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LOCALIZATION OF AREAS TO MAXIMIZE PRODUCTION OF RAMBUTAN, *Nephelium lappaceum* (Linn.) IN THE PHILIPPINES USING CLIMATIC FACTORS

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Abstract: Fruit production has an important part in the Philippine's food sector amidst the changing climate. Rambutan is regarded as one of the climate resilient fruit trees in the tropics but currently underutilized in the country. The objective of the study is to determine areas where rambutan production can be maximized using agro-climatic factors. The relationship of these factors to current production was examined. Actual datasets for mean temperature, relative humidity, amount of rainfall were processed using GIS along with land use and elevation to produce a suitability model for rambutan production at the country level. Selection criteria for areas were based on standard requirements of rambutan production from published data. Results showed that there are other highly suitable areas for rambutan production other than Region IV-A. Farmer cooperatives and concerned policy makers can utilize results from the study as baseline to improve horticultural decision making on rambutan production.

Keywords: *Nephelium lappaceum* (Linn.), fruit production, climatic factors, yield, suitability

Introduction

Rambutan (*Nephelium lappaceum Linn.*) is a seasonal fruit that has an interesting taste and color and is available in many tropical Asian countries. In these countries the rambutan fruit is planted both for household and commercial purposes. This fruit-bearing tree is widely cultivated in Thailand Malaysia, and even in the Philippines. Among these, Thailand is considered as the largest rambutan producer. In the Philippines, rambutan flowers at the end of March to early May and yields mature fruit from August to October. The ripe fruit is harvested and immediately transported to local markets within three days to maintain quality

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and freshness. Rambutan production in the country varies from year to year. For each season within a year, a rambutan tree which is 8 years or older can produce about 200 kilograms. Rambutan as a tropical fruit thrives in humid and hot regions with uniform rainfall throughout the year. It is produced in areas with significant dry seasons when irrigated during the reproductive stage. On the other hand, rambutan cannot survive cold temperatures and can grow in areas below 700 m above sea level. There have been evidences that seasonal production of rambutan is highly influenced by climatic factors such as amount of rainfall, relative humidity (RH) and temperature. Landrigan et al (1996) stated that, at high RH, infiltration with water, but not with the enzyme inhibitors, salicyl hydroxamic acid and catalase, led to a large increase in browning. Meanwhile, Diczbalis (1997) showed that relative temperature influences rambutan production particularly its germination. This was later corroborated with the research of Andrade (2018) which demonstrated that temperature is an important factor affecting germination because it affects metabolic reactions. Found that the optimal temperature for germination was at 25°C. Currently rambutan is considered as underutilized fruit in the Philippines due to less attention given and efforts for its maximized production along with bayabas (*Psidium guajava*), atis (*Annona squamosa*), kaimito (*Chrysophyllum cainito*), chico (*Manilkara zapota*), guyabano (*Annona muricata*), duhat (*Syzygium cumini*) (Wagan et al., 2009). Hence, this study was conducted to assess the influence of these climatic factors on the seasonal production of rambutan. It specifically aimed to determine which climatic factors mostly affect its production, study the relationship of production to climatic and other related factors using statistical methods and produce a suitability model for production of rambutan in the Philippines using geospatial techniques.

Methodology

Data Sources

Monthly data for precipitation, relative humidity, and temperature for 20 years period (1998-2020) were obtained from Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and data on seasonal production of rambutan (i.e. in metric tons and number of trees) was acquired from the Philippine Statistics Authority (PSA). Most recent raster dataset for 2010 Philippine land use and Digital Elevation Model (DEM) were obtained from National Mapping and Resource Information Authority (NAMRIA) and PhilGIS respectively. Vector datasets of administrative map were also obtained from PhilGIS.

Statistical Analyses

a. Correlation Analysis

Pearson correlation is a technique used to describe the relationship between two variables in a linear fashion (Pallant, 2001). In this study, Pearson correlation was used to describe the strength and direction of the linear relationship between each of the independent and dependent variables. The range of value for correlation coefficient is from -1 to +1. The value of -1 means that the two variables have perfect negative correlation. The negative sign refers to direction and the value $r = 1$ indicates the perfect strength of the relationship between two variables (Pallant, 2007). Climatic and rambutan production data (i.e. yield in tons and number of fruit-bearing trees) for Region IV-A CALABARZON within a 20 year-period was used for this analysis since this region has most complete datasets. Climatic factors for this region were obtained from PAGASA's five (5) synoptic stations namely Ambulong, Alabat, Infanta, Tayabas, and Sangley. All correlation analyses were done using IBM SPSS Statistics 23.

