Integrated Hydroinformatics for Agricultural Drought Risk Assessment in Central Region of Thailand

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IMPAC-T

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Outline

- Background
- Members
- Purpose
- Input
- Group activities
- Research activities
- Output research
- Outcomes & social application
- Self evaluation
- Related works
- Conclusion

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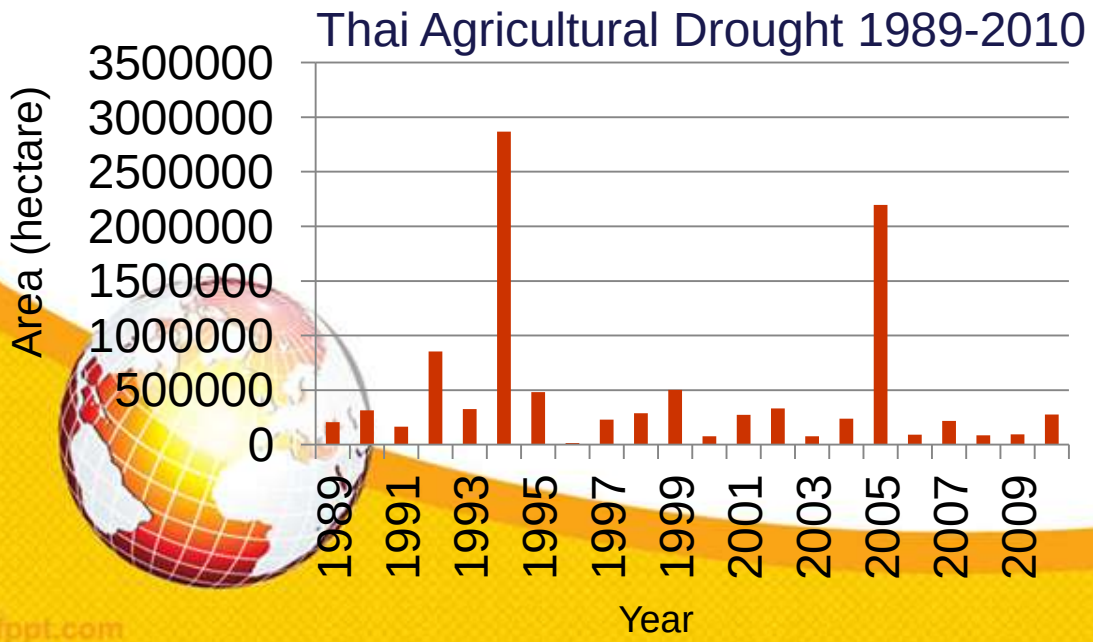
Background

- Drought is usually identified as principal constraint for the people during the dry season. During 1989-2010, drought has cost Thailand about 126,000,000 USD. (11,575,000,000 JPY.)
- Knowledge of the drought monitoring is an essential aspect of planning.



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Background

- Hydroinformatics, especially remotely sensed data and GIS, are widely accepted as a tool for the establishment of integrated information.
- The application of remote sensed data in drought studies is widely operational.
- It is very crucial to develop a warning system to detect potential agricultural drought risk at pre-planting and early crop growth stages, using a number of indicators.

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Members

- Kalyanee Suwanprasert
  - *Department of Water Resources and Faculty of Agriculture, Kasetsart University*

- Shinta Seto
  - *Graduate School of Engineering, Nagasaki University*

- Sudsaisin Kaewrueng
  - *Faculty of Agriculture, Kasetsart University*

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Purposes

- To develop near real-time agricultural drought risk assessment model by integrating rainfall satellite observation model with GIS based drought risk assessment model.
- To conduct framework of drought risk assessment and near real-time drought risk map.
- To validate model for drought risk analysis purpose.

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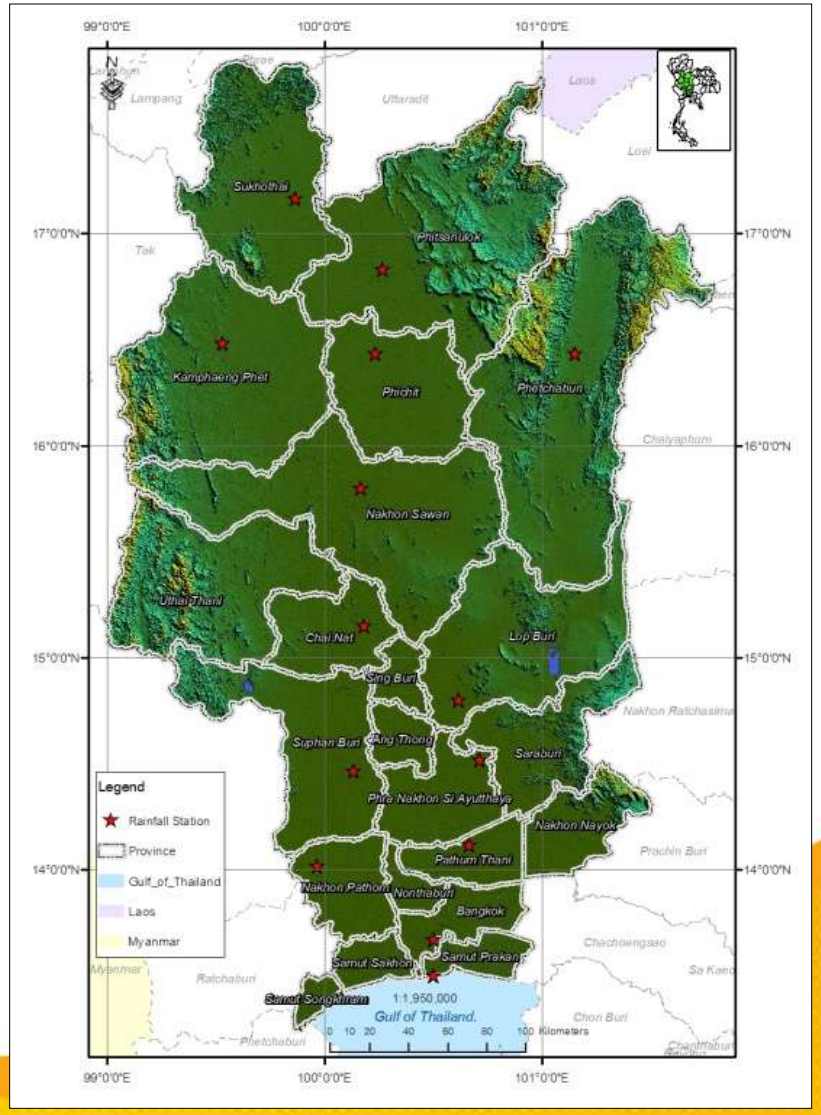
Study Area

- The study area covers 22 provinces in the Chao Phraya River basin, which are located in the central plain part of Thailand
- The main topographic features are the lowland and some mountainous area in the northern part.



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Input [1]

Financial support to research

- total: 1,303,321 Bath
  - Equipment (Spectroradiometer and accessories) ; 813,841Bath
  - Field survey in Thailand 69,680Bath
  - R.A. 157,500 Bath
  - Travel to Japan 262300Bath

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Input [2]

- Purchased Equipment
  - Spectroradiometer **813,841 Bath**

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1. Group Activities- Workshop of the IMPAC-T

- **Venue:** the Institute of Industrial Science, the University of Tokyo, Japan
- **Date:** November 2 - 7, 2009
- **Purpose:**
  - To share the knowledge what is need to drive IMPAC-T
  - To introduce and share the research case/activity in Japan.
  - To discuss about how to manage and implement our research activity of IMPAC-T

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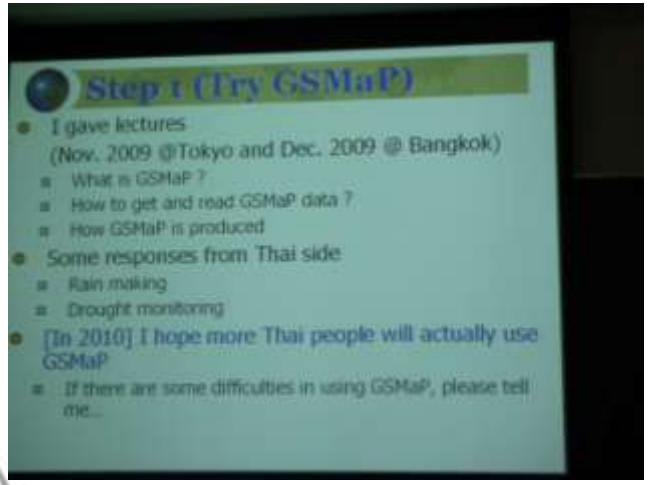
2.Group Activities- Preliminary project proposal in Japan

- **Venue:** Kyoto University, Japan
- **Date:** 27-29 March 2010,
- **Purpose: preliminary project proposal**



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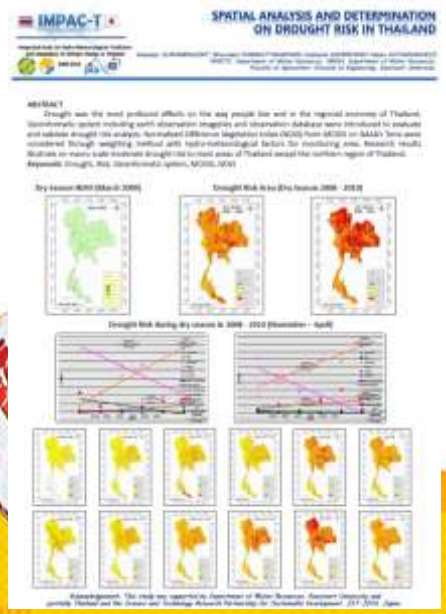
3. Group Activities- Workshop of the IMPAC-T

- **Venue:** Nakhon Nayok, Thailand
- **Date:** August 4 - 6, 2010
- To present “Spatial Analysis and Determination Drought Risk in Thailand



4. Group Activities- GSMaP Training in Japan

- **Venue:** Tokyo University, Japan
- **Date:** 7-11 June 2010,

- Practice GSMaP data extraction
- Discuss about GSMaP and MODIS relationship
- Research topic “GSMaP for Drought risk map”
- TOKYO Metropolitan Government visiting

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5. JSPS International Forum

- **6-7 January 2011 at Siam City Hotel, Bangkok, Thailand.**

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6. IMPAC-T Workshop 8-9 January 2011 at Kasetsart University, Bangkok, Thailand.

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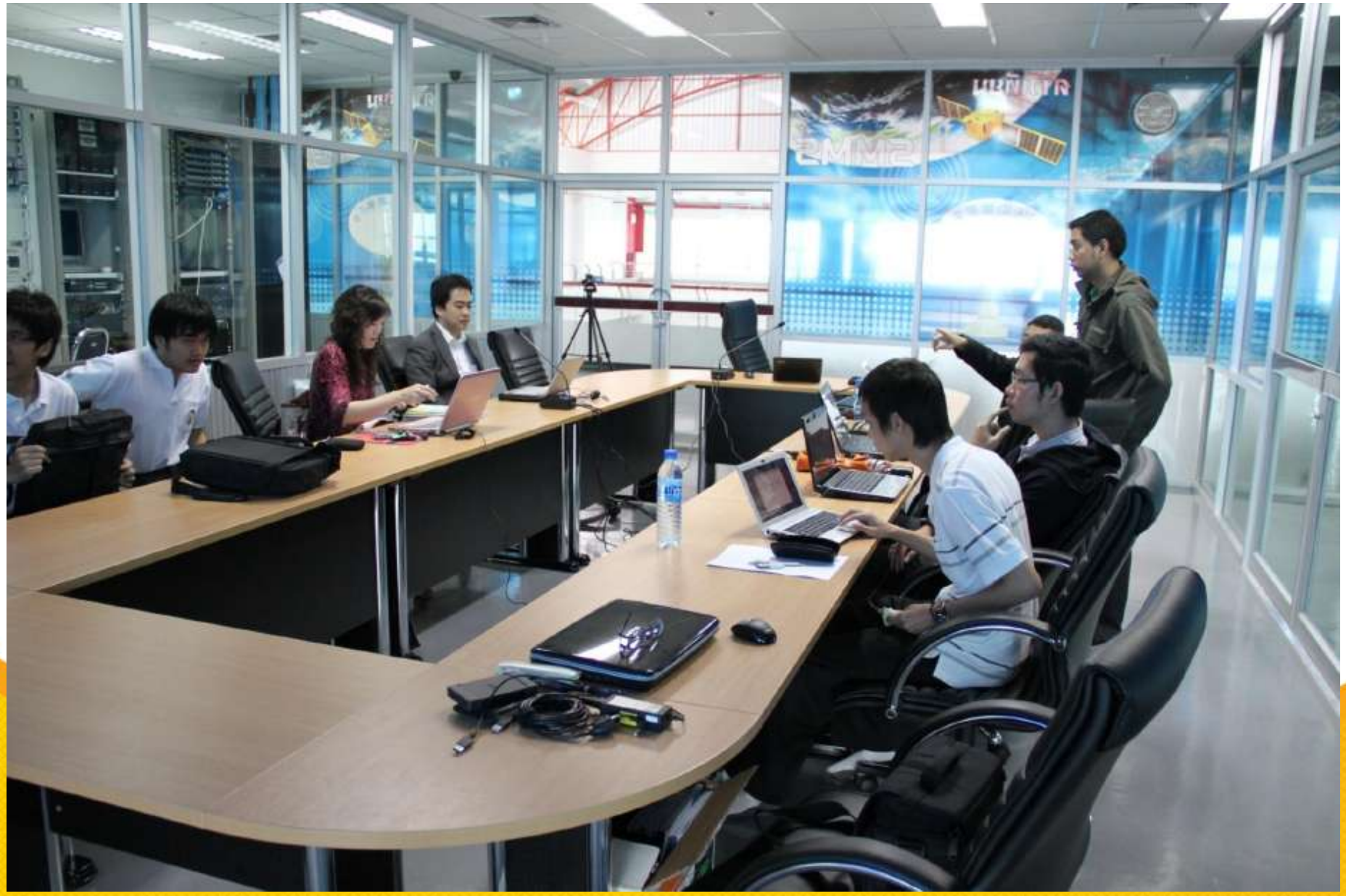
7. Rainfall Observation by Satellite Group Training from 28 – 30 March 2011 at KU



