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

by

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A report submitted in fulfilment of the requirements for the degree of
Bachelor of Applied Science (Natural Resources Science) with Honours.

**FACULTY OF EARTH SCIENCE
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DECLARATION

I declare that this thesis entitled “Comparison of Potential Habitat of Genus *Scindapsus* 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.

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LIST OF ABBREVIATIONS

AOO	Area of Occupancy
AUC	Area under the curve
CEMD	Conservation and Environmental Management Division
CSV	Comma-Separated Values
DEM	Digital Elevation Model
ENM	Ecological Niche Modelling
EOO	Extent of Occurrence
GIS	Geographical Information System
HWSD	Harmonized World Soil Database
IUCN	International Union for Conservation of Nature
MAXENT	Maximum Entropy Modelling
ROC	Receiver Operating Characteristic
SOTER	Soil and Terrain Database
SRTM	Shuttle Radar Topography Mission
WWF	World Wildlife Fund

LIST OF SYMBOL

ha	hectare
%	percentage
km sq ²	kilometer square feet

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Comparison of Potential Habitat of Genus *Scindapsus* in Kelantan Based on Different Qualitative Method

ABSTRACT

Malaysia is the countries that have a great diversity of ecosystem. The conversion on the agriculture had proven to gradualness in increasing coverage of permanent forest reserved. Therefore, the natural resource is a main treasure which is so precious and important heritage such as diversity of species should be preserved in a sustainable manner. The species distribution map will able to relocate the most abundance species on the particular places. In this research the family of Araceae had been chosen as this species is mostly abundance in humid tropics especially in Kelantan forest. The potential distribution of the family Araceae from the genus *Scindapsus* had been selected in this study. The species that been preferred from the genus *Scindapsus* is the species of *Scindapsus perakensis* and *Scindapsus treubii*. The Ecological Niche Modelling (ENM) method had been used to generate the potential map distribution of genus *Scindapsus* in Kelantan. The 19 BIOCLIM environmental layers that been obtain at online database were layered by using Geographic Information System (GIS) in order to identify the area of distribution and which the environmental variables effect the most. Meanwhile, the statistical method of MAXENT had been used to overcome the localities data of the species using the probability distribution in order to finding the largest spread in geographic dataset. The Ecological Niche Modelling (ENM) method will be compared with Area of Occupancy (AOO) and Extent of Occurrence (EOO). The result in percentage show ENM is the better used of species modelling in order to use for the conservation of species habitat. The percentage value of ENM showed about 3.25% for *Scindapsus perakensis* and 19.57 % for *Scindapsus treubii*. The EOO and AOO percentage for *Scindapsus perakensis* is 55.21 % and 0.23% while for *Scindapsus treubii* is 47.31% and 0.34% respectively.

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

ABSTRAK

Malaysia adalah negara yang mempunyai kepelbagaian ekosistem. Penukaran sistem hutan kepada sistem pertanian telah terbukti mengurangkan kawasan hutan simpanan kekal. Sumber semula jadi adalah satu khazanah utama iaitu warisan yang begitu berharga dan penting kerana kepelbagaian spesies perlu dikekalkan secara mampan. Peta taburan spesies akan dapat mengenal pasti populasi spesies paling banyak di tempat-tempat tertentu. Dalam kajian ini keluarga Araceae telah dipilih sebagai kerana taburan spesies yang kebanyakannya hidup di kawasan lembap tropika terutama di hutan Kelantan. Potensi taburan keluarga Araceae daripada genus *Scindapsus* yang telah dipilih dalam kajian ini. Spesies yang terpilih adalah dari genus *Scindapsus* adalah spesies *Scindapsus perakensis* dan *Scindapsus treubii*. Kaedah Niche Ecological Modelling (ENM) telah digunakan untuk meramalkan pemetaan potensi genus *Scindapsus* di Kelantan. 19 BIOCLIM data iaitu data lapisan alam sekitar telah digunakan dengan bantuan Sistem Maklumat Geografi (GIS) untuk mengenal pasti peta kawasan taburan dan faktor alam sekitar yang paling mempengaruhi dalam taburan spesies tersebut. Sementara itu, kaedah statistik MAXENT telah digunakan untuk mengatasi data lokaliti spesies dengan menggunakan taburan dalam set data geografi. Permodelan Niche Ekologi (ENM) akan dibandingkan dengan *Area of Occupancy* (AOO) dan *Extent of Occurrence* (EOO). Hasil dalam unit peratus akan menunjukkan kaedah mana yang lebih sesuai untuk digunakan dalam pemetaan spesies bagi tujuan pemuliharaan habitat spesies. Nilai peratusan ENM menunjukkan 3.25% untuk *Scindapsus perakensis* dan 19.57% untuk *Scindapsus treubii*. Nilai peratus EOO dan AOO *Scindapsus perakensis* adalah 55.21% dan 0.23% manakala bagi *Scindapsus treubii* masing-masing adalah 47.31% dan 0.34%.

CHAPTER 1

INTRODUCTION

1.1 Background study

Malaysia is one of the 12 mega-biodiversity countries that have a great diversity of ecosystem. It is had been estimated with more than 170,000 species including flora and fauna in Malaysia tropical rainforest (CEMD, 2006).

However, the land cover is gradually changed due to human activities. The habitat destruction and over exploitation is being the main threatening for the biodiversity. In Malaysia, the forest cover decreased by 8.58 % from 22.4 million ha in 1990 to 20.5 million ha in 2010. It is had been predict that it will be slightly change to 20.0 million ha in 2020. The conversion to the agriculture had been proven to gradualness in increasing coverage of permanent forest reserved (Hon & Shibata, 2013).

In this research, the family Araceae had been chosen as this species is mostly varied and abundant in the humid tropics in distributions with 90% of genera and about 95% of species are classified to the tropics. The family of Araceae is mostly defined by the characters of the inflorescence with small flowers borne on the fleshy axis which is at the spadix and being supported by modified leaf which is known as spathe (Boyce & Yeng, 2012).

The method that used in this study is Ecological Niche Modelling (ENM). The modelling method of ENM then is compared with the Area of Occupancy (AOO) and Extent of Occurrence (EOO) methods in order to study the most suitable method in finding the potential habitat distribution of the family Araceae from the genus *Scindapsus* at the forest in Kelantan by using map.

The Ecological Niche Modelling (ENM) is the method that use occurrence data in combinations with the environmental data to create a correlative model of the environmental conditions that come across a species ecological requirements and able to predict the relative suitability of the habitat (Warren & Seifert, 2011).

The environmental variables in GIS format will refer to the same geographic area or the study area by partitioned into grid of pixels. Therefore, the task of modelling method will be able to predict the environmental sustainability for the species as function of given environmental variables (Phillips *et al.*, 2006).

The application software of Maximum Entropy Model (MAXENT) used as the principle of maximum entropy on presence-only data to estimate a set of functions that related to the environmental variables and habitat suitability in order to predict the species' niche and potential geographic distributions. The MAXENT able to approximation the target of probability of distributions of the subject that is most spread out or closest uniform. It will makes the incomplete information as a set of real-valued variables called ad features and give the expected value of each feature should be match with the average value for the set sample from the target distributions (Phillips *et al.*, 2006).

1.2 Problem statement

Nowadays, the conservation and spatial planning are being more crucial for species either it is flora or fauna. The data accessibility regarding the species distribution is usually not available or not so far to be properly described or record. Thus, it been seems by all accounts, to be of expanding importance as the living beings reduce in size. Furthermore, information of the worldwide, local, and even nearby transferences of numerous taxa is at present insufficient.

There are many areas of the world remain genuinely under-gathered for most taxa, with the outcome that notwithstanding for higher plants, dependable orderly species range maps are accessible just for a small amount of the earth's surface. A number of these issues are especially serious in tropical zones. While it is broadly valued that most mega diverse regions happen in the tropics, rates of territory misfortune and ecological debasement likewise have a tendency to be higher in tropical. In this manner, the requirement for devices to help preservation arranging, arrangement improvement, and usage is especially pressing in tropical districts (Cayuela *et al.*, 2009).

In addition, the collection of data is costly and labour intensive. The collection of data specimen also limited in time. Therefore, this study is able to act as the preliminary information for the future study regarding the species distribution. The use of MAXENT software will be able to predict possible distribution regarding the previous and also upcoming species on that particular area. Other than that, it also will act as the rapid assessment tools for the use for the future research.

1.3 Objectives

The objectives of this study are:

1. To generate potential map of distribution of genus *Scindapsus* in Kelantan.
2. To compare the percentage of distribution of genus *Scindapsus* with Extent of Occurrence (EOO) and Area of Occupancy (AOO).

1.4 Scope of study

The scope of the study will be focused on family of Araceae from the selected species of genus *Scindapsus* which are *Scindapsus perakensis* and *Scindapsus treubii*. The selected species had been chosen due to their abundance in distributions. The locality data were obtained from the unpublished data from En. Zulhazman Hamzah. The potential habitat distribution map of the species generated using the data provided.

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1.5 Significant of study

Throughout this study, there might have the same or other different species from genus *Scindapsus* in another area in Kelantan by using Ecological Niche Modelling (ENM). The use of software Maximum Entropy Model (MAXENT), BIOCLIM, the database from Harmonized World Soil Database (HWSD) and data from Shuttle Radar Topography Mission (SRTM) will be able to trace the characteristics of the potential habitat species in the specific area and produce the potential habitat distribution map. The data will be compared the result by using the MAXENT, EOO and AOO in percentage. The result will show the better used of species modelling in order to apply for the conservation of the habitat of species either plant or animal due to the minimal data needed in the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Tropical Rainforest

Malaysia tropical rainforest had been categorized as one of the most complex ecosystem through the world. The estimated flora in Malaysia is about 8,000 species of flowering plants including 2,500 are tree species. The formation of the rain forest also different because of depending on some factors for example edaphic condition, drainage and altitude (Khuzaimah, 2000).

2.1.1 Forest in Malaysia

The website of Malaysian Wide Fund for Nature (WWF-Nature Malaysia) stated that, the major forest types in Malaysia are lowland dipterocarp forest. The forest in Malaysia is most dominated by tree from *Dipterocarpaceae* family. It is because the forest occurs at above sea level of 900 meters.

The total land area of Peninsular Malaysia is 13.18 million ha which is 5.80 million ha is forested area and 7.38 million ha is non-forested area (Forestry Department, 2014).

The lowland dipterocarp forest is the most endangered habitat as the majority of this area had been cleared for other land use such as for the development, agricultural activities whether in large or small scale. Therefore, the species diversity in Malaysia might be in the critically condition and the conservation of the species plant and animals are required in order to maintain the biodiversity and to avoid extinction.

2.1.2 Forest in Kelantan

Kelantan Darul Naim has a total land area of 1,510,500 hectares. The diversity of land uses with a population of about 1:56 to make the state of natural resources is a main treasure is so precious and important heritage and must be preserved in a sustainable manner. The total area of about 812,196 hectares is a forested land while about 689,304 hectares is non-forested land. The wooded area is also composed of the Permanent Forest Reserve, which covers an area of 623,849 hectares. Meanwhile, the forest plantation area is covered about 163,637 hectares. The total area of state land forest and wildlife reserved are 85,265 and 103,082 hectares respectively (Kelantan Forestry Department, 2015).

2.2 Family Araceae

The Araceae is from monophyletic family with comprising estimate 118 genera and approximately 3500 existing species (Boyce & Croat, 2011). The Araceae can be stated as the utmost life-form of diversity from the flowering plant family. The aroid is depending on abundant available water and prevailing high atmospheric humidity. The most abundance and diverse of Araceae located in humid tropics, and there is various in variety of life form of each in each species (Yeng, 2012).

The range in terms of life form started from submerged or free-floating aquatic to terrestrial because sometimes it is tuberous and continue to epiphytic or hemiepiphytics. There are some from the family of Araceae can be bearing small flowers or inflorescence on a fleshy axis or known as spadix that suspended by modified leaf which is spathe (Malesiana Tropicals. n.d.).