b. Time-Series Analysis

Time series analysis has several goals: for forecasting and modelling the behaviour of the series, indicate characteristics of observations, and control the possible projections of the series (Kendall, 1973). In this study, descriptive time series analysis is concerned with seasonal elements, particularly the tendency for commodity i.e. rambutan to fluctuate along with climatic factors (*viz*. amount of rainfall, temperature, and relative humidity). Data sets for CALABARZON region was also used to further elucidate pattern and relationship among variables. Data analysis and visualization to study trends among the different variables were done in IBM SPSS 23.

c. Suitability Modelling

Geographic Information System (GIS) implementation in the current study was done in three phases namely: (1) GIS Encoding and Processing (GEP) where data input, digitization , and georeferencing were done; (2) GIS Analysis and Modelling (GAM) where analysis was done; (3) GIS Output and Display (GOD) where the output maps were produced (Bantayan et al., 2015)). Data used for this analysis covered all regions in the Philippines. For the climatic data, a total of fifty-six (56) existing synoptic stations around the country were considered. Both, climatic and rambutan production data were converted as point datasets. Point data were interpolated using inverse distance weighted (IDW) technique to produce raster surface. After, rasterization all data layers (i.e DEM, precipitation, temperature and relative humidity) were reclassified using Spatial Analyst Tool in ArcMap 10.4 and then used for the weighted overlay using Map Algebra. Percentage influence of each parameter was determined based on baseline data from the literature to produce the desired weights (Table 1).

Table 1. Criteria and weight assignments for suitability modelling using climatic factors.

Criteria	Consideration	Weight Assignment
Elevation	500- 700m asl *	0.35
Temperature	22-30 ^{O}C**	0.15
Amount of Rainfall	120-300 mm*	0.35
Relative Humidity	70- 80 % *	0.15

*Magdalita and Saludes, 2015; ** Bureau of Plant Industry, Philippines

Results and Discussions

The data used for correlation and regression analyses were for CALABARZON region only since it has the most complete dataset from the PSA in terms of rambutan production. For the time-series analysis only 20-year period (1998-2018) was used. Meanwhile study considers only climatic factors, elevation, and current land use to determine the most suitable areas for rambutan production at the country level. These climatic factors specifically include amount of mean rainfall, temperature, and relative humidity during on-season that is from the months of March to November.

Table 2. Data Sets of Climatic Factors, and Fruit Rambutan Fruit and Tree numbers from Region IV-A CALABARZON (1999-2018).

	Yield (Ton)	# of TREES	TEMP (Celcius)	RAIN (mm)	RH
1999	527.46	455015	26.75	315.27	85.66
2000	9560.31	236468	26.92	312.38	86.00
2001	10514.9	241090	27.10	247.28	84.86
2002	7319.78	223325	27.05	232.20	84.80
2003	6991.15	214125	27.02	177.17	83.26
2004	5718.18	214075	26.93	197.30	84.05
2005	7516.87	215805	26.92	243.03	84.98
2006	7495.05	221333	27.26	235.14	85.17
2007	6220.96	166710	27.07	190.51	85.31
2008	4419.39	169640	27.09	272.96	85.52
2009	4168.13	169690	26.90	267.68	84.96
2010	4384.35	170308	27.08	201.07	85.08
2011	2699.84	170808	27.08	277.93	84.14
2012	2774.69	171608	27.27	277.67	84.00
2013	2925.64	173280	26.87	275.34	85.24
2014	1588.58	173530	26.65	219.65	84.11
2015	1617.99	87735	27.18	180.44	83.51
2016	1784.71	94635	27.43	234.73	84.89
2017	2123.14	95680	27.05	302.11	85.66
2018	2217.07	96180	27.30	222.54	83.83

Table 3. Test for Normality for the Data Sets (Shapiro-Wilk Test)

Shapiro-Wilk	Statistic	df	Sig.
YIELD	0.925	20	0.123
TREES	0.789	20	0.001
TEMP	0.939	20	0.232
RAINFALL	0.956	20	0.473
HUMIDITY	0.948	20	0.335

Data for all climatic variables and yield were not normally distributed as indicated by the computed values (0.232, 0.473, 0.335 and 0.123) (Table 3). Only number of trees showed normal distribution with significant value of 0.001. Based on this results, Spearman's rank method, a non-parametric test was used to correlate these variables.

a. Correlation Analysis

Table 4. Correlation of rambutan yield and number of trees to climatic factors.

	TEMP	RAINFALL	YIELD	TREES	HUMIDITY
YIELD	-0.1	0.084	1	.752**	0.373
TREES	-.448*	0.262	.752**	1	0.188

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Table 4, summarizes the correlation results of climatic data to yield for 20-year period. Results showed that only the number of trees was negatively correlated (r = -0.448) to one of the climatic factors, temperature, at 95% confidence level (p-value < 0.05). No significant relationship can be drawn from the correlation of rainfall or humidity with the rambutan yield and number of trees (r = 0.084 and 0.377 for yield and, 0.262 and 0.118 for number of trees, respectively).

