPPINES CROP=RICE SEASON=LOWLAND FIRST ----------

REGION	STATION	YMI 7	NYMI 7	PNYMI 7	PLYMI 7	YMI 8	NYMI 8	PNYMI 8	PLYMI 8	YMI 9	NYMI 9	PNYMI 9	PLYMI 9	YMI TO	NYMI TO	PNYMI TO	PLYMI TO
CENTRAL VISAYAS	CEBU	184	128	144	56	373	307	121	73	613	507	121	73	847	669	127	83
CENTRAL VISAYAS	DUMAGUETE	150	122	123	64	285	229	124	67	449	356	123	80	546	526	104	58
WESTERN VISAYAS	ILOILO	85	257	33	6	326	580	56	6	639	856	75	9	938	1096	86	35
BICOL	MASBATE	5	145	3	3	97	322	30	3	339	538	63	6	490	743	66	3
WESTERN VISAYAS	ROXAS CITY	136	220	62	19	340	445	77	19	747	694	108	64	1123	1010	111	61

CROP COEFFICIENTS:

KC5	=	.85/	PLANTING	/JUNE
KC7	=	.95/	VEGETATION	/JULY
KC5	=	1.05/	FLOWERING	/AUGUST
KC9	=	.95/	MATURITY	/SEPTEMBER

---------- YEAR=1975 COUNTRY=PHILIPPINES CROP=RICE SEASON=LOWLAND FIRST ----------

REGION	STATION	YMI 6	NYMI 6	PNYMI 6	PLYMI 6	YMI 7	NYMI 7	PNYMI 7	PLYMI 7	YMI 8	NYMI 8	PNYMI 8	PLYMI 8	YMI 9	NYMI 9	PNYMI 9	PLYMI 9
EASTERN VISAYAS	BORONGAN	190	190	100	69	399	399	100	53	737	526	118	76	921	810	114	73
EASTERN VISAYAS	CATARMAN	149	159	94	48	314	347	91	41	371	514	72	16	578	706	82	25
EASTERN VISAYAS	CATBALOGAN	49	119	41	19	235	293	80	32	658	567	116	64	774	788	98	54
BICOL	DAET	146	151	97	60	358	356	101	57	509	515	83	21	783	857	91	39
BICOL	LEGASPI	135	183	74	39	321	417	77	24	561	707	79	24	864	937	92	32
EASTERN VISAYAS	TACLOBAN	82	115	71	33	212	246	86	36	424	406	104	56	559	552	101	53
CENTRAL VISAYAS	TAGBILARAN	168	122	137	78	288	240	120	68	346	356	97	47	538	477	113	68
BICOL	VIRAC	279	199	141	80	443	406	109	77	576	501	96	51	905	828	109	67

TABLE 5.5 YMI for Lowland Rice Crop for all Stations in 1975.

PHILIPPINES: SOIL MOISTURE BUDGET

NAME=DAET (439)

STARTING BUDGET VALUE SS WITH	0.0000
STARTING BUDGET VALUE SU WITH	50.0000
STARTING BUDGET VALUE S WITH	50.0000
STARTING BUDGET VALUE AWCS WITH	25.4000
STARTING BUDGET VALUE AWCU WITH	50.0000
STARTING BUDGET VALUE AWC WITH	75.4000

SOIL MOISTURE BUDGET FOR OBSERVATION # 1

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SS	25.4000	25.4000	0.0000	0.0000	0.0000	0.0000	0.0000	25.4000	25.4000	25.4000	25.4000	25.4000
SU	50.0000	50.0000	29.6253	27.2574	19.8645	14.8699	1.8502	50.0000	50.0000	50.0000	50.0000	50.0000
S	75.4000	75.4000	29.6253	27.2574	19.8645	14.8699	1.8502	75.4000	75.4000	75.4000	75.4000	75.4000
PCP	507.2000	173.5000	68.2000	120.7000	115.9000	104.7000	57.8000	415.4000	253.9000	793.4000	404.3000	307.9000
PET	92.5333	88.4909	124.3251	125.7265	136.3504	123.6590	123.8185	108.3059	104.4972	100.9259	93.0745	87.1322
ET	92.5333	88.4909	113.9747	123.0679	123.2929	109.6946	70.8198	108.3059	104.4972	100.9259	93.0745	87.1322
PR	25.4000	0.0000	0.0000	45.7747	48.1426	55.5355	60.5301	73.5498	0.0000	0.0000	0.0000	0.0000
R	25.4000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	73.5498	0.0000	0.0000	0.0000	0.0000
PL	61.3616	67.2375	91.0002	49.7918	49.2912	32.5793	24.4187	2.6576	77.8517	75.4835	70.2770	66.3364
L	0.0000	0.0000	45.7747	2.3679	7.3929	4.9946	13.0198	0.0000	0.0000	0.0000	0.0000	0.0000
PRO	50.0000	75.4000	75.4000	29.6253	27.2574	19.8645	14.8699	1.8502	75.4000	75.4000	75.4000	75.4000
RO	389.2667	85.0091	0.0000	0.0000	0.0000	0.0000	0.0000	233.5442	149.4028	692.4741	311.2255	220.7478

SOIL MOISTURE BUDGET FOR OBSERVATION # 2

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SS	25.4000	0.0000	25.4000	0.0000	25.4000	25.4000	25.4000	11.5691	25.4000	25.4000	25.4000	25.4000
SU	50.0000	41.0480	50.0000	29.3264	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000
S	75.4000	41.0480	75.4000	29.3264	75.4000	75.4000	75.4000	61.5691	75.4000	75.4000	75.4000	75.4000
PCP	407.4000	60.9000	330.0000	71.4000	207.8000	139.2000	158.6000	105.3000	132.6000	370.9000	791.2000	508.3000
PET	89.5979	99.7996	116.0452	127.9758	124.7110	132.4579	113.8446	119.1309	111.8967	102.1308	93.9437	96.7072
ET	89.5979	95.2520	116.0452	117.4736	124.7110	132.4579	113.8446	119.1309	111.8967	102.1308	93.9437	96.7072
PR	0.0000	0.0000	34.3520	0.0000	46.0736	0.0000	0.0000	0.0000	13.8309	0.0000	0.0000	0.0000
R	0.0000	0.0000	34.3520	0.0000	46.0736	0.0000	0.0000	0.0000	13.8309	0.0000	0.0000	0.0000
PL	67.9716	74.7366	63.1754	93.4211	48.5056	98.3933	84.0503	87.5558	78.0993	76.3825	70.8534	72.6860
L	0.0000	34.3520	0.0000	46.0736	0.0000	0.0000	0.0000	13.8309	0.0000	0.0000	0.0000	0.0000
PRO	75.4000	75.4000	41.0480	75.4000	29.3264	75.4000	75.4000	75.4000	61.5691	75.4000	75.4000	75.4000
RO	317.8021	0.0000	179.6028	0.0000	37.0154	6.7421	44.7554	0.0000	6.8724	268.7692	697.2563	411.5928

SOIL MOISTURE BUDGET FOR OBSERVATION # 3

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
SS	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000	25.4000
SU	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000	50.0000
S	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000
PCP	241.7000	403.9000	169.4000	193.8000	196.3000	263.0000	141.1000	183.3000	416.8000	525.8000	377.0000	313.5000
PET	93.1983	92.1738	119.1406	122.5348	123.4590	124.3100	115.8198	129.8030	102.6858	109.6087	94.9992	96.7275
ET	93.1983	92.1738	119.1406	122.5348	123.4590	124.3100	115.8198	129.8030	102.6858	109.6087	94.9992	96.7275
PR	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PL	70.3591	69.6797	87.5622	89.8130	90.4258	90.9902	85.3601	94.6327	76.6505	81.2413	71.5533	72.6994
L	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PRO	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000	75.4000
RO	148.5017	311.7262	50.2594	71.2652	72.8410	138.6900	25.2802	53.4970	314.1142	416.1913	282.0008	216.7725

TABLE 5.6 Soil Moisture Budget for Daet.

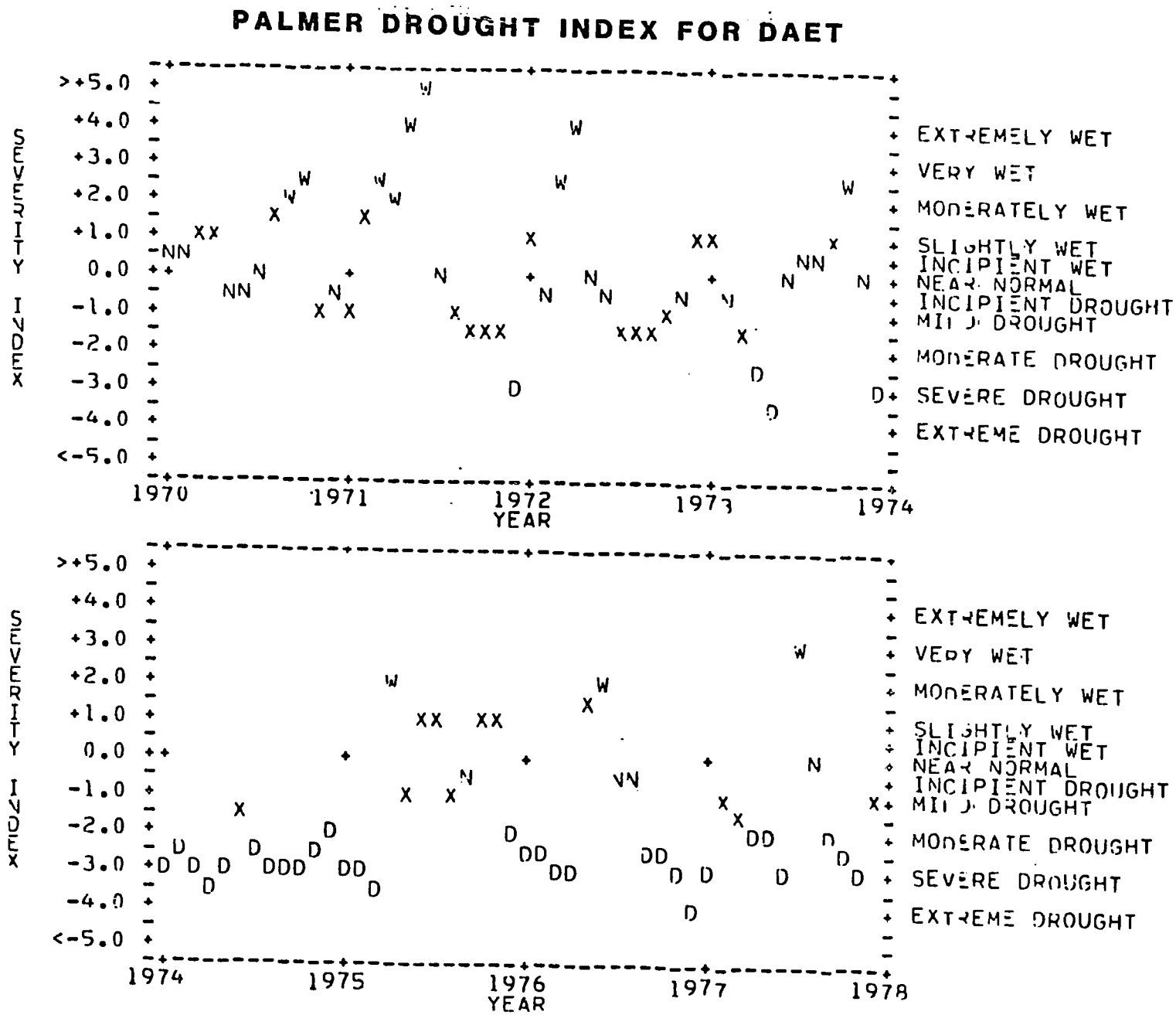


FIGURE 5.4 Palmer Drought Index Plots for Daet (1970 - 1978)

evaluation of independent predictions for years not in the data base. The predictor variables in the models should be validated to ensure that they are biologically related to the crop and reflect vulnerability of the crop to climate anomalies which lead to yield losses.