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8. IMPAC-T Project Biannual Workshop

- **Time and Date: 5th -7th August 2011**
- **Venue: KU home conference hall**

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9. Present paper in the 57th Conference on Hydraulic Engineering

4-8 March 2013 at Meijo University, Japan

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10. Technical visit in Nagasaki, Japan

- Purpose: To discuss the result of research, Integrated Hydroinformatics for Agricultural Drought Risk Assessment in Central Region of Thailand, prepare presentation in Sendi, HRL paper submission was also discussed.
- Time and Date: August 1st – 4th, 2013
- Venue:
  - The Geospatial Information Authority of Japan (GSI), Tsukuba
  - Japan Aerospace Exploration Agency (JAXA), Tsukuba
  - Nagasaki University, Nagasaki

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Research Activities

- Data Collection & Data Preparation
- Field survey for spectral reflectance measurement
- GSMaP Validation
- Near real-time drought risk indices from Remote sensing based for agricultural drought in Thailand
- Integrated hydroinformatics for agricultural drought risk assessment in central region of Thailand

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Data Collection & Data Preparation

- Collect data from related agencies
  - Land use data from Land Development Department (LDD)
  - Rainfall data from Thai Meteorological Department (TMD)
  - Drainage network from Department of Water Resources (DWR)

Attributes of Tele15Sta201103_AVG_rain_1_5

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2	Point	01	03/03/2011	.114583	1752375	612810
3	Point	01	04/03/2011	0	1752375	612810
4	Point	01	05/03/2011	0	1752375	612810
5	Point	01	06/03/2011	0	1752375	612810
6	Point	01	07/03/2011	0	1752375	612810
7	Point	01	08/03/2011	0	1752375	612810
8	Point	01	09/03/2011	0	1752375	612810

Record: 1 Show: All Selected Records (0 out of 155 Selected)

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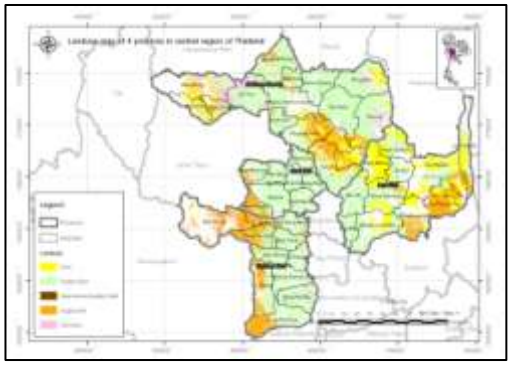
Field survey for spectral reflectance measurement

- Site survey for spectral libraries of crop water stress for comparing between drought and no-drought crop and interview with farmer and related stakeholders.
- target crops are rice, corn, cassava, and sugar cane.



-1st Field survey 25 - 29 April 2011:

Nakhon Sawan, Lop Buri, Chai Nat and Suphan Buri

-2nd Field survey 20 - 24 February 2012:

Phitsanulok, Phichit, Nakhon Sawan, and Lop Buri

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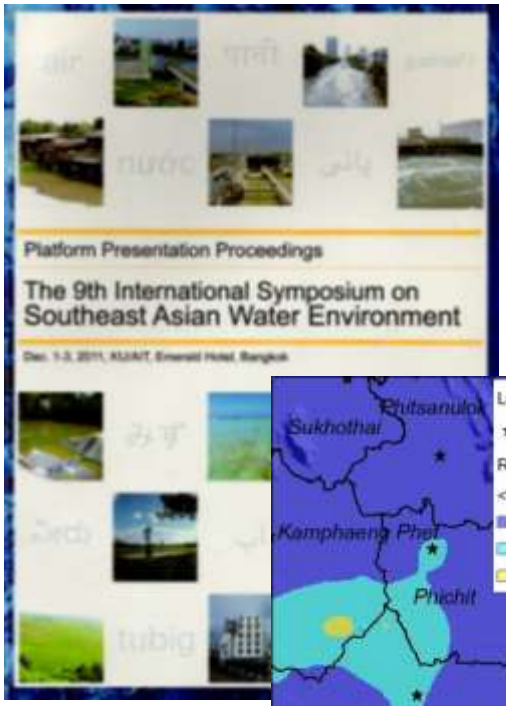
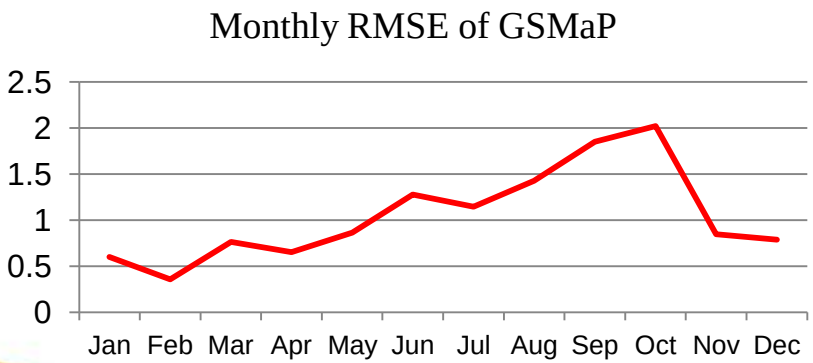
Present paper in the 9th International Symposium on Southeast Asian Water Environment

- Rainfall satellite observation model, GSMaP, was validated for drought risk analysis purpose
- GSMaP rain rate is validated by current rain measurements obtained from TMD.





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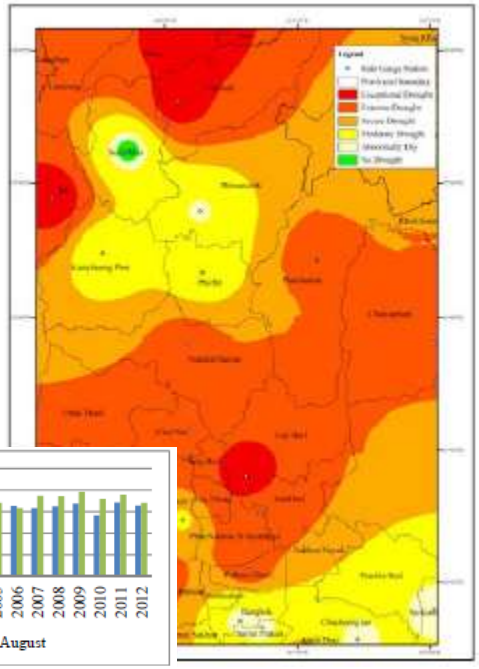
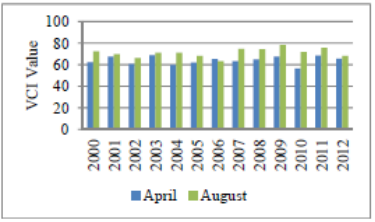
Present paper in the 57th Conference on Hydraulic Engineering





土木学会 JSCE 水工学委員会

Annual Journal of Hydraulic Engineering, JSCE, Vol.**, 2013, February

INTERGRATED DROUGHT RISK INDICES FROM CLIMATE BASED AND SATTLELITE BASED OBSERVATION FOR AGRICULTURAL DROUGHT MONITORING IN THAILAND

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[2]Member of JSCE, Dr. of Eng., Project Assoc. Prof., Institute of Industrial Science, The University of Tokyo (4-6-1 Komaba, Meguro, Tokyo 153-8505, Japan)
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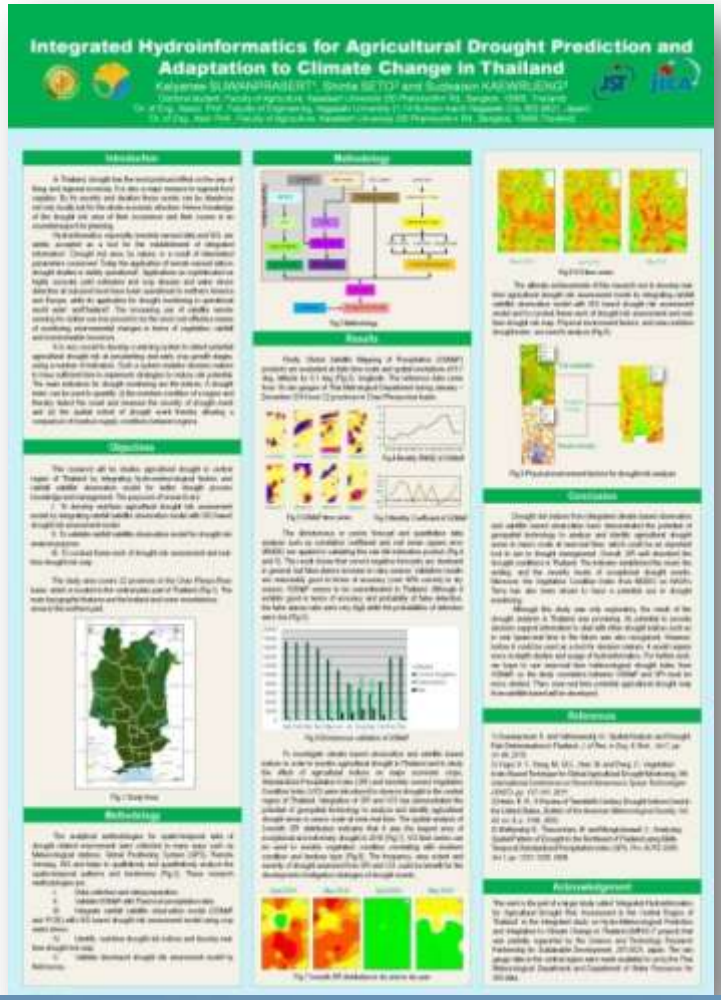
The objective of this study was to investigate climate based observation and satellite based indices in order to monitor agricultural drought in Thailand and to study the effect of agricultural indices on major economic crops. Standardized Precipitation Index (SPI) and remotely sensed Vegetation Condition Index (VCI) were introduced to observe drought in the central region of Thailand. Integration of SPI and VCI has demonstrated the potential of geospatial technology to analyze and identify agricultural drought areas in macro scale at near-real time. The spatial analysis of 3-month SPI distribution indicates that it was the largest area of exceptional and extremely drought in 2010. VCI time series can be used to monitor vegetation condition correlating with moisture condition and landuse type. The frequency, area extent and severity of drought assessed from SPI and VCI could be benefit for the development of mitigation strategies of drought events.

Key Words : Drought monitoring, Standardized Precipitation Index, Vegetation Condition Index

Poster Session in APWS 2013



2nd Asia-Pacific Water Summit

on Water Security and Water-related Disaster Challenges: Leadership and Commitment, 19th to 20th May 2013, and Technical Workshops on Water Security and Water-related Disaster Challenges, 16th to 18th May 2013, Chiang Mai, Thailand

HRL 2013

HRL 2013 - Integrated Hydroinformatics for Agricultural Drought Risk Assessment in Central Region of Thailand

Hydrological Research Letters

Integrated hydroinformatics for agricultural drought risk assessment in central region of Thailand

–Manuscript Draft–

Manuscript Number:	HRL-D-13-00047
Full Title:	Integrated hydroinformatics for agricultural drought risk assessment in central region of Thailand
Short Title:	Integrated hydroinformatics for drought risk
Article Type:	Original (Resubmission)
Keywords:	Drought risk assessment; Near real time; Vegetation Health Index
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First Author:	Kalyanee Suwanprasert
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Order of Authors:	Kalyanee Suwanprasert
	Shinta Seto, Associate Professor, Dr. Eng.
	Sudsaisin Kaewrueng, Assistant Professor, Ph.D.
Order of Authors Secondary Information:	
Abstract:	This study is aimed to develop near real-time agricultural drought risk assessment model and conduct framework by integrating rainfall satellite observation model with GIS based drought risk assessment model. Global Satellite Mapping of Precipitation (GSMaP) data and remotely sensed Vegetation Health Index (VHI) were introduced to assess drought risk in the central region of Thailand. The result shows that drought risk assessment by integrated satellite based observation and GIS based model can present drought-prone areas at near-real time. This framework can assess agricultural drought risk in 15-30 days with crop phonological consideration. The integration of hydroinformatics from remote sensing and GIS analysis would be advantage to drought mitigation and management.

