Climate Index for Estimating Nutmeg Plant Suitability under Tropical Rainforests in Maluku Province, Indonesia

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Abstract

The nutmeg (Myristica fragrans Houtt) has been known as an important plant spice since the 16th century. In order to restore the triumph of Maluku as a largest nutmeg producer, the central government had declared in 2017 that Maluku Island as "a spice island" with the priority to produce nutmeg, clove and cinnamon and therefore needed extensification of nutmeg plant to full fill the worlds demand. For the optimal nutmeg plant extensification it was necessarily to carried out a land evaluation studies to find out the areas which have a climate and soil characteristic suitable for nutmeg. However, the land requirements related to climatic particularly for nutmeg plant seem did not get much attention. This study aims to determine climatic requirements of nutmeg plant under tropical rain forest in Maluku Province and to see the correlation between climatic index and nutmeg plant productivity using a parametric approach. The research method used was a mixture of qualitative and quantitative approach in several stages i.e. determination of site location through overlying a nutmeg plant distribution map and nutmeg productivity map, field survey and data collection, data analysis, quantitative analysis for correlation between various an individual climatic characteristic with nutmeg productivity, selection of climatic characteristic, determination of climatic index according to parametric approach for each combination of climatic characteristic and correlation between climatic index with nutmeg productivity. The results showed that some climatic characteristics including precipitation, maximum temperature, degree of the days and humidity index were very strong correlated to the productivity of nutmeg plant with coefficient correlation (r) >0.95. The highest climatic index was found it in Banda Island with average of nutmeg yield was 4.966,6 kg $ha^{-1}year^{-1}$. Climatic index according to parametric seem was more appropriate in determination climatic suitability of nutmeg plant than simple limitation methods in the tropical rainforest Indonesia.

Keywords: *nutmeg, Banda, parametric approach, climatic index, tropical rainforest.*

I. INTRODUCTION

The Nutmeg (*Myristica fragran Houtt*) is an Indonesia's native plant spice originated from Maluku Province, particularly Banda Island and has been known as an important spice plant since the 16th century. The centre of nutmeg production areas in Indonesia were located mainly in Maluku and North Maluku (38,9%), Aceh (11,8%), South Sulawesi (10,3%) and the rests (8,5%) in west papua province (Martin and Saha, 2009). According to Elsheikh, Sharif, Amiri, Ahmad, Balasundram, and Soom (2013) at the present, Indonesia is the world's largest nutmeg producer country (60%), besides Granada (20%), India, Srilangka and Malaysia (20%). Accordingly He, Chen, and Ongaro (2011) in 2014, Indonesia was the world's second largest nutmeg exporter after Guatemala with export destination to Vietnam, Netherlands, The United states, Germany, India, Italy and Japan. Indonesia was able to meet the world nutmeg demands of 18,8 % of total value of nutmeg world's export.

From the historical view and the beneficiary of nutmeg plant however there is a need effort for extensification of nutmeg plant to full fill the worlds demand, moreover in order to restore the triumph of Maluku as a largest nutmeg producer, the central government had declare in 2017 that Maluku Island as " a spice Island" with the priority to produce nutmeg, clove and cinnamon.

Banda, Ambon and Seram islands were the most important nutmeg plant producing areas, all over Indonesia archipelago where Banda island historically as an area where nutmeg plant originated and had been recognized by *Dewan Rempah* Maluku Province as the highest nutmeg plant productivity in this region following by Ambon and Seram island, most of the nutmeg plant in those area were under natural tropical rain forest.

For the optimal nutmeg plant extensification it was necessarily to carried out a land evaluation studies to find out the areas which have a climate and soil characteristics suitable for nutmeg plant.

Land evaluation was a process of predicting land performance over time according to the specific types of use both for agriculture and non agriculture. The principle purpose of agriculture land suitability evaluation was to predict the potential and limitation of the land for crop production. Agriculture land suitability assessment was defined as the process of assessment of land performance when used for alternative kinds of agriculture. The choice of a suitable land for an optimal production can be done correctly through three phases including phase I data was collection of the necessary characteristic or qualities, phase II was determined the land requirements (climate and soil) of land use type intended and phase III the evaluation sensu stricto. Land requirements (climate and soil) for various annual crops as well as perennial crops were shown by a number of authors. A number of a land characteristics which influence crop growth and production had been listed particularly climate such as annual rainfall, temperature, insolation, relative humidity and some of driest month. FAO for instance using a land characteristics and quality. However, land requirements related to a climate especially for nutmeg plant still did not get much attention except one of the BBSDLP. But even though the emphasize given was more to the land quality and the evaluation assessment used was a limitation approach.

