PN-ABE-744
65449

TRAINING REPORT

SATELLITE CROP MONITORING WORKSHOP

MALAYSIA

Conducted By

U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
COOPERATIVE INSTITUTE FOR APPLIED METEOROLOGY,
UNIVERSITY OF MISSOURI-COLUMBIA
U.N. ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC
ASIAN INSTITUTE OF TECHNOLOGY

Sponsored By

USAID OFFICE OF FOREIGN DISASTER ASSISTANCE
U.N. DEVELOPMENT PROGRAMME

July 1989
Bangkok, Thailand

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Malaysian Participants

Lim Hong Choo
Yong Pok Wing
Tung Nam Ping
Jamal b. Abdullah

July 1989
Bangkok, Thailand

ACKNOWLEDGEMENT

The Malaysian participants to the workshop wish to express their appreciation to the organising agencies, UNDP and USAID/OFDA for provinding the fundings, NOAA and CIAM for the technical expertise support, and ESCAP for coordinating the project.

Sincere appreciations are also expressed to all the lecturers, Dr. Gary E. Johnson (NOAA), Dr. Roa Achutuni (CIAM), Dr. Wayne L. Decker (University of Missouri), Dr. Oranut Paisarnuchapong (Thailand Meteorological Department), for their most interesting and enlightening lectures on the various topics related to the workshop. Thanks are also due to Mr. Michael Sheinkmen and Ms. Sandra Weisman for their patience and guidance during the computer practical sessions.

The authors also wish to express their gratitude to Dr. John Lukens (AIT) for arranging the use of the excellent facilities in AIT and conducting a most interesting field trip during the workshop, and to Mr. Jan Orsini (ESCAP) for providing the logistic support throughout the programme.

Finally, the authors wish to thank fellow participants from Indonesia, Philippines and Thailand who had been most cooperative and helpful during the course of the workshop.

EXECUTIVE SUMMARY

The objective of the Phase II Satellite Crop Monitoring Workshop is to transfer to the participating countries, namely Indonesia, Malaysia, Philippines and Thailand, the latest technology of using NOAA satellite AVHRR data for crop monitoring and hence complement the national Agroclimatic Impact Assessment Program which was initiated during the Phase I project.

NOAA satellite data are used because they are readily available daily at most of the national meteorological services in the region with minimal additional cost.

The difference in the reflectance of the various conditions of crop cover in the channel 1 and channel 2 were used to develop the Normalised Difference Vegetation Index (NDVI) which can be used effectively for crop monitoring.

The latest development of the various softwares and the rapid advancement in personal computer development have made it possible for the NDVI to be computed, analysed and displayed in image forms on desk-top PCs. Compositing techniques were used to reduce cloud contamination. These images and analyses can be used to monitor the changes in the biomass over a selected area and for the development of crop yield forecast models.

The training course consisted of lectures in the morning and hands-on exercises in the afternoon. The practical sessions enabled the participants to gain experience in using the

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techniques and hence given confidence to apply these techniques on their return to their respective agencies.

A field trip was organised to demonstrate to the participants the various ground conditions in relation to the various types of satellite imageries which were of different resolutions.

On the whole, the workshop was intensive, challenging and rewarding. Hence, the workshop has achieved its objective.

4'

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SATELLITE CROP MONITORING WORKSHOP

TRAINING REPORT

By

Malaysian Participants

1. Introduction.

During the 1980's, the United States National Oceanic and Atmospheric Administration (NOAA) developed a simple and cost effective micro-computer based drought early warning system using rainfall analysis. During 1984 to 1986, NOAA in conjunction with the Economic and Social Commission for Asia and the Pacific (ESCAP) introduced this technology simultaneously to nine Asian countries, i.e. Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka and Thailand through the Phase I of the drought early warning program for South and South-east Asia which was entitled the Agro-Climatic Assessment Program. Malaysia's active participation in Phase I of the Agro-Climatic Program, and with the support from NOAA and ESCAP in the form of personnel training and equipment, had resulted in the establishment of a task team which initiated the routine preparation of a monthly bulletin known as the Agroclimatic Impact Assessment Bulletin.

Although the Phase I rainfall analysis provides a relatively simple and effective drought warning system, it gives insufficient information about the physical area affected by drought especially in areas where rainfall stations are sparsely located. The Phase II Satellite Crop Monitoring Project was

designed as an attempt to overcome this weakness and also further enhance the program by utilising NOAA/AVHRR satellite data to provide operational imagery and vegetative index analysis. Using techniques developed by the Climatic Application Branch of NOAA and CIAM, it is possible to perform real-time satellite monitoring of the phenology of any crop. This technology has been tested extensively and proven successful in the Sahelian countries of Africa. This technology, when combined with the Phase I rainfall analysis and statistical climate crop yield models, would constitute a step forward towards achieving the goal of a reliable and timely tool for crop condition assessment and improve food security in the recipient countries.

The Satellite Crop Monitoring Workshop was part of the activities of the Phase II project and had the following objectives:-

(i) To build upon Phase I activities.

(ii) To enable participants to understand the characteristics, advantages and limitations of AVHRR imagery.

(iii) To familiarise participants with the interpretation of AVHRR imageries.

(iv) To familiarise participants with the derivation and use of the Normalised Difference Vegetation Index (NDVI).

(v) To train participants in the technique to incorporate NDVI into agroclimatic models.

(vi) To train participants to produce useful agroclimatic assessment bulletins.

The funds for the Phase II activities, including the

workshop, were provided by USAID office of the Foreign Disaster Assistance (OFDA) and the United Nations Development Program (UNDP) through the ESCAP Regional Remote Sensing Project (RRSP). The technical expertise for the workshop was provided by NOAA and CIAM.

The workshop was conducted at the Asian Institute of Technology (AIT), Bangkok from 12 June to 7 July 1989. Malaysia was honoured to be selected to continue participating in the Phase II activities and had nominated the following four participants to the workshop:-

(i) Ms. Lim Hong Choo (Department of Agriculture)

(ii) Mr. Yong Pok Wing (Malaysian Meteorological Service)

(iii) Mr. Tung Nam Ping (Malaysian Meteorological Service)

(iv) Mr. Jamal bin Aodullah (Department of Drainage and Irrigation.

The full list of participants is shown in Appendix I.