Nakasone and Paul (1998) stated that rambutan trees are highly adaptable to temperature ranging from a threshold of 22-30°C. As seen in Table 4, a steady increase of average annual temperature is observed through the span of 20 years within Region IV-A. Despite the correlation of the number of rambutan trees to annual temperature, it slowly diminished from 1998 to 2018 which also affected annual yield. This means that other factors may have interplayed with rambutan production in this region. Based on the data from PSA, Region IV-A had the highest annual production of rambutan in the country. As seen in Table 5, there were correlations among the climatic factors specifically between temperature and rainfall and between relative humidity and rainfall. These correlations might indirectly affected seasonal fruit production.

Table 5. Correlation matrix of climatic factors.

	TEMP	RAINFALL	HUMIDITY
TEMP	1	-.530**	-0.233
RAINFALL	-.530**	1	.558**
HUMIDITY	-0.233	.558**	1

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Table 5, shows that temperature and rainfall are negatively correlated (r = -0.530) at 99% confidence level (α = 0.01). This means that an increase in rainfall resulted to a decrease in temperature, and vice versa. In contrast, humidity was positively correlated with rainfall (r =0.558; α = 0.01), which shows that these two factors have a direct relationship. Valmayor et al., (1970) stated that rainfall is necessary for the vegetative growth of the rambutan, especially in the tropical climate wherein monsoons develop. This hypothesis was also confirmed by Magdalita (2015) stating that the interrelationship of climatic factors may provide an indirect part of determining the growth of rambutan trees and inevitably its yield.

b. Time Series Analysis

Figure 1 shows that at present there is highly variable climatic conditions within the span of 20 years, in Region IV-A.

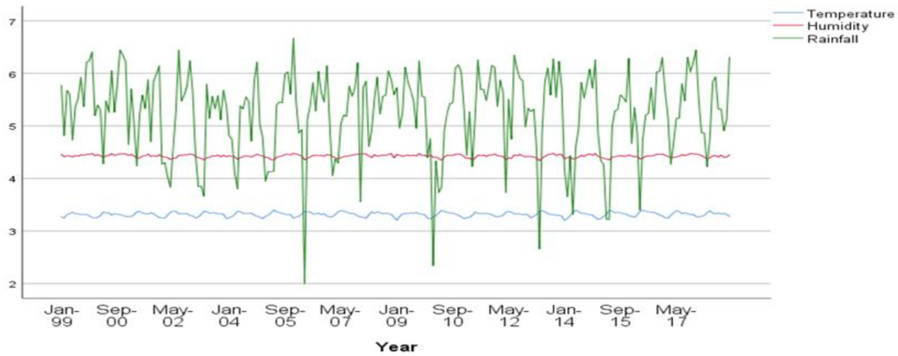

Figure 1. Average climatic conditions in CALABARZON (1999-2018).

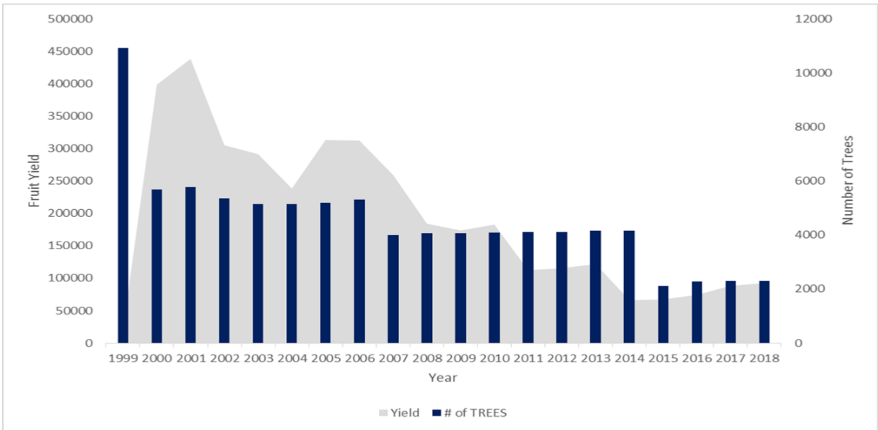

Figure 2. Plot of average rambutan yield and number of mature fruit trees planted (1999-2020).

Direct relationship between yield and the number of trees is apparent as fruit bearing trees would result to more annual production. Figure 2, depicts the graph of fruit yield and number of trees from 1999-2018 in CALABARZON. However, an observable outlier can be seen in the 1999 as the least fruit yield had been recorded during this year amidst low average temperature, and consequently high average humidity. This could probably due to the very strong La Niña of 1998 or 1999 wherein great intensities of rainfall was recorded (Jaranilla-Sanchez, et al., 2010). As discussed by Tindall et al., (1994), rain is essential for the growth of the rambutan but may hinder flowering of the tree. Valmayor et al., (1970) also concluded that rainfall controls the yield of production of rambutan. They posited that wet season leaf growth is observed in rambutan, but it requires minimal rain from the dry season to flower.

