Vegetation Indices for Harumanis Using Multispectral Data

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Abstract. Worldwide demand for agricultural crops is increasing, and may proceed to do so for decades, propelled by a 2.3 billion individual increment in worldwide population and greater per capita incomes expected through midcentury. The agriculture industry is the sector of the economy that produces livestock, poultry, fish, and crops. This can be a vital industry that is vital to the food security of each country and locale. It is additionally a noteworthy sector of the economy that incorporates a large number of small businesses. The application of remote sensing in agriculture can help the revolution in agriculture sector especially Unmanned Aerial Vehicles (UAV). Unmanned aerial vehicle (UAV)-based uses to determine the health of the tree hence give huge benefits for farmers. Besides that, UAV offers huge possibilities to obtain more accurate data for precision farming applications. Agriculture drones can be utilized to do anything from precision agriculture to productively scattering weed control or fertilizers, to optimizing field administration. The result includes decreased operation costs, improve crop quality, and expanded yield rate. This research aims to study about UAV multispectral and vegetation indices; Normalized Difference Vegetation Index (NDVI), Green Normalized Vegetation Index (GNDVI) and Soil Adjusted Vegetation Index (SAVI). The study area is in the UiTM Perlis branch, and the data collected in December 2021 and ArcGIS version 10 uses to generate the vegetation indices. From the result, the value ranges for NDVI are from 0 to 200, for GNDVI is -1.164 to 0 and for SAVI is from -0.29669 to 0.674805. The value ranges for NDVI exceed the traditional known ranges probably due to the presence of many shadows which affected the result of NDVI. However, in the maps, it is possible to recognize the same spectral discrimination of the areas.

INTRODUCTION

With the weight of expanding populations, extraordinary climate events and climate change, producers require new inventive strategies that increment efficiency whereas organizing sustainability and resilience. Remote sensing technologies play a huge role in precision farming as to provide enough food supply for the community [9]. Remote sensing technology has ended up more adaptable in recent years and offers a promising point of view [12] for precision farming via the uses of UAV in detecting the heath of the tree, crop assessment and benefiting many parties as it makes farming activities become more easier and save more time compared to the traditional method.

Precision farming implies a series of methodologies and devices that permit farmers to upgrade and increase soil quality and efficiency putting in put a series of focused on key interventions, a result that can be finished much obliged to the presentation of progressively advanced innovations [1].

The opportunity to view the world from the sky utilizing manned or unmanned aerial platforms offers the plausibility to think about a crop from an unusual point of view, watching a few quirks of field scope barely obvious from the ground [4].

Technologies are utilized, first and foremost, to gather the data and data required to form choices on how to boost production and secondly to put in place the essential remedial activities to attain this objective [1].

Customarily, the essential platforms utilized to get remote images of Earth's surface were satellites and piloted aircrafts, but these instrument frequently do not convey satisfactory spatial and temporal resolutions. These days these challenges can be overcome utilizing low-cost and adaptable unmanned platforms such as Unmanned Airborne Vehicles (UAV)—also called Remotely Piloted Aircraft Systems (RPAS) or Unmanned Airplane Systems (UAS) [4].

Unmanned Aerial Vehicles (UAVs), commonly referred to as drones are making waves within the agricultural industry providing savvy cultivating solutions that utilize real-time information gathering and processing to improve farm-wide decision-making and productivity, freeing up time and money needed elsewhere within farm businesses ([9].Nowadays the use of UAV in Malaysia's agriculture activities has improved a lot which is great as many parties start to adapt with the current technology which handier for making any decision and work related to their farm development.

As in the Harumanis plantation, UAV is essential in order to detect the health, crop assessment and fertilizing. It has been detailed that the trade of Harumanis mango in 2010 has come to 3.1 metric tons. The climate condition in Perlis is a major factor of why this Harumanis assortment is suitable to be developed here. Harumanis mango tree needs an essentially dry period to start the blooming. The blossoms begin to sprout from January to February and the fruit-bearing period is from March to April. The fruits are harvested from May to June each year [2] [10]. The aim for this research is to study about UAV multispectral data and vegetation indices; Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI) and Soil Adjusted Vegetation Index (SAVI). The objectives for this research are to extract the multispectral data of Harumanis plantation in UiTM Perlis and produce vegetation indices map to indicate the health of the tree.