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Research Outputs

- Platform Presentation Proceeding SEAWE 2011 - Validation of GSMaP rainfall estimates with local rainfall gauge in Thailand
- Journal of Hydraulic Engineering 2012 - Integrated drought risk indices from climate based and satellite based observation for agricultural drought monitoring in Thailand
- HRL 2013 - Integrated Hydroinformatics for Agricultural Drought Risk Assessment in Central Region of Thailand

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Validation of GSMaP rainfall estimates with local rainfall gauge in Thailand

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Faculty of Agriculture, Kasetsart University,
Shinta SETO, Member of JSCE, Dr. of Eng., Project Assoc. Prof.,
Nagasaki University,
Sudsaisin KAEWRUENG, Dr. of Eng., Asst. Prof.,
Faculty of Agriculture, Kasetsart University

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Objective

- To validate GSMaP, rainfall satellite observation model, for drought risk analysis purpose at daily time scales and a spatial resolution of 0.1 latitude/longitude with local rainfall gauge data.

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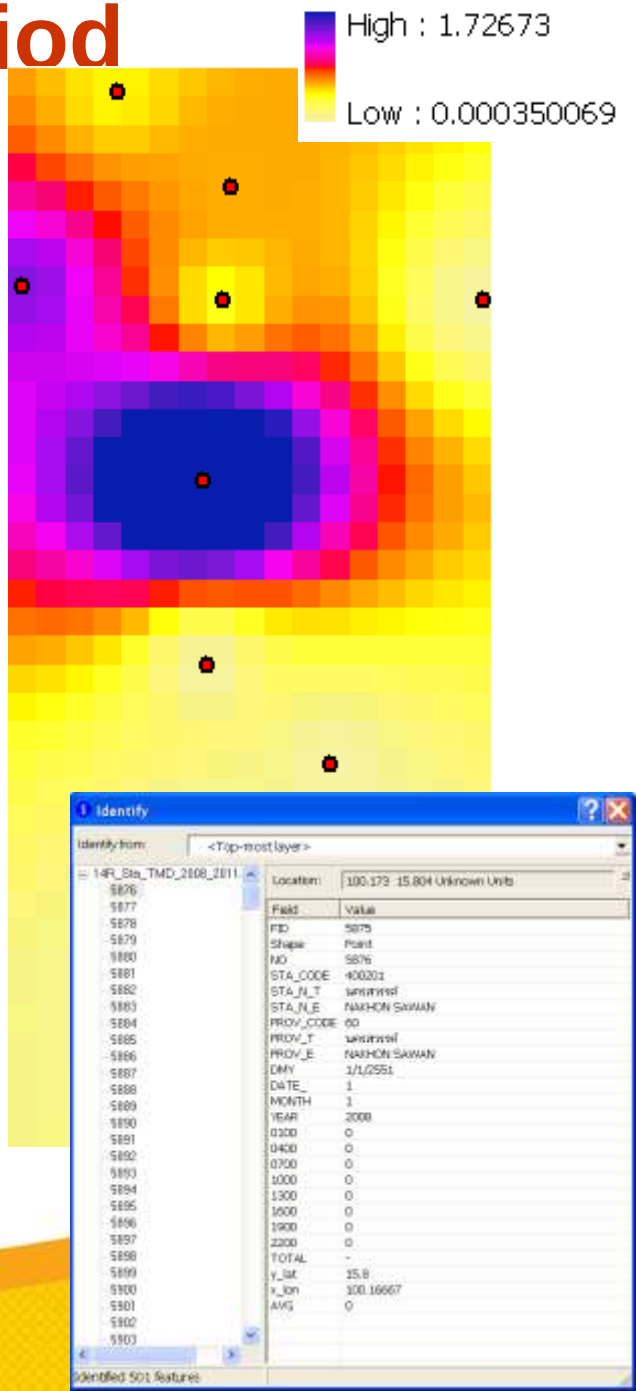
Data and Analyze Period

- Using rainfall measurement during 2010 from 14 stations to compute
  - Daily/ Weekly/Monthly comparison of rain gauge measurements
  - Spatial mean rain rate
- Using Inverse distance weighting (IDW) method to interpolate rain gauge data



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Validation Method

Validation statistics base on forecast verification issues, methods of WCRP (http://www.cawcr.gov.au/projects/verification)

- Method for dichotomous (yes/no) forecast
- Method for forecast of continuous variables

WCRP
World Climate Research Programme

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Contingency Table for dichotomous (yes/no) forecast

		Observed		
Forecast		Yes	No	Total
	Yes	hits	false alarms	forecast yes
	No	misses	correct negatives	forecast no
Total		observed yes	observed no	total

hit - event forecast to occur, and did occur

miss - event forecast not to occur, but did occur

false alarm - event forecast to occur, but did not occur

correct negative - event forecast not to occur, and did not occur

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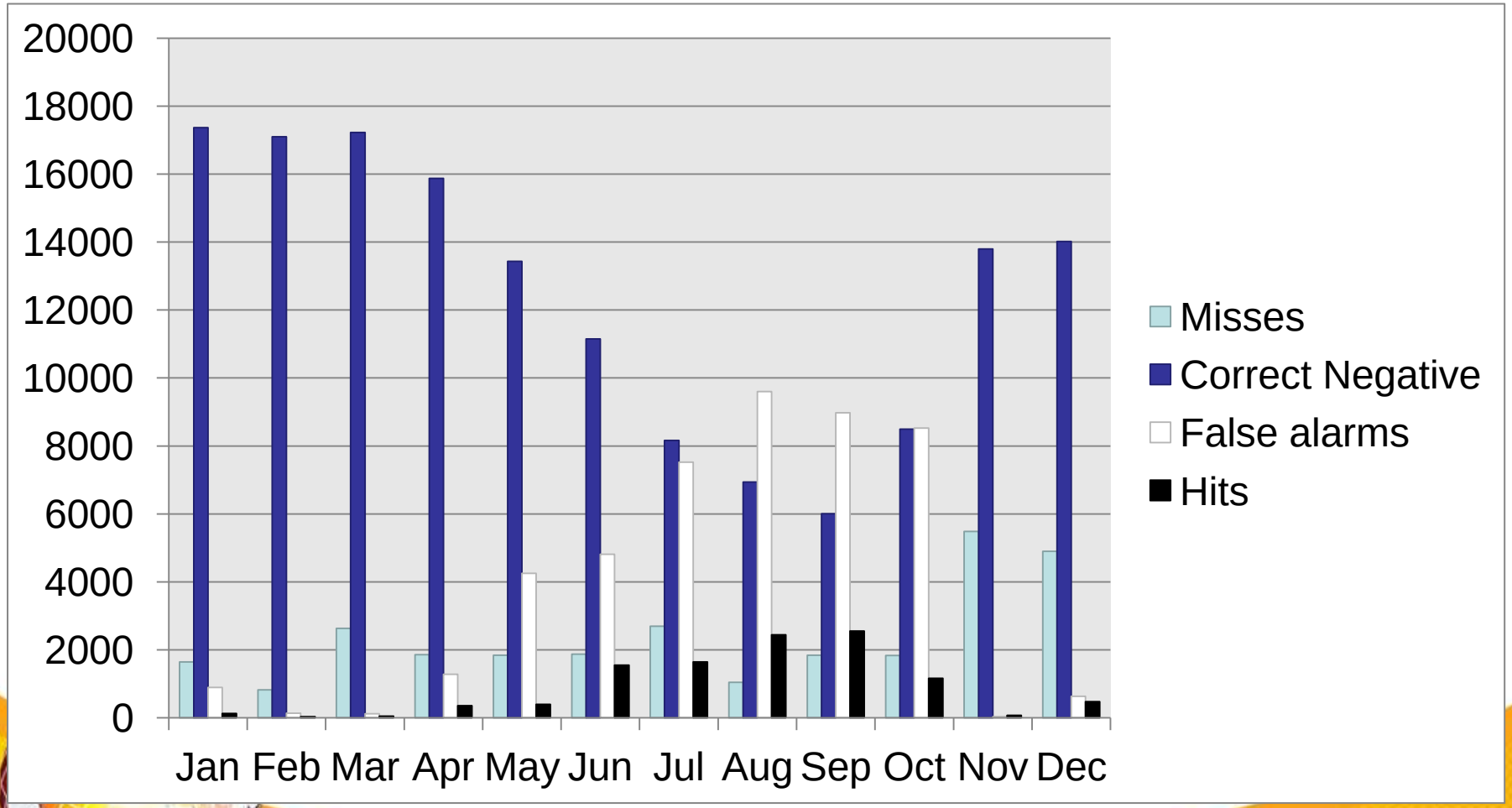
Four Scenarios of GSMaP VS. Rain Gauge



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Validation Result: dichotomous

Validation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Overall**
Accuracy	0.87	0.95	0.86	0.84	0.69	0.66	0.49	0.47	0.44	0.48	0.72	0.72	**0.68**
BIAS	0.58	0.20	0.06	0.74	2.08	1.86	2.11	3.45	2.62	3.23	0.02	0.21	**1.47**
POD	0.07	0.04	0.02	0.16	0.18	0.45	0.38	0.70	0.58	0.39	0.01	0.09	**0.28**
FAR	0.88	0.81	0.70	0.78	0.91	0.76	0.82	0.80	0.78	0.88	0.28	0.57	**0.81**
POFD	0.05	0.01	0.01	0.07	0.24	0.30	0.48	0.58	0.60	0.50	0.00	0.04	**0.24**
TS	0.05	0.03	0.02	0.10	0.06	0.19	0.14	0.19	0.19	0.10	0.01	0.08	**0.13**
ETS	0.01	0.02	0.01	0.05	-0.02	0.06	-0.03	0.03	-0.01	-0.03	0.01	0.03	**0.02**
HK	0.02	0.03	0.01	0.09	-0.06	0.15	-0.10	0.12	-0.02	-0.11	0.01	0.04	**0.04**
OR	1.48	4.91	2.82	2.40	0.68	1.92	0.66	1.68	0.93	0.63	6.37	2.13	**1.22**

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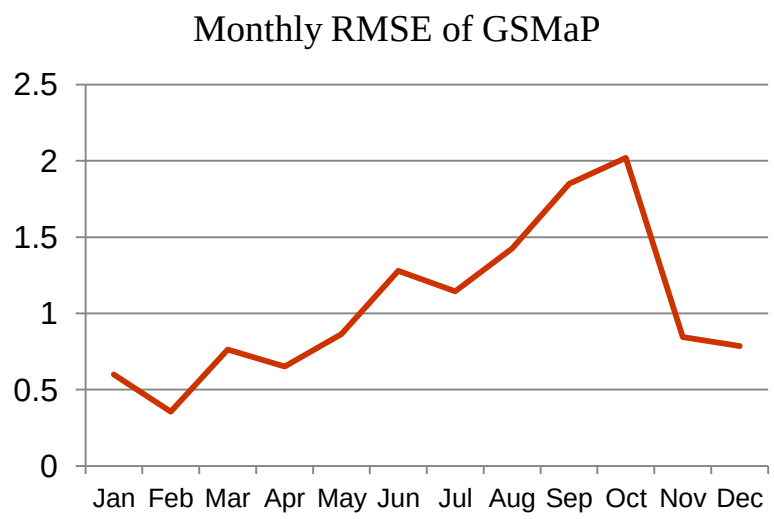
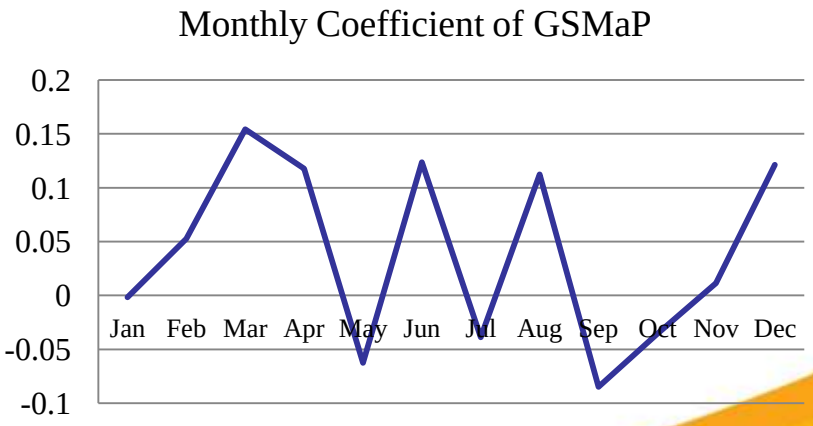
Continuous data analysis

Month	RMSE	Coefficient
Jan	0.5994	-0.0018
Feb	0.3568	0.0527
Mar	0.7623	0.1544
Apr	0.6528	0.1178
May	0.8645	-0.0626
Jun	1.2779	0.1237
Jul	1.1456	-0.0388
Aug	1.4267	0.1124
Sep	1.8490	-0.0849
Oct	2.0188	-0.0355
Nov	0.8457	0.0114
Dec	0.7862	0.1212
Overall	1.1619	0.0195





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Conclusion

- GSMaP is an alternative way to estimate rainfall in hydro-meteorological studies in Thailand.
- Although GSMaP exhibits positive accuracy, the false alarms ratios were very high while the probabilities of detection were low.