Moreover, Joo-Pérez et al., (2016), showed that extreme stress may hinder flowering of the rambutan fruit for a period of time but will recover for the following year due to the rambutan alternancy. Alternancy is a phenomenon seen among species woody fruit trees that enables them to produce high number of yield after a period of low fruit yield (Joo-Pérez et al., 2016). This means that stress may induce some changes among the yielding of rambutan. In Figure 3, mean fruit yield was plotted with the annual climatic conditions of across all regions in the Philippines. It can be seen that the variable climatic factors may have induced observable changes within the trends of annual fruit yield. This is especially true with the condition of the year 1999, wherein extreme stress caused by the La Niña may have caused fluctuations and the development of alternancy within the rambutan fruits.

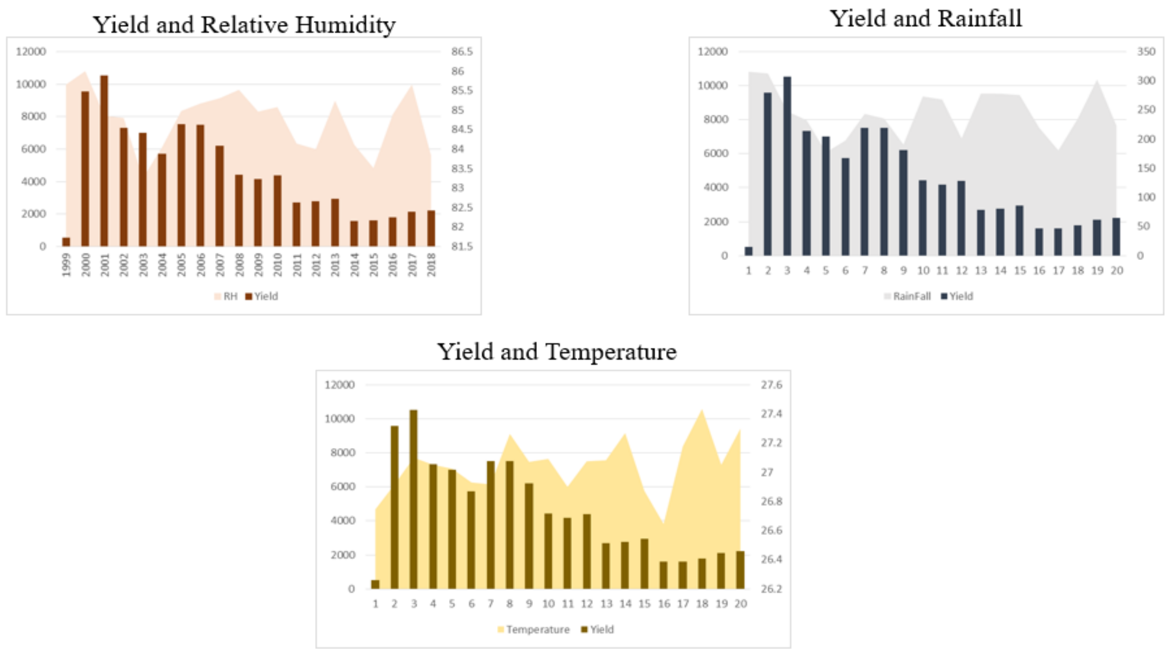

Figure 3. Plots of Climatic Conditions and Rambutan Yield (1999-2018)

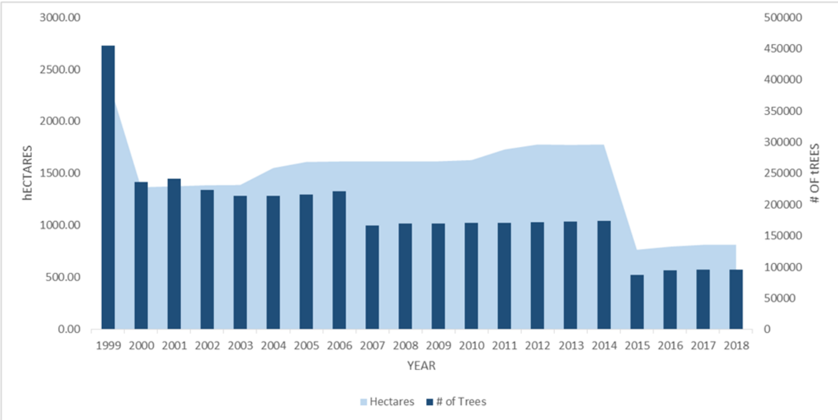

Figure 4. Plot of number of rambutan trees and total area planted (1999-2018).