The problem when the demands skyrocket, the farmers need to multiple their harvest fruits to meet the demands and the soil fertility changes due to the crop activity, manure, and application of the nutrient content [7]. The health of Harumanis is essential as to produce huge amounts of crop yield and via vegetation indices such as Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation Index (GNDVI) and Soil Adjusted Vegetation Index (SAVI), the health of the tree can be determined.

1. MATERIALS AND METHODS

In order to achieve the aim and objectives of the research works, there are several processing that should be done. The methodology of this project started with the selection of the study area, data acquisition, data processing, data analysis and result.

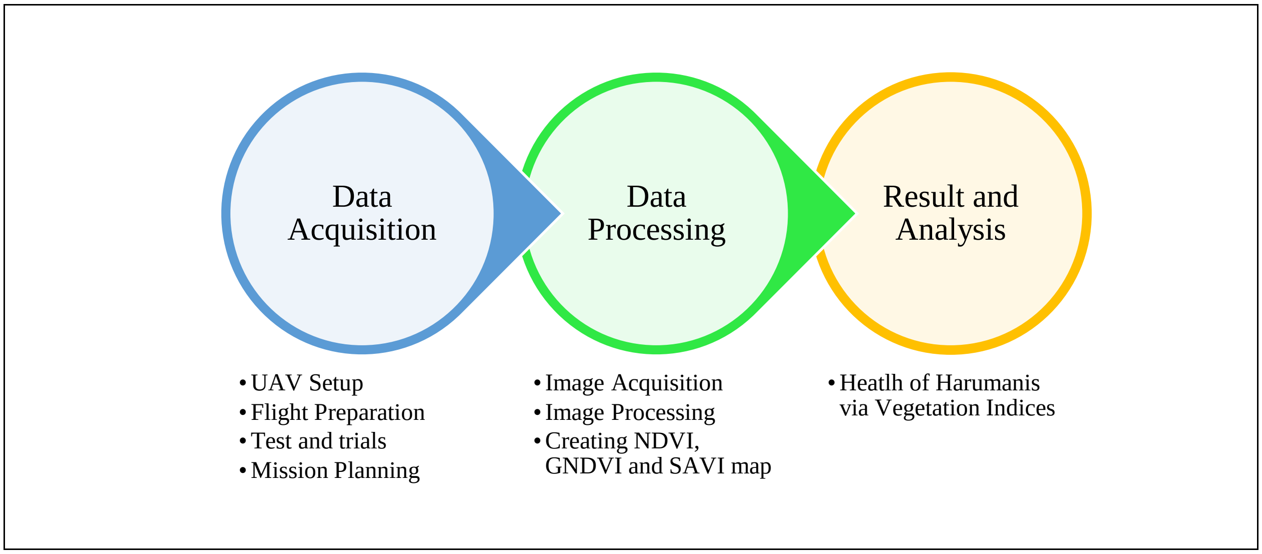

Figure 1: Flow of methodology

2.1 Planning

The study is held in the UiTM Perlis's plantation with coordinate is 6° 27' 15.4" N and 100° 17' 00.7" E, where the Harumanis is planted. The plantation is chosen due to the require for timely and dependable agricultural data has become more imperative in decision making. The predominant terrain at the study area is an undulating peneplain with an incline of 1–6% at 17–26 m above sea-level. The soil in the experimental farm is classified as a Typic Paleudult according to the U.S. Soil Taxonomy or Terap Series based on the Malaysian Soil Classification System. This soil series often lies on an undulating/wavy terrain, is yellowish brown (10YR 5/4–8) to dark brown in color (7.5YR4–5/6–8) in the Munsell Color System, and has a well-drained, loamy texture with gravels and a moderate soil depth without a plinthic layer [6].