2. Incorporation of NOAA Satellite Data in the Crop Monitoring Assessment Process.

NOAA satellite data have several intrinsic characteristics which make them valuable in the crop monitoring assessment process. The AVHRR sensor records electro-magnetic radiation for 5 spectral regions:-

- visible (Channel 1)
- near IR (Channel 2)

- middle IR (Channel 3)
- thermal IR (Channels 4 and 5)

The first two spectral regions are ideal for monitoring crop/vegetation on an operational basis. The thermal IR is useful in cloud cover analysis and hence, is used in determining the cloud threshold in the cloud elimination process in the assessment program.

The AVHRR data are available in 5 operational modes, out of which three are being utilized in this workshop, ie:-

(i) Local Area Coverage (LAC) data having a 1.1 km spatial resolution. The limitation regarding these data is that at present they are available only for selected portions of each orbit.

(ii) Global Area Coverage (GAC) data which have a 4 km spatial resolution and the data are available weekly.

(iii) Global Vegetation Index (GVI) data which have a 16 km spatial resolution and are available in daily and weekly composites.

The DRAGON Image Analysis software was used to produce satellite imageries from the NOAA satellite channel data using a micro computer. Using a technique of selecting cloud free areas of a sequence of images for a region and then compositing them, the problem of the ever present cloud cover in the equatorial region can be reduced considerably. These imagery products served as an important tool in analysing the vegetation

conditions and their changes through time.

The difference in the reflectance of the vegetation in the channel 1 and channel 2 was used to develop the Normalised Difference Vegetation Index (NDVI) which can be used for crop monitoring.

$$NDVI = [CH\ 1 - CH\ 2]/[CH\ 1 + CH\ 2]$$

Other supporting softwares were used to analyse the NDVI values which were derived from NOAA satellite data. This made it possible to analyse the biomass of the crop/vegetation quantatively and facilitates the development of crop yield models.

In the case study for Malaysia, done during the workshop, there were indications of some relationship in the NDVI time series with the crop growth stages as indicated in the crop calender (see Appendix 2). This showed that there were potential in using this technology for research in the field of crop assessment and yield forecasting.

Despite the promising indications of the usefulness of the techniques dicussed during the workshop, we need to bear in mind that compared to the African Sahel, Malaysia being an equatorial country, would have different climatic and environmental conditions, besides being of much smaller dimension. Further observations need to be carried out and appropriate modifications performed to adapt the techniques to suit the local conditions.

3. Proposed Data Products, Flow and Integration for Malaysia.

3.1 Data required for the preparation of the assessment bulletin could be broadly categorised into the following:-

(i) Climatological data

- rainfall
- temperature

The above data would be supplied by the Malaysian Meteorological Service.

(ii) Agronomic data

- crop yield data
- crop conditions
  - pest incidence
  - crop disease outbreak
  - crop calender

These data would be collected by the Department of Agriculture.

(iii) Satellite data

These data would be received by the weather satellite receiving station of the Malaysian Meteorological Service and downloaded into diskette to be used on desk top micro-computer.

(iv) Other data

- irrigation facility information

to be provided by the Department of Drainage and Irrigation and Agriculture Project offices.

- base maps (land use, soil, topography, etc.)

to be provided by the Department of Agriculture and

- the Directorate of National Mapping and Survey.

3.2 Data Integration.

Data integration would be achieved through a technical committee for Agroclimatic Impact Assessment set up by the Ministry of Agriculture. This committee would be headed by a senior officer of the Ministry of Agriculture and the committee members would comprise of representatives from the various agencies concerned. A schematic diagram showing the integration of data through this committee is shown in Appendix 3.

4. The Assessment Bulletin.

4.1 Format of the bulletin during Phase I.

The Agro-Climatic Impact Assessment bulletin prepared monthly during the Phase I project consisted of the following sections:-

(i) Summary

This gave an overview of the weather and agronomic conditions during the period of the bulletin.

(ii) Weather Analysis

This section provided the analysis of the rainfall, sunshine and other relevant weather parameters recorded in the area of interest. This section also indicated whether the meteorological conditions were favorable to crops.

(iii) Agronomy Report

This section reported on the various stages of crop growth and activities carried out in the irrigated as well as the non-

irrigated rice growing areas. Crop yield would also be reported in this section.

(iv) Pest and disease occurence.

This section reported on the occurence of pest and diseases, and estimation of the areas affected.

(vi) Tables, that summarised the precipitation records, yield moisture index, generalised monsoon index, padi hectarage and areas affected by pests and diseases, follow the text.

The bulletin was distributed to the following agencies which were involved in the monitoring and planning of rice production in the country:-

(i) The Economy Division of the Ministry of Finance.

(ii) The Economic Planning Unit of the Prime Minister's Department.

(iii) The Malaysian Agricultural Development Authority.

(vi) The Agriculture Department at the state (regional) level.

(v) National Rice Board.

(vi) Statistic Department.

(vii) Ministry of Science, Technology and Environment.

4.2 Proposed changes in the bulletin format.

In general, the same bulletin format will be adopted with some minor changes which incorporates the new materials covered during the workshop. These new materials will be added to the

bulletin in the following sections:-

(i) Vegetation/biomass conditions.

This section will analyse the vegetation/biomass based on satellite imagery and NDVI analysis. Colour images of composite satellite pictures and graph of NDVI time series might be included.

(ii) Quantitative Yield Forecast.

This section can be included in the bulletin provided that reliable yield models can be developed.

5. Plan and follow-up actions.

The following follow-up actions would be taken in Malaysia after the Malaysian participants returned on completion of the workshop:-

5.1 Installation of equipment.

Malaysia would be provided with two sets of equipment and softwares, one each for the Department of Agriculture and the Malaysian Meteorological Service. Each set of equipment consists of an NEC Multisync II monitor and a VGA Wonder card. The equipment are expected to be delivered about two weeks after the completion of the workshop. They will be installed in the respective department as soon as possible after delivery provided that the micro-computer in the respective department are compatible and of sufficient disk capacity.

Although the Malaysian Meteorological Service has an existing personal computer with sufficient disk capacity to

handle the data processing required for the satellite crop monitoring program, it is being used almost exclusively for the CLICOM project being implemented. The existing disk capacity is certainly not sufficient for both the CLICOM and the satellite data processing of this program. Hence, the assistance of ESCAP/NOAA in upgrading the disk capacity or the acquiring of a separate CPU for the program will be required. The Department of Agriculture faces problems of a similar nature. The existing computer facilities are not sufficient to handle the additional workload of satellite imagery processing. Similar assistance in this area from ESCAP/NOAA for the Department of Agriculture are required for the smooth implementation of the program.

