Parameter: The Area of Microclimate Gradient Diurnal Dynamic for Characterization and Monitoring of Forest Ecosystem and Environment

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Abstract—Microclimate forests are usually described by the parameters: quantity of microclimate differences of interior-exterior, the depth of the effect of edge and gradient. These parameters can characterize ecosystem conditions but their quantities are often inconsistent and thus less valid for monitoring ecosystem and adjacent environmental changes.This paper introduces the concepts, methods,

and the results of the application of the parameters: the area of microclimate gradiet diurnal dynamic which the advantage in: (1) characterize ecosystem conditions and their interactions with adjacent environments, (2) categorize transects (in forest ecosystems) based on ecosystem conditions and their interactions with adjacent environments, (3) monitoring the forest ecosystem changes (deforestation, natural damage etc), (4) determine the time of thermal equilibrium between forest and environment.

Keywords— microclimate, parameter, gradient, diurnal dynamic.

I. INTRODUCTION

The microclimate variables used by many researchers in describing the microclimate of forest ecosystem are: the intensity of solar radiation penetration, air temperatire, air humidity, wind speed (Hennenberg *et al*, 2008, Davies_Colley *et al*, 2000). Parameters used to express the quantity of forest microclimate are: the maximum difference of interior-exterior, the depth of edge effect, the maximum gradient at the forest boundary. These quantities can not determine the ecosystem capacity in controlling the total daily thermal diffusion between the ecosystem and the environment. Quantity of these parameters, are not consistent for the data measured at the different day, although in the same weather condition.

Mathematical modeling of temporal changes and spatial variation can produce microclimate gradient data at the edge of foret ecosystem. The mathematical modeling of daily microclimate gradient dynamics, yield the functions that describe the thermal interaction between forest and environment. Interesting information obtained from the graph of micaroclimate gradient dynamic functions are: the duration of thermal diffusion from the environment to the ecosystem and vice versa, the time of diffusion transition (marked by gradient value = 0), and the area of intersection between the dynamic gradient curve with the thermal equilibrium line. The area surrounded by gradient dynamic curve of microclimate variables may consist of two or one plane only, depending on the ecosystem condition and its adjacent environment. If the curve forms two planes of gradient dynamic, the one plane represents the thermal diffusion from the environment into the ecosystem while the other plane represent the thermal diffusion in the opposite direction. This area of mocroclimate gradient dynamics is related to the acceptance of solar radiation and thermal energy storage by the interior of the forest through the diffusion process. The thermal diffusion mathematical model that produce a gradient function is developed based on the assumption of steady flow of thermal energy. This article describes the method and examples of application of parameter "the area of diurnal dynamic of microcilamet gradient" in characterizing the interaction of forest ecosystem with the environment. These examples resulted from measurements on several transects, in 2011, 2012, 2014, and 2016.

II. LITERATURE REVIEW

Microclimate is defined as the climate condition of the localized area as a different zone with surrounding environment (Chen *et al*. 1999; Medellu, 2012). The microclimate variables were studied by experts are the intensity of solar radiation, air temperature and air humidity (Hennenberg *et al*., 2008; Medellu, 2012; de Lima *et al*. 2013). Davies-Colley *et al*. 2000, and Medellu, 2012) also

measure wind speed, soil temperature and humidity for charachterization of ecosystem. The microclimate variables change temporally following the changes of solar radiation intensity (Newmark. 2001; Medellu, 2012), Microclimate variables varies spatially due to local conditions or the earth surface (Medellu, 2012, de Paula *et al*, 2016). Spatial variation of forest microclimate influenced by the structure of the forest such as variation of tree high, the patch and the gap in the forest (Pinto *et al*., 2010; Zulkiflee and Blackburn, 2010; Medellu, 2012). Forest microclimate is significantly influenced by the density of canopy (Renaud *et al*, 2010). The results of research prove that the microclimate variables are very sensitive to change due to variability and the change of forest ecosystems and surrounding environment (Godefroid *et al*., 2006; Berger *et al*. 2008, Gradstein, 2008). Microclimate parameters describe the condition and the changes of microclimete variables quantitatively. Microclimate parameters often used by experts were: the maximum difference of edge – interior, the depth of edge effect, and the maximum edge. The depth of edge effects can indicates a fragmentation or gaps in the forest or changes in the structure of the forest (Harper *et al*. 2005, Medellu *et al*, 2012; Magnago *et al*. 2015). Edge gradient associated with the flow of thermal energy between the environment and forest ecosystems (Heithecker and Halpern, 2007; Medellu, 2013; Chatterjea, 2014). Numerical value of the depth of edge effects and the maximum edge gradient were different for transects located in different forest ecosystems and environment (Medellu, 2013; Chatterjea, 2014; Kolasa, 2014). The results of research for the air temperature and air humidity, shows the matching between parameters for transects in the similar condition of forest ecosystem and environment (Medellu 2012, 2013). The microclimate parameters also become an indication of organic conditions around the edge (Wermelinger *et al*., 2007; Horak and Rebl, 2012; Vodka and Cizek, 2013). The depth of edge effect used to identify the transition zone (Baker *et al*, 2016; Schmidt *et al*, 2017). Laurance *et al*., (2011), Pütz *et al*. (2014), and Chaplin-Kramer *et al*. (2015) used the edge effect parameter to estimate the carbon stocks in the zone. These results proved that the microclimate parameters can be used for characterization of ecologicall condition of the forest ecosystems and interaction with the environment (Renaud *et al,* 2010; Medellu, 2012, 2013).