Statistical climate/crop yield models for coconuts in the Western Visayas Region were attempted, but without success. Problems with the continous harvesting of nuts combined with annual yield statistics resulted in correlations that were not very meaningful.

Monthly precipitation and temperature are the basic meteorological predictor variables used in developing the linear regression models for the first and second lowland rice crops for the Bicol Region and for coconut in the Western Visayas Region. Linear time trend is used as a surrogate for technology factors such as fertilizer application, crop management practices, high yielding varieties, etc., and, therefore, incorporated in the regression analysis.

The basic form of the equation is,

$$\hat{Y} = a + b\ \text{TREND} + \sum_{i=1}^{n} c_i X_i$$

where:

$\hat{Y}$ = the predicted yield,

a = the regression constant (i.e., intercept),

b = the estimated regression coefficient for TREND, and

c_i = the ith estimated regression coefficient for the nth meteorological variable X_i, i = 1,...N.

Paddy Yield Models

The lowland first paddy (unhusked rice) crop is generally planted from April-June and harvested during August-October. On the other hand, the lowland second paddy crop is planted from October-December and harvested during February-April.

Input data for the two paddy models are shown in Tables 5.7a and 5.7b. Correlations between yield versus weather, detrended yield versus weather and year versus weather variables are shown in Tables 5.8a and 5.8b for the first and second lowland paddy crop, respectively. As both crops exhibited a significant trend in the yield data, detrended yield versus weather correlations were used in the selection of variables for the candidate models.

The lowland first paddy yield model for the Bicol Region was developed on 14 years of data (1964-1977) and is given by

$$\hat{Y} = 1.09 + .03\ \text{TRENDX} + .0005\ \text{LP10_11}$$

where:

$\hat{Y}$=the predicted yield (mt/ha),

TRENDX = linear trend (1964=1, 1065=2,...,1977=14), and

LP10_11= previous October through November rainfall (mm).

This preseason model has an R-square value of 58 percent and a standard error of estimate of 0.17 metric tons per hectare as shown in Table 5.9a. The variance in yield explained by trend alone is 29 percent. The model fit is shown plotted in Figure 5.5.

The full-season model for lowland first crop includes an additional variable, P5_7, forced into the model to reflect growing season moisture availability (Table 5.9b). The model fit is shown plotted in Figure 5.6.

The lowland second paddy crop yield model for the Bicol Region was developed on 18 years of data (1960-1977) and is given by:

$$\hat{Y} = 5.35 \text{ to } .05\ \text{TRENDX} - 0.16\ T_2$$

where:

TRENDX = linear time trend (1960=1, 1961=2,..., 1971=12,..., 1977=12) and

T_2 = February temperature (°C).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP --------

OBS	YEAR	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	T1	T2	T3	T4	T5	T6
1	1964	300	325	100	260	143	265	202	136	268	454	492	690	26.3	26.8	26.7	27.7	28.6	28.5
2	1955	272	122	178	116	225	217	360	242	252	338	361	437	25.4	26.2	26.4	27.7	28.2	28.4
3	1956	353	83	130	52	242	153	350	157	195	320	370	593	26.1	26.2	27.3	28.2	28.4	28.7
4	1957	451	121	144	94	53	117	101	275	183	261	470	213	25.8	25.8	26.2	27.6	28.9	28.7
5	1958	266	77	77	29	18	107	93	199	254	210	242	124	25.4	25.3	26.7	27.8	29.0	29.1
6	1959	45	23	38	101	61	153	199	170	240	199	355	475	25.9	25.7	27.1	28.1	29.3	29.3
7	1970	209	207	195	136	75	180	253	333	250	553	838	447	26.0	26.1	27.1	27.8	28.8	28.6
8	1971	248	287	263	99	380	250	313	101	183	397	404	750	25.[illegible]	25.6	25.8	27.1	27.6	27.3
9	1972	549	91	245	110	139	250	151	216	260	244	359	291	25.4	26.4	25.7	26.9	27.8	28.3
10	1973	153	78	53	44	52	133	241	226	301	647	536	919	25.5	25.6	26.3	27.7	28.8	29.1

OBS	T7	T8	T9	T10	T11	T12	I	S1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12
1	28.2	28.6	28.0	27.4	27.0	26.0	13	135	107	35	44	115	255	220	490	198	219	349	416
2	27.4	28.1	28.0	27.4	27.6	26.8	13	300	325	100	260	143	265	202	186	268	454	492	690
3	28.0	28.7	28.5	27.7	27.8	27.2	13	272	122	178	116	225	217	360	242	252	338	361	437
4	28.4	27.8	27.8	27.5	26.8	25.7	13	353	83	130	52	242	153	350	167	195	320	370	593
5	28.8	28.6	28.4	27.3	26.0	26.0	13	451	121	144	94	53	117	101	275	183	261	470	213
6	28.1	27.9	27.7	27.2	26.6	26.4	13	256	77	77	29	18	107	93	199	254	210	242	124
7	28.1	28.1	27.8	27.6	27.5	27.3	13	45	23	38	101	61	153	199	170	240	199	355	475
8	27.0	27.8	27.9	26.9	26.5	26.3	13	209	207	195	136	75	180	253	333	250	553	838	447
9	28.3	27.7	27.3	27.7	27.0	26.4	13	248	287	263	99	380	250	313	101	183	397	404	750
10	28.2	28.0	27.5	27.3	27.4	25.5	13	549	91	245	110	139	250	151	216	260	244	359	291

OBS	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8	LT9	LT10	LT11	LT12	NEPCP	SWPCP	P1	P2	P3
															2	3	4
1	24.6	25.0	26.0	27.0	28.4	28.6	28.4	28.0	27.9	27.4	27.5	26.6	1284	921	625	425	360
2	26.3	26.8	2[illegible]7	27.7	28.6	28.5	28.2	28.6	28.0	27.4	27.0	26.0	1908	1071	394	300	294
3	25.4	26.2	26.4	27.7	28.2	28.4	27.4	28.1	28.0	27.4	27.6	26.8	1489	865	436	213	182
4	26.1	26.2	27.3	28.2	28.4	28.7	28.0	28.7	28.5	27.7	27.8	27.2	1734	676	572	265	238
5	25.8	25.8	26.2	27.6	28.9	28.7	28.4	27.8	27.8	27.5	26.8	25.7	1210	653	343	154	105
6	25.4	25.3	26.7	27.8	29.0	29.1	28.8	28.6	28.4	27.3	26.0	26.0	621	762	68	61	139
7	25.9	25.7	27.1	28.1	29.3	29.3	28.1	27.9	27.7	27.2	26.6	26.4	1238	1016	416	402	331
8	26.0	26.1	27.1	27.8	28.8	28.6	28.1	28.1	27.8	27.6	27.5	27.3	2086	847	535	550	362
9	25.4	25.6	25.8	27.1	27.6	27.3	27.0	27.8	27.9	26.9	26.5	26.3	2100	877	640	336	355
10	25.4	26.4	25.7	26.9	27.8	28.3	28.3	27.7	27.3	27.7	27.0	26.4	1047	901	231	131	97

TABLE 5.7a Input Data for Modeling the Lowland First Paddy Crop.

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP ----------

OBS	P4 5	P5 6	P6 7	P7 8	P8 9	P9 T0	P10 T1	P11 T2	P1 3	P2 4	P3 5	P4 6	P5 7	P6 8	P7 9	P8 T0	P9 T1	P10 T2	P1 4
1	403	408	467	388	454	722	946	1182	725	685	503	668	610	653	656	908	1214	1636	985
2	341	442	577	602	494	590	699	798	572	416	519	558	802	819	854	832	951	1136	688
3	294	395	503	517	362	515	690	963	566	265	424	447	745	670	712	682	885	1283	618
4	147	170	218	376	458	444	731	683	716	359	291	264	271	493	559	719	914	944	810
5	47	125	200	292	453	464	452	366	420	183	124	154	218	399	545	663	706	576	449
6	162	214	352	369	410	439	554	830	106	162	200	315	413	522	609	609	794	1029	207
7	211	255	433	586	583	803	1391	1285	511	538	406	391	508	766	836	1136	1641	1838	747
8	479	630	563	414	284	580	801	1154	798	649	742	729	943	664	597	681	984	1551	897
9	249	389	401	367	476	504	603	650	885	446	494	499	540	617	627	720	863	894	995
10	95	185	374	467	527	948	1183	1455	284	175	149	229	426	600	768	1174	1484	2102	326

OBS	P2 5	P3 6	P4 7	P5 8	P6 9	P7 T0	P8 T1	P9 T2	LP10 T1	LP10 T2	AREA	PROD	YIELD	TREND X	TREND	DTYIELD
1	828	768	870	796	921	1110	1400	1904	568	984	131670	152952	1.4	1	1.5	-0.09
2	641	736	918	1044	1071	1192	1193	1388	946	1636	163130	300564	1.8	2	1.5	0.33
3	507	577	797	912	865	1032	1052	1478	699	1136	155250	225896	1.5	3	1.5	-0.09
4	412	408	365	546	676	820	1189	1127	690	1283	142170	194656	1.4	4	1.6	-0.20
5	201	231	247	417	653	756	905	830	731	944	160370	253176	1.6	5	1.6	-0.03
6	223	353	514	583	762	808	964	1269	452	576	164160	259036	1.8	6	1.6	0.13
7	613	586	644	841	1016	1389	1974	2088	554	1029	126340	156804	1.3	7	1.7	-0.35
8	1029	992	1042	1044	847	994	1085	1734	1391	1838	125310	256596	2.1	8	1.7	0.43
9	585	744	650	756	877	871	1079	1154	801	1551	167350	255628	1.6	9	1.7	-0.14
10	227	282	470	652	901	1415	1710	2403	603	894	180360	310454	1.7	10	1.8	-0.04

TABLE 5.7a Input Data for Modeling the Lowland First Paddy Crop (continued).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP ---------

