Comparison of Potential Habitat of Genus *Schismatoglottis* in Kelantan based on different qualitative methods

By

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DECLARATION

I declare that this thesis entitled "Comparison of potential habitat of genus *Schismatoglottis* in kelantan based on different qualitative methods "is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ____________________

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Date : ____________________

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Comparison of Potential Habitat of Genus *Schismatoglottis* in Kelantan Based on Different Qualitative Methods

ABSTRACT

Forest is a large area dominated by trees. Hundreds of more precise definitions of forests are used throughout the world, incorporating factors such as tree density, tree height, land use, legal standing and ecological function. *Schismatoglottis* is a genus of flowering plants in the Araceae family. They are highly diversified in life form and leaf and inflorescence characteristic. They are found on lofty soil banks in forest. Tribe schismatoglottideae is a terrestrial, rheophytic or lithophytic herbs outspread in tropical Asia. In the research, the potential distribution of genus *Schismatoglottis* had been selected in study. The species that had been preferred from the genus *Schismatoglottis* is *Schismatoglottis brevicuspis* and *Schismatoglottis calyptrata.* The Ecological Niche Modelling (ENM) method had been applied to generate the potential map distribution of *Schismatoglottis brevicuspis* and *Schismatoglottis calyptrata* in Kelantan. The 19 bioclimatic variables, harmonized world soil database and shutter radar topography mission had been obtained at online database were layered by using Geographic Information System (GIS) in order to identify the area of distribution. MAXENT had applied to overcome localities data of the species using the probability distribution by running 100 replicates model per species. The percentage of Ecological Niche Modelling (ENM) was compared with Area of Occupancy (AOO) and Extent of Occurrence (EOO). The result in percentage show ENM is suitable in species modelling for the conservation of species habitat. The value of ENM is shown about 3.26 % for *Schismatoglottis calyptrata* and 7.12 % for *Schismatoglottis brevicuspis*. The percentage of AOO and EOO for *Schismatoglottis calyptrata* is 0.55 % and 67.44 %, while for *Schismatoglottis brevicuspis* is 0.55 % and 60.73 % respectively.

Perbandingan Habitat Potensi Genus *Schismatoglottis* di Kelantan Berdasarkan Kaedah Kualitatif Yang Berbeza

ABSTRAK

Hutan adalah kawasan yang besar yang dipenuhi oleh pokok-pokok.Beratus-ratus definisi hutan telah digunakan oleh seluruh dunia dengan menggabungkan faktor-faktor seperti kepadatan pokok, ketinggian pokok, guna tanah, kedudukan undang-undang dan fungsi ekologi. *Schismatoglottis* ialah genus tumbuhan berbunga dalam keluarga Araceae. Mereka boleh diklasifikasikan dalam bentuk kehidupan dan ciri-ciri daun dan inflorescence. Mereka boleh didapati di kawasan tanah tinggi dalam hutan. Puak Schismatoglottideae adalah rheophytic daratan, atau herba lithophytic meliputi di Asia tropika. Dalam kajian ini, pengedaran potensi genus *Schismatoglottis* telah dipilih dalam kajian. Spesies yang telah dipilih dari genus *Schismatoglottis* adalah *Schismatoglottis brevicuspis* dan *Schismatoglottis calyptrata*. Kaedah permodelan nic ekologi (ENM) telah digunakan untuk menjana pengagihan peta potensi *Schismatoglottis brevicuspis* dan *Schismatoglottis calyptrata* di Kelantan. Sembilan belas data bioklimatik, pangkalan data tanah dunia dan shutter radar topography mission telah diperolehi pada pangkalan data dalam talian telah berlapis dengan menggunakan Sistem Maklumat Geografi (GIS) bagi mengenal pasti kawasan taburan. MAXENT telah digunakan untuk mengatasi masalah kawasan data daripada spesies menggunakan taburan pengagihan dengan menjalankan replikasi model sebanyak 100 bagi setiap spesies. Nilai peratus menggunakan kaedah permodelan nic ekologi (ENM) berbanding dengan *Area of Occupancy* (AOO) dan *Extent of Occurence* (EOO). Keputusan peratusan yang menunjukkan ENM amat sesuai dalam spesies pemodelan untuk pemuliharaan habitat spesies. Nilai ENM yang menunjukkan kira-kira 3.26 % bagi *Schismatoglottis calyptrata* dan 7.12 % untuk *Schismatoglottis brevicuspis*.Nilai peratus AOO dan EOO untuk *Schismatoglottis calyptrata* ialah 0.55 % dan 67.44 % manakala bagi Schismatoglottis brevicuspis 0.55 % dan 60.73 % masing-masing.

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LIST OF ABBREVIATIONS

AOO	Area of Occupancy
BIOCLIM	Bioclimatic variables
DD	Data Deficient
ENM	Ecological Niche Modelling
GIS	Geological Information System
HDF	Hill Dipterocarp Forest
LDF	Lowland Dipterocarp Forest
MDF	Mixed Dipterocarp Forest
SRTM	Shutter Radar Topography Mission

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Forest is a large area dominated by trees. Hundreds of more precise definitions of forest are used throughout the world, incorporating factors such as tree density, tree height, land use, legal standing and ecological function. Forest had covered four billion hectares or approximately 30 % of the world's land area in 2006 (Feeley el at., 2007). Forest is the dominant terrestrial ecosystem of Earth, and are distributed across the globe. Forest at different latitudes and elevations form distinctly different Eco-zones which are tropical forests near the equator, boreal forest near the poles and temperate forests at mid-latitudes. Higher elevation areas tend to support forests similar to those at higher latitudes, and amount of precipitation also affect forest composition (Swaine et al., 1987). A forest consists of many components that can be broadly divided into two categories that are biotic and abiotic components. The living parts include trees, shrubs, vines, grasses and other herbaceous plant, mosses, algae, fungi, insects, mammals, birds, reptiles, amphibians and microorganism living on the plants and animals and in the soil. A forest is made up of many layers. Starting from the ground level and moving up, the main layers of all forest types are the forest floor, the understory and the canopy. The emergent layers exist in tropical rainforests (Richards, 1952). Each layer has a different set of plants and animals depending upon the availability of sunlight.

Schismatoglottis is a genus of flowering plants in the Araceae family. They are highly diversified in life form and leaf and inflorescence characteristic. The leaves can change significantly from species to species. They are regularly found on lofty soil banks in forest. The seedlings are less likely to be covered by leaf litter (Bogner & Boyce, 2009). In addition to this, gallery forest provides a wide range of microhabitats, covering from cool and continually humid in the forest.

Tribe schismatoglottideae is a terrestrial, rheophytic or lithophytic herbs outspread in tropical Asia. *Schismatoglottis* is the largest genus in Schismatoglottideae with over 200 species. Among these species, they are usually rhizomatous or tuberous. Their inflorescences are typically rather small and ordinary, represented by a complex spadix with up to three kinds of staminode present, the fertile elements segregated into male and female zones on the spadix often separated by a sterile zone, and a sterile appendix (Boyce & Wong, 2008). According to Boyce & Wong (2014), reported that the total aroid flora for Borneo quite likely exceeds 1,000 species. In general, Borneo is an aroid habitat of global significance; and perhaps one of the wealthy and most diverse on the planet.

In this study, Ecological Niche modelling (ENM) is used to estimate the distribution of the *Schismatoglottis* species. Ecological Niche Modelling was generated using Maximum Entropy (MAXENT) software. The percentage of distribution of *Schismatoglottis* will distinguished with Extent of Occurrence (EOO) and Area of Occupancy (AOO). Locality data and environmental data were acquired by accessing herbarium database and climatic data.

1.2 Problem Statement

Kelantan state is a case study area to discover the distribution of *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* because they are mostly native and widespread. There were less data about *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* in the region of Kelantan. They should be conserved because certain of *Schismatoglottis* are rare and have not identified. This possible refugee might spread-out via land corridors, but became limited due to geological changes through a period of time. There are less plate movement involving the region (Boyce & Wong, 2014) and it could explain the historical biogeography of the complex. By using environmental data of genus *Schismatoglottis* on Maximum Entropy software and ecology niche modelling likes Area of Occupancy and Extent of Occurrence, it might show the other region might appear genus *Schismatoglottis*.

1.3 Scope of Study

This study focuses on the distribution of *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* in the region of Kelantan. Maximum Entropy (MAXENT) software is used as tool for conservation approach in ecological niche modelling which assessing habitat loss through computational and qualitative method (Philips et al., 2006).

1.4 Objectives of the Study

This study is focused with several objectives. The aims of this study are stated as follow:

- To generate potential map of distribution of *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* in Kelantan.

- To compare the map distribution of *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* in the result of MAXENT, Extent of Occurrence (EOO) and Area of Occupancy (AOO).
- To compare the percentage distribution of *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* in the result of MAXENT, Extent of Occurrence (EOO) and Area of Occupancy (AOO).

CHAPTER 2

LITERATURE REVIEW

2.1 Forest

Major forest types in Malaysia are lowland dipterocarp forest, hill dipterocarp forest, upper hill dipterocarp forest, oak-laurel forest, montane ericaeous forest, peat swamp forest and mangrove forest. In addition, there also have smaller areas of freshwater swamp forest, health forest, forest on limestone and forest on quartz ridges (Guevara et al., 1986). The forests in Malaysia are mostly dominated by trees from the Dipterocarpaceae family. (Whitmore, 1989) This type of forest can be classified according to altitude into lowland dipterocarp forest (LDF), up to 300m above sea level, and hill dipterocarp forest (HDF) found in elevation of between 300m and 750m above sea level, and the upper dipterocarp forests, from 750m to 1,200m above sea level. However in Sarawak both the lowland and hill dipterocap forests are known as mixed-dipterocarp forest (MDF). HDF, normally found in areas 500-700m above sea level, contains less undergrowth. It is a little poorer in wildlife compared to the LDF, but is the preferred habitat of birds and small mammals that are tree "specialists" such as the squirrels. The *Rafflesia* species, which have the largest flowers in the world, can be found in these forests. (Primack & Corlett, 2005). At present, LDF is a threatened habitat. There are very few areas of this forest type left outside of protected areas such as parks and wildlife reserves. While most of the country was covered with lowland forest in the past, today the majority has been cleared for other land uses. The few remaining pockets are under threat.

2.2 Climate of Malaysia

Malaysia climate is categorized as equatorial, being hot and humid throughout the year. The average rainfall is 250 centimeters per year and the average temperature is 27 ℃. The climates of the Peninsula and the East differ, as the climate on the peninsula is directly affected by wind from the mainland, opposed to the more maritime weather of the East (Kwan et al., 2013). Malaysia is exposed to the El Niño effect, which reduces rainfall in the dry season. Climate change is likely to have a significant effect on Malaysia, increasing sea levels and rainfall, increasing flooding risks and leading to large droughts (Nakagawa et al., 2000). Malaysia faces two monsoon winds seasons, the Southwest Monsoon from late May to September, and the Northeast Monsoon from October to March. (Zhang, 2013). The Northeast Monsoon brings in more rainfall compared to the Southwest Monsoon, originating in China and the north Pacific (Deni et al., 2010). The southwest monsoon originates from the deserts of Australia. March and October form transitions between the two monsoons (Suhaila et al., 2010). Local climates are affected by the presence of mountain ranges throughout Malaysia, and climate can be divided into that of the highlands, the lowlands, and coastal regions. The coasts have a sunny climate with temperature ranging between 23 and 32 ℃. The lowlands have a similar temperature, but follow a more distinctive rainfall pattern and show very high humidity levels. The highlands are cooler and wetter. It displays a greater temperature variation. A large amount of cloud cover is present over the highlands, which have humidity levels that do not fall below 75 % (Griffiths et al., 2005).

2.3 Araceae

Araceae is the third bulkiest monocot family after Orchidaceae and Poaceae, and the seven largest of all flowering plants after Asteraceae, Fabaceae, Rubiaceae, and Lamiaceae includes 117 genera and about more than 3300 species on all continents except polar regions and the driest dessert (Boyce & Wong, 2014), mostly in tropical and subtropical regions; 36 genera are listed (35 indigenous) with 670 local species in Borneo (Boyce & Wong, 2014). The largest collection of living Araceae is maintained at the Missouri Botanical Garden. Species in the araceae are often found to contain oxalate crystals or raphides when handling or consuming the raw plant tissues of genera in the family. They are evergreen and seasonally dormant. Over half of all species are monoecious plants, and almost half bisexual. In monoecious aroids, the spadix, which is almost always surrounded by a modified leaf called a spathe. The most divergent features of Araceae are located in their inflorescences, which characteristically consist of the spadix, bearing small flowers usually arranged in spirals and connected by a conspicuous leaf-like or petal-like bract called the spathe. Flower may be bisexual or unisexual. Unisexual flowers usually born in separate female and male zone of the spadix, and some has a sterile apical appendix (Sulaiman et al., 2010). Many plants in this family are thermogenic. Their flowers can reach up to 45 Celsius degree even when the surrounding air temperature is much lower. It can attract insects to pollinate the plants, rewarding the beetles with heat energy.

2.4 *Schismatoglottis*

Tribe schismatoglottideae, one of the three tribes (together with Cryptocoryneae and Philonotieae) in the *Schismatoglottid alliance* (Boyce & Wong, 2014), is one of most speciose and diverse taxa, with more than 250 species, of which over 95% are endemic. *Schismatoglottis* is defined by a constricted spathe, staminate flowers lacking thecae horns, seeds without a micropylar appendage, and parietal placentation. Growth ranges from stoloniferous, colonial helophytes to clumping or solitary rheophytes and lithophytes, with stems variously elongated and creeping to erect or even weakly climbing, to clumping and congested.

Schismatoglottideae exists in shady humid forests in tropical areas at the low elevation, extending to lower limits of the upper montane zone and is distributed from Indochina to Oceania, centered on Borneo (Barabe et al., 2004).

