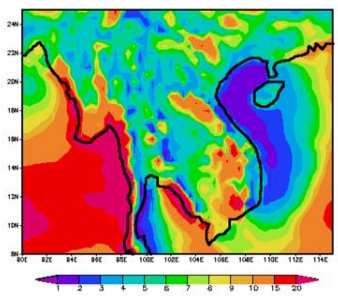
Southeast Asia START IHDP · IGBP · WCRP Regional Center

APN CAPaBLE

# The Pilot Study of Future Climate Change Impact on Water Resource and Rain-fed Agriculture Production

## Case studies in Lao PDR and Thailand

Proceedings of the APN CAPaBLE CB-01 Synthesis Workshop
Vientiane, Lao PDR
29 - 30 July 2004



Edited By:

Suppakorn Chinvanno
Anond Snidvongs

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Southeast Asia START Regional Center (SEA START RC) is an initiative of START, Chulalongkorn University and National Research Council of Thailand. For more information about SEA START RC, please contact:

Southeast Asia START Regional Center,
5th Floor, Chulawich 1 Building,
Chulalongkorn University,
Henri Dunant Road, Bangkok, Thailand 10330.
Tel (66) 22189464
Fax (66) 22519416
http://www.start.or.th

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# Introduction and Project Overview

**Suppakorn Chinvanno**

Southeast Asia START Regional Center
Chulalongkorn University
Bangkok, Thailand 10330.

## The Background and Rationales

Climate change in the future due to the increase in atmospheric carbon dioxide may alter the climate pattern in the Southeast Asia region. The impact of the climate change could affect many sectors in the natural system as well as in the socio-economic structure. Among many sectors that could be affected from climate change, water resource and agricultural system rank among the top significant sectors in the countries of the Mekong River region, as water and agriculture are foundation of the societies in this region. Livelihood of vast number of people depends on the availability of water and agriculture. Change in the climate system could bring vulnerability to communities in the Southeast Asia.

Understanding the impact of climate change would help the countries to be in better position to plan for adaptation well ahead of time in order to cope with future impact and minimize the potential vulnerability that may occur to various social groups to minimal. In addition, as most of the countries in the lower Mekong region had ratified the United Nation Framework Convention on Climate Change (UNFCCC), the countries are obligated to study impacts of climate change on various social and economic sectors and report those in the National Communication to UNFCCC.

The study of impact of climate change is considered to be the area that has not yet been widely conducted in this region. Scientists who work in this area of study are still limited in terms of number and, in many cases, also limited in capability. The CAPaBLE Scientific Capacity Building/Enhancement for Sustainable Development program under initiative of Asia Pacific Network for Global Change Research (APN) under the support of Japanese government, has main objective to enhance scientific capacity for developing countries of this region, would help fill the gap for the future study in the area of climate change.

Southeast Asia START Regional Center (SEA START RC), with financial support from Asia Pacific Network for Global Change Research (APN) under the CAPaBLE program, had conducted the capacity building activities during the year 2004, which focused on the researchers in Lao PDR and Thailand. The implemented CAPaBLE program was under the title "CAPaBLE CB-01: Building Capacity of Mekong River Countries to Assess Impacts from Climate Change – Case Study Approach on Assessment of Community Vulnerability and Adaptation to Impact of Climate Change on Water Resource and food production"

## The Climate Change

Impacts of climate change may not be clearly realized until several decades from now. In such a long-term study into the future there are many factors and uncertainties that are very difficult to predict and therefore study approach needs to take into consideration such uncertainties. At the moment the approach of using scenarios to project the condition in the future is the approach that the Intergovernmental Panel on Climate Change (IPCC) has recommended member countries to use. The more the scenarios used the more robust and resilience the country may have to respond to future climate change.

The climate scenarios used as foundation for these training workshops are result from the research project Assessment of Impacts and Adaptations to Climate Change (AIACC) Regional Study # AS07 - Southeast Asia Regional Vulnerability to Changing Water Resource and Extreme Hydrological Events Due to Climate Change.

The climate scenario was generated using mathematical modeling technique in simulating future climate scenarios under different atmospheric greenhouse gas condition, mainly $CO_2$. The climate model used in this study is Conformal Cubic Atmospheric Model, which is developed by CSIRO of Australia. The atmospheric $CO_2$ conditions used for this simulation are the concentration of $CO_2$ at 360, 540 and 720 ppms, which under IPCC SRES scenario A1FI would be around the middle and the end of this century.

Three 10-year daily climate scenarios for precipitation (mm $d^{-1}$), maximum and minimum temperature ($^{o}C$), wind speed (m $s^{-1}$) and solar radiation (W $m^{-2}$) were generated for mainland Southeast Asia (5 – $35^{o}$ N and 92 – $110^{o}$ E). These were generated for a baseline decade (1980's) and for two elevated $CO_2$ regimes, 540 and 720 ppm. Four sub-domains in the region where detailed impact and vulnerability studies had been carried out by SEA START RC, namely the Lao PDR part of the Mekong, the Northeast Thailand part of the Mekong, the delta part of the Mekong, and the Upper Chao Phraya Basin, were the main focus of this climate scenario development. In each of these sub-domains the original CCAM rainfall output at $0.1^{o}$ was empirically readjusted using the observed daily weather data obtained during the baseline period (1980-89 for Thailand and Viet Nam, and 1983-92 for Lao PDR) using non-linear regression between cumulative observed and modeled rainfall.

Climate scenarios of this study indicate that the region in general is expected to be slightly warmer and possibly wetter when the atmospheric $CO_2$ is raised to 540 ppm. On average over the region, the daily maximum temperature would be changing by $\pm 0.5\ ^{o}C$. Some simulated 'cooling' effect could be due to more cloud in the region. When the $CO_2$ is further elevated to 720 ppm, most of the region is expected to be significantly warmer by about 1 $^{o}C$ relative to the baseline period. The nighttime temperature would be more affected especially during the cool period of the year (Dec-Jan-Feb) and the number of cool days should be significantly less. Rainfall is also expected to more prominently increase, especially nearer to the coast.

The climate of the Lao PDR part of the Mekong is expected to be most affected by elevated atmospheric $CO_2$ where the area would be clearly warmer and wetter, especially during the wet period of the year (March to August). Mean rainfall during the wet period could be up by over 30% both at 540 and 720 ppm $CO_2$. On the other hand, the Upper Chao Phraya River in Thailand is expected to be least affected by elevated $CO_2$, where only temperature increase is clearly seen, but rainfall is expected to only increase during the dry period of the year (September to February).

The climate data from these climate scenarios were used for further analysis, particularly, as input to hydrological model and crop model to analyze the impact of climate change on water resource and agriculture production in Lao PDR and Thailand under the CAPaBLE CB-01 capacity building activities.

**The Capacity Building Activities**

The capacity building activities under this CAPaBLE CB-01 were conducted in form of training workshop programs under the theme "*The study of Future Climate Changes Impact on Water Resource and Rain-fed Rice Production*". In these training workshops, participants from Lao PDR and Thailand would learn the theoretical foundations on the future climate scenario under different $CO_2$ concentration and analysis on the impact of future climate change on water resource and agricultural production. The training workshops include computer lab work with analytical tools and followed by pilot research exercises on real case study.

The objective of these training workshops is to build personnel as well as institutional capacity in Lao PDR and Thailand to be able to conduct research and study on climate change and its impact in multiple scale and various aspects.

The training workshops conducted under CAPaBLE CB-01 were:

> *APN CAPaBLE CB-01 First training workshop: Course A "The Study of Future Climate Scenario and Impact of Climate Change on Hydrological Regime"*
>
> During 12-30 January 2004, at Burapha University, 12 scientists from both government line agencies as well as academic institutes from Lao PDR and Thailand, namely Hydro-Meteorological Department, Science Technology and Environment Agency (STEA), Department of Hydrology and National University of Laos (NUL), from Lao PDR as well as Meteorological Department, Burapha University, Ubonratchathani University, King Mongkut Institute of Technology and Khon Kaen University, from Thailand attended the training workshop under the title "The Study of Future Climate Scenario and Impact of Climate Change on Hydrological Regime", to work on the analysis of high resolution climate scenarios of Mekong River Basin under different $CO_2$ concentration and study the use of computation modelling technique to simulate future hydrological regime in various major river basins in Lao PDR and Thailand under different climate scenarios. The main software tool used for the hydrological study is the SEA-BASINS/VIC hydrological modelling system developed by SEA START RC and University of Washington. The workshop was organized at Burapha University.
>
> *APN CAPaBLE CB-01 Second training workshop: Course B "The Study of Impacts of Climate Change on Rain-fed Rice Production"*

During 23-29 February 2004, at Ubonratchathani University, 10 scientists from both government line agencies as well as academic institutes from Lao PDR and Thailand, namely Environmental Research Institute (STEA), National Agriculture and Forestry Research Institute (NAFRI), from Lao PDR and Khon Kaen University, Department of Agriculture, Department of Land Development, Meteorological Department, from Thailand attended the training workshop under the title "The study of impacts of climate change on rain-fed rice production", to work on the use of climate scenarios to analyze yield of rain-fed rice production by using crop analysis tool developed by Multiple Cropping Center of Chiang Mai University, Thailand. The workshop was organized with co-operation from Chiang Mai University and Ubonratchathani University.

**The Pilot Research Exercise**

As part of the APN sponsored CAPaBLE Scientific Capacity Building/Enhancement for Sustainable Development Program CB-01 "Building Capacity of Mekong River Countries to Assess Impacts from Climate Change – Case Study Approach on Assessment of Community Vulnerability and Adaptation to Impact of Climate Change on Water Resource and Food Production", in the following up to the APN CAPaBLE CB-01 training workshops, the scientists who participated in these workshops further conducted research exercise using the tool, data and know-how from the workshop to conduct the research exercise on number of topics as follows,

- *Climate Change Scenario for Thailand*
- *Climate Change Scenario for Lao PDR*
- *Impact of Climate Change on Hydrological Condition in Nam Mun watershed, Thailand*
- *Impact of Climate Change on Hydrological Condition in Nam Ngum watershed, Lao PDR*
- *Impact of Climate Change on Rain-fed Rice Production in Sawannaket Province: Analysis of Climate Change Impact on Low-land Rice Production in Lao PDR*
- *Climate Scenario Verification and Impact on Rain-fed Rice Production in Thailand*
- *Impact of Climate Change on Rice Production in Tung Kula Field, Thailand*
- *Impact of Climate Change on Maize, Sugarcane and Cassava Production in N.E., Thailand*

The research exercise under this CAPaBLE CB-01 program would help these scientists to enhance their capacity in the studying on climate change and its impact in multiple scales and various aspects; and also will be available resource to support the future preparation of the Second National Communication to UNFCCC which will emphasize substantially more on the impacts of climate change on natural system and human society than its first generation.

The finding results from these pilot research exercises were presented at the synthesis workshop, which was held at the end of July 2004.

**The Synthesis Workshop**

The Synthesis Workshop in Vientiane, Lao PDR on 29-30 July was the conclusion of the CAPaBLE CB-01. The scientists who had participated in the training workshops and conducted research exercise using the tool, data and know-how learned from the workshops, presented their findings and lessons learned from their research exercises. The event was organized by SEA START RC with co-operation of Science, Technology and Environment Agency (STEA) of Lao PDR.

The research finding as well as methodology and lesson learned were shared among other participants from relevant agency who participate in this workshop too.

The result from this capacity building activity may lead to a better understanding on long term change in water resource and agriculture production due to climate change and adaptation strategy to impact of climate change can be better preparation to cope with future situation.

The initiative under this CAPaBLE program is by no mean the ultimate study of the impact of climate change on water resource and agriculture in the countries, but the organizer hope that it will initiate more studies along this line with more sophisticate climate and hydrological scenarios. In addition, this capacity building activity would not only initially establish scientific capacity to number of Thai and Lao scientists, which would help fill the gap for the future study in the area of global change research, but also has initiated the cooperative between the scientists, which could become a network of scientific community for the future cooperation to study the impact of climate change in broader scale for the region. This group of trained people may also be able to support the future preparation of the next Second National Communication to UNFCCC which would emphasize substantially more on the impacts of climate change on natural system and human society than its First generation. r resource and agriculture in the countries, but the organizer hope that it will initiate more studies along this line with more sophisticate climate and hydrological scenarios. In addition, this capacity building activity would not only initially establish scientific capacity to number of Thai and Lao scientists, which would help fill the gap for the future study in the area of global change research, but also has initiated the cooperative between the scientists, which could become a network of scientific community for the future cooperation to study the impact of climate change in broader scale for the region. This group of trained people may also be able to support the future preparation of the next Second National Communication to UNFCCC which would emphasize substantially more on the impacts of climate change on natural system and human society than its First generation.

# Summary on Climate Change in Lao PDR and Thailand and Potential Impact on Water Resource

**Anond Snidvongs**
SEA START RC, Thailand

**Wirote Laongmanee**
SEA START RC, Thailand

**Oulaphone Ongkeo**
Dept. of Irrigation, Ministry of Agriculture, Lao PDR

**Keophusone Phonhalath**
National University of Laos, Lao PDR

**Vivarath Sihabouj**
National University of Laos, Lao PDR

**Boontium Lersupavithnapa**
Ubonratchathani University

## Abstract

Climate scenarios of this study indicate that the region in general is expected to be slightly warmer and possibly wetter when the atmospheric $CO_2$ is raised to 540 ppm. On average over the region, the daily maximum temperature would be changing by ±0.5 $^{o}$C. Some simulated 'cooling' effect could be due to more cloud in the region. When the $CO_2$ is further elevated to 720 ppm, most of the region is expected to be significantly warmer by about 1 $^{o}$C relative to the baseline period. The nighttime temperature would be more affected especially during the cool period of the year (Dec-Jan-Feb) and the number of cool days should be significantly less. Rainfall is also expected to more prominently increase, especially nearer to the coast.

The climate of the Lao PDR part of the Mekong is expected to be most affected by elevated atmospheric $CO_2$ where the area would be clearly warmer and wetter, especially during the wet period of the year (March to August). Mean rainfall during the wet period could be up by over 30% both at 540 and 720 ppm $CO_2$. On the other hand, the Upper Chao Phraya River in Thailand is expected to be least affected by elevated $CO_2$, where only temperature increase is clearly seen, but rainfall is expected to only increase during the dry period of the year (September to February).

Southeast Asia START Regional Centre

# Summary of Potential Impact of Climate Change on Water Resource


Anond Snidvongs
Southeast Asia START Regional Center
Chulalongkorn University

Wirote Laoungmanee
Southeast Asia START Regional Center
Chulalongkorn University

Oulaphone Ongkeo
Irrigation Department
Ministry of Agriculture

Keophusone Phonhalath
Department of Civil Engineering
National University of Laos

Vivarath Sihabouj
Department of Irrigation Engineering
National University of Laos

Boontium Lersupavithnapa
Faculty of Agriculture
Ubon Ratchathani University


CAPaBLE CB-01 Phase I Synthesis Workshop, Vientiane, Lao PDR, 29-30 July 2004

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## Outline

- Scenario-based assessments of impact, vulnerability and adaptation (V&A)
- Conformal Cubic Atmospheric Model (CCAM) as a climate scenario generator for Southeast Asia
- SEA START RC climate scenario for SE Asia generated by CCAM
- Variable Infiltration Capacity (VIC) Model for hydrological simulation
- Impacts some some future climate scenario on water in Nam Hgum and Nam Thuen (Lao PDR) and Chi-Mun Basins (Thailand)

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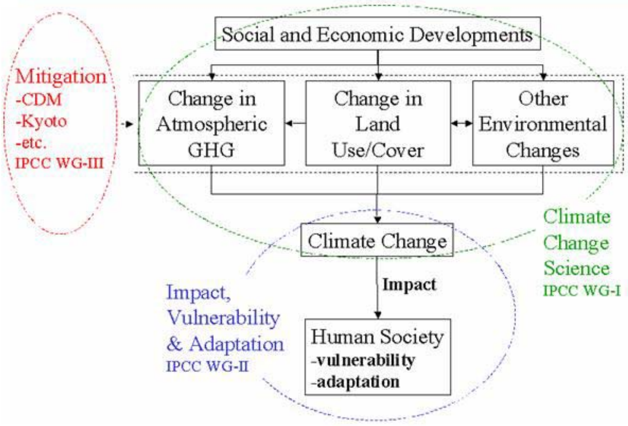
## Different Types of Climate Change Studies





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## Climate Change is a Slow, Complex and Very Uncertain Process

•At present atmospheric $CO_2$ is about 370 ppm and increased by about 2-3 ppm per year

•At the increasing rate of 1% per year, atmospheric $CO_2$ will be double in every about 70 years

•No one knows for sure how GHG emission will be in the future, subjected to several social, economic and political factors

•Besides, there are many other factors in the earth system, that also control climate, such as the ocean, aerosol, etc., and these factors are subjected to changes as well

•So then how can we 'describe' the earth climate in the future several decades from now?

## Scenario as a way to describe the 'Future'

What is **scenario**?

•Descriptions of future condition that are based on a number of factors that are internally consistent and put together according to some scientifically acceptable logics

•Something to compromise between **projection** and **prediction**

•May or may not use mathematical models, but mathematical technique usually has more advantage for generating scenarios since it can put together large number of factors and processes in quantitative way

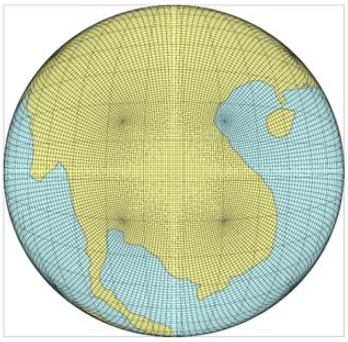
## Why Use CSIRO's Conformal Cubic Atmospheric Model (CCAM) as Scenario Generator in This Project?

•It is a stretched grid regional climate model, and therefore minimizing 'bouncing' effect at the boundary

•It address both climate change and climate variability

•It generates daily climate output which is necessary for downstream modeling of water and crop production, for examples

## CCAM for Southeast Asia



**Some Important Features**

- 18 vertical levels
- Final output domain: 5°-35° N and 92°-110° E
- Output resolution was interpolated to 0.1° (about 10 km)

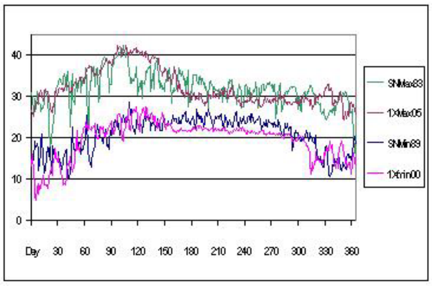
**Some Selected Outputs**

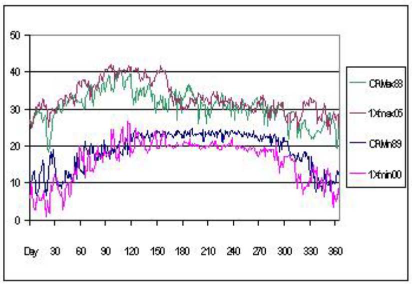
- Daily max, min and avg T (°C)
- Specific humidity (kg/kg)
- Heat flux ($W/m^2$)
- Pressure (hPa)
- Cloud cover (%)
- Rainfall (mm/d)
- Wind speed (m/s) and direction
- Radiation ($W/m^2$)

## Statistical Adjustments of CCAM Outputs

- CCAM output for daily minimum and maximum temperature, and wind speed are quite satisfactory so no adjustment are needed
- Daily rainfall from CCAM can be off by as much as 100% especially at wet locations along the coast, such as Chantaburi

## Observed and CCAM Min and Max Temperature



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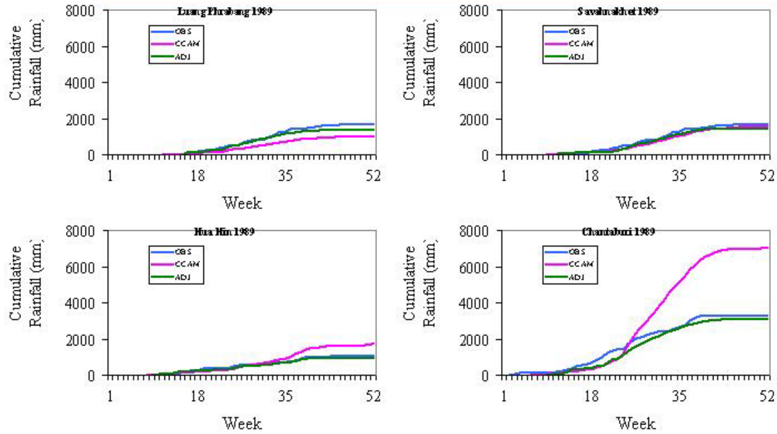
## Statistical Adjustment of CCAM Rainfall

•Thailand use 1980-89 as baseline and 33 stations to calibrate and 6 stations to verify
•Lao PDR use 1983-1992 as baseline and 8 stations to calibrate, no verification

## CCAM Rainfall Output Verification

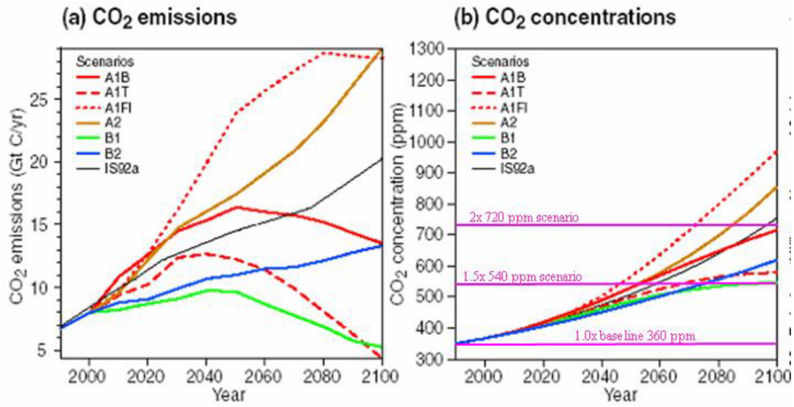



## START-1 Scenario

Available Now:
•Lao PDR (LA) 10 baseline and 20 future scenarios
•Thailand (TH) 10 baseline and 20 future scenarios

Will be Available in Future (ongoing adjustment and verification):
•Cambodia
•Viet Nam
•Myanmar

## IPCC SRES Scenario




## Example of START-1 Scenario (Thailand)

1.0x Baseline 1980-89

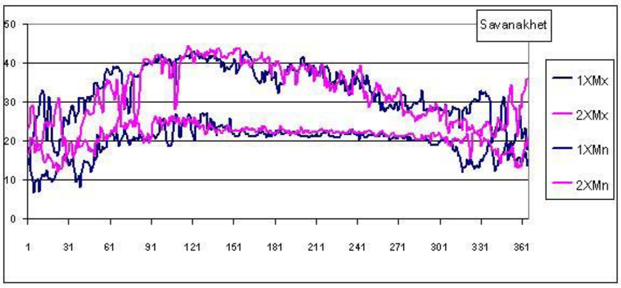
| 360ppm | TH0A* | TH0B | TH0C | TH0D | TH0E* | TH0F | TH0G | TH0H | TH0I | TH0J* |
|---|---|---|---|---|---|---|---|---|---|---|
| Rain | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| T-max | 8 | 3 | 1 | 2 | 7 | 6 | 9 | 5 | 4 | 10 |
| T-min | 2 | 7 | 10 | 8 | 4 | 5 | 3 | 9 | 6 | 1 |

1.5x Scenario 2040-49 (A1FI)

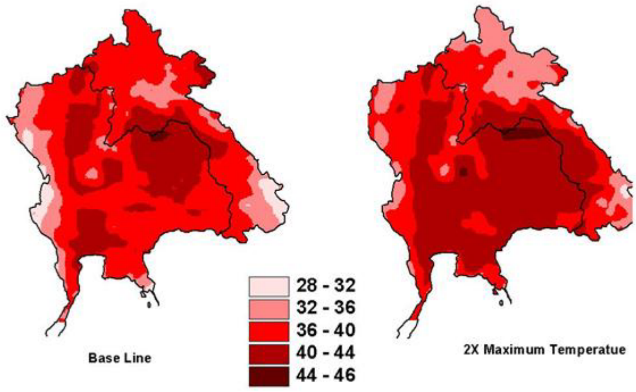
| 540ppm | TH1A* | TH1B | TH1C | TH1D | TH1E* | TH1F | TH1G | TH1H | TH1I | TH1J* |
|---|---|---|---|---|---|---|---|---|---|---|
| Rain | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| T-max | 4 | 6 | 2 | 5 | 1 | 7 | 9 | 8 | 3 | 10 |
| T-min | 5 | 3 | 7 | 2 | 6 | 1 | 4 | 8 | 9 | 2 |

2.0x Scenario 2070-79 (A1FI)

| 720ppm | TH2A* | TH2B | TH2C | TH2D | TH2E* | TH2F | TH2G | TH2H | TH2I | TH2J* |
|---|---|---|---|---|---|---|---|---|---|---|
| Rain | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| T-max | 3 | 6 | 4 | 8 | 2 | 1 | 10 | 7 | 5 | 9 |
| T-min | 5 | 4 | 7 | 2 | 10 | 9 | 1 | 6 | 8 | 3 |



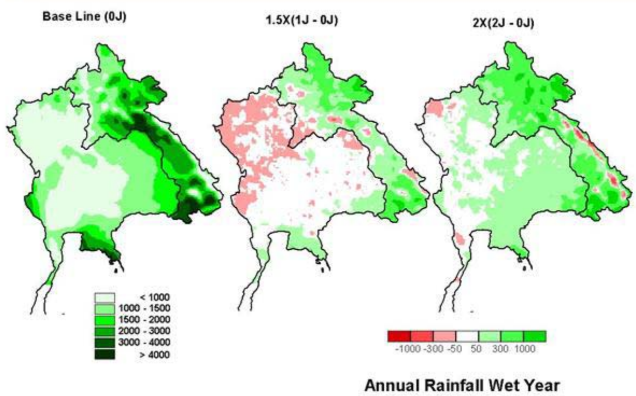
## Hottest Day Temperature




## Temperature Change

| | MAX Temp | | No. of day Temp >33 | |
|---|---|---|---|---|
| | 1X | 2X | 1X | 2X |
| Chiang Rai | 41.88 | 43.67 | 176 | 239 |
| Chiang Mai | 42.15 | 41.68 | 133 | 170 |
| Kon Kean | 43.06 | 42.83 | 149 | 144 |
| Sakon Nakorn | 42.43 | 41.49 | 116 | 131 |
| Chainat | 43.54 | 42.58 | 139 | 159 |
| Nakorn Sawan | 43.22 | 43.04 | 171 | 233 |

## Annual Rainfall for Wet Year Baseline and Rainfall Change in 2 Future Scenarios



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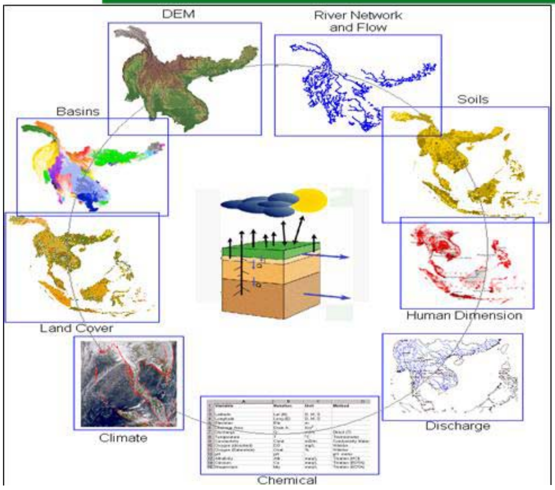
## Variable Infiltration Capacity Model




GIS Templates
- Land use/cover
- Elevation
- Soil
- River network

Climate Forcing (from CCAM)
- Rainfall
- Temperature
- Wind

VIC outputs
- Surface and subsurface runoff
- Channel flow/discharge
- Soil moisture

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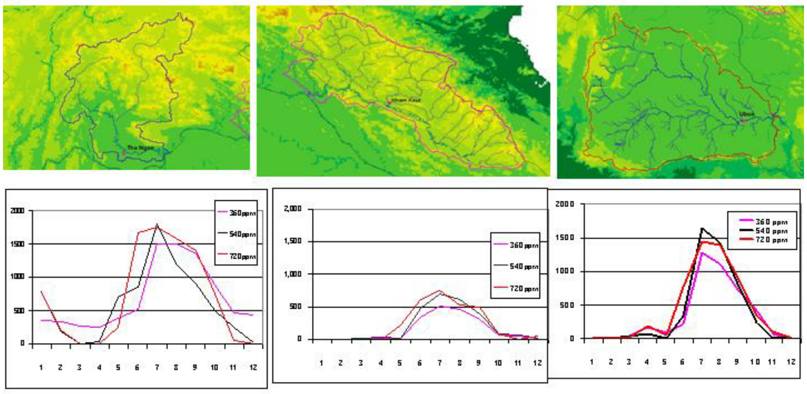
## Simulated Discharge under Diefferent Climate Scenarios

Nam Ngum at Tha Ngon | Nam Thuen at Kham Keut | Chi-Mun at Ubon

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## Overall Conclusion

- Human and technical capacity to donduct study on climate change impact on water resource are now available in Lao PDR and Thailand
- More works needed to be done in each county, including using more climate scenarios, more locations, etc.
- Baseline daily meteorological data (e.g. 1980-89) are very critical for the adjustment of climate model result

Welcome to Lao PDR

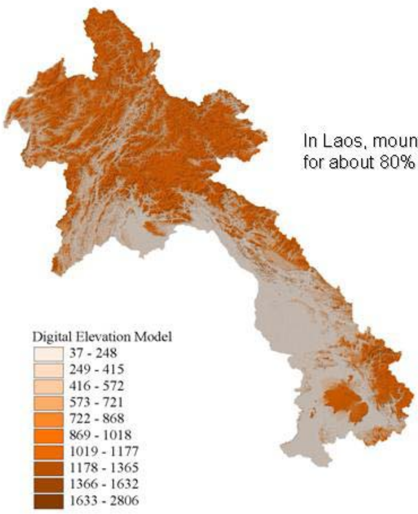
Synthesis Workshop
The Study of Future Climate Change Impact on
Water Resources and Rain-fed rice product
Vientiane Laos 29-30 July 2004

Oulaphone Ongkeo
Department of Irrigation
Ministry of Agriculture and Forestry

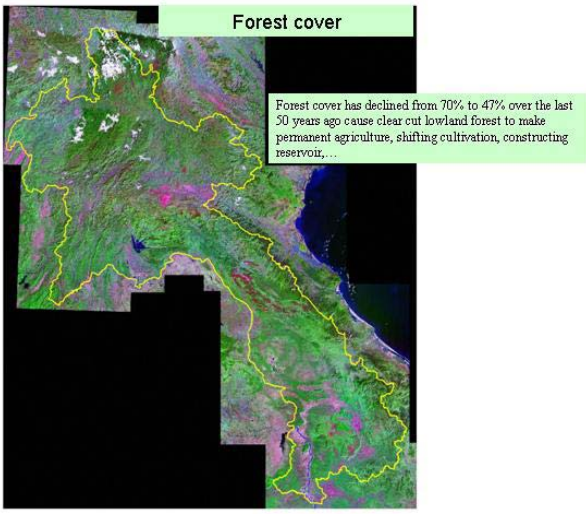

Location
Lat. 13.91° - 22.51°
Lon. 100.08° - 107.68°

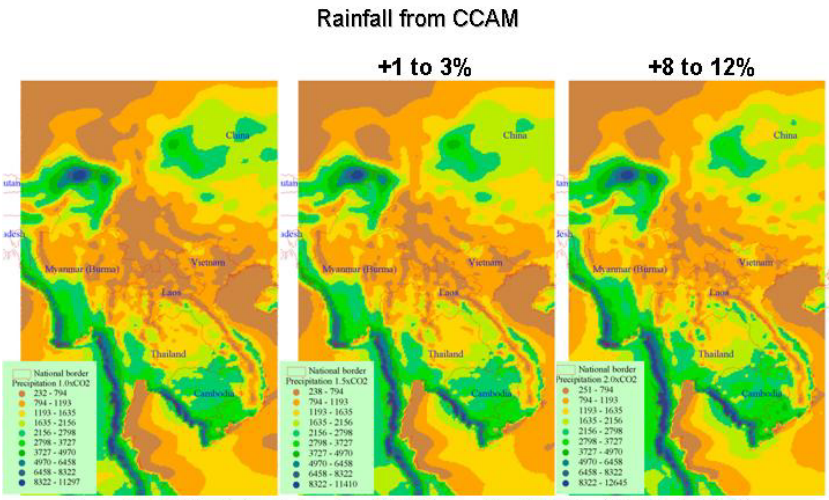
Area: 236,800 km$^2$
Population: 5,000,000

Topography

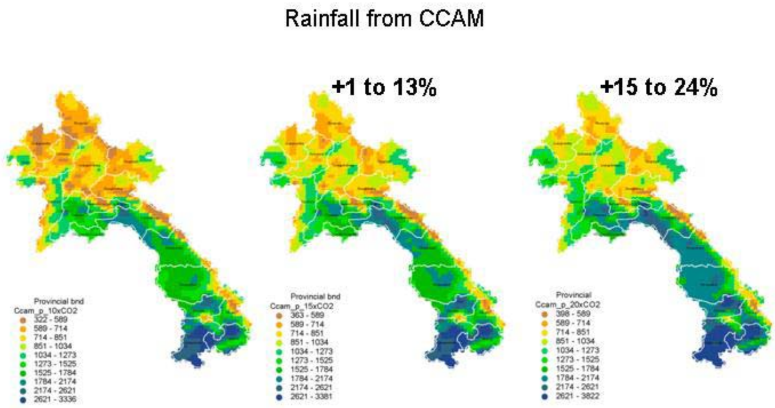



In Laos, mountains and sloping lands account for about 80% of the total land area




Comparison rainfall level between in the region at 1xCO2 at present time, 1.5xCO2 and 2xCO2 levels in the future

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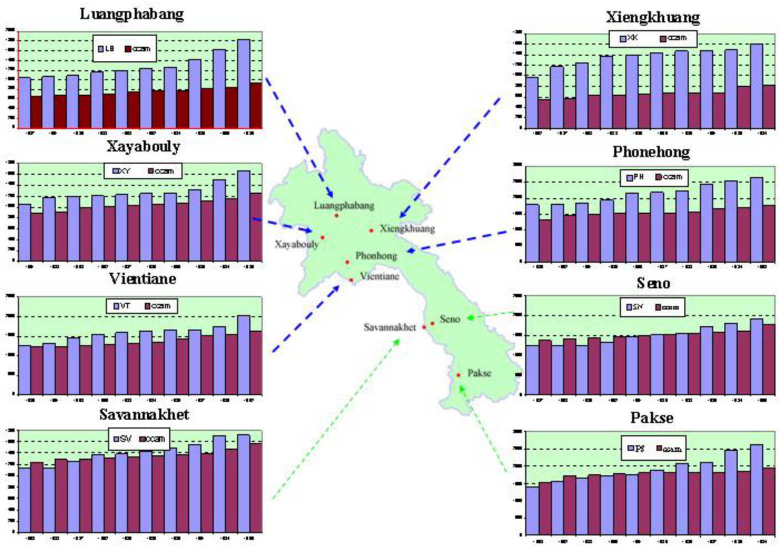


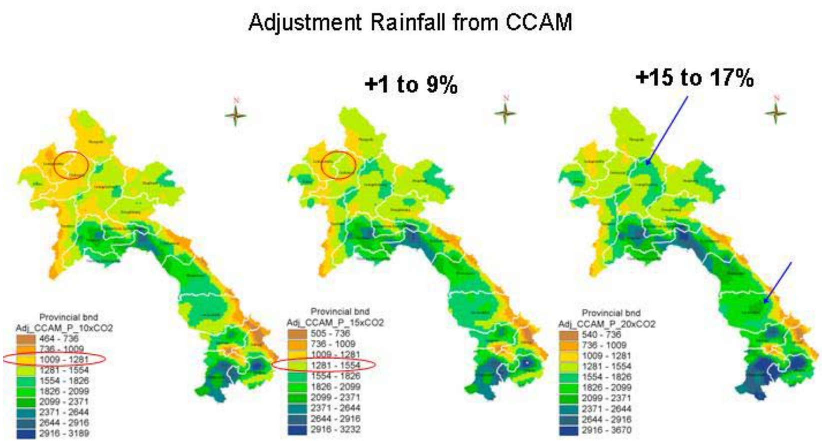


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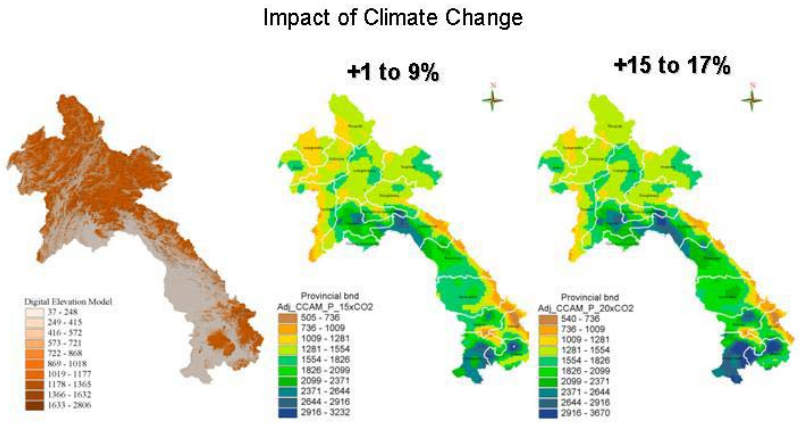
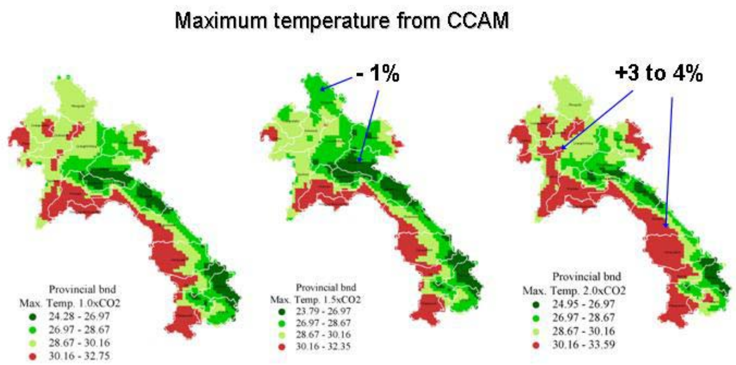
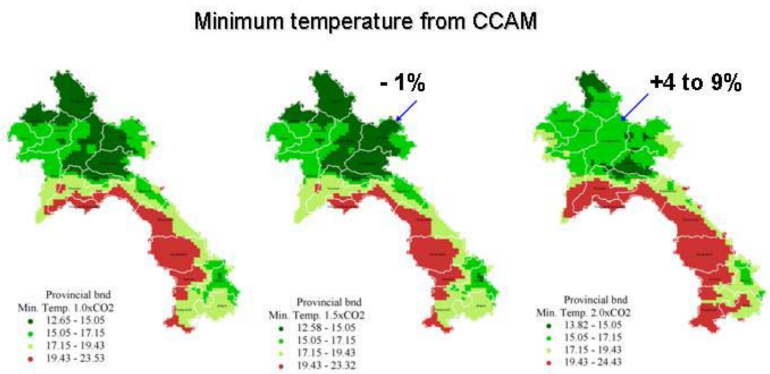



Comparison rainfall level between in Laos at 1xCO2 at present time, 1.5xCO2 and 2xCO2 levels in the future

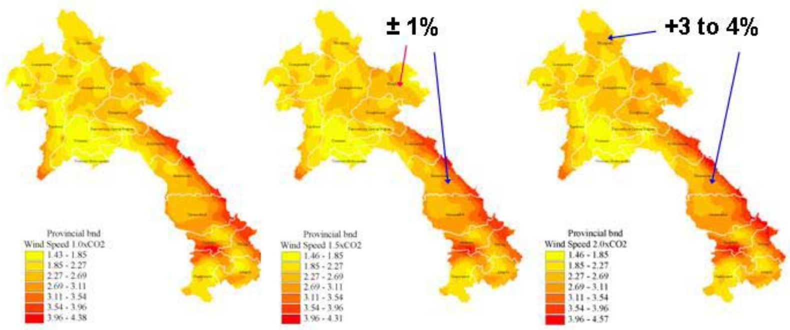



Comparison maximum temperature level between in Laos at 1xCO2 at present time, 1.5xCO2 and 2xCO2 levels in the future




Comparison minimum temperature level between in Laos at 1xCO2 at present time, 1.5xCO2 and 2xCO2 levels in the future

## Wind Speed from CCAM




Comparison wind speed level between in Laos at $1xCO_2$ at present time, $1.5xCO_2$ and $2xCO_2$ levels in the future

## The End

Thank you for your attention

# Impact of Climate Change on Rainfed Lowland Rice Production in Savannakhet Province, Lao PDR

**Thavone Inthavong**
National Agriculture and Forestry Research Institute, Vientiane, Lao PDR

**Attachai Jintrawet**
Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University, Thailand

**Suppakorn Chinvanno**
Southeast Asia START Regional Center, Chulalongkorn University, Thailand

**Anond Snidvongs**
Southeast Asia START Regional Center, Chulalongkorn University, Thailand

## Abstract

This study had an objective to estimate the impact of climate change on rice production in rainfed lowland rice growing area in Savannakhet Province, which is one of the six important rice-growing areas in Lao PDR.