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INTEGRATED DROUGHT RISK INDICES FROM CLIMATE BASED AND SATTLELITE BASED OBSERVATION FOR AGRICULTURAL DROUGHT MONITORING IN THAILAND

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Sudsaisin KAEWRUENG, Dr. of Eng., Asst. Prof.,
Faculty of Agriculture, Kasetsart University

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Objectives of study

- investigate climate based observation and satellite based indices in order to monitor agricultural drought in Thailand
- study the effect of agricultural indices on major economic crops

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Methodology

Monthly rainfall

↓

2000-2012 Rain gauge station in ASCII

↓

SPI_sl_6

↓

Standardized Precipitation Index (SPI)

↓

Kriging interpolation

NDVI from MODIS

↓

$$VCI_j = \frac{NDVI_j - NDVI_{min}}{NDVI_{max} - NDVI_{min}} * 100\%$$

↓

Vegetation Condition Index (VCI)

↓

Potential agricultural drought monitoring

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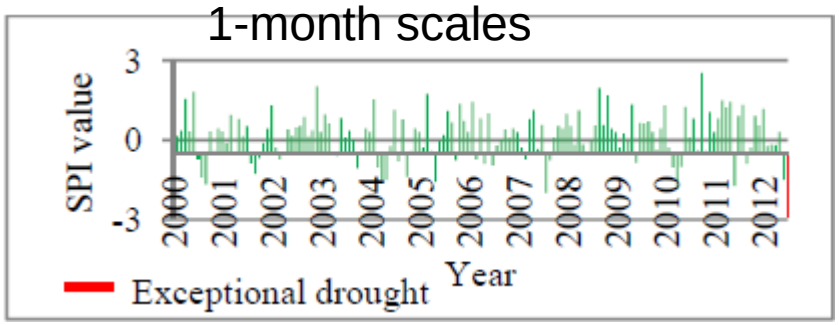
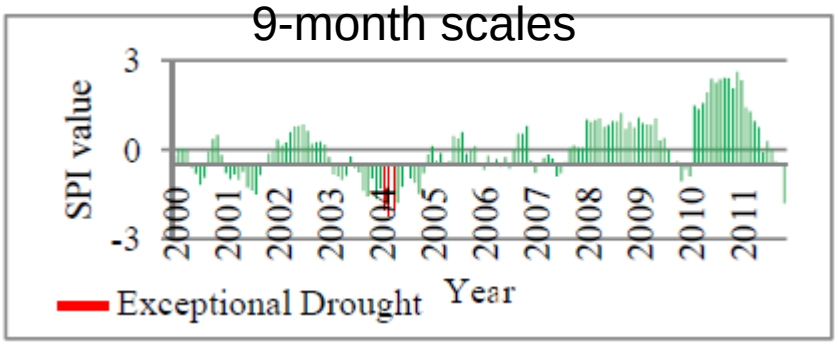
SPI analysis