According to the author opinion the climatic requirement used still to general and do not refer to the growing cycle of the nutmeg plant and the evaluation assessment used was a limitation approach which is too simple and do not in line with the increasing of a huge number of data exist and the development of computing technology. This study aims to determine climatic suitability of nutmeg plant under tropical rain forest in Maluku Province, Indonesia and to found out the correlation between climatic index with nutmeg productivity using a parametric approach.

II. MATERIALS AND METHODS

A. Study Area

The research was conducted from February through April 2018 in Seram, Ambon and Banda island, Maluku Province, Indonesia which administratively covers Central Maluku Regency and city of Ambon which include 17 subdistricts, 172 village. Geographically situated between S 03°21'10. 8"- 04°32'32.59" S and E 127°57'10.88"- 129°54'17.30", with total land area of 11.595,57 km² or 4,20%. Most of the land area of the central Maluku Regency or around 92,11% were located in Seram island and the rest were distributed in Ambon Island, Haruku, Nusa Laut and Saparua. While only 7,98% were in Banda island. Annual rainfall 2.464 mm year^{-1}, 3.077 mm year^{-1} and 2.406 mm year^{-1} respectively for Seram, Ambon and Banda island with an average air temperature of 26,4 °C, 26,4 °C and 27,32 °C . Other climate data were listed in Table 1 while type of the climate according to Schmidt and Ferguson were Seram Island belong to climate type D (intermediate), while Ambon belong to wet and Banda as slightly wet. Topographic condition in Seram island was vary starting from mostly flat (2 – 3 %) or almost flat (3 – 8 %), some rolling (8 – 15%) and hilly (15 – 25%), in Ambon were mostly flat to almost flat, some rolling and few steeply dissected (> 25 %), in Banda are some flat or almost flat and some undulating, few hilly and steeply dissected. Geologically, Seram island consist of two geological formation include alluvium formation (Qa) and complex Tehoru formation (PTRt), in Ambon island there were 4 geological formation include alluvium (Qa), Ambon volcano rock, ultramafic rock and uplifted coral rock. while in Banda were consist mainly breccia volcanic rock.

Table 1. Climatic data of research sites

Climatic characteristic	Research sites		
	Seram	Ambon	Banda
Rainfall (mm)	2.464	3.077	2.406
Rain day	17,62	18,09	18,27
Air temperature (°c)	26,38	26,44	27,32
Maximum air temperature (°c)	29,93	30.10	31,01
Minimum air temperature (°c)	23,62	23,86	22,64
Relative air humidity	85,03	83,29	83,91
Sun radiation (%)	57,76	56,30	55,06
Wind velocity (knot)	2,14	4,24	4,49

Source: BMKG (2017)

B. Research Methods

The research methods to developed nutmeg plants climatic requirements was using a mixture qualitative and quantitative approach with following on several stages as follows:

1. Determination of observation sites

The site location was obtained by overlaying a nutmeg plant distribution map (interpreted from satellite imagery analysis) and nutmeg plant production data. Based on nutmeg plant production data according to Dewan Rempah Maluku, Banda island was stated as the highest nutmeg plant productivity while Ambon has moderate and Seram has the lowest. The result of the overlay then produce 30 research sites which distributed equally 10 site for each island. These sites belong to 4 villages in Banda island namely Tanah Rata (2 sites), Rajawali (2 sites), Pancabi (4 sites), and walang (2 sites), there are three villages in Ambon city namely Seith (4 sites), Uren (2 sites) and Wakasiu (4 sites); and there are three villages in Seram island include Ruta (3 sites), Tanilau (3 sites) and Haya (4

sites). The maps of the site research showed in the Figure 1.

