UNIVERSITI PUTRA MALAYSIA

AGRICULTURE • INNOVATION • LIFE

Utilizing TVDI and NDWI to Classify Severity of Agricultural Drought in Chuping, Malaysia.

Presented by
Veena Shashikant
Universiti Putra Malaysia

Research Team

Gs Veena Shashikant

PhD candidate
Department of Biological and Agricultural Engineering,
Faculty of Engineering,
Universiti Putra Malaysia.

Professor Sr Gs Dr. Abdul Rashid Bin Mohamed Shariff

Professor
Department of Biological and Agricultural Engineering,
Faculty of Engineering,
Universiti Putra Malaysia.

Dr. Aimrun Wayayok

Senior Lecturer
Department of Biological and Agricultural Engineering,
Faculty of Engineering,
Universiti Putra Malaysia.

Assoc. Prof. Dr. Md Rowshon Kamal

Assoc. Professor
Department of Biological and Agricultural Engineering,
Faculty of Engineering,
Universiti Putra Malaysia.

Dr. Lee Yang Ping

Head of FGVIC,
Precision Agriculture & Genomics Division
FGV R&D Sdn Bhd
Malaysia.

Professor Dr. Wataru Takeuchi

Professor
Department of Human and Social SystemsInstitute of Industrial Science, The University of Tokyo,
Japan

Image Credit: PerlisAktif Facebook

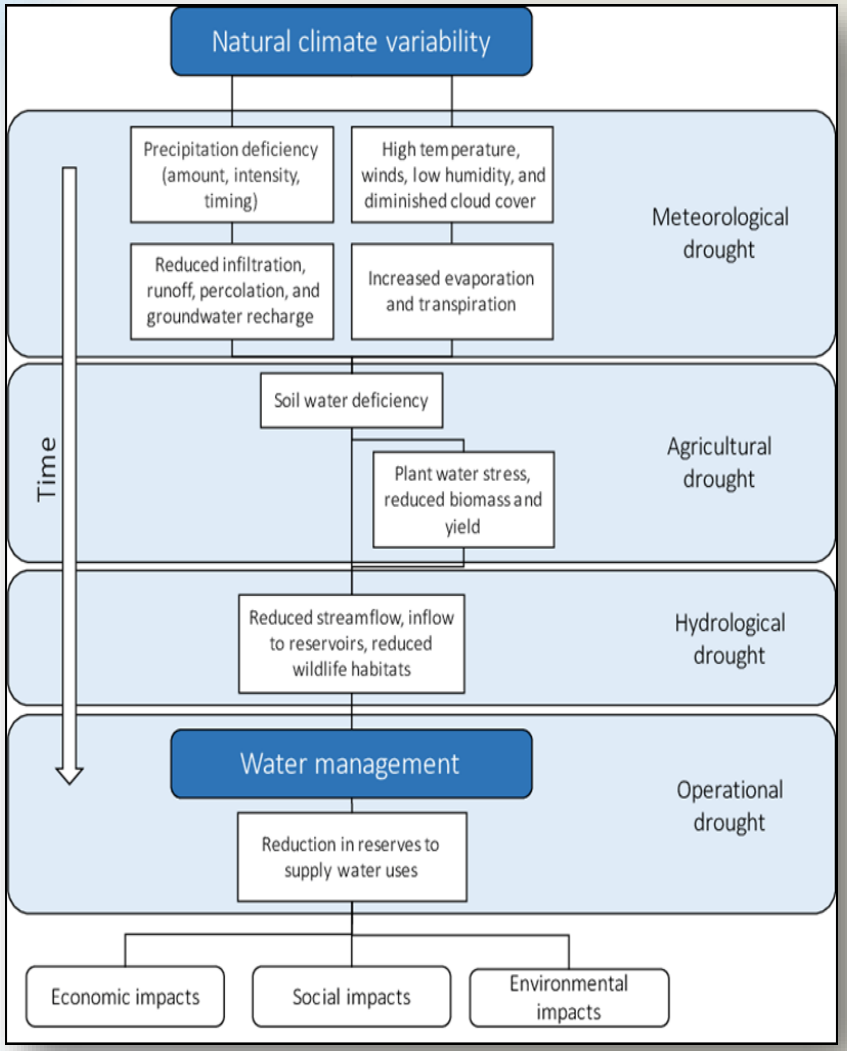
Introduction

Agricultural drought refers to a period with declining soil moisture content and serious crop stress and affects the crop productivity.