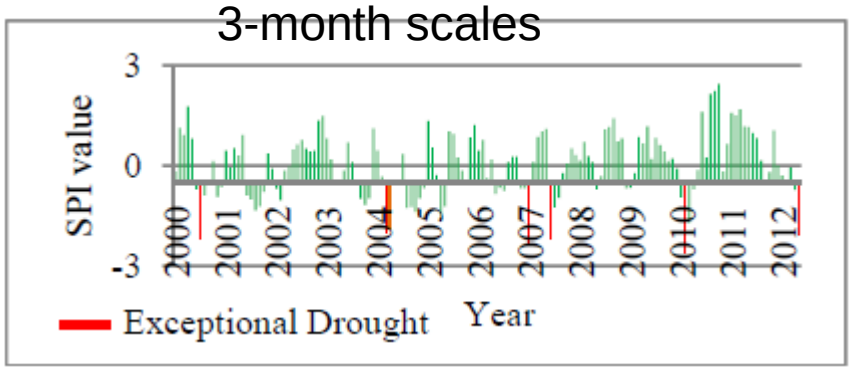
1-month scales



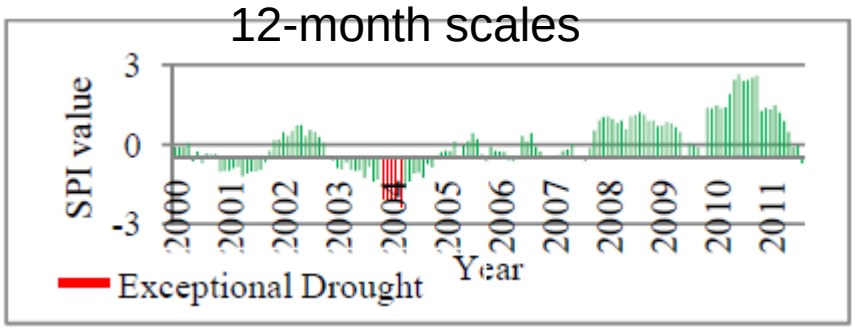
9-month scales



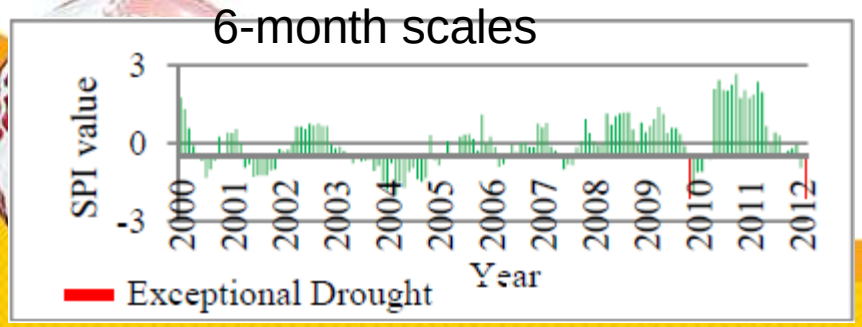
3-month scales



12-month scales



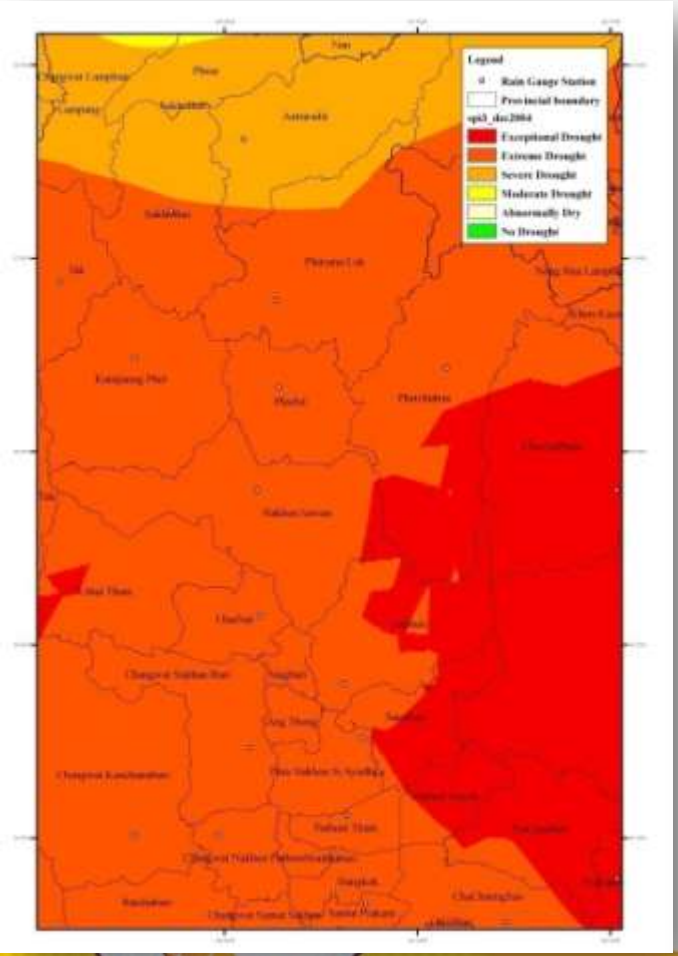
6-month scales



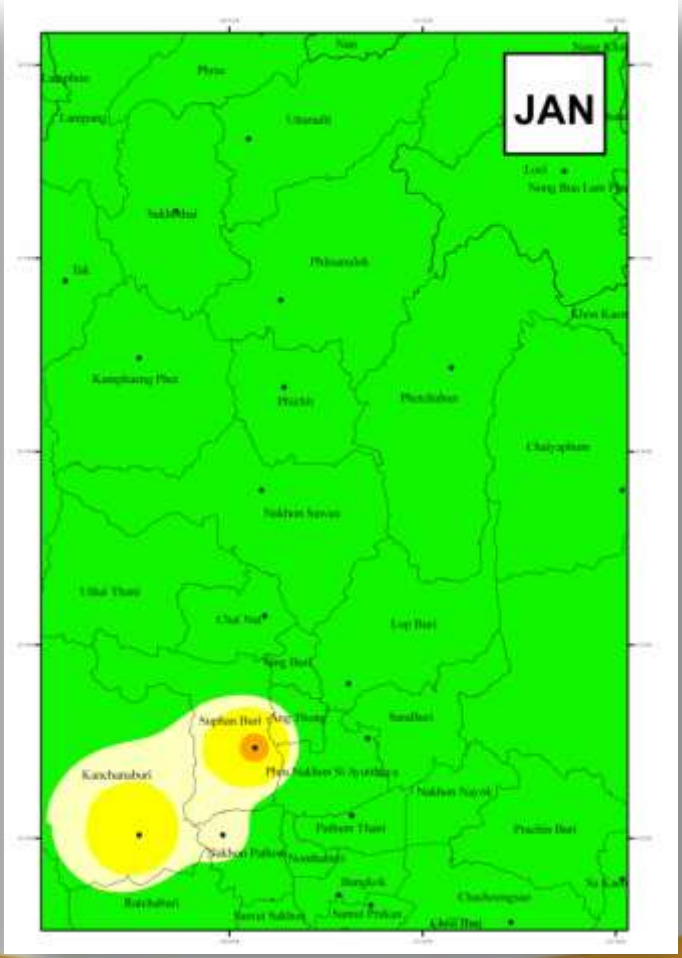
Nakhon Sawan

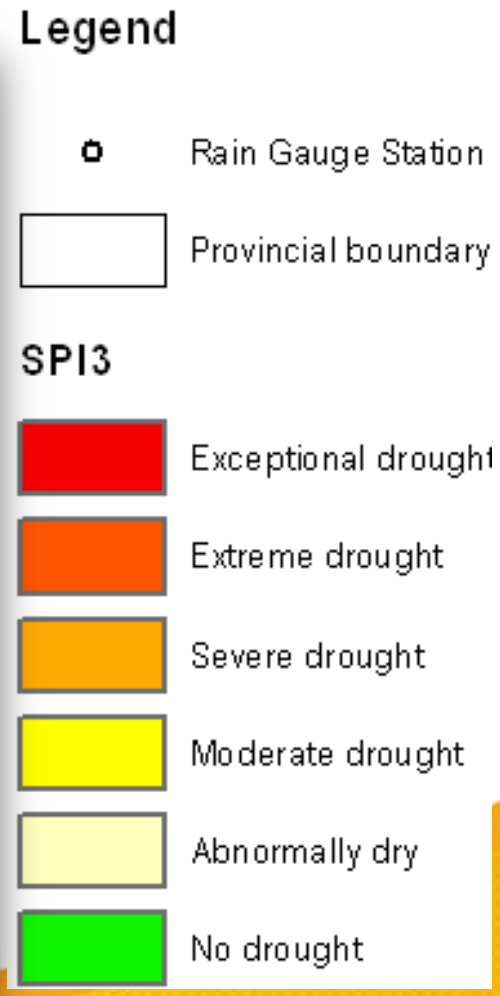
3 month SPI distribution

December 2004



2010 SPI time series





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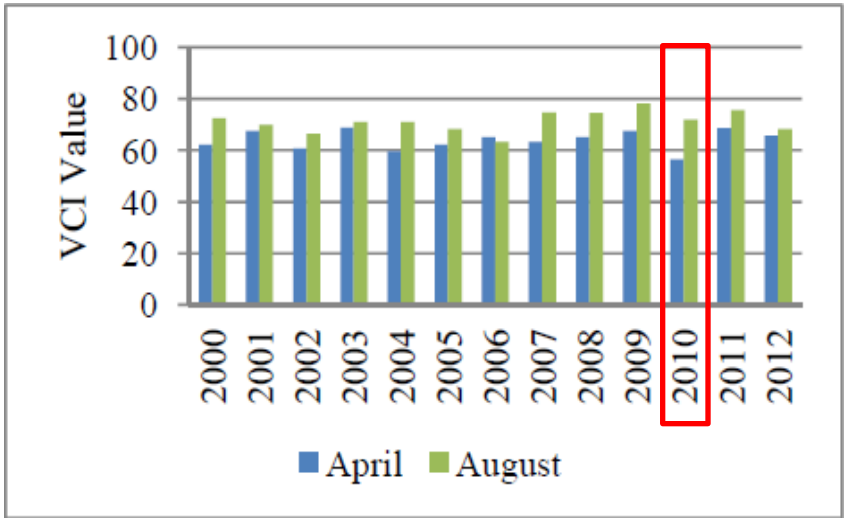
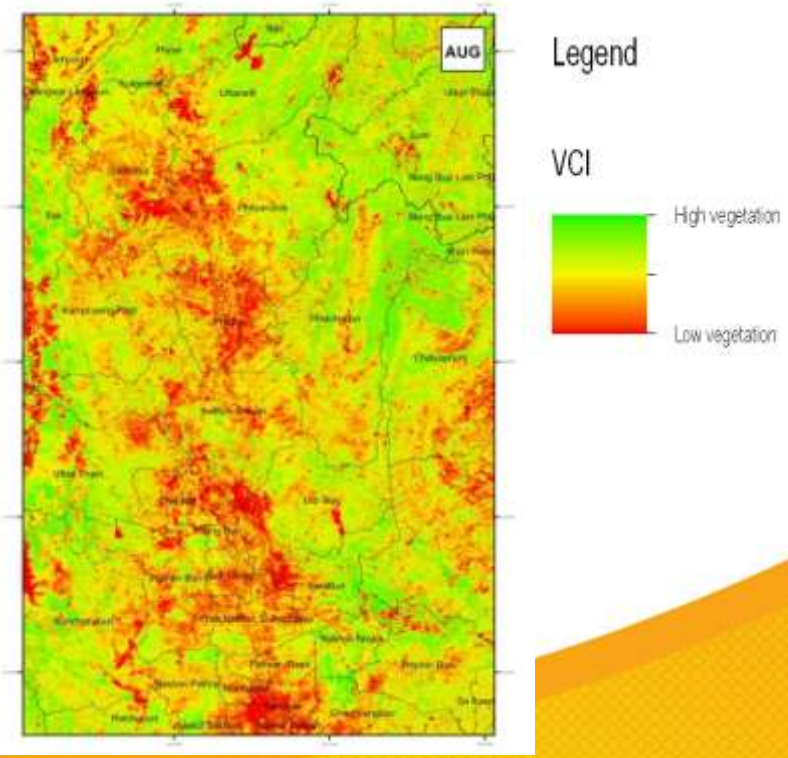
VCI analysis

- This process was analyzed by selected mean VCI value in dry season (April) and rainy season (August) during 2000 - 2012.
- Mean VCI value of dry and rainy season months indicates that the worst drought year was in 2010.
- The comparison of VCI between dry and rainy season month shows less mean VCI value in dry season than rainy season every year except in 2006.





VCI in April and August 2010 comparison

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Dry & Wet condition VCI comparison by landuse classification

	April 2010				April 2003				
	Dry condition				Wet condition				
Landuse Classification	**min**	**max**	**mean**	**S.D.**	**min**	**max**	**mean**	**S.D.**	**Change (%)**
Cassava	6.48	84.48	46.14	8.28	14.26	92.26	60.17	10.76	23.31
Corn	5.95	88.37	50.34	10.26	0.02	94.85	65.27	11.22	22.87
Corn & Sugarcane	41.25	80.27	54.74	8.20	42.79	86.16	66.19	8.40	17.29
Paddy field	0	89.99	49.33	9.57	0.09	97.30	59.86	10.40	17.59
Sugarcane	8.06	86.58	48.42	8.14	0.45	97.01	59.24	10.04	18.26

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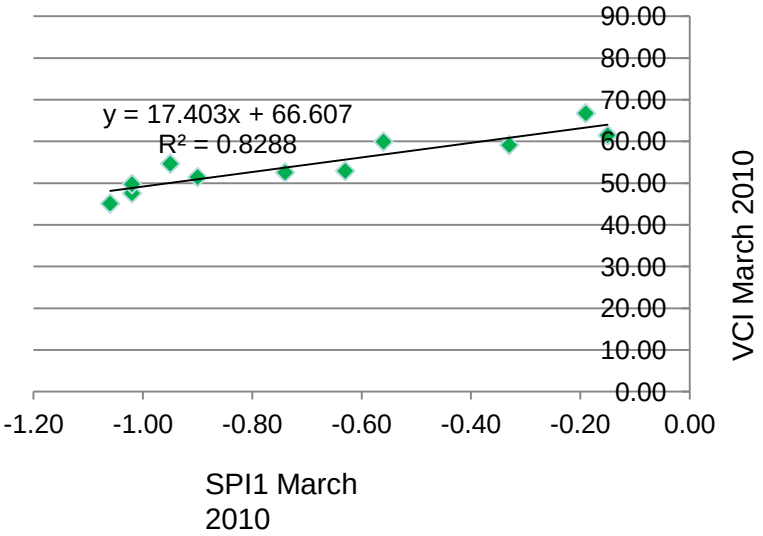
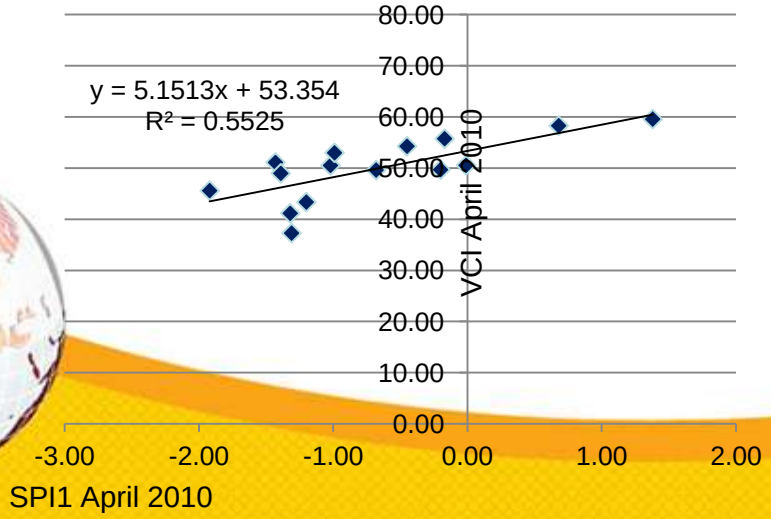
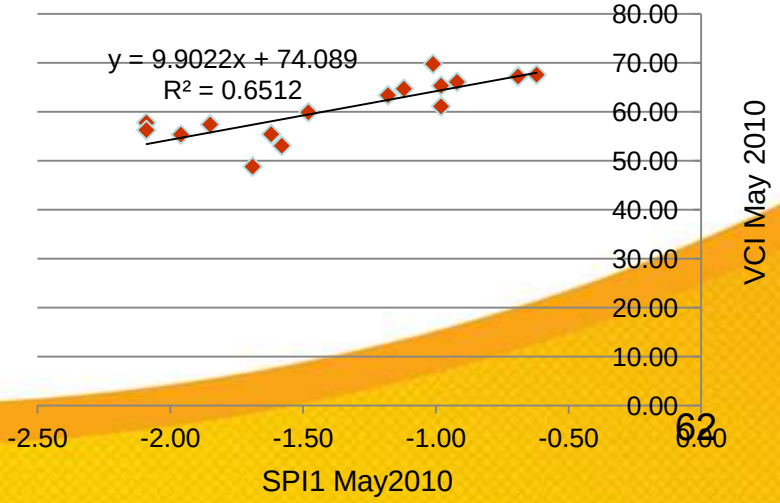
SPI1 & VCI Spatial Correlation

- Selected SPI and VCI in dry season, March, April and May 2010 which is one of the driest of study area in 12 years are compared between value in the same month.
- This positive correlation reveal that rainfall or SPI value affects the greenness or dryness of vegetation.







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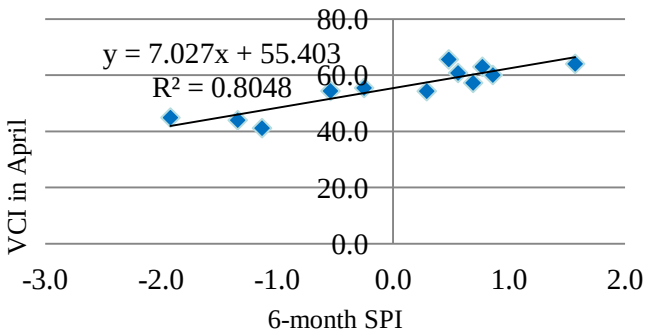
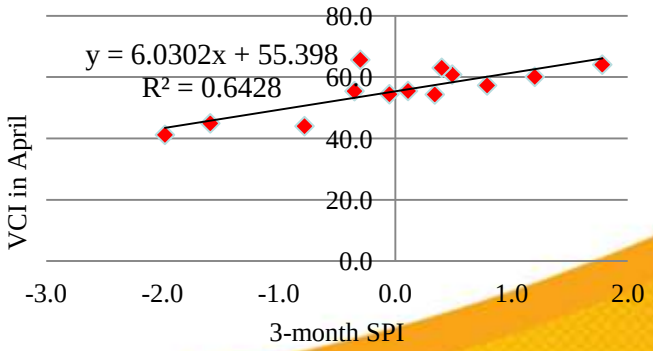
SPI & VCI Interannual Correlation

- SPI and VCI value at specific rain gauge station were plotted and regression was analyzed.
- SPI and VCI every April during 2000 – 2012 were selected to study inter-annual relationship.
- Most of them show a positive correlation but quite low correlation between SPI and VCI.
- However, some stations demonstrate a high correlation in the northern area.



Correlation of VCI with 6-month SPI in April at Phrae station



Correlation of VCI with 3-month SPI in April at Phrae station

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Conclusion

- Integrated climate based observation and satellite based observation have demonstrated the potential of geospatial technology to analyze and identify agricultural drought areas in macro scale
- SPI can use in agricultural drought monitoring as meteorological drought index
- VCI can be used as indices to drought monitoring in Thailand.
- Rainfall or SPI value effect the condition of vegetation, especially in the short time period

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INTEGRATED HYDROINFORMATICS FOR AGRICULTURAL DROUGHT RISK ASSESSMENT IN CENTRAL REGION OF THAILAND

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Nagasaki University,
Sudsaisin KAEWRUENG, Dr. of Eng., Asst. Prof.,
Faculty of Agriculture, Kasetsart University

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Objectives

- to develop near real-time agricultural drought risk assessment model and conduct framework by integrating rainfall satellite observation model with GIS based drought risk assessment model.

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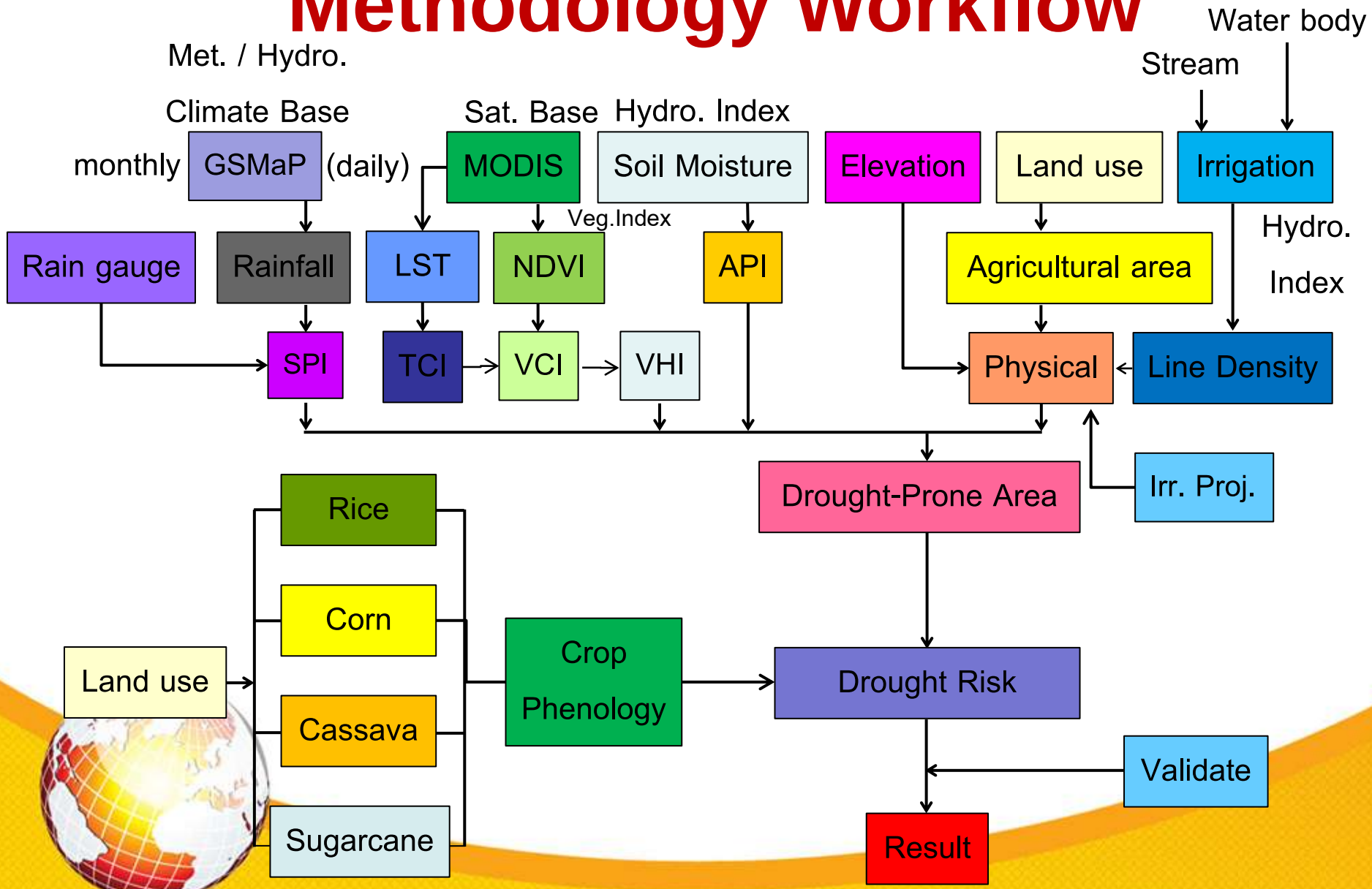
Methodology Workflow



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Drought Indices in this study

Standardized Precipitation Index (SPI)

- SPI is the number of standard deviations that observes cumulative precipitation deviating from the climatologically average and can be calculated for any time scale.