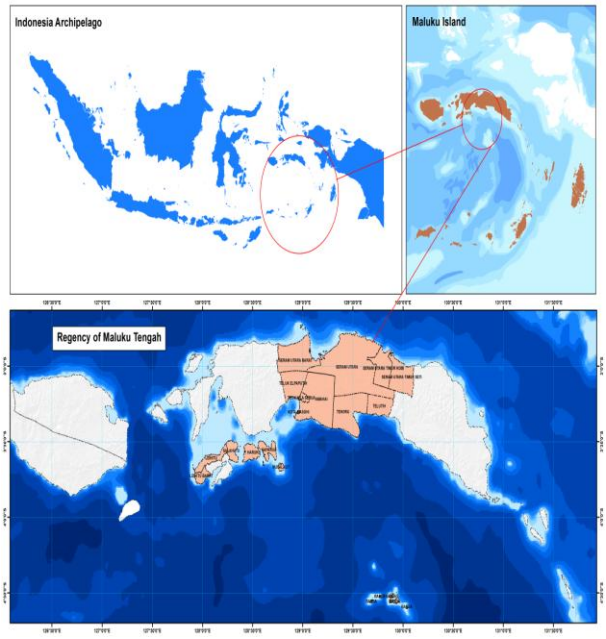


Fig. 1. The map of the research sites

2. Field survey and data collection

The main survey activities at the research site were to checked the productivity data given by Dewan Rempah Maluku village bases and compared to the growth performance of nutmeg plant and information given by the farmer at each selected site within the village. The data obtained were used for correlating with the climatic data. Climatic data were collected from BMKG (Badan Meteorologi Klimatologi dan Geofisika) Banda Naire for the last over 28 years involving rainfall (mm), air temperature (°C) and relative air humidity (%) and sunshine hours.

3. Data analysis

quantitative analysis were used for correlation analysis between various an individual climatic characteristic and with nutmeg productivity in Seram, Ambon and Banda. Selection of the individual climatic characteristic were based on its influence on nutmeg productivity using correlation analysis. Furthermore, calculation of climatic index using a Storie method and correlate the climatic index with nutmeg yield.

III.RESULT AND DISCUSSIONS

A. Climatic Characteristic

Climatic characteristic used in land suitability evaluation particularly for nutmeg was modified from BBSDLP (2012) i.e. temperature (°C), rainfall (mm), relative air humidity and the number of dry months. Generally, crops more susceptible to water stress during, flowering and fruiting compare to the earlier vegetative growth and on the state of maturity; water supply characteristic using in most land evaluation systems were annual rainfall instead of a rainfall during growing cycles particularly for nutmeg plant.

Temperature determine the growth rate and development of the crops. Low temperature caused poor seed growth and reduce flowering and maturity rate. Daily temperature would be affected the photosynthesis rate. Crop C3 photosynthesis pathways occur at optimum level under a low temperature that was 15 – 20 °C while crops C4 occur optimally at temperature of 30 – 35°C. Temperature characteristic used in land evaluation particularly for nutmeg plant was average daily temperature during a year.

Relative air humidity could be considered as one the climatic characteristic. At certain crop development stage a relative air humidity may influence a susceptibility to plant diseases, low air humidity may cause a wrinkles seeds and low yields.

Sunshine along with temperature determine the rate of photosynthesis. Growths processes give an assimilate to the crop which was required for crops development. Crops follow C3 path ways have more lower CO_2 exchange rate require lower maximum rate of photosynthesis and reach light saturation much faster than pathway C4. Therefore, C4 crops produce more biomass rate particularly in areas with high insolation. Insolation characteristic used in land evaluation were actual sunshine hours (n) annually. The effect of climate to crops development of course depend on the kinds of crops and also management and therefore it was not possible to make recommendations standard climate characteristic for all kind of land use. Since development of climatic characteristic requirements need selection of characteristic which will be consider in each type of land use. Particularly for nutmeg plant which was belong to tropical rain forest family which required a hot tropical climate with a high rainfall.

According to author opinion some climatic characteristic related to hot tropical climate namely a maximum temperature, degree day °C to reach maturity and humidity index are not yet take into consideration. Nutmeg plant with a crops cycles (blossoming) until harvest around 10 months need heat accumulation of 7.800 to 8.300 degree days to reach maturity. Total degree days are obtained by total sum of the day for each month time average daily temperature of corresponding month.

Humidity index was precipitation (R)/PET (total evapotranspiration) according to the month where water storage was used, and this were added (amount are used in the corresponding month),; precipitation + used of water storage/PET. Based on humidity index were defined; moist month if humidity index (HI)>1.0, dry

month if HI < 0.5 and moderate/intermediate month if HI 0.5 to 1.0.