If the measurement repeated in two consecutive days with the same weather conditions (no rain and wind speed less than 2 km/hour), the value of parameters: maximum difference of edge-interior, the depth of edge effect and the maximum edge gradient of air temperature and air humidity were fluctuated and occured in the different time (Medellu,

2012). The depth of edge effect will show two to four top values in different time during the day (Medellu, 2012). Chen *et al* (1999) found the top value of the depth of edge effects occur four to six times a day. This daily fluctuation was the reason for De Siqueira *et al* (2004) to use the variance of the depth of edge effect data. This result indicates that the microclimate parameters can be used to characterize the interaction between the forest and the adjacent environment (Chen *et al*, 1999; Medellu, 2012, 2013), but less valid if used as a reference for monitoring the changes of the ecosystem and its environment.

In 2012 I publish the parameters "area of microclimate gradient diurnal dynamic" through the dissertation entitled "Mathematical Modeling of Daily Dynamics of Microclimate Gradients in Mangrove Forest. This parameter indicates the change of microclimate variables during one day or one period of sun illumination, to obtain the daily response of forest ecosystem and environment on solar radiation. The reason for the using of this parameter was in line with Godefroid *et al.* (2006) and Laurance *et al*. (2011), who proposed that the effect of microclimate in the transition zone is the cumulative response on solar radiation. Determination of the area of microclimate gradient diurnal dynamic includes the stages of the temporal and spatial modeling, determination of edge gradient, modeling the edge gradient function, determination the area of microclimate gradient diurnal dynamic, and the coefficient of microclimate gradient diurnal dynamic. The area of microclimate gradient diurnal dynamic is the area (abstract) surrounded by the microclimate gradient curve with the line of thermal equilibrium. Thermal equilibrium line is the line in two-dimensional coordinate system i.e. gradient versus time, which the gradient value is zero. Thermal equilibrium line indicates the time of the changes of thermal diffusion direction between forest ecosystems - environment. The area of microclimate gradient diurnal dynamic describe the change of microclimate variables during one day according to the period of sun illmunination, acceptance-storage-reemissin of thermal energy by forest and the environment. This parameter is also influenced by the weather conditions i.e. rainfall and wind speed (Medellu, 2012; 2013). The rainfall and wind speed must be controlled during the measurement to ensure that the value will represent the condition and the changes of forest ecosystem and environment.

III.   METHOD

The parameter: area of microclimate gradient diurnal dynamic was developed through the mathematical modeling the daily gradient changes. The basic concept of modeling is

the diffusion of thermal energy caused by the sun radiation and the process of absorbtion, thermal emission by medium (soil, water, vegetation etc. The difference in the temperature (and other microclimate variables) causes thermal diffusion horizontally through the border of ecosystem and the environment. The research procedure related to the application of parameter "the Area of Microclimate Gradient Diurnal Dynamic" was as follows:

1.1. The identification and determination of` the transect

The identification and determination of transect is very important to get the diversity of thermal energy flow between forest and environment. Many transect are selected based on the diversity of the ecosystem and environmental conditions, namely: (1) the existence of variations in forest structure (e.g.: patch, the gap, and forest fragmentation), (2) mangrove type and canopy cover, (3) the adjacent environment (sea, asphalt roads, land with or without the vegetation, settlements etc). Transects were taken in the perpendicular direction on edge of forest (forest-environment boundaries).