Figure 4, depicts the trend of rambutan tree number to the total area planted within the Region IV-A. A decreasing trend among the total area planted for rambutan was observed. Diminishing land use for agricultural planting of rambutan might have also caused the steadily decreasing number of rambutan trees planted in this region.

c. Suitability Modelling

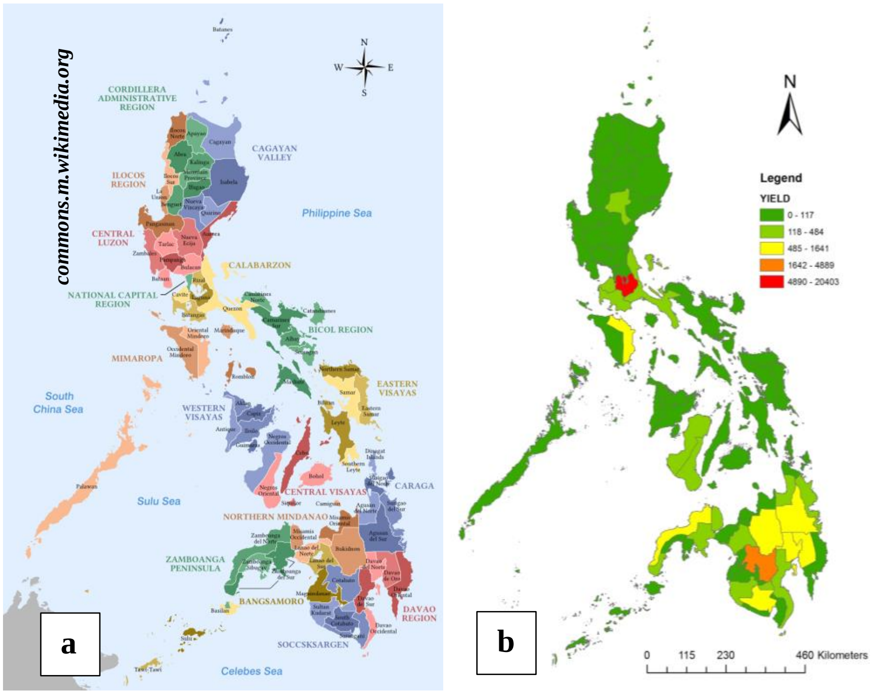

Figure 5. Current average of yield (in metric tons) in the Philippines (1990-2018). (a) administrative map and (b) rambutan yield per area.

Similar with the other countries in Southeast Asia, rambutan is seasonally produced in the Philippines. Based on the data from PSA, provinces such as Laguna and Batangas in Region IV-A (CALABARZON) had the highest mean annual yield of rambutan from 4,890 to as high as 20, 403 metric tons (mt) (Figure 5b). The province of Cotabato is the second largest producer of rambutan with average annual yield ranging from 1,642 to 4,889 mt. In the provinces of Bukidnon, Agusan del Sur, Agusan del Norte, Davao Oriental, Compostela Valley and Zamboanga del Norte in Mindanao the mean annual yield was from around 485 to 1641mt. Mean production data for more than 20 years only showed that rambutan is sparsely grown in many areas in the country where it is assumed that this fruit tree can be widely grown in the whole country given the tropical weather conditions.

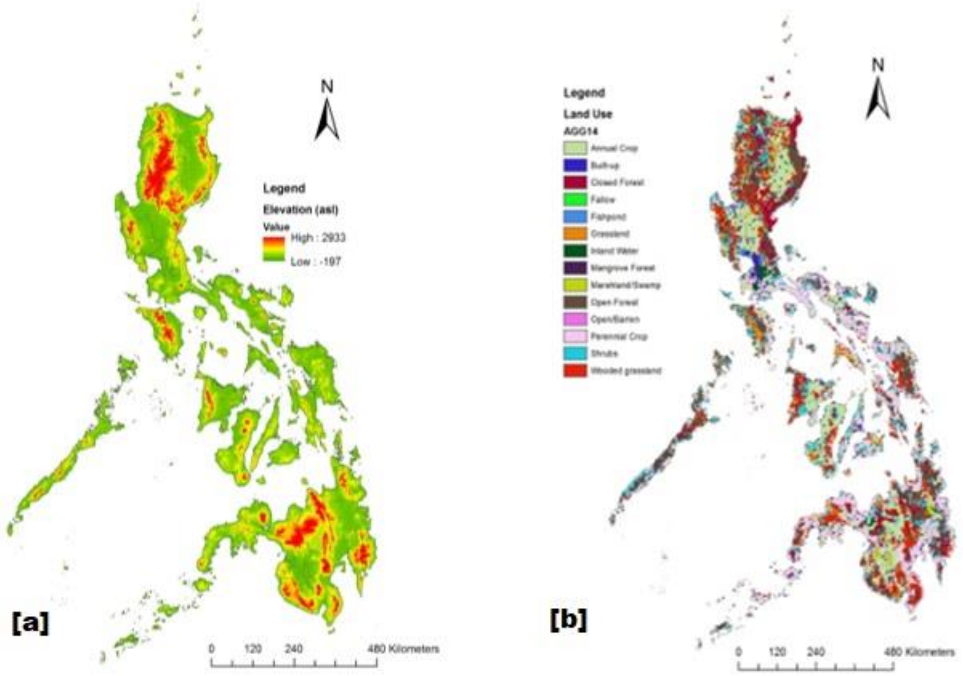

Figure 6. Altitude distribution map (a) and land use map of the Philippines (b).