OBS	YEAR	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	T1	T2	T3	T4	T5
11	1974	212	211	96	60	157	513	237	122	135	450	428	491	24.9	25.6	25.9	27.3	28.0
12	1975	258	109	71	288	49	167	149	149	296	308	224	969	24.9	25.5	26.4	27.2	27.9
13	1976	346	133	178	75	486	258	164	280	158	238	531	878	25.0	25.1	26.3	27.3	27.3
14	1977	240	241	113	66	125	106	362	171	263	170	583	127	26.2	25.4	26.1	27.4	28.4

OBS	T6	T7	T8	T9	T10	T11	T12	I	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11
11	27.9	27.6	28.0	28.2	27.2	26.6	26.1	13	153	78	53	44	52	133	241	226	301	647	536
12	28.0	27.5	27.9	27.2	27.3	26.8	25.8	13	212	211	96	60	157	513	237	122	135	450	428
13	27.5	27.9	27.2	27.6	27.6	27.0	25.9	13	258	109	71	288	49	167	149	149	296	308	224
14	28.4	27.8	28.4	27.4	27.5	26.5	26.1	13	346	133	178	75	486	258	164	280	158	238	531

OBS	LP12	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8	LT9	LT10	LT11	LT12	NEPCP	SWPCP	P1Z	P2Z
11	919	25.5	25.6	26.3	27.7	28.8	29.1	28.2	28.0	27.5	27.3	27.4	25.5	2314	1007	423	307
12	491	24.9	25.6	25.9	27.3	28.0	27.9	27.6	28.0	28.2	27.2	26.5	26.1	1627	761	367	180
13	969	24.9	25.5	26.4	27.2	27.9	28.0	27.5	27.9	27.2	27.3	26.5	25.8	1847	860	479	311
14	878	25.0	25.1	26.3	27.3	27.3	27.5	27.9	27.2	27.6	27.6	27.0	25.9	1887	902	481	354

Table 5.7a Input Data for Modeling the Lowland First Paddy Crop (continued).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP -------

OBS	P3	P4	P5	P6	P7	P8	P9	P10	P11	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
	T4	T5	T6	T7	T8	T9	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9	T0	T1	T2
11	155	217	670	750	359	257	585	878	919	519	367	313	730	907	872	494	707	1013	1369
12	359	337	216	316	298	445	604	532	1193	438	468	408	504	365	465	594	753	828	1501
13	253	561	744	422	444	438	396	769	1409	657	386	739	819	908	702	602	676	927	1647
14	179	191	231	468	533	434	433	753	710	594	420	304	297	593	539	796	604	1016	880

OBS	P1	P2	P3	P4	P5	P6	P7	P8	P9	LP10	LP10	AREA	PROD	YIELD	TREND	TREND	DTYIELD
	T4	T5	T6	T7	T8	T9	T0	T1	T2	T1	T2						
11	579	524	826	967	1029	1007	944	1135	1504	1183	2102	164440	313192	1.9	11	1.8	0.11
12	726	517	575	653	514	761	902	977	1797	878	1369	181770	308968	1.7	12	1.8	-0.12
13	732	872	997	983	1188	860	840	1207	1805	532	1501	177810	328536	1.8	13	1.9	-0.01
14	660	545	410	659	764	902	966	1187	1143	769	1647	171210	334136	2.0	14	1.9	0.06

TABLE 5.7a Input Data for Modeling the Lowland First Paddy Crop (continued).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP ----------

OBS	YEAR	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	T1	T2	T3	T4	T5	T6
15	1950	176	280	103	183	210	274	140	216	304	465	385	223	26.4	26.2	27.1	28.2	28.6	28.6
16	1951	61	39	111	94	174	129	183	302	223	293	369	374	25.2	26.4	27.2	28.0	28.6	28.6
17	1962	190	138	103	92	362	129	297	289	420	215	336	207	25.5	25.3	26.8	27.8	28.4	28.4
18	1953	135	107	35	44	115	255	220	490	198	219	349	416	24.6	25.0	26.0	27.0	28.4	28.6
19	1954	300	325	100	260	143	265	202	186	268	454	492	690	26.3	26.8	26.7	27.7	28.6	28.5
20	1955	272	122	178	116	225	217	360	242	252	338	361	437	25.4	26.2	26.4	27.7	28.2	28.4
21	1956	353	83	130	52	242	153	350	167	195	320	370	593	26.1	26.2	27.3	28.2	28.4	28.7
22	1957	451	121	144	94	53	117	101	275	183	261	470	213	25.8	25.8	26.2	27.6	28.9	28.7
23	1958	266	77	77	29	18	107	93	199	254	210	242	124	25.4	25.3	26.7	27.8	29.0	29.1
24	1959	45	23	38	101	61	153	199	170	240	199	355	475	25.9	25.7	27.1	28.1	29.3	29.3

OBS	T7	T8	T9	T10	T11	T12	I	L1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12
15	28.7	28.8	27.8	27.4	27.2	26.3	13	252	133	283	65	193	114	186	141	170	231	575	513
16	28.2	28.0	28.1	27.2	27.1	26.6	13	176	280	103	183	210	274	140	216	304	465	385	223
17	28.0	27.9	27.3	28.0	27.1	26.2	13	51	39	111	94	174	129	183	302	223	293	369	374
18	28.4	28.0	27.9	27.4	27.5	26.6	13	190	138	103	92	362	129	297	289	420	215	336	207
19	28.2	28.6	28.0	27.4	27.0	26.0	13	135	107	35	44	115	255	220	490	198	219	349	416
20	27.4	28.1	28.0	27.4	27.6	26.8	13	300	325	100	260	143	265	202	186	268	454	492	690
21	28.0	28.7	28.5	27.7	27.8	27.2	13	272	122	178	116	225	217	360	242	252	338	361	437
22	28.4	27.8	27.8	27.5	26.8	25.7	13	353	83	130	52	242	153	350	167	195	320	370	593
23	28.8	28.6	28.4	27.3	26.0	26.0	13	451	121	144	94	53	117	101	275	183	261	470	213
24	28.1	27.9	27.7	27.2	26.6	26.4	13	256	77	77	29	18	107	93	199	254	210	242	124

OBS	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8	LT9	LT10	LT11	LT12	NEPCP	SWPCP	P1	P2	P3	P4
15	25.7	26.2	26.5	27.5	28.2	29.1	28.1	29.0	28.1	27.7	27.1	26.6	1495	934	456	383	286	[illegible]
16	26.4	26.2	27.1	28.2	28.6	28.6	28.7	28.8	27.8	27.4	27.2	26.3	1134	837	100	150	205	[illegible]
17	25.2	26.4	27.2	28.0	28.6	28.6	28.2	28.0	28.1	27.2	27.1	26.6	1226	1135	328	241	195	[illegible]
18	25.5	25.3	26.8	27.8	28.4	28.4	28.0	27.9	27.3	28.0	27.1	26.2	893	1163	242	142	79	[illegible]
19	24.6	25.0	26.0	27.0	28.4	28.6	28.4	28.0	27.9	27.4	27.5	26.6	1284	921	625	425	360	[illegible]
20	26.3	26.8	26.7	27.7	28.6	28.5	28.2	28.6	28.0	27.4	27.0	26.0	1908	1071	394	300	294	[illegible]
21	25.4	26.2	26.4	27.7	28.2	28.4	27.4	28.1	28.0	27.4	27.6	26.8	1489	865	436	213	182	[illegible]
22	26.1	26.2	27.3	28.2	28.4	28.7	28.0	28.7	28.5	27.7	27.8	27.2	1734	676	572	265	238	[illegible]
23	25.8	25.8	26.2	27.6	28.9	28.7	28.4	27.8	27.8	27.5	26.8	25.7	1210	653	343	154	106	[illegible]
24	25.4	25.3	26.7	27.8	29.0	29.1	28.8	28.6	28.4	27.3	26.0	26.0	621	762	68	61	139	[illegible]

TABLE 5.7b Input Data for Modeling the Lowland Second Paddy Crop.

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL. CROP=PADDY SEASON=LOWLAND 2NDCROP ------

OBS	P4 5	P5 6	P6 7	P7 8	P8 9	P9 T0	P10 T1	P11 T2	P1 3	P2 4	P3 5	P4 6	P5 7	P6 8	P7 9	P8 T0	P9 T1	P10 T2	P1 4
15	393	484	414	356	520	769	850	608	559	566	496	667	624	630	650	985	1154	1073	742
16	269	303	312	485	525	516	662	743	211	244	379	397	486	614	708	818	885	1036	305
17	454	491	426	586	709	635	551	543	431	333	557	583	788	715	1006	924	971	758	523
18	159	370	475	710	688	417	568	765	277	186	194	414	590	965	908	907	766	984	321
19	403	408	467	388	454	722	946	1182	725	685	503	668	610	653	656	908	1214	1636	985
20	341	442	577	602	494	590	699	798	372	416	519	558	802	819	854	832	951	1136	688
21	294	395	503	517	362	515	690	963	565	265	424	447	745	670	712	682	885	1283	618
22	147	170	218	376	458	444	731	683	715	359	291	264	271	493	559	719	914	944	810
23	47	125	200	292	453	464	452	366	420	183	124	154	218	394	546	663	706	576	449
24	162	214	352	369	410	439	554	830	106	162	200	315	413	522	609	609	794	1029	207

OBS	P2 5	P3 6	P4 7	P5 8	P6 9	P7 T0	P8 T1	P9 T2	LP10 T1	LP10 T2	AREA	PROD	YIELD	TREND X	TREND	DTYIELD
15	776	770	807	840	934	1125	1370	1377	805	1319	93620	108240	1.2	1	1.2	-0.05
16	418	508	580	788	837	1001	1187	1259	850	1073	82250	99308	1.2	2	1.3	-0.06
17	695	686	880	1077	1135	1221	1260	1178	662	1036	73870	108504	1.5	3	1.3	0.15
18	301	449	634	1080	1163	1127	1256	1182	551	758	89960	122804	1.4	4	1.4	-0.02
19	828	768	870	796	921	1110	1400	1904	568	984	86790	120736	1.4	5	1.4	-0.05
20	641	736	918	1044	1071	1192	1193	1388	946	1636	91690	151888	1.7	6	1.5	0.16
21	507	577	797	912	865	1032	1052	1478	699	1136	98520	136532	1.4	7	1.6	-0.17
22	412	408	365	546	676	820	1189	1127	690	1283	125470	205436	1.6	8	1.6	0.02
23	201	231	247	417	653	756	905	930	731	944	101660	170808	1.7	9	1.7	0.00
24	223	353	514	583	762	808	964	1269	452	576	109250	213708	2.0	10	1.7	0.22

TABLE 5.7b Input Data for Modeling the Lowland Second Paddy Crop (continued).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP ----------