The species are *Schismatoglottis acutifolia*, *Schismatoglottis adoceta*, *Schismatoglottis ahmadi*, *Schismatoglottis ardenii*, *Schismatoglottis asperata*, *Schismatoglottis barbata*, *Schismatoglottis bifasciata*, *Schismatoglottis brevicuspis*, *Schismatoglottis calyptrata*, *Schismatoglottis cyria*, *Schismatoglottis scortechinii*, *and Schismatoglottis sejuncta* and so on.

Schismatoglottis calyptrata is a charming species of the genus that consist of about 100 species. It is the most broadly distributed species in the genus. It is low-growing, about 15-60cm tall. It spreads easily to form a colony of new plants (Peter & Wong, 2009). It is also variable in characters such as leaf colouration and shape. The leaf blades are generally dull mid-green, with or without variegation. It has one to two bands along midrib or between midrib, while others are irregularly spotted or mottled grey-green to yellowish. Leaves that are held on petioles are heart shaped, either cordate or sagittate at the base and patterned with submarginal veins. The foliar margin is simple and entire. Its erect and bulled-shaped inflorescences are rather small and inconspicuous, each consisting of a spadix and a bract called a spathe, with proximal part female and distal part male. The peduncle is shorter than the petioles. It is naturally found in dense tropical forests, forest understories, on rock or at river banks. Stems and leaves of Dukaruk, another type of *Schismatoglottis calyptrata* naturally growing along the river banks of Sabah are favored by the natives and cooked as edible vegetables. Elsewhere, the stems are used as a tonic medicine to treat lumbago and arthralgia.

Figure 2.1: Image of *Schismatoglottis calyptrata*
Source: Tsukaya et al. (2004)

Figure 2.2: Image of *Schismatolgottis brevicuspis*
Source: Tsukaya et al. (2004)

2.5 Ecological Niche Modeling (ENM)

Environmental niche modelling or known as species distribution modelling, predictive habitat distribution modelling and climate envelope modelling. It is the process of using computer algorithms to predict the distribution of species in Kelantan. They can relate observed presences of a species to values of environment variables at certain sites (Morales et al., 2015). Besides, certain dataset will depend on a number of factors, including the nature, accuracy of the models used and the quality of the available environmental data layers. It can utilize associations between environmental variables and known species occurrence localities to define abiotic conditions within which populations can be maintained (Warren & Seifert, 2011).

It also includes simple statistical techniques which known as a machine learning algorithm that integrated environmental data layer. It can be useful in understanding the potential distribution of species in geographic space. Ecological niche modelling overcomes a lot of the difficulties that arise with physiological estimation of the niche compare using Extent of Occurrence (EOO) and Area of occupancy (AOO) (He & Gaston, 2000). Extent of Occurrence (EOO) and Area of occupancy (AOO) method is disconcerted by how the total range size is measured. The Extent of Occurrence (EOO) can be the minimum convex polygon encompassing all known normal occurrences of a particular species and the measure of range in the field guides. The Area of occupancy (AOO) is the subset of the Extent of Occurrence (EOO) where the species occurs. In essence, the Area of occupancy (AOO) acknowledges that there are holes in the distribution of a species within its Extent of Occurrence (EOO), and attempts to correct for these vacancies (Segurado & Araujo, 2004). The results of Extent of Occurrence (EOO) and Area of occupancy (AOO) are depending on species with a broad ecological niche so that able to obtain higher local densities and a wider distribution. Species with a narrow niche bread would generate a negative O-A relationship (Jiménez-Alfaro et al., 2012).

2.6 Maximum Entropy (MAXENT)

Maxent is a purpose method for doing predictions or inferences from incomplete information. It uses a regularization approach, introduced in a companion theoretical paper (Philips et al., 2004). The idea of Maxent is to estimate a target probability distribution by finding the probability distribution of maximum entropy. The information available about the target distribution often present itself as a set of real-valued variables, called “features”. It can estimate a very large number of features by finding the distribution of maximum entropy. When it is applied to presence only-species distribution modelling, it will record the sample points, and the features are climatic variables, elevation, soil category, vegetation type or other environmental variables and functions. It needs only existence data together with environmental information for the study area. It can utilize both continuous and categorical data and can link interactions between different variables (Phillips et al., 2006). The Maxent probability distribution has a concise mathematical definition, and is therefore amenable to analysis. Maxent could also be applied to species presence by using conditional model. The computer model is a probability distribution over all the grid cells (Baldwin, 2009). Meanwhile, Maxent software can be freely downloaded from www.cs.princeton.edu/~schapire/maxent (Elith et al., 2011).

2.7 Area of Occupancy (AOO)

AOO is defined as the area within its ‘area of occupancy which is occupied by a group of organism, excluding cases of vagrancy. The measure reflects that fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. The area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon (Tobergte & Curtis, 2013). IUCN recommended that AOO calculations should be obtained from the sum of the occupied grid cells. There are many problems associated with the use of grid measurements. These include defining grid extent, grid resolution and the arbitrary positioning of the grid. The total size of the grid should be a square or rectangle sufficient to account for all the point recorded in a species distribution. Performing an AOO measurement manually requires a subjective decision in placing the grid. Utilizing as GIS to perform AOO measurements ensures consistent grid placement when the procedure is replicated.

The scale of observation will influence the value generated for AOO. By adopting a fine scale, a species will be recorded in a species distribution. Assessors must also ensure that a grid can be placed in the same species in future. Performing an AOO measurement manually requires a subjective decision in placing the grid. Utilizing a GIS to perform AOO measurements ensures consistent grid placement when the procedure is replicated. The scale of observation will influence the value generated for AOO. By adopting a fine scale, a species will be recorded from a smaller AOO and consequently the species will become more eligible for threatened status than if using a broad scale.

2.8 Extent of Occurrence (EOO)

It will be defined as the areas contained within the shortest continuous imaginary boundary which can sketch to encompass all the known or projected site of present occurrence of a taxon, excluding cases of vagrancy. It can often measure by the smallest polygon in which no internal angles exceed 180 degrees and which contains all the site of occurrence (Thorn et al., 2009). There is no specific method to calcualting EOO. Manual measurement of EOO can be subjective and time consuming, cannot be replicated consistenly and should be avoided. A convex polygon could not be calculated for collections occuring in the same plane or with less than three point localities. This measure may exclude, discontinuities or disjunctions within the overall distribution of taxa. However, this may prove difficult to implement. It is difficult to know which areas to omit from a calculation of EOO. Excluding areas within EOO should be avoided for this reason. If large areas unsuitable for species growth are identified within EOO, it would be more appropriate to apply a measurement of AOO.

2.9 Shuttle Radar Topography Mission (SRTM)

Shuttle Radar Topography Mission (SRTM) is researches that obtain a digital elevation models and generate the most complete high-resolution digital topographic database of Earth. The whole Kelantan will have displayed in a high-resolution digital topographic database. When the Space Shuttle is operating, it will be conducting remote sensing missions from low earth orbit and generate new digital elevation model data set know as DEM (digital elevation model). The background information such as sources and qualities of DEM is required by using the SRTM (Nikolakopoulos et al., 2006).

2.10 Bioclimatic data

Bioclimatic variables are derived from the monthly temperature and rainfall values in order to produce more biologically meaningful variables. The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation) seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters). A quarter is a period of three months (1/4 of the year).

Predicting the current or future distributions of species has principally been conducted using bioclimatic models to assume that climate ultimately restricts species distributions. The models can be used to identify species current potential distribution, that is, all areas with climatic values within the species bioclimatic envelope and assess whether these areas will remain climatically under future scenarios.

Table 2.1: Nineteen Bioclimatic variables used in Maxent software

BIOCLIM	**Environmental Variables**
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermally (BIO2/BIO7/)(*100)
BIO4	Temperature Seasonality (Standard deviation *100
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation of Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Source: Hijmans et al. (2005)

CHAPTER 3

MATERIAL AND METHODS

3.1 Material

3.1.1 Study Area

The study area of the whole state of Kelantan had been chosen for the distribution potential of the species from the genus *Schismatoglottis*. The total area of Kelantan is 15,105 km ^{2}. The Figure 3.1 shows the map of Kelantan state.

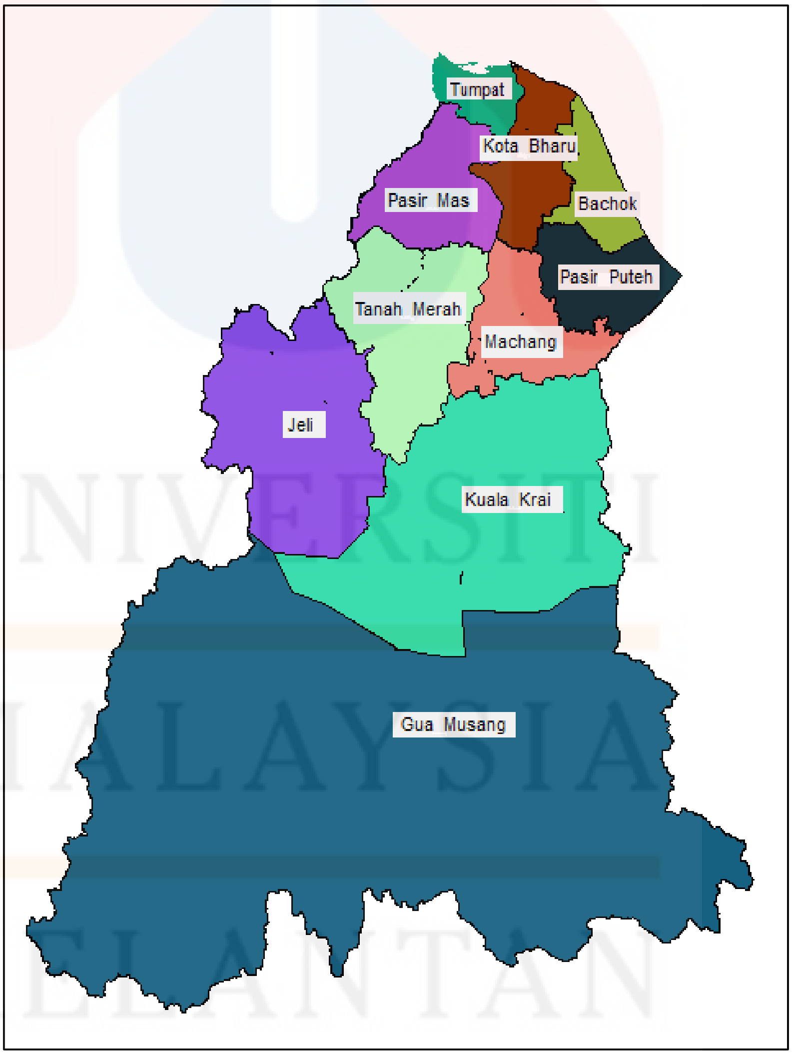

Figure 3.1: Map of Kelantan State created by using DIVAGIS version 7.5

3.1.2 Secondary dataset

The dataset that is collected by and readily available from another source. The secondary datasets are collected from Forest Research Institute of Malaysia (FRIM) which located at Kepong, Selangor. These secondary datasets are regarding the information on *Schismatoglottis* and availability of the *Schismatoglottis* in the state of Kelantan.

3.1.3 Environmental data

In general, the environmental data is needed for identification of *Schismatoglottis*. It can be obtained from the website of worldclim: (www.worldclim.org/bioclim) (Hijmans et al., 2005). This webpage is giving the information of current global climate, e.g. Current conditions (interpolations of observed data, representative of 1950-2000), future conditions: downscaled global climate model (GCM) data and past Conditions (downscaled global climate model output). Bioclimatic data for Kelantan at 30 arc-second (~1km) resolution were obtained from Worldclim. SRTM dataset were retrieved from the website of SRTM: (http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp) and it undergoes "extract by mask" from ArcGis. .

3.1.4 Study species

Two species were chosen to be studied in this research. This study focused on two species of *Schismatoglottis* which are *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis*.The prediction distribution model was used to compare the data percentage of *Schismatoglottis* species.

3.1.5 Harmonized World Soil Data (HWSD)

The Harmonized World Soil Data (HWSD) database is representing the attribute database which provides soil information on soil unit composition for each 15773 soil mapping unit. HWSD consist of raster image file which composed of 21 600 rows and 43 200 columns. It is comprises the mapping units of Kelantan as a spatial raster layer and the data characterizing as attributes in form of tables. It is using a raster format simplifies integrating spatial entities coming from diverse sources and facilitates processing numeric attributes in the spatial domain of environmental models. The raw data was download as raster and convert as shapefile from ArcGis software. The projection was defined and masking with the map of Kelantan.

3.2 Method

3.2.1 Maximum Entropy

To generate the model for the potential of *Schismatoglottis*, the maximum entropy has applied to present data and this was develop a model of the *Schismatoglottis* based on the environmental data and secondary dataset (Phillips et al., 2004). The dataset and environment variables were converted into ARCSII first then can process with the MAXENT software. Bioclimatic variables were taken in the running test with 100 replication.

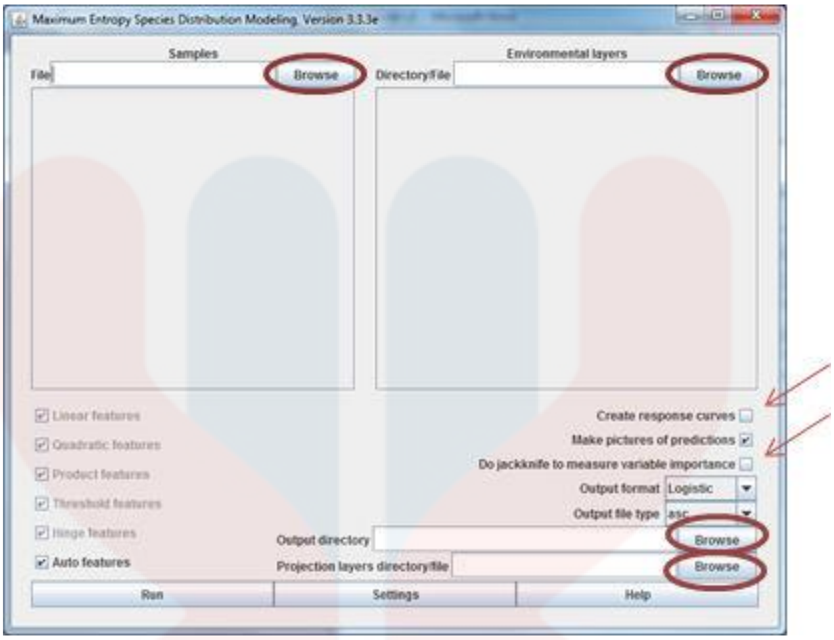

Figure 3.2: Graphic User Interface (GUI) of MAXENT software
Source: Philips et al. (2006)

In the same times, there can be multiple species in the same sample file. It can provide coordinated system other than latitude and longitude from the samples file. The directory layer contains a number of study species and is describe an environmental variable. The output file contains a picture of the model applied to the given environmental data.