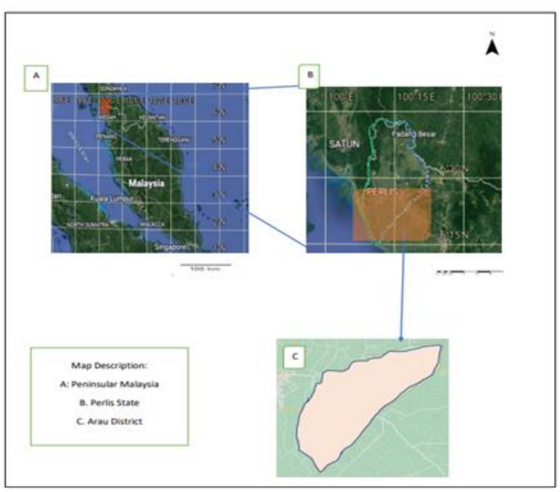

Figure 2: The study area at UiTM Arau, Perlis. (A) Map of Peninsular Malaysia; (B) Map of Perlis State; (C) Map of Arau District

2.2 Data Acquisition

For this phase, data is determined primarily which the multispectral data has been used to produce NDVI, GNDVI and SAVI map. The data collected during fruit bearing season which in March 2022. The data for this research are Harumanis surveyed plantation plan, N, P, K soil element datasets and coordinate of added soil sample for the selected tree. The data later will be processed with the ArcGIS software.

Seven Ground Control Points (GCP) had been established around the study area and were observed by using GPS Topcon GR-5 through a static method. Each georeferenced or coordinate data comprises of latitude, longitude, and elevation information. Latitude and longitude information, in common, allude to northing and easting, individually. This geographic coordinate was converted to the projected coordinate system for mapping purpose. The projected coordinate ordinarily has consistent lengths, angles, and areas on a flat, two- dimensional surface [2].

Multispectral imagery is an effective tool for distinguishing different sorts of materials and features within the landscape. Natural and man-made materials regularly have unique spectral signatures that can be used to distinguish them quantitatively. Spectral profile charts permit you to choose areas of interest or ground features on the image and review the spectral data of all bands in a chart format. A spectral profile comprises of geometry to characterize the pixel selection and an image with key metadata from which to sample [8].

The UAV Multispectral data for this study had been captured by using the autopilot quadcopter drone on 10 December 2021. The sensor used for was Micasense RedEdge, overlap was 75% horizontal and vertical, altitude used was 75 meter and spatial resolution was 5 cm gsd.

2.3 Data Processing

The data processing begins with the image acquisition of the study area collected during the flight session later the data will be processed using ArcGIS software. Before proceeding with the next step, the images obtained need to be performed correction in order to reduce the error. The atmospheric correction removes the scattering and absorption effects from the atmosphere, radiometric correction is to avoid radiometric errors or distortions, while geometric correction is to remove geometric distortion. NDVI, GNDVI and SAVI were used in this research to measure the healthiness for each selected tree.

NDVI uses two properties to evaluate healthy vegetation. It uses near infrared (NIR) since vegetation strongly reflects it. And it moreover uses red light, since plants strongly absorb it [5].

The GNDVI is computed similarly to the NDVI, but the green band is utilized rather than the red band. It is related to the proportion of photosynthetically absorbed radiation and is directly related with Leaf Area Index (LAI) and biomass. Hence GNDVI is more sensitive to chlorophyll concentration than NDVI and ranges from to 1.0 [4].

The SAVI is utilized to eliminate of the effect of soil within the vegetation observation for those regions where vegetative cover is poor, and the soil surface is uncovered. SAVI ranges from −1.0 to 1.0, with low values comparing to a small amount/cover of green vegetation [4].

Index	Computation	Reference
NDVI (Normalized Difference Vegetation Index)	$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R}$	Rouse *et al.* (1973) [24]
GNDVI (Green Normalized Difference Vegetation Index)	$GNDVI = \frac{\rho_{NIR} - \rho_G}{\rho_{NIR} + \rho_G}$	Gitelson *et al.* (1996) [27]
SAVI (Soil Adjusted Vegetation Index)	$SAVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R + L} + (1 + L)$	Huete (1988) [29]

Figure 3: Types of vegetation index

Source: Candiago et al.,2015

2. Result and Analysis

The Vegetation Indices used in this research were generated in ArcGIS. Vegetation indices (VIs) are commonly utilized to assess vegetation based on the vegetation spectral characteristics within the Near Infra-Red (NIR) and red spectral region or at the red edge. A high VI value indicates healthy vegetation, and a low value indicates senescent, infected, foliage damaged, water stressed vegetation, or non-vegetated zone [13].

The NDVI, GNDVI and SAVI maps were extracted from the processed orthoimage and are shown in the Figure 3. The zones with negative values are well recognizable and easier to compare with the other zone which have positive values.