The MRB Rice Shell of the CERES-Rice Model was used to simulate the impact of climate on processes that control growth, physiology and morphology of rice. The rice variety 'Tha Dok Kham 1' (TDK1) which was an improved variety widely grown in the area was used in this study. The model was run for present baseline climate (at 360 ppm $CO_2$) and at 1.5 times (540 ppm $CO_2$) and at 2 times (720 ppm $CO_2$) to represent some future climate scenarios. The daily climate from Conformal Cubic Atmospheric Model (CCAM) was empirically rescaled using the observed data at 8 meteorological stations in Lao PDR using the Sigmoid Curve Relationship before the adjusted climate were used to drive the rice model.

The results showed that the production of TDK1 rice under present climate (360 ppm $CO_2$) without any uses of fertilizer was between 1,800-5,100 kg/ha. However, the future climate change driven by elevated $CO_2$ under this study had only a very small effect on rice production as the production at 540 and 720 ppm $CO_2$ remained to be 2,000-5,900 and 2,000-5,600 kg/ha, respectively.

# ຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດຕໍ່ກັບການປູກເຂົ້ານານ້ຳຝົນ ໃນເຂດທົ່ງພຽງ ສະຫວັນນະເຂດ, ສປປລ

(Impact of climate change on rainfed lowland rice production in Savannakhet province, Lao PDR)

Thavone Inthavong[1], A.T.C. Jintrawet[2], S.P.K. Chinvanno[3], and A.N. Snidvongs[3],

[1] National Agriculture and Forestry Research Institute, Vientiane, Lao PDR
[2] Multiple Cropping Center, Chiang Mai University, Thailand
[3] Southeast Asia START Regional Center, Chulalongkorn University

**ບົດຄັດຫຍໍ້** (Abstract)

ການສຶກສານີ້ມີຈຸດປະສົງເພື່ອຄາດຄະເນໃຫ້ເຫັນເຖິງຜົນກະທົບຂອງການປ່ຽນແປງ ສະພາບພູມອາກາດຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນໃນເຂດທົ່ງພຽງໃຫ່ຍທາງພາກກາງ ໃນແຂວງສະຫວັນນະເຂດ ຊຶ່ງເປັນນຶ່ງໃນ 6 ທົ່ງພຽງໃຫ່ຍທີ່ປູກເຂົ້າ ທີ່ສຳຄັນຂອງ ສປປລ.

ແບບຈຳລອງ MRB Rice Shell CERES-rice Model ໄດ້ຖືກນຳໃຊ້ເຂົ້າໃນການຄາດຄະເນຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດຕໍ່ກັບຂະບວນການຕ່າງໆທີ່ກ່ຽວພັນເຖິງການເຕີບໂຕ, ການປ່ຽນແປງທາງດ້ານໂຄງສ້າງ ແລະ ຄວາມອາດສາມາດໃຫ້ຜົນຜະລິດ (physiological and morphological processes) ຂອງແນວພັນເຂົ້າທ່າດອກຄຳ(TDK1) ຊຶ່ງເປັນແນວພັນເຂົ້າປັບປຸງທີ່ນິຍົມປູກໃນເຂດທົ່ງພຽງດັ່ງກ່າວ. ການສຶກສາໄດ້ແນໃສ່ບັນຫາຂອງການປ່ຽນແປງເພີ້ມຂື້ນຂອງອາຍແກສ ກາກບອນໄດອ໊ອກຊາຍ ($CO_2$), ໂດຍກຳນົດໃຫ້ຄ່າ $CO_2$ ທີ່ມີໃນບັນຍາກາດໃນເວລາປະຈຸບັນ ເທົ່າກັບ 360ppm ແລະ ຄ່າ $CO_2$ ເພີ້ມຂື້ນ 1.5ເທື່ອຈາກຄ່າໃນປະຈຸບັນເປັນ 540ppm ແລະ ເພີ້ມຂື້ນ 2ເທື່ອເປັນ 720ppm ເປັນຄ່າ $CO_2$ ທີ່ອາດຈະມີການປ່ຽນແປງເພີ້ມຂື້ນໃນອານາຄົດ. ຂໍ້ມູນພູມອາກາດທີ່ຄາດຄະເນໄດ້ຈາກແບບຈຳລອງ Conformal Cubic Atmospheric Model (CCAM) ໄດ້ຖືກນຳມາດັດປັບ(adjust) ກັບຂໍ້ມູນພູມອາກາດທີ່ໄດ້ມີການວັດແທກໃນ 8 ສະຖານີອຸຕຸນິຍົມທີ່ກະຈາຍຢູ່ໃນຂອບເຂດທົ່ວປະເທດ ເພື່ອກຳນົດຫາຄ່າສຳພະສິດຂອງຄວາມສຳພັນ (slope ແລະ Intercept) ໂດຍນຳໃຊ້ສົມຜົນຂອງການພົວພັນແບບ Sigmoid curve relationship ແລະ ໄດ້ນຳໃຊ້ຄ່າສຳພະສິດດັ່ງກ່າວເຂົ້າໃນການຄາດຄະເນທາການປ່ຽນແປງສະພາບພູມອາກາດໃນອານາຄົດ.

ຜົນຂອງການສຶກສາໄດ້ສະແດງໃຫ້ເຫັນວ່າຜົນຜະລິດເຂົ້າທີ່ຄາດຄະເນໄດ້ຈາກແບບຈຳລອງພາຍໃຕ້ສະພາບພູມອາກາດໃນເວລາປະຈຸບັນທີ່ມີລະດັບ $CO_2$ ເທົ່າກັບ 360ppm ໃນບັນຍາກາດ ແລະ ປາສະຈາກການນຳໃຊ້ຝຸ່ນ (NPK=0) ໄດ້ສະແດງໃຫ້ເຫັນວ່າ: ຜົນຜະລິດເຂົ້າ TDK1 ມີການປ່ຽນແປງແຕ່ 1800-5100kg, ສ່ວນຜົນຜະລິດເຂົ້າພາຍໃຕ້ສະພາບພູມອາກາດທີ່ມີ $CO_2$ ເທົ່າກັບ 540 ແລະ 720ppm ມີການປ່ຽນແປງແຕກຕ່າງກັນເລັກນ້ອຍ, ແຕ່ 2000 -5900kg ແລະ 2000-5600kg ຕາມລຳດັບ.

## 1. **ຄຳນຳ** (Introduction)

ທົ່ງພຽງສະຫວັນນະເຂດເປັນທົ່ງພຽງນຶ່ງຕັ້ງຢູ່ທາງພາກກາງຂອງ ສປປລ, ຢູ່ໃນລະຫວ່າງ ເສັ້ນຂະໜານເໜືອ 15°50' ຫາ 17°10'N Latitude ແລະເສັ້ນແວງ 104°40" ຫາ 106°50' Lontitude. ມີພື້ນທີ່ປູກເຂົ້າໃນລະດູນາປີ(ນານ້ຳຝົນ) ປະມານ 103,396ha, ແລະ ພື້ນທີ່ປູກເຂົ້າໃນລະດູນາແຊງ 20,155ha (2000). ແນວພັນທີ່ນິຍົມປູກສ່ວນຫລາຍແມ່ນແນວພັນເຂົ້າພື້ນເມືອງ ແລະ ແນວພັນເຂົ້າປັບປຸງ ເຊັ່ນ: ແນວພັນທ່າດອກຄຳ-1(TDK-1), ໂພນງາມ-1(PG-1), ກໍ່ຂໍ-10(RD-10) ແລະແນວພັນອື່ນໆອີກຈຳນວນນຶ່ງ. ສະມັດຕະພາບຂອງຜົນຜະລິດຢູ່ໃນລະຫວ່າງ 2000-3000kg/ha ສຳຫລັບເຂົ້ານານ້ຳຝົນ ແລະ 3000-5000kg/ha ສຳຫລັບເຂົ້ານາແຊງລະດູແລ້ງ, ສະມັດຕະພາບຂອງຜົນຜະລິດບໍ່ສະເໝີສະເໝີ ມີການປ່ຽນແປງໄປຕາມສະພາບພູມອາກາດ. ນອກຈາກນັ້ນຍັງເກີດມີບັນຫາໄພທຳມະຊາດ ເຊັ່ນ: ໄພນ້ຳຖ້ວມ ແລະ ແຫລ້ງແລ້ງ ອັນໄດ້ສ້າງຄວາມເສັຽຫາຍໃຫ້ແກ່ຜົນຜະລິດເຂົ້າໃນເຂດດັ່ງກ່າວ. ຜົນຜະລິດເຂົ້າສະເລັ່ຽປີທັງໝົດປະມານ 425,176ໂຕນ, ໃນນີ້ຜົນຜະລິດເຂົ້າຂອງລະດູນານ້ຳຝົນ ປະມານ 336,037 ໂຕນ (J.M Schiller et al 2000).

ສະພາບພູມອາກາດໂດຍທົ່ວໄປແລ້ວທົ່ງພຽງສະຫວັນນະເຂດແມ່ນນອນຢູ່ໃນເຂດນິເວດພູມອາກາດ AEZ4- ເປັນເຂດສະພາບພູມອາກາດອົບອຸ່ນ, ຄວາມຊຸ່ມຊື່ນປານກາງ, ອຸນຫະພູມສະເລັ່ຽປີສ່ວນໃຫ່ຍໆກວ່າ 25 ອົງສາ(C°). ຄວາມອາດສາມາດໃນການເຕີບໂຕ, ຂະບວນການປ່ຽນແປງທາງໂຄງສ້າງພາຍນອກແລະຜົນຜະລິດຂອງພືດຊະນິດຕ່າງໆ ແມ່ນກ່ຽວພັນເຖິງຄຸນລັກສະນະສະເພາະຂອງແນວພັນນັ້ນ (geno-typic characteristic) ບວກກັບປັດໃຈຕ່າງໆ ເຊັ່ນ: ອຸນຫະພູມ(Tmin,Tmax), ລັງສີແສງ(Solar radiation), ລະດັບອາຍກາກບອນໄດອົອກໄຊ ($CO_2$) ທີ່ມີຢູ່ໃນບັນຍາກາດ, ຄວາມຍາວຂອງມື້ທີ່ມີແສງແດດ(Sunshine hours) ແລະ ອື່ນໆ, ໃນນີ້ລັງສີແສງໄດ້ຕອບສະໜອງພະລັງງານສຳຫລັບການດູດຊັບ $CO_2$ ເພື່ອຂະບວນການສັງເຄາະແສງ (photosynthethic process) ( H.G.S Centeno et al 1995,IRRI). ປະລິມານນ້ຳຝົນມີການກະຈາຍຕົວແຕກຕ່າງກັນ, ໂດຍສະເພາະໃນເຂດທາງພາກຕາເວັນຕົກຂອງເຂດທົ່ງພຽງ ປະລິມານນ້ຳຝົນສະເລັ່ຽປີ ໜ້ອຍກວ່າ 1700ມມ, ສ່ວນພື້ນທີ່ທາງພາກກາງຫາ ພາກຕາເວັນອອກ ມີການປ່ຽນແປງແຕ່ 1700-2300ມມ. ລະດູຝົນເລີ້ມຕົ້ນ ໃນທ້າຍເດືອນເມສາ ແລະ ສິ້ນສຸດໃນທ້າຍເດືອນຕຸລາ (Inthavong.TV et al 2003).

ພື້ນທີ່ປູກເຂົ້າສ່ວນໃຫ່ຍຈະເປັນດິນປະເພດ Alisols(AL), Cambisols(CM), Luvisols(LV), Arenosols(AR), Acrisols(AC), Solonnez(ZN), Solonchak(SC) Regosols(RG) ແລະ Fluvisols(FL) (Soil survey and Land classification,1998). ດິນສ່ວນໃຫ່ຍຈະເປັນເຊີລ້າງ, ຄວາມອຸດົມສົມບູນຂອງດິນຕ່ຳ, ສ່ວນໃຫ່ຍຈະເປັນເນື້ອດິນຊາຍ, ຊັ້ນດິນຕື້ນ, ຄວາມອາດສາມາດໃນການບັນຈຸນ້ຳໃນດິນຕ່ຳ, ປະຕິກິລິຍາ pH2O ຂອງດິນສ່ວນໃຫ່ຍມີການປ່ຽນແປງແຕ່ 4.8-6.5.( Mats Olsson).

ການສຶກສານີ້ມີຈຸດປະສົງເພື່ອຄາດຄະເນຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດ ຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນໃນເຂດທົ່ງພຽງໃຫ່ຍຂອງແຂວງສະຫວັນນະເຂດໂດຍນຳໃຊ້ແບບຈຳລອງ MRB Rice Shell CERES-rice Model ໂດຍມີການພົວພັນລະຫວ່າງດິນ, ພືດ ແລະ ພູມອາກາດ. ການຄາດຄະເນໄດ້ມຸ້ງໃສ່ບັນຫາການປ່ຽນແປງຂອງອາຍກາກບອນໄດອ໊ອກໄຊ($CO_2$) ທີ່ຄາດວ່າຈະມີການປ່ຽນແປງເພີ້ມຂື້ນໃນອານາຄົດອັນເນື່ອງມາຈາກການຂະຫຍາຍຕົວທາງດ້ານອຸດສາຫະກຳ, ການເຜົາຜານພະລັງງານ ແລະ ການນຳໃຊ້ແຫລ່ງຊັພະຍາກອນທຳມະຊາດຕ່າງໆ. ການຄາດຄະເນໄດ້ກຳນົດອອກເປັນ 3 Scenario ຄື: ຜົນຜະລິດເຂົ້າໃນສະພາບພູມອາກາດໃນເວລາປະຈຸບັນໂດຍກຳນົດໃຫ້ຄ່າ $CO_2$ ທີ່ມີໃນບັນຍາກາດເທົ່າກັບ 360ppm, ຜົນຜະລິດເຂົ້າໃນອານາຄົດທີ່ຄາດວ່າຄ່າ $CO_2$ ຈະເພີ້ມຂື້ນ 1.5 ເທື່ອ ຈາກຄ່າໃນປະຈຸບັນເປັນ 540ppm ແລະ ຜົນຜະລິດເຂົ້າໃນອານາຄົດທີ່ຄາດວ່າຄ່າ CO2 ຈະເພີ້ມຂື້ນ 2 ເທື່ອຈາກຄ່າໃນປະຈຸບັນເປັນ 720ppm.

**2. ອຸປະກອນ ແລະ ວິທີການ** (Material and method).

**2.1. ເຂດນິເວດກະສິກຳ ແລະ ພື້ນທີ່ປູກເຂົ້າໃນ ສປປລ.**

ການແບ່ງເຂດນິເວດກະສິກຳຂອງ ສປປລ ແມ່ນໄດ້ອີງຕາມການປ່ຽນແປງທາງດ້ານອຸນຫະພູມ, ການກະຈາຍຂອງປະລິມານນຳຝົນ, ຊ່ວງລະຍະເວລາທີ່ມີນ້ຳພຽງພໍສຳຫລັບການເພາະປູກ (Length of Growing Period -LGP) ແລະ ສະພາບພູມສັນຖານຂອງປະເທດ, ຊື່ງປະກອບດ້ວຍ 6 ເຂດນິເວດຄື: AEZ1-ເຂດສະພາບພູມອາກາດໜາວເຢັນ, ມີຄວາມຊຸມຊື້ນຫລາຍ, ອຸນຫະພູມຕ່ຳກວ່າ 8 ອົງສາ ໃນຊ່ວງເດືອນພຶດສະຈິກາຫາເດືອນມີນາ, ກວມເອົາທາງພາກຕາເວັນອອກສ່ຽງເຫນືອ, ເປັນເຂດທີ່ມີສະພາບພູມສັນຖານສູງຊັນ, ລະດັບຄວາມສູງໃຫ່ຍກວ່າ 800ມ ຂື້ນເມືອ, ຊ່ວງລະຍະທີ່ມີນ້ຳພຽງພໍສຳຫລັບການເພາະປູກ (LGP) ຢູ່ໃນລະຫວ່າງ 210-240ວັນ, ພື້ນທີ່ປູກເຂົ້າທີ່ສຳຄັນໄດ້ແກ່ພື້ນທີ່ປູກເຂົ້າໃນເຂດເມືອງຄຳແຂວງຊຽງຂວາງ ແລະ ເມືອງສິງໃນແຂວງຫລວງນ້ຳທາ. AEZ2- ເຂດສະພາບພູມອາກາດອົບອຸ່ນ, ມີຄວາມຊຸມຊື້ນ ຫລາຍ, ອຸນຫະພູມສະເລັ່ຽປີສ່ວນໃຫ່ຍຢູ່ໃນລະຫວ່າງ 8 ຫາ 25ອົງສາ, ກວມເອົາທາງພາກຕາເວັນຕົກຂອງເຂດພາກເຫນືອລົງມາຮອດສ່ວນນື່ງຂອງເຂດພາກກາງທາງດ້ານຕາເວັນຕົກ ແລະ ເຂດທົ່ງພຽງວຽງຈັນ, LGP ຢູ່ໃນລະຫວ່າງ 180 ຫາ 210 ວັນ. ພື້ນປູກເຂົ້າທີ່ສຳຄັນໄດ້ພື້ນທີ່ປູກເຂົ້າໃນແຂວງໄຊຍະບຸລີ ແລະ ເຂດທົ່ງພຽງວຽງຈັນ. AEZ3- ເຂດສະພາບພູມອາກາດອົບອຸ່ນ, ຊຸມຊື້ນປານກາງຫາຫລາຍ, ອຸນຫະພູມຢູ່ໃນລະຫວ່າງ 8-25 ອົງສາ, ກວມເອົາສ່ວນນື່ງຂອງພື້ນທີ່ທາງພາກເຫນືອຄື: ເຂດພິເສດໄຊສົມບູນ, ແຂວງບໍລິຄຳໄຊ ແລະ ສ່ວນນື່ງຂອງແຂວງຄຳມ່ວນ, LGP ຢູ່ໃນລະຫວ່າງ 210-240 ວັນ, ພື້ນທີ່ປູກເຂົ້າສ່ວນໃຫ່ຍແມ່ນນອນຢູ່ໃນເຂດທົ່ງພຽງຂອງແຂວງບໍລິຄຳໄຊ, ລຽບຕາມລຳແມ່ນ້ຳຂອງ. AEZ4- ເຂດສະພາບພູມອາກາດອົບອຸ່ນ, ມີຄວາມຊຸມປານກາງຫາຫນ້ອຍ, ອຸນຫະພູມສະເລັ່ຽປີ, ສ່ວນໃຫ່ຍໆກວ່າ 25 ອົງສາ, LGP ຢູ່ໃນລະຫວ່າງ 180-210ວັນ, ກວມເອົາແຂວງຄຳມ່ວນ, ສະຫວັນ

ນະເຂດ ແລະ ສ່ວນນຶ່ງຂອງ ແຂວງສາລະວັນ. ພື້ນທີ່ປູກເຂົ້າທີ່ສຳຄັນໄດ້ທົ່ງພຽງຄຳມ່ວນ, ສະຫວັນນະເຂດ ແລະ ທົ່ງພຽງ ສາລະວັນ. AEZ5- ເຂດສະພາບພູມອາກາດເຢັນ, ມີຄວາມຊຸ່ມຊື່ນຫລາຍ, ອຸນຫະພູມຕ່ຳກວ່າ 8 ອົງສາໃນຊ່ວງເດືອນພຶດສະຈິກາ ຫາ ເດືອນມີນາ, LGP ຫລາຍກວ່າ 240ວັນ, ເປັນເຂດພູພຽງ, ລະດັບຄວາມສູງໆກວ່າ1000ມ. AEZ6-ເຂດສະພາບພູມອາກາດອົບອຸ່ນ, ອຸ່ນຫະພູມໃຫ່ຍກວ່າ 25ອົງສາ ຫລາຍເດືອນໃນປີ, LGP ນອັຍກວ່າ 180ວັນ, ກວມເອົາທາງພາກຕາເວັນຕົກ ຂອງແຂວງຈຳປາສັກ ແລະ ແຂວງສາລະວັນ, ພື້ນທີ່ປູກເຂົ້າທີ່ສຳຄັນໄດ້ແກ່ທົ່ງພຽງຈຳປາສັກ ແລະ ທົ່ງພຽງສາລະວັນ.

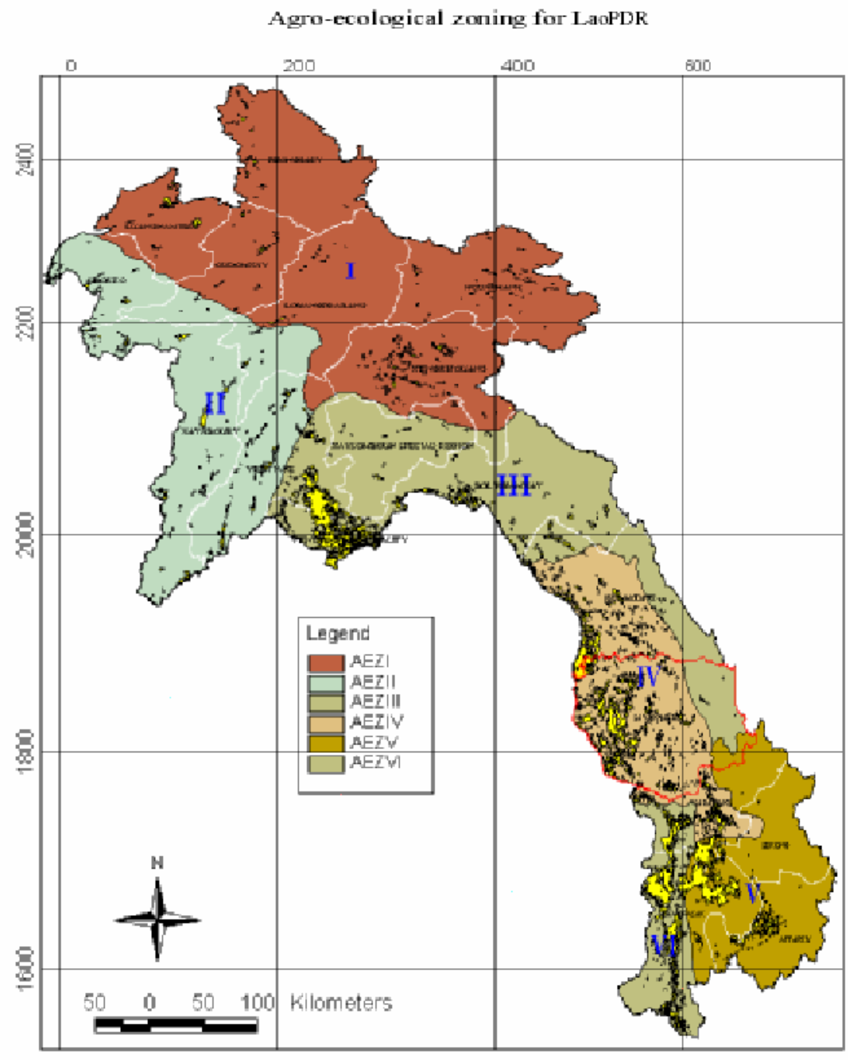



Fig.1.ຮູບສະແດງແຜນທີ່ແບ່ງເຂດນິເວດກະສິກຳຂອງ ສປປລ

## 2.2. ລະດູການປູກເຂົ້ານານ້ຳຝົນໃນ ສປປລ (Rainfed Lowland rice cropping calendar )

ລະດູການປູກເຂົ້ານານ້ຳຝົນ ໂດຍທົ່ວໄປແລ້ວແມ່ນຂຶ້ນກັບຊ່ວງລະຍະເວລາທີ່ມີນ້ຳພຽງພໍຕໍ່ການເພາະປູກ, ກໍຄືຊ່ວງທີ່ລະດູຝົນເລີ້ມຕົ້ນ ແລະ ສິ້ນສຸດ, ການຄຳນວນຊ່ວງລະຍະເວລາດັ່ງກ່າວແມ່ນໄດ້ອີງຕາມວິທີການຄຳນວນ Length of growing period (LGP) ຂອງອົງການອາຫານ ແລະ ການກະເສດ, ປີ 1987 ຄື: ມື້ເລີ້ມຕົ້ນຂອງ LGP ແມ່ນນັບຈາກເວລາທີ່ອັດຕາຂອງນ້ຳ(Precipitation rate) ເທົ່າກັບ ເຄິ່ງໜຶ່ງຂອງອັດຕາຄວາມອາດສາມາດລະເຫີຍອາຍ (0.5xPET) ຫລັງຈາກລະດູແລ້ງ. ໄລຍະທີ່ມີຄວາມຊຸ່ມຊື່ນ (Humid period) ແມ່ນໄລຍະທີ່ອັດຕາສ່ວນຂອງນ້ຳໃຫ່ຍກວ່າອັດຕາຄວາມອາດສາມາດລະເຫີຍອາຍ (PREC rate > PET rate). ການສິ້ນສຸດຂອງ LGP ແມ່ນຫລັງຈາກໄລຍະທີ່ອັດຕາຂອງນ້ຳ ເທົ່າກັບຫລືໜ້ອຍກວ່າ ເຄິ່ງນຶ່ງຂອງອັດຕາຄວາມອາດສາມາດລະເຫີຍອາຍ( PREC<=5.0PET) ແລະ LGP ອາດແກ່ຍາວຮອດລະດູແລ້ງ ແລະ ສິ້ນສຸດໃນເມື່ອຄວາມຊຸມຊື່ນທີ່ມີຢູ່ໃນດິນໜ້ອຍກວ່າ 100ມມ.

ອີງຕາມຊ່ວງລະຍະເວລາທີ່ມີນ້ຳພຽງພໍດັ່ງກ່າວນີ້ ລະດູການປູກເຂົ້ານານ້ຳຝົນໃນທົ່ວທຸກພາກຂອງປະເທດ ແມ່ນເລີ້ມຕົ້ນໃນລະຫວ່າງອາທິດທີ່ 11 ຫາ ອາທິດທີ່19 ຄືໃນລະຫວ່າງກາງຂອງເດືອນ ມີນາ ຫາ ກາງເດືອນພຶດສະພາ. ພື້ນທີ່ປູກເຂົ້າທີ່ຢູ່ລຽບຕາມແຄມແມ່ນ້ຳຂອງ ເຊັ່ນ: ທົ່ງພຽງໃນແຂວງບໍລິຄຳໄຊ ລະດູການເພາະປູກແມ່ນເລີ້ມຕົ້ນໄວ (ອາທິດທີ່11) ເພາະພື້ນທີ່ດັ່ງກ່າວແມ່ນໄດ້ຮັບປະລິມານນ້ຳຝົນສູງ, ພື້ນທີ່ປູກເຂົ້າໃນເຂດທົ່ງພຽງຈຳປາສັກ ທາງດ້ານທິດຕາເວັນຕົກ ເປັນພື້ນທີ່ໆມີປະລິມານການລະເຫີຍອາຍສູງ(Potential Evapo transpiration) ໃນຊ່ວງກາງເດືອນເມສາ ແລະ ລະດູການເພາະປູກແມ່ນຊ້າກວ່າພາກອື່ນໆ( ປະມານອາທິດທີ່ 18 ຫາ 19). ພື້ນທີ່ປູກເຂົ້າໃນເຂດທົ່ງພຽງສະຫວັນນະເຂດ ແລະ ທົ່ງພຽງໃນເຂດພາກເໜືອທາງທິດຕາເວັນຕົກ ແມ່ນເລີ້ມໃນອາທິດທີ່ 15 ຫາ 17. ປະລິມານການກະຈາຍຂອງນ້ຳຝົນ ໄດ້ຫລຸດຕ່ຳລົງ ໃນອາທິດທີ່ 40 (ຕົ້ນເດືອນຕຸລາ) ແລະ ລະດູການປູກເຂົ້ານານ້ຳຝົນ(ລະດູນາປີ) ສ່ວນໃຫ່ຍຈະສິ້ນສຸດໃນອາທິດທີ່ 42 (ທ້າຍເດືອນຕຸລາ). ສ່ວນພື້ນທີ່ປູກເຂົ້າໃນເຂດພາກເໜືອທາງພາກຕາເວັນອອກສ່ຽງເໜືອ ຊ່ວງລະຍະເວລາຂອງການເພາະປູກແກ່ຍາວກົ່ວເຂດອື່ນໆ ທັງນີ້ກໍຍ້ອນອຸນຫະພູມ ໄດ້ມີການປ່ຽນແປງຫລຸດຕ່ຳລົງໃນຊ່ວງທ້າຍເດືອນຕຸລາ, ປະລິມານການລະເຫີຍໜ້ອຍ ແລະ ຄວາມຊຸມຊື່ນສູງ.

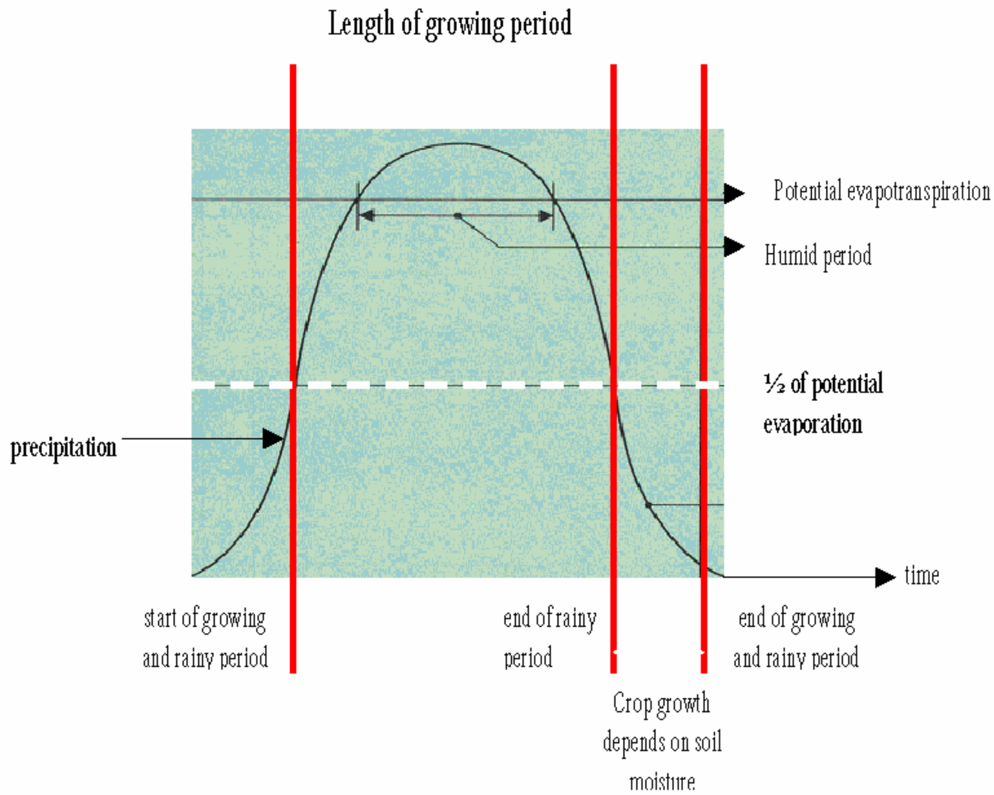



Fig.2. ຮູບສະແດງການຄາດຄະເນຊ່ວງລະຍະເວລາຂອງລະດູການປູກເຂົ້ານານ້ຳຝົນ.

### 3. ແບບຈຳລອງ MRB Rice Shell CERES-rice Model.

MRB Rice Shell CERES-rice Model ໄດ້ຖືກນຳໃຊ້ເຂົ້າໃນການຄາດຄະເນຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດຕໍ່ກັບຜົນຜະລິດເຂົ້າໃນເຂດທົ່ງພຽງສະຫວັນນະເຂດ, ປັດໃຈທີ່ສຳຄັນທີ່ໄດ້ນຳໃຊ້ເຂົ້າໃນຄາດຄະເນຜົນຜະລິດດັ່ງກ່າວໄດ້ແກ່:

#### 3.1. ດິນ ແລະ ຄຸນລັກສະນະຂອງດິນໃນເຂດທົ່ງພຽງຂອງແຂວງສະຫວັນນະເຂດ.

ຄຸນລັກສະນະທາງວັດຖຸ-ເຄມີຂອງດິນປະເພດຕ່າງໆເຊັ່ນ: ຄວາມເລິກຂອງຊັ້ນດິນ(soil depth), ເນື້ອດິນ(soil texture), %ຂອງອິນຊີວັດຖຸ(%OM), ທາດອາຫານຫລັກ NPK, ປະຕິກິລິຍາຂອງດິນ(pH2O) ແລະ ອື່ນໆ ໄດ້ຖືກນຳເຂົ້າໃນແບບຈຳລອງ(model) ໂດຍນຳໃຊ້ Soil data tool (Sbuild) ຈາກ DSSAT. ບາງຄຸນລັກສະນະຂອງດິນເຊັ່ນ: ສີຂອງດິນ, ການລະບາຍນ້ຳ, ການບັນຈຸCaCO3 ໃນດິນ ແມ່ນຍັງບໍ່ທັນມີຂໍ້ມູນພຽງພໍ, ແຕ່ຄຸນລັກສະນະດັ່ງກ່າວຈະບໍ່ເປັນຜົນກະທົບຮຸນແຮງຕໍ່ກັບຜົນຂອງການຄາດຄະເນໃນເຂດດັ່ງກ່າວ.

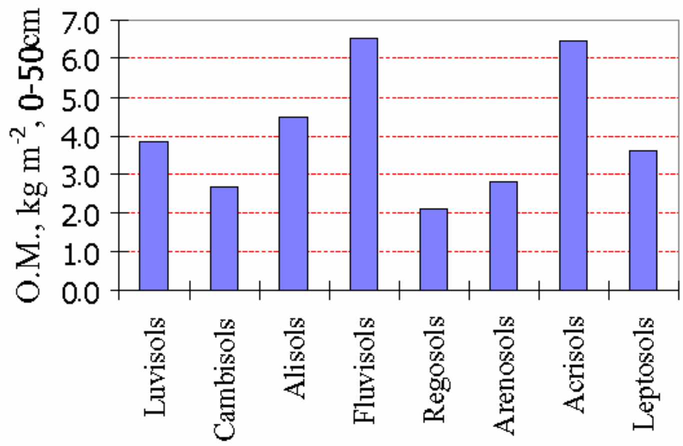



Fig.3. ຮູບສະແດງອິນຊີວັດຖຸ(%om) ບັນຈຸຢູ່ໃນດິນປະເພດຕ່າງໆຂອງແຂວງສະຫວັນນະເຂດ.

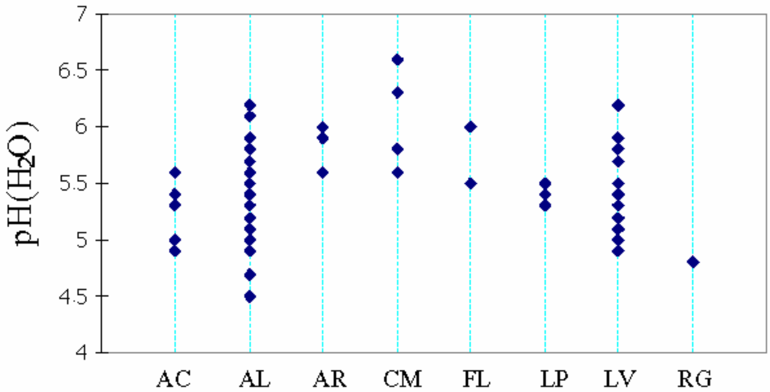



Fig.4. ຮູບສະແດງປະຕິກິລິຍາ(pH2O)ໃນດິນປະເພດຕ່າງໆຂອງແຂວງສະຫວັນນະເຂດ.

### 3.2. ແນວພັນເຂົ້າ (Rice Varieties)

ແນວພັນເຂົ້າທ່າດອກຄຳ-1(TDK1) ຊຶ່ງເປັນແນວພັນເຂົ້າປັບປຸງ, ເປັນເຂົ້າໜຽວ, ມີອາຍຸແຕ່135-140ວັນ(ເຂົ້າກາງ), ແຕກໍດີ, ລຳຕົ້ນສູງປານກາງລະຫວ່າງ 95-110 ຊັງຕີແມັດ, ມີປະຕິກິລິຍາຕອບສະໜອງຕໍ່ຝຸ່ນໄນໂຕຣເຈນ(N) ສູງ, ແລະ ມີຄວາມທົນທານຕໍ່ໂລກພະຍາດ

ເຊັ່ນ: ເພັ້ງຈັກຈັນ, ດັວງກໍ ແລະ ພະຍາດຂອບໃບແຫ້ງແລະໃບໄຫມ້. ສະມັດຕະພາບຂອງຜົນຜະລິດໂດຍປາສະຈາກການນໍາໃຊ້ຝຸ່ນເຄມີ ຢູ່ໃນລະຫວ່າງ 2-3 ໂຕນ, ຜົນຜະລິດຈະເພີ່ມຂື້ນເຖິງ 5 ໂຕນ ຖ້ານໍາໃຊ້ຝຸ່ນໄນໂຕຣເຈນໃນອັດຕາ 120 kg/ha.

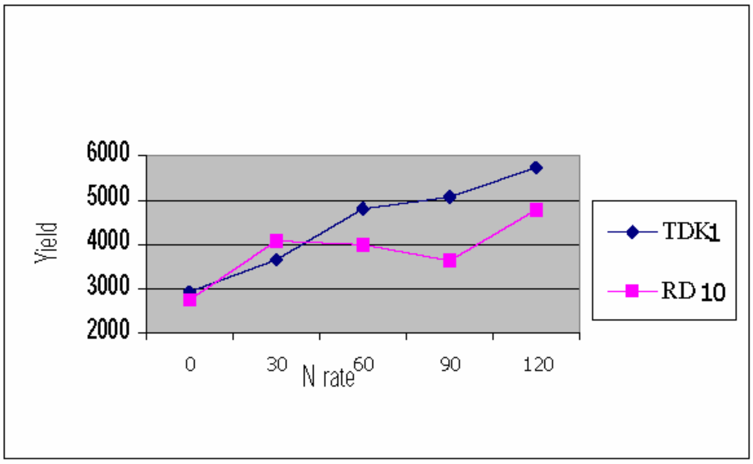



Fig.5. ຮູບສະແດງສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າ TDK1,RD10 ແລະການຕອບສະນອງຕໍ່ຝຸ່ນໄນໂຕເຈນ, ຈາກຈຸດທົດລອງໃນເຂດເມືອງໄຊບຸລີ, ແຂວງສະຫວັນນະເຂດ.