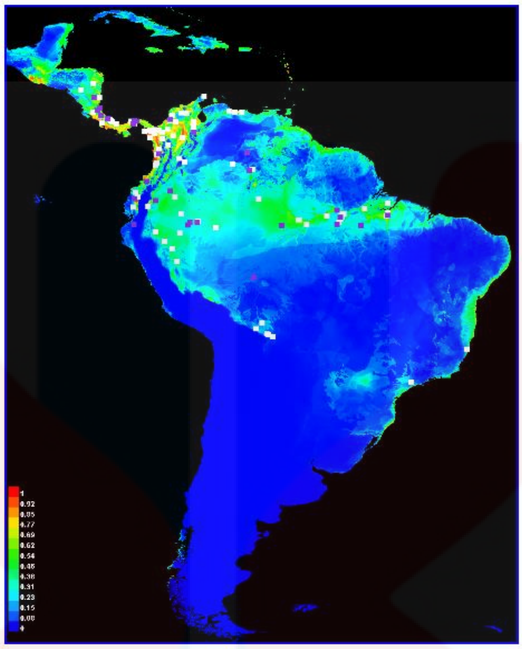

Figure 3.3: MAXENT output model by using Maxent software
Source: Philips et al. (2006)

Figure 3.3 show Maxent output of species tested using Maxent Software. The gradient color shown that the potential distribution of species run by Maxent. The red is indicates the highest potential occurrence of species whether the blue color indicates the lowest probability of species.

3.2.2 Area of Occupancy (AOO)

By using Area of Occupancy as method tool, the number of localities and number of subpopulations for any species can calculated from a database of specimens. The size of the area of occupancy has a function of the scale at which it is determined and should be at a proper scale to relevant biological aspects of the genus *Schismatoglottis*. By using Area of occupancy method, the Figure 3.4 had shown up in the calculation.

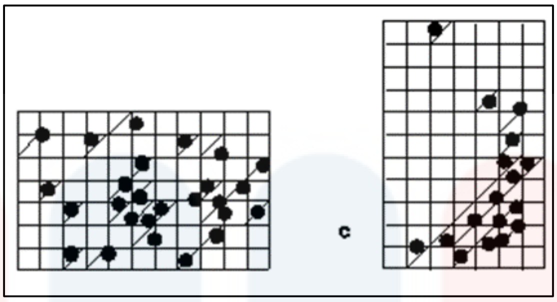

Figure 3.4: The Area of occupancy (AOO)
Source: MacKenzie (2006)

3.2.3 Extent of Occurrence (EOO)

When the range extent is estimated for genus *Schismatoglottis* that has large areas of obviously, unsuitable or unoccupied habitat that should be excluded from the calculation. The range extent was overestimated by using a minimum convex polygon like Figure 3.5 to calculate the distribution of species. The range of extent is the sum of enclosed areas.

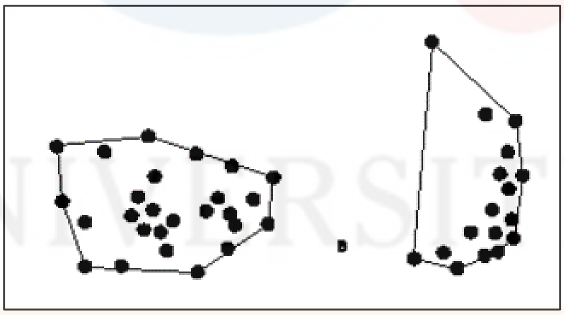

Figure 3.5: The convex polygon from the extent of occurrence (EOO)
Source: MacKenzie (2006)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Distribution of selected genus *Schismatoglottis* in Kelantan

Secondary data are required in order to identify the distribution of the selected *schismatoglottis* species which are *Schismatoglottis brevicuspis* and *Schismatoglottis calyptrata*. The data collected are review and has been processed as some of its are redundancy which means there are several localities are located near to each other thus makes it look redundant once it manipulated using Arc-GIS. Some points are in invalid location. The data collected from the sources are reviewed and has been processed. The dot map of two selected species from *Schismatoglottis* which is generated Using DIVAGIS version 7.5 is showed on Figure 4.1 and Figure 4.2.

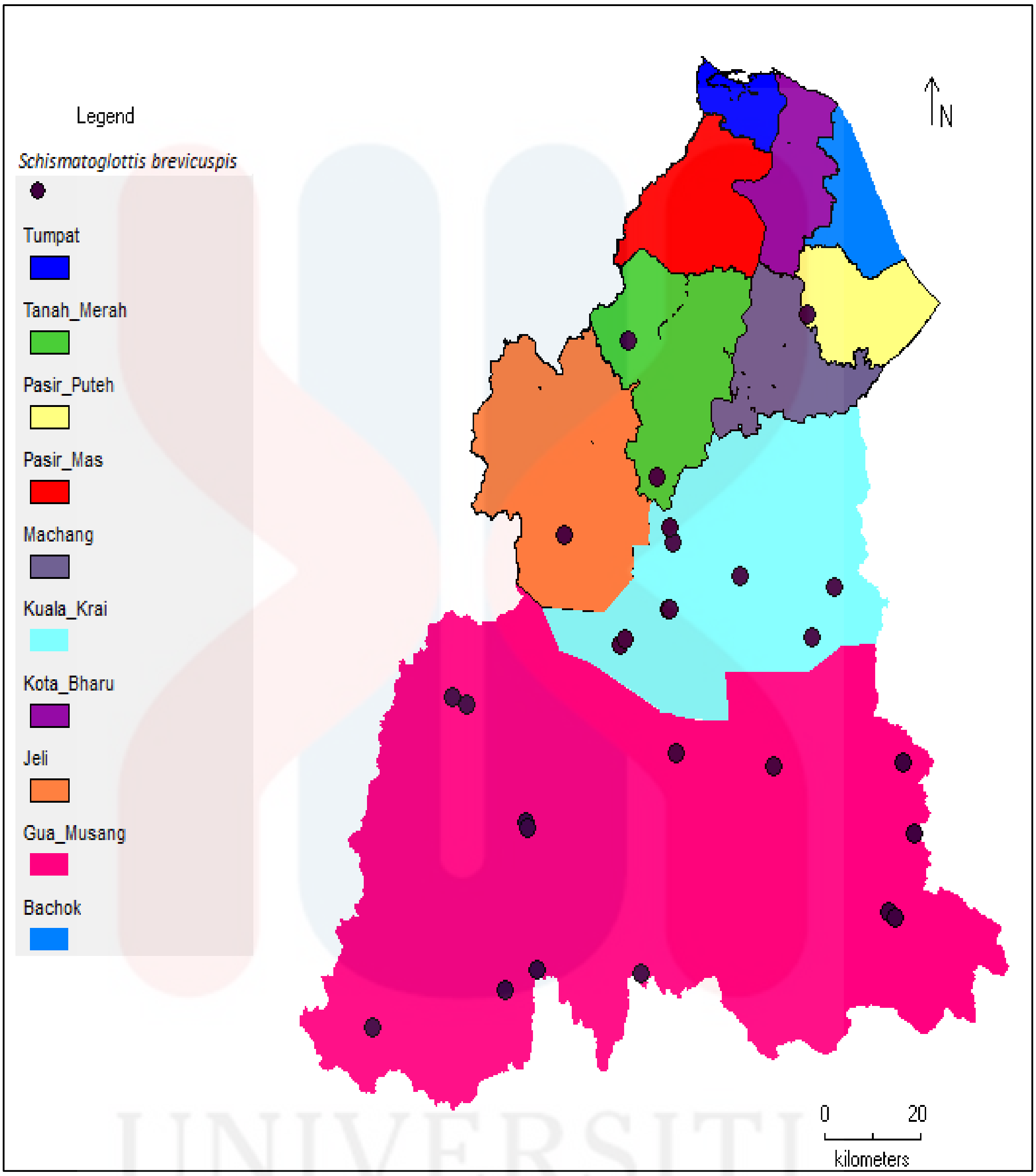

Figure 4.1: The locality data of *Schismatoglottis brevicuspis* in Kelantan state

The total locality data for *Schismatoglottis brevicuspis* are recorded with 26 points. Based from the Figure 4.1, Gua Musang is having 13 point of *Schismatoglottis brevicuspis* in the map of Kelantan.

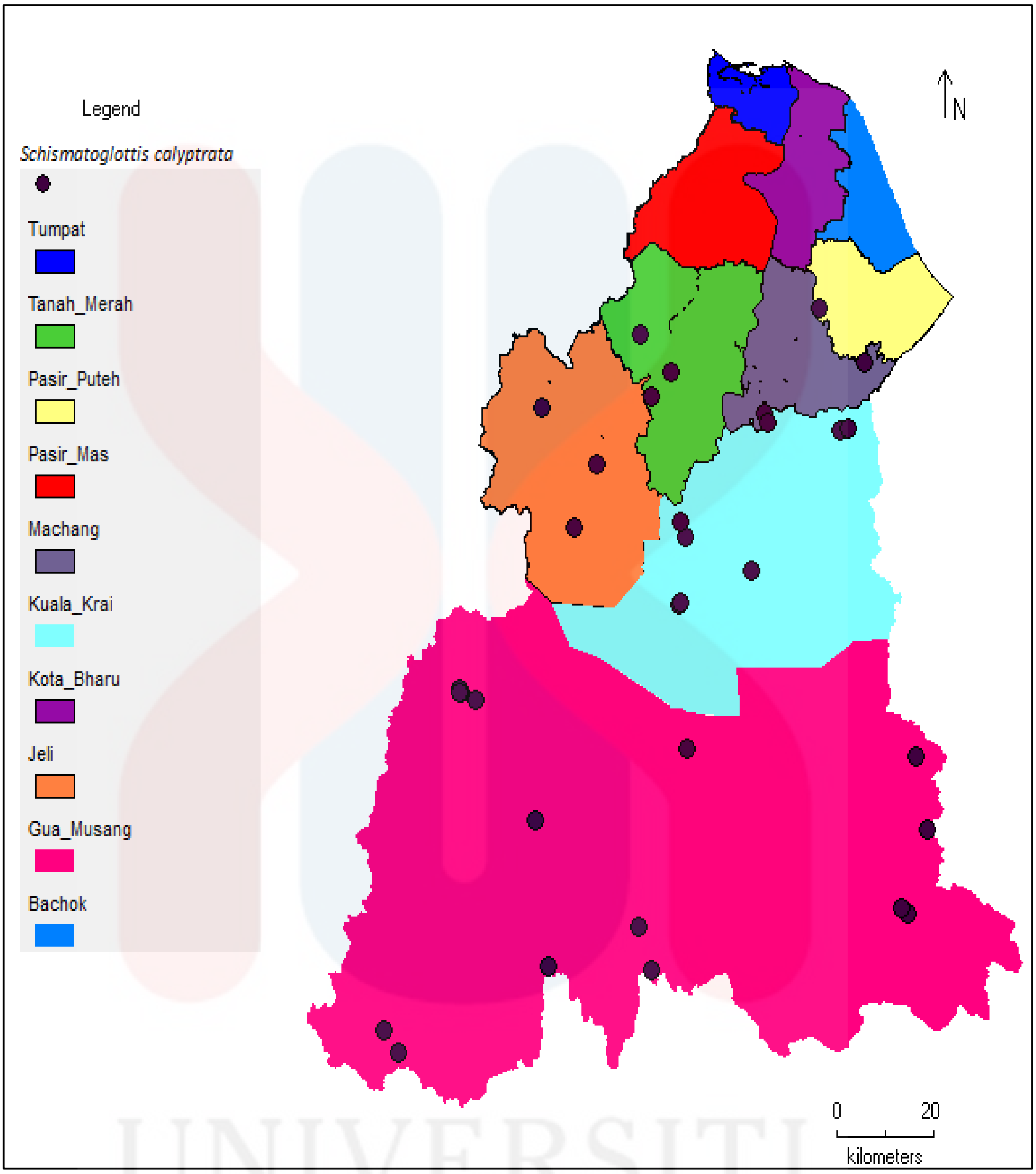

Figure 4.2: The locality data of *Schismatoglottis calyptrata* in Kelantan state

Figure 4.2 shows the locality data for *Schismatoglottis calyptrata* in Kelantan state. The total locality data that had been founded are 29 points. Most of points were appear in the region of Gua Musang.

4.2 MAXENT output

MAXENT modelling software was used to predict the potential distribution of the genus *Schismatoglottis* in Kelantan, Malaysia. It is able to characterizing the suitable of environmental condition for the genus by insert 19 bioclimatic data and Harmonized World Soil Database (HWSD).