B. Relation between individual climatic characteristic and nutmeg plant productivity

Annual rainfall gave different response to nutmeg productivity where the same annual rainfall that is 2.500 mm/year have unequal productivity, that was 5 ton/ha/year (Banda island) and around 1 ton/ha/year (Seram island). While Ambon with annual rainfall of 3.000 mm/year have a nutmeg plant productivity of 3 ton/ha/year.

Average daily temperature annually of more than 27,2°C have a productivity of more than 5 ton/ha/year (Banda island), while at daily temperature of around 26,4 °C have productivity of > 1 ton/ha/year (Seram island) and ± 3 ton/ha/year (Ambon island). Average annual temperature maximum gave good correlation with nutmeg plant productivity with r = 0.786, r= 0,9304, r= 0,7359 respectively for Seram, Ambon and Banda Islands.

Relative air humidity (RH) in respect to productivity of nutmeg plant was showed the lower productivity while RH of less than 83,5% give moderate productivity ± 3 ton/ha/year (Ambon island) and 84% gives the highest yield 5 ton/ha/year (Banda island). Sunshine was also influenced the production level. Correlation analysis indicated that lower sunshine hour (55%) tend to produce a high yield (5 ton/ha/year) with r value respectively for Seram, Ambon and Banda Islands (r= 0,6817, r= 0,8406, r= 0,8452).

Total degree days (°C) annually seem to have relation with nutmeg productivity although Seram and Ambon have a relatively the same total degree days (°C) annually but their productivity quietly differ. A similar trend was given by total degree days (°C) within growing cycle in period II (highest harvest) (r= 0,9195, r=0.7416, r= 0,9733). Humidity index also show a good relation with the nutmeg productivity. The highest humidity index has the lowest productivity (r= 0,7128, r= 0,8597, r= 0,9071)

C. Determination of the climatic requirements for the nutmeg plant

This consist the study of climatic requirements for nutmeg plant. This was done separately for climatic at one hand, landscape and soil at the other and there were of course, different ways to present the requirement data. For our use we have proposed requirement tables for the different combination of an important individual climatic characteristic for nutmeg plant. We should realize that these criteria have been elaborated in a specific agroecological zone namely Banda island and surrounding area where nutmeg plant originated. Production functions which may work adequately in one region may unreliable in others. The class or limitation levels for different characteristic should be adapted to local condition and sometimes to varieties of nutmeg plant. There were 3 combinations of climate characteristics as follows:

1. A combination of twentieth two (22) climatic characteristic which are consist of; 1. Annual rainfall, 2. Rainfall of growing season, 3. temperature maximum, at a). Annual b). growing cycles, c). blooming and fruiting (B +MB) d). seed formation and maturity (BB +MB) e). harvesrt time, 4. Total degree days (°C) a). at annual, b). growing cycles, c). (B +MB) and d). at (BB+MB), 5. Evapotranspiration potential at; a). annually, b). growing cycles, c). (B+MB), d). (BB+MB) and e). harvests and 6. Humidity index; a). annual, b). growing season, c). at (B+MB), d). at (BB+MB) and e). at harvests time (Tabel 2).
2. A combination of eleven (11) Climatic characteristic consist of, 1). rainfall; a). annual, b). Periode I, c). Periode II, d). periode III, 2). Humidity index, 3). Temperature maximum, 4). Degree days (°C), 5). Wind speed 6). relative humidity, 7). Sunshine hours and 8). averare daily temperature (Table 3).
3. A combination of eleven (11) climatic characteristic which include; 1). Rainfall of growing season, 2). Temperature maximum at; a). growing season, b). BB+MB (Periode II), c). harvests time, 3). Degree days°C at; a). growing season, b). B+MB (periode II), c). BB+MB (periode II) d). harvest (periode II) and 4. Humidity index ; a). annually, b). B+MB (periode II) and c). BB+MB (periode II) (Table 4).

The climatic requirements for nutmeg plant were given in Table 2, 3 and 4 as well in Table 5 and 6 (BBSDLP, 2011, 2012). The former had already involved the climatic characteristic which thought to be important on the tropical rain forests with high rainfall conditions and have a good correlation with productivity of nutmeg plant. For each characteristic the tables indicate the class gradients, the limitation levels and the different rating. The rating to be attributed to each characteristic can be calculated by using the equations given in the Table 7.