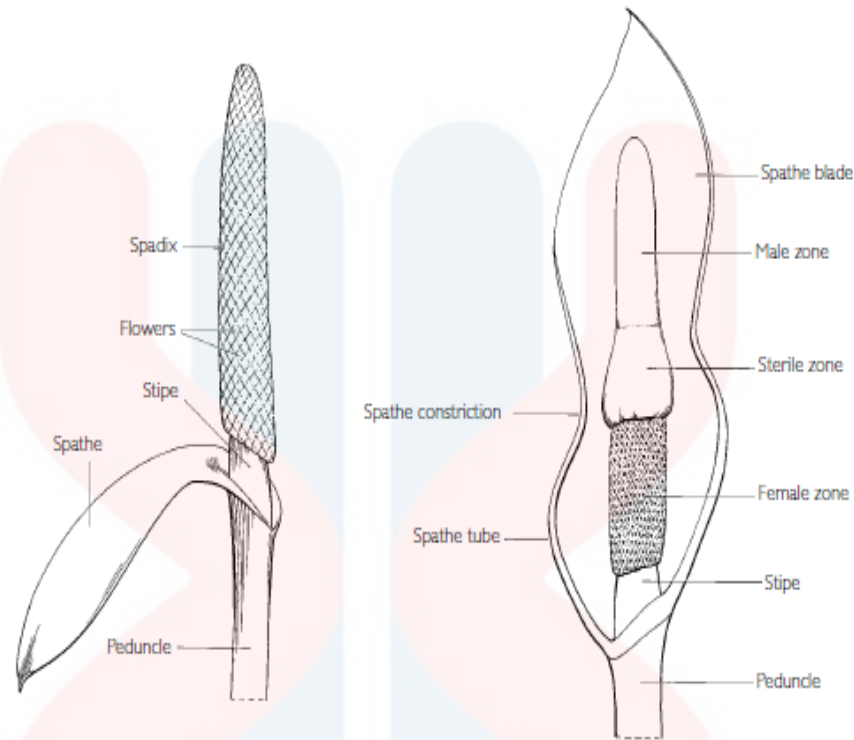


Figure 2.2: Inflorescence types: **Left**, bisexual flowered spadix with a simple, undifferentiated spathe. **Right**, unisexual flowered spadix with a spathe divided into a limb (blade) and convolute lower tube.

Source: The Genera of Araceae (Mayo *et al.*, 1997)

Hooker (1973) stated that the amount of aroid that being found in Peninsular Malaysia and Singapore is about 89 species from 18 genera. Thirty-two years later, they were about 123 species of aroids on Peninsular Malaysia which is conducted by Ridley (1925). Recently study stated the latest listing of aroids in Peninsular Malaysia by Mashhor *et al.* (2012) about 140 species in 28 genera which is including 25 species endemic.

Addition by Zulhamzah (2011) stated there are 32 species from 11 genera of aroids were recorded at Kuala Koh, Gua Musang Kelantan. This includes about 24 species which is 75 % of 32 species of aroids are being collected and produce new records and one species new to sciences.

2.2.1 Araceae Ecology in Malaysia

In Malaysia, the distribution of Araceae is mostly growth in habitat at the moist, ever wet or pre-humid lowland to hill dipterocarp forest at steep slopes above streams and small rivers.

Other than that, the basic geology is the important aspect for the distribution of Araceae. The area such as granite which is a rock that is particularly resistant to water and thus provide water shedding and then a readily draining surface are most contribute area in peninsula of Malaysia. Therefore, the enough soil covers the rock support a rich and diverse Araceae flora (Mashhor *et al.*, 2012).

However, for the soil depth which is thin or absent, the Araceae flora decreases much as the rheophytic species and those changed to lithophytism are frequently specialized to growing hardly in rock (Mashhor *et al.*, 2012). The rheophytic species is an aquatic plant that lives in fast moving water which can be found in current at rates of 1 to 2 meters per second and that are up to 3 to 6 feet deep (Bown, 2000). Therefore, the rheophytic species cannot be able to live as lithophytes which are live growth in or at rock and feed off nutrients from rain water and nearby decaying plants, including their own dead tissue (McPherson, 2010).

In addition, there are two geological areas that show in high level of endemism which is limestone and shale. The shale requirement is being stated as new recognition for the founding of Araceae distribution. Meanwhile, the forested limestone in Malaysia is divided by two different types which is the northern and southern part.

The northern Araceae distribution in limestone is being support by dry to humid semi-deciduous forest with a prevalence of geophytic taxa which is the plant that has an underground storage organ that enable the plant to survive in adverse condition.

The southern part is supporting on the criteria and exposure of per humid to moist evergreen forest with the variety of mesophytic aroids (Mashhor *et al.*, 2012). The mesophytics can be defined as the terrestrial plants which are adapted to neither a particularly dry nor particularly wet environment.

2.2.2 Genus *Scindapsus*

The genus *Scindapsus* is one of the genres from the family of Araceae. The natural range of *Scindapsus* species is form northeaster India to western Polynesia (Bogner, 1994). In Malaysia, 16 *Scindapsus* species was recorded by Saibeh (2010) which is found common and abundant in the wild at the forest in Peninsular and Borneo.

The *Scindapsus* is evergreen limbing herbs which is at times producing flagella form shoots. The shoots with leaves regularly spaced or forming resolute flowering zones separated by zones with elongated internodes and smaller leaves, or solitary leaf trapping bole epiphyte. The types of leaves often in shingle form whereas the leaves are geniculate apically. The sheath is commonly broad and rarely decomposing to form persistent net-fibrous mass together abundant with stinging sclereids.

Other than that, the *Scindapsus* species is inflorescence and always solitary. The peduncle is usually shorter than petiole. While the spathe is boat-shaped, gaping only slightly, caduceus to deciduous and the spadix is sessile to shortly stipitate, cylindric, narrowly ellipsoid or clavate, a little shorter than spathe. The flower of *Scindapsus* species is bisexual and perigone is absent. Meanwhile the stamens consist of four and free with the filaments oblong, flattened, broadish, connective slender, thecae oblong-ellipsoid, dehiscing by apical slit.

In Kelantan, the *Scindapsus* species was found in Gunung Stong Forest Reserve which is from the *Scindapsus Scortechinii* Hook.f (Zulhamzah, 2011). In year 2013, a study by Yusof *et al.* stated that the *Scindapsus perakensis* species was found least abundant in pyroclastic area at Gua Musang, Kelantan.



Figure 2.3: The *Scindapsus scortechinii*
Source: The Genera of Araceae (Mayo *et al.*, 1997)

2.2.2.1 *Scindapsus perakensis*

According to Ara (2016) on taxonomic studies in the family Araceae from Bangladesh stated the local name of *Scindapsus perakensis* is known as *Banlata*. This species is a climbing herb which is very stout and branched with the stem 10-12 m long and 5-7 cm broad.

The leaves are many with the spirally arranged, broadly or narrowly oblong and rarely ovate or sub-lanceolate. The species is acuminate, elliptic or nearly ovate with thinly coriaceous and base acute or rounded. The primary and secondary nerves are indistinguishable from the above. The nerveless is trabeculate with the dark green color in the surface of the leaves and light green on the beneath. The petioles are 10-15 cm long and broadly winged at the base.

This *Scindapsus perakensis* species is inflorescence near to stem-apices and solitary. The peduncle usually shorter than the petiole which is estimated 8-10 cm long and very stout. The characteristics of spathe are not constricted which is boat-shaped with the color of cream-white, ovate in shaped, cuspidate, leathery and estimated 8 cm long.

Other than that, the spathe is longer than the spathe which is shaped cylindric or sub-clavate. The flower of this species is biosexual with four stamens and the filaments is strap shaped. The ovary is 1-locular, anatropous, placentation basal and the stylar region is well-developed with stigma linear. The fruit usually a berry and slaty-blue with 1-seeded. While the characteristics of the seed are lenticular, black in color, and testa thick. The flowering and fruiting period usually occur on May to October throughout the year.

2.2.2.2 *Scindapsus treubii*

According to Othman (2010) on the journal of Studies on Monstereae (Araceae) of Peninsular Malaysia III: *Scindapsus lucens*, a New Record for Malaysia, and a Key to Peninsular Malaysian *Scindapsus* states the addition characteristics of *Scindapsus treubii* include short- climbing to perching epiphyte or scandentsemi- terrestrial. The stems are smooth while the leaf is usually blade sub-succulent, markedly oblique, oblongo-lanceolate, concolorous deep green, and less often with jagged grey markings in juvenile plants.



a)



b)

Figure 2.4: a) The *Scindapsus perakensis*
Retrieved from: <http://iplants.ru/scindapsus.htm>

b) The *Scindapsus treubii*
Source: Othman, 2010

2.3 Ecological Niche Modeling (ENM)

The ENM is the model that able to operate the relationship between the environmental variables and known species occurrence localities in order to describe the abiotic conditions within the specific population that can be preserved.

The practical approach regarding the modeling principally the same with the species distribution method because of the study area is exhibited as the map composed of grid cells at the precise resolution. The reliant on variables of is the current known of species distribution and the set of environmental variables are gathered to define the characteristics of each of the cell. The environmental variables also able to calibrate for sort the degree on each cell either suitable or unsuitable for the species (Raxworthy *et al.*, 2007).

Besides that, the ENM are used to estimate the relative suitability of habitat known or not known to be occupied by the species. ENM able to estimate the changes in the suitability of habitat over time given specific conditions for environmental change also with the estimates species niche (Warren & Seifert, 2011).

The systematic applications of ENM are integrated into a broad variety of research disciplines which is including the biological reaction to climate change, invasive species biology and ecology and evolutionary biology. Throughout the systematic disciplines, the ENM also be able to playing increasing significant role within the phylogenetic research (Raxworthy *et al.*, 2007).

The benefit on using ENM stated by Raxworthy (2003) is able to act as recognition of area of endemism. This could happens where the species localities are relatively rare and the ENM act as the great applications by providing an estimate of distributions that is more informative than the least area polygon or particular expert opinion.

Next, the ENM is concern on the recognition of erroneous localities. The localities which are outliers that fall outside the real geographic distribution of the species yet are reported in catalogs or the literature as accurate records. Therefore, by using ENM validation methods, the erroneous localities problems can be overcome (Graham *et al.*, 2004).

Besides that, the used of ENM method is able to discovery of new areas of endemism and new species. The ENM will clues to the discovery of isolated areas of environmental suitability that are not actually occupied by the species being model and improve the understanding on the pattern of endemism before accelerate to the discovery process for new species (Raxworthy *et al.*, 2007).

2.4 Application in Mapping Species Distribution

2.4.1 Maximum Entropy Model (MAXENT)

The MAXENT Software means the maximum-entropy approach that can be used for species habitat modelling. The software use input of a set of layers or environmental variables and including a set of geo referenced occurrence location which can produce a model range of selected species (Phillips *et al.*, 2006).

MAXENT leads to over-fitting which is resulting in prediction distribution which cluster surround the location points. A relaxation component or known as regularization will be added to constrain the estimated distribution by allowing the average value which is approximate to empirical average but still not equal to it. This can be adjusted for each study area (Baldwin, 2009).

Then, the MAXENT is applied to presence-only data species distribution modelling, the pixel of study area make up the spaceon which the MAXENT is defined. The pixel will known the species occurrence records such as the sample points, the features of climatic variables, elevation, soil category, vegetation form and others environmental variables (Philips *et al.*, 2006).

Meanwhile, according to Elith *et al.* (2011) the MAXENT will minimize the relative entropy between two probability densities which is defined in feature area or space. The model will lead for the providing background sample which is through type selection and regularization setting in order to suit the data. Presence-only data act as important resources to model same ecological relationship together with presence-absence data which provided the bias can be dealt with and accept for the non-identify ability of prevalence.

The MAXENT give more advantages than others method such as EOO and AOO because it only requires only presence data with environmental information for the study area. Then, it can utilize both continuous and categorical data and can incorporate interactions between different variables. Other than that, efficient deterministic algorithms have been developed to ensure the optimal (maximum entropy) probability distribution (Philips *et al.*,2006).