The impacts of drought in irrigated areas are normally less severe due to water availability in reservoirs. As a result, even if there is no rain, these crops will receive the water needed.

In non-irrigated areas, crops depend heavily on precipitation. If the precipitation rates are reduced, crops will suffer from water scarcity.

In such conditions and circumstances, drought stress is the most common environmental factor limiting crop productivity. It is reported that the frequency of severe drought conditions is increasing in accordance with global climate change.

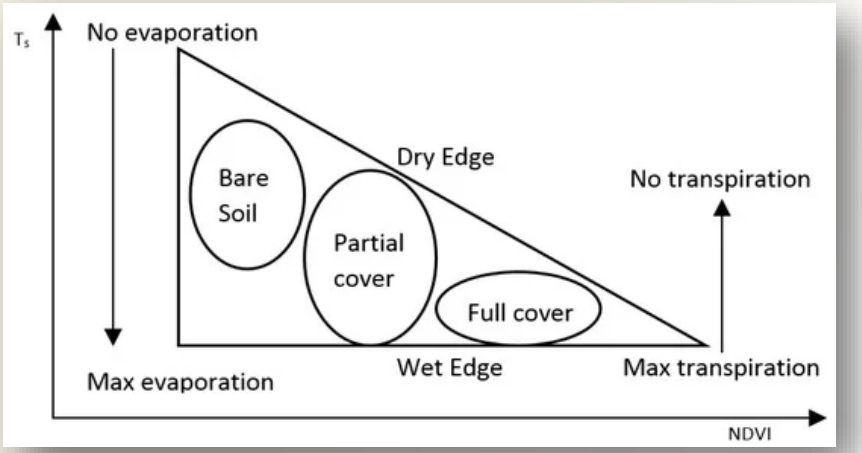


Normalized Difference Water Index (NDWI)

- The amount of water in the vegetation canopy
- where satisfactory performance to estimate canopy water content with a lower error despite saturation at high level.
- It is often used for drought assessment interpretation with an emphasis on moisture content in vegetation.

Temperature Vegetation Difference Index (TVDI)

- estimation of soil moisture using the TVDI gives root-zone moisture which is available to the plants.
- The use of TVDI is sufficient for deployment over vast areas



Conceptual Land Surface Temperature with NDVI triangle introduced by Sandholt et al (2002) .

Remote Sensing Indices

VCI

- Used for assessment of vegetation in drought situations affecting agriculture.
- Mainly used when covering a large spatial and continuous data is provided.

NDVI

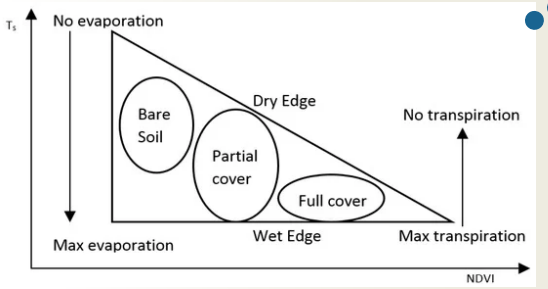
- to interpret vegetation details
- a widely used index is used to understand variations
- changes in green leaves from plants, as well as canopy spectral characteristics

TCI

- Developed to assist the VCI in assessing vegetation stress relative to temperature
- evaluating stress caused by extreme wetness
- extracted from the thermal band that is translated to brightness temperature.

TVDI

- estimation of soil moisture using the TVDI gives root-zone moisture which is available to the plants.
- The use of TVDI is sufficient for deployment over vast areas



VHI

- Combination of VCI and TCI data representing the relationship between temperature and vegetation growth
- proxy index characterizing vegetation health.

NDWI

- The amount of water in the vegetation canopy
- where satisfactory performance to estimate canopy water content with a lower error despite saturation at high level.
- It is often used for drought assessment interpretation with an emphasis on moisture content in vegetation.