Various combination of climatic requirements for nutmeg plant are presented in Table 2, 3 and 4 as follow the first combination of climatic requirements (Table 2) used 22 character under 7 climatic characteristics i.e, 1) rainfall, 2) maximum temperature, 3) degree days °C, 4) evapotranspiration potential and 5) humidity index at different time that is growing season, blooming and fruiting (B+MB), seed formation and maturity (BB+MB) and at the harvesting. The second one used six (6) climatic characteristics namely: 1)

rainfall, 2) humidity index, 3) temperature, 4) wind speed, 5) relative humidity and 6) sunshine hours under three different period of time particularly rainfall while the third combination (Table 4) consist of three climatic characteristics were 1) rainfall, 2) temperature and 3) humidity index at different time at growing season, blooming and fruiting seed formation and maturity and at the harvesting.

Table 2. Climatic requirements for nutmeg plant (The 1st combination)

No	Climatic characteristics	Climatic classes, limitation level and rating scale			
		S1	S2	S3	N
		100 95	85 60	40	25 0
1	Annual rainfall	2.000 - 2.500	2.500 - 3.000	3.000 - 3.500	< 1.500
					> 3.500
2	Rainfall of growing season	2.000 - 2.500	2.500 - 3.000	3.000 - 3.500	> 3.500
3	Average maximum temperature	30 - 32	29 - 30		< 29
4	Maximum temperature of growing season	31- 32	30 - 31	28 - 30	< 28
	B+ MB (P2)	> 30	29 - 30	28 - 30	< 28
	BB + MB (P2)	31- 32	28 - 31	< 28	
	harvest (P2)	31- 32	28 - 31	< 28	
5	Days degree (°C)	9.900-10.000	9.600 - 9.900	<9.600	
	Growing season (GS)	8.300 - 8.500	8.000 - 8.300	7.800 - 8.000	< 7.800
	B+ MB (P2)	1.600-1.650	1.580 - 1.600	< 1.580	
	BB + MB (P2)	5.800- 5.900	5.700 - 5.800	< 5.700	
	Harvest (P2)	800-850	750 - 800	< 750	
6	Potential evapotranspiration (PET)				
	Annual	800 -900	500 - 800	< 500	
	Growing seasen (GS)	700 – 750	450 - 700	< 450	
	B+ MB (P2)	140 - 160	70 - 140	< 70	
	BB + MB (P2)	500 - 650	400 - 500	< 400	
	harvest (P2)	80- 90	25 - 80	< 25	
7	Humidity index				
	Annual	2.0 - 3.0	3.0 - 7.0	> 7	
	Growing season (GS)	2.0 - 3.0	3.0 - 7.0	> 7	
	B+ MB (P2)	1 - 2	2 - 5	> 5	
	BB + MB (P2)	2 - 3	3 - 5	> 5	
	Harvest (P2)	4 - 5	5 - 10	10 -13	

Table 3. Climatic requirements for nutmeg plant (The 2nd combination)

No	Climatic Characteristics	Klas Iklim, Tingkat pembatas dan nilai skala			
		S1	S2	S3	N
		100 95	85 60	40	25 0
1	Rainfall annual	2.000 - 2.500	2.500 - 3.500	1.500 -2.000	< 1.500
					> 3.500
2	Growing season				
	Period I	1.900 - 2.200	2.200 - 2.800		< 1.900
					> 2.800
	Period II	1.900 - 2.200	1.600 - 1.900		< 1.600
					> 2.200
	Period III	2.200 - 2.500	2.500 - 2.900		> 2.900
					< 2.200
3	Humidity Index	2.50 - 3.00	3.0 – 7.0	>7	
			<2.5		
4	Maximum Temperature (,sc)	30 - 31	29 - 30		< 29
5	Day degrees (°C)	8.300 - 8.500	7.800 - 8.300		< 7.800
6	Wind Speed (knot)	3.0-4.5	2.0-3.0		< 2.0
			>4.5		
7	Relative Humidity (%)	80 - 85	85 – 90		< 80
					> 100
8	Sunshine (n/N) (%)	50 - 56	56-58		> 58
					<50
9	Average daily temperature (°C)	27 - 28	26 - 27		< 26