OBS	YEAR	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	T1	T2	T3	T4	T5	T6
25	1970	209	207	195	136	75	180	253	333	250	553	838	447	26.0	26.1	27.1	27.8	28.8	28.6
26	1971	248	287	263	99	380	250	313	101	183	397	404	750	25.4	25.6	25.8	27.1	27.6	27.3
27	1972	549	91	245	110	139	250	151	216	260	244	359	291	25.4	26.4	25.7	26.9	27.8	28.3
28	1973	153	78	53	44	52	133	241	226	301	647	536	919	25.5	25.6	26.3	27.7	28.8	29.1
29	1974	212	211	96	60	157	513	237	122	135	450	428	491	24.9	25.6	25.9	27.3	28.0	27.9
30	1975	258	109	71	288	49	167	149	149	296	308	224	969	24.9	25.5	26.4	27.2	27.9	28.0
31	1976	346	133	178	75	486	258	164	280	158	238	531	878	25.0	25.1	26.3	27.3	27.3	27.5
32	1977	240	241	113	66	125	106	362	171	263	170	583	127	26.2	25.4	26.1	27.4	28.4	28.4

OBS	T7	T8	T9	T10	T11	T12	[illegible]	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8	LP9	LP10	LP11	LP12
25	28.1	28.1	27.8	27.6	27.5	27.5	13	45	23	38	101	61	153	199	170	240	199	355	475
26	27.0	27.8	27.9	26.9	26.5	26.3	13	209	207	195	136	75	180	253	333	250	553	838	447
27	28.3	27.7	27.3	27.7	27.0	26.4	13	248	287	263	99	380	250	313	101	183	397	404	750
28	28.2	28.0	27.5	27.3	27.4	25.5	13	549	91	245	110	139	250	151	216	260	244	359	291
29	27.6	28.0	28.2	27.2	26.6	26.1	13	153	78	53	44	52	133	241	226	301	647	536	919
30	27.5	27.9	27.2	27.3	26.8	25.8	13	212	211	96	60	157	513	237	122	135	450	428	491
31	27.9	27.2	27.6	27.6	27.0	25.9	13	258	109	71	288	49	167	149	149	296	308	224	969
32	27.8	28.4	27.4	27.5	26.5	26.1	13	346	133	178	75	486	258	164	280	158	238	531	878

OBS	LT1	LT2	LT3	LT4	LT5	LT6	LT7	LT8	LT9	LT10	LT11	LT12	NEPCP	SWPCP	P1	P2	P3
25	25.9	25.7	27.1	28.1	29.3	29.3	28.1	27.9	27.7	27.7	26.6	26.4	1238	1016	416	402	331
26	26.0	26.1	27.1	27.8	28.8	28.6	28.1	28.1	27.8	27.[illegible]	27.5	27.3	2086	847	535	550	362
27	25.4	25.6	25.8	27.1	27.6	27.3	27.0	27.8	27.9	26.9	26.5	26.3	2100	877	640	336	355
28	25.4	26.4	25.7	26.9	27.8	28.3	28.3	27.7	27.3	27.7	27.0	26.4	1047	901	231	131	97
29	25.5	25.6	26.3	27.7	28.8	29.1	28.2	28.0	27.5	27.3	27.4	25.5	2314	1007	423	307	156
30	24.9	25.6	25.9	27.3	28.0	27.9	27.6	28.0	28.2	27.2	26.6	26.1	1627	761	367	180	359
31	24.9	25.5	26.4	27.2	27.9	28.0	27.5	27.9	27.2	27.3	26.8	25.8	1847	860	479	311	253
32	25.0	25.1	26.3	27.3	27.3	27.5	27.9	27.2	27.6	27.6	27.0	25.9	1887	902	481	354	179

TABLE 5.7b Input Data for Modeling the Lowland Second Paddy crop (continued).

BICOL: INPUT DATA FOR PADDY MODELS

---------- COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP ------

OBS	P4 5	P5 6	P6 7	P7 8	P8 9	P9 T0	P10 T1	P11 T2	P1 3	P2 4	P3 5	P4 6	P5 7	P6 8	P7 9	P8 T0	P9 T1	P10 T2	P1 4
25	211	255	433	586	583	803	1391	1285	511	538	406	391	508	766	835	1136	1641	1838	747
26	479	630	563	414	284	580	801	1154	798	649	742	729	943	664	597	681	984	1551	897
27	249	389	401	367	476	504	603	650	385	446	494	499	540	617	627	720	863	894	995
28	95	185	374	467	527	948	1183	1455	284	175	149	229	426	600	768	1174	1484	2102	328
29	217	670	750	359	257	585	878	919	519	367	313	730	907	872	494	707	1013	1369	579
30	337	216	316	298	445	604	532	1193	438	468	408	504	365	465	594	753	828	1501	726
31	561	744	422	444	438	396	769	1409	657	386	739	819	908	702	602	676	927	1647	732
32	191	231	468	533	434	433	753	710	594	420	304	297	593	639	795	604	1016	880	660

OBS	P2 5	P3 6	P4 7	P5 8	P6 9	P7 T0	P8 T1	P9 T2	LP10 T1	LP10 T2	AREA	PROD	YIELD	TREND X	TREND	DTYIELD
25	613	586	644	841	1016	1389	1974	2088	554	1029	114120	174592	1.5	11	1.8	-0.27
26	1029	992	1042	1044	847	994	1085	1734	1391	1838	115300	253880	2.2	12	1.9	0.35
27	585	744	650	756	877	871	1079	1154	801	1551	98290	146212	1.5	12	1.9	-0.37
28	227	282	470	652	901	1415	1710	2403	603	894	109040	194436	1.8	12	1.9	-0.07
29	524	826	967	1029	1007	944	1155	1504	1183	2102	114420	223388	2.0	12	1.9	0.10
30	517	575	653	514	761	902	977	1797	878	1369	117230	205700	1.8	12	1.9	-0.10
31	872	997	983	1188	860	840	1207	1805	532	1501	114120	218240	1.9	12	1.9	0.06
32	545	410	659	764	902	966	1187	1143	769	1647	100460	199496	2.0	12	1.9	0.13

TABLE 5.7b Input Data for Modeling the Lowland Second Paddy Crop (continued)

BICOL PADDY (LOW AND 1ST CROP) CORRELATIONS

YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 14

YIELD

T7	LP10_11	T10	LP10_12	LP11	T3	P5_7	P8	P8_9	T2
-0.70230	0.61455	-0.59683	0.58391	0.57434	-0.55598	0.55574	-0.55549	-0.55193	-0.54512
0.0051	0.0194	0.0242	0.0283	0.0317	0.0390	0.0391	0.0392	0.0407	0.0438
LP10	T6	T5	P5_6	P5	P6_7	P4_7	T1	T4	NEPCP
0.53473	-0.53317	-0.51453	0.48714	0.47931	0.47599	0.47273	-0.46507	-0.45154	0.43109
0.0488	0.0496	0.0598	0.0773	0.0829	0.0854	0.0878	0.0938	0.1051	0.1238
P5_8	P7	P8_10	P4_6	T11	LT9	P8_11	LP2	P3_6	T8
0.42249	0.39567	-0.39224	0.37591	-0.35500	-0.35478	-0.35396	0.35124	0.35022	-0.34823
0.1323	0.1614	0.1654	0.1853	0.2088	0.2132	0.2144	0.2182	0.2196	0.2224
P1	LP12	LP7	P4_5	P4	P6	P3_5	P2_5	LP9	LT12
-0.33158	0.32175	-0.31877	0.31764	0.31096	0.30465	0.28687	0.28039	0.27717	-0.26463
0.2468	0.2619	0.2666	0.2684	0.2792	0.2896	0.3200	0.3316	0.3374	0.3606
P9_11	P4	P6_8	P9	T12	P10_11	P11	LT6	P9_10	LP3
-0.26366	-0.24806	0.24594	-0.23391	-0.22347	-0.22443	-0.22274	-0.22134	-0.21973	0.19621
0.3624	0.3925	0.3967	0.4209	0.4321	0.4405	0.4440	0.4470	0.4504	0.5014
P12	T9	LT8	P1_2	T5	LT10	P2_3	P6_9	SWPCP	P7_10
0.19518	-0.19148	-0.17719	-0.17604	-0.17359	0.17283	0.17221	0.17148	0.17148	-0.16351
0.5037	0.5120	0.5445	0.5472	0.5528	0.5546	0.5561	0.5578	0.5578	0.5765
P1_4	LT4	P10	P2	P1	P3	P3_4	P7_9	P1_3	LT11
-0.16261	-0.16183	-0.15967	0.15611	0.14189	0.12257	-0.10341	-0.09924	-0.08945	-0.07988
0.5786	0.5805	0.5856	0.5941	0.6285	0.6764	0.7250	0.7357	0.7611	0.7861
LT7	P11_12	LT2	LP6	P9_12	LT3	P2_4	LP5	LT1	LP8
0.07683	0.06549	0.04053	0.03844	-0.03169	-0.02675	0.02162	-0.01963	0.01657	0.01046
0.7941	0.8240	0.8906	0.8962	0.9144	0.9277	0.9415	0.9469	0.9552	0.9717
P7_8	P10_12								
0.00738	-0.00402								
0.9800	0.9891								

DTYIELD

T10	T7	LP10_11	LP11	P9	P8_9	P5_7	LP10	P6_7	P4_7
-0.67273	-0.66497	0.63209	0.62076	-0.57169	-0.56959	0.56588	0.51701	0.50478	0.49394
0.0084	0.0095	0.0153	0.0178	0.0327	0.0334	0.0345	0.0583	0.0656	0.0726
P7	P5	LP2	P5_6	LP10_12	P5_8	P8_11	P9_10	LP9	P11
0.48860	0.46837	0.46002	0.45770	0.43387	0.42956	-0.41741	-0.37814	0.36930	-0.36041
0.0763	0.0912	0.0979	0.0998	0.1211	0.1253	0.1375	0.1825	0.1938	0.2056
P4_6	T6	P3_6	T3	P4	P9_11	P4_5	P1	T5	P3_5
0.35958	-0.35699	0.34608	-0.34412	0.33348	-0.33140	0.32442	-0.32174	-0.30701	0.30451
0.2067	0.2102	0.2255	0.2283	0.2439	0.2471	0.2578	0.2620	0.2857	0.2898

TABLE 5.8a Yield-Weather Correlations for the Lowland First Paddy Crop in the Bicol Region.