Based on Figure 4(A), the value ranges between 0-200 for NDVI. NDVI use to measure "greenness" and healthy vegetation. Based on the range value from the map, the tree is healthy as a higher NDVI value indicates a healthier tree. NDVI is a great index for recognizing vegetation and non-vegetation cover. NDVI is the ration of the reflectance difference between NIR and red and the sum of the reflectance at NIR and red. NDVI utilizes the NIR and red to measure healthy vegetation. Healthy vegetation incorporates a higher NDVI esteem than unfortunate vegetation [5] [13].

Figure 4(B) show the value ranges from -1.164-0 for GNDVI. Values between -1 and 0 are related with the presence of water or bare soil. This index is basically utilized within the intermediate and last stages of the crop cycle. GNDVI is the green vegetation index that utilized the near infrared (NIR) and green band (GREEN) of the electromagnetic spectrum. GNDVI is more sensitive to chlorophyll variety within the crop than NDVI and contains a higher saturation point. It can be utilized in crops with thick canopies or in more progressed stages of improvement whereas NDVI is reasonable for assessing crop vigor amid the early stages [11].

Figure 4(C) indicates the value ranges from -0.29669 – 0.672805 for SAVI. The Soil-Adjusted Vegetation Index (SAVI) method is a vegetation index that attempts to minimize soil brightness influence employing a soil-brightness correction factor. This can be frequently utilized in dry region where vegetative cover is low, and it yields values between -1.0 and 1.0 [8].