### 3.3. ຂໍ້ມູນພູມອາກາດ ( Climate Data)

ຂໍ້ມູນພູມອາກາດທີ່ສໍາຄັນທີ່ນໍາໃຊ້ເຂົ້າໃນແບບຈໍາລອງໄດ້ແກ່: ປະລິມານນໍ້າຝົນ (rain-fall), ອຸນຫະພູມຕໍ່າສຸດ-ສູງສຸດ (min. and max. temperature), ແລະ ລັງສີແສງ ( Solar Radiation). ຂໍ້ມູນດັ່ງກ່າວໄດ້ແມ່ນຄາດຄະເນຈາກ Conformal Cubic Atmospheric Model(CCAM) ສໍາຫລັບພູມອາກາດໃນຂົງເຂດອາຊີຕາເວັນອອກສ່ຽງໃຕ້, ທີ່ມີຂະໜາດຂອງ Grid cell ເທົ່າກັບ 60km x 60km. ຂໍ້ມູນດັ່ງກ່າວໄດ້ຖືກນໍາມາດັດປັບ (down scale) ໃຫ້ມີຂະໜາດຂອງ Grid cell ເທົ່າກັບ 10km x 10km ໂດຍນໍາໃຊ້ຂໍ້ມູນພູມອາກາດຂອງພື້ນທີ່ຕົວຈິງທີ່ໄດ້ມີການເກັບກໍາວັດແທກຕິດຕໍ່ກັນໃນຊ່ວງປີ 1980-1999 ຂອງ 8 ສະຖານີອຸຕຸນິຍົມທີ່ກະຈາຍຢູ່ໃນຂອບເຂດທົ່ວປະເທດ, ເພື່ອກໍານົດຫາຄ່າສໍາພະສິດຂອງການພົວພັນ (slope ແລະ intercept) ການຄໍານວນໄດ້ອີງຕາມສົມຜົນຂອງການພົວພັນແບບ Sigmoid curve relationship ແລະ ຄ່າສໍາພະສິດດັ່ງກ່າວໄດ້ຖືກນໍາໃຊ້ເຂົ້າໃນການຄາດຄະເນທາການປ່ຽນແປງຂອງສະພາບພູມອາກາດໃນເວລາປະຈຸບັນແລະອານາຄົດ. ການຄາດຄະເນໄດ້ກໍານົດອອກເປັນ 3 Scenario ຄື: ຜົນຜະລິດເຂົ້າໃນສະພາບພູມອາກາດໃນເວລາປະຈຸບັນໂດຍກໍານົດໃຫ້ຄ່າ $CO_2$ ທີ່ມີໃນບັນຍາກາດເທົ່າກັບ 360ppm, ຜົນຜະລິດເຂົ້າໃນອານາຄົດທີ່ຄາດວ່າຄ່າ $CO_2$ ຈະເພີ່ມຂື້ນ 1.5 ເທື່ອ ຈາກຄ່າໃນປະຈຸບັນເປັນ 540ppm ແລະ ຜົນຜະລິດເຂົ້າໃນອານາຄົດທີ່

ຄາດວ່າຄ່າ $CO_2$ ຈະເພີ້ມຂື້ນ 2 ເທື່ອຈາກຄ່າໃນປະຈຸບັນເປັນ 720ppm, ດັ່ງຕາຕະລາງ2 ຂ້າງລຸ່ມນີ້:

**ຕາຕະລາງ2. ລັກສະນະຂອງການປ່ຽນແປງ $CO_2$ ທີ່ຄາດວ່າຈະເປັນຜົນກະທົບຕໍ່ກັບຜົນຜະລິດເຂົ້າ ໃນເຂດທົ່ງພຽງສະຫວັນນະເຂດ.**

| Scenario | ລັກສນະຂອງການປ່ຽນແປງ$CO_2$ ທີ່ມີໃນບັນຍາກາດ |
|---|---|
| 1 | ສະພາບພູມອາກາດປະຈຸບັນ: $CO_2$ ໃນບັນຍາກາດໃນເວລາປະຈຸບັນເທົ່າກັບ 360ppm |
| 2 | ສະພາບພູມອາກາດທີ່ມີຄ່າ $CO_2$ ເພີ້ມຂື້ນ 1.5 ເທື່ອຈາກຄ່າ $CO_2$ ທີ່ມີໃນປະຈຸບັນ (1.5x$CO_2$) ເທົ່າກັບ 540ppm. |
| 3 | ສະພາບພູມອາກາດທີ່ມີຄ່າ $CO_2$ ເພີ້ມຂື້ນ 2 ເທື່ອຈາກຄ່າ $CO_2$ ທີ່ມີໃນປະຈຸບັນ (2x$CO_2$) ເທົ່າກັບ 720ppm. |

## 4.ຜົນທີ່ໄດ້ຮັບ ແລະ ວິຈານ (Results and Discussion)

### 4.1. ຜົນທີ່ໄດ້ຮັບ(Results)

ຜົນຂອງການສຶກສາໄດ້ສະແດງໃຫ້ເຫັນວ່າຜົນຜະລິດເຂົ້າທີ່ຄາດຄະເນໄດ້ຈາກແບບຈໍາລອງ MRB Rice Shell CERES-rice Model ພາຍໃຕ້ສະພາບພູມອາກາດ ໃນເວລາປະຈຸບັນທີ່ມີລະດັບ $CO_2$ ເທົ່າກັບ 360ppm ໃຫ້ຜົນຜະລິດຢູ່ໃນລະຫວ່າງ 1800-5100kg/ha, ສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າສ່ວນໃຫ່ຍ ຈະນ້ອຍກວ່າ 2000kg/ha, ກວມເອົາພື້ນທີ່ປະມານ 46.76% ຂອງພື້ນທີ່ປູກເຂົ້າທັງຫມົດ, ພື້ນທີ່ໆໃຫ້ສະມັດຕະພາບຢູ່ໃນລະຫວ່າງ 2000-3000kg ມີປະມານ 24,83%, ສ່ວນພື້ນທີ່ໆໃຫ້ສະມັດຕະພາບຫລາຍກວ່າ 3000kg ມີພຽງແຕ່ 0.14%. ຖ້າປຽບທຽບສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າທີ່ຄາດຄະເນຈາກແບບຈໍາລອງ ກັບສະມັດຕະພາບຂອງຜົນຜະລິດຈາກຈຸດທົດລອງໃນເຂດເມືອງໄຊບູລີ ຂອງໂຄງການ Lao-IRRI ປີ 2000 ເຫັນວ່າມີຄວາມໃກ້ຄຽງກັນຄື: ສະມັດຕະພາບຂອງຜົນຜະລິດຈະຢູ່ໃນລະຫວ່າງ 3000kg ຂື້ນເມື່ອ. ຜົນຂອງການສຶກສາໄດ້ສະແດງໃຫ້ເຫັນດັ່ງຮູບ Fig.6 ຂ້າງລຸ່ມນີ້:

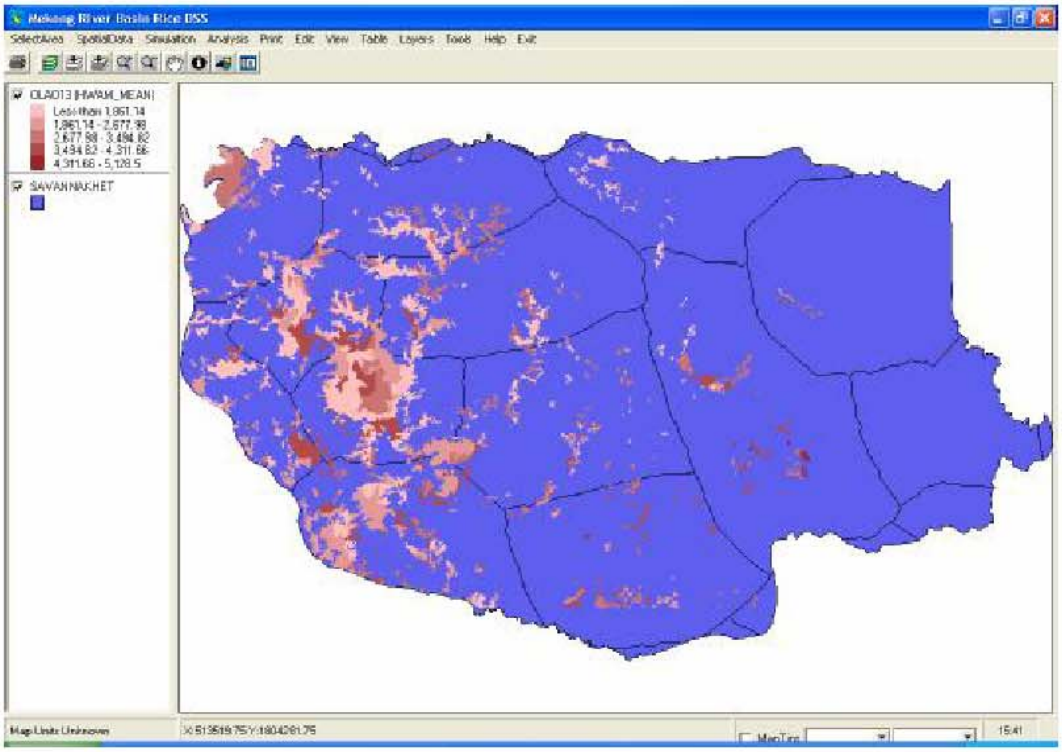



Fig.6. ຮູບສະແດງສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າTDK1 ເມື່ອລະດັບ$CO_2$ ເທົ່າ 360ppm ທີ່ມີໃນບັນຍາກາດໃນເວລາປະຈຸບັນ(ຄາດຄະເນຈາກແບບຈຳລອງ MRB Rice Shell CERES rice Model).

### 4.2. ການປ່ຽນແປງສະພາບພູມອາກາດໃນອານາຄົດ ແລະ ຜົນກະທົບຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນຈາກການປ່ຽນແປງເພີ້ມຂື້ນຂອງ $CO_2$. (Climate change scenario and the effect of increments of $CO_2$ on potential yields)

ຜົນຂອງການຄາດຄະເນຜົນກະທົບຈາກການປ່ຽນແປງຂອງ ອາຍແກສກາກບອນໄດດິອອກໄຊ($CO_2$) ທີ່ຄາດວ່າຈະມີການປ່ຽນແປງເພີ້ມຂື້ນໃນອານາຄົດ ຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນໃນເຂດທົ່ງພຽງໃຫ່ຍຂອງແຂວງສະຫວັນນະເຂດໄດ້ສະແດງໃຫ້ເຫັນວ່າ: ສະມັດຕະພາບ ຂອງຜົນຜະລິດເຂົ້າທ່າດອກຄຳ1 ຈະມີການປ່ຽນແປງເພີ້ມຂື້ນ ເມື່ອລະດັບຂອງ$CO_2$ ເພີ້ມຂື້ນ 1.5 ເທື່ອ (540ppm), ຜົນຜະລິດຈະຢູ່ໃນລະຫວ່າງ 2000-5900kg/ha ດັ່ງຮູບ Fig.7.

ສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າໃນເຂດດັ່ງກ່າວຈະຫລຸດລົງເລັກນ້ອຍ,ຢູ່ໃນລະຫວ່າງ 2000-5600kg/ha ໃນເມື່ອລະດັບຂອງ $CO_2$ ຫາກເພີ້ມຂື້ນເຖິງ 2 ເທື່ອ (720ppm) ດັ່ງຮູບ Fig.8. ແລະຕາຕະລາງປຽບທຽບສະມັດຕະພາບຂອງຜົນຜະລິດຈາກການປ່ຽນແປງຂອງ $CO_2$ ທີ່ມີໃນບັນຍາກາດ ຂ້າງລຸ່ມນີ້:

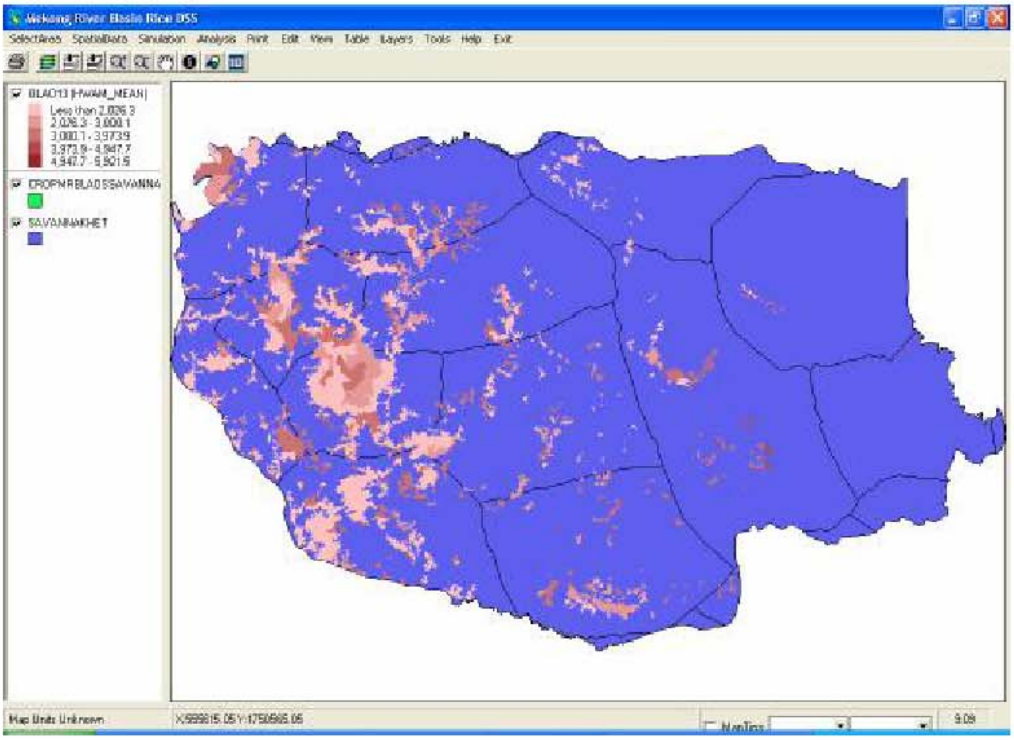



Fig.7. ຮູບສະແດງສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າTDK1 ເມື່ອລະດັບ$CO_2$ ເພີ້ມຂື້ນ 1.5ເທື່ອ ຈາກ 360ppm ເປັນ 540ppm ທີ່ມີໃນບັນຍາກາດໃນອານາຄາດ. (ຄາດຄະເນຈາກແບບຈຳລອງ MRB Rice Shell CERES rice Model).

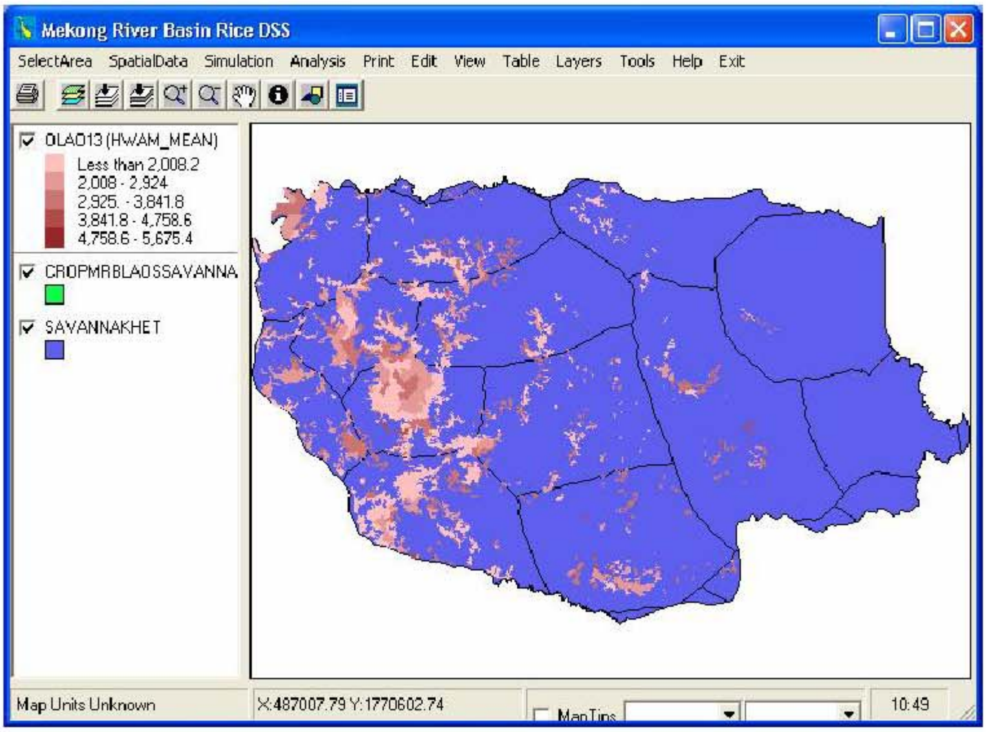



Fig.8. ຮູບສະແດງສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າTDK1 ເມື່ອລະດັບ$CO_2$ ເພີ້ມຂື້ນ 2 ເທື່ອ ຈາກ 540ppm ເປັນ 720ppm ທີ່ມີໃນບັນຍາກາດໃນອານາຄາດ.

ຕາຕະລາງ3. ຕາຕະລາງປຽບທຽບສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້ານານ້ຳຝົນຈາກການປ່ຽນແປງຂອງ $CO_2$ ທີ່ມີໃນບັນຍາກາດໃນເຂດທົ່ງພຽງສະຫັວນນະເຂດ.

| ແນວພັນເຂົ້າ | ຜົນກະທົບຈາກ $CO_2$ | | |
|---|---|---|---|
| | $CO_2$(360ppm) | 1.5x$CO_2$(540ppm) | 2x$CO_2$(720ppm) |
| TDK1 | 1000-5100kg/ha | 2000-5900kg/ha | 2000-5600kg/ha |

**4. ສະຫລູບ** (Conclusion)

ຜົນຂອງການສຶກສາຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນໃນເຂດທົ່ງພຽງໃຫ່ຍຂອງແຂວງສະຫວັນນະເຂດເຫັນວ່າ ສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າຈະເພີ້ມຂຶ້ນເມື່ອລະດັບຂອງ $CO_2$ ປ່ຽນແປງເພີ້ມຂື້ນຈາກ 360ppm ເປັນ 540ppm (1.5x$CO_2$). ສາເຫດອາດເນື່ອງມາຈາກປັດໃຈທາງດ້ານພູມອາກາດເພີ້ມຂື້ນເປັນຕົ້ນວ່າ: ລັງສີແສງທີ່ໃຊ້ໃນການສັງເຄາະແສງຂອງພືດ( Photosynthethic active radiation-PAR) ອາດມີຫລາຍຂຶ້ນ, ຈຳນວນຊົ່ວໂມງທີ່ມີແສງແດດອາດຍາວຂື້ນ, ຊ່ວງລະຍະເວລາທີ່ມີນ້ຳສຳຫລັບການປູກເຂົ້າ ຫລື ປະລິມານນ້ຳຝົນອາດມີຫລາຍຂື້ນ, ປັດໃຈທັງຫມົດເຫລົ່ານີ້ອາດເປັນເງື່ອນໄຂທີ່ເຫມາະສົມສຳຫລັບການປູກເຂົ້ານານ້ຳຝົນ. ແຕ່ເຖິງແນວໃດຕາມ, ເມື່ອລະດັບຂອງ $CO_2$ ຫາກເພີ້ມຂື້ນເຖິງ 720ppm(2x$CO_2$) ຜົນຂອງການສຶກສາໄດ້ສະແດງໃຫ້ເຫັນວ່າສະມັດຕະພາບຂອງຜົນຜະລິດເຂົ້າແມ່ນມີແນວໂນ້ມລຶດລົງ, ການປ່ຽນແປງຂອງສະພາບພູມອາກາດທີ່ເກີນກວ່າຄວາມຕ້ອງການອາດເປັນສາເຫດທີ່ສົ່ງຜົນກະທົບຕໍ່ກັບແນວພັນເຂົ້າດັ່ງກ່າວ.

**5. ຮູ້ບຸນຄຸນ**(Acknowledgements)

ຂໍສະແດງຄວາມຮູ້ບຸນຄຸນຕໍ່ອົງການວິທະຍາສາດເຕັກໂນໂລຊີ ແລະ ສິ່ງແວດລ້ອມ, ສະຖາບັນຄົ້ນຄ້ວາກະສິກຳແລະປ່າໄມ້ ໂດຍໄດ້ຮ່ວມມືກັບສູນເຄືອຂາຍການຄົ້ນຄ້ວາວິໃຈ ແລະ ຝຶກອົບຮົມໃນຂົງເຂດອາຊີຕາເວັນອອກສ່ຽງໃຕ້ (Southeast Asia for START Regional Center), Multiple Cropping Ceter, ມະຫາວິທະຍາໄລຊຽງໃຫ່ມ ທີ່ໄດ້ຈັດຕັ້ງປະຕິບັດການຝຶກອົບຮົບ, ຊ່ວຍເຫລືອທາງດ້ານທຶນຮອນ ແລະ ວິຊາການເຂົ້າໃນການສຶກສາຜົນກະທົບຂອງການປ່ຽນແປງສະພາບພູມອາກາດຕໍ່ກັບຜົນຜະລິດເຂົ້ານານ້ຳຝົນ ໃນເຂດທົ່ງພຽງສະຫວັນນະເຂດຂອງ ສປປລ.

**6.references**

Inthavong, T.V., S.P.Kam, J.Basnayake, S.Fukai, B.Linquist and Monthathip Chanphengsay.2004. Using GIS technology to develop crop water availability maps for LaoPDR. Water in agriculture, ACIAR proceeding No.116.

R.B.Matthews, M.J.Kropff, D.Bachelet, H.H Van Laar. Modeling the impact of climate change on rice production in ASIA.1995. International Rice Research Institute (IRRI).

Gordon.Y.Tsuji, Gerrit Hoogenboom, Philip.K. Thornton.1998. Understanding Options for Agricultural production. Kluwer Academic Publishers in cooperation with ICASA.

Annual Technical Report.1998. National Rice Research Program and LAO-IRRI Project.

Inthavong,T.V.,B.Linquist, S.Fukai, J.Basnayake, S.P.Kam, K.Khounphonh, and M.Chanphengsay.2002. GIS-based temperature maps for Laos: development of maps and their use for estimating low-temperature risks for dry season rice production.

# Impacts of Climate Change on Rice Production in Kula Ronghai Field

**Vichien Kerdsuk**
Research and Development Institute, Khon Kaen University, Thailand

**Sahaschai Kongton**
Land Development Department, Ministry of Agriculture and Cooperatives, Thailand

**Attachai Jintrawet**
Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University, Thailand

## Abstract

The objectives of this study are 1) to pilot study the potential of climate change impacts on KDML105 rice 2) to study adaptation of rice farmer to climate change situations and 3) to propose the short and long term policy for rice production in Tung Kula field. The study uses MRB-Rice shell, which link the CERES-Rice model V4.0 and spatial databases. We use simulated weather data from the CCAM climate model, which cover three periods (year 1980-89, 2040-49 and 2066-75). The simulation setting are as follows; growing KDML105 rice on June1 by direct seeding method and set $CO_2$ concentration at 1.5, 2.0 times of normal year (year 1980-89 ) in the year 2040-49 and year 2066-75 simultaneously.

The results shown that climate change have positive impact on KDML105 rice yield in Tung Kula field in the future. The rice yield is higher under climate condition at $CO_2$ when $CO_2$ increase to 1.5 time and 2 times, with little deviation from year to year under each period. The comparison of simulation result in cultivating KDML105 rice by having planting date changed from 1 June to 15 May shows that KDML105 rice yield is significantly reduced.

The recommend from this study are: 1) the government have to the master plan to improve KDML105 rice variety to a suitable for Tung Kula field. 2) It has work plan for protecting the area from flood. And 3) Studying a suitable of planting methods and managements for KDML105 rice in the future.

# ผลกระทบของการเปลี่ยนแปลงภูมิอากาศต่อการผลิตข้าวในทุ่งกุลาร้องไห้

**ดร. วิเชียร เกิดสุข**
สถาบันวิจัยและพัฒนา มหาวิทยาลัยขอนแก่น
**นายสหัสไชย คงทน**
กรมพัฒนาที่ดิน กระทรวงเกษตรและสหกรณ์
**ดร. อรรถชัย จินตะเวช**
คณะเกษตรศาสตร์ มหาวิทยาลัยเชียงใหม่

**บทนำ**

ข้าวขาวดอกมะลิ105 หรือเรียกกันทั่วไปว่า "ข้าวหอมมะลิ" เป็นพันธุ์ข้าวที่ได้รับความนิยมอย่างมากเนื่องจากมีคุณภาพดี มีความนุ่มและรสชาติอร่อย อีกทั้งเป็นข้าวที่มีราคาต่อหน่วยสูงกว่าพันธุ์ข้าวอื่น ปัจจุบันพื้นที่เพาะปลูกข้าวขาวดอกมะลิ105 ของประเทศไทยมีประมาณ 16 ล้านไร่ โดยแหล่งผลิตที่สำคัญอยู่ในภาคตะวันออกเฉียงเหนือประมาณร้อยละ 80 ของพื้นที่เพาะปลูกข้าวหอมมะลิทั้งหมด

"ทุ่งกุลาร้องไห้" เป็นแหล่งผลิตข้าวหอมมะลิที่ให้คุณภาพดีที่สุดของประเทศไทยและได้ชื่อว่าเป็นแหล่งปลูกข้าวหอมมะลิใหญ่เป็นอันดับหนึ่งของโลก มีพื้นที่ประมาณ 2.1 ล้านไร่ ครอบคลุมพื้นที่ 5 จังหวัด คือ ร้อยเอ็ด มหาสารคาม สุรินทร์ ศรีสะเกษ และยโสธร พื้นที่ประมาณ 1.8 ล้านไร่ หรือร้อยละ 84 เป็นนาข้าว อย่างไรก็ตามมากกว่าครึ่งของพื้นที่ยังประสบปัญหาน้ำท่วมสลับกับฝนทิ้งช่วงในหน้าฝน และมีความแห้งแล้งและขาดแคลนน้ำในหน้าแล้ง ผลผลิตข้าวหอมมะลิในปี 2541/2542 มีผลผลิตเฉลี่ยเพียง 280 กก./ไร่ (โครงการปรับปรุงประสิทธิภาพการผลิตข้าวหอมมะลิระดับเกษตรกร, 2542)

การปลดปล่อยบรรดาก๊าซเรือนกระจกขึ้นสู่บรรยากาศ ทั้งจากกลไกธรรมชาติและที่เกิดจากกิจกรรมของมนุษย์ที่ผ่านมา เป็นสาเหตุของอุณหภูมิโลกที่ร้อนขึ้น ก๊าซเรือนกระจกดังกล่าวได้แก่ ก๊าซคาร์บอนไดออกไซด์ ($CO_2$) ก๊าซคาร์บอนมอนออกไซด์ (CO) ก๊าซมีเทน ($CH_4$) ก๊าซไนตรัสออกไซด์ ($N_2O$) และ ก๊าซคลอโรฟลูโอโรคาร์บอน ($CFC_s$) เป็นต้น แหล่งกำเนิดหลักของการปลดปล่อยก๊าซดังกล่าวคือ การเผาไหม้ของน้ำมันเชื้อเพลิงฟอสซิล การเปลี่ยนแปลงการใช้ที่ดิน โดยเฉพาะการทำลายป่า จากรายงานของคณะกรรมการระดับรัฐบาลว่าด้วยการเปลี่ยนแปลงภูมิอากาศ หรือ IPCC ในปี 1990 (อ้างใน Barret, 2000) พบว่า หากปริมาณก๊าซคาร์บอนไดออกไซด์ ($CO_2$) เพิ่มขึ้น 2 เท่าอุณหภูมิของโลกจะเพิ่มขึ้น 1-3.5 เซลเซียส จากสถานการณ์ที่มีการใช้น้ำมันเชื้อเพลิงที่ผ่านมา (A1F1) ผลการทำนายแสดงให้เห็นว่า อุณหภูมิของโลกจะเพิ่มขึ้นอีก 2 เซลเซียส และ 2.5 เซลเซียลในช่วงปี พ.ศ. 2543-2593 และ 2594-2643 เมื่อเทียบกับในอดีต เชื่อกันว่าการ

เปลี่ยนแปลงภูมิอากาศโลกอันเนื่องน้ำมือมนุษย์ยังเป็นสิ่งที่ไม่อาจหลีกเลี่ยงได้ แม้ว่าจะได้มีสนธิสัญญาสหประชาชาติว่าด้วยการเปลี่ยนแปลงภูมิอากาศโลก พ.ศ. 2531 และพิธีสารเกียวโต (Kyoto Protocol) พ.ศ. 2540 ที่มีเป้าหมายการลดระดับของการปลดปล่อยก๊าซเรือนกระจกของประเทศภาคสมาชิกก็ตาม จากสภาวะเรือนกระจกดังกล่าวอาจส่งผลกระทบต่อการผลิตข้าวหอมมะลิในทุ่งกุลาร้องไห้ การศึกษานี้มีวัตถุประสงค์เพื่อ ศึกษาผลกระทบของการเปลี่ยนแปลงภูมิอากาศต่อผลผลิตข้าวหอมมะลิ การปรับตัวของเกษตรกรต่อการเปลี่ยนเปลงภูมิอากาศที่ผ่านมา และเสนอแนะเชิงนโยบายต่อรัฐบาลเกี่ยวกับการผลิตข้าวในทุ่งกุลาร้องไห้

**อุปกรณ์และวิธีการ**

**ข้อมูลภูมิอากาศ** ที่ใช้สำหรับการคาดคะเนผลผลิตของข้าวขาวดอกมะลิ105 เป็นข้อมูลภูมิอากาศที่ได้จากการทำนายของแบบจำลองภูมิอากาศที่เรียกว่า CCAM (Conformal Cubic Atmospheric Model) ซึ่งทำการพัฒนาโดย Gordon et al. (2001) มีการพัฒนาและทดสอบในภูมิภาคเอเชียตะวันออกเฉียงใต้โดยศูนย์เครือข่ายงานวิเคราะห์ วิจัย และฝึกอบรมการเปลี่ยนแปลงของโลกแห่งภูมิภาคตะวันออกเฉียงใต้ (START) จุฬาลงกรณ์มหาวิทยาลัย

**โปรแกรมเชื่อมโยงข้าวในเขตลุ่มน้ำโขง (MRB-Rice shell)** เป็นโครงสร้างที่ผู้ใช้งานสามารถกำหนดพื้นที่ศึกษา พร้อมกำหนดระบบการผลิตข้าวได้ และสามารถเชื่อมโยงฐานข้อมูลเชิงพื้นที่ ที่เลือกศึกษาเข้ากับการใช้งานของแบบจำลองข้าว เมื่อแบบจำลองข้าวเสร็จสิ้นการคำนวณ ผู้ใช้งานสามารถแสดงผลการทำงานของแบบจำลองข้าว (CERES-Rice, DSSAT4) และข้อมูลของระบบสารสนเทศทางภูมิศาสตร์ (GIS) โปรแกรมนี้พัฒนาโดยศูนย์วิจัยเพื่อเพิ่มผลผลิตทางการเกษตร (MCC) มหาวิทยาลัยเชียงใหม่ (http://mccweb.agri.cmu.ac.th/research/DSSARM/MRBRice.htm) ร่วมกับ ศูนย์เครือข่ายงานวิเคราะห์ วิจัย และฝึกอบรมการเปลี่ยนแปลงของโลกแห่งภูมิภาคตะวันออกเฉียงใต้ (START) จุฬาลงกรณ์มหาวิทยาลัย

**ข้อมูลพื้นที่ปลูกข้าวในพื้นที่ทุ่งกุลาร้องไห้** ในรูป SHP format ดำเนินการบนโปรแกรม ELWIS V3.2 (ITC) โดยการประยุกต์จากข้อมูลการใช้ประโยชน์ที่ดินของกรมพัฒนาที่ดิน (2547) เป็นข้อมูลนำเข้าโปรแกรมเชื่อมโยงข้าวในเขตลุ่มน้ำโขง

**ข้อมูลชุดดิน ขอบเขตการปกครอง** จากฝ่ายวางแผนการใช้ที่ดิน กรมพัฒนาที่ดิน และจากการตรวจสอบในภาคสนาม ดำเนินการบนโปรแกรม ELWIS V3.2 (ITC) ในรูป SHP format เป็นข้อมูลนำเข้าโปรแกรมเชื่อมโยงข้าวในเขตลุ่มน้ำโขง

**ข้อมูลการปรับตัวของเกษตรกรจากสภาพภูมิอากาศที่เปลี่ยนไป** โดยการสุ่มสัมภาษณ์ตัวแทนเกษตรกรในพื้นที่ที่เกิดน้ำท่วมและฝนแล้ง ครอบคลุมพื้นที่ทุ่งกุลาร้องไห้ 4 จังหวัด 5

อำเภอ 6 ตำบล โดยทำการเลือกพื้นที่จากแผนที่แสดงพื้นที่น้ำท่วมปี พ.ศ. 2544 และพื้นที่เสียงภัยแล้ง ของศูนย์ภูมิสารสนเทศเพื่อการพัฒนาภาคตะวันออกเฉียงเหนือ มหาวิทยาลัยขอนแก่น

**ข้อมูลสัมประสิทธิ์พันธุกรรมข้าวขาวดอกมะลิ105** ของ Kerdsuk (2002)

**ข้อมูลผลผลิตข้าวขาวดอกมะลิ105** ในพื้นที่ทุ่งกุลาร้องไห้ ดำเนินการโดยการสอบถามเกษตรกรในพื้นที่เดียวกับการสอบถามเรื่องการปรับตัวของเกษตรกร และข้อมูลเพิ่มเติมจากสำนักงานเกษตรอำเภอในพื้นที่

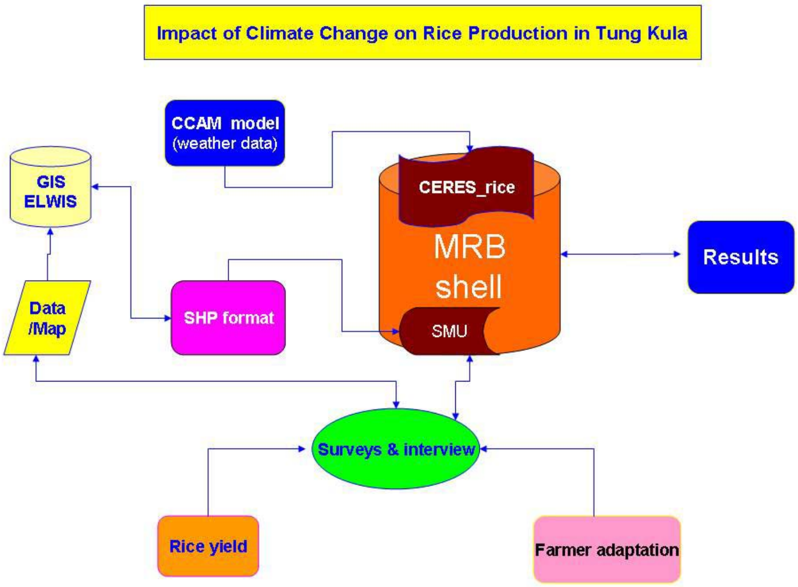
**การวิเคราะห์ข้อมูล**

การวิเคราะห์ผลกระทบของการเปลี่ยนแปลงภูมิอากาศต่อผลผลิตข้าวขาวดอกมะลิ105 ใช้ข้อมูลภูมิอากาศจาก CCAM 3 ช่วงเวลา ช่วงละ 10 ปี คือ ช่วงปี พ.ศ. 2523-32, 2583-2592 และ 2609-2618 เป็นข้อมูลนำเข้าของแบบจำลองข้าว (CERES-Rice) เพื่อประเมินศักยภาพของผลผลิตข้าวขาวดอกมะลิ105 ในระยะยาว 10 ปี (seasonal analysis) โดยที่วิธีการปลูกข้าวแบบนาหว่านในวันที่ 1 มิถุนายนของทุกปี ซึ่งส่วนใหญ่ของพื้นที่จะปลูกข้าวในช่วงนี้ การให้ปุ๋ยเคมีตามคำแนะนำของกรมวิชาการเกษตร และทำการปรับเปลี่ยนปริมาณคารบอนไดออกไซด์ในอากาศในช่วงปี 2583-2592 และ 2609-2618 เป็น 1.5 และ 2 เท่าของปีปกติ (ปี 2523-32 มี $CO_2$ เท่ากับ 330 ppm)

การประเมินศักยภาพการผลิตข้าวในปีที่ฝนดีและฝนแล้ง จากข้อมูลภูมิอากาศ CCAM ทั้ง 3 ช่วงเวลา นำศักยภาพผลผลิตมาเปรียบเทียบกัน โดยวิธีการและการจัดการเช่นเดียวกับที่กล่าวในเบื้องต้น

การประเมินศักยภาพการผลิตข้าว ตามวิธีการปรับตัวของเกษตรกรกล่าวคือ เปลี่ยนวันปลูกข้าวนาหว่านเป็นวันที่ 15 พฤษภาคมของทุกปี ทำการประเมินศักยภาพผลผลิตข้าวในระยะเวลา 10 ปี 3 ช่วงเวลาดังข้างต้น

**กรอบแนวคิดในการศึกษา**




**ผลการศึกษา**

1. การเปลี่ยนแปลงภูมิอากาศต่อผลผลิตข้าวขาวดอกมะลิ105 ในช่วงปี พ.ศ. 2523-32, 2583-2592 และ  พ.ศ. 2609-2618 พบว่า ผลผลิตเฉลี่ยของข้าวขาวดอกมะลิ105 โดยรวมทั้งทุ่งกุลาร้องไห้ช่วงปี พ.ศ. 2583-2592 และ ปี พ.ศ. 2609-2618 สูงกว่าช่วงปี พ.ศ. 2523-32 เป็นอย่างมากถึงร้อยละ 184 และ 182 ตามลำดับ (รูปที่ 1) แต่มีแนวโน้มว่า ผลผลิตเฉลี่ยของข้าวโดยรวมจะลดลงเล็กน้อยในช่วงปี พ.ศ. 2609-2618 หากพิจารณาพื้นที่ปลูกข้าวกับผลผลิต พบว่า พื้นที่นาข้าวที่ให้ผลผลิตช่วง 2001-2500 กิโลกรัมต่อเฮกตาร์ เพิ่มขึ้นประมาณ 6 เปอร์เซนต์ทั้งในช่วงปี 2583-2592 และ 2609-2618 เมื่อเทียบกับช่วงปี 2523-32 ส่วนพื้นที่นาข้าวที่ให้ผลผลิตช่วง 2501-3000 กิโลกรัมต่อเฮกตาร์ เพิ่มขึ้นประมาณ 5 เปอร์เซ็นต์ในช่วงปี 2583-2592เมื่อเทียบกับช่วงปี 2523-32

2.  การพิจารณาปริมาณน้ำฝนกับการปลูกข้าวในปีที่ฝนดีและฝนแล้ง มิสามารถนำปริมาณน้ำฝนรวมรายปีมาเป็นเกณฑ์กำหนดว่า ปีใดเป็นปีฝนดีหรือฝนแล้งสำหรับการเจริญเติบโตและผลผลิตข้าวได้ เช่นพืชไร่อื่นๆ เช่น มันสำปะหลัง  อ้อย เป็นต้น สำหรับการปลูกข้าวต้องพิจารณาปริมาณน้ำฝนเฉพาะในช่วงฤดูการปลูกข้าวเท่านั้น แล้วสรุปว่า ปีใดเป็นปีฝนดีและฝนแล้งในช่วงเวลาดังกล่าว จากเกณฑ์ดังกล่าวและข้อมูลภูมิอากาศ CCAM สรุปได้ว่า ปี พ.ศ.2523, 2587, 2615 เป็นปีฝนดี ส่วนปี พ.ศ. 2524, 2589, 2617 เป็นปีฝนแล้ง (รูปที่ 2)

ผลการวิเคราะห์ผลผลิตข้าว พบว่า ผลผลิตข้าวขาวดอกมะลิ105 ทั้งพื้นที่ทุ่งกุลาร้องไห้ไม่แตกต่างกันในปีฝนดีและปีฝนแล้ง หากพิจารณาผลผลิตของข้าวในแต่ละช่วงภูมิอากาศมีแนวโน้ม