SVI

- based on the NDVI to the severity and duration of vegetation stress.
- capacity to work in tandem with standard drought indices, weather and supplementary data, to help drought-response decisions.

Objectives

1. The goal of this research is to use NDWI and TVDI to determine the agricultural drought.
2. To categorize locations within the research region that have been severely impacted by the drought.

Image Credit: Suria Amanda Blog

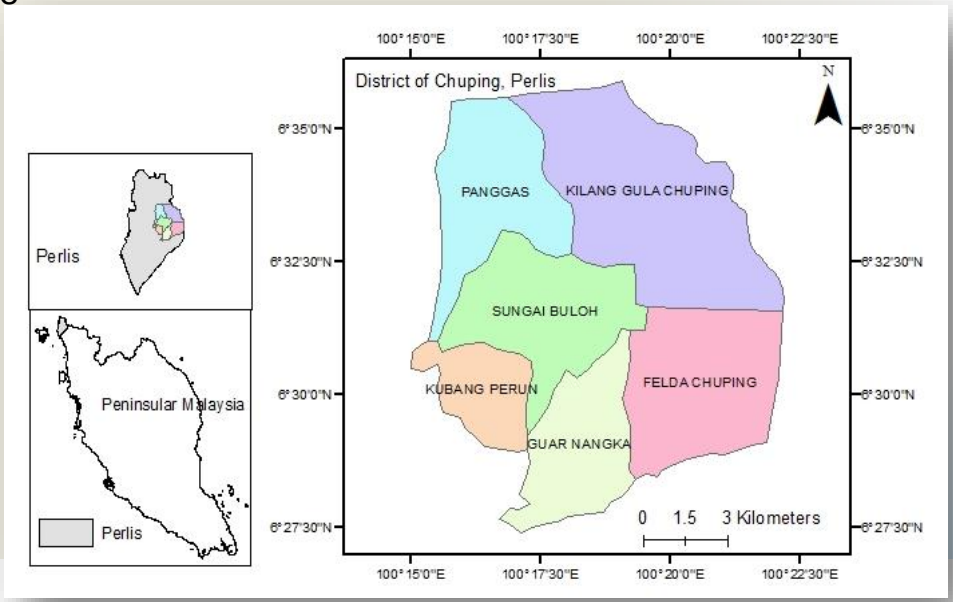
Your are now at Chuping, Perlis. Most hottest place at Malaysia recorded at 40.1 ^{0}C on 9 April 1998

Data Used

1. This study used Malaysian Meteorological Data and Global Agriculture Monitoring—JASMIN, GCOM to choose three different Landsat 8 satellite imagery dated 18 March 2015, 20 March 2016 and 23 March 2017 based on the drier seasons.
2. This research is limited to the mentioned data and the availability of resources as a case study.