5.2 Installation of software.

Installation of the softwares, DRAGON, MICVEGI and other supporting programs, will be performed after the installation of the equipment.

5.3 Downloading of satellite data onto diskettes.

Satellite data received at the Satellite Receiving Station in the Malaysian Meteorological Service need to be downloaded onto diskettes in order to be used on the micro-computer system. For the time being, it was not certain whether the satellite data recorded at the MMS Satellite Station are level 1 B data or not. A sample tape recorded with NOAA AVHRR data was sent to the AIT computer department for confirmation. If the data were in level 1 B format, there would be little problem of downloading the data

onto diskettes using the MMS Perkin-Elmer Mini computer and with the assistance provided by NOAA and CIAM. If the data recorded at MMS are not level 1 B data, then the MMS would need to upgrade its satellite data receiving facilities. This would depend on the availability of funds from the Malaysia central agency, failing which the alternative would be to make arrangements with the Thailand Meteorological Department for a copy of their level 1 B data on diskettes to be sent routinely to MMS. The cooperation from the Thailand Meteorological Department and ESCAP's assistance on this matter would be very much appreciated.

5.4 Establishment of Analysis.

(i) Collection o ' se maps and ground data information for the setting up of criteria for analysis is to be initiated by the Department of Agriculture.

(ii) Testing of analysis technique on irrigated (project) areas where good data are available.

5.5 Technical Mission

To ensure the smooth implementation of the program, a technical mission to Malaysia between mid November to early December would be of great assistance to trainees in solving some of the problems that would be encountered or in the finalising of any modifications to the softwares.

5.6 Evaluation Seminar

The progress and evaluation of the implementation of the

program would be presented in a seminar sometime during March/April 1990 pending on the recomendation by the Technical Mission.

6. Conclusions

6.1 The NOAA satellite AVHRR data such as GAC and GVI data have been proven to be very useful in detecting the changes in vegetation cover in the African Sahel regions. Attempts should be made to use these data to the fullest in this region in view of the fact that they are readily available, relatively inexpensive and of high temporal resolution. Experience gained during the workshop indicated the possibility that the technology of using the NOAA satellite AVHRR for crop monitoring could be applied in Malaysia.

6.2 The rice growing areas in Malaysia are generally small in area. It was felt that satellite data of higher resolution like the LAC data would be more effective for the crop monitoring program in Malaysia.

6.3 Attempts would be made to incorporate the technology aquired during this workshop to improve the agro-climatic impact assessment bulletin. Near real-time data from the NOAA satellite would make it possible to prepare early warnings should the need arise.

6.4 Based on the experience gained during the workshop, it was felt that the existing computer facilities in the agencies

directly involved in the program are not sufficient for the additional satellite data processing required. Assistance in the form of upgrading the existing facilities or additional equipment would be required from ESCAP/NOAA.

6.5 It was felt that the workshop has been very intensive. An extension of the workshop period for a further two weeks would be just sufficient to cover all the hands-on exercises and to carry out fool-proof test on the newly developed software packages. Nevertheless, the training workshop had been very challenging, often exciting and generally rewarding. The experience and technique acquired during this four week workshop would certainly enhance Malaysia's National Agroclimatic Impact Assessment Program.

6.6 On the whole the transfer of technical knowledge has been successful.

APPENDIX I

List of Participants
Satellite Crop Monitoring Workshop
12 June - 7 July
Bangkok.

Indonesia

1. Ms. Erly Tapisari B. Harahap
   Directorate of Food Crop Protection (DFCP)

2. Mr. Mohd. Ismet
   National Logistics Agency (BULOG)

3. Ir. Sutrisno
   Meterological and Geophysical Institute (BMG)

4. Mr. Bambang Untoro
   National Institute of Aeronautics and Space (LAPAN)

Malaysia

1. Ir. Jamal b. Abdullah
   Drainage and Irrigation Department (DID)

2. Ms. Lim Hong Choo
   Department of Agriculture (DOA)

3. Mr. Tung Nam Ping
   Malaysian Meteorological Service (MMS)

4. Mr. Yong Pok Wing
   Malaysian Meteorological Service (MMS)

Philippines

1. Ms. Marcelina Dumayac
   National Mapping and Resources Information Authority (NAMRIA)

2. Mr. Amadeo Lucido
   Bureau of Agricultural Statistics (BAS)

3. Mr. Felizardo Magnayon
   Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

List of Participants
p2

Thailand

1. Mr. Somporn Isaranurak
   Department of Agriculture (DOA)

2. Mr. Supan Karnchanasuthum
   Office of Agricultural Economics (OAE)

3. Mr. Somwang Martchaipoom
   Meteorological Department

4. Ms. Nongnat Ouprasitwong
   Meteorological Department

5. Ms. Uthaiwan Pornprasertchai
   The National Research Council of Thailand (NRC)

APPENDIX 2

COUNTRY CASE STUDY

NDVI Time-Series for Kedah, Malaysia.

1. Background

The area chosen for this program was the MADA (Malaysian Agricultural Development Authority) Project area which has a total physical land surface of 124841 hectares, out of which 93107 hectares were cultivated with rice (Land use report 1974). The project area was irrigated with water from the Pedu Dam.

Double cropping of rice was practised in the project area and the cropping schedule synchronised with the irrigation schedule. The cropping schedule was reflected in the crop calender attached (Figure 1)

The NDVI time series would show the biomass of both the main season crop as well as the off-season crop. For instance, in 1986, the main season cropping began during the first week of March 1986 and harvesting was completed during mid November 1986. The off-season started in early September 1986 and completed harvesting sometime during March/April 1987.

2. Discussion.

The NDVI time series were plotted for 5 regions of the MADA project area. These regions were represented by polygons, AAAA, BBBB, CCCC, DDDD and EEEE. The first four polygons were mutually exclusive areas in the MADA areas while the EEEE polygon almost cover the whole of the MADA project area.

The NDVI of polygons AAAA and BBBB do not relate very well to the biomass of the various crop growth stages as shown in the crop calender. However, the graphs generally show a peak/maximum NDVI during June which correspond to the maximum planting (main season) for almost all the years selected. The next peak was observed during December when maximum planting occurred for the off-season crops.

The relationship pattern between the NDVI time series and the crop calender are more significant for the polygons CCCC, DDDD and EEEE. A possible explanation for the difference is that the AAAA and BBBB polygons selected covered relatively a larger sector of crop lands other than the rice fields.