ว่า ในช่วงปีพ.ศ. 2523-32 และปี พ.ศ.2583-2592 ผลผลิตข้าวขาวดอกมะลิ105 ปีฝนแล้งสูงกว่าปีฝนดี ขณะที่ช่วงปี พ.ศ. 2609-2618 ผลผลิตข้าวขาวดอกมะลิ105 ในปีฝนดีสูงกว่าปีฝนแล้ง อย่างไรก็ตาม ผลผลิตข้าวทั้งปีฝนดีและฝนแล้งในช่วงนี้จะต่ำกว่าในช่วงปีอื่น (รูปที่ 3 และ 4)

3. ผลการสัมภาษณ์เกษตรกรในพื้นที่ทุ่งกุลาร้องไห้ ทั้งในพื้นที่ที่ประสบปัญหาฝนแล้งและน้ำท่วมเป็นประจำ พบว่า เกษตรกรมักประสบปัญหาฝนแล้งช่วงต้นฤดู น้ำท่วมในปลายฤดู หรือมีปัญหาทั้งน้ำท่วมและฝนแล้งควบคู่กันไป และโดยเฉพาะในช่วง 5 ปีที่ผ่านมา บางพื้นที่โดยเฉพาะบริเวณที่อยู่ใกล้ลำน้ำหรือแม่น้ำประสบปัญหาน้ำท่วมจากน้ำที่มาจากนอกพื้นที่ทุ่งกุลาร้องไห้ ส่งผลให้เกษตรกรปรับตัวโดยทำการปลูกข้าวให้เร็วกว่าในอดีต เพื่อให้ต้นข้าวแข็งแรงและเจริญเติบโตก่อนจะมีน้ำท่วมขัง อย่างไรก็ตามเกษตรกรยังคงต้องการปลูกข้าวขาวดอกมะลิ105 เนื่องจากมีราคาสูงกว่าข้าวพันธุ์อื่น เกษตรกรได้ปรับเปลี่ยนช่วงเวลาปลูกข้าวให้เร็วขึ้น กล่าวคือ ทำการหว่านข้าวแห้งตั้งแต่ปลายเดือนเมษายนเป็นต้นไป และส่วนใหญ่จะหว่านข้าวแล้วเสร็จในเดือนพฤษภาคม

จากการปรับเปลี่ยนวันปลูกข้าวเป็นวันที่ 15 พฤษภาคมของทุกปี พบว่า ทั้ง 3 ช่วงเวลา พื้นที่ปลูกข้าวส่วนใหญ่ในทุ่งกุลาร้องไห้ให้ผลผลิตระหว่าง 2001-2500 และ น้อยกว่า 2000 กิโลกรัมต่อเอกตาร์ ตามลำดับ โดยในช่วงปี พ.ศ.2609-2618 พื้นที่ปลูกข้าวที่ให้ผลผลิตระหว่าง 2001-2500 กิโลกรัมต่อเอกตาร์จะมากกว่าช่วงปี พ.ศ.2583-2592 และช่วง พ.ศ. 2523-32 ตามลำดับ เมื่อเปรียบเทียบผลผลิตข้าวเฉลี่ยรวมทั้งทุ่งกุลาร้องไห้พบว่า ผลผลิตข้าวแตกต่างกันเล็กน้อยทั้ง 3 ช่วงปี กล่าวคือ ในช่วงปี พ.ศ. 2583-92 และพ.ศ. 2609-18 ให้ผลผลิตข้าวสูงกว่าช่วงปี พ.ศ. 2523-32 ร้อยละ 6 และ 1 ตามลำดับ (รูปที่ 5)

จากการเปรียบเทียบวันปลูกข้าวใน 2 วันปลูกคือ วันปลูกที่ 15 พฤษภาคม และ 1 มิถุนายน ทั้ง 3 ช่วงปี พบว่า การปลูกข้าวนาหว่านในวันที่ 1 มิถุนายน ทั้ง 3 ช่วงปีให้ผลผลิตข้าวสูงกว่าการปลูกในวันที่ 15 พฤษภาคม เป็นอย่างมาก คิดเป็นร้อยละ 140 , 544 และ 568 ในช่วงปี พ.ศ. 2523-32, 2583-2592 และ 2609-2618 ตามลำดับ(รูปที่ 6)

**สรุปและเสนอแนะ**

1. การเปลี่ยนแปลงภูมิอากาศมีต่อผลกระทบในทางบวกต่อผลผลิตข้าวขาวดอกมะลิ105 ในทุ่งกุลาร้องไห้ กล่าวคือ การเปลี่ยนแปลงภูมิอากาศในอนาคต ส่งผลทำให้ผลผลิตข้าวขาวดอกมะลิ105 ในพื้นที่จะเพิ่มขึ้น เนื่องจากปริมาณก๊าซคาร์บอนไดออกไซด์ในบรรยากาศสูงขึ้น 1.5-2 เท่าของปัจจุบัน ทำให้พืชทำการปรุงอาหารได้มากขึ้น แม้อุณหภูมิอากาศโดยเฉลี่ยจะสูงขึ้น แต่ปริมาณน้ำฝนเพิ่มขึ้นเช่นกัน ทำให้ไม่กระทบต่อการเจริญเติบโตและการสังเคราะห์แสงของข้าว

และข้าวไม่ขาดน้ำตลอดช่วงฤดูปลูก ภายใต้เงื่อนไขในของการปลูกข้าวนาหว่านวันที่ 1 มิถุนายน และไม่เกิดน้ำท่วมขังจนทำให้ข้าวเสียหาย

ภายใต้เงื่อนไขเดียวกัน หากหว่านข้าวในวันที่ 15 พฤษภาคม การเปลี่ยนแปลงของภูมิอากาศในอนาคตมีผลต่อเล็กน้อยต่อผลผลิตข้าวขาวดอกมะลิ105 อย่างไรก็ตาม หากเปรียบเทียบกับการปลูกข้าวนาหว่านในวันที่ 1 มิถุนายนแล้ว พบว่า การเปลี่ยนแปลงวันปลูกเร็วขึ้นมา 2 สัปดาห์จะมีผลให้ผลผลิตข้าวขาวดอกมะลิ105 ลดลงเป็นอย่างมาก แสดงให้เห็นว่า การที่เกษตรกรปรับตัวต่อการเปลี่ยนแปลงของภูมิอากาศโดยการหว่านข้าวขาวดอกมะลิ105 ให้เร็วขึ้น อาจมิใช่เป็นแนวทางปฏิบัติที่ดีในอนาคต

2. จากการศึกษาครั้งนี้มีข้อเสนอแนะดังนี้

2.1 รัฐบาลควรจัดทำแผนการปรับปรุงพันธุ์ข้าวขาวดอกมะลิ105 ที่เหมาะสมกับสภาพปัญหาในทุ่งกุลาร้องไห้ให้มีลักษณะกึ่งข้าวขึ้นน้ำ และปรับตัวต่อปริมาณน้ำฝนที่เพิ่มขึ้นและสภาพน้ำท่วมขังได้ เนื่องจากทุ่งกุลาร้องไห้มีลักษณะเป็นแอ่งรองรับน้ำที่ไหลมาจากนอกพื้นที่ ข้อมูลพื้นที่ในรอบ 5 ปีที่ผ่านมา พื้นที่ดังกล่าวประสบปัญหาเกิดน้ำท่วมรุนแรงติดต่อกันมาทุกปีและมีการท่วมขังเป็นช่วงเวลานานกว่าในอดีต ทำให้ข้าวเสียหายเป็นอย่างมาก

2.2 จัดทำแผนงานป้องกันน้ำท่วมขังและระบายน้ำออกจากพื้นที่ อันเนื่องจากน้ำจากนอกระบบ

2.3 นอกจากนี้ควรศึกษาหาวิธีการปลูกและการจัดการข้าวขาวดอกมะลิ105 ที่เหมาะสมในอนาคต

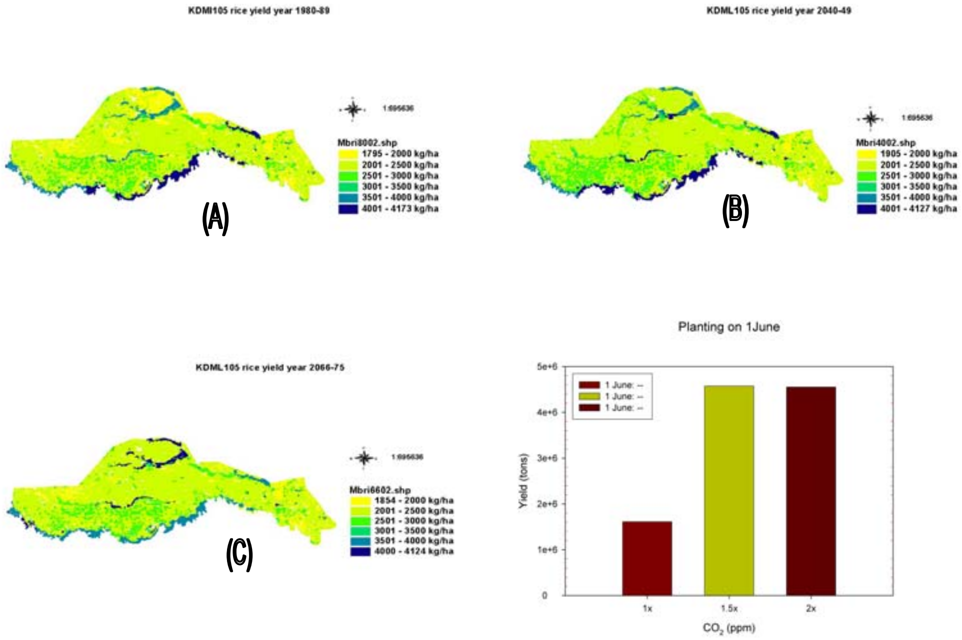
**คำนิยม**

ผู้วิจัยขอขอบคุณโครงการวิจัย Assessment on Impact and Adaptation to Climate Change (AIACC) ที่ได้สนับสนุนข้อมูลโดยเฉพาะอย่างยิ่ง Climate change scenarios และได้สนับสนุนการพัฒนา MRB Rice Shell ที่ใช้ในงานวิจัยในครั้งนี้ และขอขอบคุณ Asia Pacific Network for Global Change Research ที่สนับสนุนทุนวิจัยในครั้งนี้ โดยจัดสรรทุนวิจัยผ่านทางโครงการ CAPaBLE CB-01 ซึ่งดำเนินการโดย ดร.อานนท์ สนิทวงศ์ ณ อยุธยา และ คุณศุภกร ชินวรรโณ ศูนย์เครือข่ายงานวิเคราะห์ วิจัย และฝึกอบรมการเปลี่ยนแปลงของโลกแห่งภูมิภาคเอเชียตะวันออกเฉียงใต้ จุฬาลงกรณ์มหาวิทยาลัย (SEA START RC)

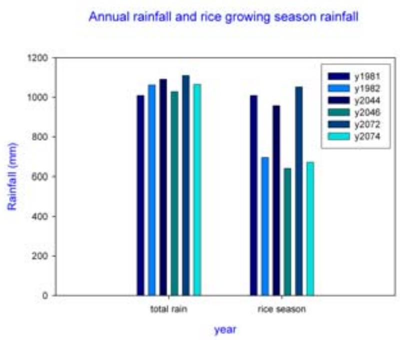
**เอกสารอ้างอิง**

1. Barret, S. 2000. "Political Economy of Kyoto Protocol" in Environmental Policy: Objective, Instruments, and Implementation. Edited by Dieter Helm, N.Y.: Oxford University Press.

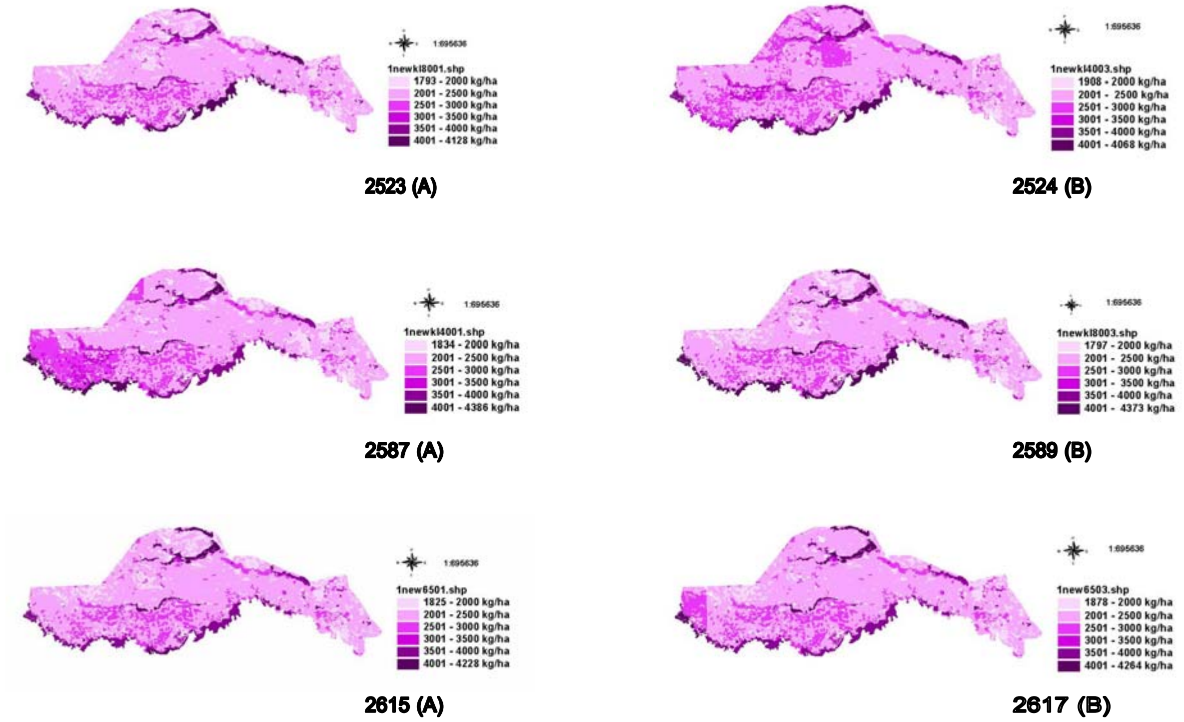
2. Gordon, H.B. Rotstayn, L.D., McGregor, J.L., Dix, M.R., Kowalczyk, E.A., O'Farrell, S.P., Waterman, L.J., Hirst, A.C., Wilson, S.G. Collier, M.A., Watterson, I.G. and Elliott, T.I. ( 2001). The CSIRO Mk3 Climate System Model. CSIRO Atmospheric Research Technical Paper No.60, 134 p.
3. Jintrawet, A. Sringam, P. and Snidvongs, A. 2004. Simulating Rice Production in the Mekong River Basin Using MRB-Rice shell. In Proceeding of AFITA/WCCA2004 Joint Congress on IT in Agriculture, Bangkok, Thailand, 9-12 August 2004 (173-178pp), ISBN 974-229-639-1.
4. Kerdsuk, V. 2002. Application of Crop Modeling and GIS for Agroclimatic of KDMO105 in Tung Samrit, Nakon Rachasima, Thailand. Ph.D. Dissertation. Suranaree University of Technology, Thailand.
5. โครงการปรับปรุงประสิทธิภาพการผลิตข้าวหอมมะลิระดับเกษตรกร. 2542. รายงานโครงการปรับปรุงประสิทธิภาพการผลิตข้าวหอมมะลิระดับเกษตรกร. คณะเกษตรศาสตร์ มหาวิทยาลัยขอนแก่น.
6. กองสำรวจดิน. 2515. แผนที่ดินทุ่งกุลาร้องไห้. กองสำรวจดิน, กรมพัฒนาที่ดิน: กรุงเทพฯ.
7. กองสำรวจดิน. 2547. การศึกษาทรัพยากรดินและศักยภาพของที่ดินบริเวณทุ่งกุลาร้องไห้. กองสำรวจดิน, กรมพัฒนาที่ดิน: กรุงเทพฯ.



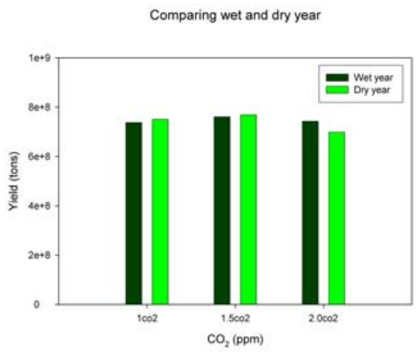

รูปที่ 1 แสดงการกระจายตัวบนพื้นที่ของผลผลิตเฉลี่ยและผลผลิตรวมของข้าวขาวดอกมะลิ105 ในทุ่งกุลาร้องไห้ ช่วงปี 2523-32 (A), 2583-93 (B) และ 2609-18 (C)



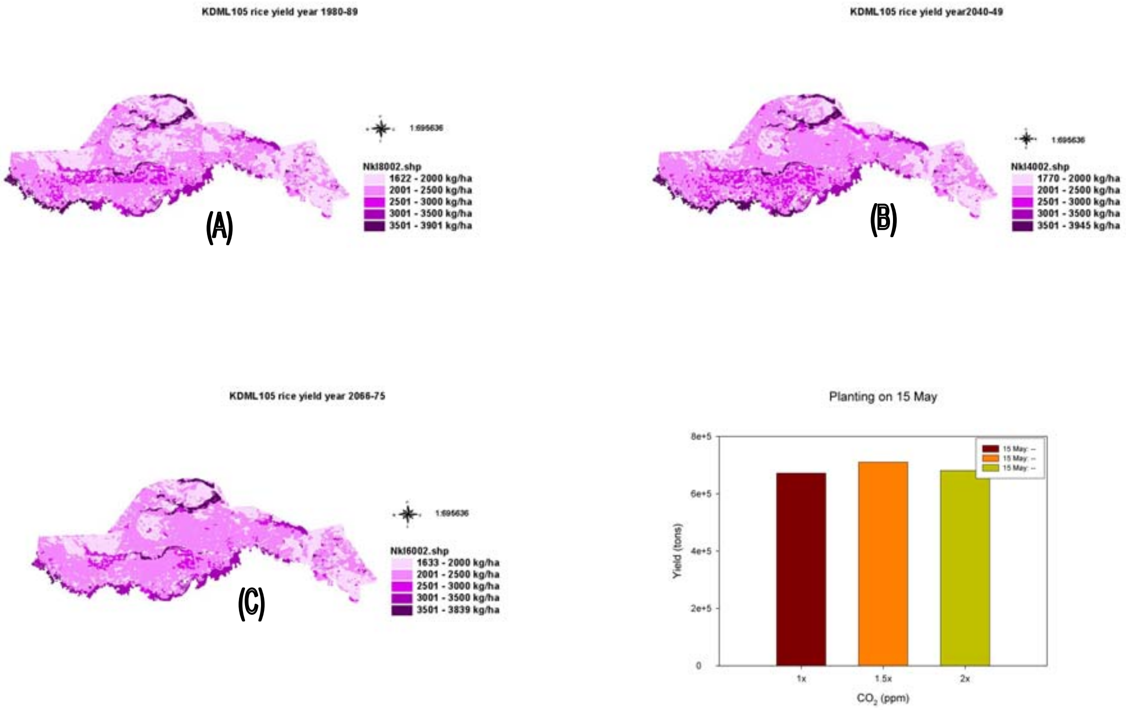

รูปที่ 2 แสดงปริมาณน้ำฝนรายปีและในช่วงฤดูการปลูกข้าวในปี 2523, 2524, 2587, 2591, 2615 และ 2617



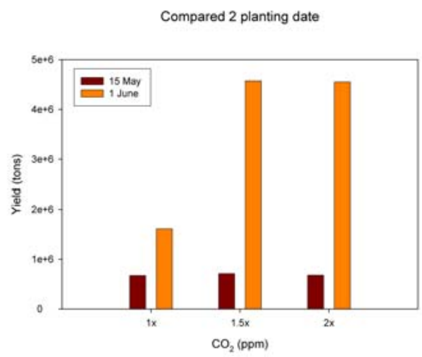

**รูปที่ 3 แสดงการกระจายตัวบนพื้นที่ของผลผลิตเฉลี่ยข้าวขาวดอกมะลิ105 ในทุ่งกุลาร้องไห้ ช่วงปีฝนดี (2523, 2587, 2615) (A) และ ปีฝนแล้ง (2524, 2589, 2617) (B)**




**รูปที่ 4 เปรียบเทียบผลผลิตข้าวขาวดอกมะลิ105 ในปีฝนดี (2523, 2587, 2615) และฝนแล้ง (2524, 2589, 2617)**




**รูปที่ 5 แสดงการกระจายตัวบนพื้นที่ของผลผลิตเฉลี่ยและผลผลิตรวมข้าวขาวดอกมะลิ105 ในทุ่งกุลาร้องไห้ปลูกวันที่ 15 พฤษภาคมของทุกปี ช่วงปี 2523-32 (A) , 2583-92 (B) และ 2609-18 (C)**




**รูปที่ 6 แสดงการเปรียบเทียบผลผลิตเฉลี่ยข้าวขาวดอกมะลิ105ในทุ่งกุลาร้องไห้ ปลูกวันที่ 15 พฤษภาคมและ 1 มิถุนายน ของทุกปี ในช่วงปี 2523-32, 2583-2592 และ 2609-18**

# Climate Scenario Verification and Impact on Rain-fed Rice Production

**Chitnucha Buddhaboon**
Prachin Buri Rice Research Center, Bansang, Prachin Buri, Thailand

**Sahasachai Kongton**
Land Development Department, Ministry of Agriculture and Cooperatives, Thailand

**Attachai Jintrawet**
Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University, Thailand

## ABSTRACT

Three selected provinces for conducting the research to verify climate scenarios and its' potential impact on rain-fed rice production were Chiang Rai, Sakonnakorn and Sakaeo province. They were located at high, medium and low latitude along Maekong River Basin (MRB), Thailand. Climate data were separately generated to be three scenarios by the Conformal Cubic Atmospheric Model (CCAM) under governing of SEA START RC (Southeast Asia START Regional Center), base year line (1x$CO_2$, 1980-1989), 1.5x$CO_2$ (2040-2049), and 2.0x$CO_2$ (2066-2075). While the observed weather data were recorded and provided by the Department of Meteorology. Simulated and observed weather data of each location were compared and were used to run simulation model for assessment their impacts on rice production. Yield of KDML105 rice variety was simulated by MRB-rice shell. Weather comparisons found that the observed annual rain fall tended to be slightly higher than simulated value. The agreements between observed and simulated value of minimum and maximum temperature were good. The seasonal pattern of the temperature was also good agreement. Simulated rice yields on the best year line were not significant difference to observed yields. The agreement between simulated and recorded rice yields was good. Simulated rice yields under three climate scenarios were not significant difference. Even though, the average rice yields of 2.0 $CO_2$ scenarios tended to be slightly increased, compared to other two scenarios, but it was also higher standard deviation. Over three locations of 1.0, 1.5 and 2.0 $CO_2$ scenarios, the average rice yields were 2522 ($\pm$216), 2552 ($\pm$270) and 2836 ($\pm$540) kg $ha^{-1}$, respectively. In addition, dry, medium and wet year scenarios did not affect on rice yields.

## Introduction

Over the last century, both industrial and agricultural sectors were rapidly developed to meet world population consumption demand. One of by products of those anthropogenic activities was green house gases (GHGs). They contributed rising the global temperature (Matthew *et al*, 1995). Global climate phenomenon was changing due mainly to those GHGs, especially $CO_2$ concentration. It has been increasing at the rate of about 1.5 ppm year$^{-1}$ (Keeling *et al,* 1984).

Climate is an important factor affecting on agricultural sector. They ultimately affect on every day lively hood of human. Preparation for the future, weather generator can be used to simulate future climate of our planet base on recent anthropogenic activities and base on possibility way to be occurred. Another recent advantage technology is crop model. It can be used to simulate the growth and yield of plant under given necessary inputs, soil properties, weather data, genetic coefficient of target plant, and management of plant cultivation further developing a decision.

Agricultural sector as well as security in food supply for world populations is partly affected by risk and uncertainty of weather behavior (Semenov and Jamieson, 2000). The validated crop simulation models and stochastic weather generator are becoming an integral part of a decision making system. For example, DSSAT is a tool for a risk assessment in a crop production and developing a decision support system (Tsuji *et al,* 1998).

From Chiang Rai province in the north to Sakaeo province in the east region of Thailand is an area of MRB. Most of the peoples in the area are rice growers. They produce rice for their consumption and sell the exceed product for their expenses in every day lively hood. The question is that, what would be happen on their product, if the climate would be changed in the future. Yield predictions under a large uncertainty of future weather have to be derived not in terms of point predictions, but in terms of probability distribution of yields. For example, the next season rice yield of an area will be 4 ton hectare$^{-1}$ and a standard deviation of 0.5 ton hectare$^{-1}$. Stochastic weather generators and crop simulation models offer a way deriving such a probabilistic distributions (Semenov and Jamieson, 2000).

Three provinces along MRB were selected as the representative of low, medium and high latitude of rice production area for conducting the research. The Climate Scenario Verification and Impact on Rain-fed Rice Production was conducted for, (1) analyzing and checking similarity of simulated and observed weather data, (2) simulating rice yields of study areas on the base line year and verify against actual yields, (3) simulating rice yields of the study area on the future climate scenarios and (4) summarize the impact of climate change on rice production under given scenarios.

## Sites selection

Three provinces of Thailand located along the MRB were selected (Figure 1). They are:

1. Chiang Rai province, the total area is 1,151,837 hectares. Agricultural activity covers area of 359,271 hectares with a proportion of rice field of 180,490 hectares. The average yield of 2,800 kg ha$^{-1}$(Center for Agricultural Information, 2000). Weather station coordinate to observe weather data of the province is located at 99.80$^{o}$ E and 19.96$^{o}$ N. The simulated weather data set to be a representative of that coordinates to compare with the observed data is the generated weather of the grid number 2260 of the CCAM.
2. Sakonnakorn province, total area is 931,795 hectares. The activity of agriculture covers area of 374,415 hectares. The rice field proportion is 317,317 hectares with the

averaged yield of 2,263 kg $ha^{-1}$ (Center for Agricultural Information, 2000). Weather station coordinate to observe weather data was located at 104.13$^o$ E and 17.15$^o$ N. While the grid number of generated weather data to compare with the observed value is the data set of the grid number 3384.

3. Sakaeo province, area of the province was 719,514 hectares. Agricultural activities cover area of 310,276 hectares. It is partly covered by 131,959 hectares of paddy field (Center for Agricultural Information, 2000). The productivity of rice field is 1,844 kg $ha^{-1}$. The coordinate of weather station to observe weather data is located at 102.58$^o$ E and 13.70$^o$ N, which covered by the grid number of 5436 of simulated weather data generated by CCAM.

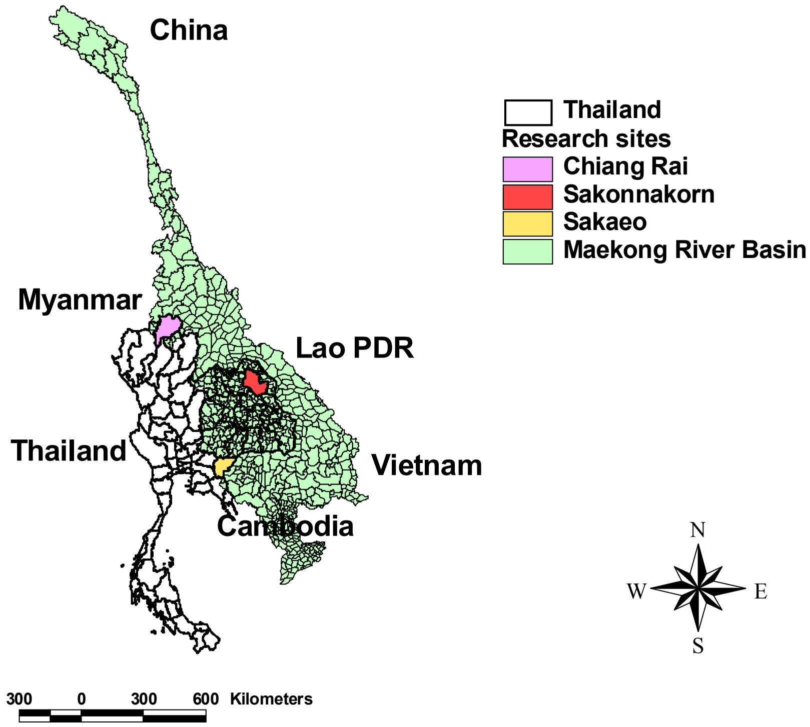



Figure 1. Maekong River Basin, map of Thailand and selected sites of the research in the basin

**Data collections**

Input data sets to simulate rice yields were soil data, weather data, crop management techniques and genetic coefficient of specific rice variety. Soil chemical and physical characteristics were provided by Department of Land Development, Ministry of Agriculture and Cooperative. They were the soil characteristics of paddy field in Thailand, and updated by a group of soil experts. Soil file was show in the attached appendix.

There were two sources of weather data to be compared. The first source is observed weather data. It was provided by the Department of Meteorology. The data sets of three selected provinces for conducting the research were recorded during the year of 1980 to 1989, except Sakonnakorn province there was no 1980 data set to be provided. The second source of simulated weather data set was provided by SEA START RC. CCAM was run to generate data set. It was separated to be three scenarios. Those scenarios were 1.0x$CO_2$ ($CO_2$ 360 ppm of carbon dioxide) base year line scenario, 1.5x$CO_2$ ($CO_2$ 540 ppm) and 2.0x$CO_2$ ($CO_2$ 720 ppm). They were determined to occur during 1980-1989, 2040-2049 and 2066-2075, respectively.

The detail of crop managements was determined by File X. It was a specific format for running the DSSAT model. A set of common cultural practice of the present recommendation for rice production of Rice Research Institute, Department of Agricultural, Ministry of Agriculture & Co-operatives was applied. Crop managements comprised of crop cultivars, planting field, initial condition of the field before planting, planting detail (method and plat density), water management, and both organic and inorganic fertilizer application. The model allows user to modify the environment e.g. solar radiation, maximum/minimum temperature, and amount of rain fall. Beside weather data of three scenarios, the concentrations of $CO_2$ have to be modified depending on climate scenario before running MRB rice shell.

Rice genetic coefficient is consisted of development coefficients and growth coefficients. Development coefficients determine rice basic vegetative phase, critical photoperiod affecting on panicle initiation, lag phase during the highest of rice plant tillering to panicle initiation and grain filling period. Growth coefficients are potential spikelet per main culm at anthesis stage, potential single grain weight, tillering ability compared with IR 64 and temperature tolerance. These coefficients were experimented and were calculated by rice researcher and rice modeler. The examples of four mentioned input data sets were shown in the appendices.

## Materials and Methods

### Materials

1. A computer set;
   System: Microsoft XP Professional V.2002
   Processor: Intel Pentium M 1.4GHz
   RAM: 256 MB
   Hard Drive: 40 GB
2. MRB Rice shell
3. Program crop model DSSAT v.4
4. ArcView progam

### Methods

Collected data sets were reformatted in to suitable form and allocated before running model. Simulated and observed weather data sets were compared to check similarity. Maximum/minimum temperatures were calculated to find a mean value and its' standard deviation. Line graph of maximum/minimum temperatures of simulated and observed weather data were plotted to see similarity of seasonal pattern. There was no observed solar radiation. It was calculated from sun shine hours and maximum/minimum temperature. So that solar radiation comparison was not made.

The observed weather data of base year line ($CO_2$ 360 ppm) collected during 1980 to 1989 were used to simulate rice yields to compare with simulated rice yields under generated weather data from the CCAM. The observed weather data were collected from the weather station with in the selected provinces. For unbiased comparisons, the recorded weather data set from a weather station was compared with a generated weather data set at a weather grid area (10x10 km) covering that station. The weather data, soil properties, rice genetic coefficient and rice area within the selected grid were input to simulate the rice yields for making comparisons (Table 1). Beside simulated rice yields of selected grid comparisons, the simulated rice yields under simulated weather data and recorded yields over all rice area of the province in the same period were also compared. KDML105 rice variety was a representative of rice cultivar in three selected provinces. It was a weakly photo sensitive variety. Harvesting date varies from 10 to 30 November depending on plating date and latitude of paddy field. Transplanting method was a common planting technique with a spacing of 20 x 20 centimeter and 3 plants per hill. Ammonium sulphate was broadcasted on flooded field at the rate of 38 kilogram of nitrogen per hectare. Fertilizer application was made two times, during tillering period. Rice plant was cultivated under rain-fed condition.

*Table 1. Coordinate of weather stations, grid number of weather data from the CCAM, which covers the weather stations and number of soil group in paddy field covered by the weather grid*

| Weather station | Co ordinate | | WSTA code (CCAM) | Soil group | Soil series |
|---|---|---|---|---|---|
| | E | N | | | |
| Chiang Rai | 99.88 | 19.96 | 2260 | 5 | Hang dong(Hd) |
| Sakonnakorn | 104.13 | 17.15 | 3384 | 17 | Roi et (Re) |
| Arunyapratate (Sakaeo) | 102.58 | 13.70 | 5436 | 17 | Roi et (Re) |

*Source: Data from CCAM weather grid and soil group map of Department of Land Development and Department of Meteorology*

Future climate scenarios were generated by the CCAM weather generator base on the existing climate of the past decade (1980-89) and recent anthropogenic activities. Extreme anthropogenic activities of world populations were reasonable to generate the extreme phenomenon, one and a half time of $CO_2$ concentration of the base year line (540 ppm), and two times of $CO_2$ concentration of the base year line (720 ppm). Two future scenarios were expected to occur in 2040-2049 and 2066-2075, respectively.

Rice yields under dry year, medium year and wet year of each scenario were simulated to compare the impact of those scenarios. Precipitation was a criterion to separate dry year, medium year and wet year. Less amount of precipitation refer to dry year, medium year and wet year for more rain, respectively.

**Results and discussions**

The results of the research were separately explained for four parts. The first part showed simulation and observed weather data comparisons. Precipitation characteristics comprising of amount of rainfall, maximum rainfall per day, and numbers of rain fall days were compared. Maximum/minimum temperatures pattern were also compared to see seasonal pattern similarity. The second part was rice yields comparison. Simulated rice yields under generated weather data from CCAM and under observed weather data on base year line were compared. More over, simulated rice yields over the rice areas of the province were also compared with the recorded yields. The third part was simulated rice yields under future climate scenarios to evaluate the impact of climate scenarios on rain-fed rice production. The fourth part was the effect of the selected dry year, medium year and wet year on rice yields.

## Simulated and observed weather data comparisons

### Chiang Rai weather data comparisons

Annual rain fall, maximum rain fall per day and average temperature was not significant difference between simulated and observed weather data. The agreement of seasonal pattern of temperature was good (Figure 2). Average of annual rain fall, maximum rain fall per day (Figure 5) and average temperature of simulation (Figure 4) were 1,413 ($\pm$74) mm, 63 ($\pm$12) mm and 24.4 ($\pm$0.6) $^{o}$C, compared with 1,648 ($\pm$23) mm, 102 ($\pm$33) mm and 24.7 ($\pm$0.2) $^{o}$C of observation, respectively. Number of rain fall day per year of observation weather data (140 $\pm$8 days) was higher than simulation data (115 $\pm$8 days). Consideration of maximum/minimum temperature, the gap between maximum and minimum temperature of simulation (32.0 $\pm$0.8 - 16.7 $\pm$0.5 $^{o}$C) was greater than observation (30.7 $\pm$0.3 - 18.8 $\pm$0.2 $^{o}$C). However, average temperature was not significant difference between simulated and observed weather data.

There was a good agreement of observation and simulation weather data in term of annual precipitation and daily temperature pattern (Figure 6). But in terms of precipitation distributions (Figure 3) and the gap of maximum and minimum of air temperature would be a little readjusted for more accurate generation scenario.