1.2. Determination of measurement position

For each transect, the position of the measurement using the logarithmic distance, starting from the edge as the zero point. The distance of measurement points to the edge of the forest are: 0 (forest edge), 1 m, 2 m, 4 m, 8 m, 16 m, and 32 m inward the forest (Medellu, 2013). The measurement is also done on the outward positions in 2 m and 4 m from the edge. The distance between positions are smaller near the edge and increase with the increasing of the distance from the edge. This measurement position is more guarantee the validity of the spatial function modeling of microclimate variables. The position of measurement follows the phenomenon of thermal energy absorption by the medium (air, water) which is greater around the edge and decreased with the increasing of the distance from the edge. Theoritically, the physics variables (f) change due to absorption as $f = k_o.e^{-k_1 x}$, where k_1 is the constant of absorption, x is the distance from the edge, and k_0 is physics variables value at the edge. The value of f is greater near the edge and gradually desreased by the increasing of the distance from the edge.

1.3. Variables, measurement and tabulation of data**.**

The measurement of variables on each position is done with one hour interval. The measurement was conducted by switch from one position to the next position (moving station). The measurement on each position is done simultaneously for four variables i.e: air temperature, air humidity, the intensity of the light and the water/mud temperature. The measurement of air temperature, air

humidity and solar illumination was done on the height of 50 cm above ground, using instrument "four in one", which also measured the wind speed for controlling. The measurement on the position of 50 cm vertically assumed represents the vertical variation of air temperature and humidity (Didham and Ewers, 2014). Wind speed measured for controlling the other microclimate variables. The measurement is only done if the wind speed is less than 2 km/hour that quarantee the free or unforced diffusion. Water or mud temperature measured using the water/land termometer, with the depth variation of 0 - 2 meters. The measurement position is determined using GPS. The measurement position marked for the next measurement. One day measurement on each position produced 24 data. The measurement result data recorded in form as Table-1

Table.1: The matrix for the recording the data

Variable: ……Location:……….transect: …….…...

Posi tion	Time of measurement						
	6.00	7.00	..	t1	..	5.00	6.00
- 4 m							
- 2 m							
0				T(0,t1)			
1 m							
2 m							
4 m							
8 m							
16 m							
32 m							

(Source: Medellu, 2012, 2013)

1.4. Analysis: mathematical modeling and the determination of the microclimate parameters

As described in Medellu (2012, 2013), the steps of analysis and mathematical modeling for determination the microclimate parameters are as follows:

1.5. The modeling of temporal function of microclimate variables.

The modeling of temporal function performed for each measurement position (data rows in Table-1). For each position there were twenty-four data. The mathematical modeling of microclimate function using the procedure of Fourier function modeling, according to sinusoidal changes of data as the respons of earth surface on sun illumination. The periodic (Fourier) function for each measurement position was:

$$T(t) = T_o + \sum_{m=1}^{N/2} a_m \cos \omega_m t + b_m \sin \omega_m t \ldots (1)$$

where,

$$\omega_m = 2\pi m/N \quad \ldots\ldots\ldots\ldots\ldots\ldots (2a)$$

$$a_m = \frac{2}{N} \sum_{t=0}^{N-1} f(t) \cos \omega_m t \quad \ldots\ldots\ldots (2b)$$

$$b_m = \frac{2}{N} \sum_{t=0}^{N-1} f(t) \sin \omega_m t \quad \ldots\ldots\ldots (2c)$$

T_0 is the mean of microclimate data, m is the harmonic enumerator, and N is the number of pair of data: independent variable (time (t)) – dependent viable (microclimate – T(t)). N/2 is the number of harmonic that is the number of sinusoidal component of Fourier function construted from 24 pairs of data. There are 12 harmonics for variabels: air temperature, air humidity and water temperature, and 6 harmonic for light intensity. The steps of Fourier function modeling are:

1.5.1. Determine the coefficient a_m and b_m, using the equation (2b) and (2c).
1.5.2. Determine the coefficient of $c_m^2 = a_m^2 + b_m^2$.
1.5.3. Determine the contributions of diversity: $s_m = (c_m^2/(2.\sigma)).100$

σ is standart of deviation of microclimate data. Through these steps, obtained the value a_m, b_m, c_m and s_m for m = 1, 2, ...,12.