The model was developed using the full set of locality data to provide best estimates of potential distribution. It was using random selection of 0% to testing the resulting model. The second model was undergoing random selection of 25% as training data to get resulting model. This data is used to manipulate the average data taken from the result of modelling to determine the exact distribution place and to predict the optimum place for plant growth. The model has been run with 100 replicates model per species. The result from MAXENT software used for validation process called area under the curve (AUC). Table 4.1 show the AUC values for each genus *Schismatoglottis* based on different model run in MAXENT which is Full Run Training Data and 25% testing data. Table 4.1 shows area under the curve (AUC) for *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis*. *Schismatoglottis calyptrata* in full run training data has obtained 0.862% without HWSD data, 0.869% when include HWSD data and 0.874% after include HWSD and SRTM data. This classification for the AUC of *Schismatoglottis calyptrata* is good, which in the range of 0.8 to 0.9. *Schismatoglottis brevicuspis* has require 0.972 without the input of HWSD, 0.973 when cover HWSD data and 0.980 after include HWSD and SRTM data. The classification for the AUC of *Schismatoglottis brevicuspis* is very good in the range of above 0.9.

Table 4.1: Area under the curve (AUC) for *Schismatoglottis calyptrata and Schismatoglottis brevicuspis*

Species		**Area Under the Curve**		
		Without HWSD	**Include HWSD**	**Include HWSD and SRTM**
Schismatoglottis brevicuspis	Full run training data	0.862	0.869	0.874
Schismatoglottis calyptrata	Full run training data	0.972	0.973	0.980

Table 4.2: Range of AUC and its classification

RANGE	CLASSIFICATION
<0.6	Fail
0.6-0.7	Poor
0.7-0.8	Fair
0.8-0.9	Good
>0.9	Very good

Figure 4.3 had show the graph of Area under Curve of *Schismatoglottis brevicuspis* with 19 bioclimatic variables. Figure 4.4 had shown the graph of Area under Curve of *Schismatoglottis brevicuspis* include HWSD dataset. Figure 4.5 had display the graph of Area under Curve of *Schismatoglottis brevicuspis* include

HWSD dataset and SRTM dataset. Figure 4.6 had present the graph of Area under curve of *Schismatoglottis calyptrata* with 19 bioclimatic variables. Figure 4.7 had exhibit the graph of area under curve of *Schismatoglottis calyptrata* include HWSD dataset. Figure 4.8 had illustrate the graph of area under curve of *Schismatoglottis calyptrata* include HWSD dataset and SRTM dataset.

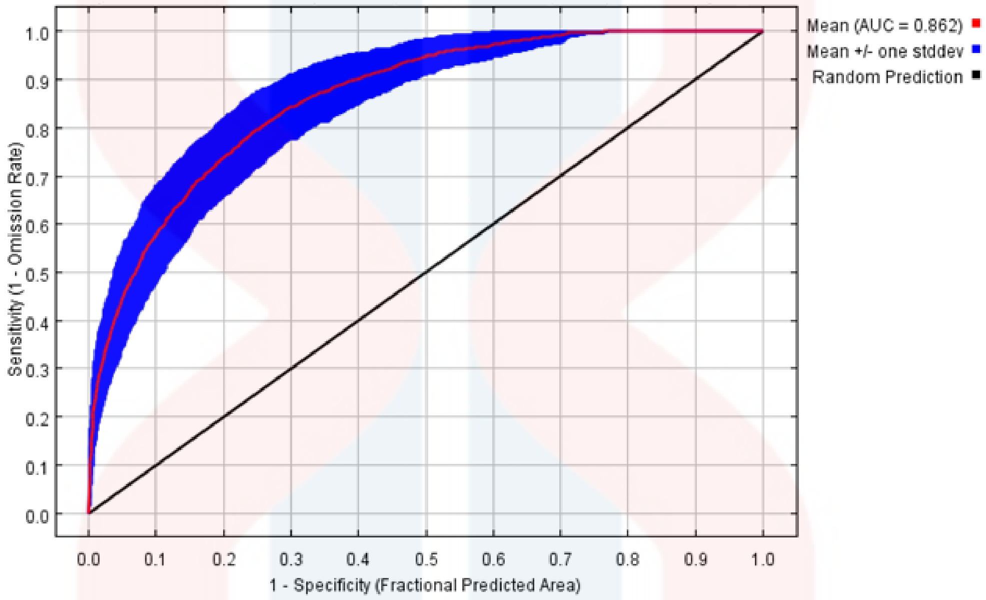

Figure 4.3: The graph of Area under Curve of *Schismatoglottis brevicuspis* with 19 bioclimatic variables

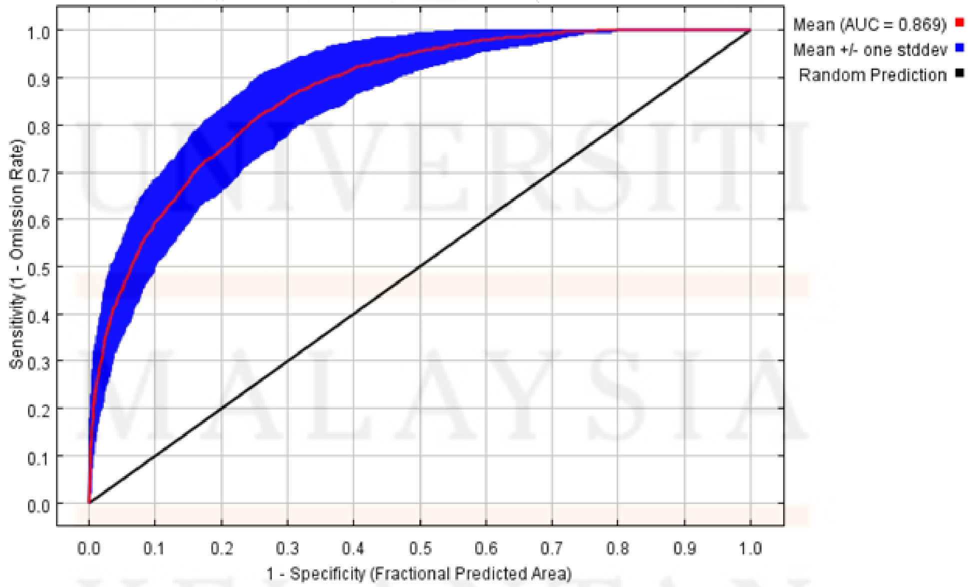

Figure 4.4: The graph of Area under Curve of *Schismatoglottis brevicuspis* include HWSD dataset

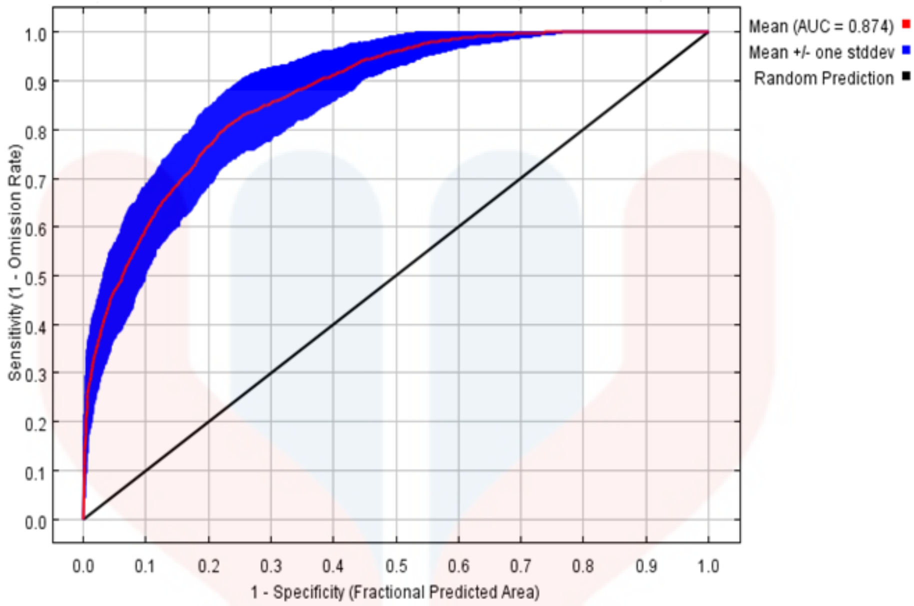

Figure 4.5: The graph of Area under Curve of *Schismatoglottis brevicuspis* include HWSD dataset and SRTM dataset

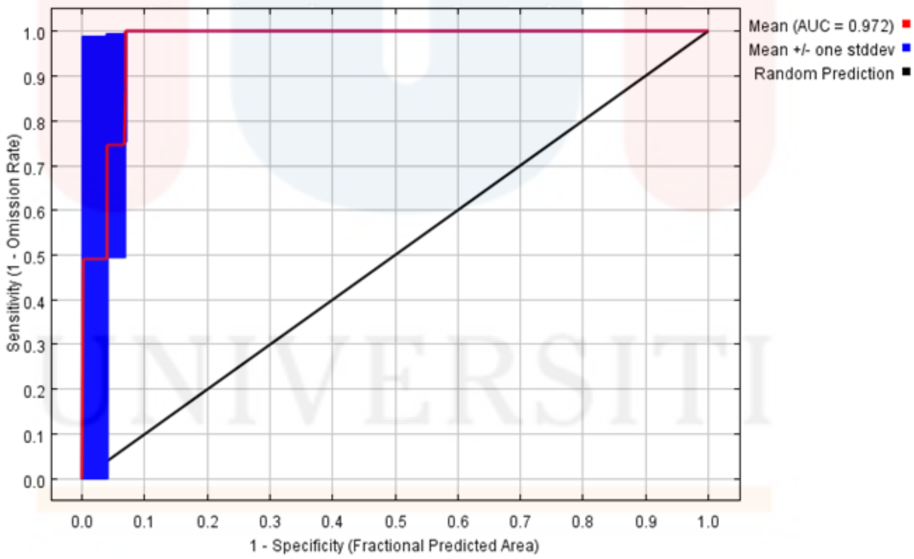

Figure 4.6: The graph of Area under curve of *Schismatoglottis calyptrata* with 19 bioclimatic variables

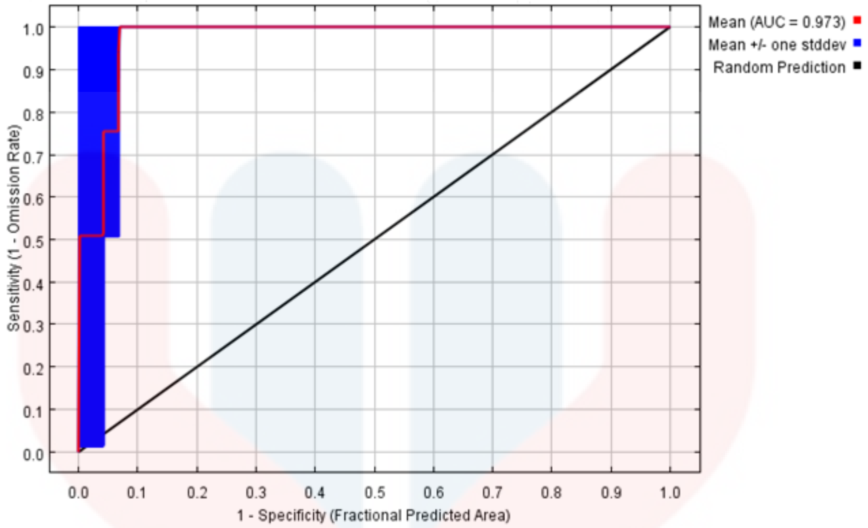

Figure 4.7: The graph of area under curve of *Schismatoglottis calyptrata* include HWSD dataset

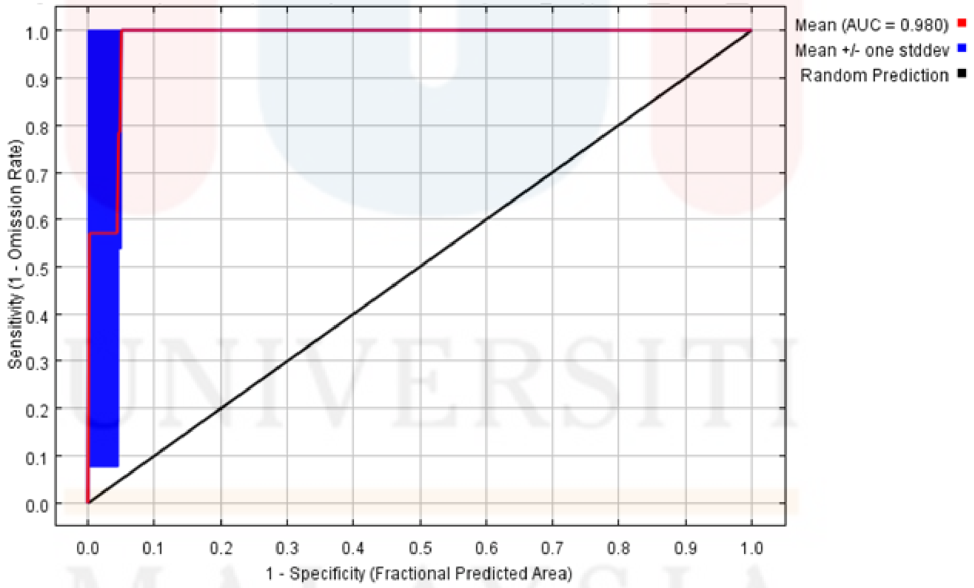

Figure 4.8: The graph of area under curve of *Schismatoglottis calyptrata* include HWSD dataset and SRTM dataset

4.3 Distribution of *Schismatoglottis brevicuspis*

Figure 4.9 show the predicted distribution using 19 bioclimatic data. Figure 4.10 show the predicted distribution using 19 bioclimatic variables, HWSD data, and SRTM dataset. Both of figures had been shown different changes in color. Both figures had been processed by MAXENT software by replicate 100 times and undergo 19 bioclimatic variables. The color represents suitability and possibility for the species distribution. Color towards red indicates high probability for growth. Green color indicates typical condition of the species to exist and blue indicates low probability of the species to be occurred in suitable habitat.