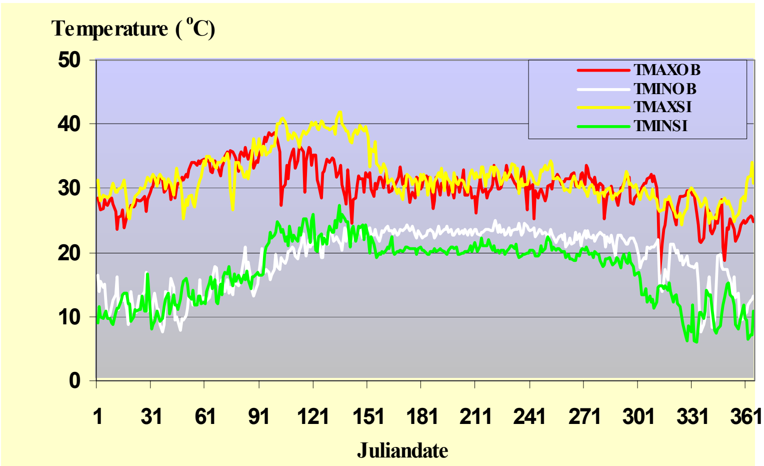



Figure 2. Seasonal pattern of observed and simulated minimum/maximum temperature comparison of Chiang Rai province, 1981 (TMAXOB = maximum temperature of observation, TMINOB = minimum temperature of observation, TMAXSI = maximum temperature of simulation, TMINSI = minimum temperature of simulation)

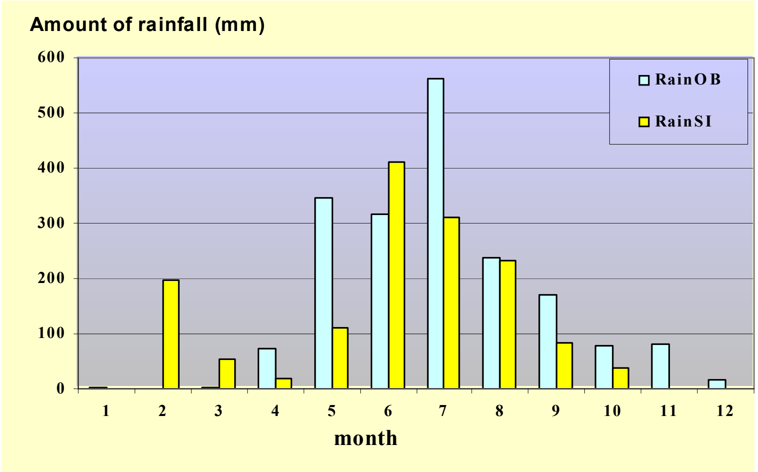



Figure 3. Simulated and observed amount of monthly rain fall comparisons of Chiang Rai province, 1981 (RainOB = observation rain fall RainSI = Simulation rain fall)

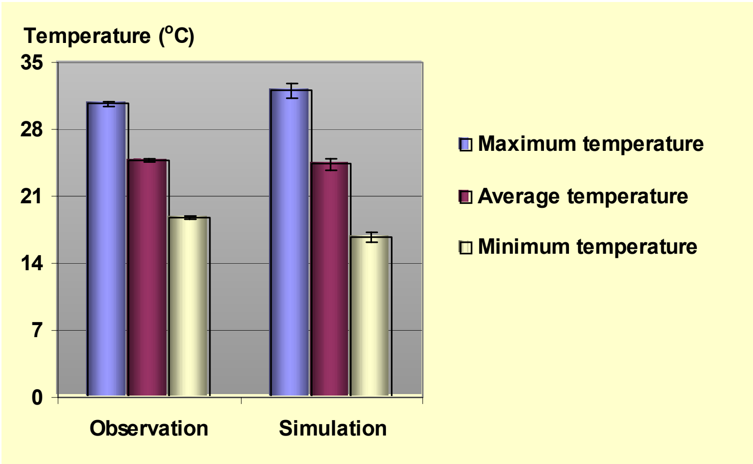



Figure 4. Minimum/minimum and average temperature of observation and simulation weather data comparison of Chiang Rai, 1981 ( I = standard deviation)



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Southeast Asia START Regional Center Technical Report No. 13

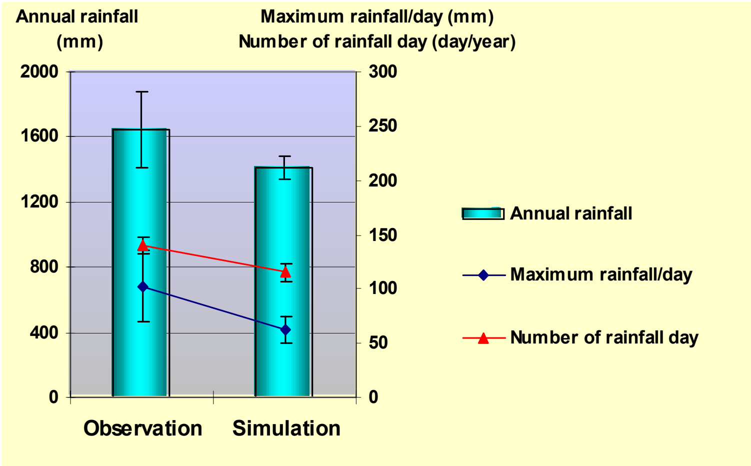



Figure 5. Annual rain fall, maximum of rain fall per day and number of rain fall day per year of observation and simulation comparison of Chiang Rai province, 1981 (I = standard deviation)

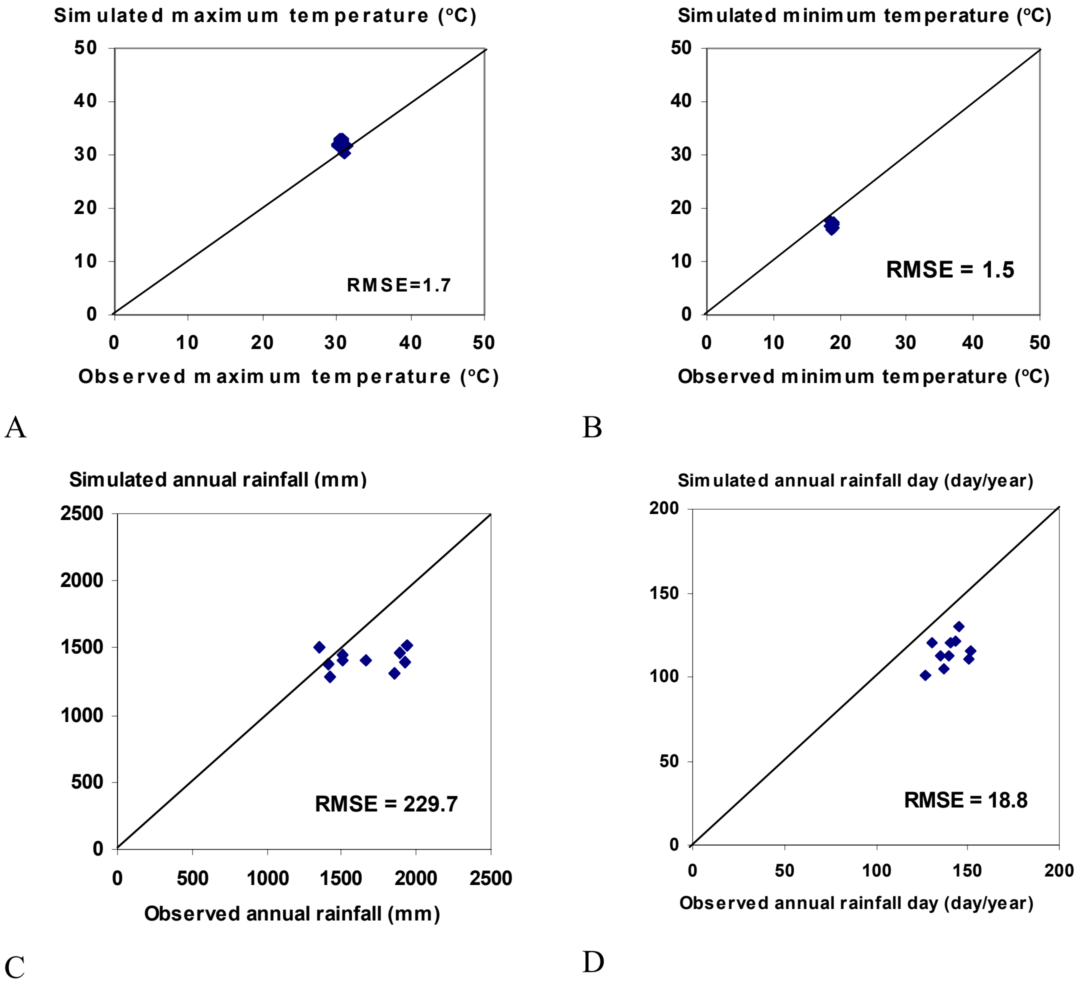



Figure 6. Comparisons of observed and simulated weather data of Chiang Rai province during 1980-1989, A = maximum temperature, B = minimum temperature C = annual rain fall and D = number of rain fall day per year.

**Sakonnakorn weather data comparisons**

There was no significant difference of annual rain fall, maximum rain fall per day (Figure 10), maximum/minimum and average temperature of simulated and observed weather data (Figure 9). The agreement of seasonal pattern of temperature was good (Figure 7). Even the average ten years of annual rain fall of observation (1,576 mm) was higher than simulation in term of average value, but standard deviation (286) of which was high, so that there was no significant difference. Same as Chiang Rai province, there was a significant difference of the number of rain fall day per year. The average ten year of rain fall day of simulation was 89 (±9) days per year compared with 130 (±10) days of observation. The over all agreement of weather data between simulation and observation was good, both quantity and seasonal pattern (Figure 11), except the distribution of precipitation (Figure 8).

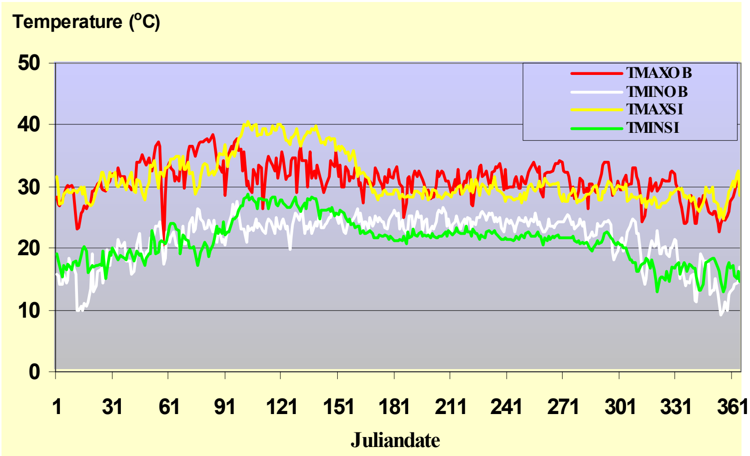



Figure 7. Seasonal pattern of observed and simulated minimum/maximum temperature comparisons of Sakonnakorn province, 1981 (TMAXOB = maximum temperature of observation, TMINOB = minimum temperature of observation, TMAXSI = maximum temperature of simulation, TMINSI = minimum temperature of simulation)

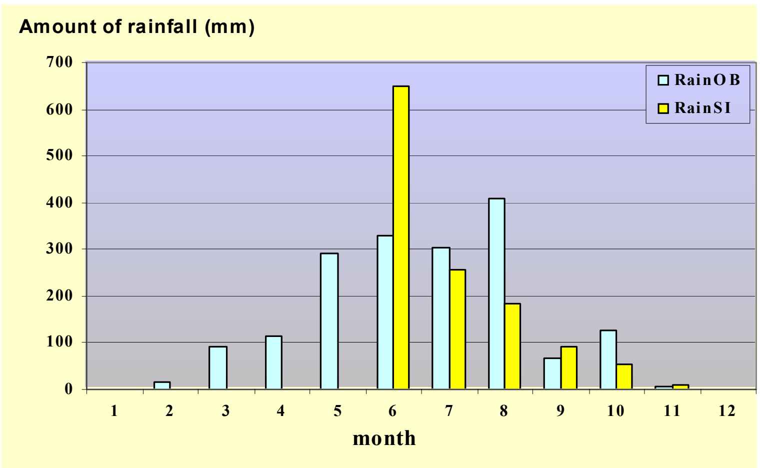



Figure 8. Simulated and observed amount of monthly rain fall comparisons of Sakonnakorn province, 1981 (RainOB = observation rain fall, RainSI = Simulation rain fall)


Chinvanno, S. and Snidvongs, A. (eds.) 2005. The Study of Future Climate Changes Impact on Water Resource and Rain-fed Agriculture Production.
Southeast Asia START Regional Center Technical Report No. 13

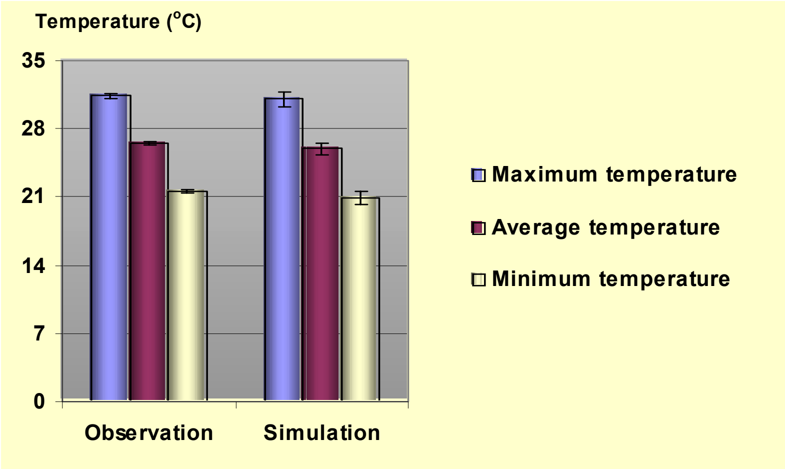



Figure 9. Maximum/minimum and average temperature of observation and simulation weather data comparison of Sakonnakorn province, 1981 ( I = standard deviation)

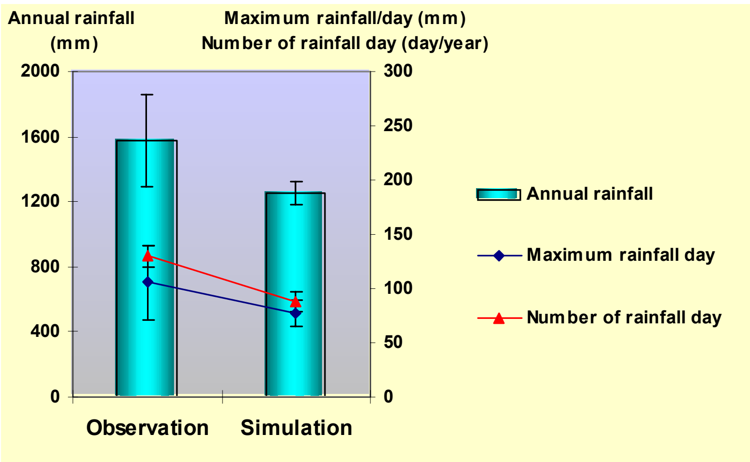
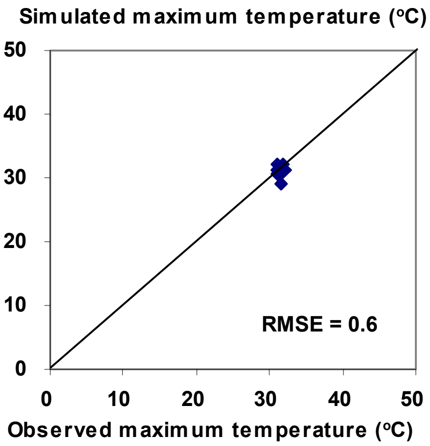
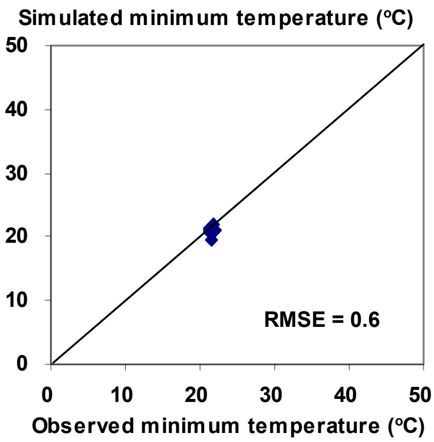


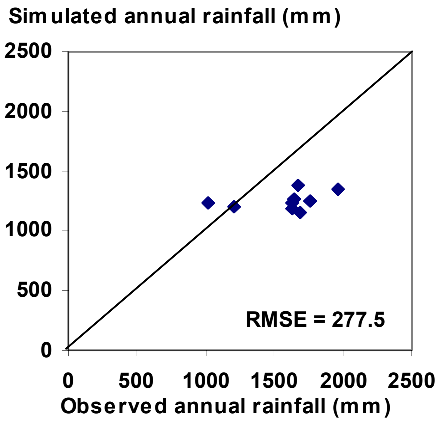

Figure 10. Annual rain fall, maximum of rain fall per day and number of rain fall day per year of observation and simulation comparison of Sakonnakorn province, 1981 (I = standard deviation)



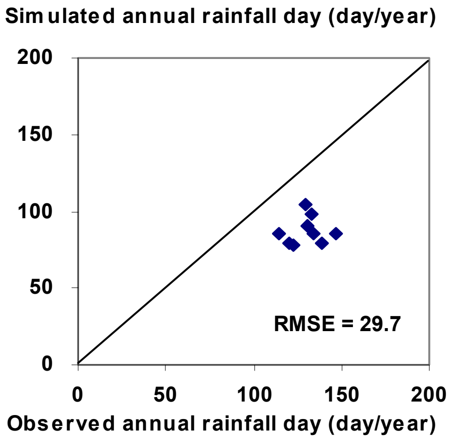

A




B




C




D

Figure 11. Comparisons of observed and simulated weather data of Sakonnakorn province during 1980-1989, A = maximum temperature, B = minimum temperature C = annual rain fall and D = number of rain fall day

**Sakaeo weather data comparison**

The agreement of seasonal pattern of temperature was good (Figure 12). The annual rail fall and the number of rain fall day per year was not significant difference between simulation and observation data (Figure 15). Maximum rain fall per day of observation was 84 (±20), which was higher than 48 (±14) of simulation (Figure 15). The maximum/minimum and average temperature of observations were 33.4 (±0.3), 23.3 (±0.2) and 28.3 (±0.3) $^{o}$C, which were higher than 31.9 (±0.6), 20.6 (±0.3) and 26.2 (±0.5) $^{o}$C of simulation, respectively (Figure 14). The agreement of precipitation pattern of simulation and observation was good, in term of rain fall distribution compared with the other two provinces (Figure 13). The over all agreement of weather data between simulation and observation was good (Figure 16).

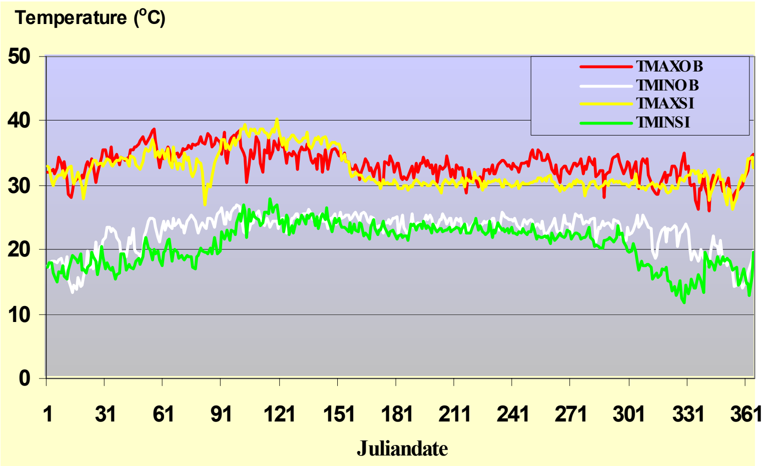



Figure 12. Seasonal pattern of observed and simulated minimum/maximum temperature comparisons of Sakaeo province, 1981 (TMAXOB = maximum temperature of observation, TMINOB = minimum temperature of observation, TMAXSI = maximum temperature of simulation, TMINSI = minimum temperature of simulation)

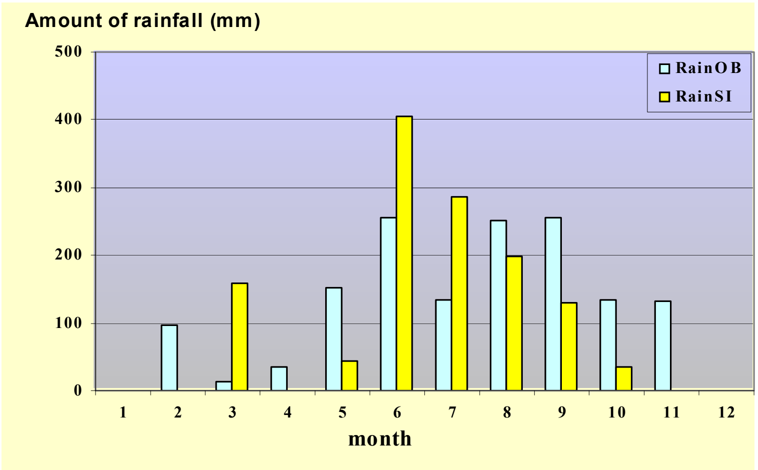



Figure 13. Simulated and observed amount of monthly rain fall comparisons of Sakaeo province, 1981 (RainOB = observation rain fall, RainSI = Simulation rain fall)

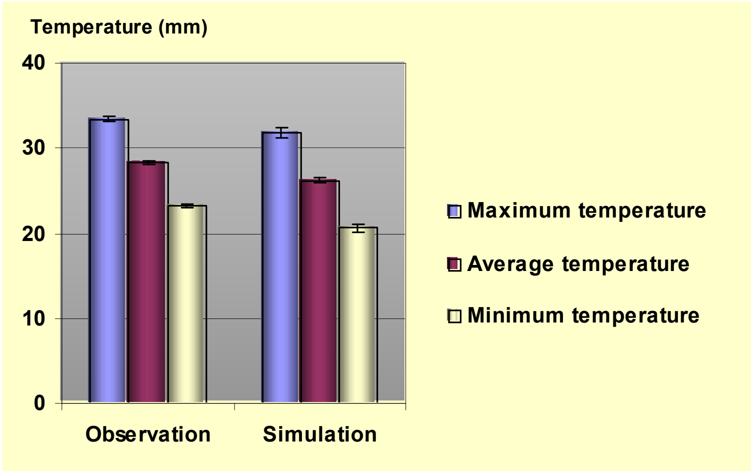



Figure 14. Maximum/minimum and average temperature of observation and simulation weather data comparison of Sakaeo province, 1981 ( I = standard deviation)

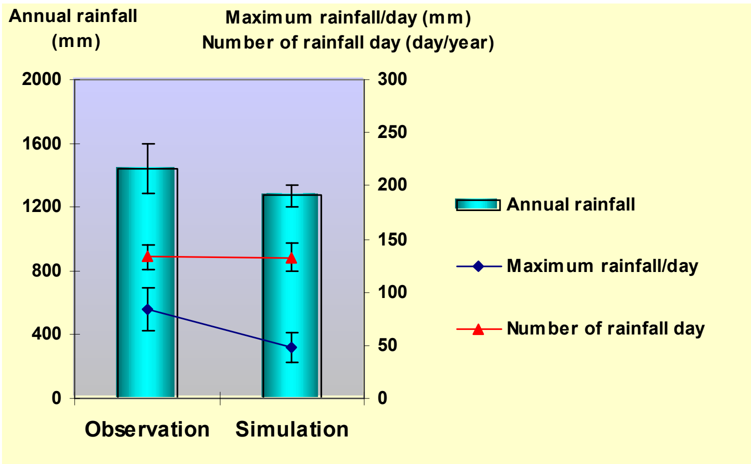



Figure 15. Annual rain fall, maximum of rain fall per day and number of rain fall day per year of observation and simulation comparison of Sakonnakorn province, 1981 (I = standard deviation)

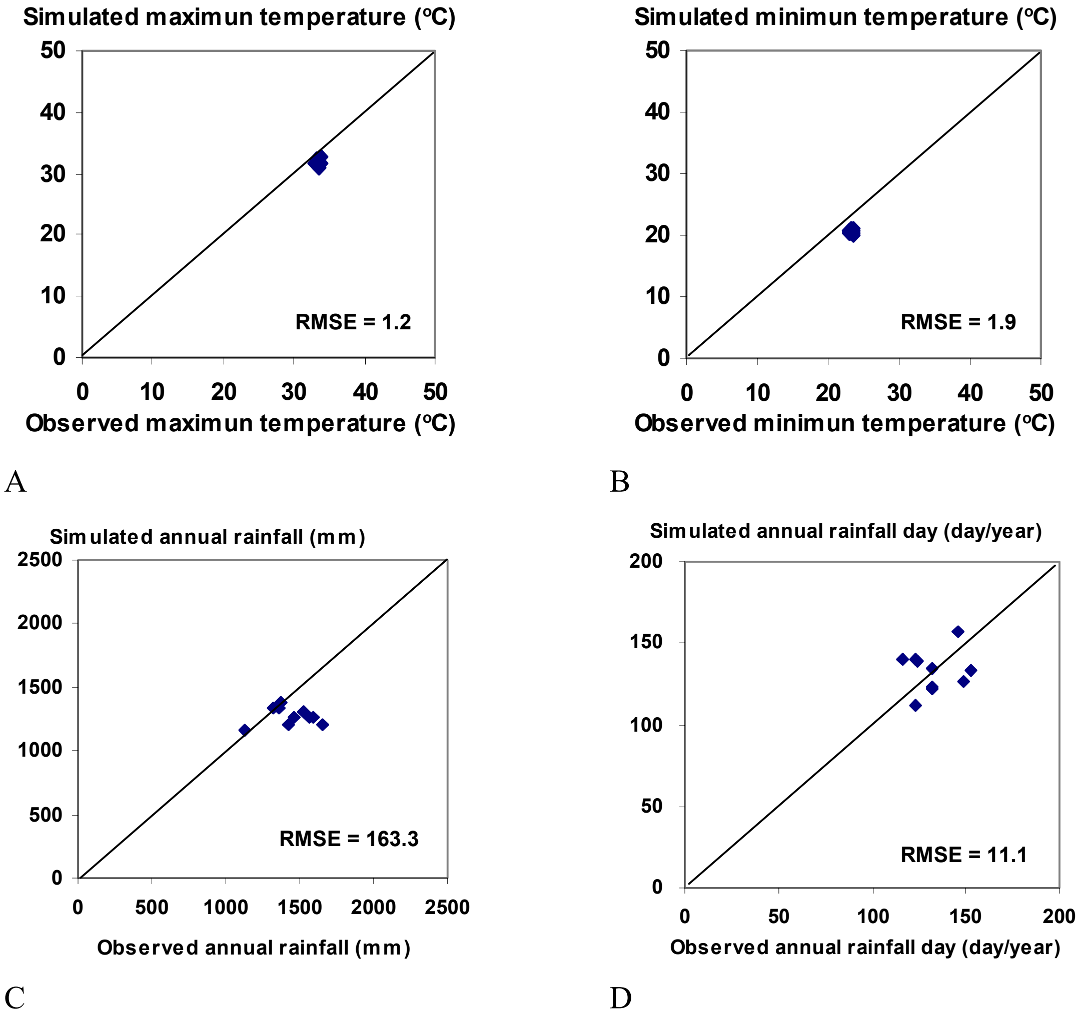



Figure 16. Comparisons of observed and simulated weather data of Sakaeo province during 1980-1989, A = maximum temperature, B = minimum temperature C = annual rain fall and D = number of rain fall day

**Rice yields on the base year line**

Comparison of simulated rice yields under generated and under observed weather data of the base year line was not significant difference (Figure 17). The rice yields under simulated weather data were 2,984 (±195), 1829 (±77) and 1,956 (±241) kg ha$^{-1}$ compared with 2,984 (±195), 1,871 (±156) and 1906 (±39) kg ha$^{-1}$ under observation weather data of Chiang Rai, Sakonnakorn and Sakaeo province, respectively. Beside the effect of soil fertility, there is a tendency for rice yield to be higher at higher latitudes (Mathews *et al.,* 1995). Comparison of simulated rice yield under generated weather data with recorded yield (of Office of Agricultural and Economic) found that recorded yield at Chiang Rai was slightly higher than simulated yield. Vice versa, simulated yields under observed weather data were slightly higher than recorded yield at Sakonnakorn and Sakaeo province. How ever, over all agreement between recorded and simulated yield was good (Figure 18).

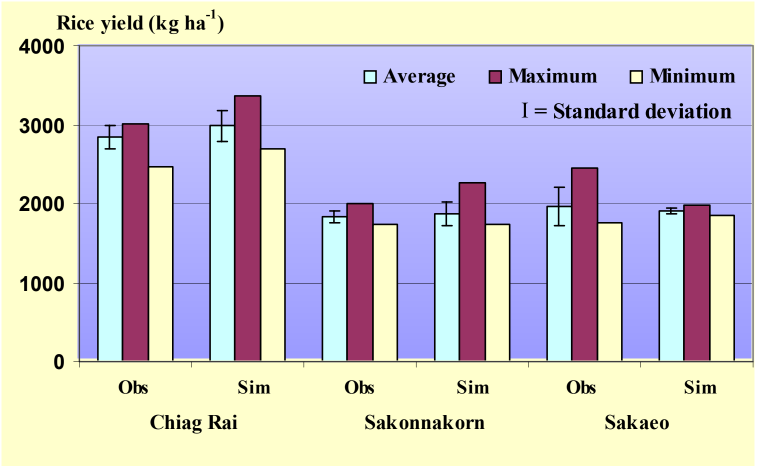



Figure 17. Comparison of simulated rice yields under observation and generated weather data on base year line (1981-89) of Chiang Rai, Sakonnakorn and Sakaeo province

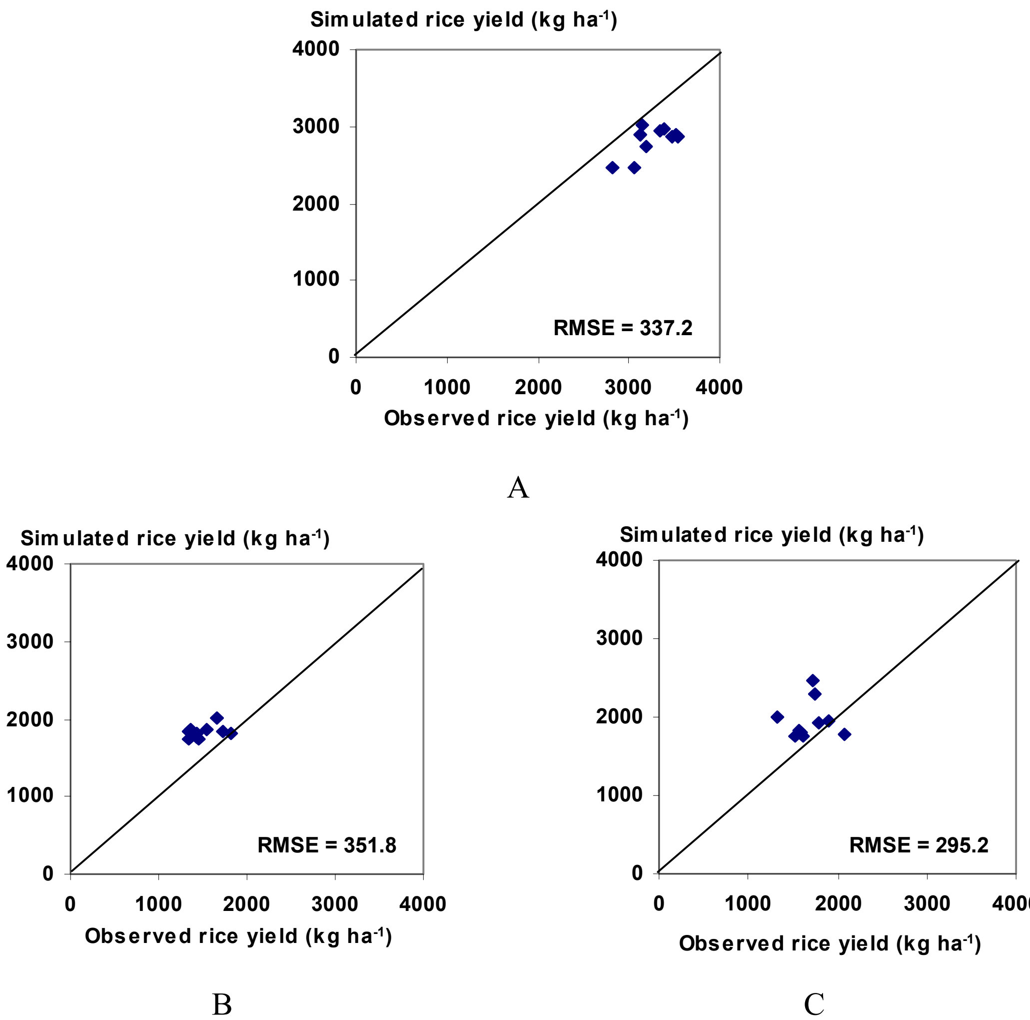



Figure 18. Comparisons of recorded rice yields and simulated rice yield under generated weather data from CCAM weather generator over all rice area of the province, A = Chiang Rai, B = Sakonnakorn and C = Sakaeo province.

## Rice yields on the future climate scenarios

The research found that the rice yields were not significant difference between the 1.0 $CO_2$ (base year line), 1.5 $CO_2$ and 2.0 $CO_2$ scenarios of over three locations, Chiang Rai, Sakonnakorn and Sakaeo province (Figure 19). The base line year of Chiang Rai gave simulated rice yield of 2,768 (+394) kg $ha^{-1}$, while the rice yield under 1.5 $CO_2$ and 2.0 $CO_2$ scenarios were 2,844 (+517) and 3,455 (+986) kg $ha^{-1}$ (Figure 20-22), respectively. How ever, the average rice yield of Chiang Rai tended to be increased due to $CO_2$ concentration (Matthews *et al.,* 1995). Simulated rice yields under three $CO_2$ scenarios of Sakonnakorn were 2,363 (+540), 2,311 (+508) and 2,433 (+797) kg $ha^{-1}$ (Figure 23-25), where as simulated rice yields of Sakaeo province were 2,435 (+869), 2,500 (+783) and 2,619 (+970) kg $ha^{-1}$, respectively (Figure 26-28).

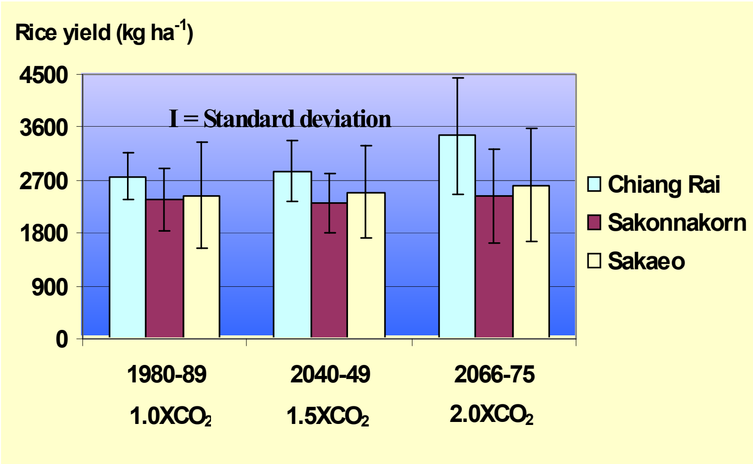



Figure 19. Simulated rice yields under three scenarios of three provinces

## Effect of dry, medium and wet year

Effect of dry, medium and wet years of each scenario on three locations was quantified. The research found that the dry, medium and wet year selected from generated scenarios did not affect on rice yields. The average yields over three scenarios of three provinces were 2,609, 2,655 and 2,651 kg $ha^{-1}$ with the average standard deviation of 739, 756 and 856 kg $ha^{-1}$ of the dry, the medium and the wet year, respectively. Consideration of $CO_2$ concentration, it tended to increase on rice yield the research found that the average rice yields over three provinces were 2,534, 2,568 and 2,814 kg $ha^{-1}$ of 1.0, 1.5 and 2.0 $CO_2$, respectively. How ever, standard deviations were also high. There was a research found that doubling of $CO_2$ could increase yield by 34% for ORIZA1 and 21% for SIMRIW model (Matthews *et al.,* 1995).

*Table 2. Simulated rice yields under selected dry, medium and wet year of three scenarios in Chiang Rai, Sakonnakorn and Sakaeo province*

| *Locations* | *Scenarios* | *Selected years* | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dry | | Medium | | Wet | |
| | | Yield | SD | Yield | SD | Yield | SD |
| | | kg ha$^{-1}$ | | kg ha$^{-1}$ | | kg ha$^{-1}$ | |
| Chiang Rai | 1.0$CO_2$ | 2685 | 537 | 2340 | 399 | 2781 | 638 |
| | 1.5$CO_2$ | 2834 | 480 | 2678 | 480 | 2700 | 574 |
| | 2.0$CO_2$ | 2553 | 875 | 3402 | 1104 | 3248 | 975 |
| Sakonnakorn | 1.0$CO_2$ | 2544 | 557 | 2459 | 591 | 2635 | 1083 |
| | 1.5$CO_2$ | 2644 | 887 | 2257 | 617 | 2355 | 842 |
| | 2.0$CO_2$ | 2615 | 1137 | 2771 | 1400 | 2812 | 1384 |
| Sakaeo | 1.0$CO_2$ | 2421 | 732 | 2481 | 743 | 2456 | 720 |
| | 1.5$CO_2$ | 2657 | 623 | 2633 | 671 | 2360 | 681 |
| | 2.0$CO_2$ | 2527 | 823 | 2878 | 796 | 2516 | 803 |

In addition, rice yields were simulated under 1,264 mm of annual rain fall, 33.4 $^{o}$C and 21.7 $^{o}$C of average maximum/minimum temperature of driest year, compared with rice yields under 1,547 mm of precipitation, 32.4 $^{o}$C and 21.5 $^{o}$C of average maximum/minimum temperature of wettest year of Sakaeo province. There was no significant difference between two simulated yields, 2,593 ($\pm$1,037) kg ha$^{-1}$ for wet year and 2,595 ($\pm$1,043) kg ha$^{-1}$ for dry year. Considering of precipitation amount during rice growing period, there was 925 mm for wet year and 1,043 mm for dry year. It indicated that the distribution and amount of rain fall during growing period was more significant than the total amount of rain fall.

## Conclusions

The research found that overall agreement between simulated and observed weather data was good in terns of seasonal pattern. Distribution of rain fall (the number of rain fall day per year) and the amount of rainfall in some area has to be a little readjusted.

There was not significant difference between rice yields under simulated and observed weather data on the best year line. There was a good agreement between recorded rice yields and simulated rice yield under generated weather data from the CCAM. The rice yields under three scenarios 1.0, 1.5 and 2.0 $CO_2$ were not significant difference, how ever; it tended to be higher when $CO_2$ concentration was increased. The rice yields under dry, medium and wet year were also not significant difference due mainly to amount of rain fall during growing period. Chiang Rai paddy field gave higher yield than Sakonnakorn and Sakaeo province.

**Acknowledgements**

I wish to acknowledge Mr. Arkom Payomjamsri, (Department of Meteorology) who provided me the observed weather data, and to thank Mr. Wirote Laongmanee (SEA START RC) for giving a generated weather data set. I would also like to thank Sakonnakorn Rice Research Center, Chiang Rai Rice Experiment Station for providing crop management of KDML105 rice variety production. I am also thankful to Asia-Pacific Network for Global Change Research, who provides support funding through SEA START RC for conducting the research, and to be thankful to Prachin Buri Rice Research Center for providing facilities to run the research. Without the above persons and organizations, the research could not be completed.

**References**

Center for Agricultural Information. 2000. Agricultural Statistics of Thailand Crop Year 1998/99. Office of Agriculture Economics, Ministry of Agriculture & Co-operatives, Bangkok, Thailand. 311 p.

Keeling, C. D., A. F. Carter and W. G. Mook, 1984. Seasonal, Lattitudinal and secular variations in the abundance and isotopic ratios of atmospheric CO2. J. Geophys. Res. 89:4615-4628.

Matthew, R. B., M. J. Kropff and D. Bachelet. 1995a. Introduction, p. 3-7. In R. B. Mattews, M. J. Kropff, D. Bachelet and H. H. V. Laar (eds). Modeling the Impact of Climate Change on Rice Production in Asia. CAB INTERNATIONAL, Wallingford, UK.

Matthew, R. B., T. Horie, M. J. Kropff, D. Bachelet, H. G. Centeno, J. C. Shin, S. Mohandass, S. Sing, Zsu Defeng and Moon Hee Lee. 1995b. A Regional Evaluation of the Effect of Future Climate Change on Rice Production in Asia, p. 95-139. In R. B. Mattews, M. J. Kropff, D. Bachelet and H. H. V. Laar (eds). Modeling the Impact of Climate Change on Rice Production in Asia. CAB INTERNATIONAL, Wallingford, UK.

Semenov, M. A. and P. D. Jamieson. 2000. Using Weather Generators and Crop Modeling, p. 119-142. In M. V. K. Sivakumar (ed). Climate Prediction and Agriculture. International START Secretariat, Washington DC, USA.

Tsuji, G. Y., G. Hoogenboom and P. K. Thornton (eds.). 1998. Understanding Options for Agricultural Production. Kluwer Academic, Dordrecht, 399 p.