Altitude is a major consideration in crop suitability studies due to its large contribution to climate-related factors such as precipitation and temperature and it can also influence biodiversity especially of pollinator species which are critical to fruit production. Production of rambutan in areas which are highly elevated such as in some parts of Cordillera region, Zambales, some parts of Quezon and Bicol are expected to be low or nil. It is also given that there is an inverse relationship between altitude and temperature, that is the higher the area the lower the temperature will be, and hence less likely for production of tropical fruit species like rambutan. Figure 6a shows the altitude distribution of the Philippines and the areas above 700 meters above sea level which are unsuitable for rambutan.

Figure 6b shows the current land use in the Philippines. There were a total of 14 types of land use identified in the country. Being in the tropics, forested areas form the largest portion of land use in the country which includes closed forest, open forest and mangrove forest. Among these three forest landscapes, open forest is the most likely suitable area for production of rambutan. Meanwhile areas for annual crops (e.g. rice) were definitely considered unsuitable for rambutan. Some of the landscapes also considered for the suitability mapping were areas in grassland, perennial crop, open-barren area, shrubs and wooded grasslands.

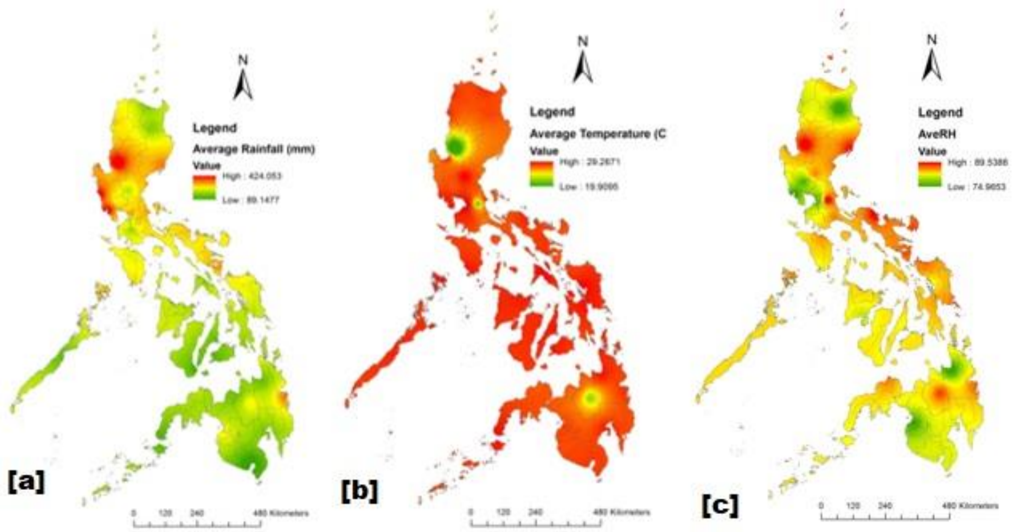

Figure 7. Climatic factors used for suitability mapping: average mean distribution of amount of rainfall (a), relative humidity (b) and temperature (c) in the months of March to November (1990-2018).

As shown in Figure 7 there is variability in terms of the different climatic factors namely amount of rainfall, relative humidity and temperature varies in the different in the Philippines. This variability can affect the production of any fruit species either for those commercially grown or not. Based on the 20-year interpolated point data used in the current study the highest average annual rainfall is around 424.53 mm while the lowest is at 89.14 mm. From the same dataset, the highest mean annual temperature is 29.27 ^{o}C while lowest at 19.91 ^{o}C. In relation with, for relative humidity was at the highest at 89.54% and least at 74.97 %. The average temperature which is favorable to rambutan is at around 22-30 ^{o}C. At low temperature at around 15 ^{o}C, the rambutan tree has been reported to manifest leaf burn and leaf drop which usually cause delays in the flowering and fruit set (Diczbalis, 1997).