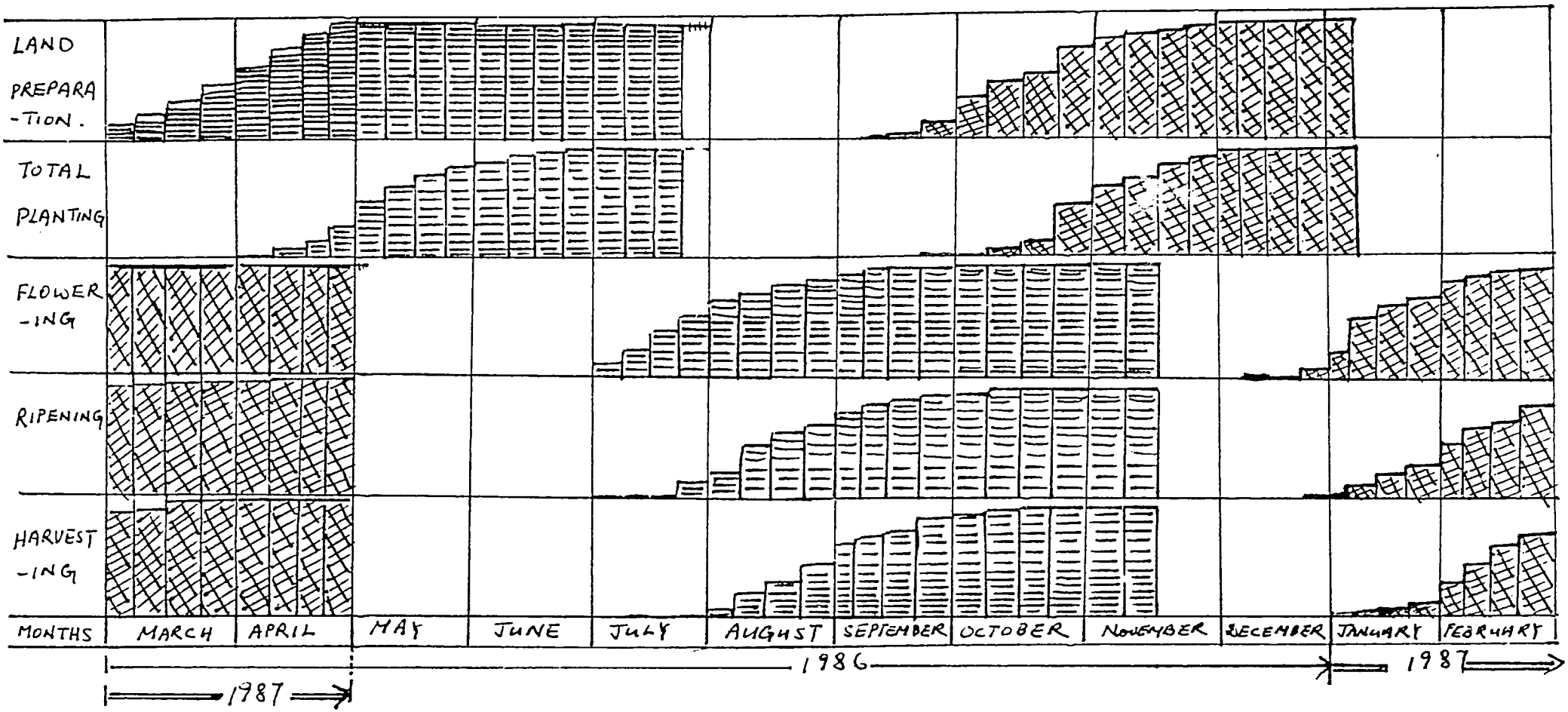
Although during March/April and October, flowering and ripening were at their maximum (March-April for the off-season crop, October for the main season crop), the quantity and quality of photosynthetically active biomass during these periods were lower than that of the earlier stages of crop growth. Thus the NDVI were lower during these periods.

The variability of the peak/maximum NDVI among the different years could possibly be caused by the slightly different cropping schedule or the occurrence of cloud cover that could not be completely eliminated during compositing. However, this need further investigation with data of a longer period before any conclusions can be made.

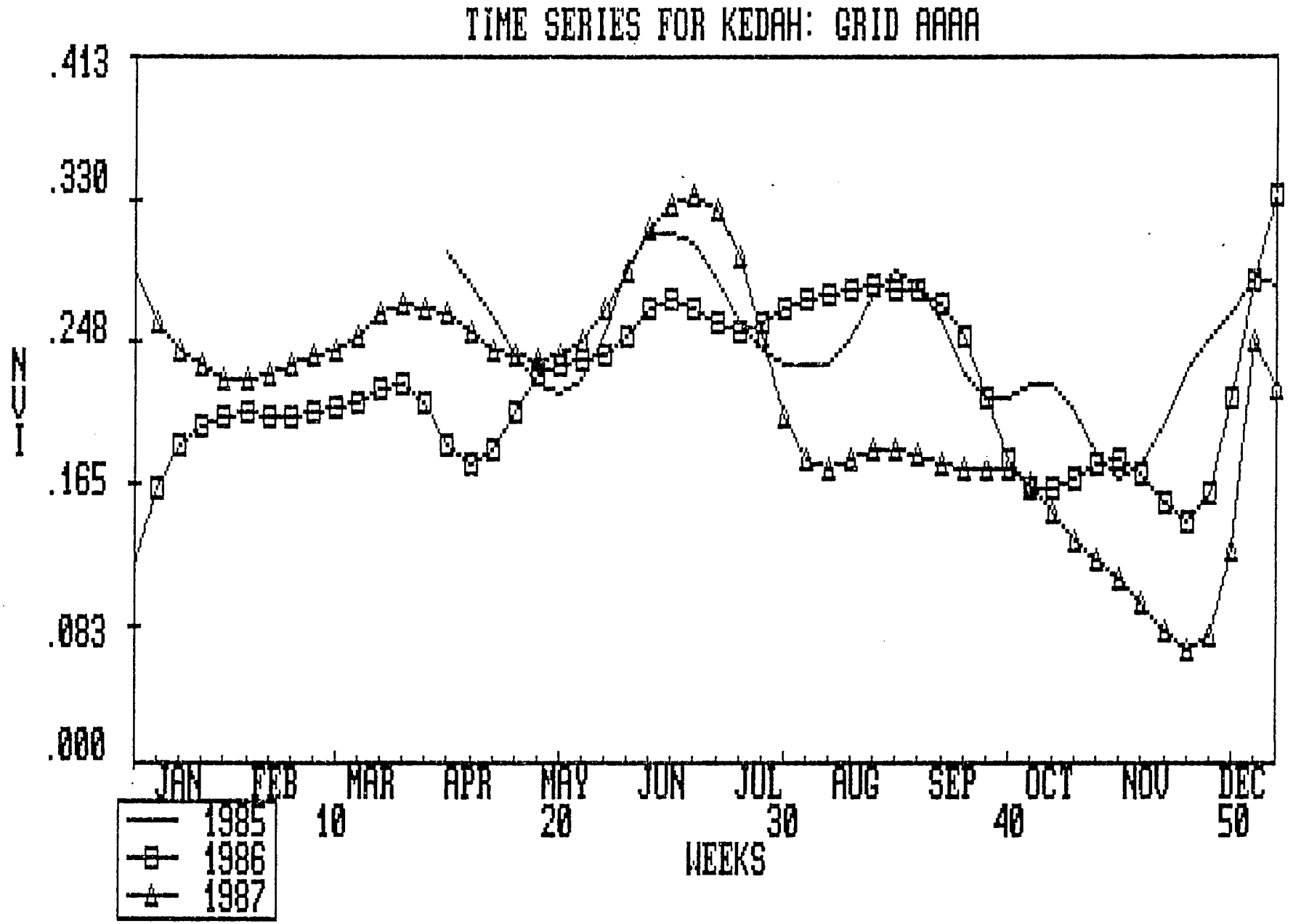
3. Conclusion.