In addition, the MAXENT probability distribution has a concise mathematical definition that amenable for analysis. The dependence of the MAXENT probability distribution of occurrence localities is explicit, therefore there is the possible to address the issue of sampling bias formally. Meanwhile, if the output is constant, the MAXENT able to allow fine distinctions to be prepared between the modelled suitability of different area.

Other than that, the benefit of MAXENT is the software able to be applied to the species presence or absence data with the conditional model which can inherent advantage when the value of training data is limited. Therefore, MAXENT is an active area for the research in the statistics and machine learning and progress in the field can be practical.

2.4.2 Extent of Occurrence (EOO)

The EOO is the species distribution that identified the region encompassing all localities where the species has been recorded. EOO is also known as the ‘shortest continuous imaginary boundary’ or convex polygon enclosing set of distribution points. There is no specific method for calculating EOO but it can easily being interpreted within a GIS by plotting a point of distribution map then generating a polygon enclosing the points and calculating the area of the shape. The measurement of EOO by manual can be subjective and contributes to the longer in time as the different assessor perhaps interpret different polygon and cause the area derived different and incorrect for species distribution (Willis *et al.*, 2003).

The IUCN states that the measurement may exclude breaks or incoherence with the total distribution taxa. Therefore, the EOO concept had been cause of errors due to overestimation of the area occupied by species. To estimate the EOO of a species, point locality data are usually degraded to grid cells of several sizes Other than that, if the particular limits of species distributions are known, then the geographic ranges should correspond with the EOO. However, the varieties are typically defined using the extreme localities where the species is known usually to happen and ecological favorite (Gaston *et al.*, 2003).

2.4.3 Area of Occupancy (AOO)

The AOO measurement is most appropriate to the herbarium data as it accounts for the species distribution more reasonable than EOO (Willis *et al.*, 2003). The AOO is the detachment of the EOO, because it excludes all areas within the EOO which is not occupied by the species (Tyre *et al.*, 2001). This is because the species are not suitable or the conditions are not occupied.

Meanwhile, the locality point for the AOO scales is much more nearer because the methods that been used by the original observation or collection of the specimen. In other words, the local-scale and ecologically realistic model of the species including where the species habitat relationships will be derived from the locality data with the high resolutions environmental data can be able to represent AOO (Scott *et al.*, 2002).

2.4.4 Harmonized World Soil Database (HWSD)

The HWSD is a 30 arc-second raster database with over 16000 altered soil mapping units that combines present regional and nation update of soil information worldwide (SOTER, ESD, Soil Map of China, WISE) together with the soil information contained within 1:5 000 000 scale FAO-UNESCO Soil Map of the world (Fischer *et al.*, 2008). Then, it will produce raster database contain of 21600 rows and 43200 column which is related to the soil belongings data. The systematic data allows the raster map to show the configuration in terms of soils unit and the description of selected soil parameters (Nachtergaele, 2010).

2.4.5 Shuttle Radar Topography Mission (SRTM)

The SRTM is the production of the most comprehensive, highest resolution digital elevation model of the earth. This is obviously important for the high- quality of global Digital Elevation Model (DEM). The elevation of model will produce in form of topographic maps and also provide a base and context for airborne navigation systems. The conventional topographic mapping technologies were not produce a good quality of maps, some with not suitable accuracy and less adequate. The maps were produce in assortment of scale and resolutions and cause for the unbalance in national boundaries (Farr *et al.*, 2007).

2.4.6 Model Validation Map

The data that derived from the locality data and environmental variables are used to develop a model that predicts environmental sustainability as a use for the environmental variables (Philips *et al.*, 2006). The model validation will be conduct by trying the prediction success of the model on an independent dataset (Cayuela *et al.*, 2009).

The use of model validation map by using ROC curve or Area under the Curve (AUC) which shows the performance of a classifier whose output depends on the threshold parameter. It will plot true positive rate against false positive rate for each threshold. The use of ROC with the presence-only data should interpret as the negative examples all grid cells with no occurrence localities even though they support good environmental conditions of species (Philips, 2004).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study area

The study area was covered the whole state of Kelantan in order to assess the distribution potential of the species from the genus *Scindapsus*. The total area of Kelantan is 15, 105 km². The Figure 3.1 shows the map of Kelantan state.

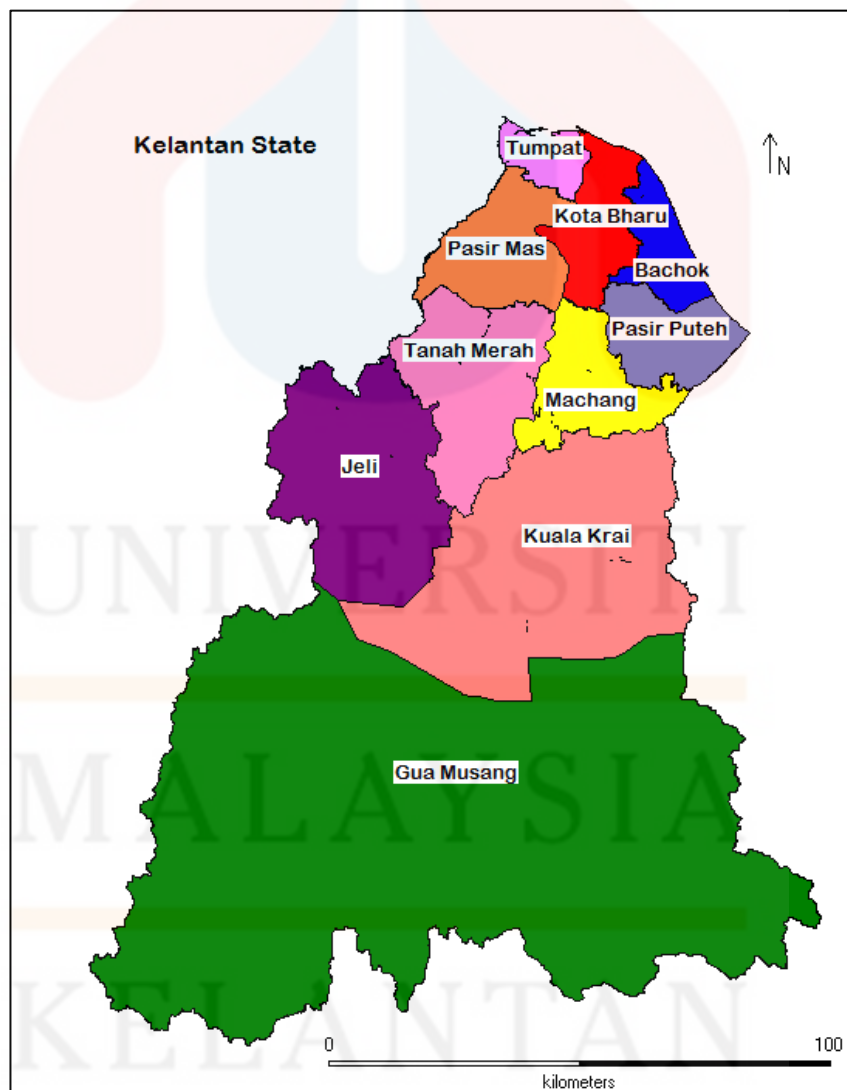


Figure 3.1: The state of Kelantan

3.2 Requirement of Ecological Niche Modeling (ENM)

3.2.1 Locality Data

The locality of data of *Scindapsus perakensis* and *Scindapsus treubii* is by using secondary data. The locality data were obtained from the unpublished data from En. Zulhazman Hamzah. The data contained the latitude and longitude of the species founded area. The database had been stored in Comma-Separated Values (CSV) file. The CSV format can be imported to and exported from the programs that store data in table of Microsoft Excel. Therefore, the data can be imported to the MAXENT software to be interpreted.

3.2.2 Environmental Data

Meanwhile, the environment data needed such as climate data that will be collect from the website of WORLDCLIM (www.worldclim.org/bioclim). This website will give the information about climate data of current conditions, future conditions and past conditions. Figure 3.2 shows the 19 types of BIOCLIM environmental layers that will be used (Hijmans *et al.*, 2005).

Table 3.2 19 WORLDCLIM variables downloaded from
(www.worldclim.org/bioclim).

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

Next, the database from Harmonized World Soil Database (HWSD) is the raster that contains of 21600 rows and 43200 column which linked to harmonized soil property data. The custom of the standardized structure allows for the relation of the element data with the raster map to display or query the structure in terms of soil units and the description of selected soil factors (FAO/IISA/ISRIC/JRC, 2012). The data obtained then is processed in the ArcMap GIS application.

Meanwhile, the data of Shuttle Radar Topography Mission (SRTM) has provided the Digital Elevation Data (DEMs) which have a resolution of 90m at the equator and in mosaicked with 5 degree x 5 degree tiles for download .

The SRTM data is available as 3 arc second DEMs while 1 arc second DEMs is also available for certain countries. The data was download in Arcinfo ASCII format and being processed in ArcMap GIS application (Jarvis *et al.*, 2008).

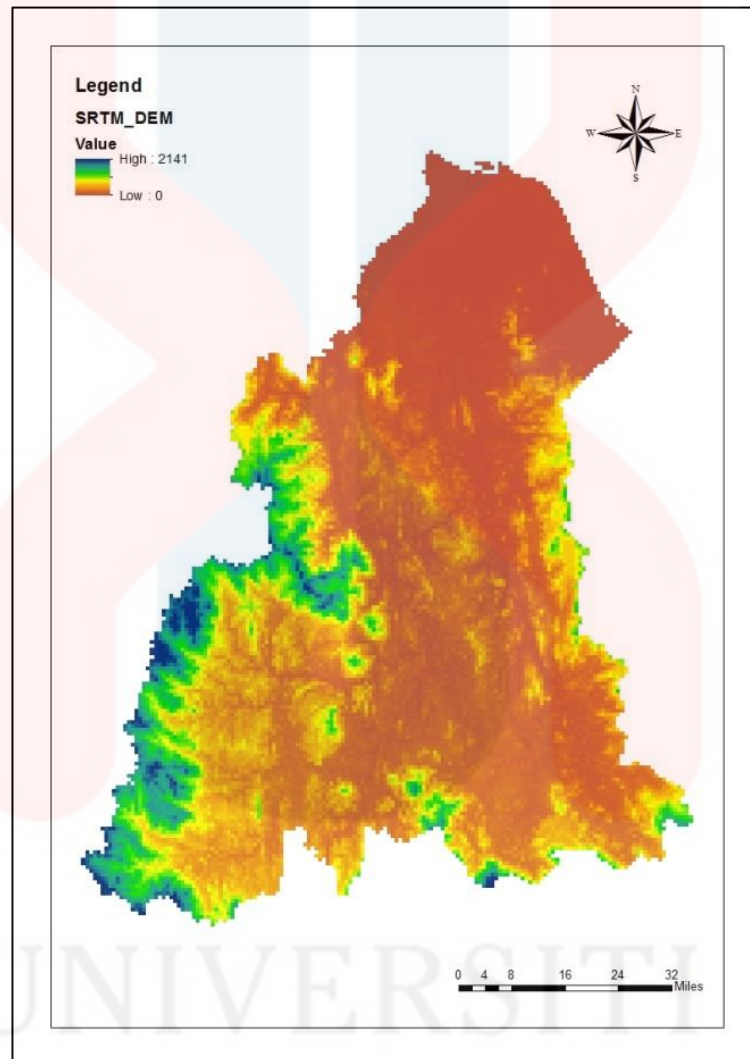


Figure 3.2 : Elevation Map of Kelantan

Therefore, all the environmental variable in GIS format is needed to obtain same geographic area in study area which divided into a grid of pixel as to predict environmental sustainability for the species. This will allows visualisation of spatial data in graphics form or the related, locally attached and attribute data of the areas within a map or the species (Guarino *et al.*, 2005).