BICOL PADDY (LOW AND 1ST CROP) CORRELATIONS
YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 14

DTYIELD

LT7	NEPCP	P2_5	P10_11	LT10	P6_8	LP8	LT1	P6	LT2
0.30247	0.30077	0.30050	-0.29218	0.28373	0.26931	0.26503	0.26414	0.26306	0.26150
0.2932	0.2961	0.2965	0.3107	0.3255	0.3518	0.3598	0.3615	0.3635	0.3665
T1	P9	T11	LP7	P4	T2	P2_3	P9_10	P6_9	SWPCP
-0.24696	-0.24388	-0.23277	-0.22204	-0.21555	-0.20975	0.20248	-0.19707	0.19292	0.19292
0.3947	0.4008	0.4232	0.4455	0.4593	0.4717	0.4875	0.4995	0.5087	0.5087
LT8	T9	P2	LP5	T3	P1_2	P3	T4	P9_12	P10
0.18640	0.17478	0.17362	-0.17043	0.15408	-0.15799	0.15685	-0.15325	-0.13868	-0.13086
0.5234	0.5501	0.5528	0.5602	0.5994	0.5898	0.5923	0.6009	0.6364	0.6557
P1_4	LP1	LP3	P10_12	T5	P7_10	LT11	LP6	P12	T8
-0.12929	0.12539	0.11507	-0.11137	0.11082	-0.10997	0.10588	-0.10508	0.09469	-0.09254
0.6596	0.6693	0.6953	0.7047	0.7060	0.7082	0.7187	0.7207	0.7475	0.7530
P11_12	P7_8	LT9	LP12	P1_3	P2_4	P3_4	LT12	P7_9	LT6
-0.09071	0.08328	-0.07809	0.06436	-0.06432	0.06100	-0.05497	-0.04942	-0.03747	0.03527
0.7578	0.7771	0.7907	0.8270	0.8271	0.8359	0.8519	0.8668	0.8988	0.9047
T12	LT4								
-0.02898	0.02338								
0.9216	0.9368								

YEAR

T2	T9	LT8	T4	T9	T8	LP12	T3	LT5	T1
-0.68063	-0.62441	-0.61608	-0.59558	-0.53358	-0.49908	0.49394	-0.49227	-0.49227	-0.47521
0.0074	0.0170	0.0190	0.0246	0.0494	0.0692	0.0726	0.0737	0.0737	0.0859
T5	LT6	T6	LT12	LP10_12	LP8	LT1	T12	LT4	LT2
-0.47334	-0.46314	-0.43023	-0.41169	0.40462	-0.39174	-0.37907	-0.37666	-0.33489	-0.33077
0.0873	0.0954	0.1247	0.1436	0.1513	0.1660	0.1813	0.1844	0.2418	0.2480
NEPCP	LT7	LT11	T11	T3	T7	P11_12	LP7	LP6	LP5
0.32905	-0.32733	-0.31161	-0.29963	-0.29453	-0.26467	0.26155	-0.24389	0.23390	0.22810
0.2507	0.2533	0.2781	0.2980	0.3067	0.3605	0.3664	0.4008	0.4209	0.4329
P12	P5_6	LP10	LP3	P10_12	P5	P9_12	P6	LP10_11	P11
0.21333	0.18910	0.18491	0.18361	0.16531	0.15810	0.15659	0.15420	0.15374	0.14793
0.4640	0.5173	0.5268	0.5298	0.5722	0.5893	0.5929	0.5986	0.5998	0.6138
P5_7	P8	P8_10	P4_6	P5_9	P7_10	P7_9	P4	LT10	P7_8
0.14635	-0.13846	-0.13736	0.13601	-0.13466	-0.13118	-0.12502	-0.12347	-0.12119	-0.11554
0.6176	0.6369	0.6396	0.6429	0.6462	0.6549	0.6702	0.6741	0.6798	0.6941
P5_8	P1	P3_6	P4_7	P3_4	P9_10	P1_4	LP11	P6_7	P10
0.11343	-0.11290	0.10954	0.10629	-0.10558	-0.09995	-0.09955	0.09712	0.09530	-0.09171
0.6994	0.7008	0.7093	0.7176	0.7194	0.7342	0.7349	0.7412	0.7459	0.7552

TABLE 5.8a Yield-Weather Correlations for the Lowland First Paddy Crop in the Bicol Region.(continued).

BICOL PADDY (LOW AND 1ST CROP) CORRELATIONS

YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 1STCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 14

YEAR

P4_5	P1_2	LP1	P1_3	P2	LP9	T10	P3_5	LP4	P2_4
0.08301	-0.07998	0.06737	-0.06531	-0.06529	-0.06129	-0.05801	0.05771	0.05663	-0.05471
0.7779	0.7858	0.8190	0.8245	0.8245	0.8351	0.8438	0.8463	0.8475	0.8526
P9	P2_5	P10_11	P6_8	P7	P9_11	P2	SWPCP	P6_9	P3
-0.05340	0.05136	0.03901	0.03618	-0.02763	0.02742	0.01881	0.01724	0.01724	-0.01708
0.8561	0.8616	0.8947	0.9023	0.9253	0.9259	0.9491	0.9533	0.9533	0.9538
P8_11	P2_3								
-0.00580	0.00375								
0.9843	0.9899								

TABLE 5.8a Yield-Weather Correlations for the Lowland First Paddy Crop in the Bicol Region (continued).

BICOL PADDY (LOW-AND 2ND CROP) CORRELATIONS

YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 18

YIELD

T7	P8_9	T11	T3	P3	T2	P8_10	TH	LP10_12	T10
-0.62773	-0.59371	-0.55089	-0.52241	-0.51520	-0.49794	-0.45999	-0.43932	0.42649	-0.41799
0.0053	0.0095	0.0178	0.0261	0.0287	0.0355	0.0548	0.0681	0.0776	0.0843
T4	T6	NEPCP	T12	LP10_11	P7_9	LP12	P11_12	P9	P12
-0.40998	-0.39183	0.37168	-0.36136	0.35583	-0.35032	0.33253	0.32983	-0.32561	0.32356
0.0911	0.1078	0.1288	0.1406	0.1451	0.1541	0.1776	0.1813	0.1873	0.1903
LP10	LP11	P7_10	T5	P5	LP1	P6_9	SWPCP	P6_7	P8_11
0.31986	0.30404	-0.30363	-0.29733	-0.27515	0.25956	-0.25788	-0.25788	0.24521	-0.23816
0.1957	0.2200	0.2206	0.2308	0.2573	0.2983	0.3015	0.3015	0.3267	0.3413
P7_8	P7	P10_12	P5_7	P4	T1	LT8	P9_10	LP7	LT12
-0.23398	0.22984	0.22943	0.22018	-0.21214	-0.20741	-0.20726	-0.20400	-0.20224	-0.20064
0.3501	0.3589	0.3598	0.3800	0.3981	0.4089	0.4092	0.4168	0.4209	0.4247
LT2	T9	P9_12	P3	T4	LT9	LT11	P2_3	P5_6	P4_7
-0.19801	-0.19091	0.17910	0.17869	-0.16395	-0.16651	-0.16269	0.15749	0.15657	0.14858
0.4309	0.4479	0.4770	0.4781	0.5079	0.5090	0.5189	0.5326	0.5350	0.5563
LT1	LT6	P5	P6	P3	P11	P3_6	P1_3	LP2	P6_8
-0.14615	-0.13783	0.12416	0.12386	-0.11149	0.11043	0.11006	0.10673	-0.10636	-0.10613
0.5628	0.5855	0.6235	0.6244	0.6596	0.6627	0.6637	0.6734	0.6744	0.6751
P2	LT3	P2_5	P10	P3_5	P4_6	P1_2	P9_11	LP9	LT10
0.09038	-0.09029	0.08865	-0.07108	0.07070	0.06871	0.06539	-0.06423	-0.05743	-0.04996
0.7213	0.7216	0.7265	0.7793	0.7804	0.7865	0.7966	0.8001	0.8209	0.8439
LP4	P3_4	P1_4	P2_4	P10_11	LP6	P1	LP8	LT5	LT7
0.04703	-0.03412	0.03062	0.02923	0.02510	0.02334	0.01969	0.01754	-0.01412	0.01201
0.8530	0.8931	0.9040	0.9083	0.9213	0.9268	0.9382	0.9449	0.9557	0.9623
P4_5	P5_8								
0.00711	0.00452								
0.9777	0.9858								

DTYIELD

LT7	T7	T10	T2	T11	P1	LP11	LT3	P5_7	P8_10
0.49383	-0.48502	-0.43033	-0.42703	-0.41937	-0.39349	0.39044	0.38615	0.37530	-0.36797
0.0373	0.0413	0.0746	0.0772	0.0832	0.1062	0.1092	0.1135	0.1249	0.1330
P5	LP8	LP10_11	P8_11	P7	LT10	P7	P4_7	P5_6	LP5
0.36747	0.36040	0.36003	-0.34136	-0.33337	0.32966	0.32566	0.30870	0.29828	-0.27593
0.1336	0.1418	0.1422	0.1656	0.1778	0.1816	0.1872	0.2134	0.2293	0.2679
P9_11	P8_9	P8	P6_7	P6	P5_8	T6	P9_10	T12	P10_11
-0.27119	-0.26605	-0.26344	0.26292	-0.26247	0.25845	-0.25433	-0.25225	-0.24997	-0.24875
0.2764	0.2859	0.2909	0.2918	0.2927	0.3004	0.3085	0.3126	0.3171	0.3196

TABLE 5.8b Yield-Weather Correlations for the Lowland Second Paddy Crop in the Bicol Region.

BICOL PADDY (LOW AND 2ND CROP) CORRELATIONS

YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 18

DTYIELD

LT5	P4_5	P10	LP10	T6	LT4	P1_4	P4_6	LP10_12	P1_2
0.24488	0.24176	-0.23519	0.23342	0.23320	0.22054	-0.21909	0.21005	0.20899	-0.20207
0.3274	0.3338	0.3475	0.3512	0.3517	0.3792	0.3824	0.4028	0.4053	0.4213
P3_4	P2_5	LT8	P11	P4	P2	P1_3	P7_10	LP3	T3
-0.19399	0.19391	0.19330	-0.19321	-0.19026	0.18893	-0.18159	-0.17953	-0.17874	-0.17223
0.4405	0.4407	0.4422	0.4424	0.4495	0.4528	0.4708	0.4760	0.4779	0.4944
LP9	P9_12	P3_5	T8	P3_6	LT11	P10_12	LP4	P9	LT1
0.16538	-0.15987	0.15895	-0.15585	0.15418	0.14935	-0.14132	0.10874	-0.10135	0.09919
0.5119	0.5263	0.5287	0.5369	0.5413	0.5542	0.5759	0.6676	0.6891	0.6954
T1	P2_3	LT2	P11_12	P3	NEPCP	P6_8	LT9	T5	P6
-0.09443	0.09085	0.09000	-0.08268	-0.08204	0.07306	0.07184	0.06531	-0.06379	0.06375
0.7094	0.7200	0.7225	0.7443	0.7462	0.7733	0.7770	0.7968	0.8015	0.8016
LP2	T9	LP1	P7_8	P6_9	SWPCP	P7_9	P2_4	LP12	P12
-0.06176	0.05865	0.05440	0.03367	0.02481	0.02481	-0.01984	-0.01304	-0.00876	0.00499
0.8077	0.8172	0.8303	0.8945	0.9222	0.9222	0.9377	0.9590	0.9725	0.9843
LT12	T4								
0.00478	-0.00250								
0.9850	0.9921								