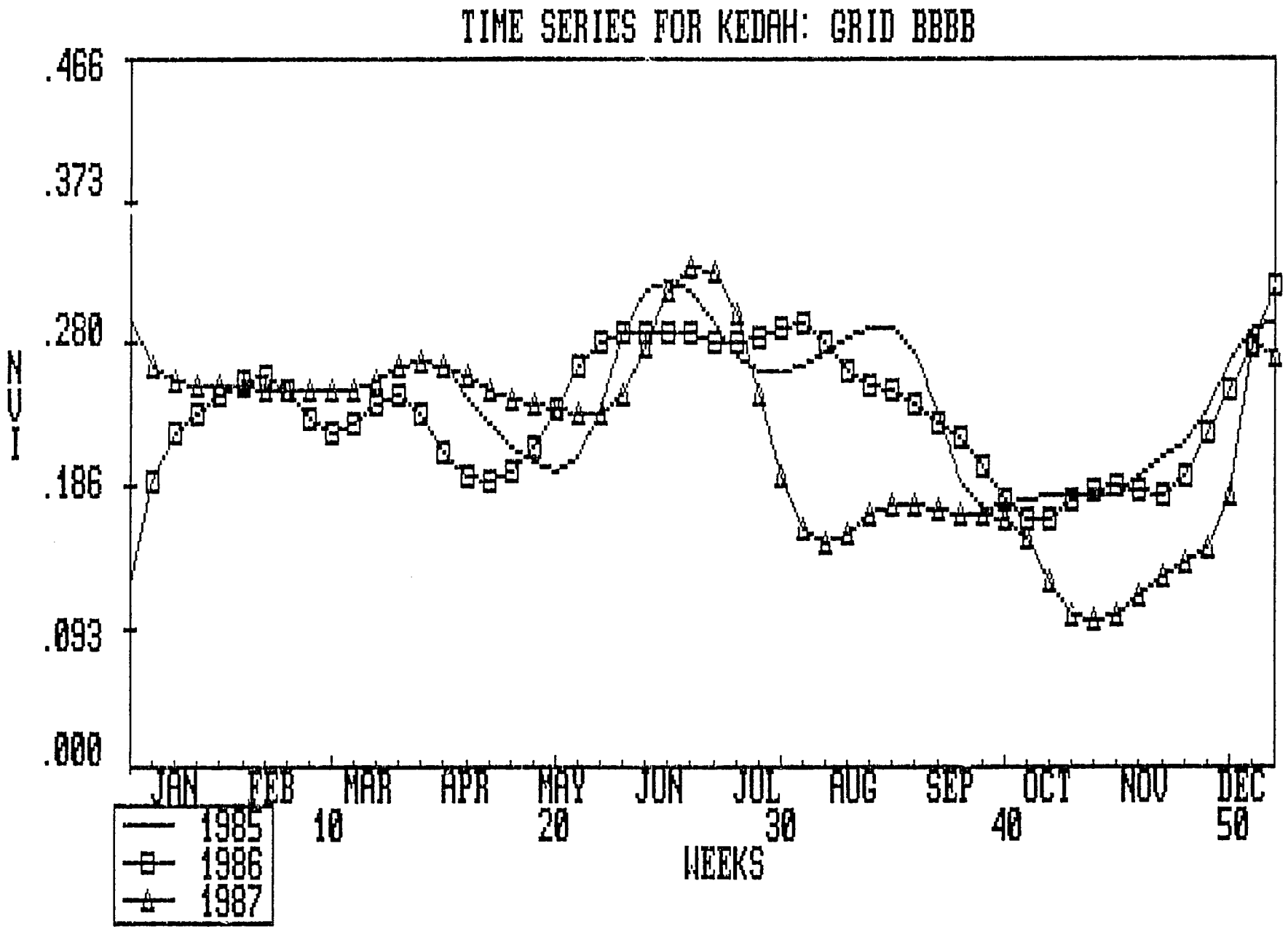
The above study using only 4 years of NOAA satellite data indicates that there is a relationship between the NDVI time-series and the cropping stages. However, more detail investigation with data of longer periods are required before any conclusive results can be obtained. This initial study shows that there is potential in the use of NDVI values to correlate with the crop conditions.