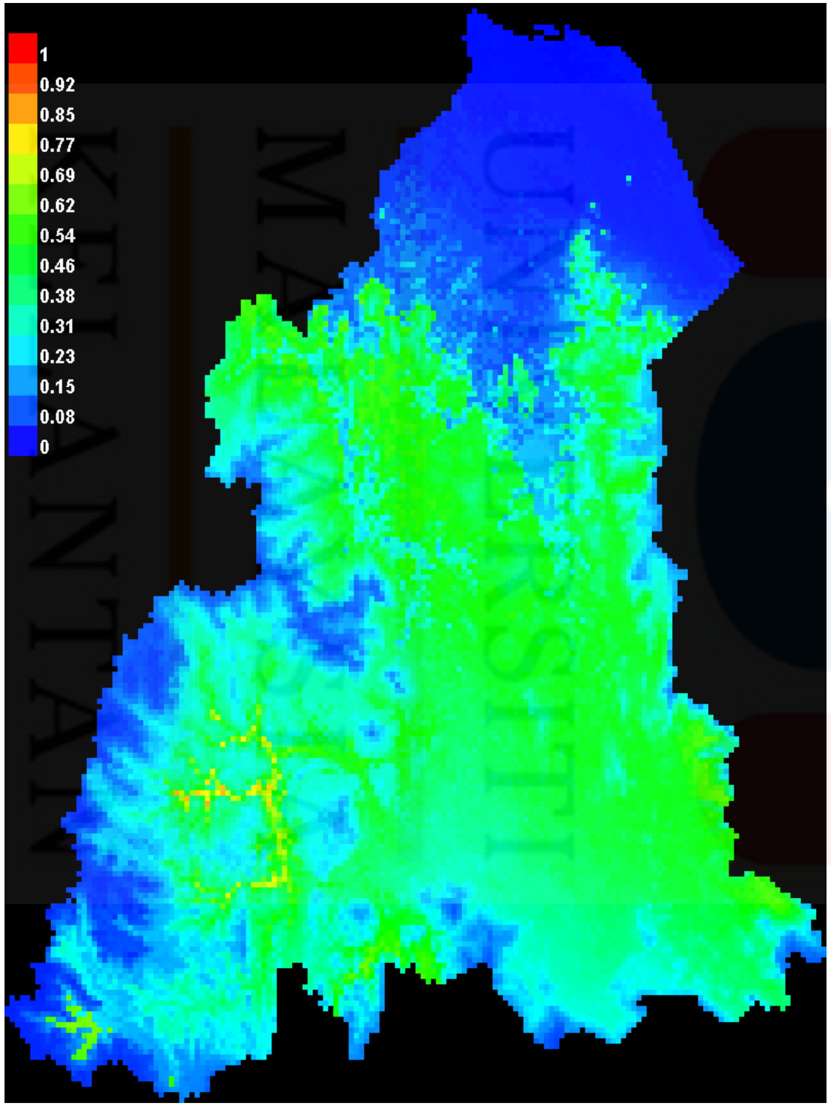

Figure 4.9: Predicted distribution of *Schismatoglottis brevicuspis* with 19 Bioclim variables

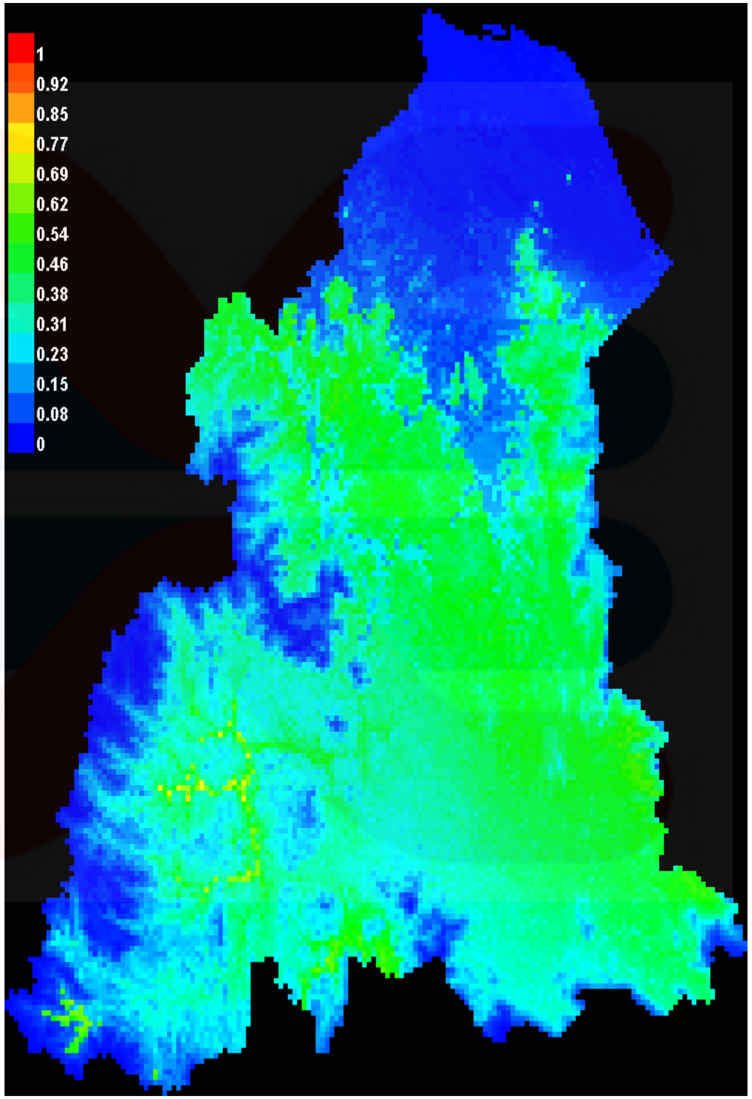

Figure 4.10: Predicted distribution of *Schismatoglottis brevicuspis* with HWSD data and SRTM dataset

Table 4.3: Percentage contribution of environmental variable of *Schismatoglottis brevicuspis* in Kelantan

Variable	Percentage contribution (%)		
	Without HWSD	Include HWSD	Include HWSD and SRTM
BIOCLIM 10	18.4	19.7	15.7
BIOCLIM 15	13.6	12.6	13.1
BIOCLIM 16	12.9	10.1	12.7
BIOCLIM 2	9.1	9.5	6.2
BIOCLIM 13	7.9	8.5	8.6
BIOCLIM 1	7.9	7.3	5.5
BIOCLIM 12	6.6	6.2	5.7
BIOCLIM 8	5.1	2.4	1.5
BIOCLIM 17	4.8	5.4	2.7
BIOCLIM 7	2.9	2.1	1.6
BIOCLIM 5	2.6	2.7	2.5
BIOCLIM 11	1.9	2.4	0.9
BIOCLIM 9	1.6	1.3	0.7
BIOCLIM 19	1.6	1.3	2.8
BIOCLIM 14	1.1	1.6	1.8
BIOCLIM 3	0.9	1.2	1.0
BIOCLIM 4	0.6	0.8	1.1
BIOCLIM 6	0.5	1.5	0.6
BIOCLIM 18	0.1	0.1	0.3

HWSD	0	3.2	3.0
SRTM	0	0	12.0

The variables percentage contribution in Table 4.3 shows the factor that affects the predicted distribution of *Schismatoglottis brevicuspis* in Kelantan.

This table shows the environmental variables used in the model and their percent predictive contribution of each variable. The higher the contribution, the more impact that particular variable has on predicting the occurrence of that species. From the Table 4.3, BIOCLIM 10, the mean temperature of warmest quarter had the higest predictive contribution of 18.4%. BIOCLIM 15, Precipitation Seasonality contribute 13.6 % on the growth of *Schismatoglottis brevicuspis.* The variables had least contribution is BIOCLIM 18, Precipitation of Warmest Quarter. When the HWSD data included in the table 4.3, BIOCLIM 10, the mean temperature of warmest quarter had the highest predictive contribution of 19.7%. BIOCLIM 18, Precipitation of Warmest Quarter still remain at 0.1% which had less conribution on the growth of *Schismatoglottis brevicuspis.* Besides, the results were combined with 19 bioclimatic variables, SRTM dataset and HWSD dataset have some changes of precentage. BIOCLIM 10 conributte 15.7% to *Schismatoglottis brevicuspis* and still was highest contributors. SRTM dataset was giving 12% in overall percentage contribution of *Schismatoglottis brevicuspis.* The least contribution of bioclimatic variables is BIOCLIM 6. Both of them were Minimum temperature of coldest Month and Precipitation of Warmest Quarter.

4.4 Distribution of *Schismatoglottis calyptrata*

Figure 4.11 shows the predicted distribution using 19 bioclimatic data in Map of Kelantan while Figure 4.12 shows the expected distribution using 19 bioclimatic variables, HWSD dataset and SRTM dataset. Both of figures had been shown different changes in color. Both figures had been processed by MAXENT software by replicate 100 times and undergo 19 variables factors. The color represents suitability and the possibility for the species distribution. Color towards red indicates high probability for growth. Green color indicates medium probability of the species to live and blue indicates low probability of the species to be occurred in suitable habitat.

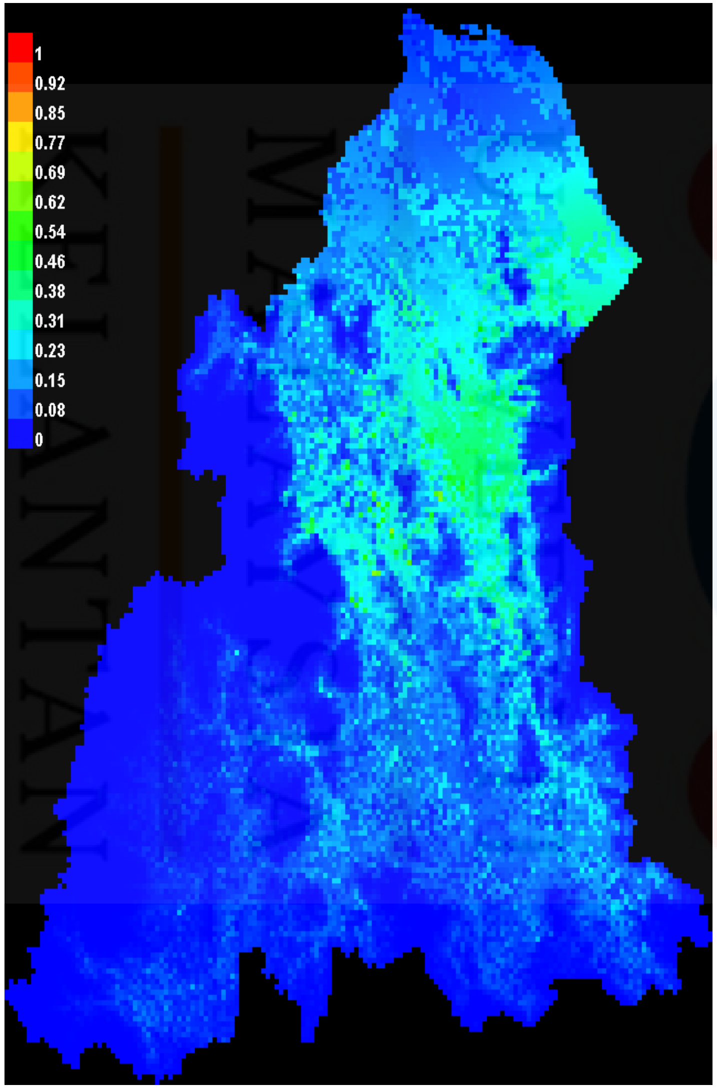

Figure 4.11: predicted distribution of *Schismatoglottis calyptrata* with 19 Bioclim dataset

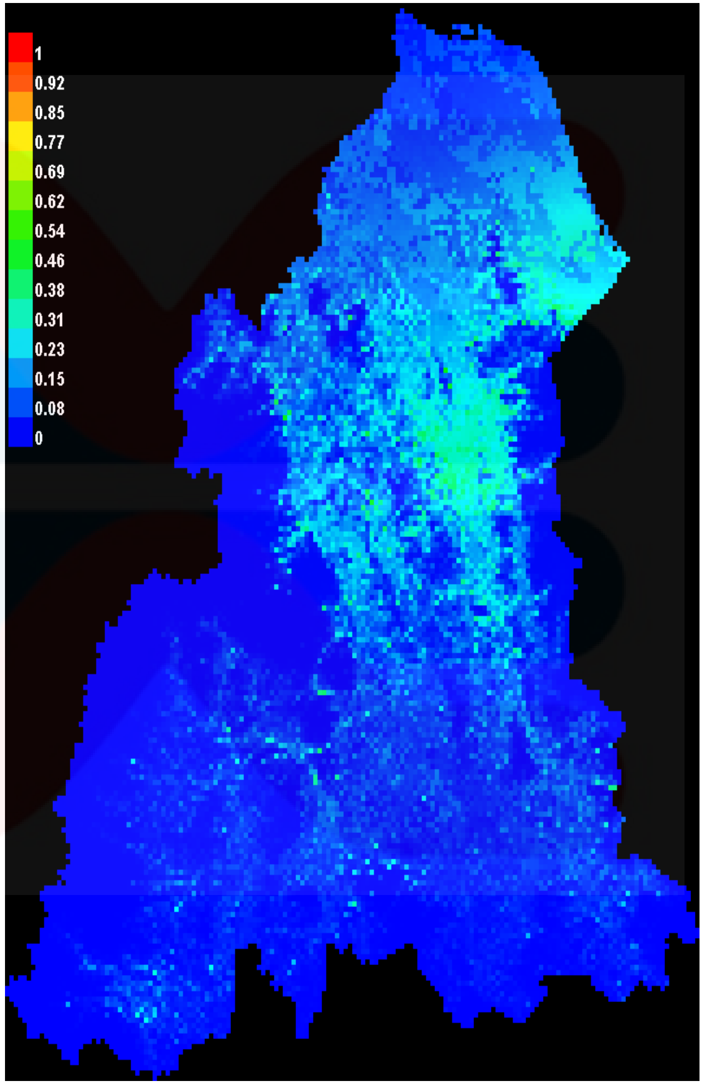

Figure 4.12: predicted distribution of *Schismatoglottis calyptrata* with 19 Bioclim data, HWSD dataset and SRTM dataset

Table 4.4: Percentage contribution of environmental variable of *Schismatoglottis calyptrata* in Kelantan

Variable	**Percentage contribution (%)**		
	Without HWSD	**Include HWSD**	**Include HWSD and SRTM**
BIOCLIM 8	13.9	42.5	8.8
BIOCLIM 1	41.5	8.9	32.9
BIOCLIM 5	5.5	6.8	3.8
BIOCLIM 17	10.1	6.8	7.1
BIOCLIM 3	5.7	6.3	8.4
BIOCLIM 14	8.9	5.6	5.5
BIOCLIM 13	4.0	4.3	5.3
BIOCLIM 15	2.2	3.4	3.3
BIOCLIM 4	2.6	3.3	4.1
BIOCLIM 12	0.1	2.7	2.1
BIOCLIM 11	1.2	1.9	2.6
BIOCLIM 19	0.7	1.0	0.8
BIOCLIM 6	0.5	0.6	0.1
BIOCLIM 2	0	0.4	0
BIOCLIM 7	2.1	0.2	0.1
BIOCLIM 18	0.9	0.2	1.8
BIOCLIM 16	0	0.1	0.1
BIOCLIM 10	0	0	0
BIOCLIM 9	0	0	0

HWSD	0	5.3	7.6
SRTM	0	0	5.5

Table 4.4 shows the environmental variables used in the model and their percent predictive contribution of each variable. From this table , it is found that BIOCLIM 1, Annual mean Temperature and BIOCLIM 8, Mean temperature of wettest quarters give the high amount of the growth effect on *Schismatoglottis calyptrata* which at 41.5% and 13.9%. while, the factor that has the least effect on the growth of *Schismatoglottis calyptrata* is BIOCLIM 12 at 0.1%. BIOCLIM 2, 9, 10 and 16 are all shows at 0%, which are mean diurnal range, mean temperature of driest quarter, mean temperature of warmest quarter and precipitation f wettest quarter. this meant these factors are not given any effect growth of *Schismatoglottis calyptrata*.