3.2.3 Modeling Algorithm (MAXENT)

The ENM data analysis is gain by applying the modelling algorithm. The modelling algorithm that will be used is MAXENT. The version of MAXENT used is MAXENT v. 3.3.1 (<http://www.cs.princeton.edu/~schapire/maxent/>). The use of this application, it will use the covariate data from occurrence records and background sample in order to estimate the ratio. This is because many distributions are possible but this application will choose the one who closet with the ratio (Elith *et al.*, 2011).

MAXENT modeling software is used to create the predictions of distributions of the two selected species from genus *Scindapsus* with two different set of the data. The first data set, the model was run with the 19 bioclimatic data with Harmonized World Soil Database (HWSD) and Shuttle Radar Topography Mission (SRTM). The second set of data included all the previous data except the HWSD data is excluded.

The first model was developed using full set of locality data in order to provide the best estimates of the potential distributions. The genus *Scindapsus* from *Scindapsus perakensis* species with the locality data is 16, meanwhile the *Scindapsus treubii* species with the locality data of 15.

Then, from the localities data, the first model will develop by using the full set of locality data as to provide the best estimation of the species distributions. While, the second model will develop by using random selection which is 75 % of the locality data at each iteration as for the training dataset, with the balance 25 % will reserved for testing resulting model.

The model testing run that will be use is the area under the curve of the receiver-operating characteristic. The 100 replicated runs of MAXENT on the locality data and the average of the predicted distribution from 100 replicated run was used to estimate the total distribution of each species (Maycock. *et al.*, 2012).

Meanwhile, the method for the locality data that used from IUCN Standards & Petitions Subcommittee in 2010 to determine the EOO, by measure the spatial spread of the area occupied by the species and will not intended to be estimate on the amount of potential habitat or range size. The EOO and AOO will be calculating by using the minimum convex polygon method and 2 x 2 km grid cell using the Conservation Assessment Tools (CATS) produced by Royal Botanic Garden Kew (Brummitt, 2008). The used of ArcView GIS 3.3 will produce the potential distribution map of EOO and AOO.

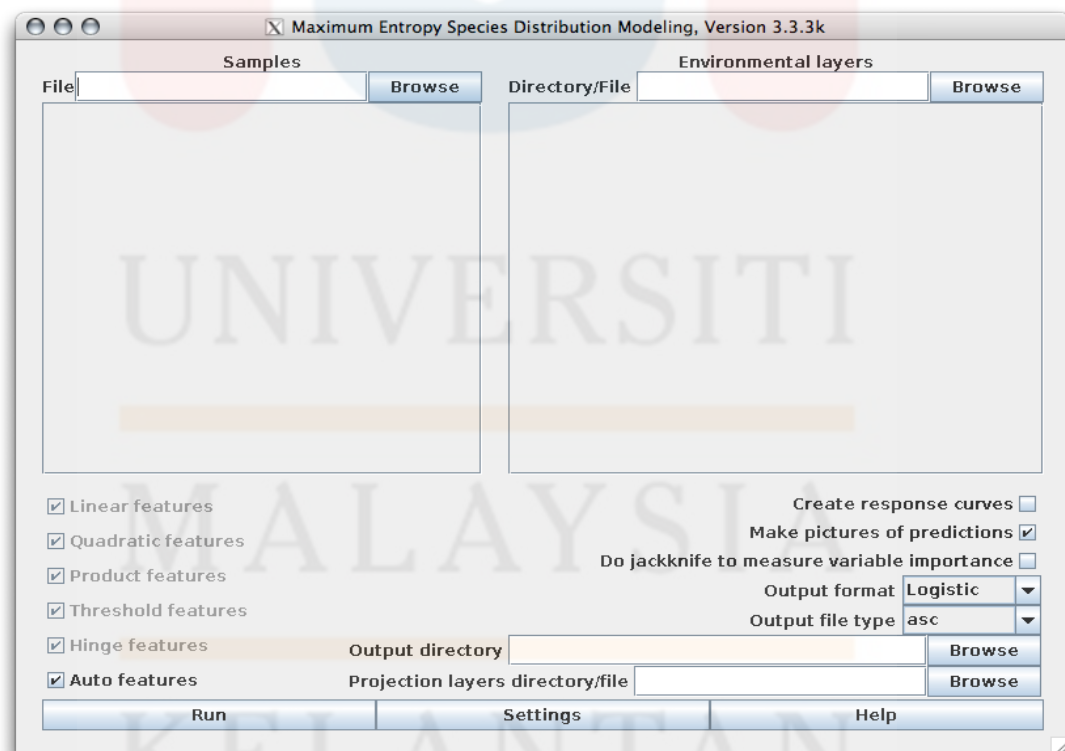


Figure 3.3: The MAXENT Interface Version 3.3.3k
Source: (Phillips, 2005)

3.2.4 Model Performance Measurement

The judgment for the ability of an ENM is measure by Receiver Operating Characteristic (ROC), or known as AUC. This method is being used in order to access the accuracy of predictive distributions of the model (Lobo *et al.*, 2008).

The AUC ranges are calculated from 0 to 1, where a score of 1 will indicates the perfect discrimination, a score of 0.5 will implies the predictive discrimination that is no better than a random guess. Meanwhile the values of ≤ 0.5 indicate performance worse than random. The AUC values can be understood as specifying the probability that, when a presence site and an absence site are drawn at random from the population, the first will have a higher predicted value than the second (Elith *et al.*, 2006).

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Distribution of selected genus of *Scindapsus* in Kelantan

The locality data are needed in order to generate the distributions of the selected *Scindapsus* species which are *Scindapsus perakensis* and *Scindapsus treubii*. In this study, the locality data is been obtained from the secondary data of previous research on the family of Araceae.

The data collected from the sources were reviewed and processed. The dot map of two selected species of genus *Scindapsus* which were generated using Arc GIS version 10.3.1 and shown in Figures 4.1 and 4.2.

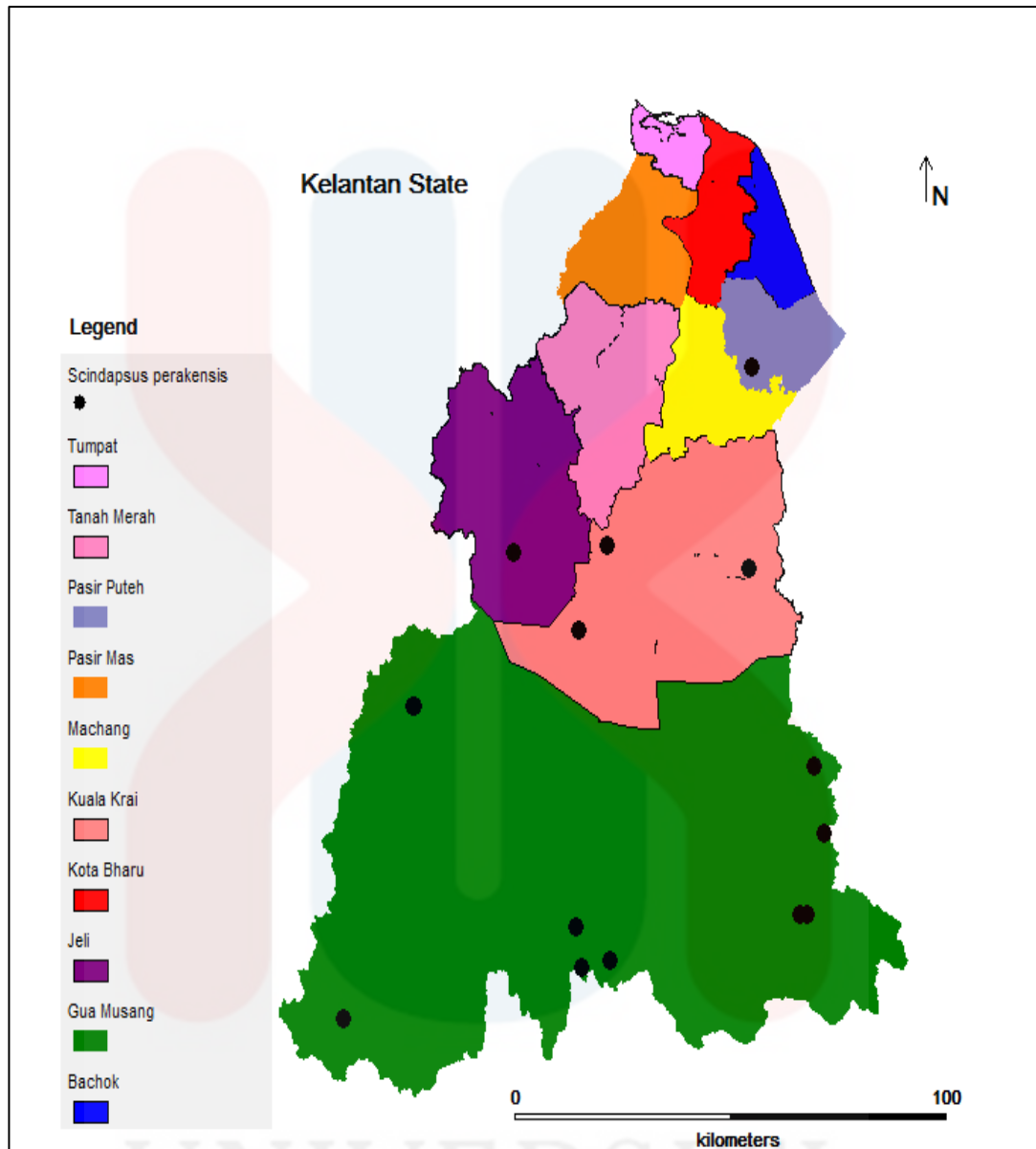


Figure 4.1: Localities data for *Scindapsus perakensis*.

Figure 4.1 shows the locality data of *Scindapsus perakensis*. The image was generated using DIVA-GIS version 7.5.0. The total number of locality data for *Scindapsus perakensis* are 16 points.

Based on distributions map, the most abundance are *Scindapsus perakensis* noted in Gua Musang, Kelantan which is with the nine points.