Vegetation condition Index (VCI)

- VCI assesses changes in the Normalized Difference Vegetation Index (NDVI) signal through time due to weather conditions, reducing the influence of ‘geographic’ (Kogan, 1990) or ‘ecosystem’ (Kogan, 1995c) variables i.e. climate, soils, vegetation type and topography.

$$VCI_j = \frac{NVDI_j - NDVI_{min}}{NDVI_{max} - NDVI_{min}} * 100\%$$

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Drought Indices in this study (2)

- Temperature Condition Index :TCI

  Its algorithm is calculate similar to VCI but its formulation was modified to reflect vegetation ‘s respond to temperature.

  $$TCI = 100* (LST_{max} – LST_i)/ (LST_{max} – LST_{mix})$$

- Vegetation Health Index: VHI

  VHI represents overall vegetation health

  $$VHI = 0.5(VCI + TCI)$$

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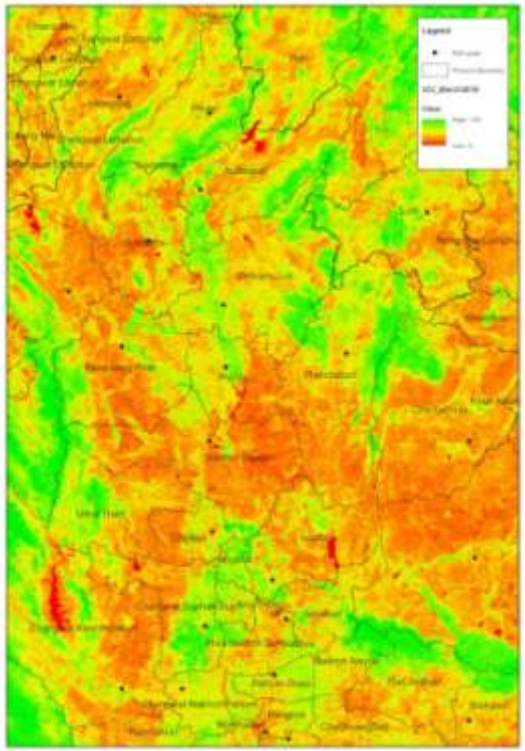
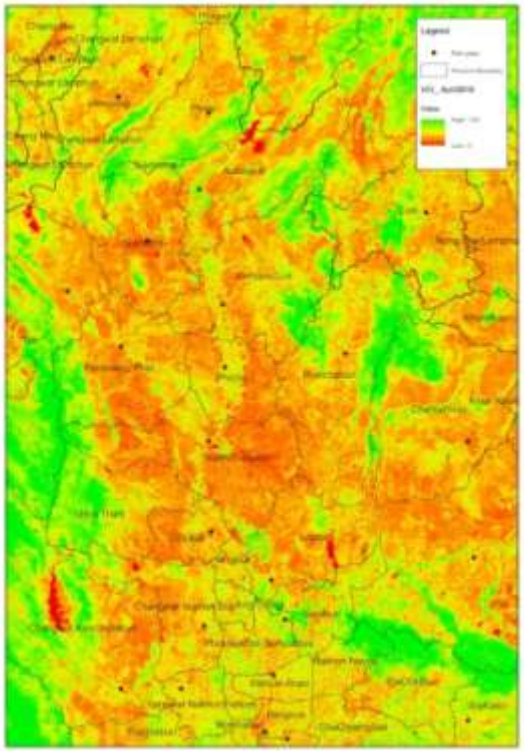
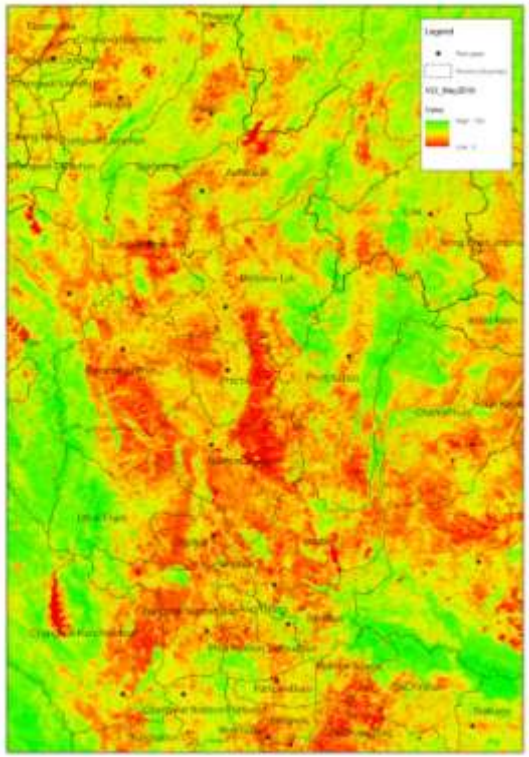
VCI time series



March 2010



April 2010



May 2010

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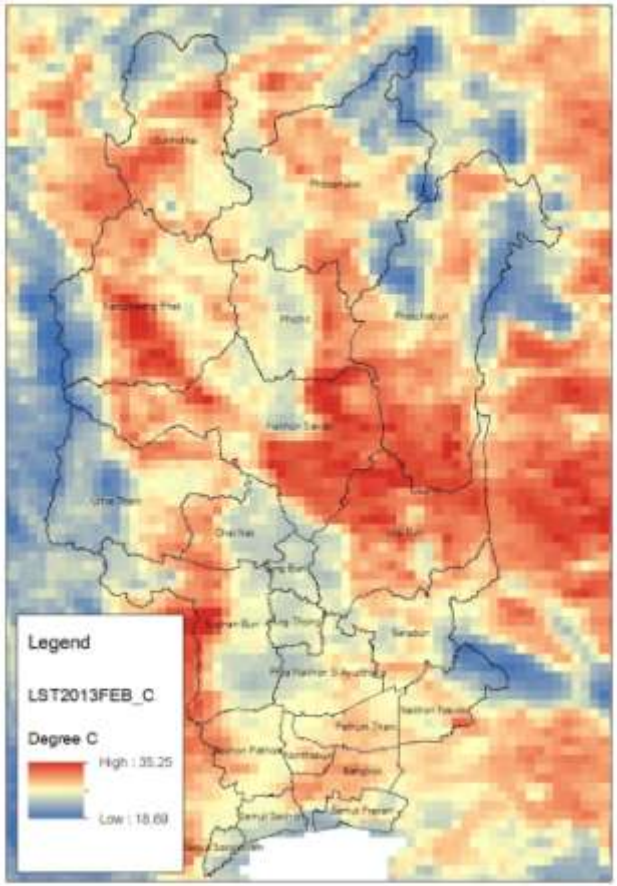
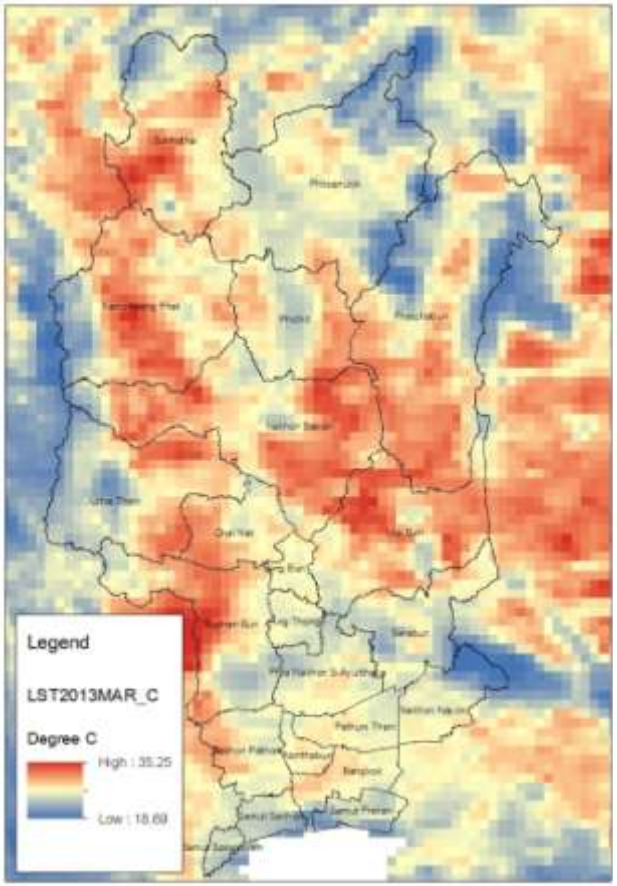
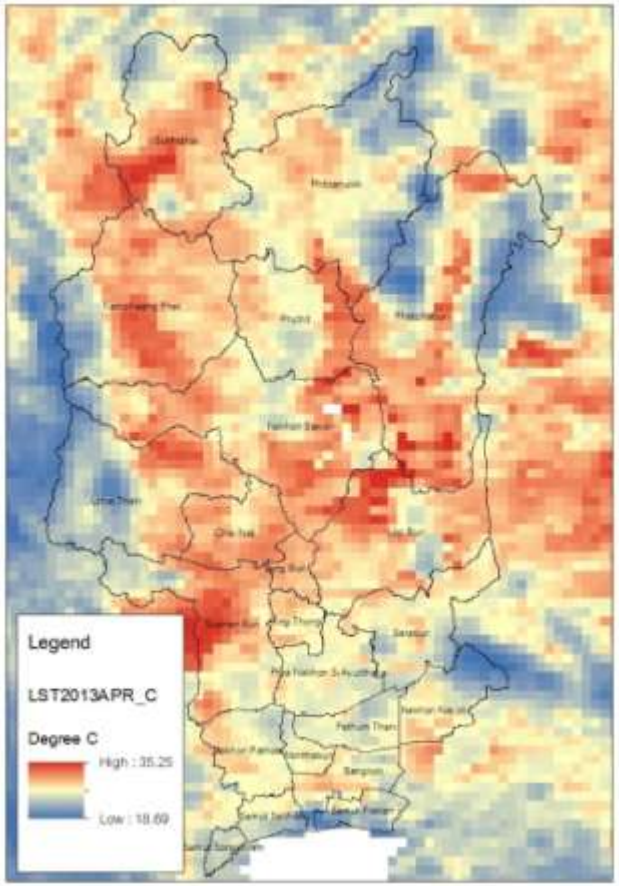
Land Surface Temperature