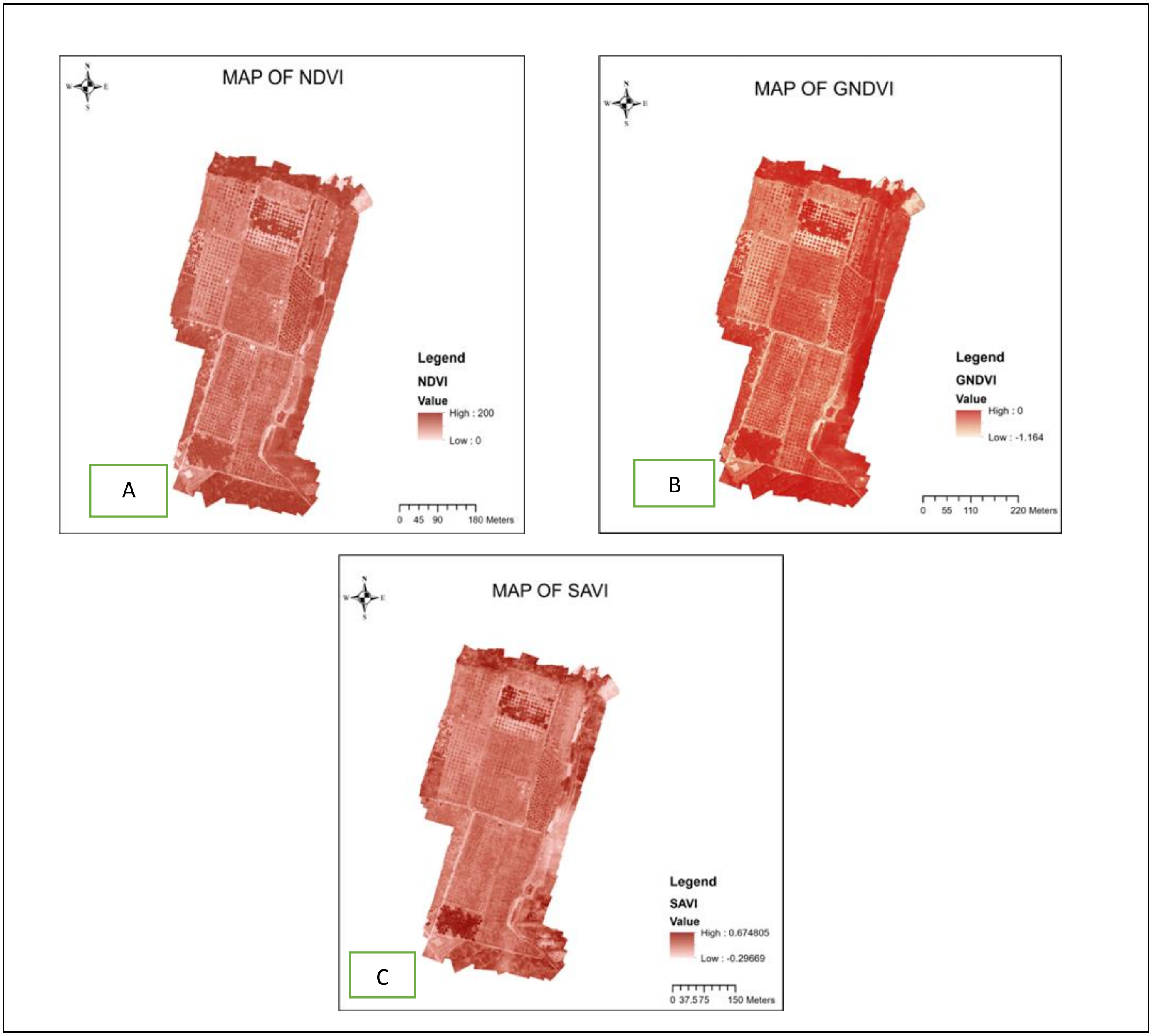

Figure 4: (A) Map of NDVI, (B) Map of GNDVI and (C) Map of SAVI

Based on the result above, NDVI is the most widely used vegetation indices in remote sensing and reasonable for evaluating vigor all through the crop cycle based on how plants reflect certain ranges of the electromagnetic spectrum. It permits to know its current state, which can at that point be compared with another temporal image to watch its advancement over time [11]. From the result, the value ranges for NDVI are from 0 to 200, for GNDVI is -1.164 to 0 and for SAVI is from -0.29669 to 0.674805. The value ranges for NDVI exceed the traditional known ranges probably due to the presence of many shadows which affected the result of NDVI. However, in the maps, it is possible to recognize the same spectral discrimination of the areas.