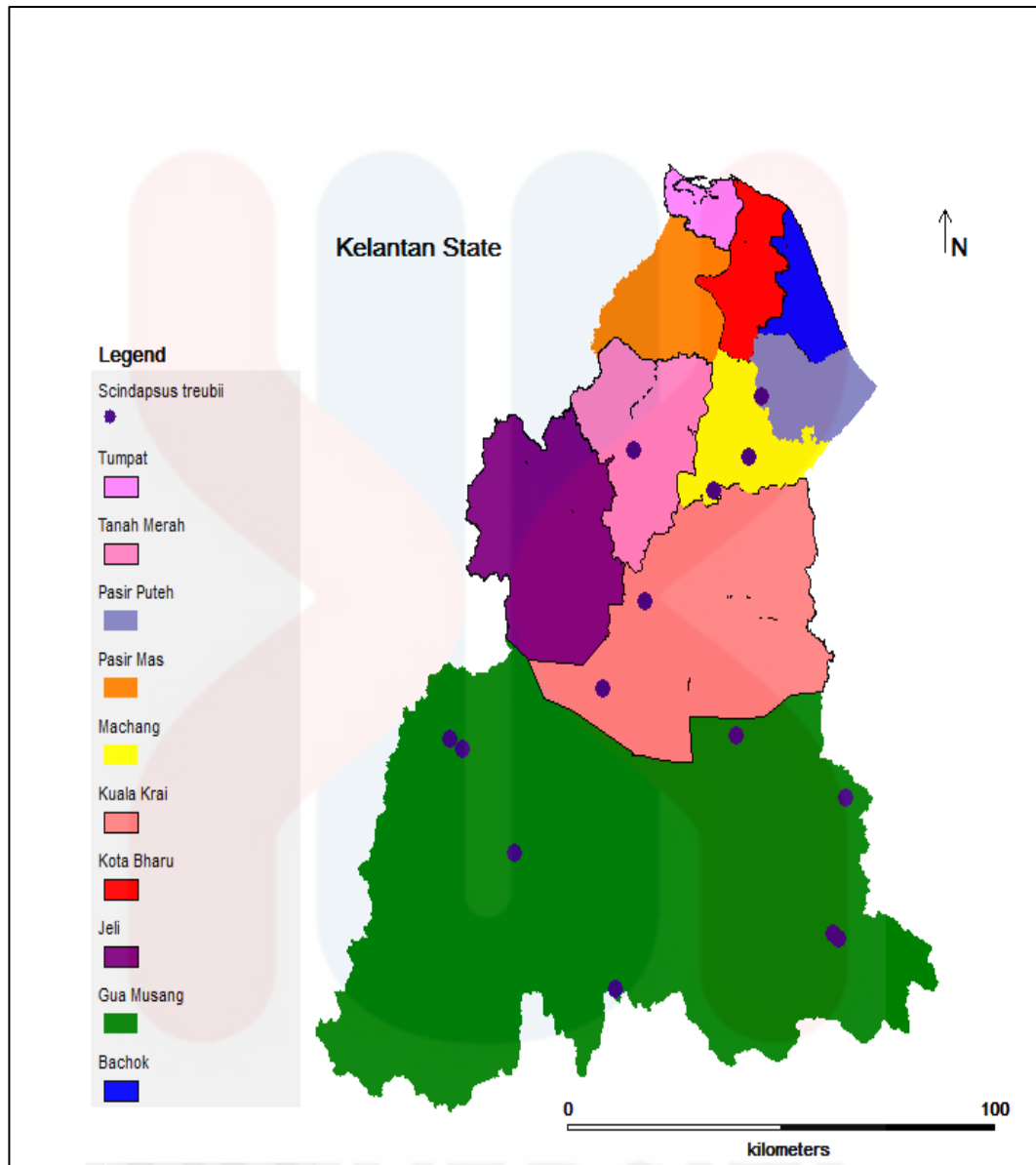


Figure 4.2: Localities data for *Scindapsus treubii*

Figure 4.2 shows the locality data for *Scindapsus treubii*. The distribution map was generated by DIVA-GIS version 7.5.0. The total locality data that had been recorded is 15 points.

Based on the distribution map of *Scindapsus treubii*, the species was scattered across Kelantan but most commonly found in Gua Musang.

4.2 MAXENT Output

Based on the raw result from the MAXENT, the color indicates the suitability and possibility for the species distribution. The color towards red indicates the high probability for growth. Meanwhile, the green color indicates the typical conditions and blue color indicates the low probability of the species predicted at the particular habitat.

Table 4.1: Area under the curve (AUC) for each selected *Scindapsus* species

Species		Value of training AUC	
		Include HWSD	Without HWSD
<i>Scindapsus perakensis</i>	Full Run Training Data	0.924	0.921
	25% Testing Data	0.761	0.737
	75% Testing Data	0.803	0.763
<i>Scindapsus treubii</i>	Full Run Training Data	0.737	0.750
	25% Testing Data	0.731	0.732
	75% Testing Data	0.746	0.713

Next, the table above shows the AUC values for each selected *Scindapsus* species based on the different model run in MAXENT which is used for validation process.

Table 4.2: Range of AUC and its classifications (Araújo *et al.*, 2005)

RANGE	CLASSIFICATION
≤ 0.6	Fail
0.6-0.7	Poor
0.7-0.8	Fair
0.8-0.9	Good
≥ 0.9	Very good

4.3 Distribution of *Scindapsus perakensis*

The Figure 4.3 presented the predicted distribution generated by MAXENT version 3.3.3 software. Figure 4.3 (a) shows the predicted distributions using 20 environmental layers including the data from Harmonized World Soil Database (HWSD), meanwhile the Figure 4.3 (b) indicates the predicted distributions using the same environmental layers excluding the HWSD data. Meanwhile the Figures 4.4 (a) and 4.4 (b) shows the predicted distributions using the same environmental layers including and excluding the HWSD data by using DIVA-GIS. Then, Figures 4.5 (a) and (b) showed the graph Area under the Curve of *Scindapsus perakensis* in order to check the validation of the map with and without HWSD data.

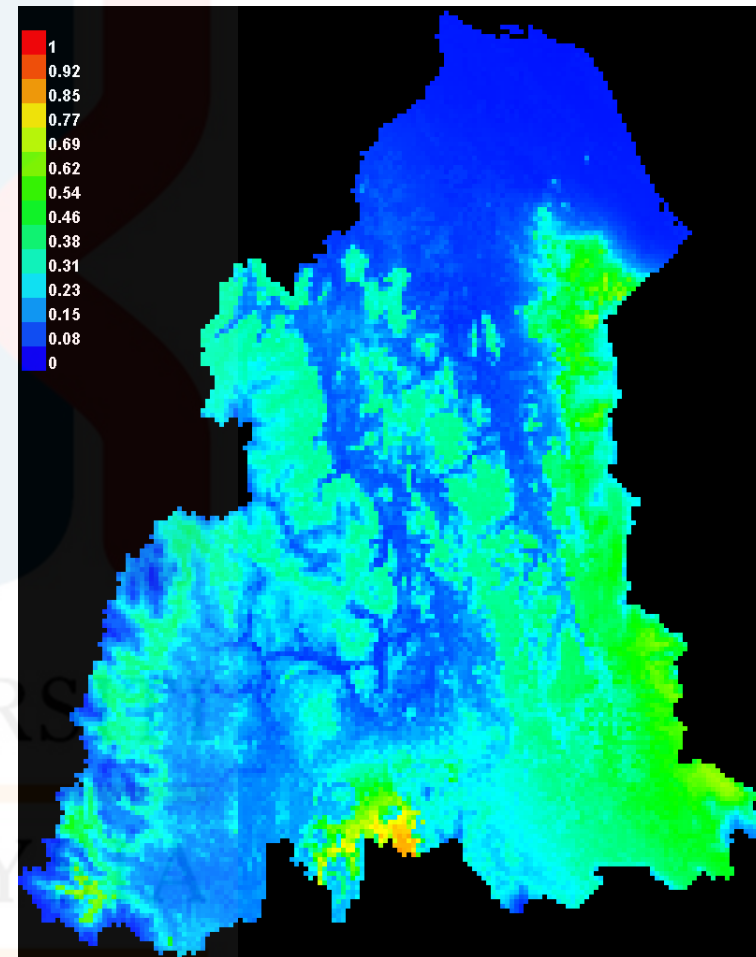
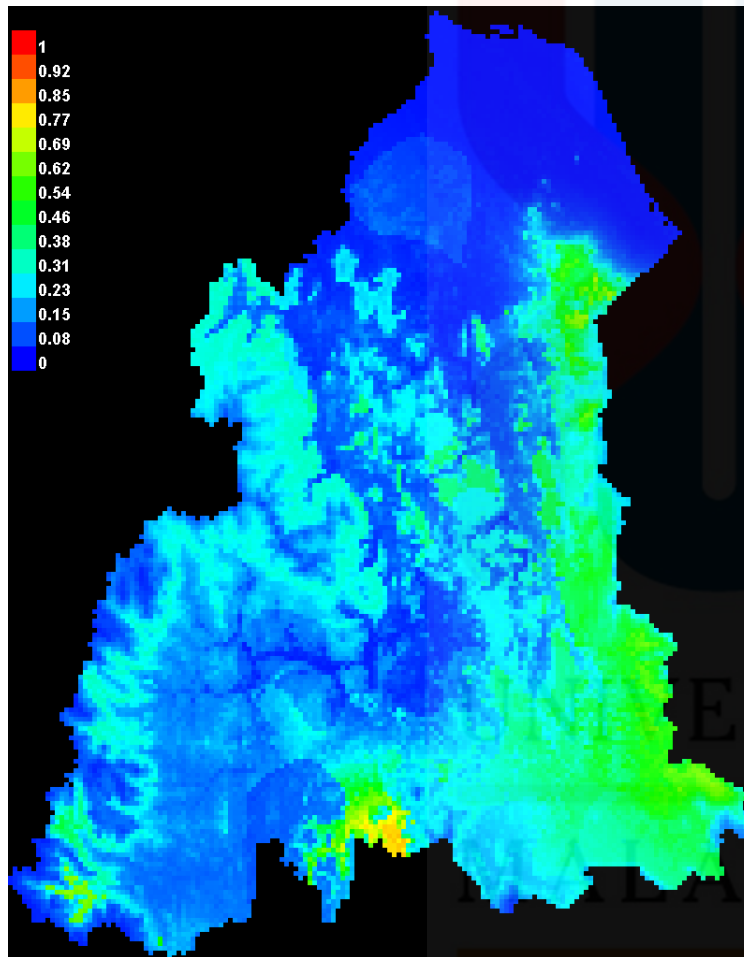


Figure 4.3 (a):

Figure 4.3 (b):

Comparison between predicted distributions of *Scindapsus perakensis* with (a) and without (b) HWSD data using MAXENT

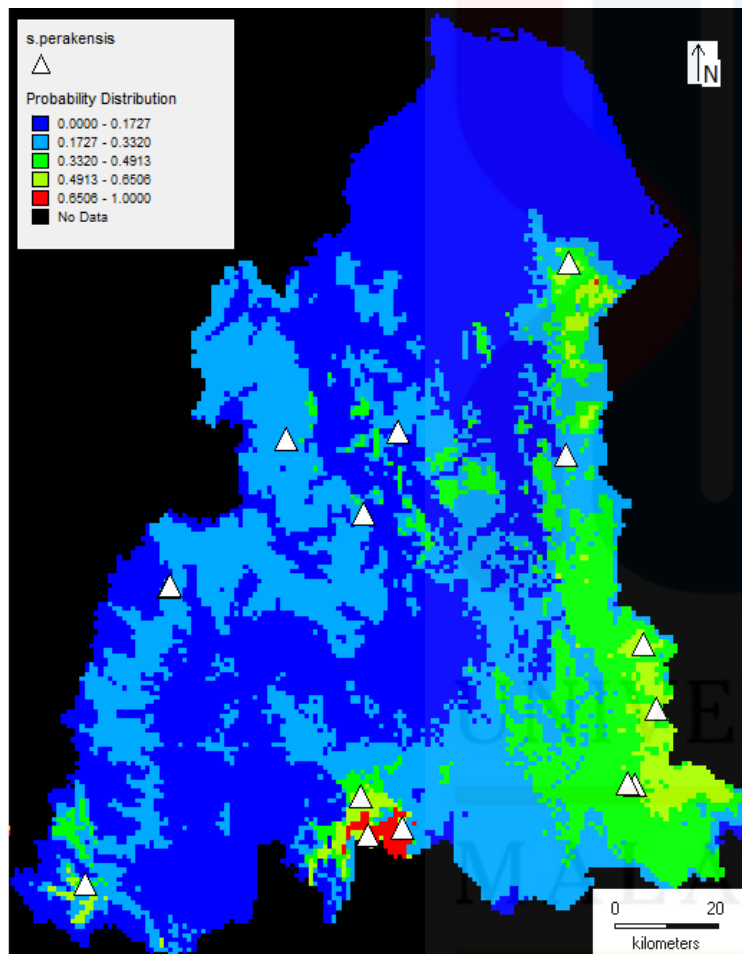


Figure 4.4 (a):