Based on the value of the contribution of diversity (s_m), determined the number of harmonic component needed to construct the Fourier function that is considered valid. The validity of modeling of Fourier function indicates by the vaule of total contributions of diversity. More number of harmonic components, more precision of Fourier function. If the entire hamonic used to construct the function, the total contribution of diversity reached 100 percent. Through these stages can be displayed temporal changes of microclimate variables for each measurement position. Through these stages also obtained the maximum value of microclimate at the day and night, and the maximum difference of edge-interior of forest. The sinusoidal model of the daily changes of air temperature and air humidity also described by Davies-Colley *et al*. (2000), Spittlehouse *et al*. (2004), and Saxena,(2007).

1.6. The synchronization of data.

The synchronization must be done because the data were not measured simultaneously, but switching from one to the next position, along transect. Synchronization is done by measuring the difference of time measurement between the two consecutive positions and then submits into the temporal function to get a new microclimate data. This process of synchronization does not alter the temporal function but gives a new data wich synchron between positions along transect. The synchronized data used for analysis and modeling of spatial function wich describe the microclimate variations along transect.

1.7. Modeling of spatial function.

Modeling of spatial function using the exponential model as presented in equation (3). This hypothetical function contains four unknown constants. These constants can be determine at least using three pairs of data (distance (x) – microclimate T(x)), including the edge data as a reference of position: x = 0.

$$T(x) = k_1 + k_2.e^{k_3 - k_4.x} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where x is the distance from the reference or the edge of the forest. The constants: k_1, k_2, k_3 and k_4 obtained by computer iteration techniques, using the pair of data:. $(0,T_0)$, (x_1,T_1), and (x_2,T_2). Stages of iterations to generate the constants of spatial function are:

$$(T_0-T_1)/(T_0-T_2)=[(\exp(k_4.x_2).(\exp k_4.x_1-1)]/$$
$$[(\exp(k_4.x_1).\exp(k_4.x_2-1)]$$

$k_3 = (T_0 - T_1)/(1-1/\exp(k_4.x_1))$

$k_2 = (T_0 - T_1)/(\exp(k_3) - \exp(k_3 - k_4.x_1))$

$k_1 = y_0 - k_2.\exp(k_3)$

The validity of spatial function is indicated by the biased of model data to the measured data. The spatial function can be used to generate the microclimate data on the other position in a range or outside the range of the measurement position. The software outputs through this stage are: (1) the depth of edge effect, obtained using condition: dT(x)/dx = 0, (2) edge gradient value dT(x)/dx for x = 0, (3) the maximum value of edge gradient at the day and night. Edge gradient value obtained using the equation:

$$G = dT(x)/dx \big|_{x=0} = - k_2.k_4.\exp(k_3) \quad \ldots\ldots..(4)$$

Edge gradient value is a function of time. Modeling of edge gradient function produces the function of diurnal dynamics of microclimate gradient.

1.8. Modeling of diurnal dynamics gradient.

Edge gradient data are fluctuates sinusoidally to follow the quantity and the direction of thermal diffusion through the forest edge. The modeling of diurnal dynamics gradient function using the procedure of periodic function modeling as described in point a.

1.9. Determine the area of the diurnal dynamics gradient of microclimate.

The area of microclimate gradient diurnal dynamic is the area restricted by the curve of microclimate gradient dynamic with the thermal equilibrium line. The thermal equilibrium line is the line that has a zero gradient value. Physically, the thermal equilibrium line shows the

condition where no thermal diffusion between forest and environment.

The measurement for 24 hours can produce two areas of diurnal dynamics gradient, above and below the thermal equilibrium line, depends on the changes of gradient sign (Figure-1).

If the gradient has the negative sign, the area of diurnal dynamics gradient lies below the line of equilibrium, indicates the thermal diffusion from the environment to the forest. If the gradient sign is positive, the area of diurnal dynamic gradient lies above the equilibrium line that indicates the thermal diffusion from forest to environment. The area of diurnal dynamics microclimate gradient (A) determined using the the numerical integral:

$$A = \sum_{i=1}^{n} \left| G_t . \Delta t \right| \dots \dots \dots .5)$$

Where n is the number of elements of area. G_t is the value of the function gradient. Δt is the interval of time sampling.