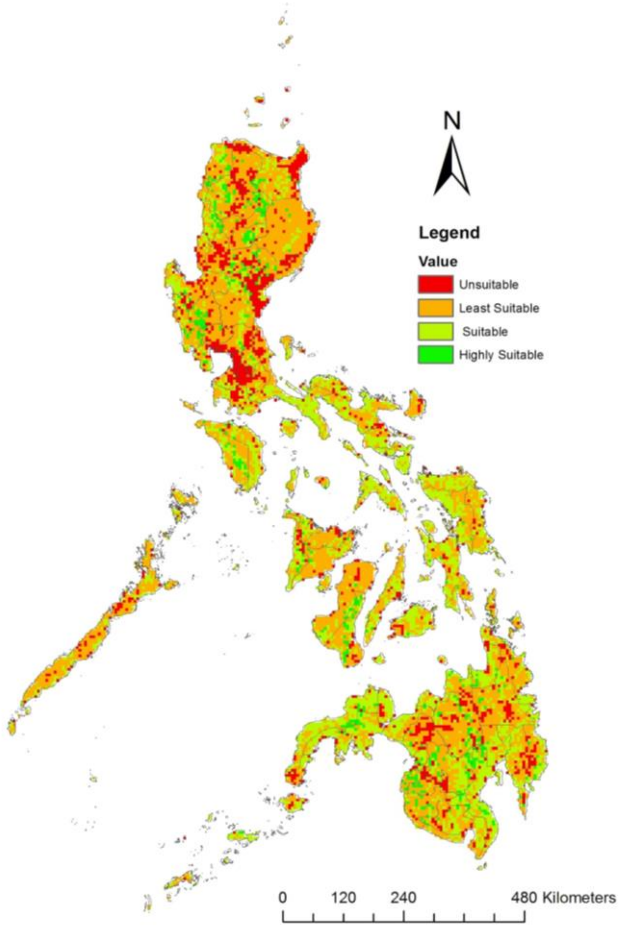

Figure 8. Suitability map for production of rambutan in the Philippines.

Largest part of the Philippines with a total land area of 294,554 square kilometers has been devoted to agricultural production (Ragrario, 2003) and a part of it is fruit production. By overlaying the different thematic maps for the parameters considered for rambutan production, a final thematic map presented herein as Figure 8 was produced using GIS. From GIS analysis, in terms of rambutan suitability using climatic factors, there were four classifications namely unsuitable, least suitable, suitable and highly suitable. In the map it was shown that apart from CALABARZON and other average producing provinces of rambutan, there are also other areas identified which are highly suitable for rambutan. These areas are in selected parts of the Ilocos region, Negros Oriental, Negros Occidental, Davao and Zamboanga among others (Figure 8). This is in agreement with agro-edaphic suitability model generated in Western Visayas region for rambutan in combination with other crops including marang, lanzones, avocado and rubber by the Department's Agriculture Regional Field Office 6 (Western Visayas) in 2016; wherein the provinces of Iloilo, Aklan, Antique and Negros Occidental were identified as highly suitable (S4). Meanwhile various suitable areas were found in other provinces in Luzon, Visayas and Mindanao. The highly suitable and suitable areas were mainly identified based on the climatic factors and can be recommended for maximized production to fruit farmers. In Indonesia, Hamdan and Rahman (2015) conducted land suitability on fruit crops in Mukomuko District, Bengkulu Province which included rambutan. Their results showed that suitability of land for fruit crops can be classified according to altitude and the limiting factors were water and oxygen availability, nutrient retention, erosion hazard and temperature. Limsawad et al. (2015) conducted a similar study in Chantaburi Province in Thailand wherein zoning for rambutan was done using Geoinformatics, a mixture of GIS, remote sensing and global positioning system. These authors used their suitability model to illustrate the potential level for rambutan production zoning and divided it into 2 levels including production potential area level 1 and production potential area level 2. The same technique was used in the current study except that economic parameters were not included in coming up with the model to identify prospective sites of rambutan production. Nevertheless, these studies corroborate that climate-related factors can strongly influence zoning fruit crops in a particular agro-ecosystem. Selection of the appropriate farming system and thereby areas is very important in order to attain high production and maintain good quality of fruit trees, (Dixon, et al., 2001).

Conclusion

Based on the results of the study it was shown that only rambutan trees and temperature (r = -.0048) have correlation, but the other climatic factors have significant correlation with one another and may indirectly affect rambutan trees and yield. Furthermore the data showed that high variability in climate factors may influence its production. There are other highly suitable areas for rambutan production other than Region IV-A based on the suitability map produced. These include selected areas such as Ilocos region, Negros Oriental, Negros Occidental, Davao and Zamboanga. With extensive considerations other than climatic factors such as edaphic characteristics, varietal adaptation, detailed landscape characteristics, farmer cooperatives and policy makers can utilize the data generated in the study as baseline to improve decision making on rambutan production. However, more comprehensive data is needed to improve zoning for rambutan production in the Philippines.

