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THE USE OF GOOGLE MAPS AND UNIVERSAL TRANSVERSE MERCATOR (UTM) COORDINATE IN LAND MEASUREMENT OF REGION IN DIFFERENT ZONE

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ABSTRACT

The methods in determining land area measurement based on UTM coordinate are very few. In this paper, we present the use of Google Maps and Universal Transverse Mercator (UTM) to determine the measurement of land area in two or four different zones of UTM coordinate based on the proposed method. We proposed the rectangular method. The proposed method is then applied in determining of regional area of regencies in Central Kalimantan such as Kapuas Regency and Murung Raya Regency. If the method is applied to determine the measurement of land area in Kalimantan Tengah, the mean of absolute percentage error (MAPE) is 14.45 %.

Keywords: *Universal Transverse Mercator, Google Maps, Land Measurement, Zone, Coordinate System*

1. INTRODUCTION

Measuring the area of land and the establishment of the land boundary is critical. Especially an area of an extensive estate. It needs time and money.

Universal Transverse Mercator (UTM) coordinate systems are rarely used compared to latitude-longitude coordinate systems [1]. However, in order to determine the distance between two points using Euclid distance method, it will be more precise to UTM coordinate system (for more information of UTM coordinate system see [2]). In the paper [3], it has been explained how the rectangular method is proposed to determine the area of Gili Air island, Salatiga city, Central Java province, Daerah Istimewa Yogyakarta province and Daerah Khusus Ibukota Jakarta province. However, these areas are within one UTM zone. In this paper, it will be proposed how the rectangular method can also be used to determine the area located in different UTM zones. The proposed method is then used in determining the area of districts in Central Kalimantan. The selection of this province based on the location of the regencies within the regions located in two zones and some in four zones.

2. LITERATURE REVIEW

In the latitude and longitude coordinate system, it is not easy to determine the distance between two points on the surface of the earth because the distance Euclid can be used only on the plane while the surface of the earth is considered to be an ellipsoidal surface. Therefore, the coordinate system needs to be transformed into Universal Transverse Mercator (UTM) coordinate system. The transformation method is described below.

Many methods can be used to convert latitude-longitude coordinates into UTM coordinate systems. One of the methods that can be used is described in the article [4], other method have been described in papers [3] and [5]. Furthermore, by using UTM coordinates it can be determined the distance between 2 points using the Euclid distance provided if the two points are in one zone. The method is then used in determining the area of Gunung Mas Regency by using the rectangular

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method. In this literature review, it is presented the methods to convert the geographical coordinate based on [4] and the recent paper [5].

Suppose a point is present on the surface of the earth with coordinates (φ, λ) where φ representing latitude coordinate and λ representing longitudinal coordinate. To facilitate the calculation of the distance between two points on the surface of the earth then the coordinate system needs to be transformed into a UTM coordinate system by using the following calculation (in meter) [4] :

$a = 6378137$ (semi-major axis),
$b = 6356752.314245$ (semi-major axis),
$f = (a-b)/a$,

$$e^2 = \frac{a^2 - b^2}{a^2},$$

$$n = \frac{a-b}{a+b} = \frac{f}{2-f},$$

$$\rho = \frac{a(1-e^2)}{(1-e^2\sin^2\phi)},$$

$$\upsilon = \frac{a}{(1-e^2\sin^2\phi)^{1/2}},$$

$$S = A\phi - B\sin 2\phi + C\sin 4\phi - D\sin 6\phi + E\sin 8\phi,$$

$$A = a\left[1 - n + \frac{5}{4}\left(n^2 - n^3\right) + \frac{81}{64}\left(n^4 - n^5\right) + \dots\right],$$

$$B = \frac{3}{2}a\left[n - n^2 + \frac{7}{8}\left(n^3 - n^4\right) + \frac{55}{64}n^5 + \dots\right],$$

$$C = \frac{15}{16}a\left[n^2 - n^3 + \frac{3}{4}\left(n^4 - n^5\right) + \dots\right],$$

$$D = \frac{35}{48}a\left[n^3 - n^4 + \frac{11}{16}n^5 + \dots\right],$$

$$E = \frac{315}{512}a\left[n^4 - n^5 + \dots\right],$$

λ_0 = longitude of the meridian,
$\Delta\lambda = \lambda - \lambda_0$
k_0 = central scale factor = 0.9996,
FN = False Northing,
FE = False Easting (= 500000),
E = grid easting,
N = grid northing,

$$T1 = Sk_0,$$

$$T2 = \frac{v\sin\phi\cos\phi k_0}{2},$$

$$T3 = \frac{v\sin\phi\cos^3\phi k_0}{24}\left(5 - \tan^2\phi + 9e'^2\cos^2\phi + 4e'^4\cos^4\phi\right),$$

$$T4 = \frac{v\sin\varphi\cos^5\varphi k_0}{720}(61 - 58\tan^2\varphi + \tan^4\varphi + 270e'^2\cos^2\varphi$$
$$-330\tan^2\varphi e'^2\cos^2\varphi + 445e'^4\cos^4\varphi + 324e'^6\cos^6\varphi$$
$$-680\tan^2\varphi e'^4\cos^4\varphi + 88e'^8\cos^8\varphi - 600\tan^2\varphi e'^5\cos^6\varphi$$
$$-192\tan^2\varphi e'^8\cos^8\varphi),$$

$$T5 = \frac{v\sin\phi\cos^7\phi k_0}{40320}(1385 - 3111\tan^2\phi + 543\tan^4\phi - \tan^6\phi),$$