1.10. Location of research

Research was performed on several locations that to show the consistent results according to ecosystem and environment conditions. Research in 2011 taken on 10 transects which the condition as describes in Tabel-2

Table.2: Research location and transects condition in May 2011

Location	Transect number	Edge coordinate*		Mangrove type and characteristic of ecosystem	Adjacent environment
		Latitude	Longitude		
Talengen Bay, District of Sangihe	1	3°35'20.14"	125°34'10.68"	fringe, homogeny, *Rhizophora*, gap at 36 m from the edge, canopy cover 72 %-85 %	Sea, Talengen Bay
	2	3°35'25.17"	125°34'8.22"	fringe, homogeny, *Rhizopho ra,* canopy cover 75%-85 %	Sea, Talengen Bay
	3	3°35'31.70"	125°33'59.55"	riverine, homogeny, *Rhizophora,* canopy cover: 78% – 88%	River/Talengen Bay
Ratatotok Bay, District of South-East Minahasa	1	0°52'9.09"	124°42'21.52"	hammock, fragmented at 12 m; bruguiera: 0-12m, canopy cover of 90% - 95%	Pavement/shrubs mangrove at 8 m from edge
				Domination of Avicenia 12 - > 80 m, canopy cover 55% - 70%	Mangrove (heterogeny)
	2	0°51'2195"	124°42'24.82"	fringe, homogeny, *Rhizopho ra*, canopy cover 75 %-80 %	Coast (shrubs)
	3	0°50'59.76"	124°42'29.69"	Basin. Heterogeny, variation in high and canopy cover (40% - 65%)	Coast.shrub, sea infront
	4	0°50'50.53"	124°42'11.51"	Basin heterogeny, domination of A*vicenia,* canopy cover 35% - 55%	Pavement/schrubs
	5	0°51'52.42"	124°42'2.61"	Scrub heterogeny, domination of A*vicenia,* canopy cover 50% - 60%	Coast/shrub
Arakan village, South Minahasa	1	1°22'8.87"	124°32'49.12"	Fringe, homogeny, *Rhizophora,* canopy cover 75% – 85%	Sea
	2	1°21'59.07"	124°32'55.33"	Basin, heterogeny in mengrope type, high and canopy cover. (55% - 65%)	Coast, shrub & high trees

* The position of the zero point on transect, located at the edge of the forest. Source: Medellu, 2012.

IV.   RESULTS AND DISCUSSION

4.1. Daily fluctuation of microcimate variabels

Figure-1 shows the graph of the air temperature gradient changes of transect number-2, located in Talengen Bay, start from 07.00 a.m, date of May 8th 2011 to 07.00 a.m. on May 9th 2011.
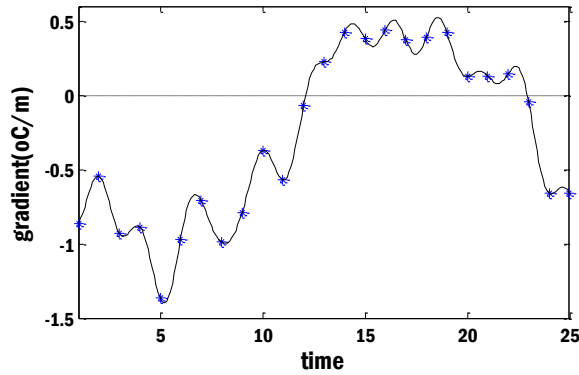

Fig.1: Graphic of air temperature gradient of transect-2, Talengen Bay

The horizontal line represents the thermal equilibrium line between the mangrove ecosystem and the adjacent environment. The number 1 on the abscissa was in accordance with 07.00 a.m., while the number 25 associated with 07.00 a.m. of the next day. The gradient dynamics curve that lies below the thermal equilibrium line shows the direction of the thermal diffusion from the environment into the ecosystem. The negative sign of gradient represents the thermal diffusion during the day. At night, the direction of the thermal diffusion from the ecosystem to the environment and the gradient dynamics curve lies above the thermal equilibrium line.