In Table 4.4 the result shows when including HWSD data, the percentage contribution of variable has change in order. BIOCLIM 8, Mean Temperature of wettest quarters give the high amount of the growth effect on *Schismatoglottis calyptrata* which at 42.5% and BIOCLIM 1, Annual mean Temperature has 8.9%. HWSD data contain 5.3% of contribution. The variables that has the least effect on the growth of *Schismatoglottis calyptrata* is BIOCLIM 16, Precipitation of Wettest Quarter. BIOCLIM 10 and 9 are shows at 0% which are Mean Temperature of Driest Quarter and Mean Temperature of Warmest Quarter. In the view of table, HWSD data have a great influence in the percentage distribution of variables. BIOCLIM 9 & 10 is not contributing for the species distribution of *Schismatoglottis calyptrata.* Furthermore, Table 4.4 includes HWSD dataset and SRTM dataset have some changes. As a result, it shows that BIOCLIM 1 has the highest contribution of 32.9%

as Table 4.4. Whereas, SRTM contributes about 5.5% of the growth of *Schismatoglottis calyptrata*. The variables that have the least effect on the germination of *Schismatoglottis calyptrata* was BIOCLIM 7, BIOCLIM 6 and BIOCLIM 16.

4.5 Comparison of Ecological Niche Modelling (ENM) with Area of Occupancy (AOO) and Extent of Occurrence (EOO)

Figure 4.13 shows the comparison of distribution area of *Schismatoglottis brevicuspis* in Kelantan using Extent of Occurrence (EOO) and Area of Occupancy (AOO). Predicted area of EOO of this species is about 9173.98 km^2. The species fall under the category of Vulnerable (VU) according to IUCN. The area of AOO for this species is 84 km^2 and it fall under Least Concern (LC) category. Figure 4.14 shows the availability of *Schismatoglottis brevicuspis* are mainly occurring in the left bottom side of Gua Musang, Kelantan when only involve 19 bioclimatic variables. Figure 4.15 displays *Schismatoglottis brevicuspis* on the map when involve 19 bioclimatic variables, HWSD dataset and SRTM dataset. The red color indicates a high probability for the appearance of *Schismatoglottis brevicuspis.* The yellow color represents the medium probability for the expose of *Schismatoglottis brevicuspis*. The dark green color symbolizes the low probability for the finds of *Schismatoglottis brevicuspis.*

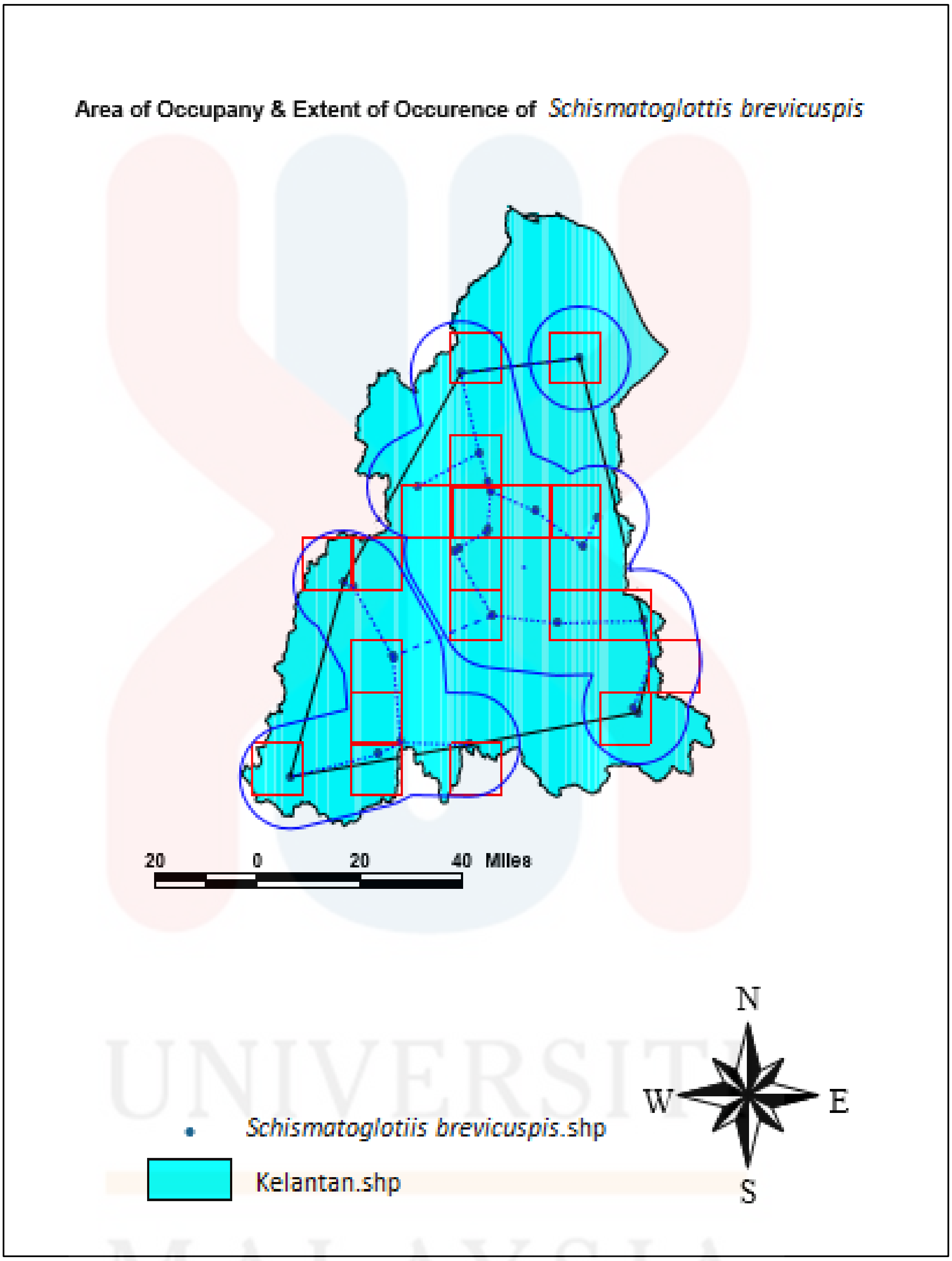

Figure 4.13: The comparison of distribution area of *Schismatoglottis brevicuspis* in Kelantan using Area of Occupancy (AOO) and Extent of Occurrence (EOO)

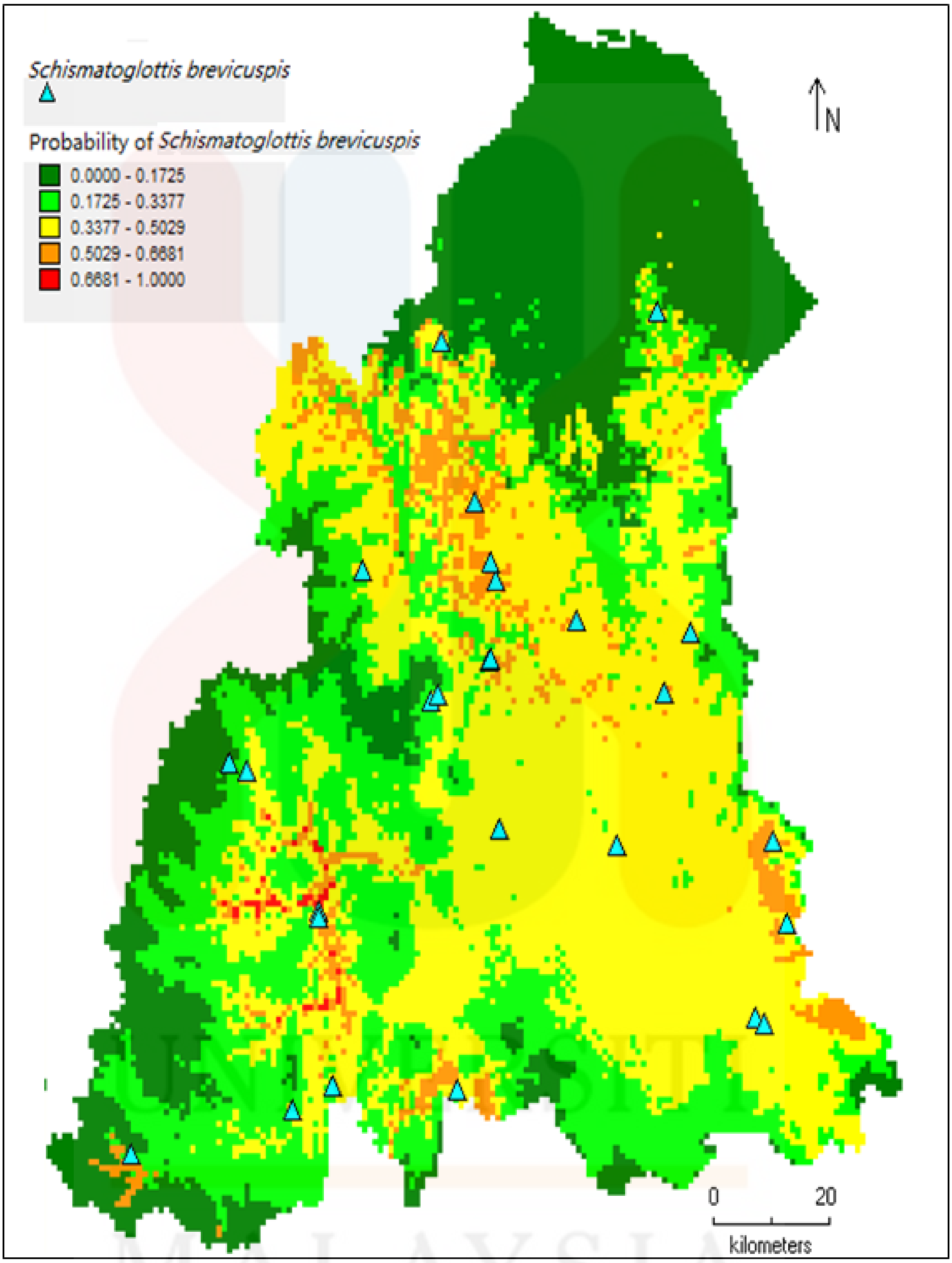

Figure 4.14: The comparison of distribution area of *Schismatoglottis brevicuspis* in Kelantan using 19 Bioclimatic variables