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References

[1] Andrade, Renata & Bagatim, Amanda & Nacata, Guilherm. (2018). Rambutan seed germination: temperature and storage. *Comunicata Scientiae*. 8. 383-388.

[2] Bantayan, Nathaniel C., E.A. Combalicer, C.L. Tiburan, Jr., L.D. Barua, and J.J. V. Dida. GIS in the Philippines: Principles and Applications in Forestry and Natural Resources Second Edition. ISBN 978-971-547-318-7 UPLB 168 pp. 45-46.

[3] Diczbalis, Yan. & Menzel, C.M. & Eamus, Derek. (1997). Environmental factors influencing the growth and yield of rambutan and cupuacu. Northern Territory, Department of Primary Industry and Fisheries. & Rural Industries Research and Development Corporation (Australia)

[4] Dixon J., Glulliver A. and Gibbon D. (2001). Farming system and Poverty – Improvement of Farmer's livelihood in changing world – FAO and Word Bank, Rome, Italy, Principle Editor Malcolm Hall.

[5] Department of Agriculture- Regional Field Office 6- Western Visayas, Philippines. (2016). Retrieved from: rfu6.da.gov.ph/suitability

[6] Forest Management Bureau –Department of Environment and Natural Resources. 2006. Philippine Official Reference of Forest-related Terms and Definitions.

[7] Jaranilla-Sanchez, P. A., Wang, L. and Koike, T. (2010). ENSO Influence on the 1982-2000 Hydrological Properties of the Pantabangan-Carranglan Watershed. *Annual Journal of Hydraulic Engineering, JSCE*, *54*.

[8] Joo-Pérez, R., Avendaño-Arrazate, C.H., Sandoval-Esquivez, A., Espinoza-Zaragoza, S., Alonso-Báez, M., Moreno-Martínez, J.L. and Morales-Nieto, C.R. (2016). Alternancy study on Rambutan (*Nephelium lappaceum* L.) tree in Mexico. *American Journal of Plant Sciences*, *8*(1), 40-52.

[9] Kendall, M. (1973). Time Series. London: Griffin.

[10] Landrigan, Margaret & Morris, Stephen & McGlasson, Barry. (1996). Postharvest Browning of Rambutan is a Consequence of Water Loss. *Journal of the American Society for Horticultural Science*.121. 10.21273/JASHS.121.4.730.

[11] Li T, Zhaoquan G, Fang J, Wang P and Fan J. (2018). Agroclimatic zoning of fresh fruit growing areas in Beijing using GIS technology. *Bangladesh J. Bot.* 47(3): 581-590

[12] Limsawad Y, Babpraserth C., Taychasinpitak T.and Kingpaiboon S. (2015). Zoning for rambutan using geo-informatics in Chanthaburi Province, Thailand. *American Journal of Agricultural Science, Engineering and Technology*. 1(3): 18-29

[13] Magdalita, P.M., & Saludes, R.B. (2015). Influence of Changing Rainfall Patterns on the Yield of Rambutan (*Nephelium lappaceum* L.) and Selection of Genotypes in Known Drought-tolerant Fruit Species for Climate Change Adaptation. *Science Diliman*, *27*(1).

[14] Malhotra, N.K., & Dash, S. (2011). Marketing Research an Applied Orientation. London Pearson Publishing.

[15] Morton, J. (1987). Rambutan. p. 262–265. In: Fruits of warm climates., Miami, Florida, USA.

[16] Nakasone, H. Y. RE-Paul. (1998). Tropical fruits. CAB International, Wallingford, UK.

[17] PhilGIS. (2019). Retrieved from https://www.philgis.org/.

[18] Ragragio J.M. (2003). The case of Metro Manila, Philippines Understanding Slums: Case Studies for the Global Report on Human Settlements

[19] Rahman H. and T. Rahman (2015). Land Suitability for Horticultural (Fruit) Crops Development in Mukomuko District, Bengkulu Province. Proceeding of International Seminar on Promoting Local Resources for Food and Health, 12-13 October, 2015: 259-264. Bengkulu Indonesia.

[20] Tindail, H.D. (1994). Rambutan Cultivation. In: FAO Plant Production and Protection Paper. Vol. 121. Rome, 1994.

[21] Valmayor, R.V., Mendoza, D.B., Aycardo, H.B., & Palencia, C.O. (1970). Growth and flowering habits, floral biology and yield of rambutan (*Nephelium lappaceum* Linn.). *Philippine Agr*.

[22] Whiteley, P. (1980). Time series analysis. *Quality and Quantity*, 14(1), 225–247.

[23] Wagan, A.M. Medina, C.M. Tamisin, L.L. Jr. (2009). Underutilized crops: their importance in the sustainable management of the agricultural landscape of Laguna province, Philippines. *Journal of International Society for Southeast Asian Agricultural Sciences [ISSAAS]*.