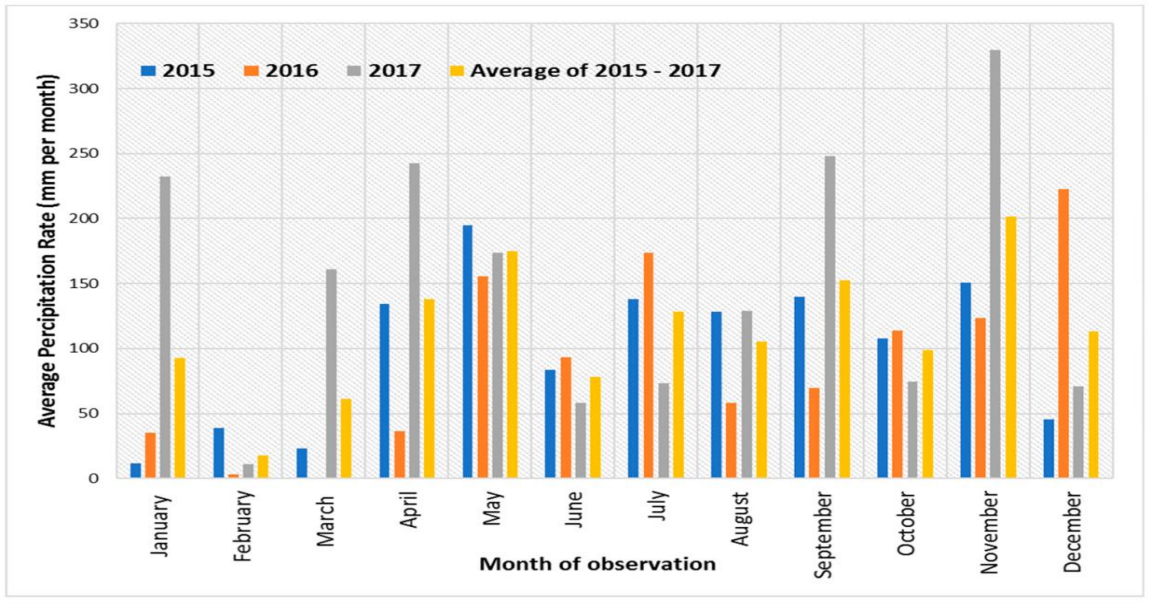
Study Area

1. Chuping, Perlis is in the northwestern part of peninsular Malaysia
2. mostly covered in oil palm, paddy, rubber trees and sugarcane.
3. the study region borders southern Thailand is estimated to be about 102 km^2.



Meteorological Data

- February and March where it is considered to be the driest period of the years 2015-2017 on satellite Global Agriculture Monitoring, GCOM-JASMIN Sensor from Japanese Aerospace Agency, Japan.
- Data from Malaysian Meteorological Department (MMD) was acquired for the mentioned time showed that the research site was under a dry spell.



Year	Maximum Length of Dry Spell per Year (Days)
2015	20
2016	43
2017	22

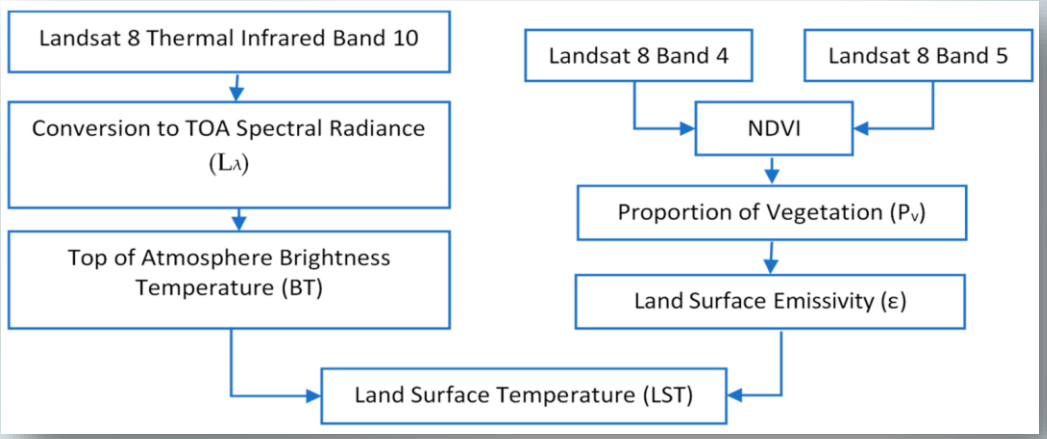
Data processing

- Landsat data available from National Aeronautics and Space Administration (NASA) where three images of Landsat 8 Operational Land Imager (OLI) data, dated 18 March 2015, 20 March 2016 and 23 March 2017 were collected to derive NDWI, NDVI, LST and TVDI.