Table 4. Climatic requirements for nutmeg plant (The 3rd combination)

No	Karakteristik Iklim	Klas Iklim, Tingkat pembatas dan nilai skala			
		S1	S2	S3	N
		100 95	85 60	40	25 0
1	Annual rainfall growing cycle	2.000 - 2.600	2.600 - 3.000	3.000 - 3.500	> 3.500
2	Maximum temperature growing cycle	30 - 32	30 - 29	28 - 29	< 28
	BB + MB (P2)	30 -32	28 - 31	< 28	
	Harvest (P2)	31- 32	28 - 31	< 28	
3.	Average day (°C) GS	8.300 - 8.500	8.000 - 8.300	7.800 - 8.000	< 7.800
	B+ MB (P2)	1.500 - 1.650	1.650 - 1.700	< 1.500	
				> 1.650	
	BB + MB (P2)	5.000 - 6.000	6.000 - 6.500	< 5.000	
				> 6.500	
	Harvest (P2)	750 - 850	850 -900	< 750	
				> 900	
4.	Humidity Index	2.5 - 4.0	4.0 - 7.0	> 7	
	B+ MB (P2)	1 – 3	3 – 5	> 5	
	BB + MB (P2)	2 – 3	3.5 – 4	> 4	

Table 5. Criteria for the determination of the ratings for the climatic characteristic of nutmeg

Climatic characteristic	Rating (R)
Insolation (n)	If n 50-56 then R = 100 If n 56-58 then R = 85 If n > 58 and <50 then R= 40
Temperature (mean temperature (°C)	If temp 27 - 28 then R= 100 If temp 26 – 27 then R = 85 If temp < 26 then R= 40
Rainfall (total rainfall (mm)	R= 100 (2.000 – 2.500 mm) R= 85 (2.500 – 3.500 mm) R= 40 (1.500 – 2.000 mm) R = 25 <1.500 > 3.500 rain
Relative air Humidity (mean RH (%) pre-ripening)	If RH 2,5 – 4,0 then R = 100 If RH > 7 then R= 60

Table 6. Climatic requirements of nutmeg plant according to BBSDLP (2012)

Climatic Characteristic	Land suitability classes			
	S1	S2	S3	N
Average daily temp. (°C)	25 – 30	18 – 24		< 18
		31 – 34		34
Annual rainfall (mm)				
	2000-4.500	1.800-2.000		<1.800
		4.500-4.800		
Relative humidity (%)	≤75	>75		
Dry month (months)	none	1 – 2		>2

Source: Lubis, 1992

Table 7. Climatic requirements of nutmeg according to BBSDL (2013)

Climatic characteristic	Land suitability classes			
	S1	S2	S3	N
Daily temperature	23 – 32	20 – 23		>34
		>32 – 34		<20
Annual rainfall (mm)	2000-2.500	2.500-3.000	3.000-4.000	<1.500
			1.500-2.000	>4.000
Relative Humidity (%)	60 -80			<50
				>100
Dry month (months)	< 2	<3	3-4	>5

Source: Wahid and Ujang, 1986

Table 8. Rating of the individual climatic characteristics of the studied area and thein climatic suitability classes.

No	Climatic Characteristics	Seram Island		Ambon Island		Banda Island	
		Climatic value	Scale value	Climatic value	Scale value	Climatic Value	Scale Value
1	Annual rainfall	2,464.33	95.94	3,077.75	56.89	2,406.56	95.94
2	Rainfall of growing season	2,060.64	99.39	2,585.85	80.71	2,049.93	99.5
3	Maximum temp. annual	29.93	84.13	30.01	99.98	31.01	97.48
4	Maximum temp. growing season	29.72	78	30.06	83.5	31.05	99.75
	B+ MB (P2)	29.12	82	29.55	71.25	29.95	61.25
	BB + MB (P2)	28.93	77.25	30.94	60.5	31.53	97.35
	Harvest (P2)	28.51	80.75	28.70	79.17	31.30	98.5
5	Annual Average day degree (°C)	9,626.92	72.76	9,647.93	81.01	9,969.09	96.55
	B+ MB (P2)	1,574.17	82.25	1,583.47	80.7	1,605.83	99.42
	BB + MB (P2)	5,751.31	72.18	5,742.86	74.29	5,896.39	95.19
	Harvest (P2)	762.60	78.7	769.20	84.04	806.93	99.32
6	Potential evapotranspiration	542.25	81.48	949.85	80.85	890.82	95.46
	Growing season (GS)	454.59	84.54	795.67	99.04	742.26	99.58
	B+ MB (P2)	71.78	84.37	158.32	95.45	142.21	99.45
	BB + MB (P2)	402.70	84.33	613.95	96.21	532.06	99.68
	Harvest (P2)	29.14	83.12	60.41	68.9	80.41	99.8
7	Annual Humidity index	6.76	61.5	3.7	80.63	2.74	96.3
	Growing season (GS)	6.04	66.00	3.91	79.31	2.78	96.1
	B+ MB (P2)	4.81	61.58	2.15	83.75	1.15	99.25
	BB + MB (P2)	3.55	78.13	2.68	96.6	2.99	95.05