The function of air temperature gradient of transect number-2, located in Talengen Bay is:

$$Gt(2) = -0.2944 -0.2822*COS((2\pi t/180)/24) -0.7046* SIN((2\pi t/180)/24)+ 0.0246*COS((4\pi t/180)/24)+ 0.0455* SIN((4\pi t/180)/24) -0.0479* COS((6\pi t/180)/24) -0.0306* SIN((6\pi t/180)/24) - 0.0440* COS((8\pi t/180)/24)+ 0.0658* SIN((8\pi t/180)/24) -0.0937* COS((10\pi t/180)/24)+0.0001* SIN((10\pi t/180)/24) -0.0812* COS((12\pi t/180)/24)+ 0.0189* SIN((12\pi t/180)/24) +0.0163* COS((14\pi t/180)/24) -0.0278* SIN((14\pi t/180)/24)+ 0.0649* COS((16\pi t/180)/24)+ 0.0734* SIN((16\pi t/180)/24) -0.0478* COS((18\pi t/180)/24) -0.0040* SIN((18\pi t/180)/24)+ 0.0099* COS((20\pi t/180)/24) -0.0577* SIN((20\pi t/180)/24)+ 0.0359* COS((22\pi t/180)/$$

$$24)+0.0021* SIN((22\pi t/180)/24)+ 0.0808* COS((24\pi t/180)/24) -0.0402* SIN((24\pi t/180)/24)$$

Graph of gradient dynamics of air humidity, sun light intensity and sea water temperature of the same transect, measured simultaneously with the air temperature, respectively presented in Figure-2, Figure-3, and Figure-4
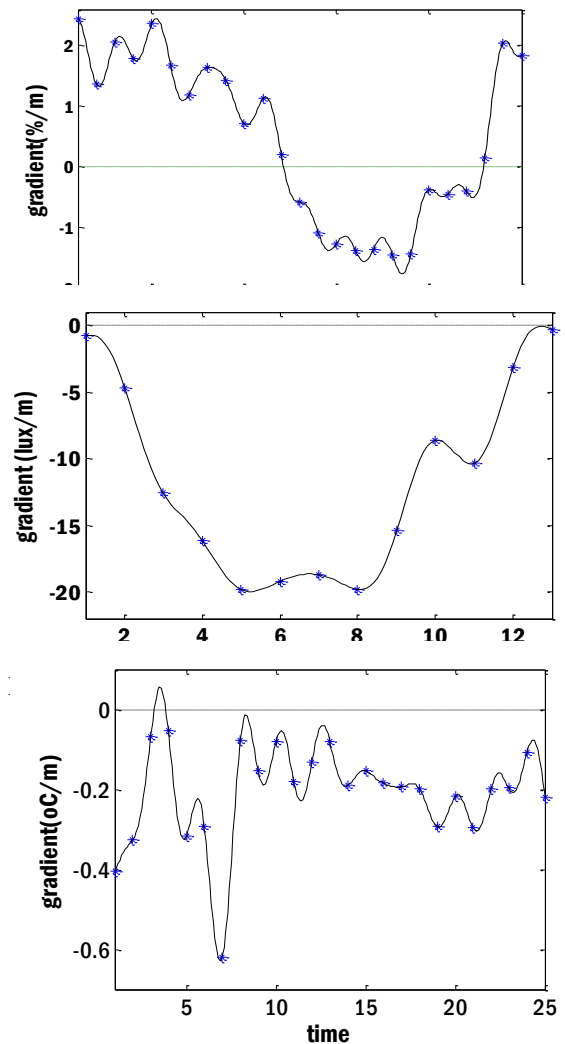

Fig.4: Graphic of water temperature gradient of transect-2 Talengen Bay

Figure-3 to show the light intensity gradient at the edge of mangrove forest measured at 06.00 to 18.00, May th 9 2011.

At night, the air temperature in mangrove forest was higher than in edge or in the environment, which shows the direction of thermal diffusion was from the forest to the environment (Medellu 2012, Medellu, 2013). This result was accordance with Renaud *et al*. (2010). The

graph of diurnal dynamic of air temperature gradient generally shows more fluctuate on the day than night. This fluctuation caused by the change of sun elevation, cloud cover, wind speed and its direction. Air humidity gradient graph shows that in the daytime, air humidity in interior of forest higher than the air humidity above the open sea surface. This result in accordance with Renaud *et al.* (2010); Wicklein *et al*., (2012), and Williams-Linera *et al*., (1998) as reported in Schmidt *et al.* (2017). The air above the open sea surface, receive the direct warming by sun shining, and then the humidy decreased faster than the air under the mangrove canopy. At night, the air above the open sea surface shows the slightly higher moisture than the air under the mangrove canopy. The function of the radiation gradient dynamic consists of 6 harmonics part and one part of illumination gradient mean. The water temperature gradient has the negative sign throughout the day (24 hours), shows that the water temperature of open sea surface is higher than under the mangrove canopy. Physically, this condition caused by the higher acceptance and storage of solar energy by the open sea. This result was in line with Hawley (2010) conclusion which to compare the water temperature of open sea with under the closed canopy. Another factor influence the water temperature under the canopy was the flow of fresh water from the land inform of water leaks, through openings or pores of soil.