- $NDWI = \frac{\rho_{nir} - \rho_{swir}}{\rho_{nir} + \rho_{swir}}$

- $NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}}$

- $TVDI = \frac{T_s - T_{S_{min}}}{a + bNDVI - T_{S_{min}}}$

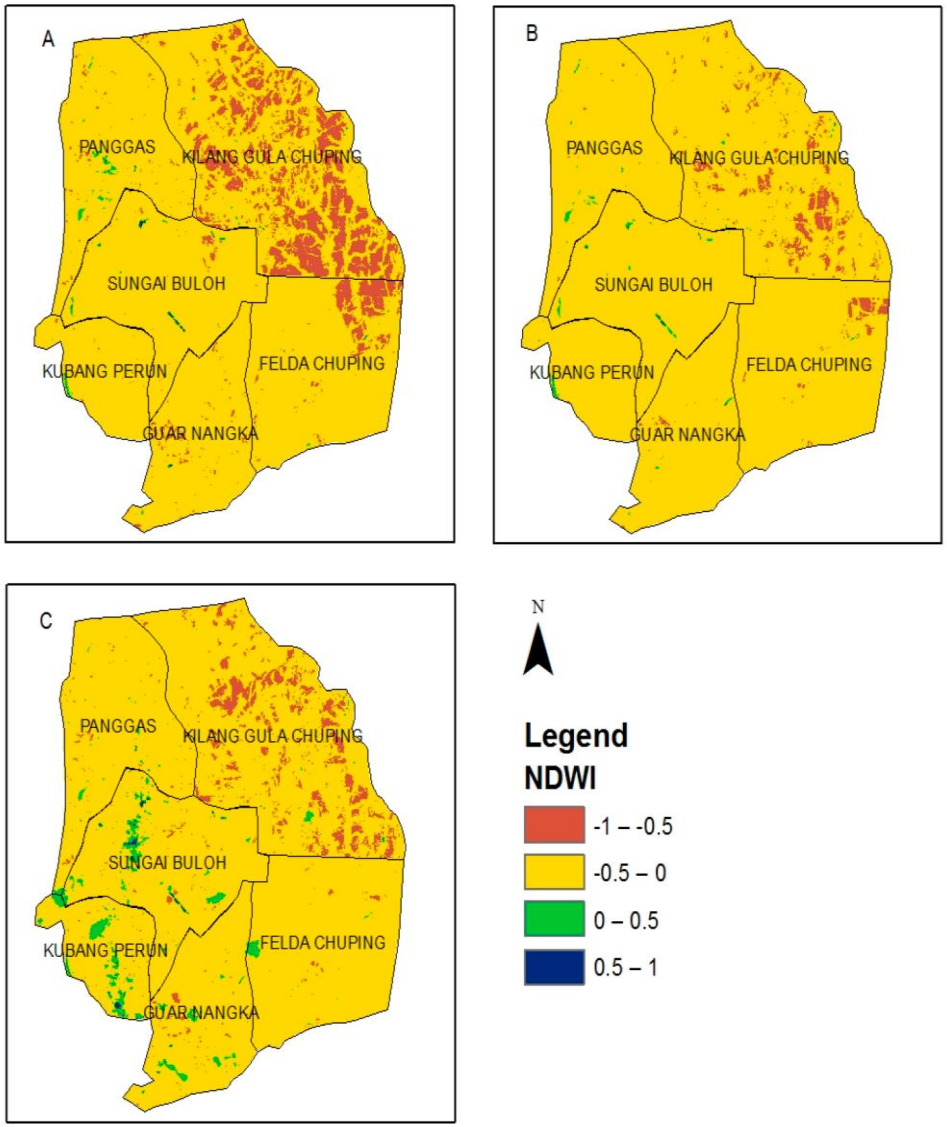


Steps to derive Land Surface Temperature (LST)

- Moran's *I* approach is one of the earliest methods for assessing spatial autocorrelation and most commonly used approach. Adding on, Z score is an excellent technique to determine where an observation falls into the distribution as a whole.

- Moran's *I* is defined as a measure of the correlation among neighboring observations in a pattern between feature locations and values.

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}\,(x_i - \bar{x})(x_j - \bar{x})}{s^2 \times \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}}$$