# Appendix A

**Weather data file**

```
*WEATHER DATA : XXXX
@ INSI      LAT     LONG  ELEV   TAV   AMP REFHT WNDHT
  2043    20.35    99.85   -99  00.0   0.0   -99   -99
@DATE  SRAD  TMAX  TMIN  RAIN
40001 14.45 23.89  9.16   .00
40002 15.22 21.54  8.30   .00
40003 15.56 20.11  3.06   .00
40004 15.43 22.25  3.90   .00
40005 14.32 24.05  4.27   .00
40006 15.37 25.15  4.79   .00
40007 15.27 23.92  6.82   .00
40008 15.74 23.51  7.39   .00
40009 15.81 23.72  7.44   .00
40010 15.69 21.21  8.45   .00
40011 15.35 20.26  6.36   .00
40012 16.72 19.11  5.18   .00
40013 17.15 19.42  5.00   .00
40014 16.95 20.81  3.13   .00
40015 17.38 22.42  1.66   .00
40016 17.13 24.78   .36   .00
40017 17.18 25.99   .83   .00
40018 16.79 28.03  1.93   .00
40019 17.13 29.52  2.76   .00
40020 17.09 29.07  4.37   .00
40021 15.11 28.28 10.71   .00
40022 14.66 26.39  7.83   .00
40023 15.34 26.61  6.34   .00
40024 16.17 30.64  7.22   .00
40025 16.19 31.94  8.39   .00
40026 16.63 34.13 11.72   .00
40027 15.55 33.61 12.82   .00
40028 16.08 32.52  9.34   .00
40029 16.80 31.36  9.33   .00
40030 10.59 23.21  8.81   .00
40031 15.07 29.42  9.22   .00
40032 15.02 29.12 10.15   .00
40033 11.79 25.06 11.12   .00
40034 13.80 24.47 10.61   .00
40035 13.82 24.15  8.03   .00
40036 16.31 25.89  6.66   .00
40037 16.79 26.95  7.64   .00
……………………………………………
……………………………………………
……………………………………………
40363 15.17 28.70  8.84   .00
40364 11.67 25.19 10.92   .00
40365 10.48 23.59 10.62   .00
```

# Appendix B

## Soil data file

```
*THRI250000  DLD         LO      180 Phen(Pn)***
@SITE        COUNTRY          LAT     LONG USDA FAMILY
 NONGKHAI    THAILAND       0.000    0.000 L-sk,mixed,subactive,iso Aeric Plinthic Paleaquults
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
 BN     0.13   9.3  0.20    87  1.00  1.00 IB001 IB001 IB001
@  SLB SLMH   SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
    14 Ap    0.107 0.236 0.373  0.50  1.34  1.49  0.85  15.9  43.3   0.0  0.07   4.7   3.7   5.2
    40 Bt1   0.227 0.357 0.391  0.01  0.26  1.43  0.62  44.5  50.6   5.0  0.05   5.1   4.1   9.8
    41 Bt1   0.227 0.357 0.391  0.00  0.26  1.43  0.62  44.5  50.6   5.0  0.05   5.1   4.1   9.8
    77 Btc   0.083 0.140 0.386  0.00  0.31  1.45  0.48  34.5  40.0  70.0  0.04   4.9   3.7   7.1
   120 BCg1  0.059 0.099 0.390  0.00  0.31  1.44  0.31  33.6  42.3  80.0  0.03   4.8   3.7   7.1
   180 BCg2  0.062 0.102 0.383  0.00  0.27  1.46  0.60  36.8  37.3  80.0  0.05   4.9   3.7   7.7

*THRI170000  DLD         SALO     93 Roi Et(Re)***
@SITE        COUNTRY          LAT     LONG USDA FAMILY
 KALASIN     THAILAND       0.000    0.000 Fine-loamy,mixed,subactive,iso Aeric Kandiaquults
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
 BN     0.13   9.6  0.20    84  1.00  1.00 IB001 IB001 IB001
@  SLB SLMH   SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
    19 Ap    0.127 0.241 0.333  0.50  0.61  1.61  0.33  20.5  11.6   0.0  0.03   5.2   4.6   2.5
    38 BA    0.129 0.245 0.336  0.05  0.61  1.60  0.06  21.0  16.2   0.0  0.01   5.5   4.5   2.0
    40 Btg1  0.147 0.260 0.337  0.01  0.40  1.60  0.03  25.0   9.6   0.0  0.01   5.5   4.4   2.9
    50 Btg1  0.147 0.260 0.337  0.00  0.40  1.60  0.03  25.0   9.6   0.0  0.01   5.5   4.4   2.9
    74 Btg2  0.141 0.255 0.337  0.00  0.45  1.60  0.04  23.5  13.3   0.0  0.01   5.0   4.0   3.3
         93 BCg   0.110 0.210 0.334  0.00  0.62  1.61  0.05  20.5  14.2  20.0  0.01   5.1   4.0   3.1
```


Chinvanno, S. and Snidvongs, A. (eds.) 2005. The Study of Future Climate Changes Impact on Water Resource and Rain-fed Agriculture Production.
Southeast Asia START Regional Center Technical Report No. 13

# Appendix C

## Crop management file (File X)

```
*EXP.DETAILS: DTSP8502RI EFFECTS OF APPL. N & ENVIR. ON RICE

*GENERAL
@PEOPLE
-99
@ADDRESS
-99
@SITE
-99

*TREATMENTS                        -------------FACTOR LEVELS------------
@N R O C TNAME.................... CU FL SA IC MP MI MF MR MC MT ME MH SM
! 1 1 0 0 0-0-0 NPK                  1  1  0  1  1  1  0  1  0  0  0  0  1
  1 1 0 0 38 kg ha-1 of applied N    1  1  0  1  1  1  1  1  0  0  1  0  1
! 3 1 0 0 75 kg ha-1 of applied N    1  1  0  1  1  1  2  1  0  0  0  0  1
! 4 1 0 0 113 kg ha-1 of applied N   1  1  0  1  1  1  3  1  0  0  0  0  1
! 5 1 0 0 150 kg ha-1 of applied N   1  1  0  1  1  1  4  1  0  0  0  0  1
! 6 1 0 0 188 kg ha-1 of applied N   1  1  0  1  1  1  5  1  0  0  0  0  1

*CULTIVARS
@C CR INGENO CNAME
 1 RI TR0001 KDML 105

*FIELDS
@L ID_FIELD WSTA....  FLSA  FLOB  FLDT  FLDD  FLDS  FLST SLTX  SLDP  ID_SOIL    FLNAME
 1 DTSK0001 29467101   -99     0 IB000     0     0 00000 -99     51  THRI030000 -99
@L ...........XCRD ...........YCRD .....ELEV .............AREA .SLEN .FLWR .SLAS
 1         0.00000         0.00000      0.00               0.0   0.0   0.0   0.0

*INITIAL CONDITIONS
@C   PCR ICDAT  ICRT  ICND  ICRN  ICRE  ICWD ICRES ICREN ICREP ICRIP ICRID ICNAME
 1    RI 71145   500   -99  1.00  1.00   1.0     0  0.00  0.00   100    15 -99
@C  ICBL  SH2O  SNH4  SNO3
 1     5 0.374  10.0   0.7
 1     8 0.374  10.0   0.7
 1    19 0.341   5.0   0.5
 1    28 0.369   3.0   0.3
 1    38 0.369   3.0   0.3
 1    51 0.344   3.0   0.3

*PLANTING DETAILS
@P PDATE EDATE  PPOP  PPOE  PLME  PLDS  PLRS  PLRD  PLDP  PLWT  PAGE  PENV  PLPH  SPRL
PLNAME
 1 71165   -99  75.0  25.0     T     H    20     0   5.0     0    25  25.0   3.0   0.0
-99

*IRRIGATION AND WATER MANAGEMENT
@I  EFIR  IDEP  ITHR  IEPT  IOFF  IAME  IAMT IRNAME
 1   -99   -99   -99   -99   -99   -99    10 -99
@I IDATE  IROP IRVAL  IIRV
 1 71213 IR003  50.0     0
 1 71213 IR009 100.0     6
 1 71213 IR008   2.0     0
 1 71213 IR010   0.0     0

*FERTILIZERS (INORGANIC)
@F FDATE  FMCD  FACD  FDEP  FAMN  FAMP  FAMK  FAMC  FAMO  FOCD FERNAME
 1 71214 FE002 AP016    10    19   -99   -99   -99   -99   -99 -99
 1 71246 FE002 AP012     1    19   -99   -99   -99   -99   -99 -99
 2 71246 FE002 AP016    10    37   -99   -99   -99   -99   -99 -99
 2 71276 FE002 AP012     1    37   -99   -99   -99   -99   -99 -99
 3 71246 FE002 AP016    10    56   -99   -99   -99   -99   -99 -99
 3 71276 FE002 AP012     1    56   -99   -99   -99   -99   -99 -99
 4 71246 FE002 AP016    10    75   -99   -99   -99   -99   -99 -99
 4 71276 FE002 AP012     1    75   -99   -99   -99   -99   -99 -99
 5 71246 FE002 AP016    10    94   -99   -99   -99   -99   -99 -99
 5 71276 FE002 AP012     1    94   -99   -99   -99   -99   -99 -99

*RESIDUES AND ORGANIC FERTILIZER
@R RDATE  RCOD  RAMT  RESN  RESP  RESK  RINP  RDEP  RMET RENAME
 1 71145 RE001   500  0.53   -99   -99   -99    15   -99 -99

*ENVIRONMENT MODIFICATIONS
@E ODATE EDAY  ERAD  EMAX  EMIN  ERAIN ECO2  EDEW  EWIND ENVNAME
 1 71160 A 0.0 A 0.0 A 0.0 A 0.0 A 0.0 M 2.0 A 0.0 A 0.0

*SIMULATION CONTROLS
```

```
@N GENERAL     NYERS NREPS START SDATE RSEED SNAME....................
 1 GE              2     1     S 71160  2150 Effects of appl. N & envi
@N OPTIONS     WATER NITRO SYMBI PHOSP POTAS DISES  CHEM  TILL
 1 OP              Y     Y     Y     N     N     N     N     N
@N METHODS     WTHER INCON LIGHT EVAPO INFIL PHOTO HYDRO NSWIT MESOM
 1 ME              M     M     E     R     S     C     R     1     G
@N MANAGEMENT  PLANT IRRIG FERTI RESID HARVS
 1 MA              R     R     R     R     M
@N OUTPUTS     FNAME OVVEW SUMRY FROPT GROUT CAOUT WAOUT NIOUT MIOUT DIOUT  LONG CHOUT OPOUT
 1 OU              N     N     Y     7     N     N     N     N     N     N     N     N     N

@  AUTOMATIC MANAGEMENT
@N PLANTING    PFRST PLAST PH2OL PH2OU PH2OD PSTMX PSTMN
 1 PL          71001 71371    71    90    20    71    10
@N IRRIGATION  IMDEP ITHRL ITHRU IROFF IMETH IRAMT IREFF
 1 IR             30    50   100 IB005 IB001    10  0.50
@N NITROGEN    NMDEP NMTHR NAMNT NCODE NAOFF
 1 NI             30    50    25 IB001 IB001
@N RESIDUES    RIPCN RTIME RIDEP
 1 RE            100     1    20
@N HARVEST     HFRST HLAST HPCNP HPCNR
                                  1 HA              0 71365   100     0
```

# Appendix D

```
RICE GENETIC COEFFICIENTS

*RICE GENOTYPE COEFFICIENTS: RICER030 MODEL
!
! COEFF       DEFINITIONS
! ========    ===========
! VAR#        Identification code or number for a specific cultivar.
! VAR-NAME    Name of cultivar.
! ECO#        Ecotype code for this cultivar points to the Ecotype in the ECO
!             file (currently not used).
! P1          Time period (expressed as growing degree days [GDD] in øC above
!             a base temperature of 9øC) from seedling emergence during which
!             the rice plant is not responsive to changes in photoperiod. This
!             period is also referred to as the basic vegetative phase of the
!             plant.
! P20         Critical photoperiod or the longest day length (in hours) at
!             which the development occurs at a maximum rate. At values higher
!             than P20 developmental rate is slowed, hence there is delay due
!             to longer day lengths.
! P2R         Extent to which phasic development leading to panicle initiation
!             is delayed (expressed as GDD in øC) for each hour increase in
!             photoperiod above P20.
! P5          Time period in GDD øC) from beginning of grain filling (3 to
!             4 days after flowering) to physiological maturity with a base
!             temperature of 9øC.
! G1          Potential spikelet number coefficient as estimated from the
!             number of spikelets per g of main culm dry weight (less lead
!             blades and sheaths plus spikes) at anthesis. A typical value
!             is 55.
! G2          Single grain weight (g) under ideal growing conditions, i.e.
!             nonlimiting light, water, nutrients, and absence of pests
!             and diseases.
! G3          Tillering coefficient (scaler value) relative to IR64 cultivar
!             under ideal conditions. A higher tillering cultivar would have
!             coefficient greater than 1.0.
! G4          Temperature tolerance coefficient. Usually 1.0 for varieties
!             grown in normal environments. G4 for japonica type rice growing
!             in a warmer environment would be 1.0 or greater. Likewise, the
!             G4 value for indica type rice in very cool environments or
!             season would be less than 1.0.
!

@VAR#  VAR-NAME........   ECO#     P1    P2R     P5    P2O     G1     G2     G3     G4
!                                   1      2      3      4      5      6      7      8
TR0001 KDML105          IB0001 502.31233.0 386.5   12.8   45.7 .0270   1.00   0.95
TR0002 KDML105Jun       IB0001 580.01344.0 390.0   12.7   75.0 .0238   1.00   1.00
TR0003 KDML105Jul       IB0001 580.01000.0 390.0   12.7   75.0 .0238   1.00   1.00
TR0004 KDML105Aug       IB0001 580.0 100.0 390.0   12.7   75.0 .0238   1.00   1.00
TR0005 NIEW SANPATONG   IB0001 495.81283.4 364.2   12.7   40.7 .0277   0.70   0.85
TR0006 SUPANBURI 60     IB0001 540.0 154.7 497.0   11.9   77.7 .0280   1.00   1.03
TR0007 CHAINAT 1        IB0001 570.0 122.8 334.8   11.9   63.1 .0278   1.00   1.00
TR0008 DOA 1            IB0001 388.5  20.0 381.8   12.0   73.8 .0275   1.10   1.15
!
```

## Appendix E

Map of simulated rice yield under generated scenarios of Chiang Rai, Sakonnakorn and Sakaeo province

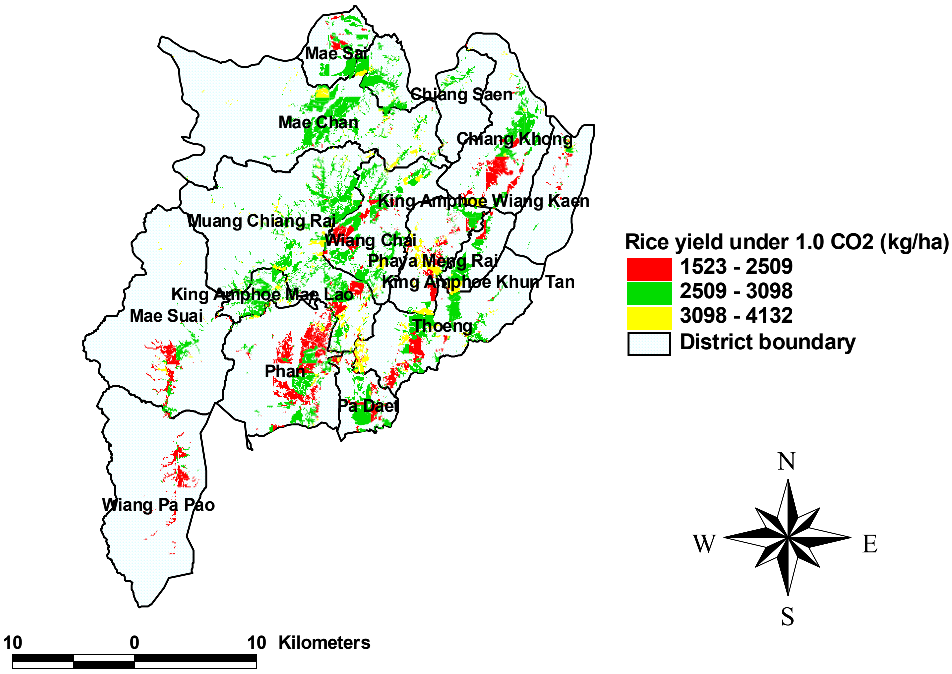



Figure 20. Simulated rice yield under the base year line (1.0 $CO_2$ scenario) of Chiang Rai province

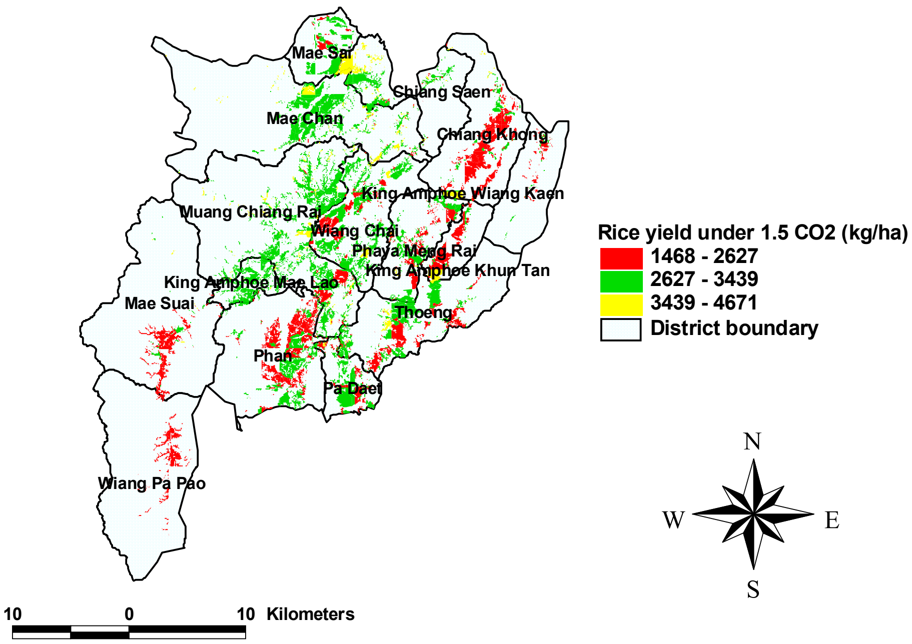



Figure 21. Simulated rice yield under the 1.5 $CO_2$ scenario of Chiang Rai province

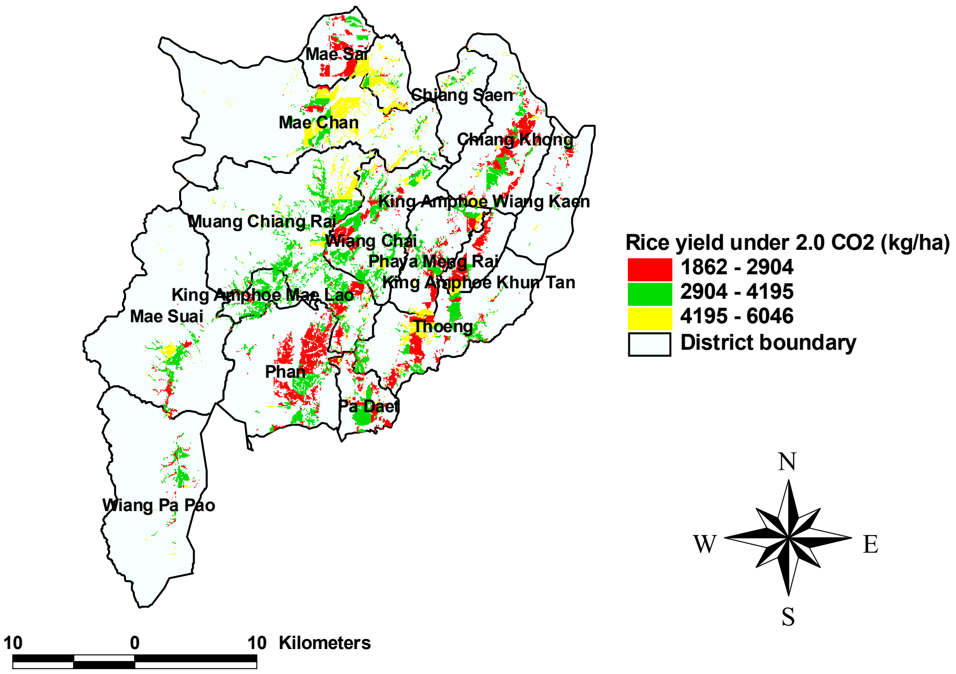



Figure 22. Simulated rice yield under the 2.0 $CO_2$ scenario of Chiang Rai province

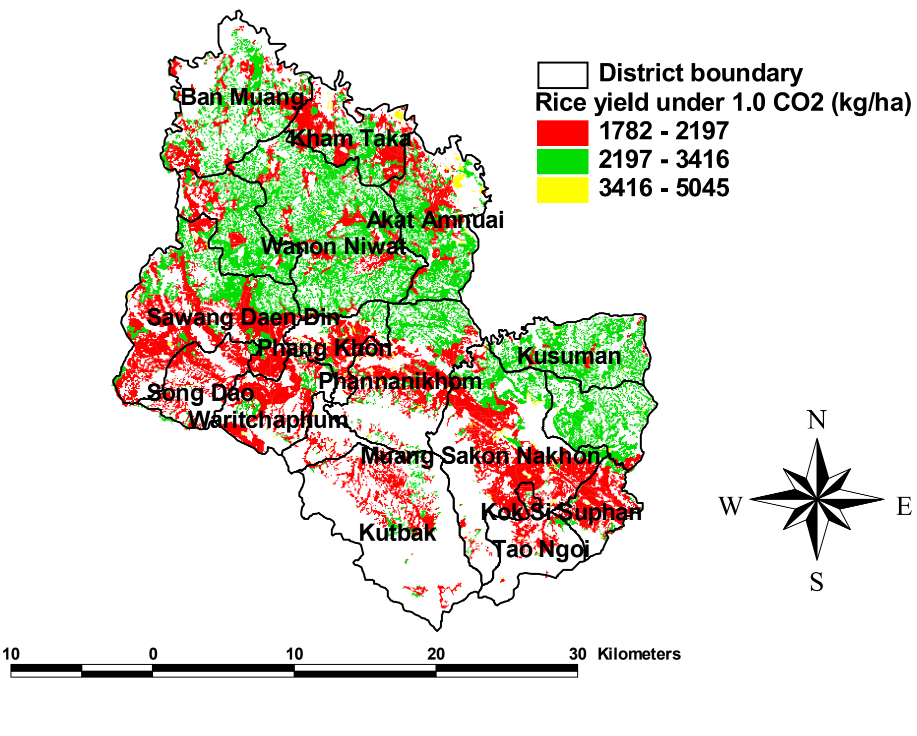



Figure 23. Simulated rice yield under the 1.0 $CO_2$ scenario of Sakonnakorn province

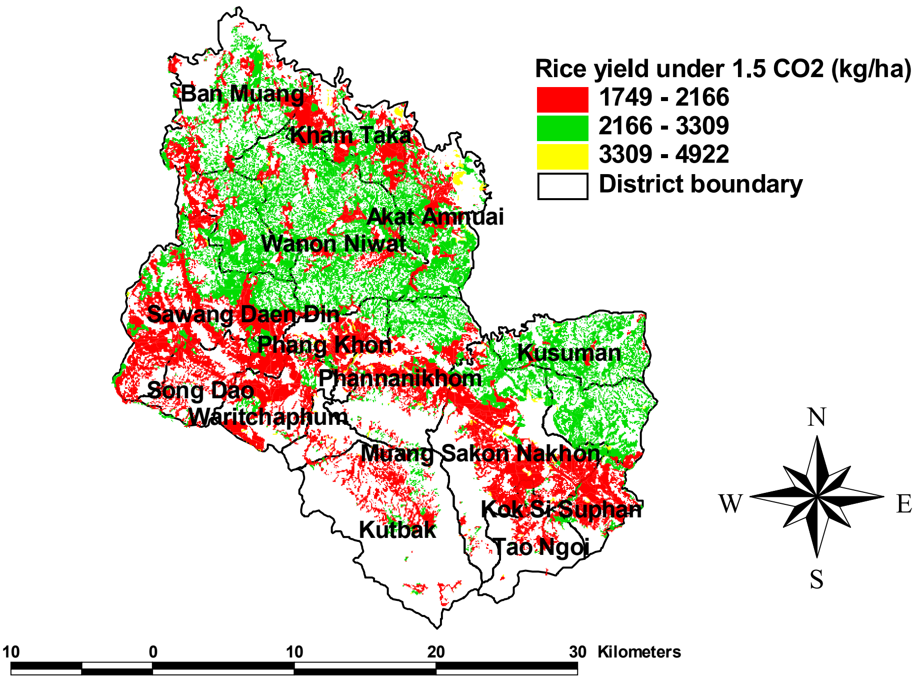



Figure 24. Simulated rice yield under the 1.5 $CO_2$ scenario of Sakonnakorn province

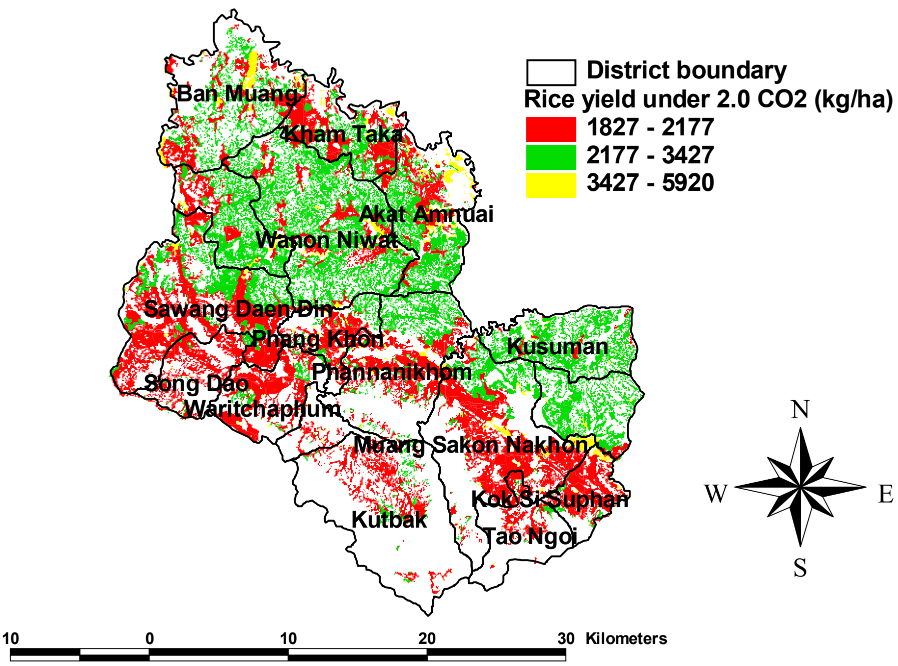



Figure 25. Simulated rice yield under the 2.0 $CO_2$ scenario of Sakonnakorn province

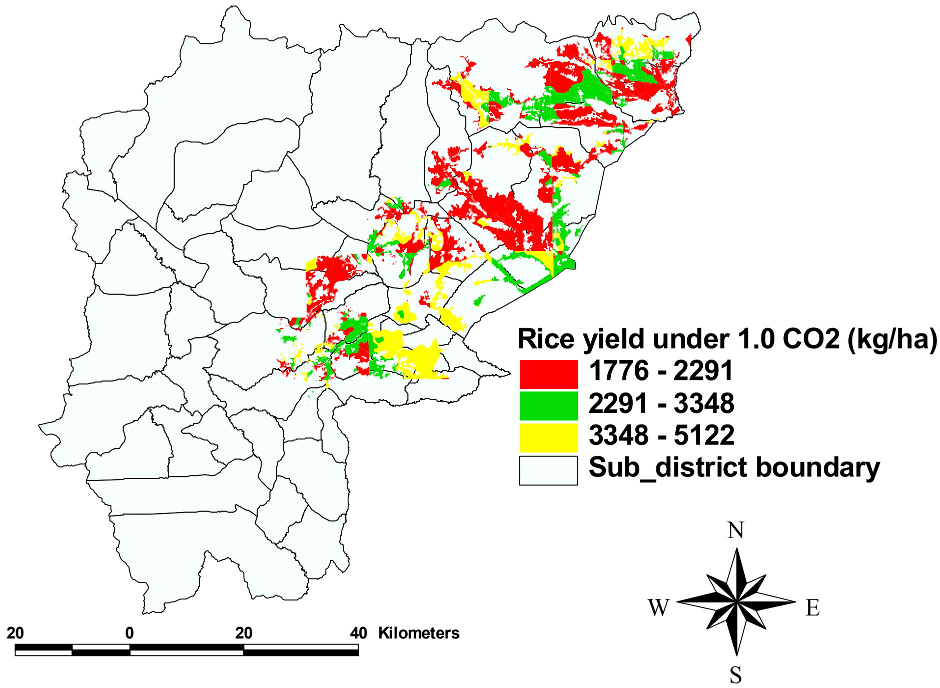



Figure 26. Simulated rice yield under the 1.0 $CO_2$ scenario of Sakaeo province

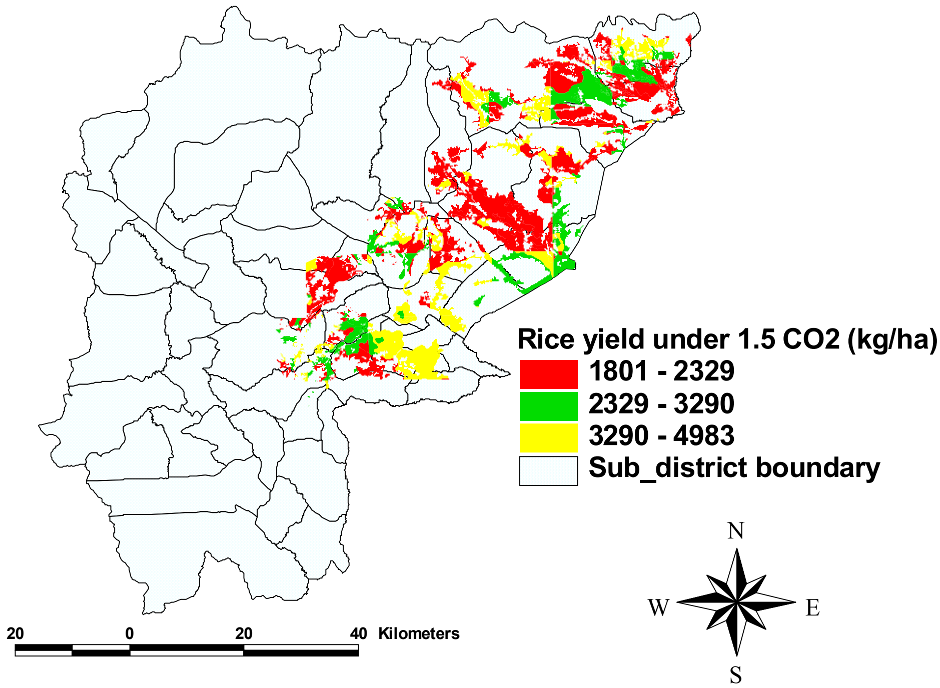



Figure 27. Simulated rice yield under the 1.5 $CO_2$ scenario of Sakaeo province

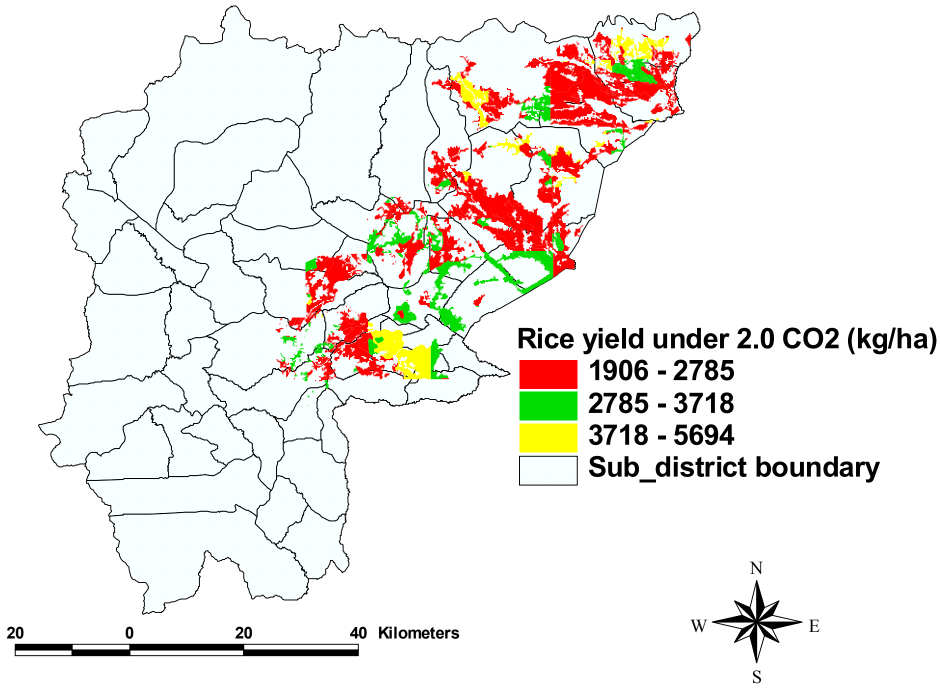



Figure 28. Simulated rice yield under the 2.0 $CO_2$ scenario of Sakaeo province

# Potential Impact of Climate Change on Maize, Sugarcane and Cassava Production in N.E. Thailand: Case study at Khon Kaen province

**Mr. Vinai Sarawat**
Khon Kaen Field Crop Research Center

**Mr. Sukit Ratanasriwong**
Roi Et Agricultural Resources Service Center

**Mr. Sahaschai Kongton**
Land Development Department
Ministry of Agriculture

**Abstract**

Comparison between the yields of maize, sugarcane and cassava among the scenarios of GHGs generated by CCAM models using as input to analyze the impact of climate change at Khon Kaen province as the representative area of NE. The results from the models show that under different scenarios of $CO_2$ conditions affected the flowering and maturity days of maize and some characterization of sugarcane and cassava phenology. Effect of with and without fertilizer application is determined separately. The result of the simulation using scenarios of 1.5 – 2X of $CO_2$ derived from CCAM models developed in Australia shows relatively change with maximum temperature increased 1-2 $^0$C while precipitation increased when compared to 1X scenarios.

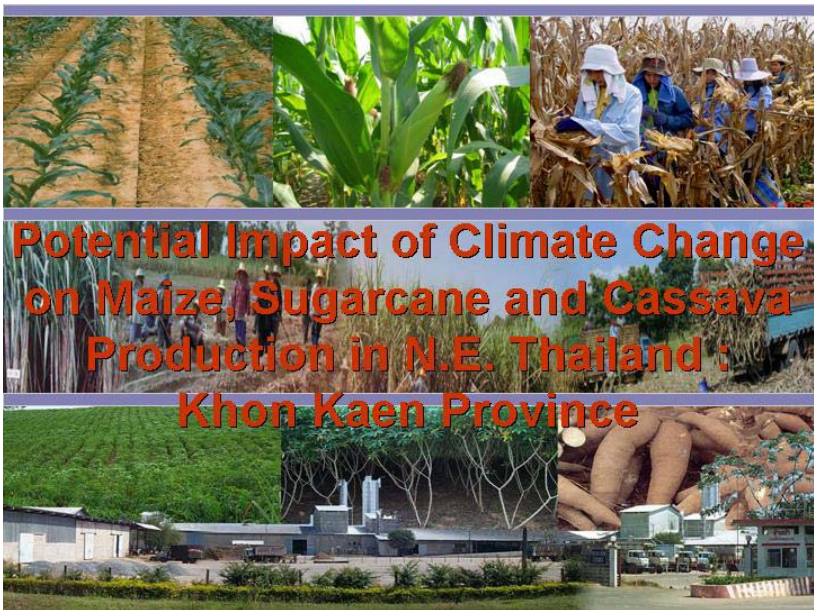
It is found that climate change increased maize and sugarcane yield in Khon Kaen but decreased for cassava. Applying fertilizer could reduce the fluctuation of impact and even reduce 2 – 4 anthesis days and 3 – 10 maturity days. The period of sugarcane development is shorter while $CO_2$ increase however cane biomass at 14 $^{th}$ leaf stage shows slightly increase. It is obvious that for wet year biomass at 14 $^{th}$ leaf stage decrease while $CO_2$ increased. Both sucrose and stalk yield showed the same trend as biomass at 14 $^{th}$ leaf stage for dry year at 2X $CO_2$ has noticeable increased. Storage root yield of cassava evidenced decrease in the dry and median year but remarkable increased for the wet year while first branching date generally decrease between 1.5 and 2X compare to 1X. In case of harvest index show that it decreased while $CO_2$ increased but contrast with maximum LAI except in dry year.

The analysis of potential climate change impacts of 3 crops, despite its limitations, suggests that Thailand is exposed to the risk of such negative effects. Since the impacts of climate change are expected to occur over a long-term horizon, vulnerability and adaptation also depends on the structural change in the agriculture sector in the future. It is difficult to



Chinvanno, S. and Snidvongs, A. (eds.) 2005. The Study of Future Climate Changes Impact on Water Resource and Rain-fed Agriculture Production.
Southeast Asia START Regional Center Technical Report No. 13

envisage the structure of agriculture in Thailand over the next 50 – 100 years. Nevertheless, it was forecasted that about 40 – 50 % of population would still be dependent on the agriculture sector over the next 25 years. The major economic crops in Thailand would probably remain the same, though others crops such as fruit tree and market vegetables will increase. Livestock would also be important in the future soon.