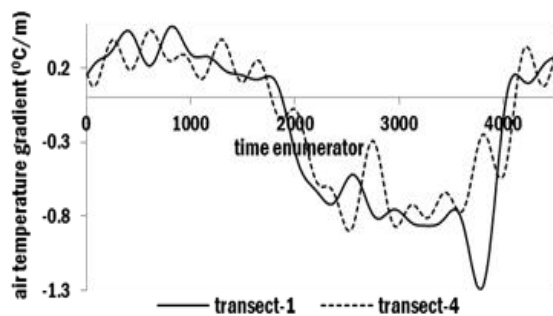4.2. Comparison between transect in different ecosystem and adjacent environment

Fig.5: The graphs of air temperature gradient of transect no 1 and no 4, Location: Ratatotok Bay

The differences of the area of air temperature gradient diurnal dynamic between the two transects that measured at the same time and on the same weather conditions (no rain), proves that the difference is caused mainly by canopy cover (sea basic data in Table-2). Figure-5 shows the morning thermal eguilibrium reached

earlier in transect-4 then in transect-1; on the afternoon the thermal equilibrium reached earlier in the transect-1 than in the transect-4. Physically this is influenced by the process of acceptance and storage of thermal energy by mangrove ecosystem, among others related to canopy density and temperature changes around the mangrove edge.

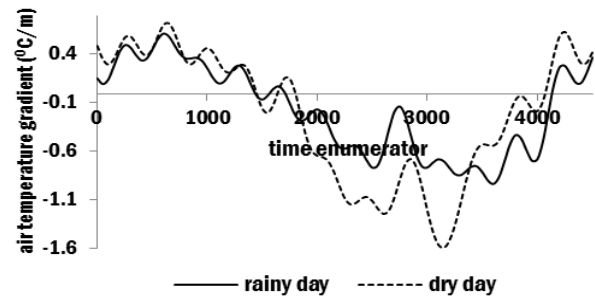4.3. Weather influence on the microclimate of mangrove

Figure-6. The graph of air temperature gradient in rainy and dry day, Location: Ratatotok Bay

until 19.00 p.m., October 14, 2011. The condition of the mangrove ecosystem and environment along transect 2 on the first and second measurements were the same. The area of air temperature gradient diurnal dynamis in dry day was 9.024^0C.hours/m at the day, and 3.064^0C.hours/m at night. The area of air temperature gradient diurnal dynamis in rainy day was 7.30^0C.hours/m at the day, $2,623^0$C.hours/m at night. Decreasing the area of air temperature gradient diurnal dynamic due to rainfall was in line with the decreasing of other parameters such as the maximum difference of interior - edge, maximum edge gradient and the depth of edge effects.

4.4. The monitoring the change of forest width and the gap size in mangrove forest
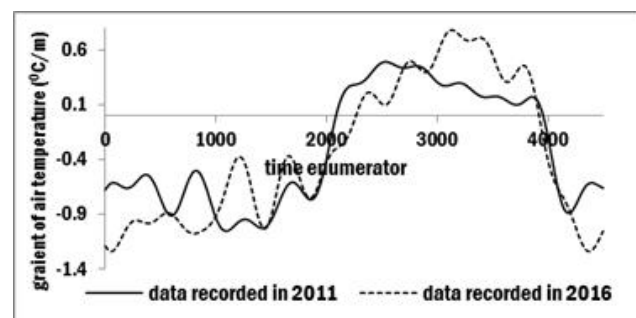

Fig.7: Graph of air temperature gradient of the transect 1, location Talengen Bay, result of measurement in 2011 and 2016

Figure-7 shows two graphics of air temperature gradient dynamic of the transect-1 at Talengen Bay in two different ecosystem conditions. The solid curve related to the first measurement conducted at 07.00 a.m. on May 8, 2011 to 07.00 a.m. on May 9, 2011 In interior of mangrove there is the gap which the width was 30 m, while the distance of the gap edge from the main edge (border of forest with the open sea) was 68 m.