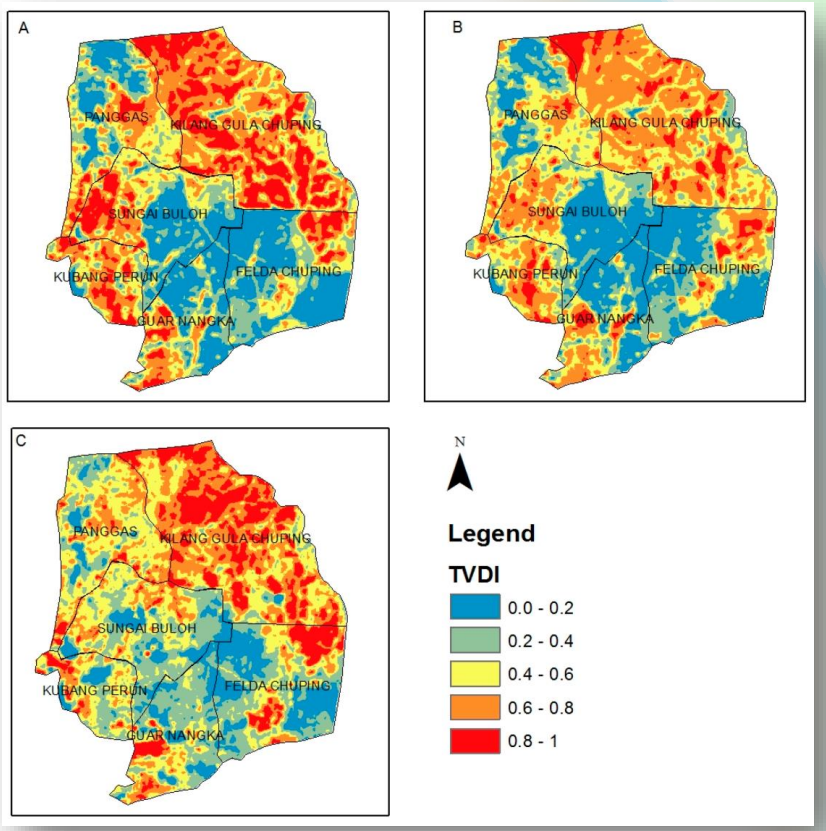


NDWI Map for 2015 (A), 2016 (B) and 2017 (C).

- NDWI was used in this analysis to assess the reflection of water content in the soil and on plant surfaces.
- Rather than focusing exclusively on a spectral band whose reflection strength is largely determined by the phase of chlorophyll in leaves, adding short wave near-infrared (SWIR) emphasized light absorption by water.
- the average NDWI value representing the water content of vegetation decreases numerically, −0.39, −0.37 and −0.36 for the given Chuping area images from 2015, 2016 and 2017.
- However, the values for the Kilang Gula Chuping region were significantly different with NDWI values of −0.46, −0.44 and −0.45 were observed.