## Researchers

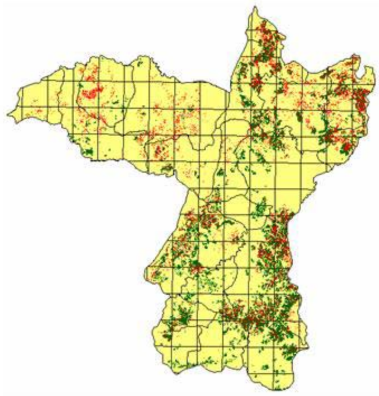

- **Sahaschai Kongton** (LDD. BANGKOK)
- **Vinai Sarawat** (DOA. KHON KAEN )
- **Sukit Ratanasriwongs** (DOA. ROIET)


## Objective of the Study

- **To analyze the climate impacts on maize cassava and sugarcane using crops simulation model**
- **To propose the short and long term policies for agriculture sector in Thailand to adapt to climate change**

## Study Area

◆ Khon Kaen (16.78° N – 102.95° E)



## Scope of the Study

- Collect and analyze the basic information
- Collect and review the studies conducted at domestic and international level
- Prepare attribute and spatial data base
- Generate input data for crops model
- Northeastern is emphasized with 3 major crops

## INPUT DATA

- CLIMATE
- SOIL
- GENETICS COEFFICIENT
- SPATIAL DATA

# SOIL DATA

## Upland and Low Land Soil Series
## (US. Soil Taxonomy)

```
*THUL980015  DLD          LS       210 Maha Sarakham(Msk)***
@SITE        COUNTRY           LAT     LONG SCS FAMILY
 MAHASARAKAM THAILAND         0.000   0.000 loamy,siliceous,subactive,iso Oyaquic(Arenic)Haplu
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
    BN  0.14   7.2  0.40  84.0  1.00  1.00 IB001 IB001 IB001
@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
SADC
    23    Ap 0.044 0.142 0.311 0.500 10.06  1.68  0.54   2.5  12.0   0.0 0.050   5.4   5.0   2.9
    38    AE 0.047 0.151 0.309 0.200 10.45  1.69  0.16   2.0  14.2   0.0 0.010   5.6   5.1   1.5
    50     E 0.043 0.137 0.309 0.010 11.23  1.69  0.01   2.0  11.6   0.0 0.010   6.6   5.9   0.9
    70     E 0.043 0.137 0.309 0.000 11.23  1.69  0.01   2.0  11.6   0.0 0.010   6.6   5.9   0.9
    95   Bt1 0.104 0.218 0.325 0.000  1.31  1.64  0.08  15.3  12.5   0.0 0.010   6.0   4.8   3.3
   130   Bt2 0.111 0.226 0.329 0.000  1.01  1.62  0.05  16.8  15.5   0.0 0.010   5.4   4.0   3.8
   180   Bt3 0.105 0.216 0.327 0.000  1.14  1.63  0.07  16.3  12.1   5.0 0.010   5.1   3.6   3.4
   210   Bt4 0.134 0.248 0.335 0.000  0.55  1.60  0.09  22.0  13.2   0.0 0.010   4.6   3.6   4.7
```

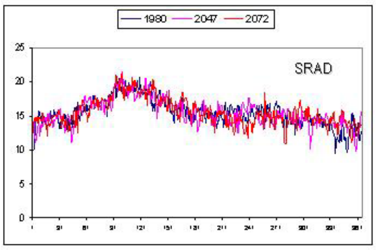
# Climate Data
# (CCAM Simulation)

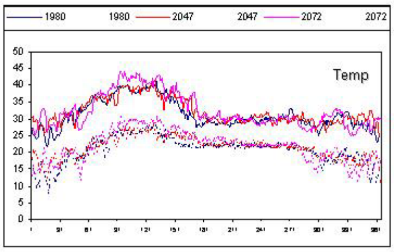
- $CO_2$ x 1 **1980 - 1989**
- $CO_2$ x 1.5 **2040 - 2049**
- $CO_2$ x 2 **2066 – 2075**

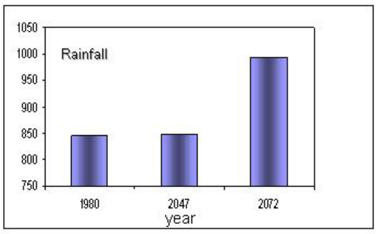
```
*WEATHER DATA : XXXX
@ INSI      LAT     LONG  ELEV
  3781    16.35   102.85   -99
  @DATE  SRAD  TMAX  TMIN  RAIN
  80154 15.39 34.50 22.66 17.77
  80155 15.87 33.77 22.56 16.66
  80156 15.52 32.53 22.03 26.91
  80157 14.00 31.51 22.01 12.97
  80158 15.74 32.91 21.65 16.11
  80159 16.72 32.55 21.85 17.45
  80160 15.85 32.35 22.24 20.45
  80161 14.43 30.28 22.07 12.76
  80162 16.22 31.40 21.98 12.19
  80163 16.72 31.45 21.70 16.41
  80164 15.57 29.79 21.63 12.37
  80165 15.69 30.18 21.89   .00
  80166 17.77 32.32 22.44   .00
  80167 15.86 30.87 21.37 14.86
  80168 16.22 30.78 22.57  8.75
  80169 16.63 30.15 21.80 15.18
  80170 14.70 30.03 21.79 14.64
  80171 16.32 29.90 21.75 12.87
  80172 15.76 29.30 21.45 10.50
  80173 14.59 27.60 21.45 15.21
  80174 15.52 28.36 21.43 13.31
  80175 14.21 27.96 21.38 12.52
  80176 15.60 28.52 21.44 16.66
  80177 13.54 27.73 21.71 17.51
  80178 14.15 27.52 21.84 12.12
  80179 16.93 28.90 21.55  8.06
```

# Climate Data

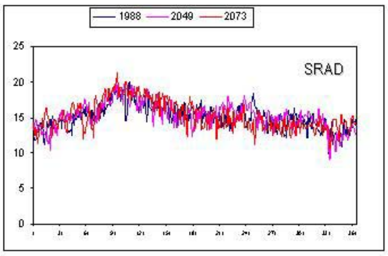
## (CCAM Simulation)

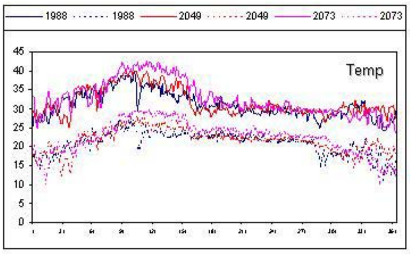


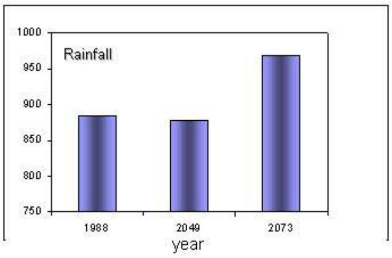



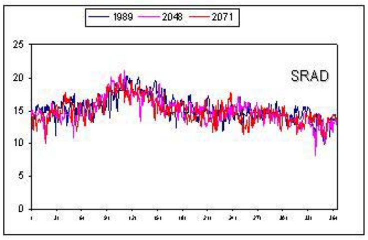

**Comparison between Scenarios of Dry Year**

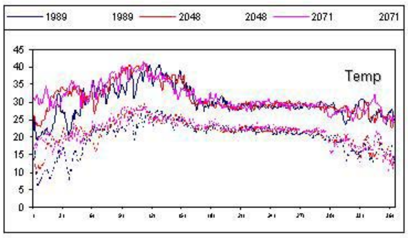


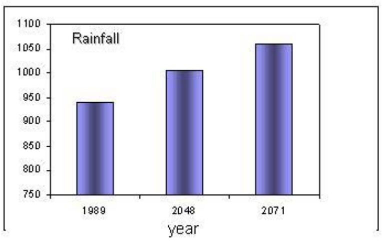




**Comparison between Scenarios of Median Year**




**Comparison between Scenarios of Wet Year**

## Climate Input Data for Scenarios

| | SRAD | Tmax | Tmin | Rain |
|---|---|---|---|---|
| Dry | 15.5 | 31.9 | 21.4 | 895.0 |
| Median | 15.2 | 31.8 | 21.7 | 911.0 |
| Wet | 15.1 | 30.7 | 21.0 | 1001.0 |

## GENETICS COEFFICIENT

- **Maize** (Single Cross Hybrid)
- **Cassava** ( KU 50)
- **Sugarcane** (Uthong 2)

### Maize

| @VAR# | VRNAME.......... | EC # | P1 | P2 | P5 | G2 | G3 | PHINT |
|---|---|---|---|---|---|---|---|---|
| ! | | | 1 | 2 | 3 | 4 | 5 | 6 |
| TH0006 | SW 3601 | IB0001 | 280.0 | 0.500 | 1050. | 824.0 | 8.20 | 48.00 |

### Cassava

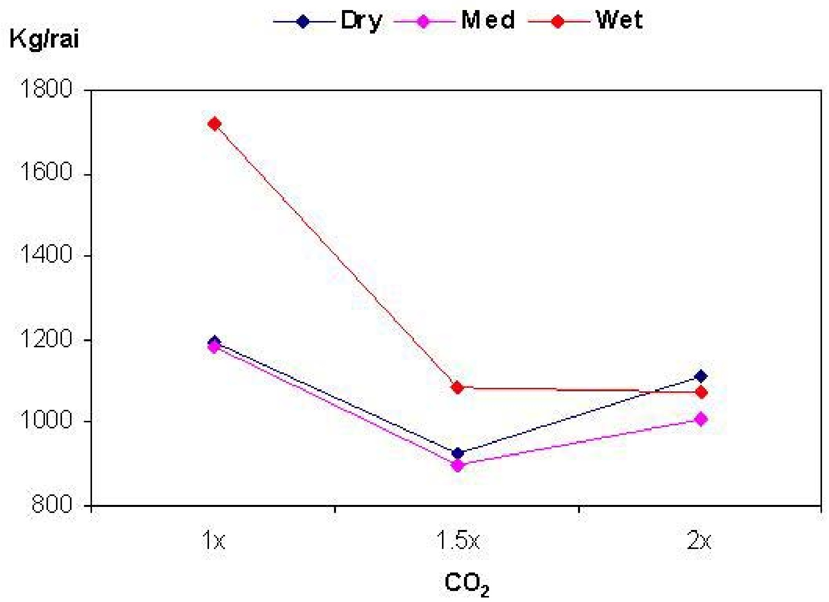
| @NGENO | NAME... | TYPE | DUB1 | DUBR | DESP | PHCX | S#PE | S#FX | S#PX | SWNX | L#IS | L#IP | LALX | LAXA | LAL3 | LAWS | LFLI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ! | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 990001 | Default | 1 | 44.1 | 35.3 | 0.0 | 27.5 | 1.0 | 3.00 | 30.0 | .650 | 1.21 | 235 | 300 | 60 | 50 | 240 | 70 |
| UC0001 | KU50 | 1 | 200.0 | 1000.0 | 0.0 | 27.5 | 2.5 | 2.80 | 8.0 | .750 | 1.45 | 350 | 400 | 70 | 70 | 275 | 130 |

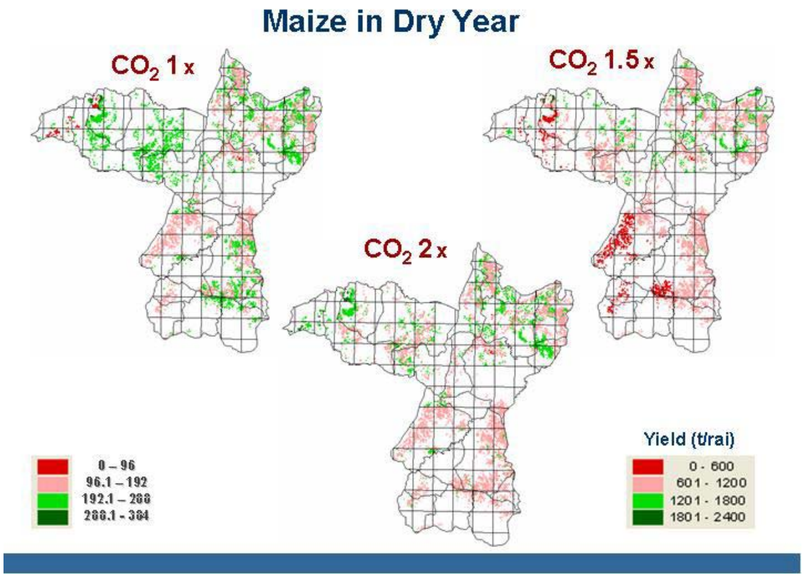
### Sugarcane

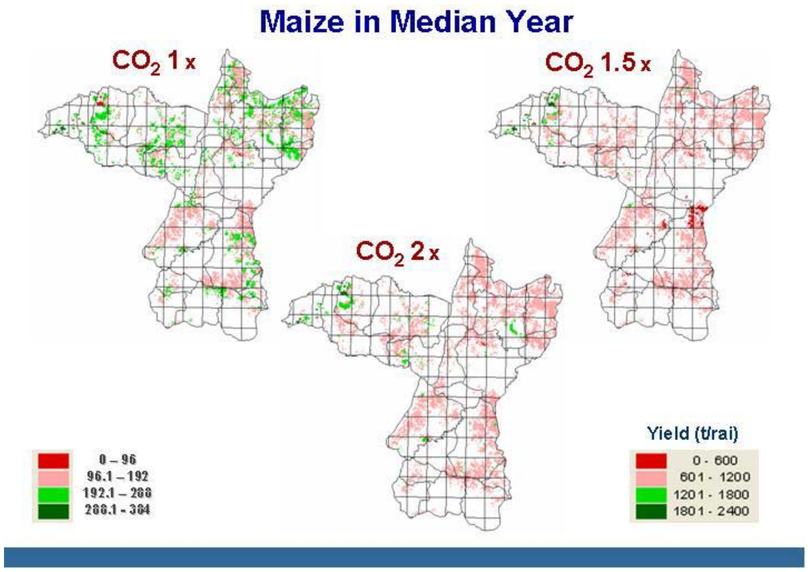
| @VAR# | VAR-NAME........ | ECO# | P1 | RATPT | LFMAX | G1 | PI1 | PI2 | DTPI |
|---|---|---|---|---|---|---|---|---|---|
| ! | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| IB0001 | NCo376 | SC0001 | 8500. | 5.0 | 11.0 | 1.0 | 109.0 | 169.0 | 1526. |
| IB0002 | UTONG2 | SC0001 | 8500. | 5.0 | 11.0 | 2.0 | 109.0 | 169.0 | 1526. |
| IB0003 | GEOFF'S FAV | SC0001 | 8500. | 5.0 | 11.0 | 1.0 | 71.0 | 133.0 | 800. |

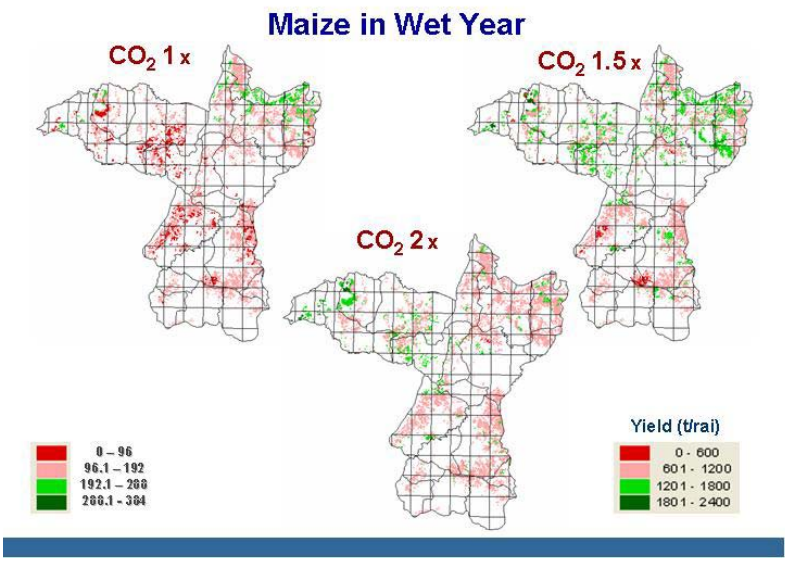
# Maize

## Comparison between different climate scenario on maize yield



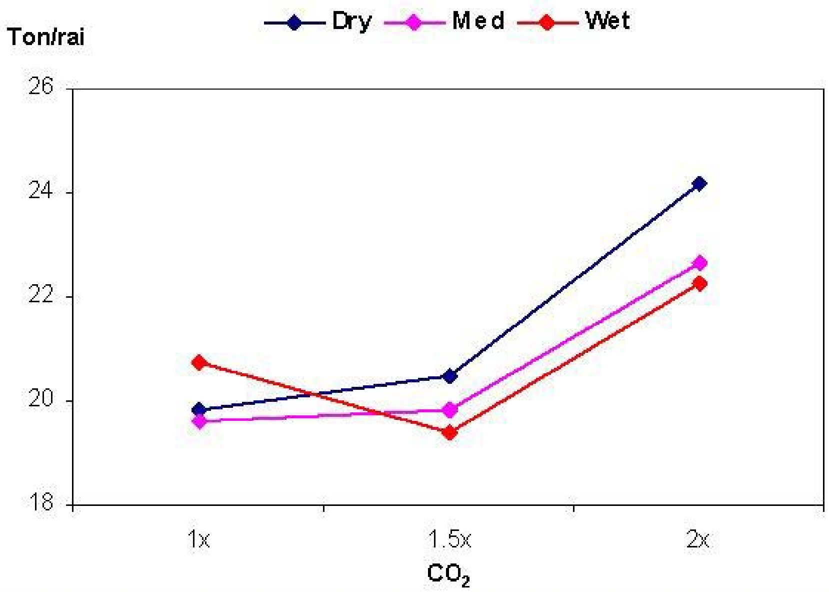

Maize in Dry Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0 – 96
96.1 – 192
192.1 – 288
288.1 - 384
Yield (t/rai)
0 - 600
601 - 1200
1201 - 1800
1801 - 2400

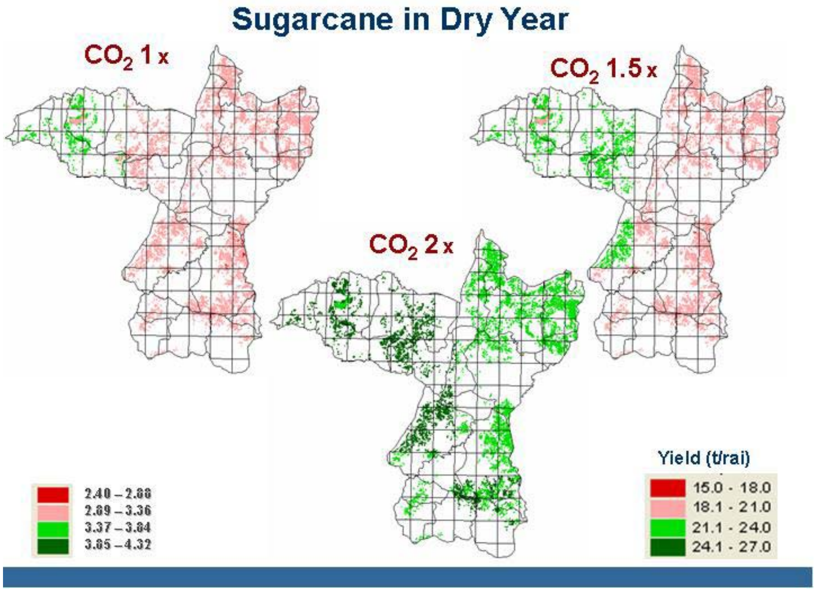

Maize in Median Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0 – 96
96.1 – 192
192.1 – 288
288.1 - 384
Yield (t/rai)
0 - 600
601 - 1200
1201 - 1800
1801 - 2400

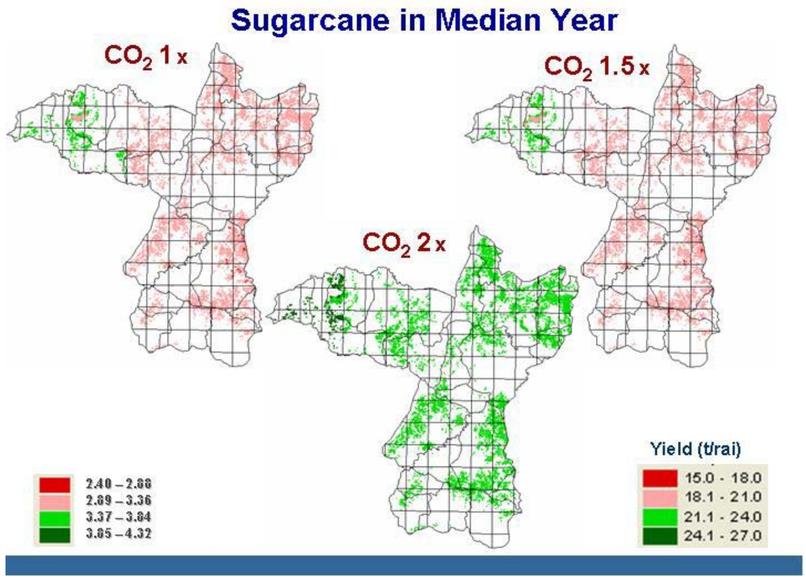

Maize in Wet Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0 – 96
96.1 – 192
192.1 – 288
288.1 - 384
Yield (t/rai)
0 - 600
601 - 1200
1201 - 1800
1801 - 2400

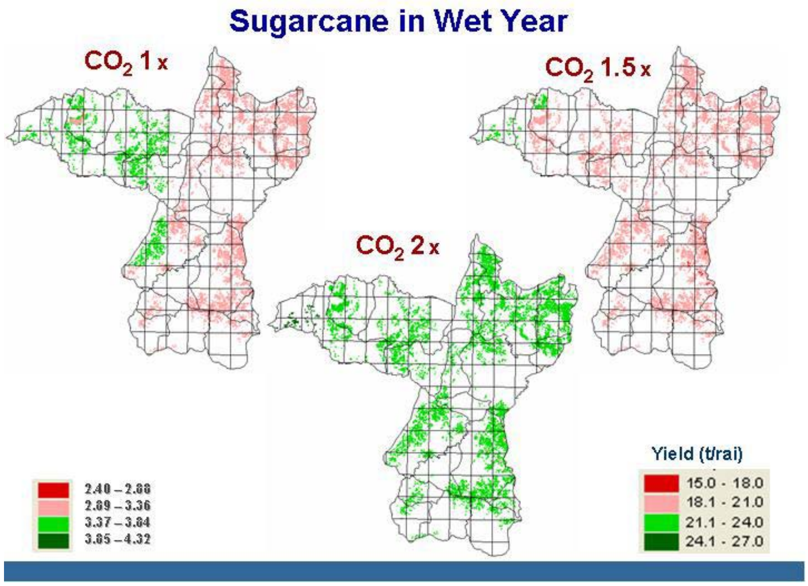
# Sugarcane

## Comparison between different climate scenarios on sugarcane yield



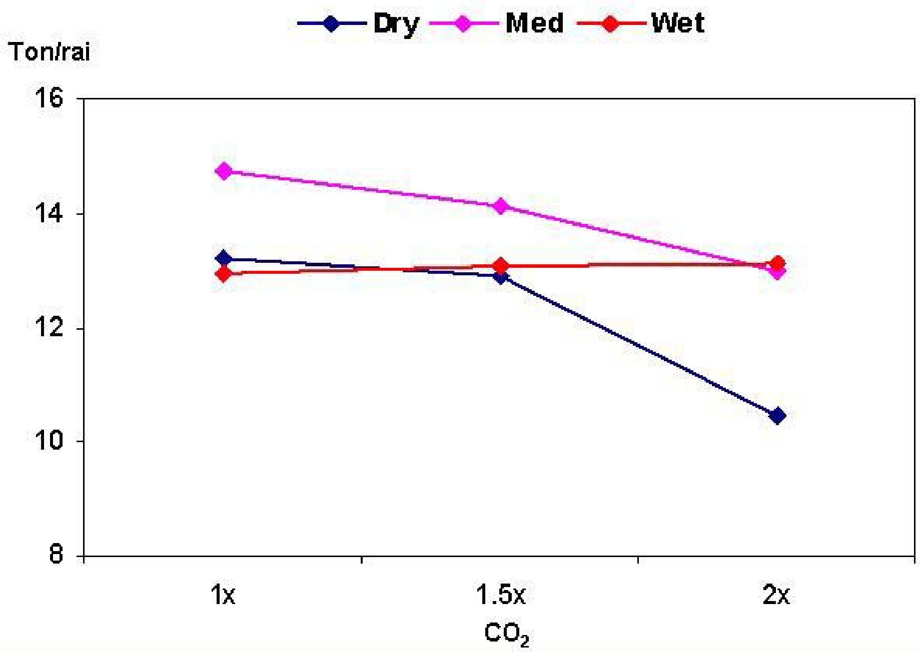

Sugarcane in Dry Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
2.40 – 2.88
2.89 – 3.36
3.37 – 3.84
3.85 – 4.32
Yield (t/rai)
15.0 - 18.0
18.1 - 21.0
21.1 - 24.0
24.1 - 27.0

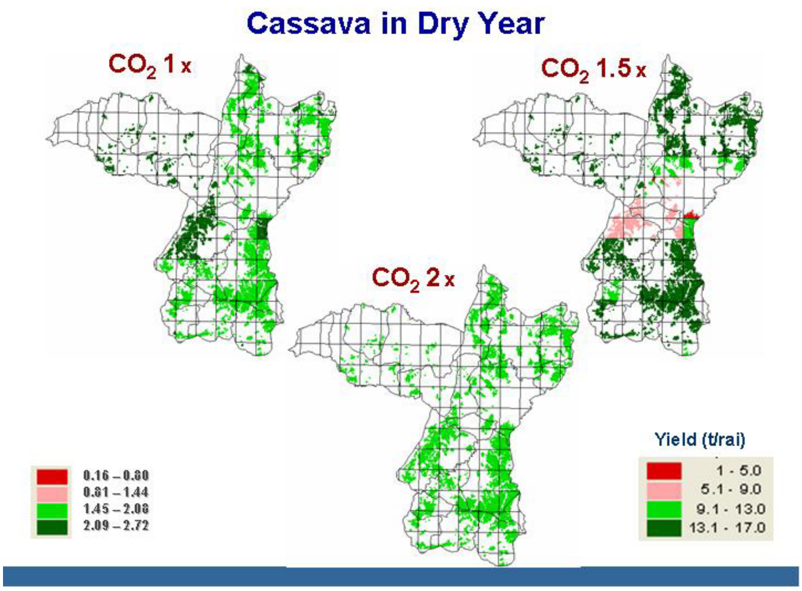

Sugarcane in Median Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
2.40 – 2.88
2.89 – 3.36
3.37 – 3.84
3.85 – 4.32
Yield (t/rai)
15.0 - 18.0
18.1 - 21.0
21.1 - 24.0
24.1 - 27.0

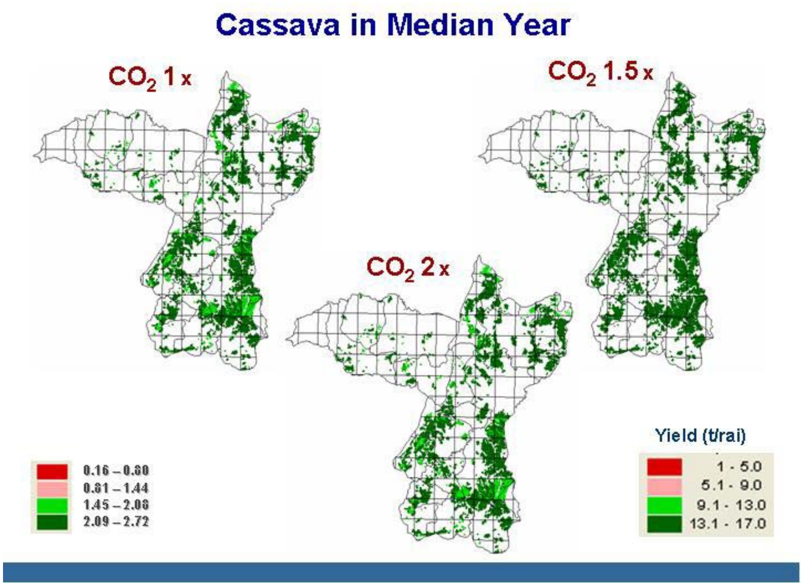

Sugarcane in Wet Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
2.40 – 2.88
2.89 – 3.36
3.37 – 3.84
3.85 – 4.32
Yield (t/rai)
15.0 - 18.0
18.1 - 21.0
21.1 - 24.0
24.1 - 27.0

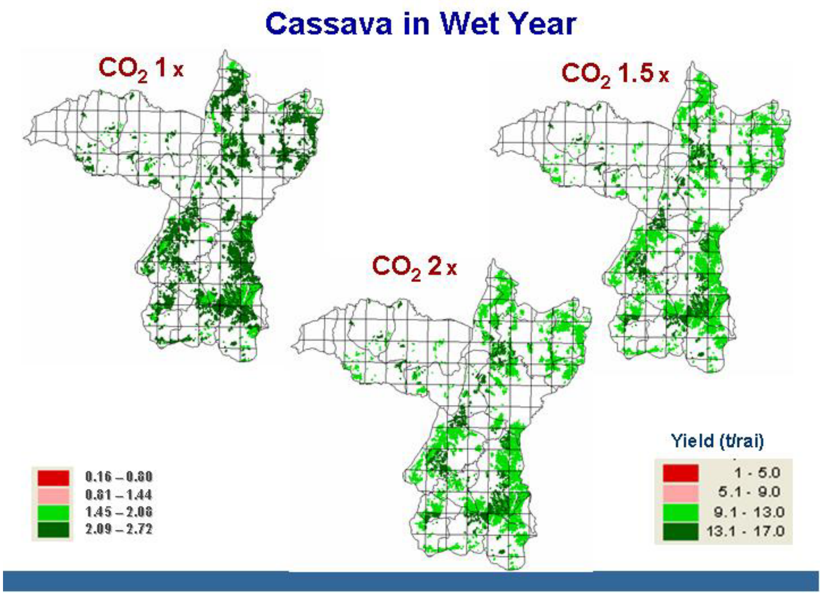
# Cassava

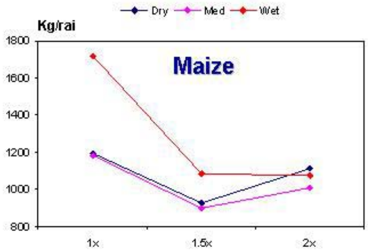
## Comparison between different climate scenarios on cassava yield

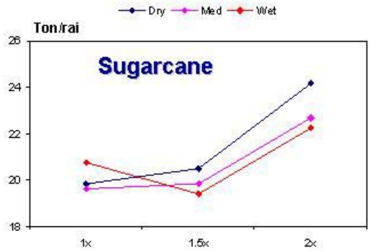


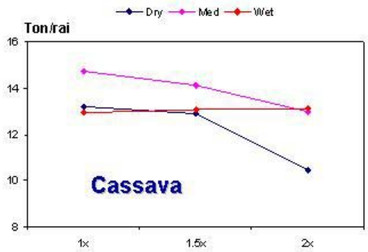

Cassava in Dry Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0.16 – 0.80
0.81 – 1.44
1.45 – 2.08
2.09 – 2.72
Yield (t/rai)
1 - 5.0
5.1 - 9.0
9.1 - 13.0
13.1 - 17.0


Cassava in Median Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0.16 – 0.80
0.81 – 1.44
1.45 – 2.08
2.09 – 2.72
Yield (t/rai)
1 - 5.0
5.1 - 9.0
9.1 - 13.0
13.1 - 17.0


Cassava in Wet Year
$CO_2$ 1 x
$CO_2$ 1.5 x
$CO_2$ 2 x
0.16 – 0.80
0.81 – 1.44
1.45 – 2.08
2.09 – 2.72
Yield (t/rai)
1 - 5.0
5.1 - 9.0
9.1 - 13.0
13.1 - 17.0




**Yield Comparison between Scenarios on Maize Sugarcane and Cassava**

# CONCLUSION

- Maize: Generally yield drop at climate condition of $CO_2$ = 1.5x and increased again at climate condition of $CO_2$ = 2x
- Cassava: Generally yield decreased for median and dry year scenarios
- Sugarcane: Generally yield increased but drop at climate condition of $CO_2$ = 1.5x in wet year scenario

# CONCLUSION (cont.)

- Higher temperature for TMAX at median and dry year
- Still enough rain for the next century
- Maize Cassava and Sugarcane should be developed for heat tolerant

# Summary of Potential Impact of Climate Change on Rain-fed Agriculture in Lao PDR and Thailand

**Attachai Jintrawet,** Soil Sciences Dept, & Multiple Cropping Center, Chiang Mai Univ., Chiang Mai.

Thavone Inthavong, NAFRI, Laos PDR

Chitnucha Boodhaboon, PCRRC, OARD6, Prachinburi, MOAC, Thailand

Sahaschai Kongtong, Soil Survey, Land Dev. Dept, MOAC, Thailand

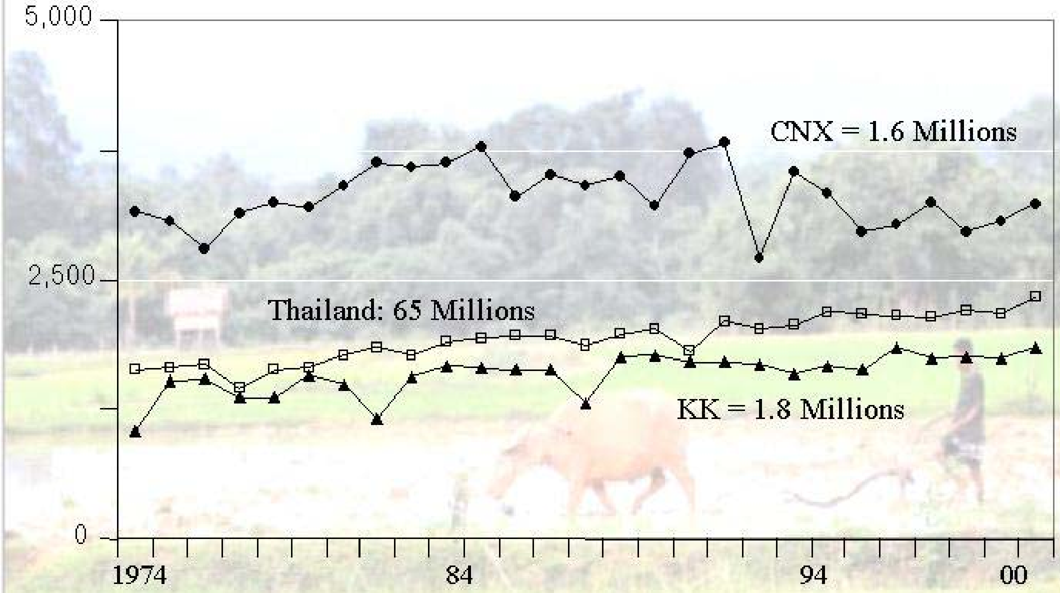
Vinai Sarawat, KKFCRC, OARD3, Khon Kaen, DOA, MOAC, Thailand

Sukit Ratanasriwong, REAgS, OARD4, Roi Et, DOA, MOAC, Thailand

Vichien Kerdsuk, RDI, Khon Kaen Univ., Khon Kaen, Thailand.

Southeast Asia START Regional Center

## Rice yield (kg $ha^{-1}$) and population

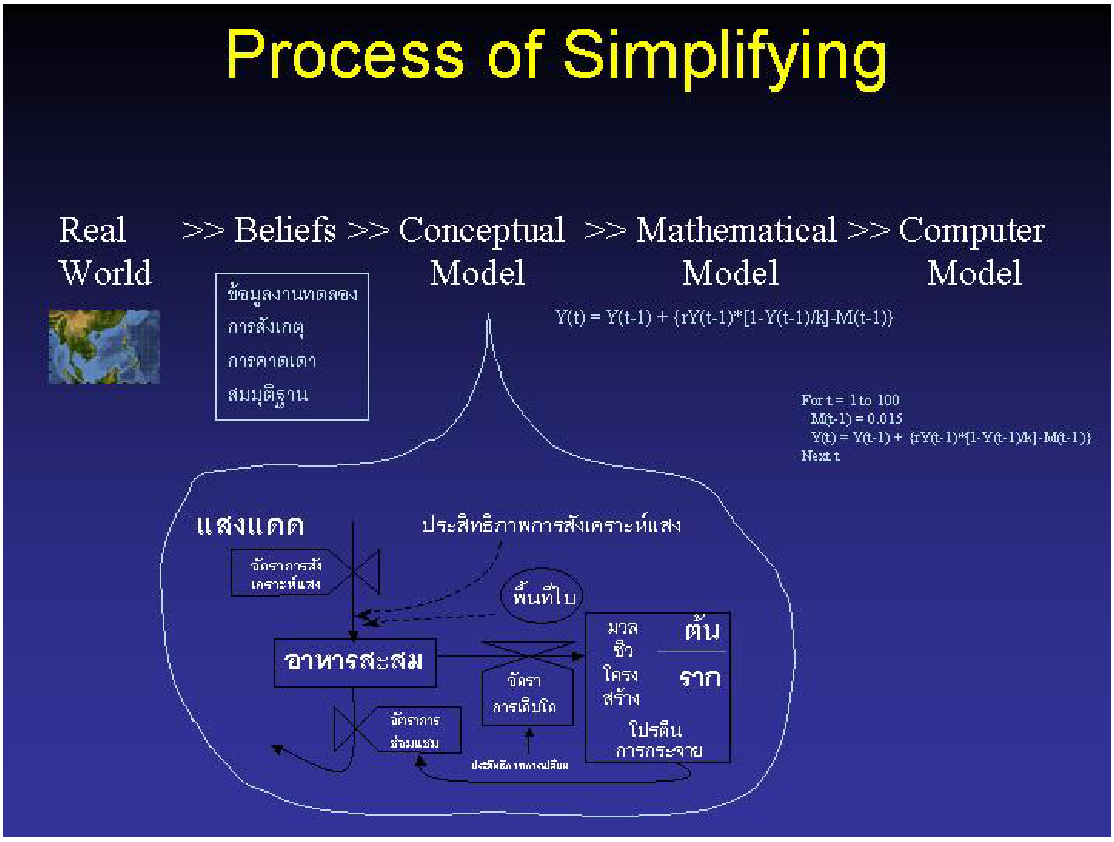



OAE, 1975-2001

## Need for Modeling, Systems Approach

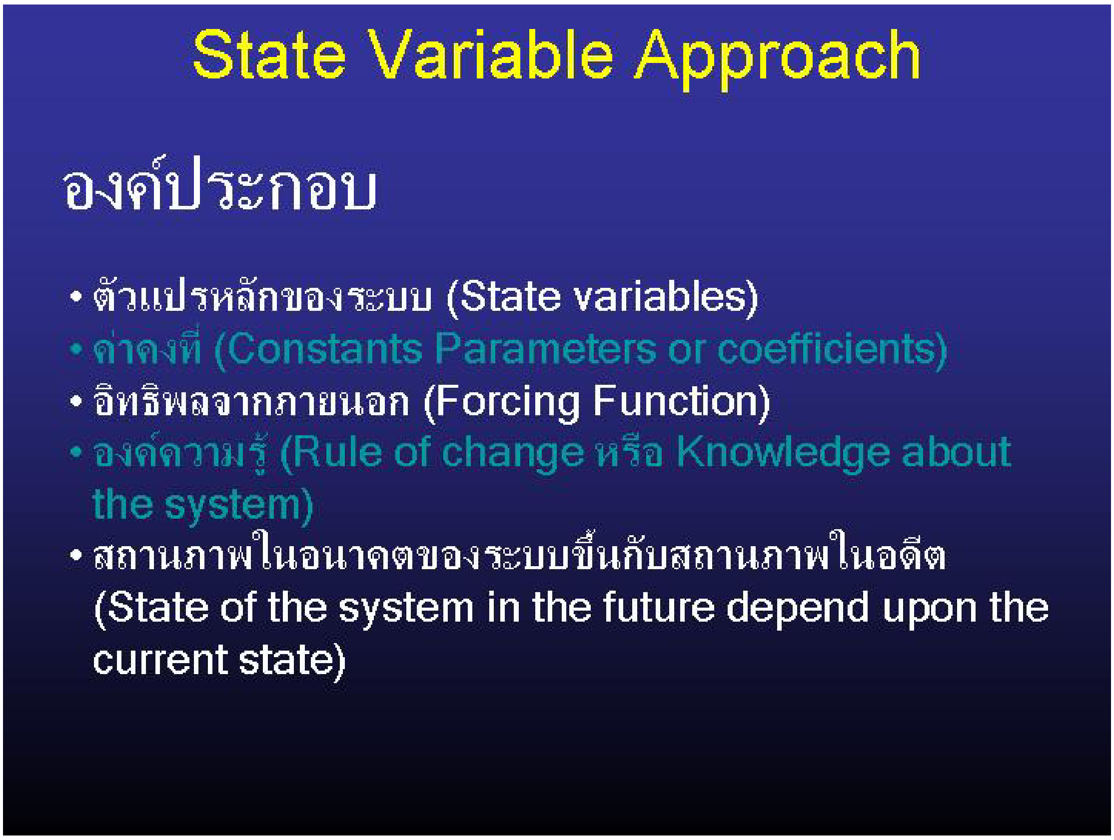
- Complex problems, Interdisciplinary Research Needed
- Increased demands for agricultural products
- Increased pressures on natural resources
- Rapid changes in technology, ...
- Globalization of trade, economies
- Information needed for decision making
- Gap between information needed and that created by disciplinary research
- Trial & Error approach to agricultural research is inadequate
- Integration of knowledge is essential