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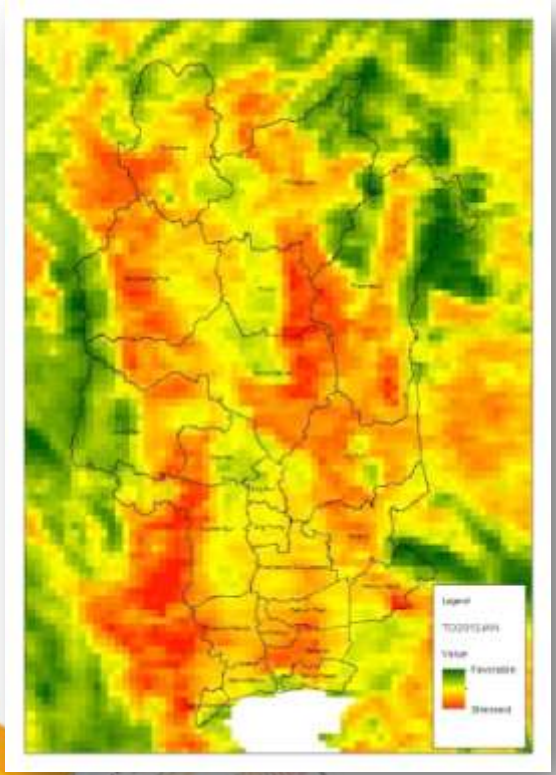
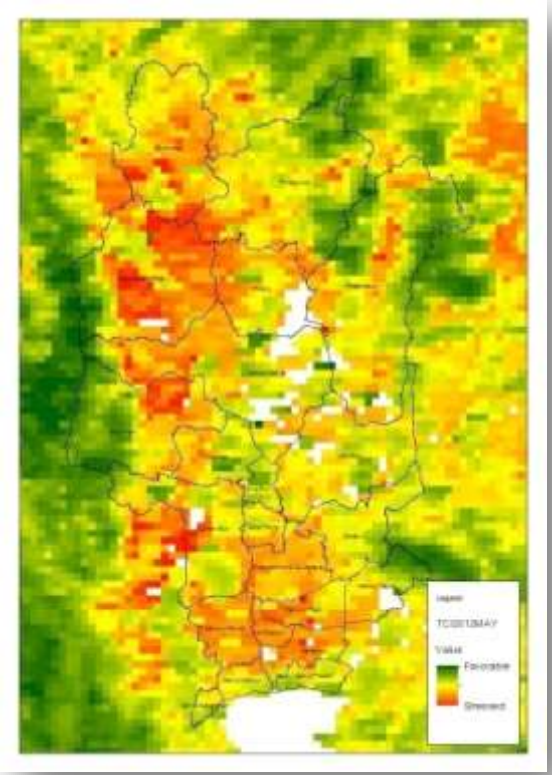
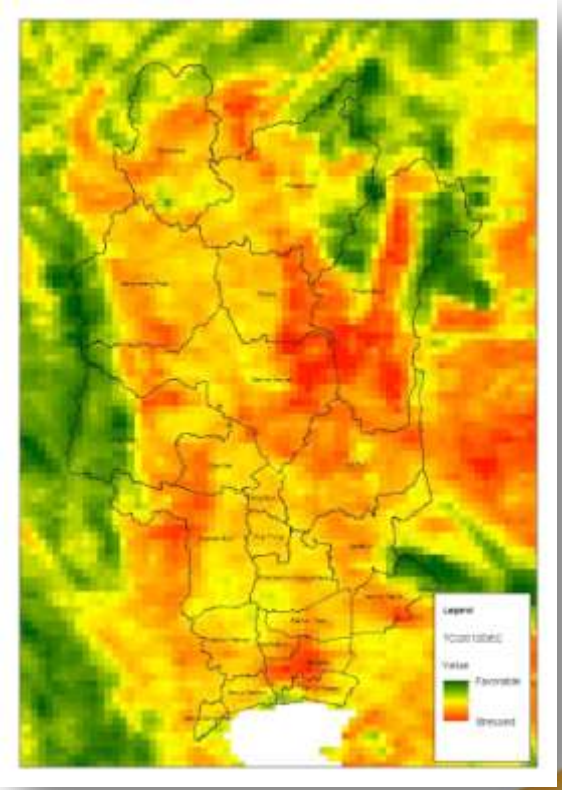
Temperature Condition Index (TCI)



JAN 2012



MAY 2012



DEC 2012

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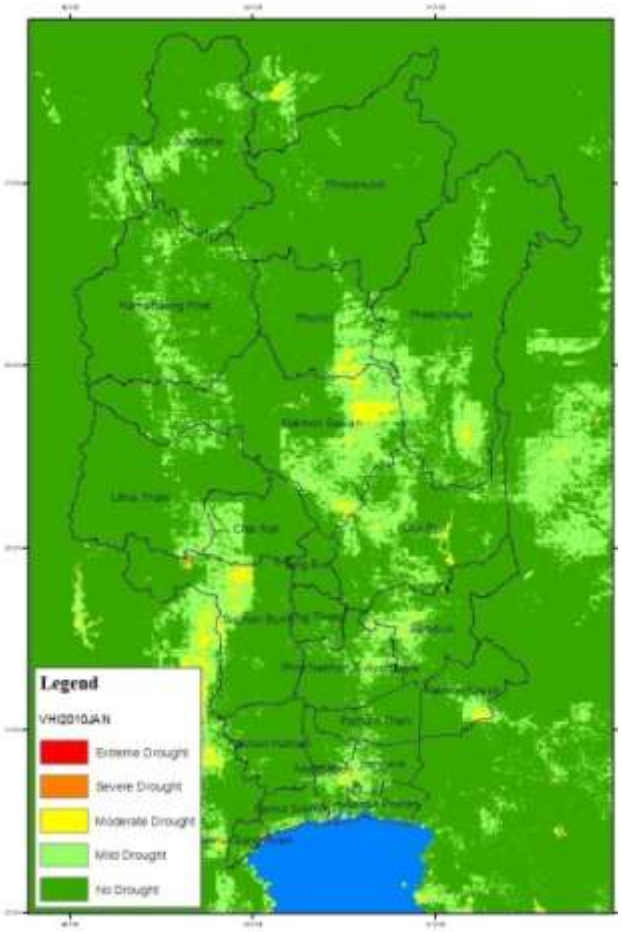
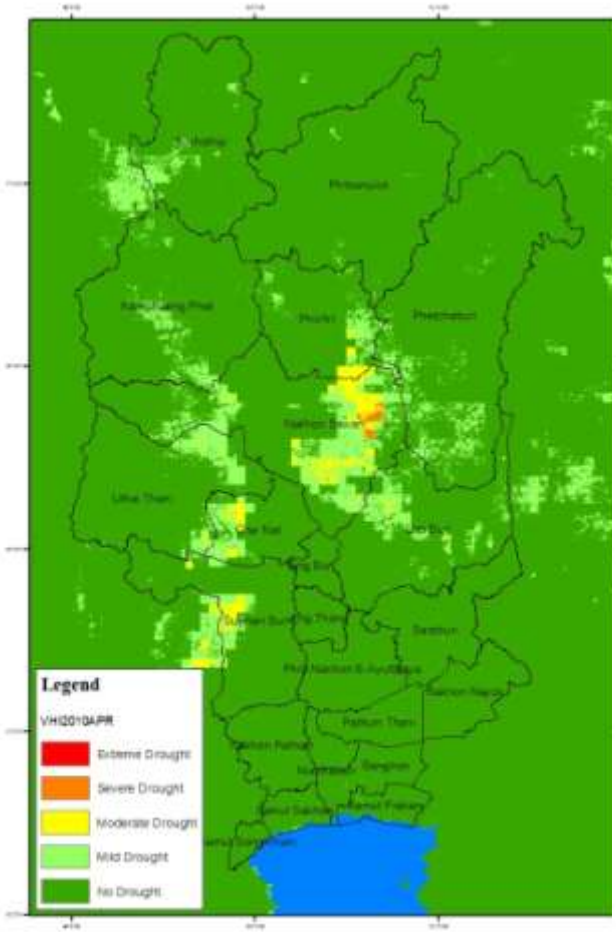
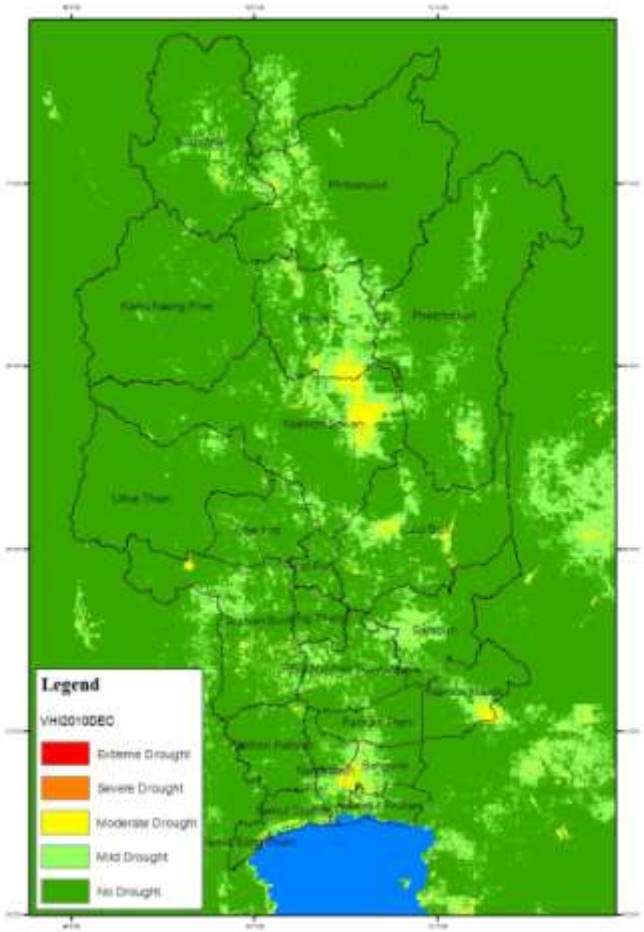
Vegetation Health Index (VHI)



VHI JAN2010



VHI APR2010



VHI DEC2010

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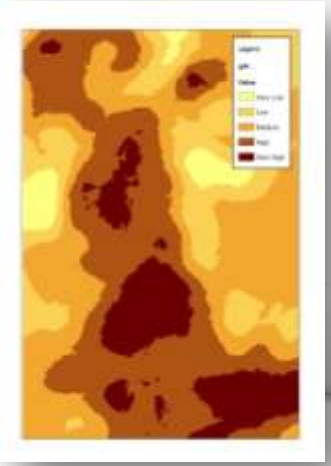
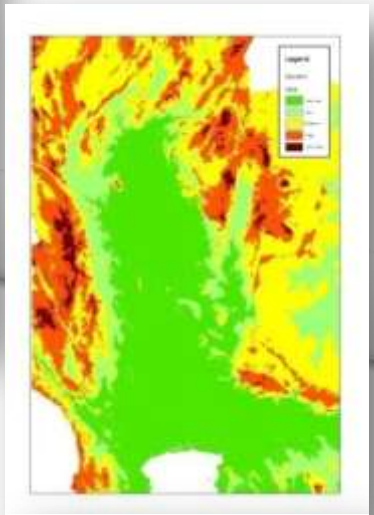
Physical environment factors for drought risk analysis