FIG. 1 CROP CALENDER (1986/87)



LEGEND	CROPPING SEASONS
	MAIN SEASON
	OFF SEASON


TIME SERIES FOR KEDAH: GRID AAAA
.413
.330
.248
.165
.083
.000
NVI
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
10
20
30
40
50
WEEKS
1985
1986
1987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.280
.186
.093
.000
NVI
JAN
FEB
MAR
APR
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40
50
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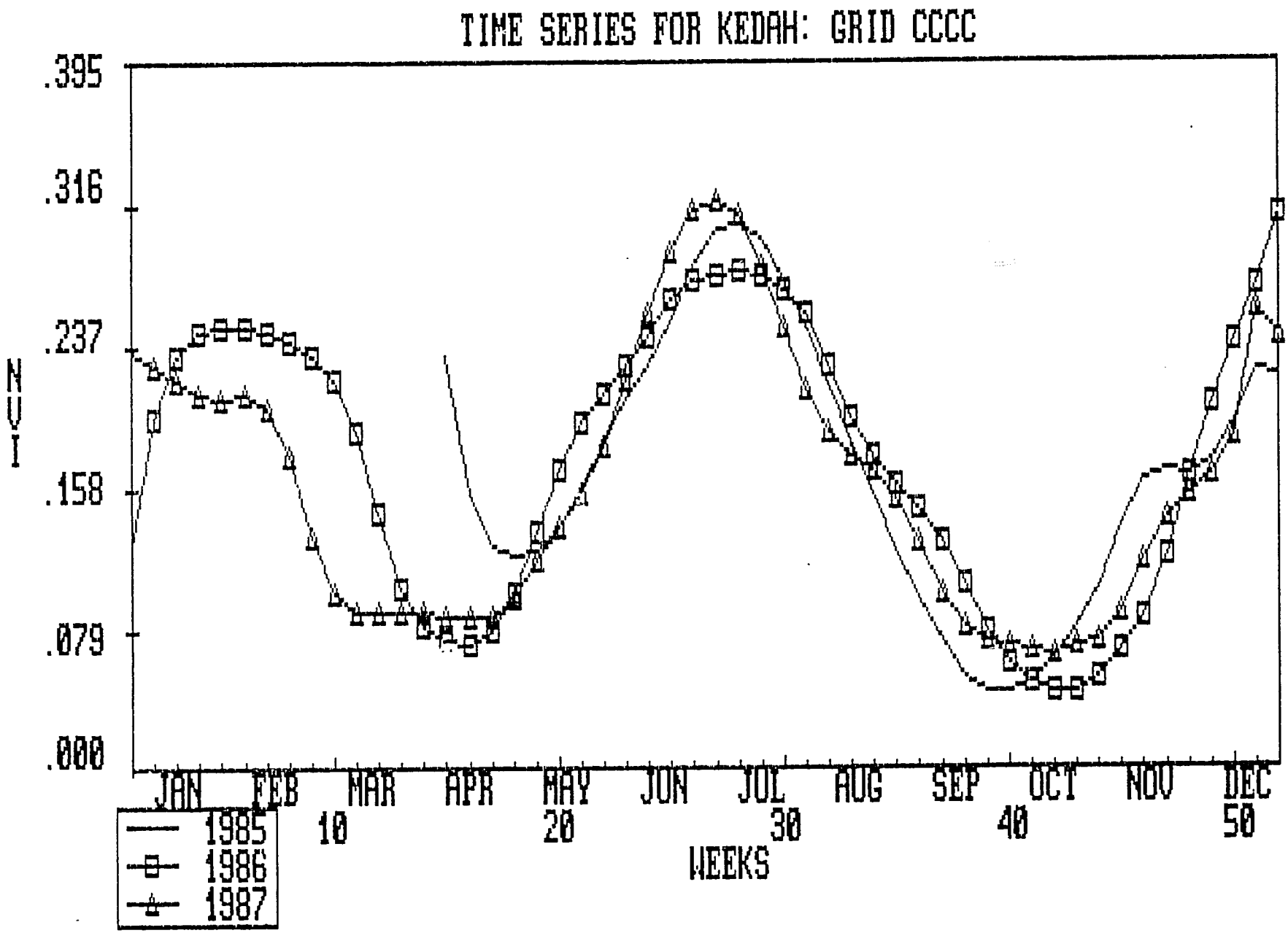
1985
1986
1987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.158