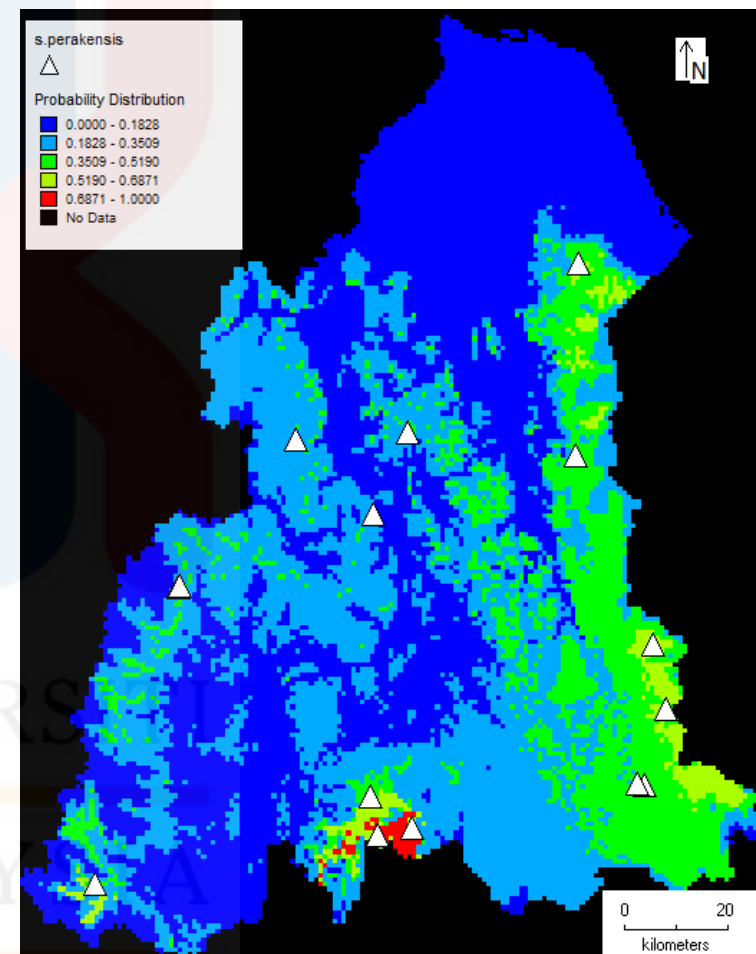


Figure 4.4 (b):

Comparison between predicted distributions of *Scindapsus perakensis* with (a) and without (b) HWSD data using DIVA- GIS

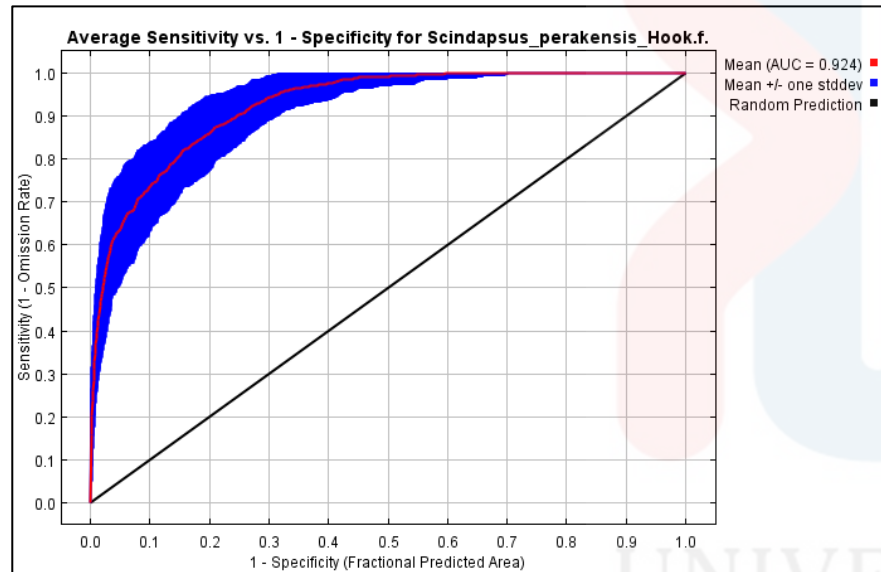


Figure 4.5 (a):

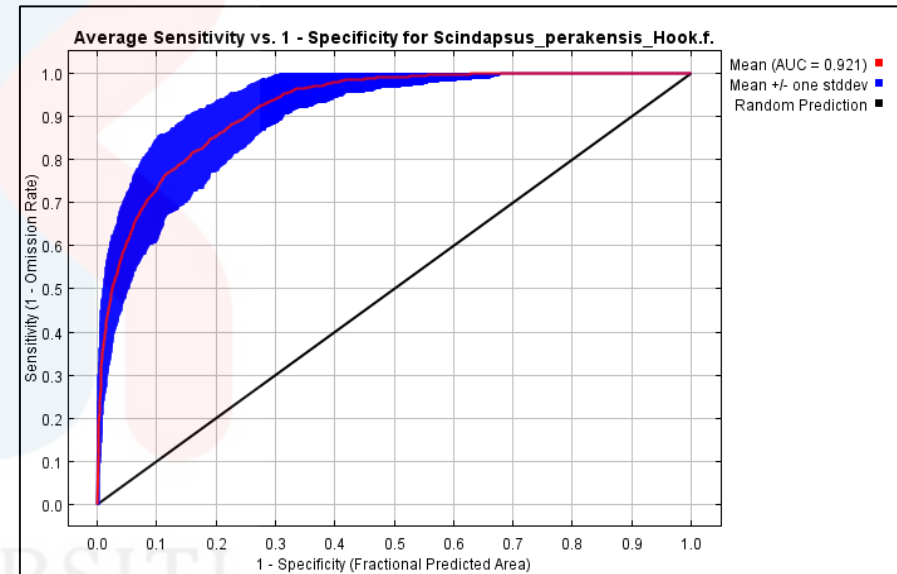


Figure 4.5 (b):

The graph Area under the Curve (AUC) of *Scindapsus perakensis* (a) with and (b) without HWSD

Table 4.3: Percentage contribution of environmental variable of *Scindapsus perakensis* in Kelantan

Variables	Percentage Distribution (%)	
	Include HWSD	Without HWSD
Bioclim 1	7.7	7.8
Bioclim 2	2.3	2.7
Bioclim 3	0.3	1.2
Bioclim 4	0.6	0.9
Bioclim 5	6.4	8.7
Bioclim 6	0	0
Bioclim 7	1.1	1.5
Bioclim 8	3.6	3.8
Bioclim 9	0	0
Bioclim 10	0.4	1.2
Bioclim 11	0.4	0.5
Bioclim 12	16.1	18.6
Bioclim 13	29.1	29.7
Bioclim 14	1.1	1.1
Bioclim 15	12.2	10.9
Bioclim 16	3.2	4.3
Bioclim 17	0.8	0.8
Bioclim 18	0.1	0.3
Bioclim 19	0.1	0.3
HWSD	9.6	-
SRTM	5	5.7

The percentage contribution in Table 4.3 presented the factors that affect the predicted distribution of *Scindapsus perakensis* in Kelantan. The highest amount contributes to the prediction distribution with the HWSD data on Bioclim 13 which is the precipitation of wettest month with the value 29.1%.

Meanwhile, for the prediction distribution without the HWSD data, it also found that the highest amount contributes by Bioclim13 with the 29.7% respectively. The lowest data percentage contribution that affects *Scindapsus perakensis* predicted distribution with HWSD data is Bioclim 6 and Bioclim 9 with the value of 0%. This show that, the bioclim characteristics of minimum temperature of coldest month and mean temperature of driest quarter does not contribute on the prediction of *Scindapsus perakensis* distribution.

For the prediction without HWSD data at 0% test percentage, also the Bioclim 6 and bioclim 9 which is minimum temperature of coldest month and mean temperature of driest quarters which mean this factor give no effect on prediction distribution.

Based on the map, the possible distribution of *Scindapsus perakensis* is mostly distributed at southern area of Kelantan such as Kuala Krai and Gua Musang. Meanwhile, one had been recorded on Jeli and Pasir Puteh area.

4.4 Distribution of *Scindapsus treubii*

The figure 4.5 presented the predicted distribution by MAXENT version 3.3.3 software. The Figure 4.6 (a) indicates the predicted distribution using 20 environmental layers including Harmonized World Soil Database (HWSD) data, meanwhile the Figure 4.6 (b) indicates the predicted distribution using the same environmental layers without HWSD data. Meanwhile, the figure 4.7 (a) and Figure 4.7 (b) shows the predicted distributions using the same environmental layers including and excluding HWSD data by using DIVA-GIS. Meanwhile, Figure 4.8 (a) and (b) shown the graph Area under the Curve of *Scindapsus treubii* in order to check the validation of the map with and without HWSD data

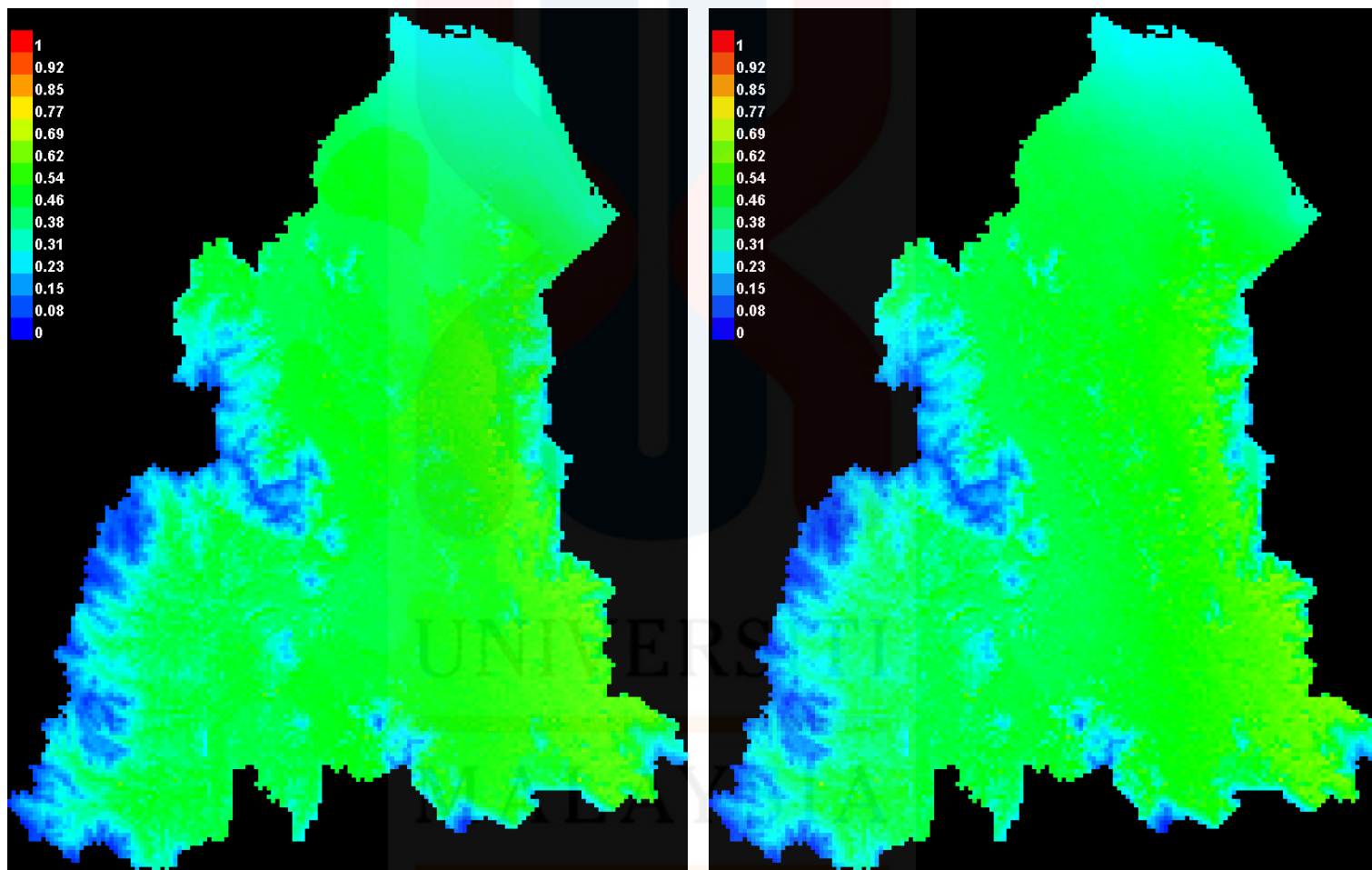


Figure 4.6 (a):