YEAR

LP12	T3	T4	LT8	P5_9	P11_12	LT6	LT3	LT4	NEPCP
0.55397	-0.53401	-0.53052	-0.50163	-0.50071	0.46872	-0.46478	-0.45920	-0.45786	0.45707
0.0171	0.0224	0.0235	0.0339	0.0343	0.0498	0.0520	0.0552	0.0560	0.0565
LP10_12	T7	T8	P8	T5	P12	LT7	LT1	T2	LT5
0.44547	-0.43106	-0.42914	-0.42200	-0.41456	0.39894	-0.39400	-0.39001	-0.38350	-0.38120
0.0639	0.0741	0.0755	0.0811	0.0871	0.1010	0.1057	0.1096	0.1162	0.1186
LT2	T11	T9	P7_9	T6	LT12	P10_12	T12	LT9	P8_10
-0.37991	-0.37727	-0.37558	-0.37508	-0.37508	-0.37437	0.36275	-0.35715	-0.34581	-0.33284
0.1199	0.1227	0.1246	0.1251	0.1251	0.1259	0.1390	0.1457	0.1598	0.1771
P9_12	LP6	LT11	P9	P5_9	SWPCP	P7_8	LP1	P1	P11
0.31961	0.31181	-0.29494	-0.29279	-0.28353	-0.28353	-0.28272	0.27871	0.27498	0.27397
0.1961	0.2078	0.2348	0.2384	0.2542	0.2542	0.2567	0.2627	0.2694	0.2713
LT10	P7_10	LP8	P1_3	P1_2	T1	LP9	LP10	P3	P1_4
-0.26856	-0.26477	-0.25926	0.23275	0.22455	-0.21550	-0.21272	0.21215	0.18935	0.18097
0.2812	0.2882	0.2989	0.3527	0.3703	0.3902	0.3967	0.3980	0.4517	0.4724
P10_11	LP10_11	P6_8	T10	P5_7	P6	P9_10	P5_8	P2_3	P4
0.16830	0.14986	-0.14698	-0.13870	0.13536	0.12193	-0.11814	-0.11787	0.11216	-0.08569
0.5044	0.5528	0.5606	0.5831	0.5923	0.6298	0.6406	0.6413	0.6577	0.7353

TABLE 5.8b Yield-Weather Correlations for the Lowland Second Paddy Crop in the Bicol Region (continued)

BICOL PADDY (LOW-AND 2ND CROP) CORRELATIONS

YIELD VS WX. DETRENDED YIELD VS WX. YEARS VS WX.

COUNTRY=PHILIPPINES REGION=BICOL CROP=PADDY SEASON=LOWLAND 2NDCROP

CORRELATION COEFFICIENTS / PROB > |R| UNDER H0:RHO=0 / N = 18

YEAR

P9_11	P4_5	LP2	LP7	P8_11	P7	P3_4	P3_6	P5_7	LP11
0.08494	-0.08218	-0.07696	-0.06961	-0.06536	0.06543	0.06523	0.05681	0.05565	0.05478
0.7375	0.7458	0.7615	0.7837	0.7875	0.7964	0.7971	0.8228	0.8264	0.8291
P2_4	P5	P5_6	LP4	P4_7	LP5	P2	LP3	P2_5	P10
0.04953	-0.04238	0.03608	0.03293	0.02726	-0.02216	0.01849	-0.01731	0.01073	0.00978
0.8450	0.8674	0.8870	0.8968	0.9145	0.9305	0.9419	0.9456	0.9663	0.9693
P3_5	P4_6								
0.00484	0.00221								
0.9848	0.9930								

TABLE 5.8b Yield-Weather Correlations for the Lowland Second Paddy Crop in the Bicol Region (continued).

MODEL:	MODEL01	SSE	0.320310	F RATIO	7.68
		DFE	11	PROB>F	0.0082
DEP VAR:	YIELD	MSE	0.029119	R-SQUARE	0.5827

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	1.092356	0.160442	6.8084	0.0001
TRENDX	1	0.026618	0.011450	2.3248	0.0402
LP10_11	1	0.0005064666	0.0001834338	2.7603	0.0185

TABLE 5.9a Regression Analysis for Lowland First Paddy Crop (Model 1) in Bicol.

MODEL:	MODEL01	SSE	0.272775	F RATIO	6.05
		DFE	10	PROB>F	0.0129
DEP VAR:	YIELD	MSE	0.027277	R-SQUARE	0.6446

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	1.031786	0.161922	6.3721	0.0001
TRENDX	1	0.025435	0.011118	2.2877	0.0452
LP10_11	1	0.0003735758	0.0002041347	1.8300	0.0972
P5_7	1	0.0002917998	0.0002210438	1.3201	0.2162

TABLE 5.9b Regression Analysis for Lowland First Paddy Crop (Model 2) in Bicol.

MODEL:	MODEL01	SSE	0.402513	F RATIO	19.15
		DFE	15	PROB>F	0.0001
DEP VAR:	YIELD	MSE	0.026841	R-SQUARE	0.7186

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	5.351872	2.167397	2.4687	0.0261
TRENDX	1	0.053005	0.010583	5.0083	0.0002
T2	1	-0.161077	0.082948	-1.9419	0.0712

TABLE 5.9c Regression Analysis for Lowland Second Paddy Crop (Model 1) in Bicol.

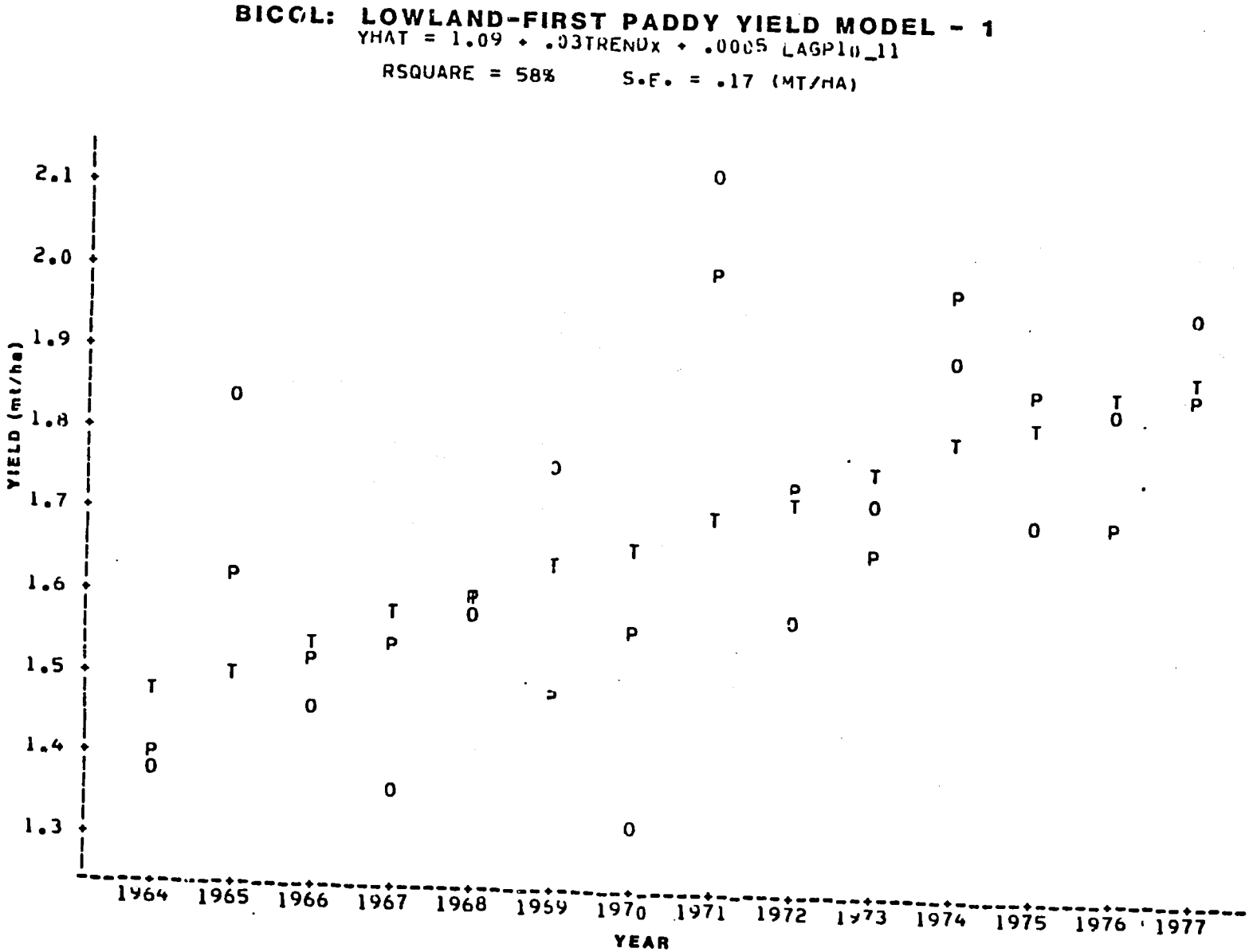


FIGURE 5.5 Lowland First Paddy Crop Yield Model (1) Fit for Bicol (O=Observed Yield, P=Predicted Yield and T=Linear Trend).