Table 9. Rating of the individual climatic characteristic in studied area and thein climatic suitability classes

No	Climatic characteristics	Seram Island		Ambon Island		Banda Island	
		Climatic value	Scale value	Nilai Iklim	Nilai Skala	Nilai Iklim	Nilai Skala
1	Annual rainfall	2,464.33	95.36	3,077.75	84.99	2,406.56	95.94
2	Rainfall of Growing cycle						
	Season I	2,207.00	84.71	2,747.48	84.98	1,984.36	98.6
	Season II	1,720.00	75	2,142.46	99.04	1,947.64	99.21
	Season III	2,253.00	99.12	2,867.61	62.03	2,217.80	99.7
3	Humidity Index (HI)	6.04	66	3.91	79.31	2.79	97.2
4	Maximum Temp (₀c)	29.93	61.75	30.06	99.7	31.05	99.38
5	Average days degree (°C)	8,035.00	73.25	7,804.26	84.79	8,332.08	99.2
6	Wind speed (knot)	2.14	81.5	4.24	95.87	4.49	95.1
7	Relative humidity (%)	85.03	84.25	83.29	96.71	83.91	96.09
8	Sun shine (n/N)	57.76	63	56.30	81.25	55.06	96.39
9	Average temp. (°C)	26.38	75.5	26.40	75	27.32	98.4
	Climatic Index (Ic)		**19.01**		**32.28**		**85.96**

Table 10. Rating of the individual climatic characteristic of the studied area and their climatic suitability classes

No	Climatic Characteristics	Seram Island		Ambon Island		Banda Island	
		Climatic Value	Scale Value	Climatic Value	Scale Value	Climatic Value	Scale Value
1	Rainfall Growing season.	2,060.64	99.5	2,585.85	95.12	2,049.93	99.59
2	Maximum temp. of growing season	29.72	67	30.06	99.85	31.05	97.38
	BB + MB (P2)	28.93	77.25	30.94	97.65	31.53	96.18
	Harvest (P2)	28.51	80.75	28.70	79.17	31.30	98.5
3	Degree days °C B+ MB (P2)	1,574.17	97.53	1,583.47	97.22	1,605.83	96.47
	BB + MB (P2)	5,751.31	96.25	5,742.86	96.29	5,896.39	95.52
	Harvest (P2)	762.60	99.37	769.20	99.04	806.93	97.16
4	Annual Humidity Index	6.76	62.00	3.7	96	2.74	99.2
	B+ MB (P2)	4.81	62.38	2.15	97.13	1.15	99.63
	BB + MB (P2)	3.55	82.5	2.68	96.6	2.99	95.05
	Climatic Index (Ic)		27,70		59.47		85.70
	Suitability class		**S3**		**S2**		**S3**

The third combination of climatic characteristics (Table 4) involve only the three (3) major climatic characteristics namely 1) rainfall (1), 2) temperature (6), and 3) humidity index. Then each climatic characteristics of the area studied were rated by comparing climatic requirements as listed in Table 4. The rated of each climatic characteristics and the value of climatic index were shown on Table 1. The climatic index were 27,70; 59,47 and 85,70 for Seram, Ambon and Banda respectively and their climatic suitability classes were marginally suitable (S3), moderately suitable (S2) and highly suitable (S1) for Seram, Ambon and Banda respectively.