Figure 4.6 (b):

Comparison between predicted distributions of *Scindapsus treubii* with (a) and without (b) HWSD data using MAXENT

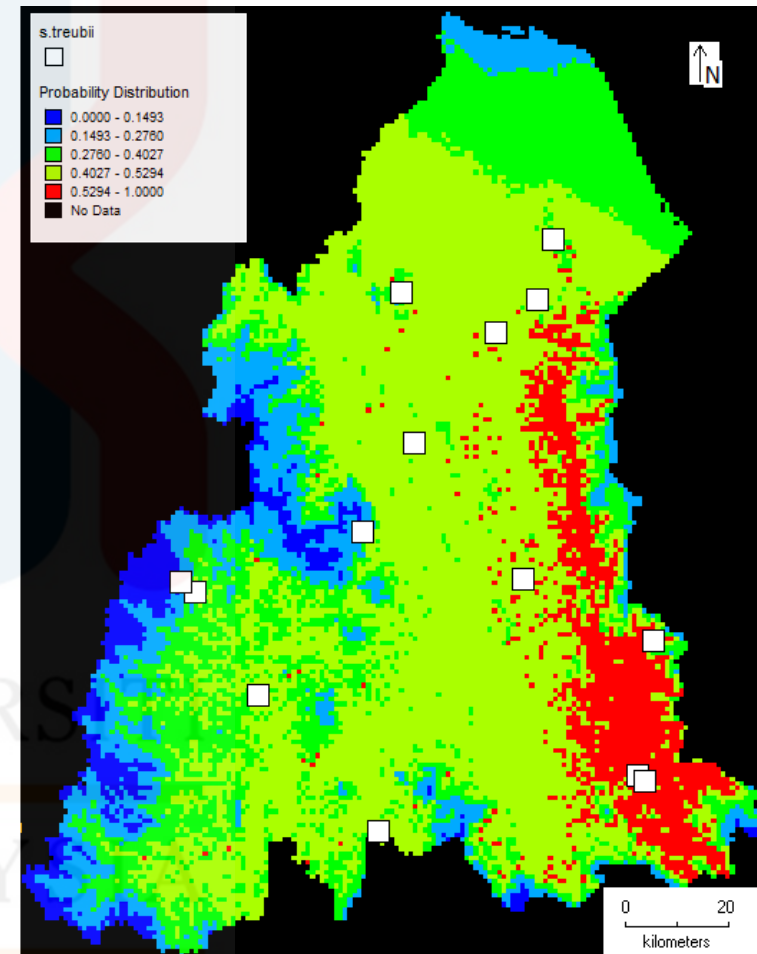
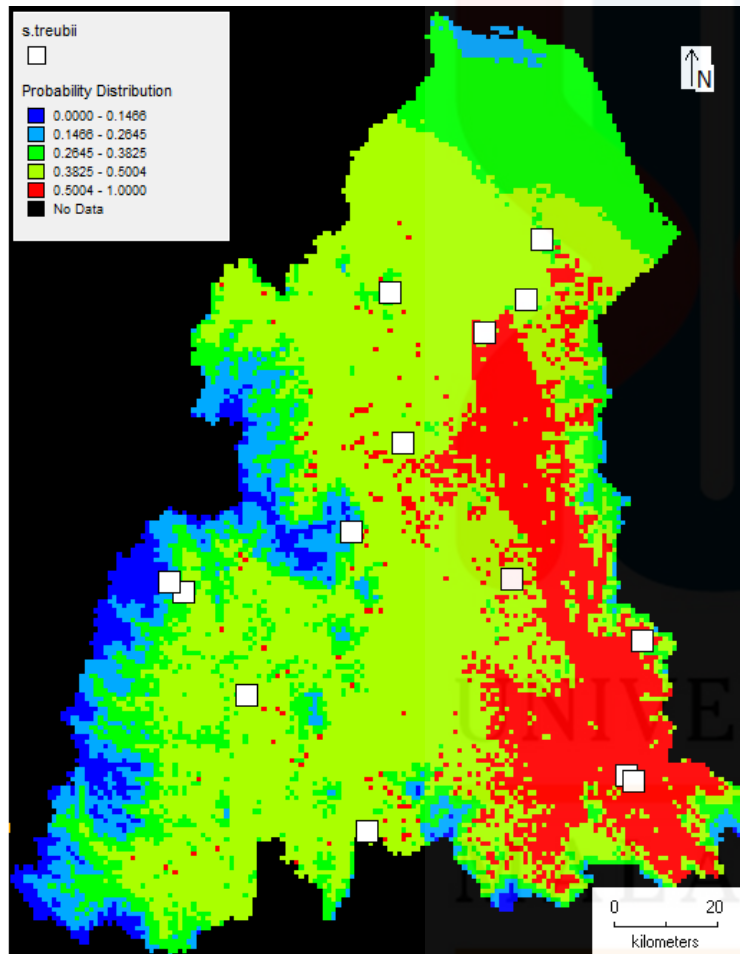


Figure 4.7(a):

Figure 4.7 (b):

Comparison between predicted distributions of *Scindapsus treubii* with (a) and without (b) HWSD data using DIVA- GIS

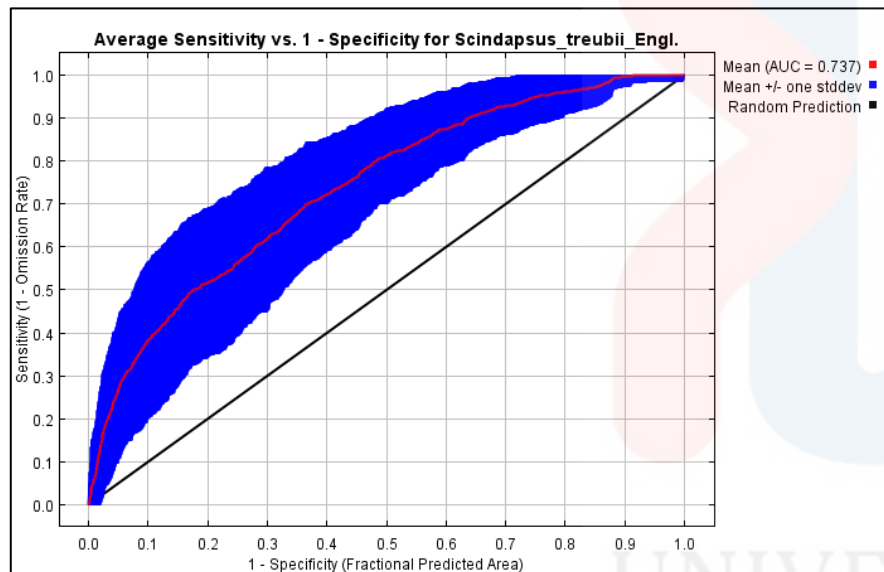


Figure 4.8 (a):

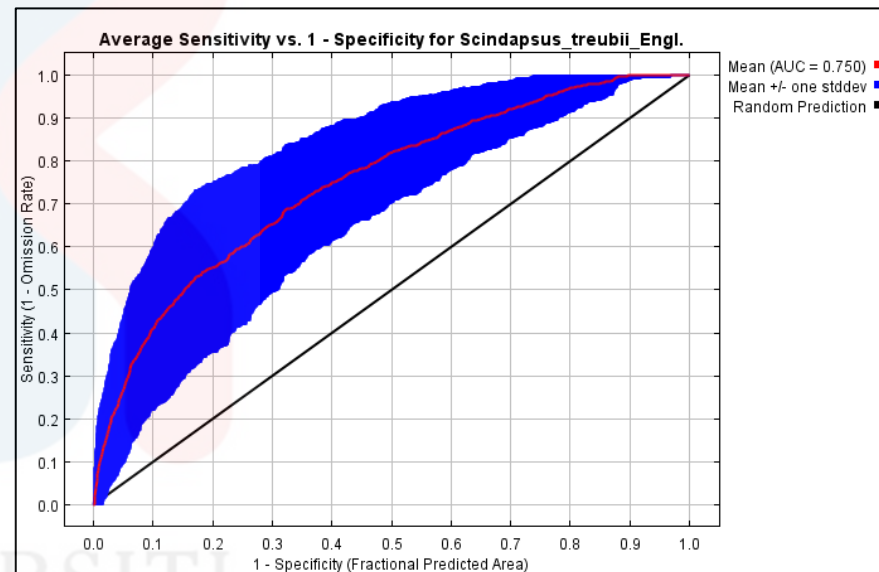


Figure 4.8 (b):

The graph Area under the Curve (AUC) of *Scindapsus treubii* (a) with and (b) without HWSD

Table 4.4: Percentage contribution of environmental variable of *Scindapsus treubii* in Kelantan

Variables	Percentage Distribution (%)	
	Include HWSD	Without HWSD
Bioclim 1	0.1	0.2
Bioclim 2	0.3	0.2
Bioclim 3	2.5	2.3
Bioclim 4	0.1	0.3
Bioclim 5	0.9	1
Bioclim 6	0.1	0.4
Bioclim 7	1.2	1.9
Bioclim 8	0.2	0.7
Bioclim 9	1.7	1.1
Bioclim 10	0	0
Bioclim 11	0.4	1.1
Bioclim 12	11.2	10.5
Bioclim 13	2.2	2.3
Bioclim 14	5.5	4.9
Bioclim 15	7.4	13.6
Bioclim 16	0.6	0.3
Bioclim 17	0.5	1
Bioclim 18	0	0.5
Bioclim 19	0.2	0.1
HWSD	9.6	-
SRTM	55.3	57.6

Table 4.4 presented the variables percentage contribution which is the factors that affect the predicted distribution of *Scindapsus treubii* in Kelantan state. Based on the result, the highest amount of percentage contribution of environmental variable with and without HWSD data is SRTM data with the value of 55.3% and 57.6% value in contribution of the species distribution. This means the DEMs give the most of the factors of distribution of the species.

The least affecting factor that contributes to the predicted distribution of *Scindapsus treubii* with and without HWSD data is Bioclim 10 with the value of 0% which is the factor mean temperature of warmest quarters give no effect on prediction distribution.

Therefore, based on the map that had been generated, it is predicted that there is a possible distribution of *Scindapsus treubii* scattered in most of the district in Kelantan state. The highest prediction at the district of Gua Musang, followed by Machang with the prediction at three places, then there is two places in Kuala Krai also and one place in Tanah Merah.

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

The comparison of distribution area of *Scindapsus perakensis* and *Scindapsus treubii* in Kelantan as presented on Figure 4.9 and Figure 4.10 which are between, and Extent of Occurrence (EOO), Area of Occupancy (AOO) and Ecological Niche Modeling (ENM).

Next, Table 4.5 shown the comparison on the percentage of distribution of genus *Scindapsus* with Extent of Occurrence (EOO), Area of Occupancy (AOO) and Ecological Niche Modeling (ENM).

Table 4.5: Comparison on the percentage of distribution of genus *Scindapsus* with Extent of Occurrence (EOO), Area of Occupancy (AOO) and

Species	<i>Scindapsus perakensis</i>		<i>Scindapsus treubii</i>	
	km ²	%	km ²	%
Extent of Occurrence (EOO)	8338.97	55.21	7145.67	47.31
Area of Occupancy (AOO)	48	0.32	52	0.34
Ecological Niche Modeling (ENM)	491	3.25	2956	19.57

Total Area of Kelantan: 15,105 km² (Kelantan Forestry Department, 2015)

4.5.1 *Scindapsus perakensis*

Based from Table 4.5, the area of EOO of *Scindapsus perakensis* is from the area that contained within the polygon drawn in order to create the shortest-boundary solution encompassing all known site of occurrence of a species. The estimated area of EOO is 8338.97 km² where is obtained by using Arc View GIS version 3.3. Then, the area is divide by the total area of Kelantan and being multiplied by 100 in order to get in percentage value.