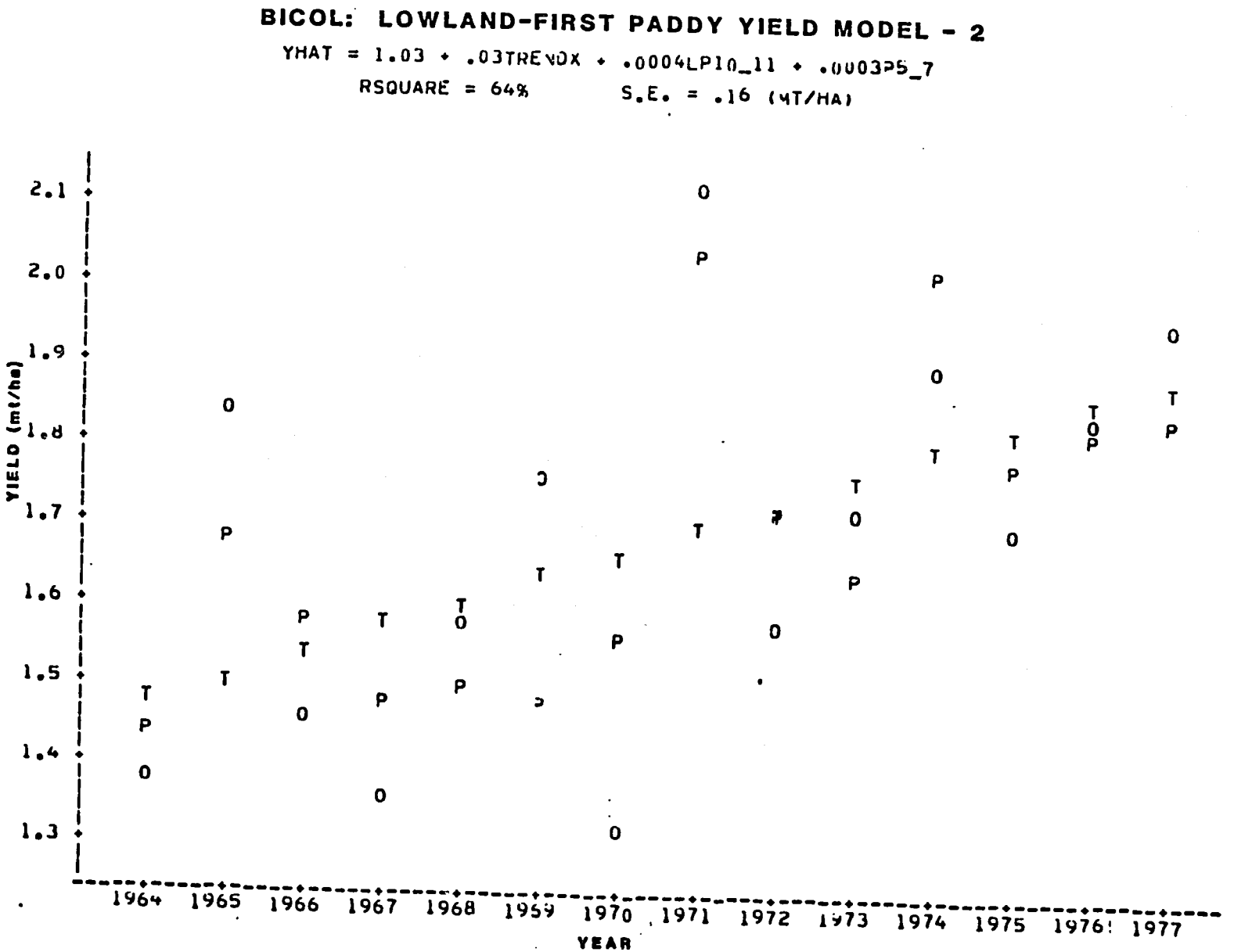


FIGURE 5.6 Lowland First Paddy Crop Yield Model (2) Fit for Bicol (O=Observed Yield, P=Predicted Yield and T=Linear Trend.)

The model has an R-square value of 72 percent and a standard error estimate of 0.16 metric tons per hectare as shown in Table 5.9c. Trend alone explains nearly 65 percent of the variability in yield. The only weather variable appearing in the model is February temperature and results from this model should be interpreted with caution. The model fit is shown plotted in Figures 5.7.

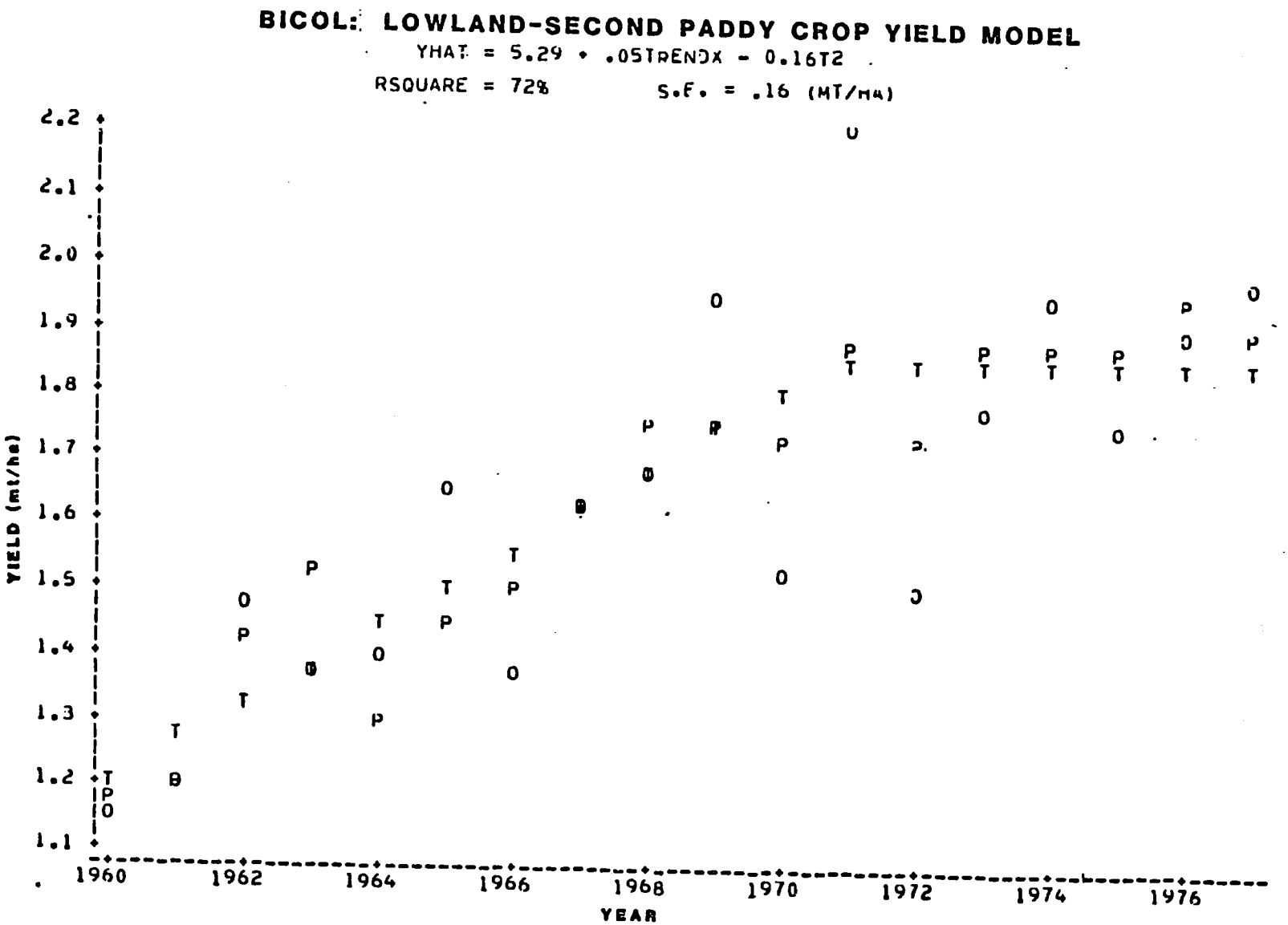


FIGURE 5.7 Lowland Second Paddy Crop Yield Model Fit for Bicol (O=Observed Yield, P=Predicted Yield and T=Linear Trend).

CHAPTER VI

ASSESSMENT PROCEDURES

This chapter describes the structure of climatic impact assessments, the types of assessments proposed for the Bicol and Visayas Regions, the agro-climatic models, display of the data, steps in making an assessment and comments on user interpretation of assessments. Test and evaluation procedures for the period May-october 1983 are discussed.

A. Definition and Assessment Format

1. Definition

The climatic impact assessment is a concise statement which provides decision makers with quantified information on the current or potential effect of climate and weather variability on some aspect of socio-economic activity. Assessments could address agriculture and food security, as discussed in this study, and other economic sectors (e.g., fisheries, energy, transportation, construction, health, etc.). The assessment provides decision makers with needed information on climate impact, one of the many factors which influences policy and economic planning. Assessments represent a method for converting meteorological data into economic information. This process can be viewed as a means for interdisciplinary communication and in many cases promote interagency dialogue.

The meteorologist prepares a basic assessment from agroclimatic models and real-time meteorological input data. The assessment is provided to users such as food security managers, economic policy analysts, agricultural statisticians, extension officials and others. They can use the assessment to supplement information from other sources available to them. This process can frequently benefit the user's individual products, reports and forecasts. For example,

the agricultural statistician or economist involved in the crop production and yield forecast problem can combine the assessment with analysis from area farm survey results, crop cutting reports, farmers reports and other data sources.

There are no fixed rules for preparing an assessment and it is very important to adapt the assessment to individual user needs. However, the following basic structure is recommended.

2. Format

The format for an assessment includes the following sequential statements: 1) Impact, 2) Perspective, 3) Model Results, 4) Weather Analysis and 5) Support Information. Only information and data relevant to the impact are used in statements 2 through 5. These justify the impact statement.

Impact

This is the statement which directly communicates needed information to the decision maker. The terminology is strictly associated with the user's discipline. Preparing the impact statement is the most difficult task of the assessor. It must be objective and clearly stated.

Some example statements could include: 1) there will be a crop failure in Region X due to drought, 2) crop conditions are very poor in Region X and potentially represent the worst case of crop failure in the last 10 years, 3) there is the potential for isolated food shortages in Region X due to severe drought , or 4) agricultural crops are in very good condition and the prospects for this year's harvest are exceptionally good. If abnormal rainfall was a problem in the early part of the growing season, the impact statement could be, "farmers probably could not plant" or "planting was delayed due to a delayed rainy season (heavy rains)" etc. The impact of typhoons and tropical storms should be discussed, as appropriate.

The impact statement does not include any technical discussion of meteorological events or data. These are described in subsequent portions of the assessment.

Perspective Statement

The perspective statement can be used to qualify the impact by describing the expected scope and magnitude of the potential problem. For example, the statement that a maize crop failure is likely in Region X could be followed by a statement which describes the favorable situation at other locations within Region X or other regions in the country. Another example is, "this is the worst drought in the past 30 years" or "the typhoon damage is comparable to that in 1981." The decision maker is provided with information on, "how large is the expected problem."

Model Results

The perspective statement is followed by a discussion which lists the quantitative results from the assessment models. The model could be a drought or crop condition index, a statistical crop yield model or soil moisture information. The model output is presented as a percent of normal or percentile rank. For example, the statement could be, "Agroclimatic/crop condition indices are 60 percent of normal which is below the 20th percentile", or "The southwest monsoon index is at the 5th percentile which has a probability of occurrence of about one chance in 20." Decision makers frequently find it useful to know how this year's information compared to last year (e.g., as a percent of last year) or by also listing recent good (poor) years which are comparable. For example, an assessment of crop conditions made at the end of August and describing conditions as bad or worse than conditions in the Philippines during a recent drought year would be well understood by users.

Weather Analysis

The weather analysis section describes the weather and climatic conditions which were associated with the impact. Only relevant information and data are provided. Information such as seasonal rainfall amount, August rainfall, tropical storm conditions, etc., are provided. Statements on the behavior of the monsoon (erratic, late arrival, early retreat, etc.,) are included. This is the classical weather description.

Support Information

The very last portion of the assessment is optional and provides reliable support statements taken from secondary sources of information. For example, reports from the field would be appropriate. News media accounts are generally not recommended.

B. Types of Assessments for the Bicol and Visaysas Regions

This study developed three types of assessments including: 1) Drought Early Warning (GMI), 2) Agricultural Crop Condition (YMI) and 3) Weather Advisories for the Extension Service (Soil Moisture). Depending on the user's requirements, the drought early warning and crop condition assessments can be combined into one report. The advisory assessment for the extension service should provide weather analysis in great detail and considerable information and data on soil moisture. A table providing soil moisture estimates for each month could be included. The specific requirements and format desired by users must be obtained.

C. Frequency for Making Assessments

The models developed in this study use monthly meteorological data; therefore, primary assessments are made within about 5 days after end of each month during the growing season. However, update assessments providing current weather and other qualitative information can also be provided each week or every two weeks. These help the user maintain continuity.

Frequently, users require special assessment reports which elaborate on the potential impact problems. These could be 5-10 page reports.