.079
.000
NVI
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FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
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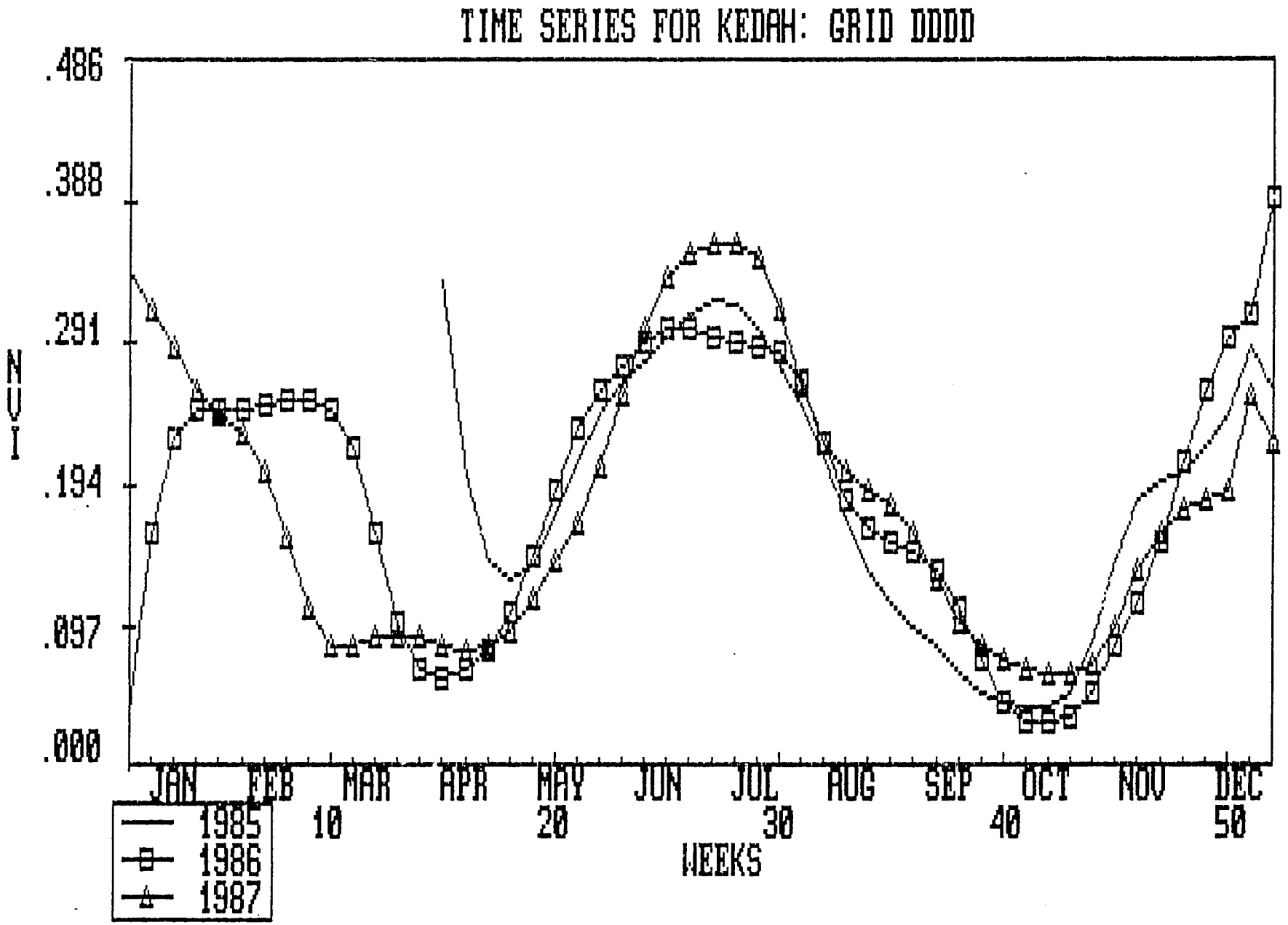
30
40
50
WEEKS
1985
1986
1987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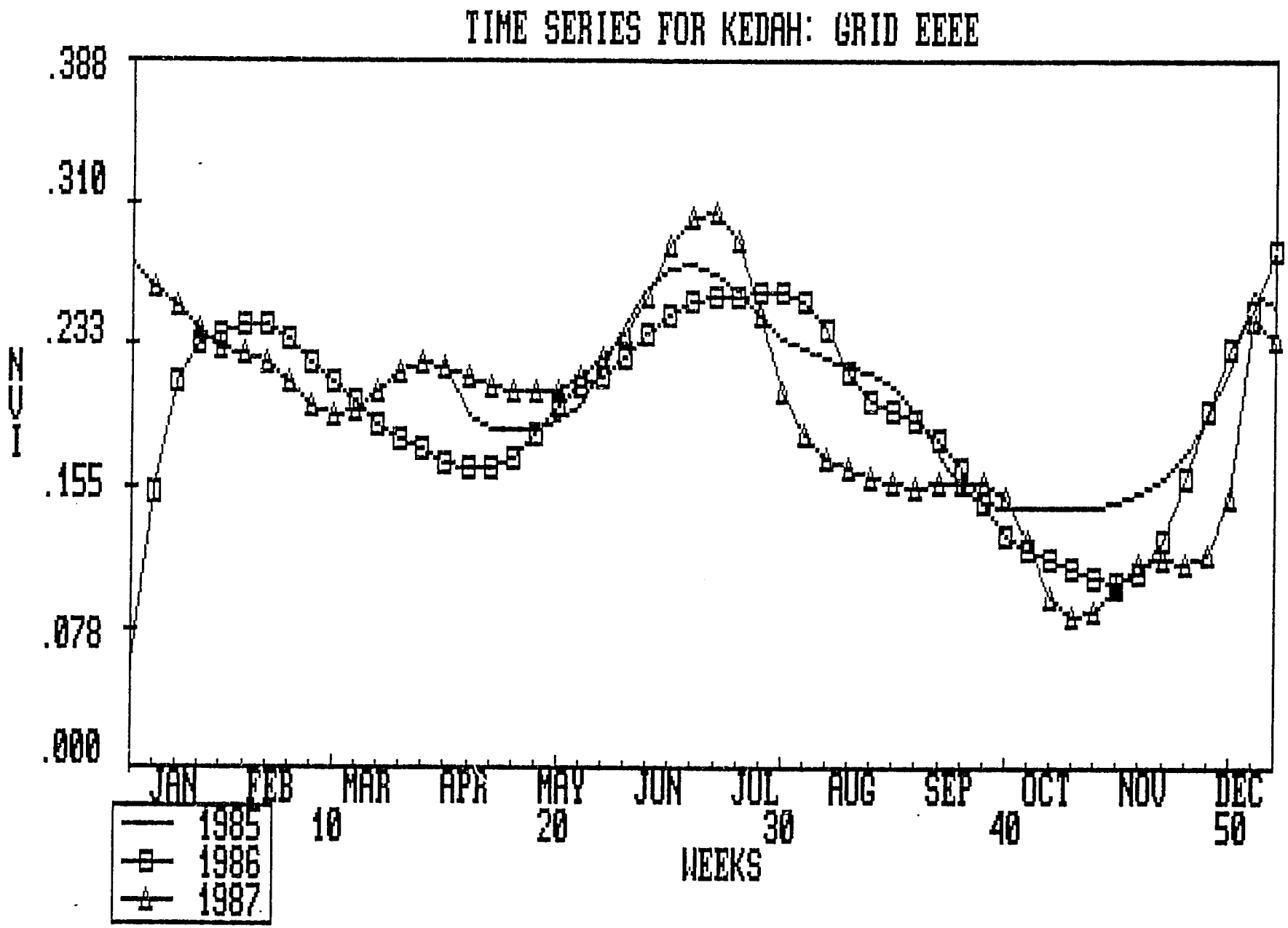
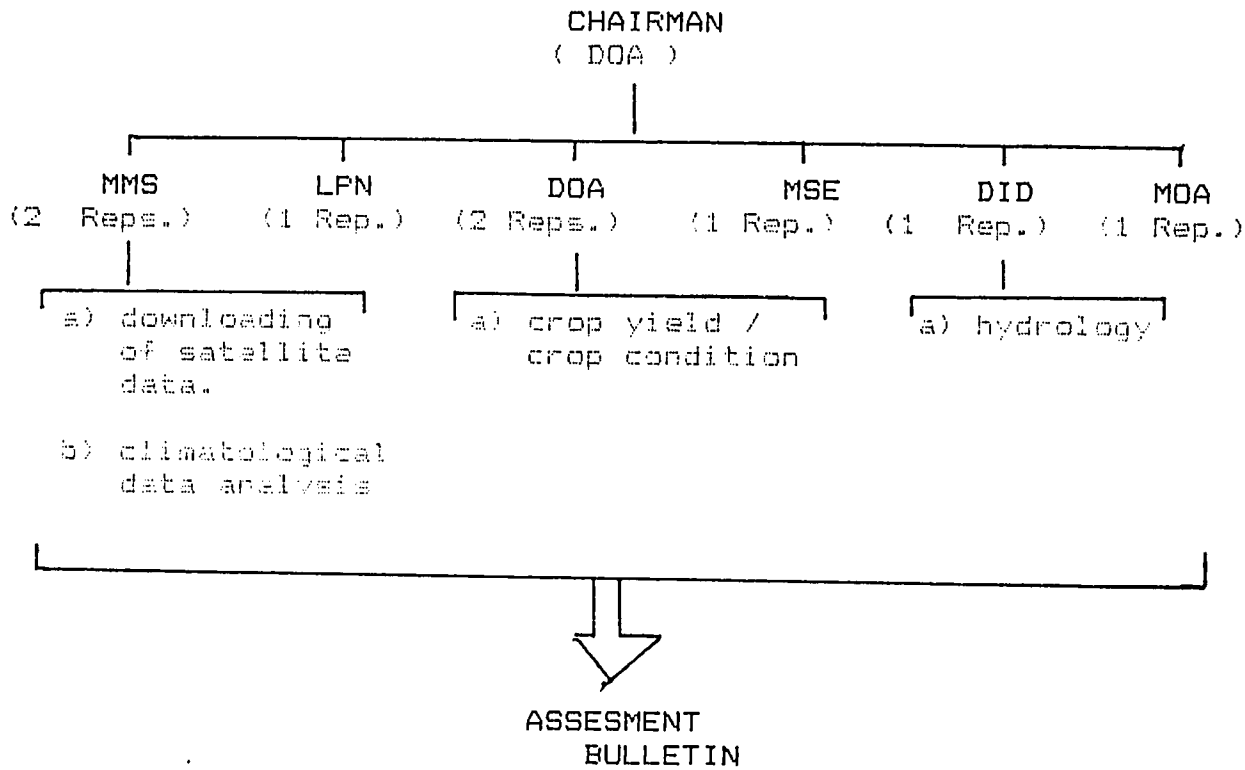
.486
.388
.291
.194
.097
.000
NVI
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
10
20
30
40
50
WEEKS
1985
1986
1987