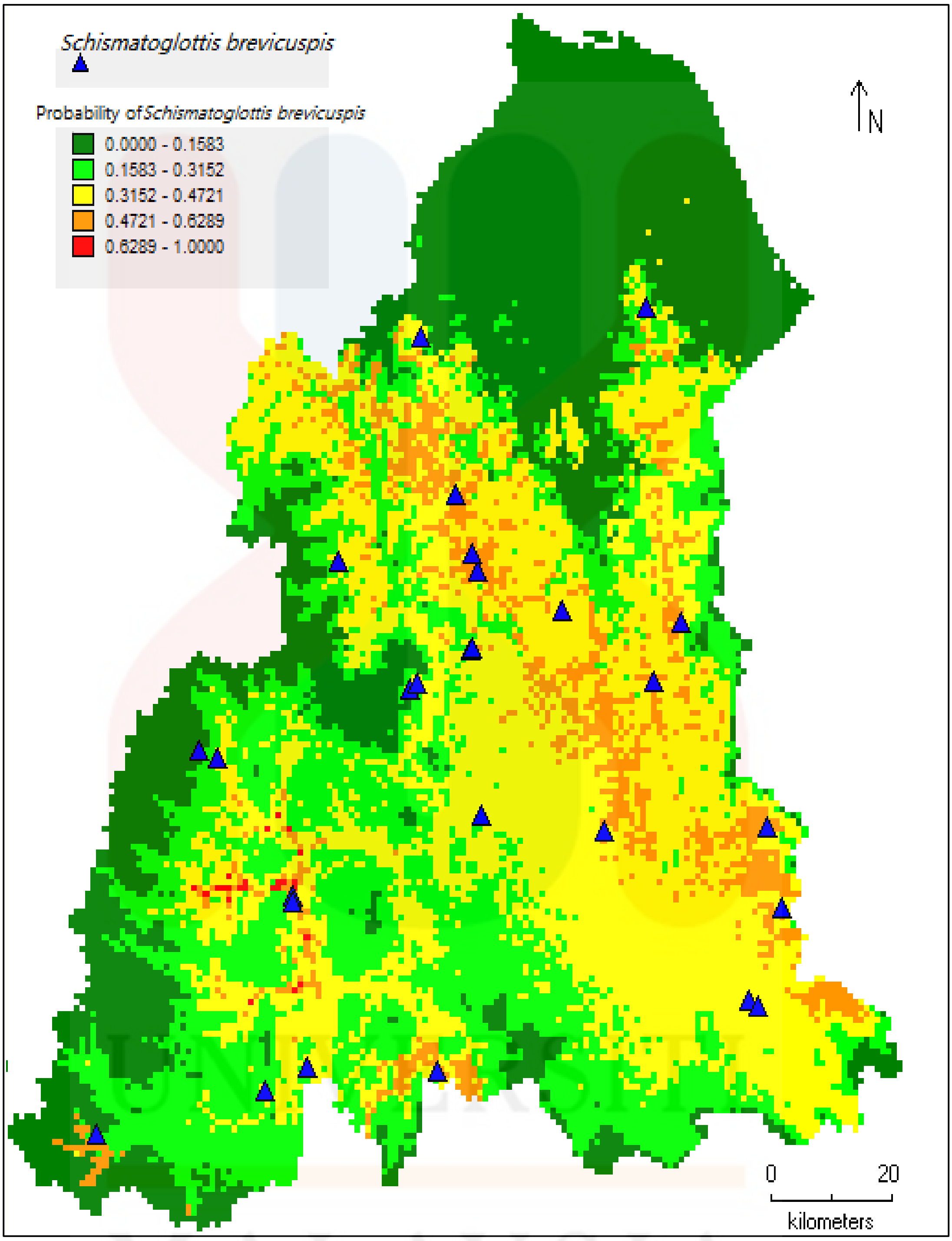

Figure 4.15: The comparison of distribution area of *Schismatoglottis brevicuspis* in Kelantan using 19 Bioclimatic variables, HWSD dataset and SRTM dataset

Figure 4.16 shows the comparison of distribution area of *Schismatoglottis calyptrata* in Kelantan using Extent of Occurrence (EOO) and Area of Occupancy (AOO). Predicted area of EOO of this species is about 10186.17 km^2. The species fall under the category of Vulnerable (VU) according to IUCN. The area of AOO for this species is 84 km^2 and it fall under Least Concern (LC) category. Figure 4.17 shows the availability of *Schismatoglottis brevicuspis* are mainly occurred in the right top side of Pasir Puteh and Machang, Kelantan. Figure 4.18 display the determination of *Schismatoglottis calyptrata* in Kelantan by insert 19 bioclimatic variables, HWSD dataset and SRTM dataset. The red color indicates a high probability for the appearance of *Schismatoglottis calyptrata.* The yellow color represents the medium probability for the expose of *Schismatoglottis calyptrata*. The dark green color symbolizes the low probability for the finds of *Schismatoglottis calyptrata.*

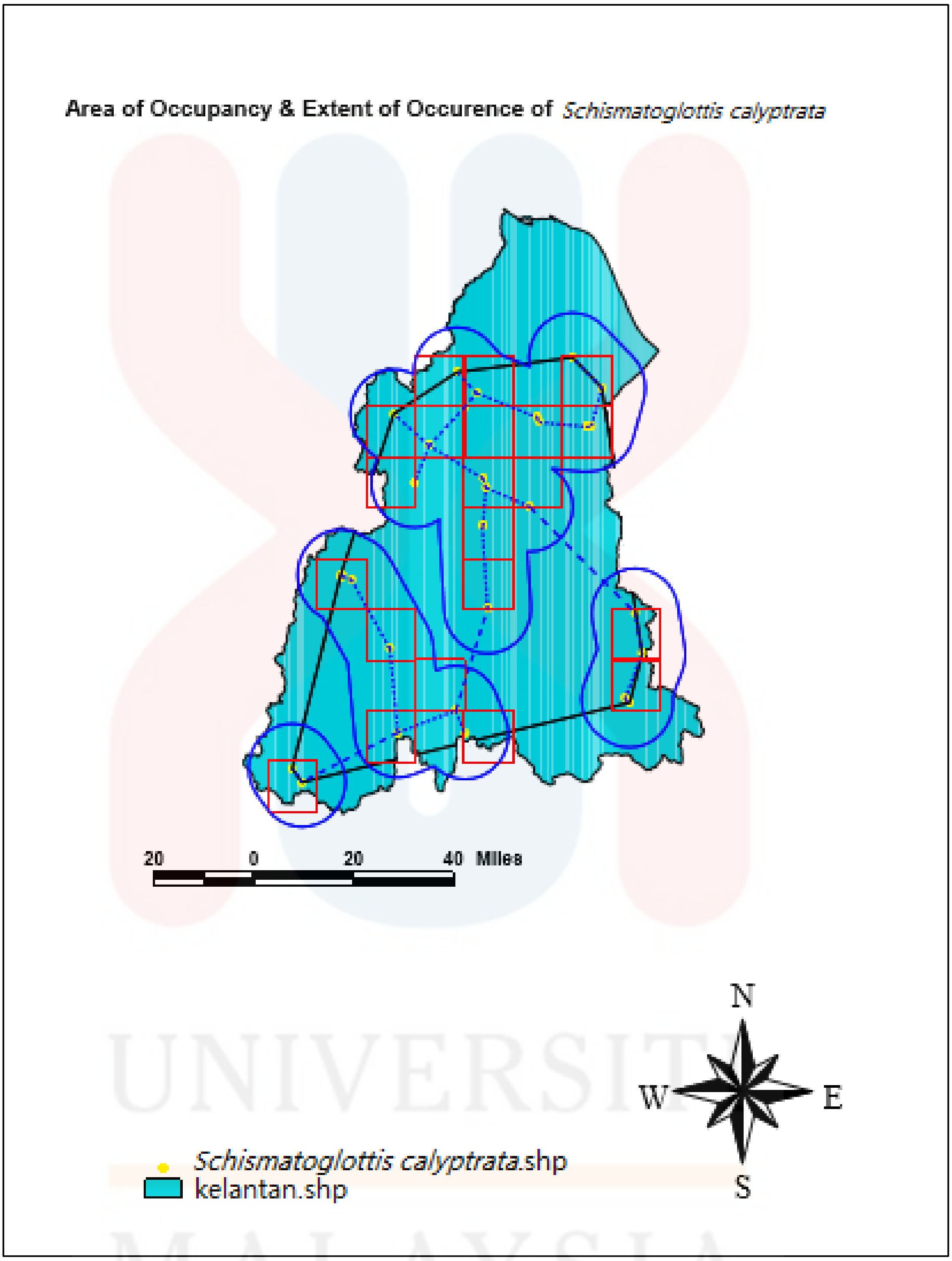

Figure 4.16: The comparison of distribution area of *Schismatoglottis calyptrata* in Kelantan using Area of Occupancy (AOO) and Extent of Occurrence (EOO)

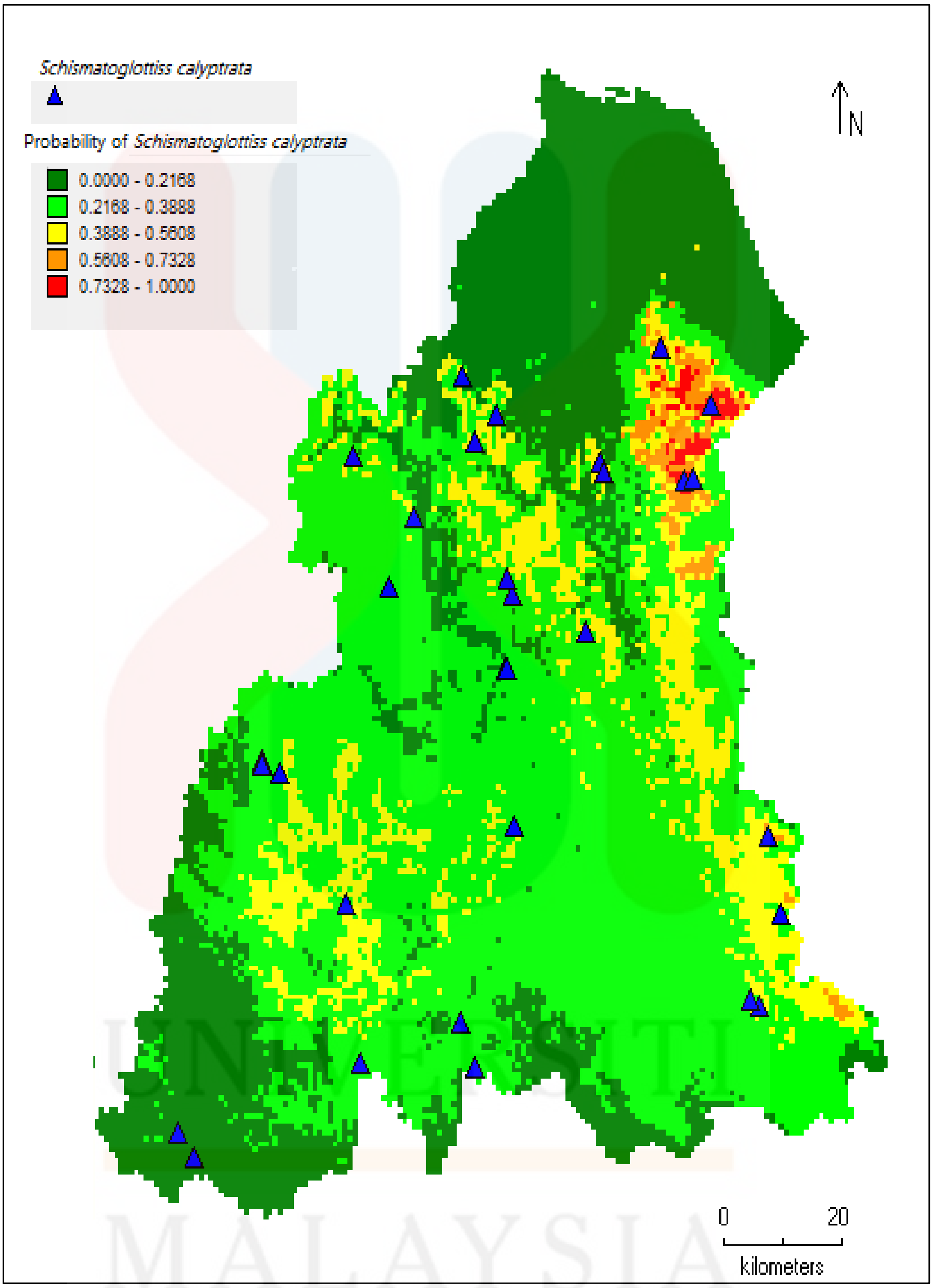

Figure 4.17: The comparison of distribution area of *Schismatoglottis calyptrata* in Kelantan using 19 Bioclimatic variables

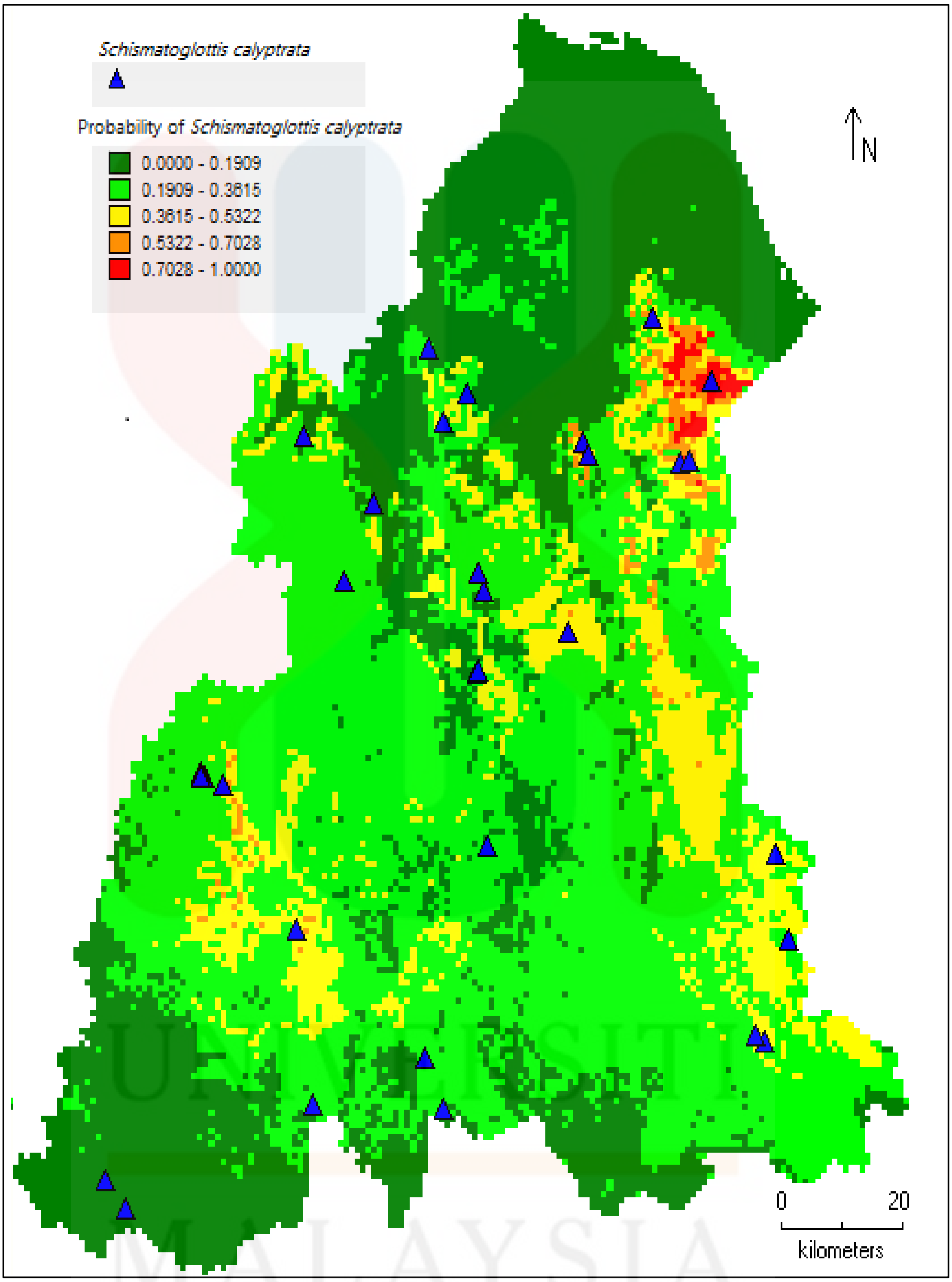

Figure 4.18: The comparison of distribution area of *Schismatoglottis calyptrata* Kelantan using 19 Bioclimatic variables, HWSD dataset and SRTM dataset