Assessment models could be developed from decadal meteorological data (e.g., 10 day total rainfall) and assessments made every 10 days.

D. Assessment Models

Primary

The primary assessment models to be tested include the Generalized Monsoon Index (GMI) for southwest and northeast rainy seasons, the Yield Moisture Index (YMI) defined for rainy season maize and rice, monthly soil moisture estimates determined from the Palmer two-layer model and preliminary statistical climate/crop yield models for main rice and maize crops.

The historic indices have been summarized in computerized tables and time-series plots for each station in the Philippines (see Chapter V for examples). The index is listed for each year and assessment period (GMI: Table 5.2 and Figure 5.1; YMI: Tables 5.36 and 5.2). Indices are expressed in raw numerical form as well as percent normal and percentile rank. Percentile ranks range from zero to 100. Each table can be used as a worksheet to compute real-time index values for the current year (1982, 1983, etc.). Current year index values can also be placed on the time-series plots for analysis. The tables and graphs permit the assessor to easily make comparisons with previous index years.

Each index has also been summarized in tables which provide index values for each location but for a specific year. This is useful in performing a spatial analysis.

Soil moisture tables provide monthly moisture estimates for each layer in the soil (see Table 5.6).

Secondary models

The climatic diagram and the Palmer Drought Index (PDI) are very important secondary assessment tools. The climatic diagram can be determined from the soil moisture budget tables; however, the PDI (Figure 5.4) is usually calculated on a computer.

The climatic diagram can be presented in either table or graphic format. It is very useful as a tool to analyze conditions during the progress of the crop season.

The extension service and other users may be interested in receiving this information as a regular assessment product. Variables would include monthly rainfall, normal Potential Evapotranspiration (PET), Actual Evapotranspiration (AET), Soil Moisture (SM) and runoff. Rainfall or soil moisture normals could also be added.

It is also possible to define normal PET values for 10 day periods within each month. These can be used with real-time, decadal rainfall to provide the climatic diagram assessment every 10 days. Daily assessments can also be developed. For example, NOAA/AISC converts monthly rainfall normals into daily normals. This same process could be used with PET.

E. Display of Data

In addition to the tables and graphs discussed above for the index models and climatic diagram, there are other useful ways to display the data for enhanced analysis. For example, it is useful to prepare station location maps for the Bicol and Visayas Regions and to spatially analyze rainfall data and index values. Rainfall data can be plotted as a percent of normal for individual months or the growing season. Cumulative rainfal during the growing season can be displayed on a graph which also shows the normal cumulative rainfall.

F. Steps for Preparing Assessments

Some of the suggested procedural steps for preparation of an assessment include:

1) Obtain monthly rainfall data for the assessment stations and conduct quality control. Perform a spatial analysis.
2) Enter the rainfall data into the tables for the GMI, YMI and Soil Moisture.
3) Calculate the raw values for the GMI and YMI for the assessment period, as appropriate.
4) Calculate soil moisture, AET, etc.
5) Use the historic index tables to calculate percent of normal (YMI & GMI) and interpolate the percentile rank from the tables.
6) Plot the GMI and YMI percentile rank on the historic time-series plots.
7) Determine climatic diagrams for the current year.
8) Prepare maps which indicate the spatial variability of rainfall (percent normal) and indices (percentile rank).
9) Prepare the assessment using the above results and in the recommended format as outlined above, and
10) Obtain approval for the assessment and distribute to users in the Ministry of Agriculture and others, as appropriate.

G. Comments on Interpretation of Assessments by Users

The assessment should be viewed as an additional source of information that is available for making decisions on drought early warning, crop condition analyses and extension services. The assessment <u>only</u> provides information in potential or actual climatic impact. It does not consider the many other factors, for example, which could cause crop yield variability. These may include changes in planted area, fertilizer and pesticide applications, varieties and

other management decisions, crop losses due to pests are not assessed. The assessment is most reliable for potential drought impact, not flooding damage or other extreme weather events.

Drought impact can be reliably assessed by about 30 days before the crop harvest. This may represent as much as 3-6 months lead-time before economic impacts.

H. Comments on Test and Evaluation

It is proposed that the assessment models be tested and evaluated on the 1983 southwest monsoon season. Test assessments would be prepared at the end of May, June, July, August, September and October. These would be provided to users.

The purpose of this test period is to evaluate the models, learn how to interpret them, gain experience in preparing the assessment and to establish a dialogue with users. The users needs must be determined and their comments are very necessary.

CHAPTER VII

RECOMMENDATIONS FOR PROGRAM IMPLEMENTATION AND FUTURE WORK IN THE PHILIPPINES

The proposed program on agroclimatic assessments for policy decision making, economic planning and agricultural development in the Philippines is a multi-disciplinary activity in which the following agencies and organizations could participate:

1. Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)
2. Bureau of Agricultural Economics (BAEcon)
3. Bureau of Soils (BS)
4. Bureau of Plant Industry (BPI)
5. National Food Authority (NFA)
6. National Economic Development Administration (NEDA)
7. Bureau of Agricultural Extension (BAE)
8. Ministry of Agriculture (MA)
9. Ministry of Human Settlements (MHS)
10. Philippine Council for Agricultural Research and Resource Development (PCARRD)

Technical cooperation and assistance may be requested from foreign and international organizations such as the Food and Agricultural Organization (FAO), World Meteorological Organization (WMO), United States Agency for International Development (USAID) and the U.S. National Oceanic and Atmospheric Administration, National Environmental Data and Information Service, Assessment and Information Services Center, Climate Impact Assessment Division - Models Branch (NOAA/NESDIS/AISC/CIAD-MB) together with Atmospheric Science Department, University of Missouri, both in Columbia, Missouri.

The implementation of the proposed program is basically composed of four phases as described below.

A. Phase I: Agroclimatic Assessment Orientation Program

This phase was sponsored by AID/OFDA through NOAA/AID agreements and conducted by NOAA's Assessment and Information Services Center (AISC, formerly CEAS), Washington, D.C. at AISC's Models Branch, Columbia, Missouri in cooperation with the Atmospheric Science Department, University of Missouri, Columbia, Missouri. The objectives of this six-week orientation program were:

1) To obtain an understanding of the potential contribution that agroclimatic assessments can make:
   - for improved drought/disaster preparedness and national food security through drought early warning and crop condition assessments,
   - to improve national economic planning through the above assessments,
   - for a more effective use of national resources, and
   - for the effective use of improved agricultural technologies.
2) To develop agroclimatic models and agroclimatic assessments for:
   - evaluation of water supply to crops and assessment of water availability and soil moisture,
   - development of agroclimatic indices to assess drought and crop conditions,
   - application of agroclimatic data and indices to assess climate impact on crops to support BAEcon's crop forecast program, and
   - use of agroclimatic data in land and water resource management studies for agricultural planning and rural development.

3) To understand derivation and use of mathematical models which simulate crop response from climatic data through
   - o statistical models,
   - o agroclimatic index models, and
   - o other models.
4) To learn how to prepare meaningful assessment statements based on:
   - o the users in government and their specific requirements,
   - o scientific analysis of agroclimatic data, and
   - o the use of remotely sensed information in assessments.

This initial phase of the program has been accomplished. This report on agroclimatic assessment techniques for the Bicol and Visayas Regions documents the Orientation Program.

B. Phase II - Test and Evaluation of the Models

Before the agroclimatic models and indices developed for the Bicol and Visayas Regions can be used for operational climatic impact assessments on crop conditions they must be tested and evaluated. The agroclimatic/crop condition indices should be calibrated to determine the critical index values associated with weather condition impact. Statistical crop/yield models should be tested for reliability, generality and sensitivity using future and other agronomic and weather data not used in the development of the models. This test and evaluation of the models will be based on test assessments issued to users during the 1983 crop growing season and should include:

- o decadal and montly weather analysis plus monthly crop condition assessments for the regions,
- o drought/early warning assessments,
- o special assessments on the magnitude and extent of weather impact for agencies and organizations involved in providing disaster relief. Timeliness in providing this information is of the utmost importance.

A report on the test and evaluation will be prepared. This will provide the decision-makers with information on the capabilities and limitations of the proposed early warning assessment program for the Bicol and Visayas Regions. The report shall also contain recommendations for development of the same early warning program for other administrative regions in the Philippines after which this program will be on the national level. These recommendations shall be addressed to all concerned cooperators including economic planners and policy-makers.

The implementation of this phase within PAGASA shall be carried out primarly by the Data Applications Center with the support of the Agricultural Meteorology Division which will ultimately handle the operations of this activity in line with its program on advisory services for agriculture.

C. Phase III - Development of National Early Warning Assessment Program

Having developed and made operational the pilot early warning assessment program for the Bicol and Visayas Regions, it is hoped that a similar program can be carried out on the national level.

Simultaneous to the operations of the pilot early warning assessment program, similar processes to those of the pilot project shall be made for the other remaining administrative regions, including test and evaluation.

D. Phase IV: Operational Implementation of the National Early Warning Assessment Program

This is the last stage of the proposed Early Warning Assessment Program in the Philippines. It is envisioned that this operational early warning system can provide decision-makers and planners with needed information to improve short and long-term decisions involving economic plans, agricultural development and food security in the Philippines.

The development and operational implementation of the proposed National Early Warning Assessment Program is by its nature a multi-disciplinary team effort. Such activities can be made successful by taking into consideration certain important requirements towards this end. It is recommended that the following requirements and strategies be served:

- Continuously developing an agrometeorological data base while improving and making maximum use of the existing rainfall station network.
- Improving the network of agrometeorological stations; each agroclimatic zone must be well represented.
- Making phenological observations on the main crops in each agroclimatic zone; this will be very useful in updating or establishing crop calendars for each zone.
- Conducting crop-weather studies for local conditions to improve on the existing climate/crop condition assessment models.
- Developing agroclimatic zones based on major crops; in the Philippines, for example, rice or corn based agroclimatic zones. This will facilitate and improve assessments of climate impact on agricultural crops and long-term land utilization planning.
- Improving knowledge of local agricultural practices; this is an important input for modeling and testing of models.
- Standardizing the sampling techniques on agricultural data collection. Agricultural data at the provincial level for each region is highly desireable for improvement of assessments.
- Expanding computer facilities to improve the assessment process.
- Incorporating information from meteorological satellites to develop tools for improving the assessment program.

- Enhancing linkages and dialogue between and among different disciplines of meteorologists, agriculturalists, socio-economic scientists, and policy and decision-makers in the implementation of this collaborative effort.
- Improving communication systems for quick data collection and timely dissemination of assessments and advisories and end-users.
- Continuing this training/technology transfer process towards a national assessment capability.

E. Concluding Remark

This study represents a good beginning. Policy makers, economists, statisticians, extension officials, soil scientist and other users in government can be provided with timely, reliable information on potential or existing climatic impact in agriculture. The system of drought early warning and agroclimatic/crop condition assessments can provide highly useful information 30 days before the crops are harvested. This can mean up to a 3-6 month lead-time before economic impacts occur. Disaster preparedness and food security programs can be improved.

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