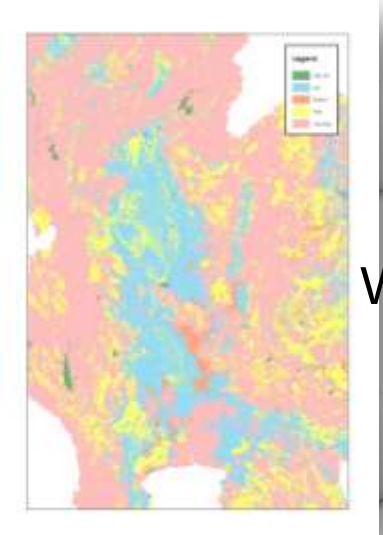


Soil Moisture

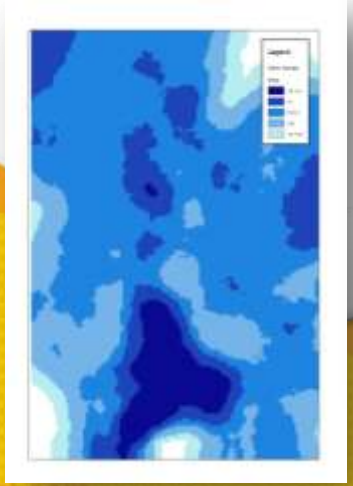
Elevation

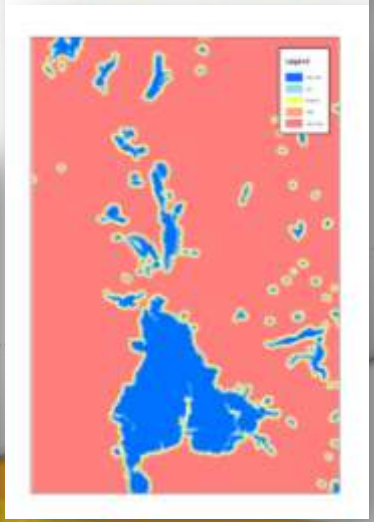


Soil suitability



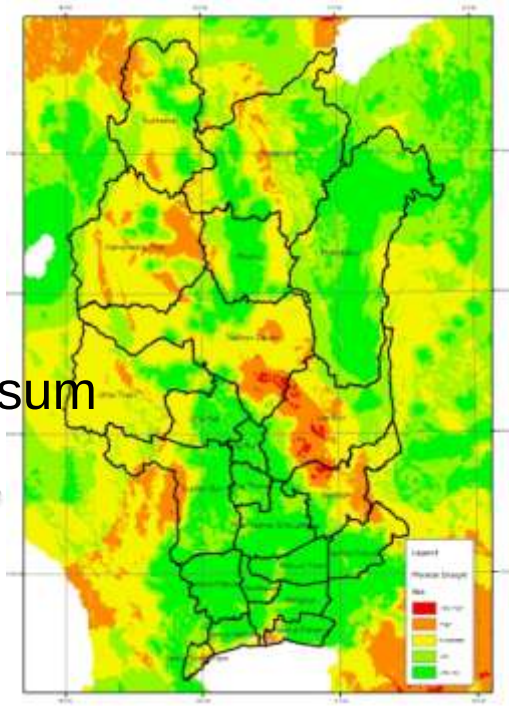
Stream density





Irrigation Area

Weighted sum



Physical drought vulnerability map

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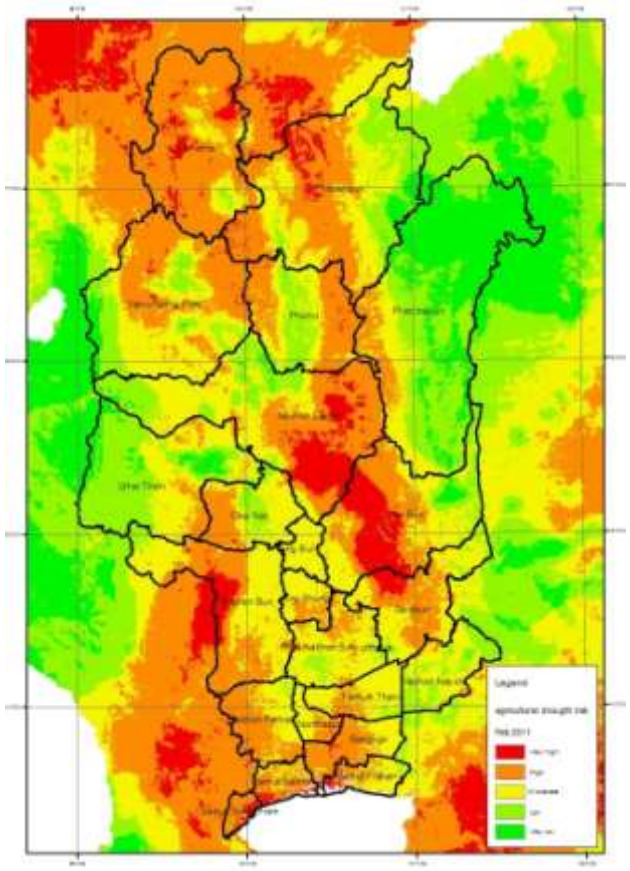
Example of output



Agricultural drought risk map
in February 2011

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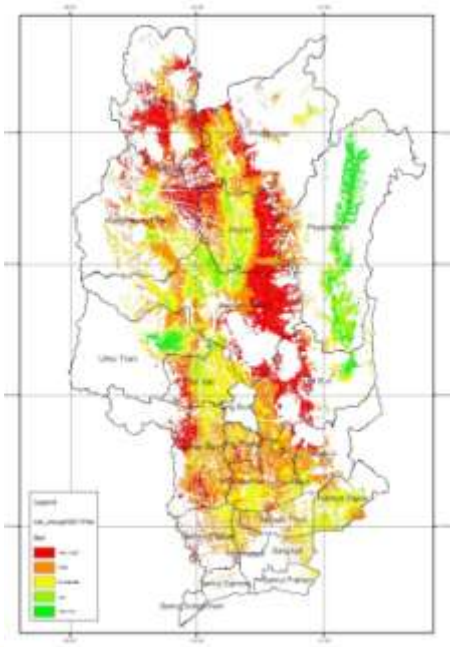
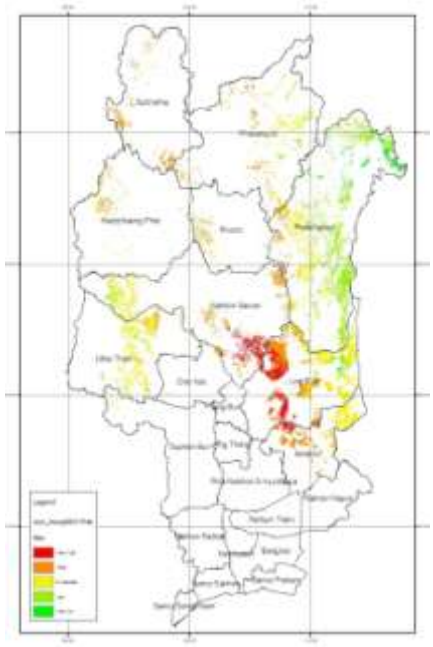
Specific crop drought risk assessment based on crop phenology

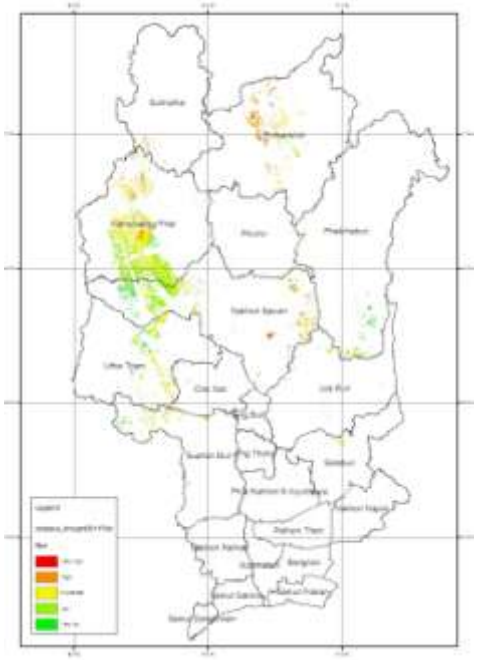
Rice



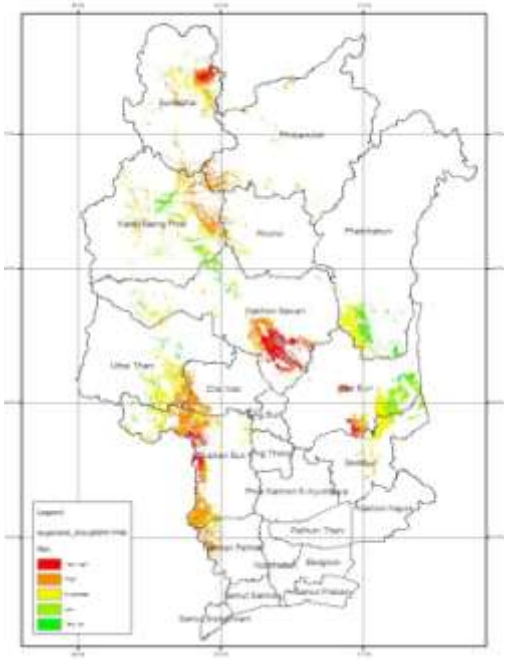
Corn



Cassava



Sugar Cane



Example of economic crop drought risk map in February 2011

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Model validation

- Damage agricultural area database from drought crisis are selected to compare with the result of drought risk assessment.
- The validation using result of drought risk assessment and validate area is in Phitsanulok province

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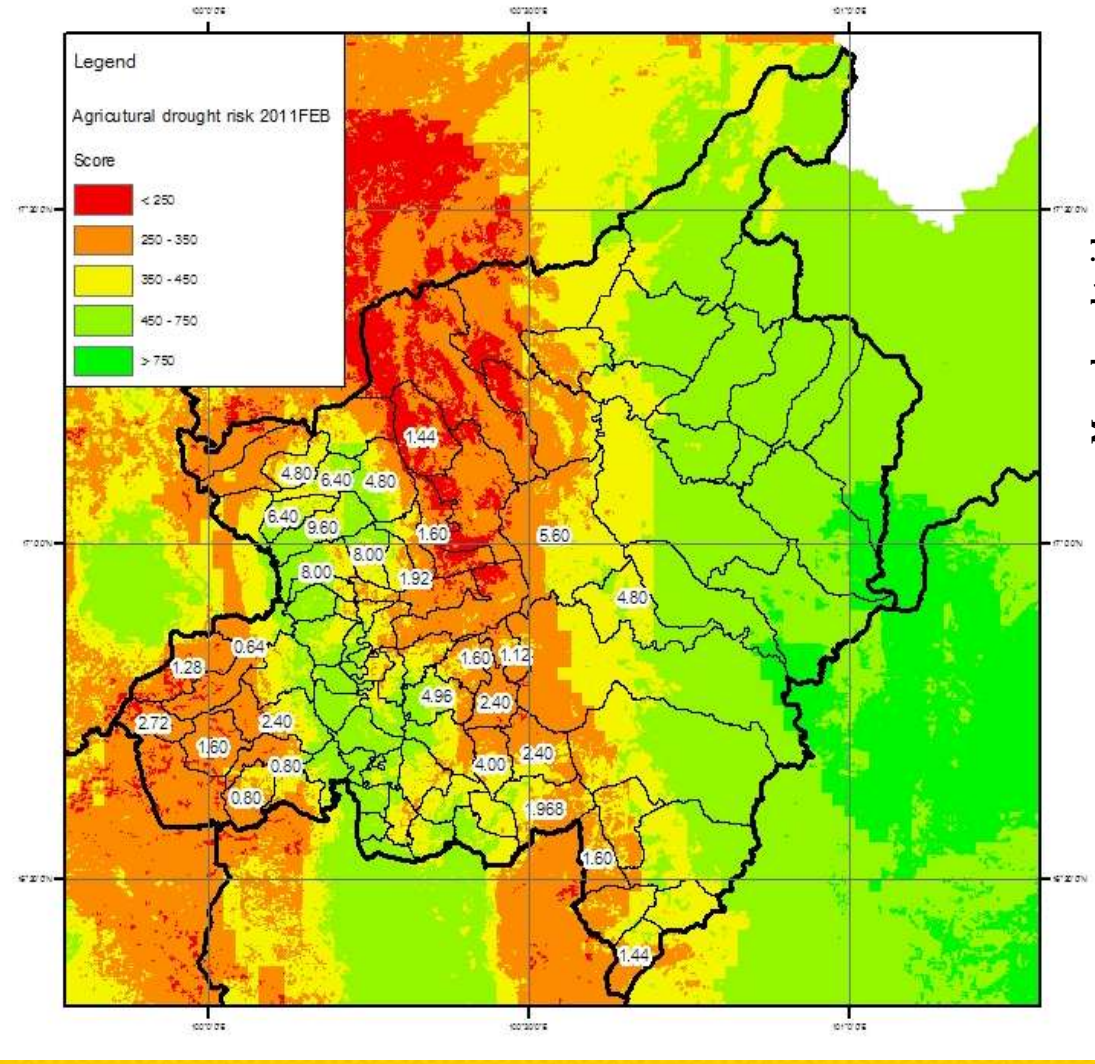
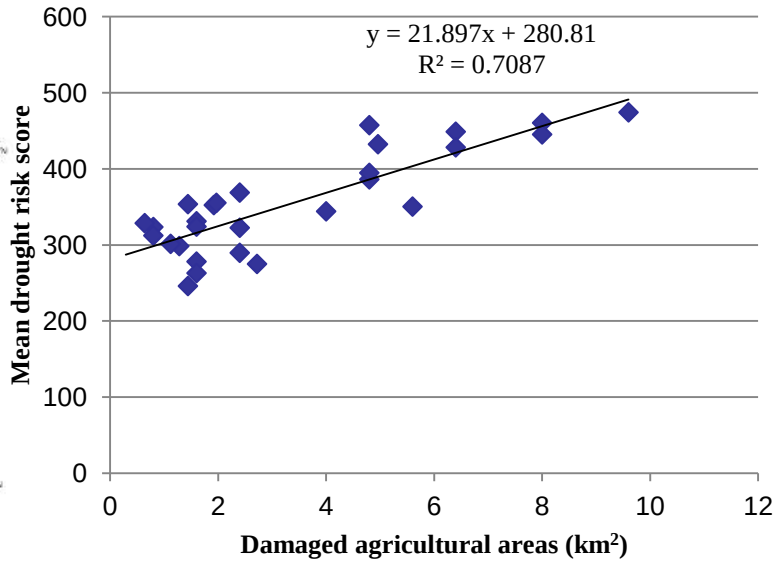
Damaged agricultural area (km^2) in sub district and drought risk score in February 2011 at Phisanulok





Correlation of damaged agricultural area and mean drought risk score in February 2011 at Phisanulok province

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Conclusion

- Agricultural drought risk assessment from integrated satellite based observation and GIS based model have demonstrated the potential of geospatial technology to analyze and identify agricultural drought risk areas.
- Overall, VHI and VCI well described the drought conditions in Thailand.
- GSMaP derived data and vegetative indices have also been shown to be a potential use in drought monitoring and risk assessment.

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Outcomes & Social Application

- Monthly drought risk map
- Monthly vegetative indices
  - VCI
  - VHI
  - TCI

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Self evaluation of achievement

- 95% - frame work for near real time agricultural drought risk assessment
- 5% - need to further development
  - Automatic processing
  - Web map service / Web processing service

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Final conclusion

- The outcome are integrated hydro-meteorological factors and rainfall satellite observation model, modeling for knowledge integration and systems analysis of drought risk assessment.
- The result can be used in drought risk management

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Thank you

Q&A

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