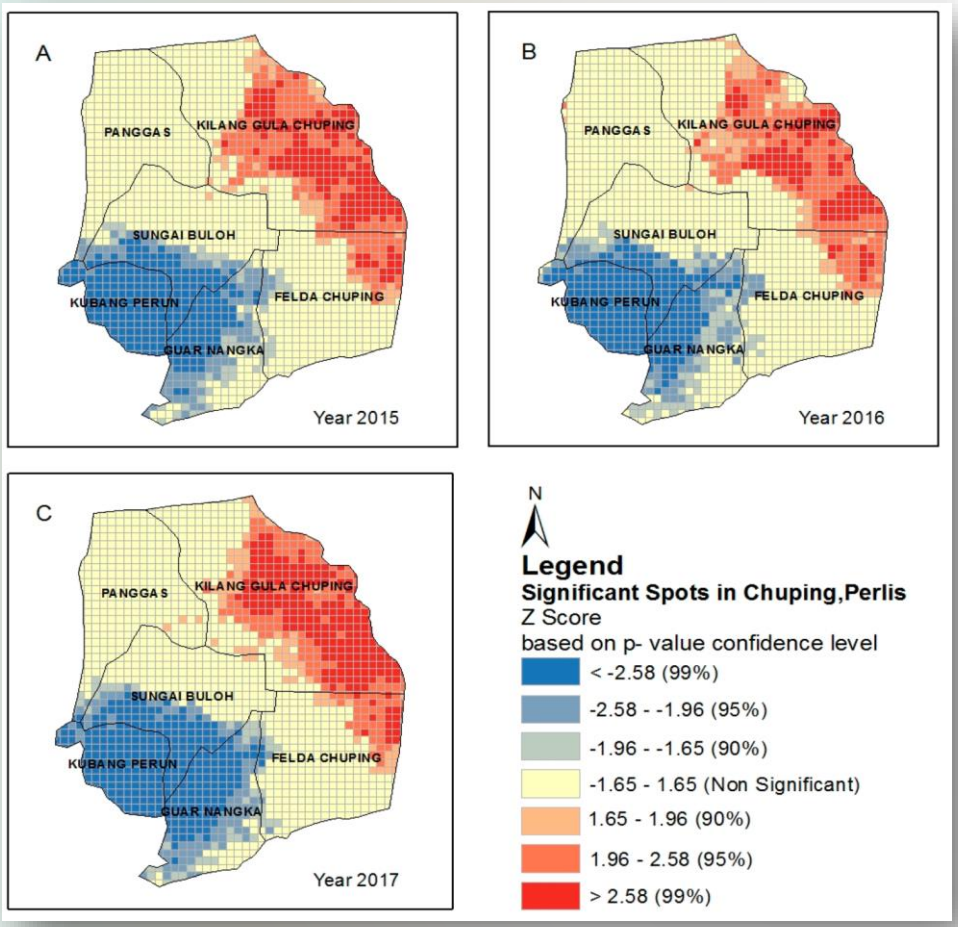
NDVI and TVDI Derivation

- NDVI indices indicating a sensitive reactivity to green vegetation even in places with little vegetation cover.
- When using the TVDI approach, LST and NDVI coupled will provide information on vegetation and surface temperature.
- The wavelengths of the thermal and visible spectrum have been successful in monitoring vegetation conditions when water stress occurs
- Interpretations LST-NDVI relationship is based on vegetation crops, climate, at various scales and useful when the vegetation stays green after the onset of the stress, the NDVI alone as a water stress indicator is less reliable .
- LST in the Chuping area generally shows a significant difference ($p \leq 0.05$) of a declining trend from year image 2015 to year image 2017 with an average temperature of 32.70 °C, 28.50 °C and 26.99 °C
- Temperature vegetation dryness index indicates that all the 3 years of images of the Kilang Gula Chuping area are significantly different ($p \leq 0.05$).



TVDI Map of Chuping for 2015 (**A**), 2016(**B**) and 2017 (**C**).

TVDI	Value Interpretation
0.0–0.2	most wet value
0.2–0.4	generally wet
0.4–0.6	balance value of wet to dry
0.6–0.8	generally dry
0.8–1.0	extremely dry



Regression analysis of NDWI against TVDI for the year 2015 (A), 2016 (B) and 2017 (C) in the month of March where clustered significant spots are identified with 90%, 95% and 99% accuracy are shown using Z Score.

the relationship of the local regression of TVDI and NDWI was observed at R-squared at 0.8399, 0.6969 and 0.6974 for the respective years of 2015, 2016 and 2017.

Year	Moran's Index	Z score	p Value	Variance
2015	0.6252	17.806	0.0001	0.0012
2016	0.2962	8.625	0.0001	0.0012
2017	0.2299	6.769	0.0001	0.0011

When looking at the Kubang Perun, Guar Nangka and part of Sungai Buluh areas, represented in blue the dispersed pattern was due to the sufficient water content in the areas.

- ✓ a better understanding of indices representing the surface water content utilizing the NDWI and the NDVI-LST relationship taking the vegetation cover by TVDI in Chuping was explored.
- ✓ The localized relationship for the mentioned area improved agricultural drought assessment provided a significant classification of very dry areas of the Chuping identifies using the Moran's I spatial relationship.
- ✓ It is observed that Kilang Gula Chuping and part of Felda Chuping have experienced the most impact in all the dry seasons in the years 2015, 2016 and 2017.

TERIMA KASIH/*THANK YOU*

www.upm.edu.my

Complete details and reference available at:

Shashikant, Veena, Abdul R. Mohamed Shariff, Aimrun Wayayok, Md R. Kamal, Yang P. Lee, and Wataru Takeuchi. 2021. "Utilizing TVDI and NDWI to Classify Severity of Agricultural Drought in Chuping, Malaysia" Agronomy 11, no. 6: 1243.

Image Credit: From RojakDaily and Flickr/YazirYacob