The second measurement has been done at 07.00 a.m. on July 20, 2016 to 07.00 a.m., July 21, 2016. In the second measurement the width of gap decreased to 18 m, while the width of mangrove or the distance of the two edges was increased to 76 m. The green color graph shows the air temperature gradient dynamic constructed by the data of second measurement. Weather conditions for the first and second measurement were the same, by controlling wind speed less than 2 km/hour and no precipitation. The dense of canopy was relatively in the same range, around 72 %-85% in the first and (72 %-86%) in the second measurement. The area of air temperature gradient diurnal dynamic derived from the first measurement data are 9.586^0C.hours/m at the day, and 3.034^0C.hours/m at night. In the second measurement, the area of air temperature gradient diurnal dynamic was 9.982^0C.hours/m at the day, 3.424^0C.hours/m at night.

4.5. The grouping of mangrove ecosystem based on the area of air temperature and humidity gradient diurnal dynamic

Figure-8 and Figure-9 shows the map of the transect grouping based on the area of air temperature gradient (absis) and the humidity gradient (ordinate) on night and day. The numbers on the map represent the number of ten transects on Table-1, without distinguish location, for example the transect number 4 was the transect no-1 Location Ratatotok etc. Based on the area of air temperature and humidy gradient data at night and day, the transects grouping was:: (a) group of transects (1,2,3,5,9), and (b) group of transects (6,7,8). Transect-4 and transect-10 was not grouping, each transect stand alone.
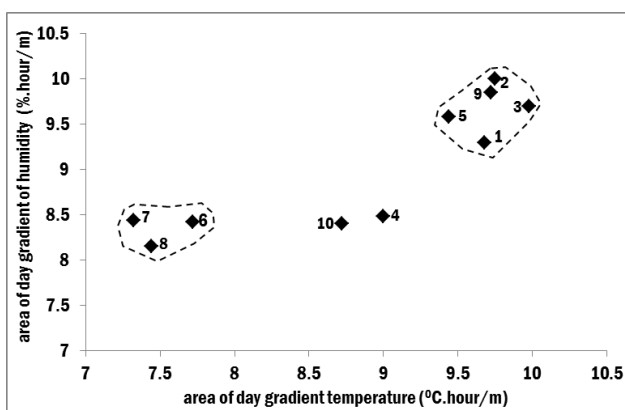

Fig.8: Transect grouping based on the area of gradient dynamic of temperature versus humidity at the day
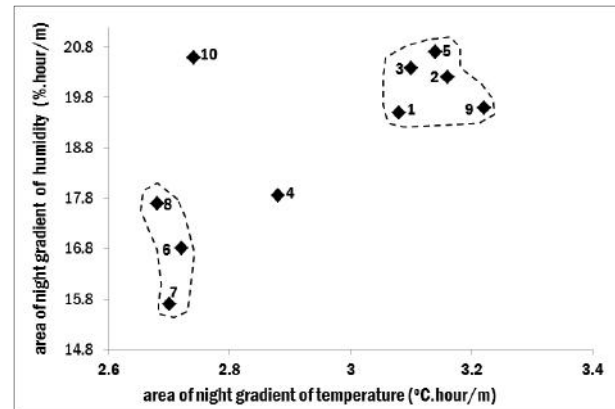

Fig.9: Transect grouping based on the area of gradient dynamic of temperature versus humidity at night (Medellu, 2013)

Group of transects (a) have the high value of the area of air temperature and humidity gradient at the day and night. The group (b) represesnts transects with the low value of the area of air temperatre and humidity gradient at the day and night

V.   CONCLUSION

The area of microclimate gradient diurnal dynamic represents the one day accumulative response of forest ecosystem and environment wich more stable than the other parameters: interior-edge differences, the depth of depth edge, maximum edge gradient. Parameter the area of microclimate gradient diurnal dynamic can be used to: (1) characterize, identify and classify or grouping the transects, (2) monitor the changes in forest structure, the change of forest or changes the gap size in the forest, (3) monitor the impact of environment to forest ecosystems. The application of parameter the area of microclimate gradient diurnal dynamic for mangrove ecosystem monitoring, limited to variable: air temperature, air humidity and illumination. For variable of water/mud temperature needed the control of water flow which caused the complex of spatial variation and temporal changes of water temperature. To quarantee the good ouput, the measurement of microclimate conducted in the condition of the wind speed less than 2 km/hour; this to ensure the unforced thermal diffusion.

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