Table 4.5 shows the comparison of the percentage distribution of Schismatoglottis calyptrata and Schismatoglottis brevicuspis in the Area of occupancy, Extent of occurrence and Ecological niche modelling. The total area of Kelantan is 15,105km^2 and calculated with the area of Area of occupancy, Extent of occurrence and Ecological niche modelling. The area of *Schismatoglottis calyptrata* in AOO is 84km^2 in 21 grid cells same to the area of *Schismatoglottis brevicuspis*. The result shown 21 grid cells multiplied by four because of the 2 x 2 km grid cell. The percentage of *Schismatoglottis calyptr*ata and *Schismatoglottis brevicuspis* in AOO are 0.55% too. The result is divided by the total area of Kelantan and converts into a percentage number. *Schismatoglottis calyptrata* and *Schismatoglottis brevicuspis* have different result in a percentage and areas of EOO. *Schismatoglottis calyptrata* has 10186.17 km^2 in area of EOO and 67.44% in the percentage of EOO. *Schismatoglottis brevicuspis* has 9173.98 km^2 in area of EOO and 60.73% in the percentage of EOO. Furthermore, *Schismatoglottis calyptrata* gain 493 km^2 in the area of ENM and 3.26% in the percentage of ENM. *Schismatoglottis brevicuspis* obtain 1075 km^2 in the area of ENM and 7.12% in the percentage of ENM. The total area of ENM being divide with total area of Kelantan and multiplied by 100 percent.

Table 4.5: Comparison on the percentage of distribution with Area of occupancy (AOO0, Extent of Occurrence (EOO), and Ecological Niche Modelling (ENM)

Species	***Schismatoglottis calyptrata***		***Schismatoglottis brevicuspis***	
	km^2	%	km^2	%
Area of Occupancy (AOO)	84	0.55	84	0.55
Extent of Occurrence (EOO)	10186.17	67.44	9173.98	60.73
Ecological Niche Modelling (ENM)	493	3.26	1075	7.12

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The potential distribution of selected species are apparently scattered around Gua Musang, Jeli, kuala Krai, Tanah Merah, Machang and Pasir Mas. As the predicted suitable area for these selected species generated by MAXENT, there is an area founded to be common to all of the species. The percentage distribution of *Schismatoglottis* species were relies on some Bioclimatic variables, SRTM dataset and HWSD dataset. This factor will influence these species to survive in the tropical forest.

Firstly, the area under the curve for *Schismatoglottis brevicuspis* and *Schismatoglottis calyptrata* is in the range of good and very good by the classification. The growth factors that affect the habitat distribution of each species were determined. For *Schismatoglottis calyptrata*, the factors that affected the distribution is annual mean temperature. Mean temperature of wettest quarter give high amount of growth effect on *Schismatoglottis calyptrata*. Meanwhile, the factors that influence the distribution species growth of *Schismatoglottis brevicuspis* in Kelantan is mean of warmest quarter.

The comparison on the percentage of distribution of *Schismatoglottis brevicuspis* and *Schismatoglottis calyptrata* with Area of Occupancy (AOO), Extent of Occurrence (EOO) and Ecological Niche Modeling (ENM) is obtained. In this research, AOO is not suitable in estimating species because it is not accurate in predicting species by draw grid cell on certain point. Number of grid cells were only counted on the point and there are other species might be outside of the grid cell. EOO is not reliable in calculate species distribution. The convex polygon could not be able to determine for the locality points that occurred in the same plane or less than three points of localities.

5.2 Recommendation

There are several recommendation upon the end of this study, which are, firstly is applying the factor on these species to see the relationship of availability of these species with study area. By applying variables factor, the occurrences of species despite of development of the area can determined and to prevent habitat loss. It is recommended that study use more updated land use map to increase the accuracy and give current condition of habitat loss.

A good land use map with high resolution and details will provide more precise estimation of habitat loss. Thus this information can be used to raise the initiatives on conserving species in the future. The use of MAXENT entropy can act as an assessment tools for conservation to scheme the protected area. Therefore, the data of species will be able to notice by some researchers to take a quick action. This research could be perfect by increasing the fund relating to the research. More time should be given when conducting the research. The secondary data used should more up-to-date, comparing to this one because there might have some localities data can help to improve the prediction of species distribution.

REFERENCES

A Brief Tutorial on Maxent - University of Connecticut. (2006). Retrieved June 13, 2016, from http://web2.uconn.edu/cyberinfra/module3/Downloads/Maxent tutorial.doc

A Maxent Model v3.3.1 Tutorial (ArcGIS v10). (2011) Retrieved June 13, 2016, from http://ibis.colostate.edu/WebContent/WS/ColoradoView/TutorialsDownloads/Other_Tutorial1.html

Bachman, S., Moat, J., Hill, A. V., De la Torre, J., & Scott, B. (2011). Supporting Red List threat assessments with. *E-Infrastructures for data publishing in biodiversity science*, *150*, 117.

Baldwin, R. A. (2009). Use of maximum entropy modeling in wildlife research. *Entropy*, *11*(4), 854–866. http://doi.org/10.3390/e11040854

Barabe, D., Lacroix, C., Bruneau, A., Archambault, A., & Gibernau, M. (2004). Floral development and phylogenetic position of *Schismatoglottis* (Araceae). *International Journal of Plant Sciences*, *165*(1), 173–189. http://doi.org/10.1086/380980

Bogner, J., & Boyce, P. C. (2009). Studies on the Schismatoglottideae (Araceae) of Borneo VI : A New *Schismatoglottis* Species from Sarawak , Malaysian Borneo. *Garden's Bulletin Singapore*, *60*(2), 1–9.

Boyce, P. C., & Wong, S. Y. (2008). Studies on Schismatoglottideae (Araceae) of Borneo VII: Schottarum and Bakoa, two new genera from Sarawak, Malaysian Borneo. *Botanical Studies*, *49*(4), 393–404.

Boyce, P. C., & Wong, S. Y. (2014). Studies on Schismatoglottideae (Araceae) of Borneo XXXVIII: three novel *Schismatoglottis* species, and notes on the *Schismatoglottis* Asperata Complex. *Webbia*, *69*(2), 225–238. http://doi.org/10.1080/00837792.2014.961731

Butchart, S. H., & Bird, J. P. (2010). Data Deficient birds on the IUCN Red List: What don't we know and why does it matter?. *Biological Conservation*, *143*(1), 239-247.

Deni, S. M., Suhaila, J., Zin, W. Z. W., & Jemain, A. A. (2010). Spatial trends of dry spells over Peninsular Malaysia during monsoon seasons. *Theoretical and applied climatology*, *99*(3-4), 357-371.

Elith, J., Phillips, S. J., Hastie, T., Dud k, M., Chee, Y. E., & Yates, C. J. (2011). A statistical explanation of MaxEnt for ecologists. *Diversity and Distributions*, *17*(1), 43–57. http://doi.org/10.1111/j.1472-4642.2010.00725.x

Farr, T. G., Rosen, P. A., Caro, E., Crippen, R., Duren, R., Hensley, S., & Alsdorf, D.

E. (2007). The shuttle radar topography mission. *Reviews of Geophysics*, *45*(2), 1–43. http://doi.org/10.1029/2005RG000183

Feeley, K. J., Joseph Wright, S., Supardi, N., Kassim, A. R., & Davies, S. J. (2007). Decelerating growth in tropical forest trees. *Ecology letters*, *10*(6), 461-469.

Griffiths, G. M., Chambers, L. E., Haylock, M. R., Manton, M. J., Nicholls, N., Baek, H. J., & Lata, R. (2005). Change in mean temperature as a predictor of extreme temperature change in the Asia–Pacific region. *International Journal of Climatology*, *25*(10), 1301-1330.

Guevara, S., Purata, S. E., & Van der Maarel, E. (1986). The role of remnant forest trees in tropical secondary succession. *Vegetatio*, *66*(2), 77-84.

He, F., & Gaston, K. J. (2000). Occupancy-abundance relationships and sampling scales. *Ecography*, *23*(4), 503-511.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, *25*(15), 1965–1978. http://doi.org/10.1002/joc.1276

Jiménez-Alfaro, B., Draper, D., & Nogués-Bravo, D. (2012). Modeling the potential area of occupancy at fine resolution may reduce uncertainty in species range estimates. *Biological Conservation*, *147*(1), 190–196. http://doi.org/10.1016/j.biocon.2011.12.030

John&Jacq~s Garden. (2015). Retrieved November 17, 2016, from http://www.jaycjayc.com/schismatoglottis-calyptrata/

Kwan, M. S., Tangang, F. T., & Juneng, L. (2013). Projected changes of future climate extremes in Malaysia. *Sains Malaysiana*, *42*(8), 1051-1058.

MacKenzie, D. I. (2006). *Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence*. Academic Press.

Morales, N. S., Fernandez, I. C., Carrasco, B. A., & Orchard, C. (2015). Combining niche modelling, land use-change, and genetic information to assess the conservation status of Pouteria splendens populations in Central Chile. *bioRxiv*, *2015*, 026336. http://doi.org/10.1101/026336

Nakagawa, M., Tanaka, K., Nakashizuka, T., Ohkubo, T., Kato, T., Maeda, T., & Teo, S. (2000). Impact of severe drought associated with the 1997–1998 El Nino in a tropical forest in Sarawak. *Journal of Tropical Ecology*, *16*(03), 355-367.

Nikolakopoulos, K. G., Kamaratakis, E. K., & Chrysoulakis, N. (2006). SRTM vs ASTER elevation products. Comparison for two regions in Crete, Greece. *International Journal of Remote Sensing*, *27*(21), 4819–4838.

http://doi.org/10.1080/01431160600835853

Peter, C., & Wong Sin, Y. (2009). The Aroids of the West Sarawak Limestone. *The IAS Newsletter*, *31*(2), 1-8.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological modelling*, *190*(3), 231-259.

Phillips, S. B., Aneja, V. P., Kang, D., & Arya, S. P. (2006). Modelling and analysis of the atmospheric nitrogen deposition in North Carolina. *International Journal of Global Environmental Issues*, *6*(2-3), 231–252. http://doi.org/10.1016/j.ecolmodel.2005.03.026

Phillips, S., Dud k, M., & Schapire, R. (2004). A maximum entropy approach to species distribution modeling. *Proceedings of the Twenty-First International Conference on Machine Learning*, 655–662. http://doi.org/10.1145/1015330.1015412

Primack, R. B., & Corlett, R. (2005). *Tropical rain forests: an ecological and biogeographical comparison* (No. Sirsi) i9780632045136). Blackwell Pub.

Richards, P. W. (1952). The tropical rain forest: an ecological study. *The tropical rain forest: an ecological study*

Segurado, P., & Araujo, M. B. (2004). An evaluation of methods for modelling species distributions. *Journal of Biogeography*, *31*(10), 1555-1568.

Suhaila, J., Deni, S. M., Zin, W. Z. W., & Jemain, A. A. (2010). Trends in peninsular Malaysia rainfall data during the southwest monsoon and northeast monsoon seasons: 1975–2004. *Sains Malaysiana*, *39*(4), 533-542.

Sulaiman, B., Shunmugam, V., & Basin, M. (2010). A preliminary survey of Aroids (Family Araceae) in Maliau Basin , Sabah , Malaysia. *Nature*, (1954), 35 – 37.

Swaine, M. D., Lieberman, D., & Putz, F. E. (1987). The dynamics of tree populations in tropical forest: a review. *Journal of tropical ecology*, *3*(04), 359-366.

Thorn, J. S., Nijman, V., Smith, D., & Nekaris, K. A. I. (2009). Ecological niche modelling as a technique for assessing threats and setting conservation priorities for Asian slow lorises (Primates: Nycticebus). *Diversity and Distributions*, *15*(2), 289–298. http://doi.org/10.1111/j.1472-4642.2008.00535.x

Tobergte, D. R., & Curtis, S. (2013). No Title No Title. *Journal of Chemical Information and Modeling*, *53*(9), 1689–1699. http://doi.org/10.1017/CBO9781107415324.004

Tsukaya, H., Okada, H., & Mohamed, M. (2004). A novel feature of structural variegation in leaves of the tropical plant *Schismatoglottis* calyptrata. *Journal of plant research*, *117*(6), 477-480.

Warren, D. L., & Seifert, S. N. (2011). Ecological niche modeling in Maxent: the importance of model complexity and the performance of model selection criteria. *Ecological Applications*, *21*(2), 335-342.

Whitmore, T. C. (1989). Canopy gaps and the two major groups of forest trees. *Ecology*, *70*(3), 536-538.

Zhang, C. (2013). Madden-Julian oscillation: Bridging weather and climate. *Bulletin of the American Meteorological Society*, *94*(12), 1849-1870