TIME SERIES FOR KEDAH: GRID EEEE
.388
.310
.233
.155
.078
.000
NVI
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
10
20
30
40
50
WEEKS
1985
1986
1987

12.

ORGANIZATION OF THE MALAYSIAN TECHNICAL COMMITTEE FOR AGROCLIMATIC IMPACT ASSESMENT PROGRAM



LPN....National Rice Board

MMS....Malaysian Meteorological Service

DOA....Department Of Agriculture

DID....Drainage And Irrigation Department

MSE....Ministry Of Science, Technology And Enviroment

MOA....Ministry Of agriculture

Appendix 4

AGRO-CLIMATIC IMPACT ASSESSMENT REPORT

(NOVEMBER, 1985)

DATE ISSUE : 18th. DECEMBER, 1985.

SUMMARY

North-West Peninsular Malaysia

Average rainfall amounts of 200 - 300 mm were recorded in the region. They were sufficient to meet the water requirement of padi in its planting or initial vegetative phases.

During the month another 56,557 hectares were planted bringing the total hectarage planted to date 122,878 hectares. By the end of November about 93% of the total paddy area are already planted. The crop is expected to continue to grow well.

Slight increase of the hectarage affected by pests and diseases was reported · 500 ha.

Latest weather reports indicated that the first part of December is relatively drier.

Weather Analysis

Above normal rainfalls were reported in the MADA scheme while near normal rainfalls were recorded outside the scheme. Average total monthly rainfalls were about 315 mm in Kedah area and 210 mm in Perlis area. The agroclimatic indices for the period October to November were above normal in the Mada scheme. These rainfall amounts were enough to meet the water requirement for the paddy at its planning or initial vegitative phases. Mean daily sunshine duration of the region was about 5.5 hours

Agronomy

More areas have been planted by the end of November. The total area planted to-date is 122,878 hectares which is about 93% of the total area prepared.

In MADA, another 45,690 hectares were planted during the month, bringing the total area planted to-date to 90,827 hectares which is about 95.8% of the area prepared. Whereas outside MADA the total area planted to-date is 8,815 hectares.

Pests and Diseases

No area outside the MADA scheme were affected by pest and diseases. However the area affected in the scheme has increased from 127 hectares in previous month to 500 hectares in November. The major pest attack was from rats were approximately 224

hectares were affected.

The details of these pests and diseases breakdown are shown in table 5.

Table 1. PRECIPITATION

AREA	RAINFALL (MM)		PERCENTAGE NORMAL
	Mean	Range	Mean
MADA (19 stations)	287	200-389	138
OFF MADA			
i) Kedah (7 stations)	314	198-449	119
ii) Perlis (6 stations)	210	156-258	99

Table 2. YIELD MOISTURE INDEX (YMI)

AREA	Mean YMI	Range	Mean % Normal	Mean Percentile
MADA (19 stations)	665	413-963	131 %	78
OFF MADA				
i) Kedah (7 stations)	665	515-912	110 %	59
ii) Perlis (6 stations)	429	309-591	92 %	44

Table 3. GENERALISED MONSOON INDEX (GMI)

AREA	Mean GMI	Range	Mean % Normal	Mean Percentile
MADA (19 stations)	344	208-537	130 %	79
OFF MADA				
i) Kedah (7 stations)	337	189-477	108 %	57
ii) Perlis (6 stations)	215	154-305	91 %	42

Table 4. PADI ACREAGE IN KEDAH AND PERLIS
(MAIN SEASON - NOVEMBER)

AREA	Under Preperation (ha)	Planted (ha)	Flowering (ha)	Matured (ha)	Harvested (ha)
MADA	94,787	90,827	0	0	500
OFF MADA					
i) Kedah	27,911	23,236	N.A.	N.A	0
ii) Perlis	8,815	8,815	N.A.	N.A.	0

Table 5

AREA AFFECTED BY PESTS AND DISEASES

(Hectares)

PEST & DISEASES AREA	MADA	OFF MADA	
		KEDAH 1	PERLIS
1. Brown Planthopper	7.1	0	0
2. Rice Black Bug	91.1	0	0
3. Stem Borer	87.1	0	0
4. Leaf feeder	56.9	0	0
5. Rice Grain Bug	13.2	0	0
6. Blast	16.9	0	0
7. Bacteria Leaf Blight	1.3	0	0
8. Bacteria Leaf Streak	2.8	0	0
9. Brown Spot	0.1	0	0
10. Rat	223.9	0	0
Total	500.4	0	0