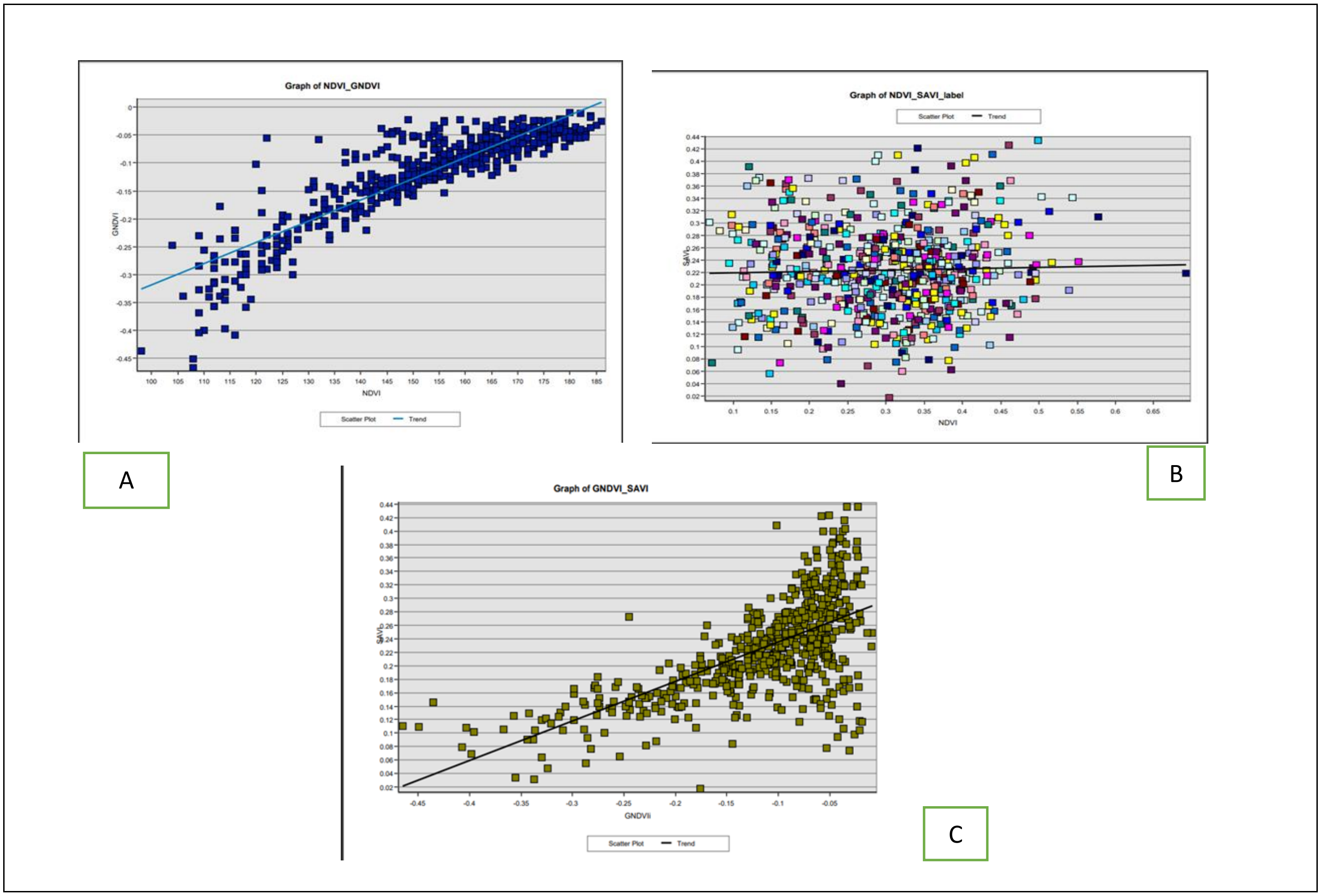

Figure 5: (A) Scatterplot of NDVI vs GNDVI, (B) Scatterplot of NDVI vs SAVI (C) Scatterplot of GNDVI vs SAVI

Scatterplots are uses to measure and show the relationship between two numeric variables. Identification of correlational relationships are common with scatterplots and can be beneficial for identifying other patterns in data. For the scatterplot of NDVI vs GNDVI, the relationship is strong, positive, and linear. Meanwhile for NDVI vs SAVI, there is no relationship between those two variables and the relationship between GNDVI vs SAVI is strong, positive, and linear. The higher the NDVI and SAVI, the denser and healthier the tree. NDVI is reasonable for evaluating vigor throughout the crop cycle based on how plants reflect certain ranges of the electromagnetic spectrum. It permits to know its current state, which can at that point be compared with another temporal image to observe its evolution over time. A plant is green since the chlorophyll pigment it contains reflects green waves and absorbs red waves. This implies that a healthy plant–with lots of chlorophyll and cell structures–actively absorbs red light and reflects NIR when photosynthesis happens. The plant creates and develops and contains more cell structures. With an unhealthy plant, the exact opposite is true [11].

Besides that, GNDVI is more sensitive to chlorophyll variation within the crop than NDVI and has a higher saturation point. It can be utilized in crops with thick canopies or in more advanced stages of development whereas NDVI is appropriate for estimating crop vigor amid the early stages (Retrieved from Auravan,2022). SAVI is a vegetation index that attempts to minimize soil brightness influences employing a soil-brightness correction factor. Usually frequently utilized in dry locales where vegetative cover is low [8].

3. CONCLUSION

From the study, mapping for NDVI, GNDVI and SAVI have been established by using ArcGIS software to determine the health of the Harumanis tree in UiTM Perlis's plantation. From the result, the healthiness of Harumanis can be determined by using the advanced technology in remote sensing which become handier for the farmers to observe the plantation compared to the traditional method. The NDVI value ranges from -1 to 1 and indicates the vigor of the crop as if the values close to 1, it means the more intense the green, the more vigorous the vegetation and vegetation cover while negative values usually indicate the areas of water, snow, or clouds. GNDVI mostly used to determine water and nitrogen uptake in the crop canopy and value ranges from -1 to 1. Values between -1 and 0 indicates the presence of water or bare soil. finally, SAVI is regularly utilized in arid regions where vegetative cover is low, and it output values between -1 and. As for the recommendation, the bigger the study area, the better the result will be as it will cover much tree and easier to come with the great decision for the growth of the tree. For the flight time, it is preferred to fly during the clear sky or in the morning as to get more precise image. Through this research, farmers will gain some basic knowledge related to the latest technology in remote sensing for agriculture activity which may and will help them to maintain the health of Harumanis in every season and produce huge amount of quality fruits to fulfill the demand either local or international.

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