Meanwhile, the area of AOO is determined by counting the number of occupied cells in uniform grid covering the species range and then multiplying the number of occupied cell by the size of the grid cell adopted. The result showed the 12 the number of occupied cells and being multiplied by four because of the 2 x 2 km grid cell. The result is also dividing with the total area of Kelantan and multiplied by 100 to get in percentage value.

The Ecological Niche Modeling (ENM) area is obtained from inserting the MAXENT output result into Arc GIS then transfer the image from raster to polygon format in order to get the estimated area. The result shown the area of the high probability in distribution is 491 km². Then, the total area being dividing with total area of Kelantan and multiplied by 100 percent for the value in percentage.

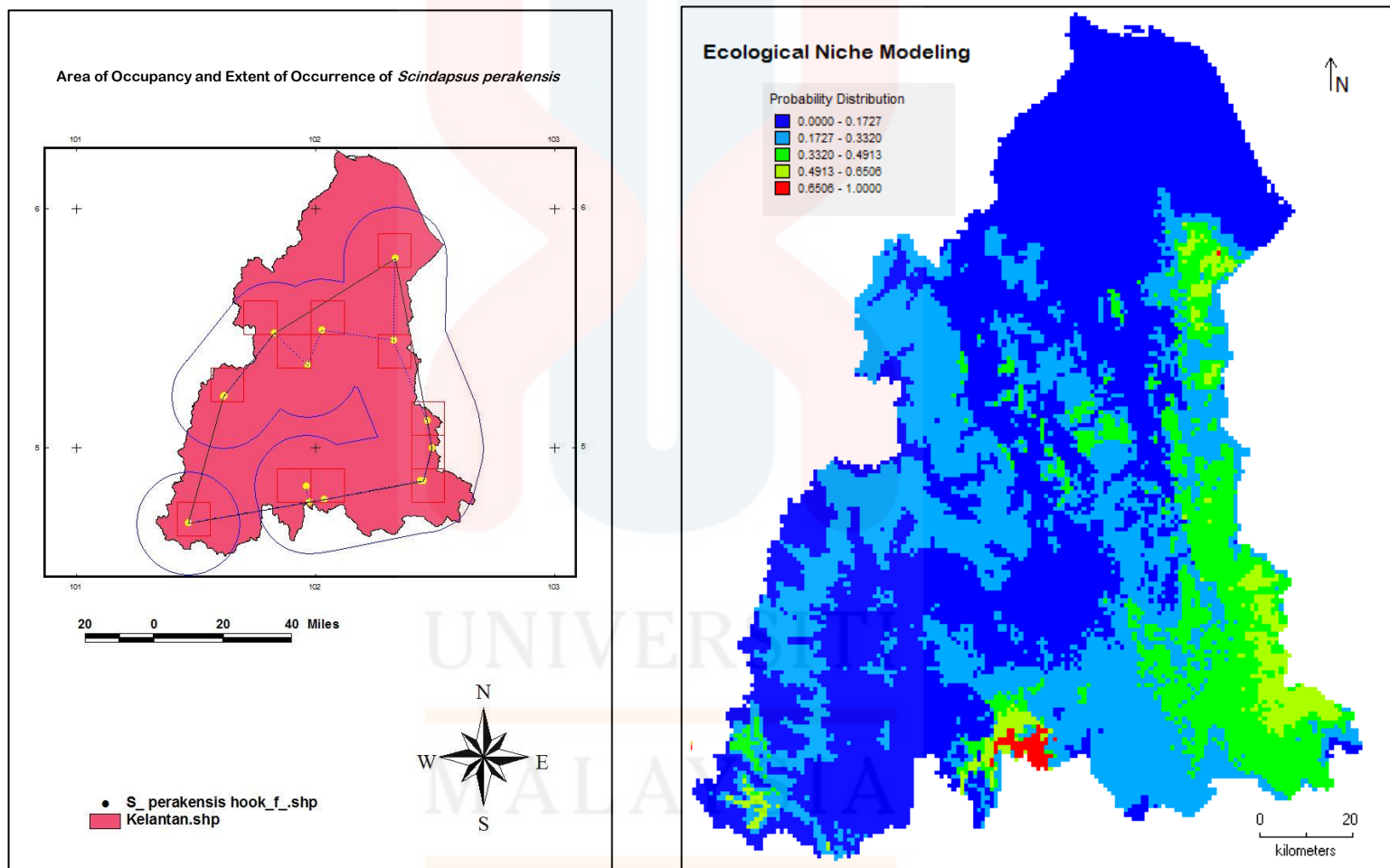


Figure 4.9: The comparison of distribution area of *Scindapsus perakensis* in Kelantan between Ecological Niche Modeling (ENM), Extent of Occurrence (EOO) and Area of Occupancy (AOO)

4.5.1 *Scindapsus treubii*

Table 4.5 shown, the area of EOO of *Scindapsus treubii* which is from the area that contained within the polygon drawn in order to create the shortest-boundary solution encompassing all known site of occurrence of a species. The estimated area of EOO is 7145.67 km² where is obtained by using Arc View GIS version 3.3. Then, the area is divide by the total area of Kelantan and being multiplied by 100 in order to get in percentage value.

Meanwhile, the area of AOO is determined by counting the number of occupied cells in uniform grid covering the species range and then multiplying the number of occupied cell by the size of the grid cell adopted. The result showed the 13 the number of occupied cells and being multiplied by four because of the 2 x 2 km grid cell. The result is also dividing with the total area of Kelantan and multiplied by 100 to get in percentage value.

The Ecological Niche Modeling (ENM) area is obtained from inserting the MAXENT output result into Arc GIS software then transfer the image from raster to polygon format in order to get the estimated area. The result shown the area of the high probability in distribution is 2956 km². Then, the total area being dividing with total area of Kelantan and multiplied by 100 percent for the value in percentage.

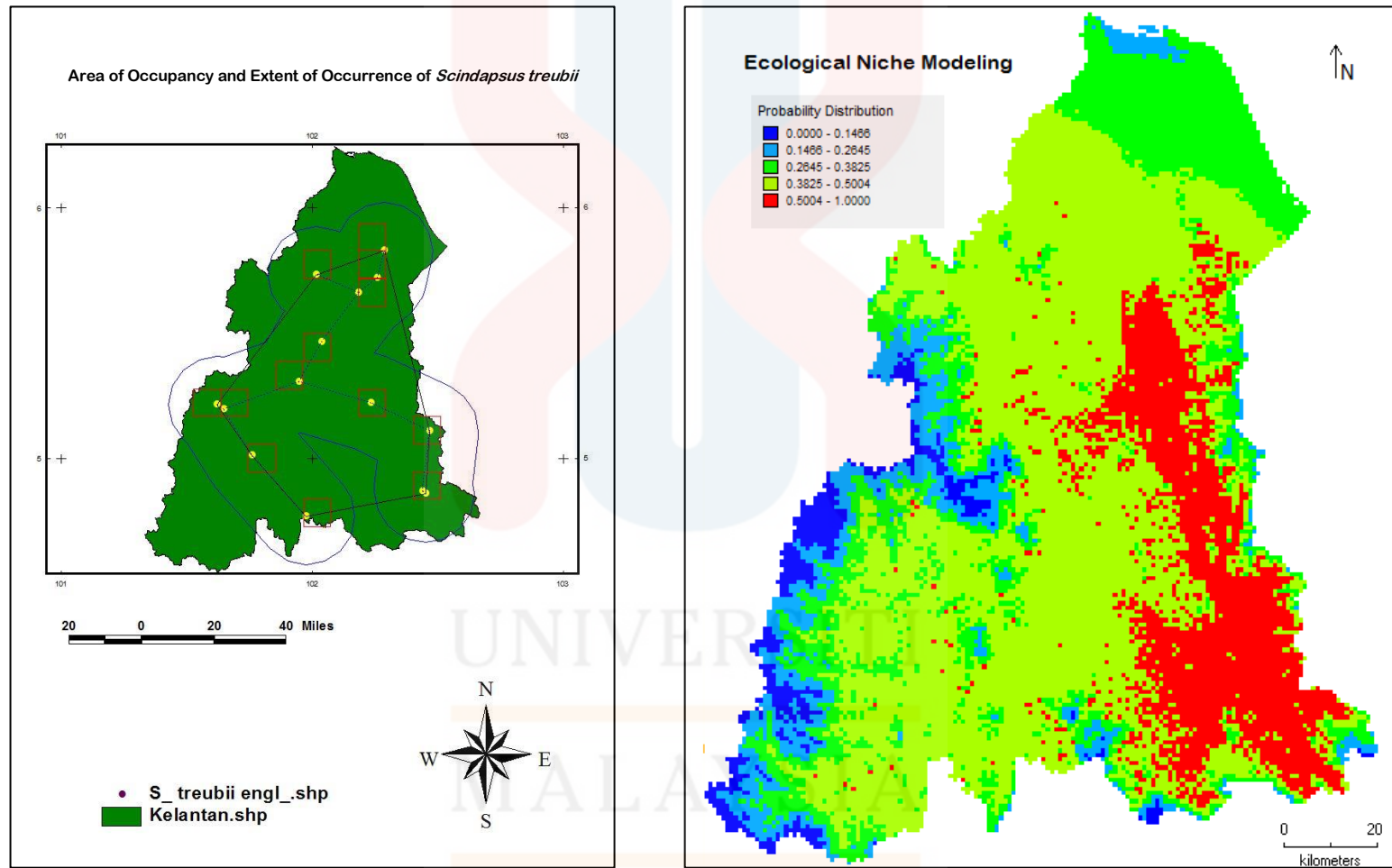


Figure 4.10: The comparison of distribution area of *Scindapsus treubii* in Kelantan between Ecological Niche Modeling (ENM), Extent of Occurrence (EOO) and Area of Occupancy (AOO).

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The output map of distribution habitat of the selected species from genus Kelantan was generated by MAXENT. The species of *Scindapsus perakensis* distribution was scattered most in southern area of Kelantan, which is the most distributed area in Gua Musang, followed by Kuala Krai and each at Jeli and Pasir Puteh. Meanwhile, the distribution of species *Scindapsus Treubii* distribution was scattered in most area in Kelantan.

The growth factors that influenced the habitat distribution of each species were determined. For the *Scindapsus perakensis* the factors that affected the distribution is precipitation of wettest month. The precipitation of the wettest month gives the higher factors on the distribution of species of *Scindapsus perakensis*. While, the factors that affected the distribution species growth of *Scindapsus treubii* distribution in Kelantan is the elevation of the area.

The comparison on the percentage of distribution of genus *Scindapsus* with Extent of Occurrence (EOO) and Area of Occupancy (AOO) and Ecological Niche Modelling (ENM) is obtained. The EOO and AOO is the approach for conducting IUCN Red List assessment on estimating a species (IUCN, 2006).

Therefore, according to Solano and Feria (2007) stated the EOO and AOO approach not suitable for accessing the estimating species. Thus, compared to ENM models is more accurate on predicting species and widely used on conservation of species as they are insensitive to aspect of species biology (Maycock *et al.*, 2012).

The problems that cause the EOO not suitable because of the convex polygon could not be able to calculate for the collections that occurred in the same plane or else with the less than three points of localities. Meanwhile, the AOO problems are because of the use of grid measurement. The size of grid measuring should be square or rectangle sufficient to calculate the point that recorded in species distribution. The assessors also need to be sure that the grid could be placed in the same location in order to avoid the generated of inconsistent result.

5.2 Recommendations

Future recommendation that suitable on estimates the distribution of species by ground truth activity based on the map predicted distribution in order to check their availability. The uncertainty regarding the species can be reduces by referring to the previous predicted distribution model.

The added information regarding the species may also be taken such as the land use map of Kelantan, type of soil, the surrounding area and others. This information can be used for the future research regarding the species. The accuracy of the species also can be approved by using Ecological Niche Modeling (ENM).

Other than that, the use of ENM able to predict the habitat loss and the conservation status of threatened species. The ENM will act as the rapid assessment tools for conservation to scheme the protected area. Therefore, the data regarding the species will be able to act as preliminary data for the researcher to conserve the species that near to threatened.

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APPENDIX A

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