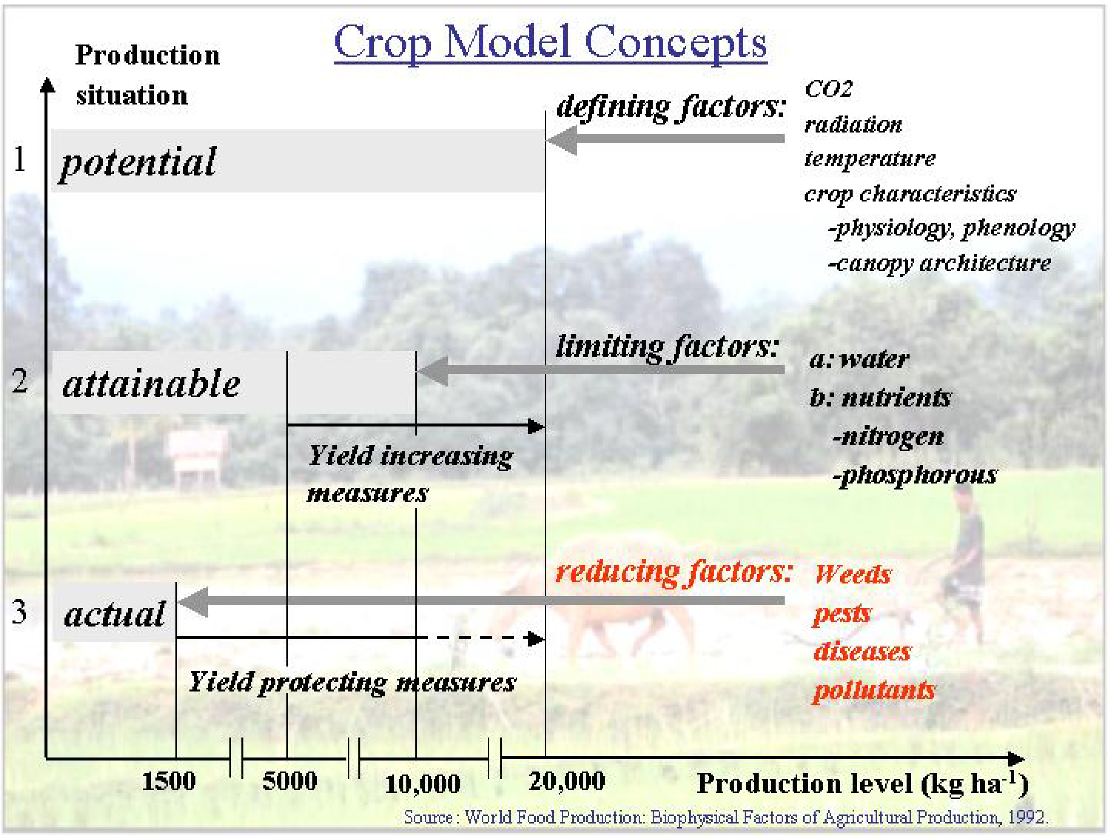
*Hoogenboom, 2003 and 2004.*

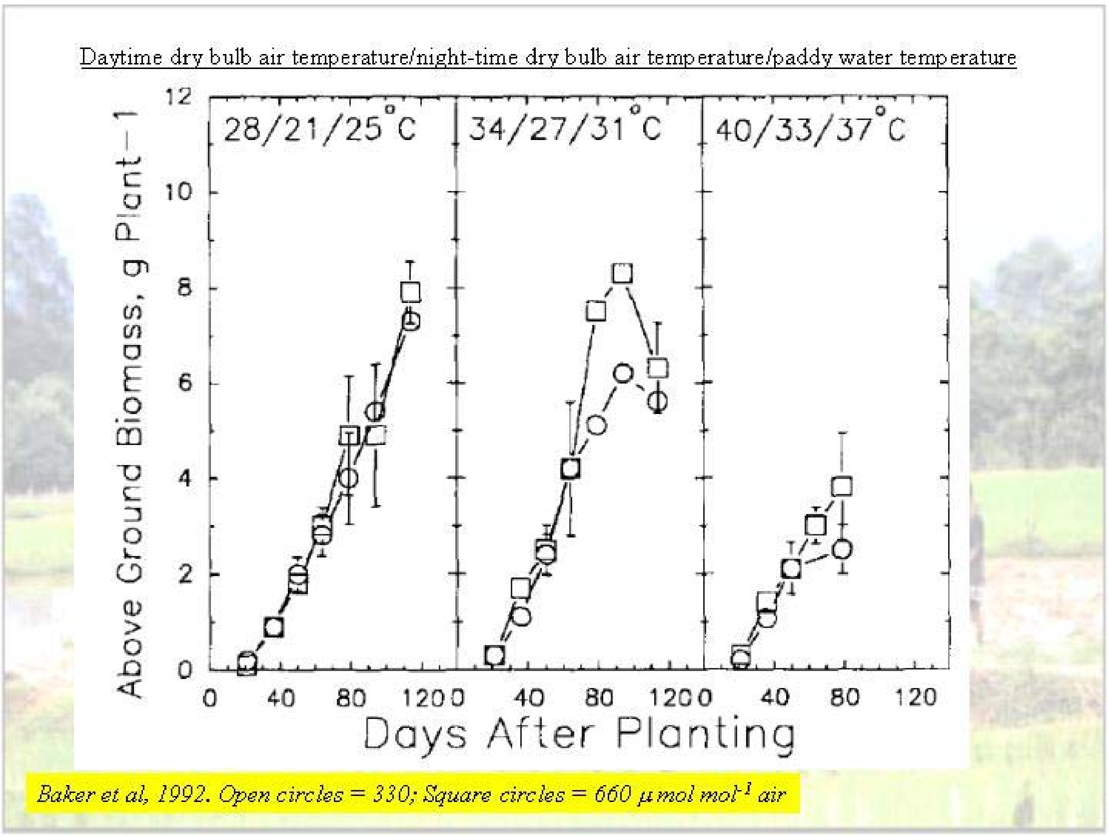




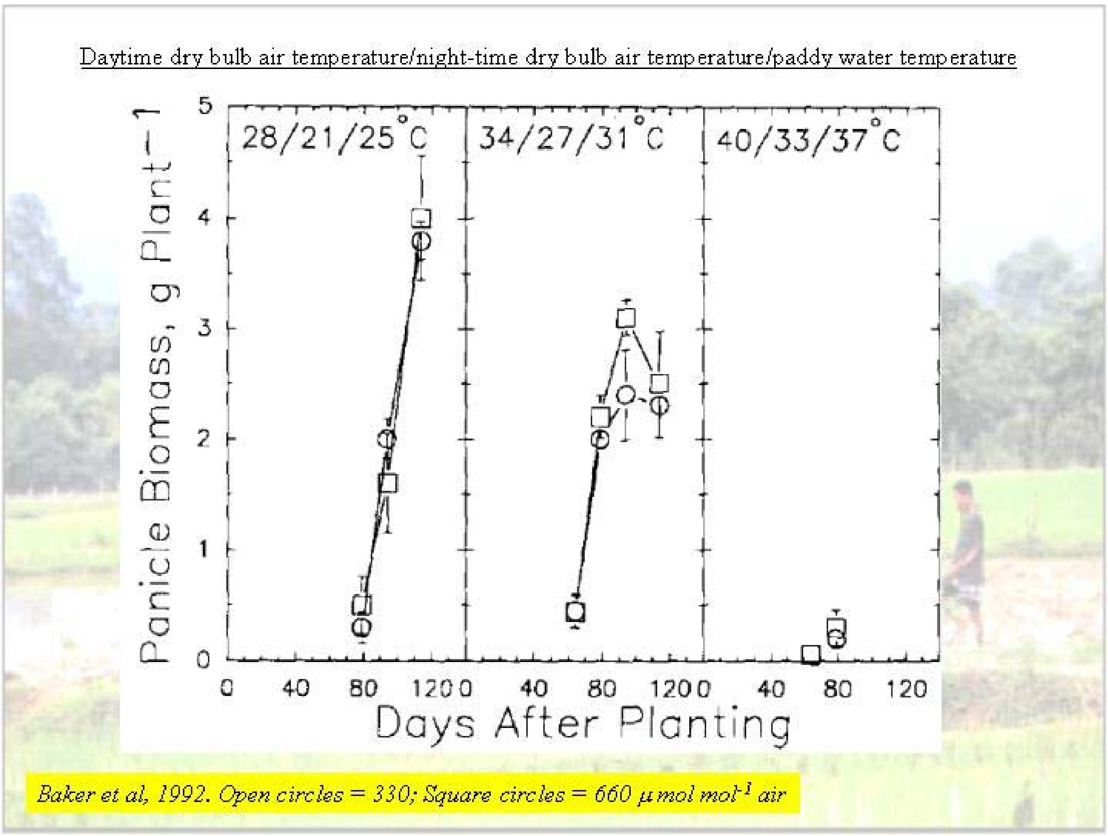
Chinvanno, S. and Snidvongs, A. (eds.) 2005. The Study of Future Climate Changes Impact on Water Resource and Rain-fed Agriculture Production.
Southeast Asia START Regional Center Technical Report No. 13


State Variable Approach
องค์ประกอบ
• ตัวแปรหลักของระบบ (State variables)
• ค่าคงที่ (Constants Parameters or coefficients)
• อิทธิพลจากภายนอก (Forcing Function)
• องค์ความรู้ (Rule of change หรือ Knowledge about the system)
• สถานภาพในอนาคตของระบบขึ้นกับสถานภาพในอดีต (State of the system in the future depend upon the current state)


Crop Model Concepts
Production situation
1 potential
2 attainable
3 actual
defining factors:
CO2
radiation
temperature
crop characteristics
-physiology, phenology
-canopy architecture
limiting factors:
a: water
b: nutrients
-nitrogen
-phosphorous
Yield increasing measures
reducing factors:
Weeds
pests
diseases
pollutants
Yield protecting measures
1500
5000
10,000
20,000
Production level (kg ha-1)
Source : World Food Production: Biophysical Factors of Agricultural Production, 1992.



Daytime dry bulb air temperature/night-time dry bulb air temperature/paddy water temperature
28/21/25°C
34/27/31°C
40/33/37°C
Above Ground Biomass, g Plant−1
Days After Planting
Baker et al, 1992. Open circles = 330; Square circles = 660 μmol mol-1 air

Daytime dry bulb air temperature/night-time dry bulb air temperature/paddy water temperature
28/21/25°C
34/27/31°C
40/33/37°C
Panicle Biomass, g Plant−1
Days After Planting
Baker et al, 1992. Open circles = 330; Square circles = 660 μmol mol-1 air

Daytime dry bulb air temperature/night-time dry bulb air temperature/paddy water temperature

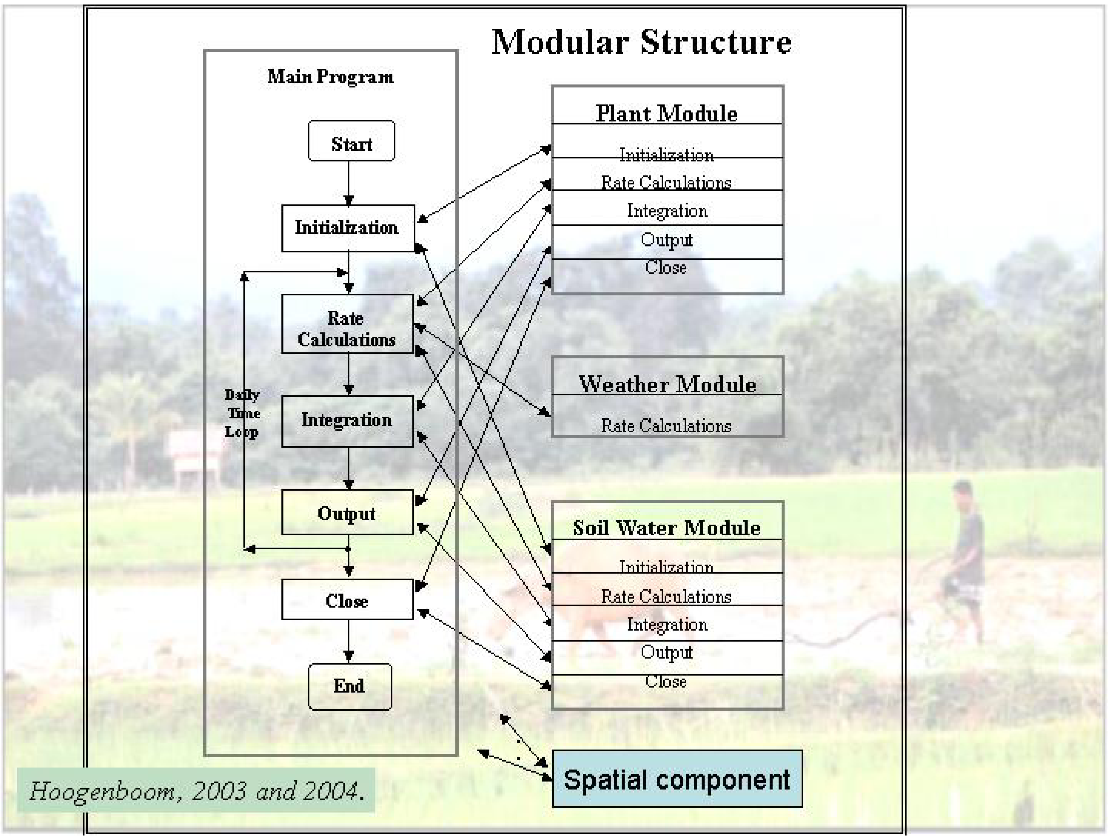
TABLE 1

Grain yield, components of yield, total above ground biomass and harvest index for flooded rice (cv. IR-30) plants grown in controlled environment chambers at Gainesville, FL in two $CO_2$ concentrations and three temperature treatments

| $CO_2$ ($\mu$mol mol$^{-1}$) | Temperature[a] (°C) | Grain yield (Mg per ha) | Grain yield (g per plant) | Panicles (no. per plant) | Filled grain (no. per panicle) | Grain mass (mg per seed) | Total above ground biomass (g per plant) | Harvest[b] index |
|---|---|---|---|---|---|---|---|---|
| 330 | 28/21/25 | 7.9 | 3.43 | 5.1 | 34.5 | 17.4 | 7.27 | 0.42 |
| | 34/27/31 | 4.2 | 1.87 | 7.7 | 15.2 | 16.2 | 5.61 | 0.32 |
| | 40/33/37 | 0[c] | 0 | - | - | - | - | - |
| 660 | 28/21/25 | 8.4 | 3.65 | 5.0 | 37.7 | 18.0 | 7.89 | 0.42 |
| | 34/27/31 | 4.8 | 2.09 | 6.4 | 18.6 | 16.7 | 6.27 | 0.29 |
| | 40/33/37 | 0[c] | 0 | - | - | - | - | - |
| *F-Values* | | | | | | | | |
| $CO_2$ concentration | | 0.4 NS | 0.4 NS | 1.8 NS | 1.5 NS | 1.9 NS | 1.2 NS | 0.3 NS |
| Temperature | | 18.5** | 18.5** | 16.8** | 54.0** | 10.3* | 7.7* | 17.0** |
| $CO_2$ × Temperature | | 0.0 NS | 0.0 NS | 1.4 NS | 0.0 NS | 0.0 NS | 0.0 NS | 0.2 NS |

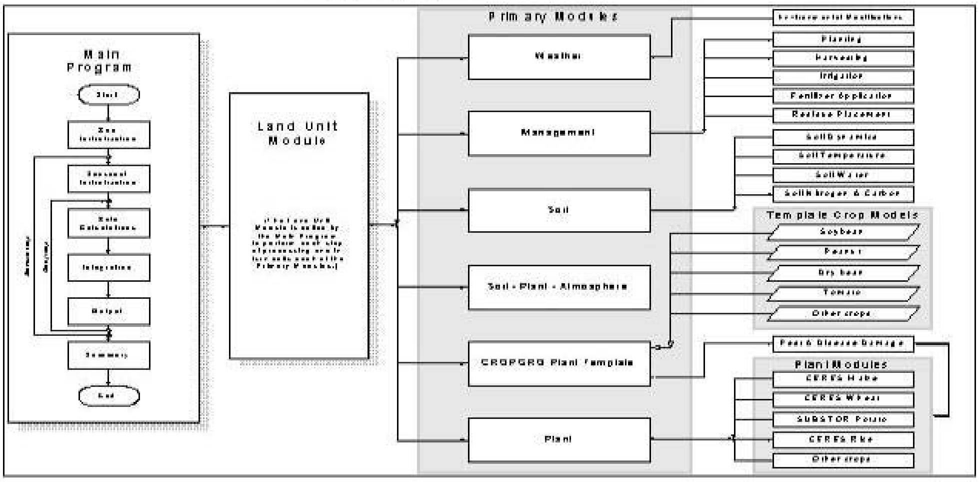
[a] Day/night/constant paddy water.
[b] Based on 15 individual plants from three separate rows. The values are slightly different if the average grain yield is divided by the average total above-ground biomass.
[c] High temperature treated plants failed during mid-stem extension prior to anthesis. Biomass accumulation also ceased about this time.
**, * Significant at the 0.01 and 0.05 probability levels, respectively. NS, not significant.

*Baker et al, 1992. Agricultural and Forest Meteorology, 60: 153-166.*



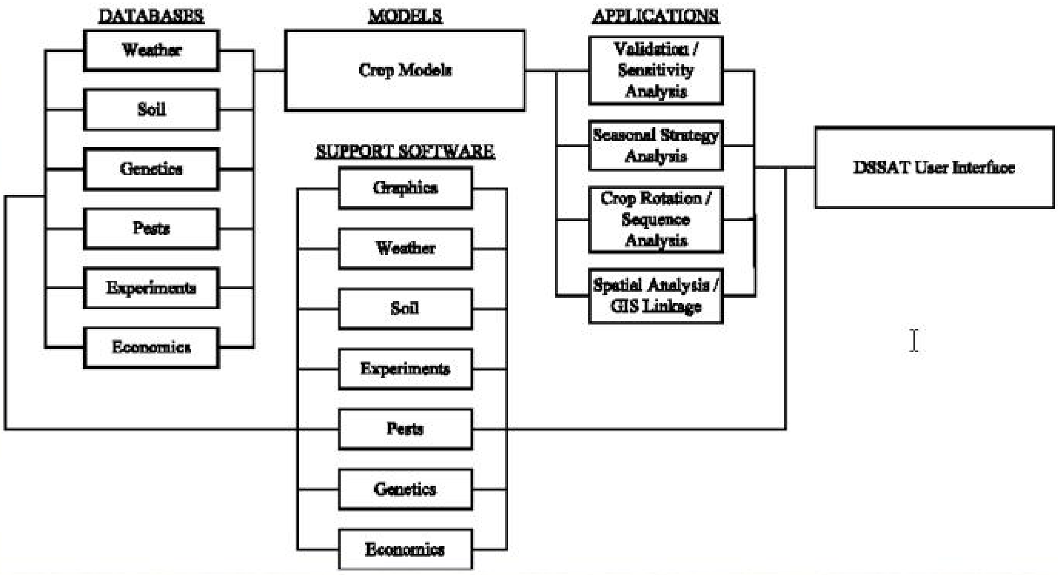
## A New Modular Version of DSSAT Cropping System Models

Overview of the components and modular structure of the DSSAT cropping system model v4.0.




*Hoogenboom, 2003 and 2004.*

## DSSAT I/O

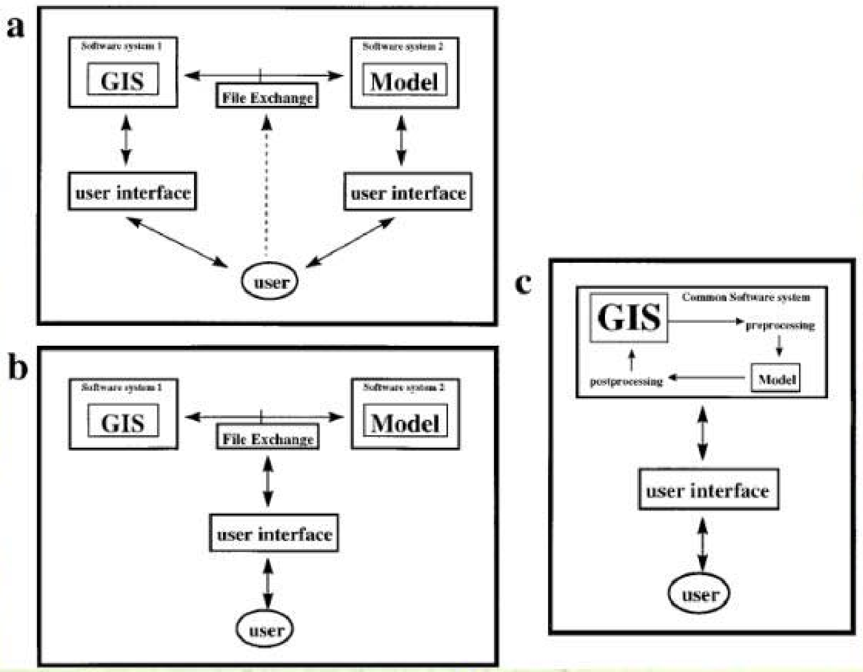



*Jones et al, 2003*. European Journal of Agronomy 18: 235-265.

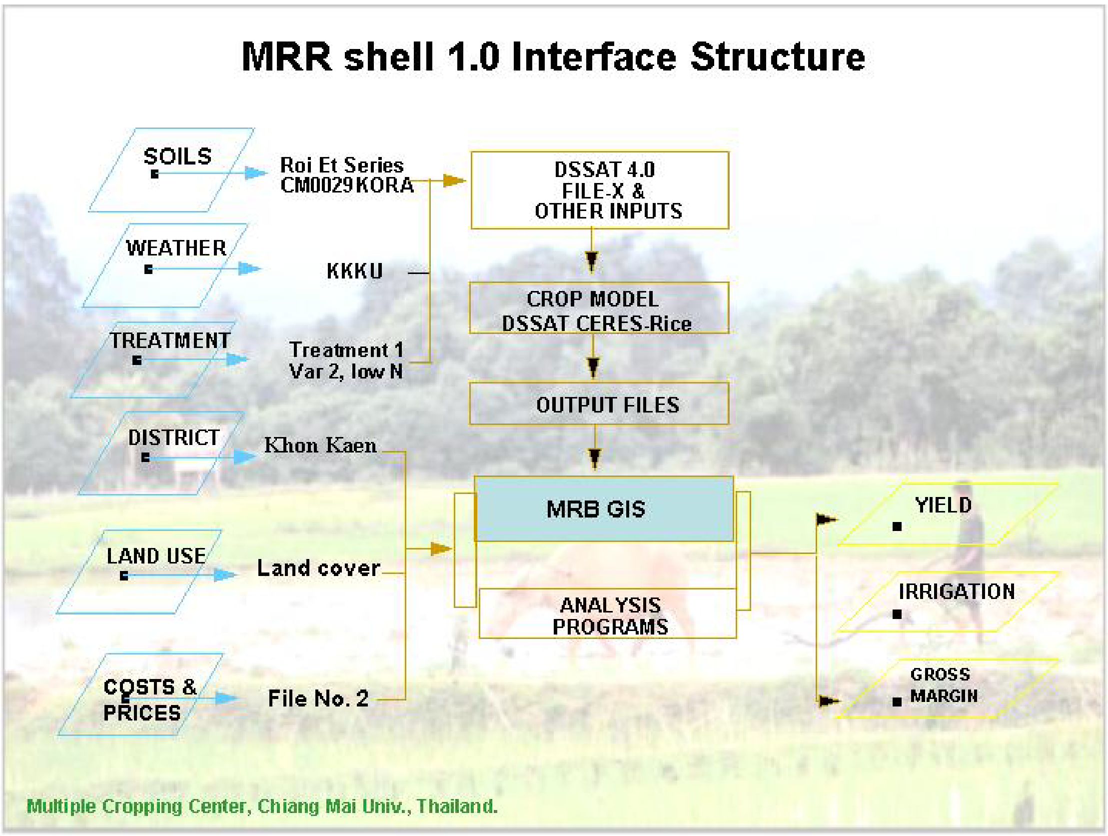
# Approach to simulate rice production

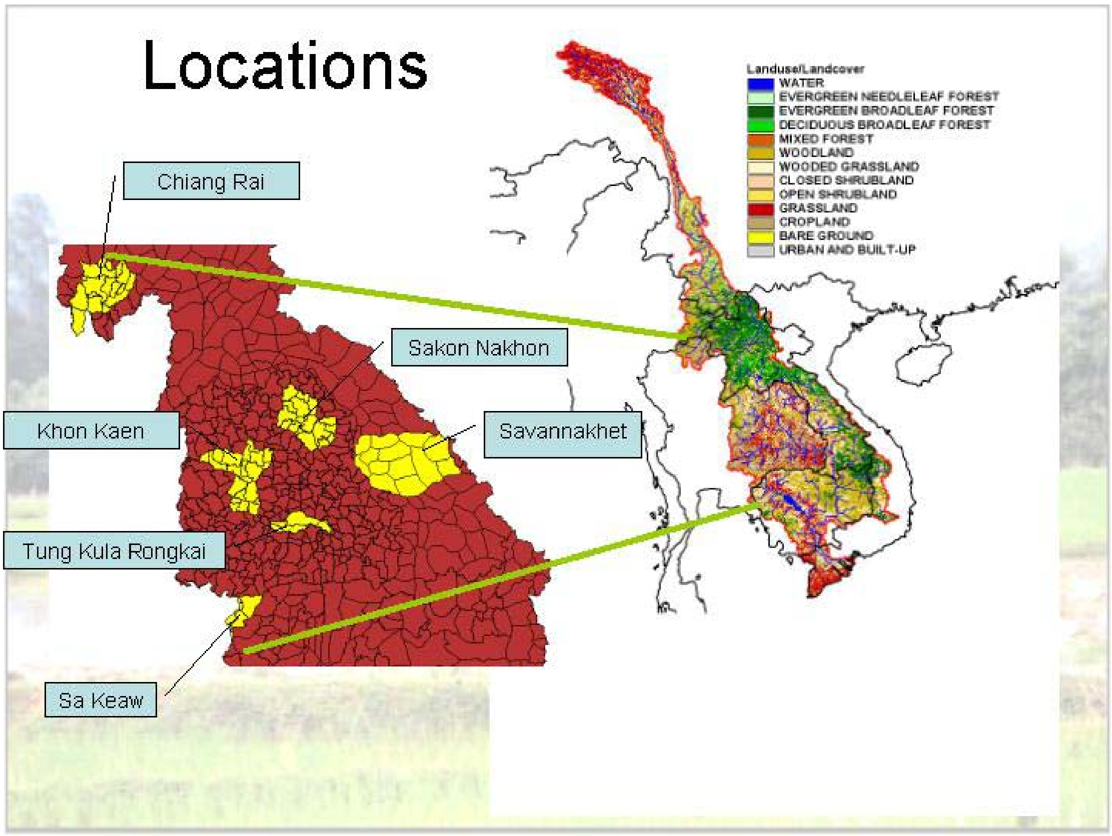
| Characteristics | Attributes |
|---|---|
| Total area | 800,000 $km^2$ |
| Rice area | 80,000 $km^2$ |
| People | 55 Million |

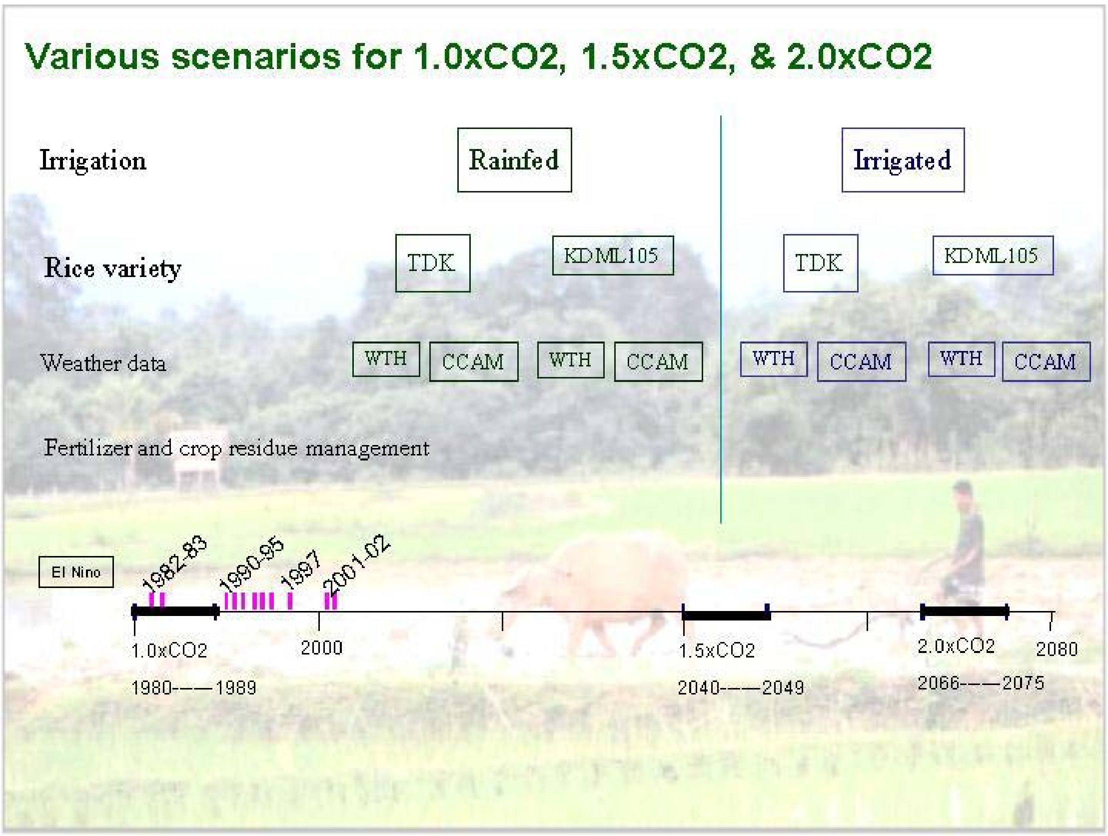
# GIS & Model Integration Approaches




*Hartkamp et al, 1999*. Agronomy Journal 91:761–772.


MRR shell 1.0 Interface Structure
SOILS
WEATHER
TREATMENT
DISTRICT
LAND USE
COSTS & PRICES
Roi Et Series CM0029KORA
KKKU
Treatment 1 Var 2, low N
Khon Kaen
Land cover
File No. 2
DSSAT 4.0 FILE-X & OTHER INPUTS
CROP MODEL DSSAT CERES-Rice
OUTPUT FILES
MRB GIS
ANALYSIS PROGRAMS
YIELD
IRRIGATION
GROSS MARGIN
Multiple Cropping Center, Chiang Mai Univ., Thailand.


Locations
Chiang Rai
Sakon Nakhon
Khon Kaen
Savannakhet
Tung Kula Rongkai
Sa Keaw
Landuse/Landcover
WATER
EVERGREEN NEEDLELEAF FOREST
EVERGREEN BROADLEAF FOREST
DECIDUOUS BROADLEAF FOREST
MIXED FOREST
WOODLAND
WOODED GRASSLAND
CLOSED SHRUBLAND
OPEN SHRUBLAND
GRASSLAND
CROPLAND
BARE GROUND
URBAN AND BUILT-UP




## CAPaBLE Studies in Laos PDR & Thailand

| | 1.0xCO2 | 1.5xCO2 | 2.0xCO2 |
|---|---|---|---|
| Thavone (Rice)<br>• Suwannaket | | | |
| Vichien (Rice)<br>• Onset of rains, dry spills<br>• Salt and sand | Similar rice yields for dry, median and wet years | | |
| Chitnucha (Rice)<br>• Chiang Rai (CR)<br>• Sakonnakorn (SK)<br>• Sa Kaew (SW) | | | |
| Vinai (Cassava)<br>• Khon Kaen | | | |
| Sukit (Sugarcane)<br>• Khon Kaen | | | |
| Sahaschai (Maize)<br>• Khon Kaen | | | |

## Impacts of the changes (Based on CCAM)

- Dry-median-wet CCAM weather scenarios appear have little impact on rice yields.
- Double CO2 and higher temperature appear to have negative impact on rice yields.
- Slight impact on rice production during the next 40 years, lower rice yield may be expected thereafter.
- CERES-Rice model predicts longer crop durations.

## Impacts of high rainfall

- Flooding and soil erosion
- More leaching of soil nutrients
- Less efficiency of chemical fertilizer
- Need higher energy to dry the harvested products.

## Summary

- It is possible to use a process-oriented rice model alone with MRB-rice shell to simulate rice production options under various climatic, edaphic, and management conditions
- Need to develop warning systems.
- Need some fund for more fun, network building and data sharing.

## Further analysis

| Variables Of interest | 1.0xCO2 1980-89 | 1.5xCO2 2040-49 | 2.0xCO2 2066-75 |
|---|---|---|---|
| Dry | Mean ± SD | | |
| Median | | | |
| Wet | | | |

## Evaluation of Crop Models for Intended Applications is Critically Important

- Conduct sensitivity analysis of model, critically evaluate results based on existing knowledge, trends
- Demonstrate ability to re-create results from existing and/or new experiments
- Do conclusions from model agree with conclusions from experiments?
- Evaluate using independent data
- Be careful and ensure that inputs are accurate
- Be critical; characterize limitations

## What's next?

- Website for Spatial modeling at http://mccweb.agri.cmu.ac.th
- MRB-Rice shell updates thru the website
- More analytical functions with MRB shell
- Allow local language interface modification.
- CERES-Rice model testing with other CCAM
- More crops to be added under DSSAT4 shell, http://www.icasa.net
- May be a training program on DSSAT4 & MRB shell in May 2005

# Annex 1

## Workshop Agenda

**29 July 2004**

**Opening Session**

0900 - 0910 Background of CAPaBLE CB-01 Implementation
*Mr. Suppakorn Chinvanno, CAPaBLE CB-01 Program coordinator*
0910 - 0920 Welcome and Opening Address
*Mr. Sakhone Chaleunvong*
*Vice-Chair of Science Technology Environment Agency*
0920 - 0945 Group photo session & coffee break

**Technical Sessions (Parallel Sessions)**

0945 - 0955 Objective, program and expected outcome of the workshop
*Mr. Suppakorn Chinvanno, CAPaBLE CB-01 Program coordinator*
0955 - 1010 Scenario based approach for the assessment of climate change impacts, vulnerability and adaptation
*Dr. Anond Snidvongs, Chulalongkorn University*

**Session A: Modelling of Potential Impact of Climate Change on Water Resource (Facilitator: Dr. Anond Snidvongs)**

1010 - 1200 Model results verification and finalizing impact output
**Lunch**
1300 - 1630 Summary & Discussion: Potential impact of climate change on major river basins in Lao PDR and Thailand

**Session B: Modelling of Potential impact of Climate Change on Rain-fed Agriculture (Facilitator: Dr. Attachai Jintrawet)**

1010 - 1200 Model results verification and finalizing impact output
**Lunch**
1300 - 1630 Summary & Discussion: Potential impact of climate change on rain-fed agriculture in Lao PDR and Thailand

**30 July 2004**

**Presentation Session (Joint Session)**

**Theme 1: Future Climate Scenarios Used in CAPaBLE CB-01 Project**

0830 - 0850 Future Climate Scenario in Thailand
*Mr. Wirote Laongmanee, SEA START RC, Thailand*

0850 - 0910 Future Climate Scenario in Lao PDR
*Mr. Oulaphone Ongkeo, Department of Irrigation, Ministry of Agriculture and Forestry, Lao PDR*

**Theme 2: Potential Impacts of Climate Change on Hydrological Condition**

0910 - 0930 Potential Impact of Climate Change on Hydrological Condition in Mun River Basin - Thailand
*Dr. Boontium Lertsupavitnapa, Ubonratchathani University, Thailand*

0930 - 0950 Potential Impact of Climate Change on Hydrological Condition in Nam Ngum River Basin - Lao PDR: Impact on inflow to Nam Ngum Reservoir
*Ms. Keophusone Phonhalath, National University of Laos, Lao PDR*

0950 - 1010 Potential Impact of Climate Change on Hydrological Condition in Nam Thuene Watershed - Lao PDR
*Mr. Vivarath Sihabouj, National University of Laos, Lao PDR*

**Theme 3: Potential Impacts of Climate Change on Rain-fed Agriculture**

1010 - 1030 Potential Impact of Climate Change on Rain-fed Rice Production in Thailand
*Mr. Chitnucha Buddhaboon, Ministry of Agriculture, Thailand*

1030 - 1050 **Coffee Break**

1050 - 1110 Potential Impact of Climate Change on Rice Production in Tung Kula Field, Thailand
*Dr. Vichien Kerdsuk, Khon Kaen University, Thailand*

1110 - 1130 Potential Impact of Climate Change on Maize, Sugarcane and Cassava Production in N.E. Thailand
*Mr. Sahaschai Kongton, Mr. Vinai Sarawat and Mr. Sukit Ratanasriwong, Ministry of Agriculture, Thailand*

1130 - 1150 Potential Impact of Climate Change on Rice Production in Sawannaket Province - Lao PDR
*Mr. Thavone Inthavong, National Agriculture and Forestry Research Institute, Lao PDR*

1150 - 1215 General discussion

1215 - 1330 **Lunch**

1300 - 1400 **Registration for Participants and Guests of the Project Conclusion Event**

**CAPaBLE CB-01 Phase 1 Conclusion Event**

1400 - 1420 Introduction to Asia Pacific Network for Global Change Research and background of CAPaBLE capacity building program
*Dr. Anond Snidvongs, APN Liaison Officer for Southeast Asia*

1420 - 1430 Special Address - APN Lao PDR
*Mr. Chanthanet Boualapha, Science, Technology and Environment Agency, on behalf of Mr. Phonechaleune Nonthaxay, APN Focal Point - Lao PDR)*

1430 - 1440 Special Address - APN Thailand

*Dr. Asdaporn Krairapanond, Ministry of Natural Resource and Environment, (on behalf of Dr. Plodprasob Surasswadi, APN Focal Point - Thailand)*

1440 - 1500 Keynote Speech: Obligation of UNFCCC Non-Annex 1 Countries in the Study of Impact of Climate Change
*Dr. Asdaporn Krairapanond, Ministry of Natural Resource and Environment, Thailand*

1500 - 1520 Framework and Direction in Study of Impact of Climate Change and Achievement of CAPaBLE CB-01 Capacity Building Program
*Mr. Suppakorn Chinvanno, CAPaBLE CB-01 Program coordinator*

1520 - 1540 Summary of Potential Impact of Climate Change on Hydrological Condition in Lao PDR and Thailand
*Dr. Anond Snidvongs, Chulalongkorn University, Thailand*

1540 - 1600 Summary of Potential Impact of Climate Change on Rain-fed Agriculture in Lao PDR and Thailand
*Dr. Attachai Jintrawet, Chiang Mai University, Thailand*

1600 - 1610 Closing Remark
*Mr. Chanthanet Boualapha, Environmental Research Institute, STEA, Lao PDR*

1610 - 1630 Group Photo Session

1630 - 1800 **High Tea & Cocktail Reception**

1800 - 2000 **Farewell Dinner**

# Annex 2
# List of Participants

## Research Participants (Lao PDR)

Mr.Vivarath Sihabouj
Lecturer
Faculty of Engineering
National University of Laos

Ms. Keophusone Phonhalath
Lecturer
Faculty of Engineering
National University of Laos

Mr. Oulaphone Ongkeo
Lecturer
Department of Irrigation
Ministry of Agriculture and Forestry

Ms. Chithdavone Southammavong
Meteorologist
Meteorology and Hydrology Department
Ministry of Agriculture and Forestry

Mr. Soulideth Souvannalath
Coordinating Officer
Water Resources Coordination Committee
Secretariat
Prime Minister's Office

Mr. Thavone Inthavong
GIS Specialist
National Agriculture and Forestry
Research Institute
Ministry of Agriculture and Forestry

## Research Participants (Thailand)

Dr. Boontium Lersupavithnapa
Assistant Professor
Faculty of Agriculture
Ubonratchathani University

Dr. Vichien Kerdsuk
Researcher
Research and Development Institute
Khon Kaen University

Mr. Sukit Ratanasriwong
Roi Et Agricultural Resources Service
Center
Department of Agriculture
Ministry of Agriculture and Cooperatives

Mr. Vinai Sarawat
Khon Kaen Field Crop Research Center
Department of Agriculture
Ministry of Agriculture and Cooperatives

Mr. Sahaschai Kongton
Land Development Department
Ministry of Agriculture and Cooperatives

Mr. Chitnucha Buddhaboon
Prachinburi Rice Research Center
Department of Agriculture
Ministry of Agriculture and Cooperatives

## Resource Persons

Mr. Wirote Laongmanee
GIS Specialist
SEA START RC
Chulalongkorn University

Mr. Suppakorn Chinvanno
Program Coordinator
SEA START RC
Chulalongkorn University

Dr. Anond Snidvongs
Director
SEA START RC
Chulalongkorn University

Dr. Attachai Jintrawet
Associate Professor
Multiple Cropping Center
Chiang Mai University

## Observers

Mrs. Bouangeun Oudomchit
Meteorology and Hydrology Department
Ministry of Agriculture and Forestry

Mr. Manolat Soukhanuvong
Meteorology and Hydrology Department
Ministry of Agriculture and Forestry

Mr. Chansamoud Keosoutha
Head,
Department of Irrigation Engineering
National University of Laos

Mr. Bounhome Silimanotham
Lecturer
Department of Irrigation Engineering
National University of Laos

Mr. Bounngeun Paseuthkoun
Lecturer
Department of Irrigation Engineering
National University of Laos

Mr. Loekham Thammalat
Lecturer
Department of Irrigation Engineering
National University of Laos

Mr. Somphone
Lecturer
Department of Irrigation Engineering
National University of Laos

Mr. Souvanh Talavong
National Agriculture and Forestry
Research Institute
Ministry of Agriculture and Forestry

Mr. Phetdavone
Water Resource Coordinating Committee
Office of Prime Minister

Mr. Chanthalangsy
Water Resource Coordinating Committee
Secretariat
Office of Prime Minister

Ms. Pailin Boukaew
Water Resource Coordinating Committee
Secretariat
Office of Prime Minister

Mr. Phonepaseuth Phoulipan
Technical Officer
Lao National Mekong Committee

Mr. Khampraseuth Keomany
Student
Department of Civil Engineering
National University of Laos

Mr. Khamvanh
Student
Department of Civil Engineering
National University of Laos

**Invited Guests**

Mr. Chanthanet Boualapha
APN SPG Member
Environmental Research Institute
Science, Technology and Environment Agency
Lao PDR

Mrs. Latsamay Sylavong
Program Manager
IUCN - Lao PDR

Dr. Asdaporn Krairapanond
Senior Environmental Officer
Ministry of Natural Resource and Environment
Thailand

Dr. Kansri Boonprakob
IPCC Council Member
Associate Professor
Ramkhamhang University
Thailand

Dr. Jariya Boonjawat
APN SPG Member
Associate Professor
Chulalongkorn University
Thailand

Mr. Kamol Sukin
Science and Environment Correspondence
The Nations Multimedia Group
Thailand

Ms. Rutchanee Uerpairojkit
Third Secretary
Royal Thai Embassy
Vientiane
Lao PDR