Table 11. Climatic index of studied area using different combination of climatic characteristics

Area of study	Combination		
	1	2	3
1. Seram	3.64	19.01	27.70
2. Ambon	14.03	32.28	59.47
3. Banda	49.23	85.96	85.70

Table 13 show that the suggest value of climatic index of the studied areas given by climatic characteristic under combination there (3) which use the smallest under of climatic characteristics i.e. rainfall, temperature, days degree °C and humidity index which involve only ten (10) characters; annually, season, B+MB, BB+MB, and harvest time. The successful application of parametric approach implies the respect of following node:

1. The number of land/climatic

The number of land /climatic characteristics to under than to be reduced to a strict minimum to avoid repetition of related characteristics in the formula lead

to a depression of the climatic/land index. There fine all climatic/land characteristics by one characteristics land can be rate together.

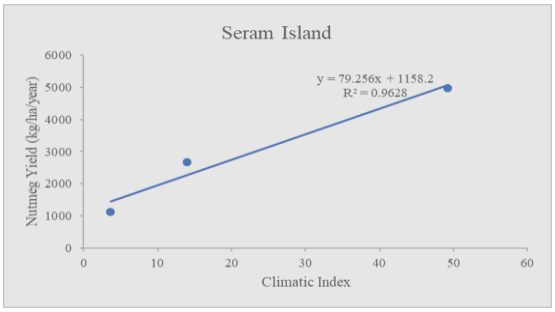
2. Limitation approach

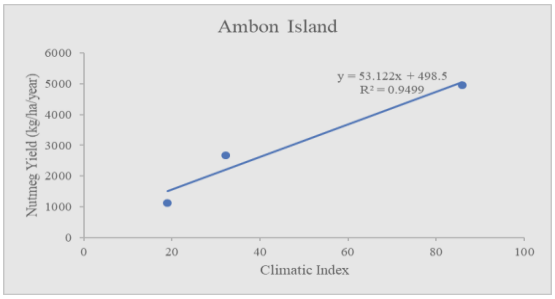
Evaluation of climatic characteristic by compared the data in Table 8 and 9 using the limitation method. Temperature, annual rainfall, relative humidity and number of dry month of the area studied was related in table 8. Seram was evaluated as moderately suitable (S2), Ambon as moderately suitable (S2) and Banda very suitable (S1) and based on climatic requirements listed in table 9, Seram and Ambon was evaluated as a moderately suitable (S2) while Banda was very suitable (S1).

D. Relation between climatic index and nutmeg productivity

1. Parametric approach

Correlation between climatic index and productivity of nutmeg plant depend on the climatic characteristic used i.e. kind and number of climatic characteristic and the period either annually or periodically (growing season). The strong correlation between climatic index and nutmeg productivity were obtained by combination of climatic requirements of nutmeg plant showed in the Fig.2 where the climatic characteristics used at the growing cycle; are rainfall, temperature maximum, degree days and humidity index. Except rainfall the latter characteristic also required at the bean formation and bean maturity as well as at the harvest time.





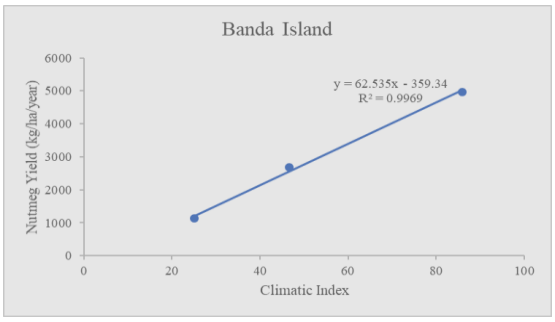


Fig. 2 (a , b, c). The correlation between climatic index with nutmeg yield at Seram Island (a); Ambon Island (b) and Banda Island (c).

2. Limitation approach

Using climatic requirements given by BBSDLP (2011, 2012) as proposed by Wahid and Ujang (1986) and Lubis (1992) it was showed that climatic suitability classes of the studied are were not correspond with the productivity of nutmeg plant. Seram and Ambon which classed as moderately suitable in respect of climatic suitability have different nutmeg plant productivity.

IV.CONCLUSIONS

1. The climatic characteristics which important to the productivity of Nutmeg plant were rainfall, maximum temperature degree days and humidity index.
2. The time of climatic data we called it was climatic attributes for nutmeg productivity were at the growing season, blooming, bean formation and maturity and the harvest time.
3. The smallest number of climatic characteristics considered in calculation of climate index tends to give highest climatic index.

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