$$T6 = v\cos\phi k_0,$$

$$T7 = \frac{v\cos^3\phi k_0}{6}\left(1 - \tan^2\phi + e'^2\cos^2\phi\right),$$

$$T8 = \frac{v\cos^5\varphi k_0}{120}(5 - 18\tan^2\varphi + \tan^4\varphi + 14e'^2\cos^2\varphi$$
$$-58\tan^2\varphi e'^2\cos^2\varphi + 13e'^4\cos^4\varphi + 4e'^6\cos^6\varphi$$

$$T9 = \frac{v\cos^7\phi k_0}{5040}\left(61 - 479\tan^2\phi + 179\tan^4\phi - \tan^6\phi\right),$$

such that the Easting coordinate is

$$N = FN + (T1 + (\Delta\lambda)^2 T2 + (\Delta\lambda)^4 T3 + (\Delta\lambda)^6 T4 + (\Delta\lambda)^8 T5),$$

and the Northing coordinate is

$$E = FE + (\Delta\lambda T6 + (\Delta\lambda)^3 T7 + (\Delta\lambda)^5 T8 + (\Delta\lambda)^7 T9).$$

Suppose that the coordinates A_1 and B_1 are (-0.289287, 113.41617) and (-1.653229, 113.504159), respectively, where the first axis is latitude coordinate and the second axis is longitude coordinate. Coordinate A_1 can be converted to UTM coordinates by using

f = 0.00335281,
e^2 = 0.00669438,
e'^2 = 0.0067397,
n = 0.00167922,
ρ = 6335440.94905524,
υ = 6378137.54423084,
A = 6367449.14582333,
B = 16038.50866311,
C = 16.83261326,
D = 0.02198440,
E = 0.00003115,
S = 768997.22156522,
T_1 = -31974.90817774,
T_2 = -16094.92794697,
T_3 = -6787.608130672,
T_4 = -2809.243975975,
T_5 = -1105.580064766,
T_6 = 6375505.02454235,
T_7 = 1069690.91279259,
T_8 = 270651.53490600,
T_9 = 77148.40380713,

such that the Easting = 768936.077649187 ≈ 768936.08, the Northing = 9967996.448422255 ≈ 9967996.45 and located in zone 49 *M*. Similarly, the coordinates of Easting and Northing are 778624.15 and 9817092.27, respectively and located in zone 49 *M*. Since both points are in one UTM zone and by using the Euclid distance, it can be obtained that the distance between point A_1 and point B_2 is

$$d = \sqrt{(768936.08 - 778624.15)^2 + (9967996.45 - 9817092.27)^2}$$

$$d = \sqrt{(-9688.07)^2 + (150904.17)^2}$$

i.e. 151.2149 km. The distance is relatively close to the Vincenty distance between the two points i.e. 151,1311 km (for more information of the Vincenty distance see [6] and [7]).

Conversely, if the UTM coordinates (E, N) and the zone of the location are known then to obtain the geographical coordinates can be used the following procedures. Suppose

$M_0 = 0$,

$$M = M_0 + \frac{N}{k_0},$$

$$e_1 = \frac{\left[1-\left(1-e^2\right)^{\frac{1}{2}}\right]}{\left[1+\left(1-e^2\right)^{\frac{1}{2}}\right]},$$

$$\mu = \frac{M}{\left[\alpha\left(1-\frac{e^2}{4}-3\frac{e^4}{64}-5\frac{e^6}{256-\ldots}\right)\right]},$$

$$\phi' = \mu + \sin 2\mu\left(\frac{3}{2}e_1 - \frac{27}{32}e_1^3+\ldots\right)$$
$$+\sin 4\mu\left(\frac{21}{16}e_1^2-\frac{55}{32}e_1^4+\ldots\right)+\sin 6\mu\left(\frac{151}{96}e_1^3+\ldots\right)$$
$$+\sin 6\mu\left(\frac{1097}{512}e_1^4-\ldots\right)+\ldots$$

$\Delta E = E - FE$,

$$T10 = \frac{\tan\phi'}{2\rho v k_0^2},$$

$$T11 = \frac{\tan\phi'}{24\rho v^3 k_0^4}(5+3\tan^2\phi'+e'^2\cos^2\phi'-4e'^4\cos^4\phi'$$
$$-9\tan^2\phi' e'^2\cos^2\phi'),$$

$$T12 = \frac{\tan\phi'}{720\rho v^5 k_0^5}(61+90\tan^2\phi'+46e'^2\cos^2\phi'+45\tan^4\phi'$$
$$-252\tan^2\phi' e'^2\cos^2\phi'-3e'^4\cos^4\phi'+100e'^6\cos^6\phi'$$
$$-66\tan^2\phi' e'^4\cos^4\phi'-90\tan^4\phi' e'^2\cos^2\phi'$$
$$+88e'^8\cos^8\phi'+225\tan^4\phi' e'^4\cos^4\phi'$$
$$+84\tan^2\phi' e'^6\cos^6\phi'-192\tan^2\phi' e'^8\cos^8\phi'),$$

$$T13 = \frac{\tan\phi'}{40320\rho v^7 k_0^8}(1385+3633\tan^2\phi'+4095\tan^4\phi'$$
$$+1575\tan^6\phi'),$$

$$T14 = \frac{1}{v\cos\phi' k_0},$$

$$T15 = \frac{1}{6v^3\cos\phi' k_0^3}(1+2\tan^2\phi'+e'^2\cos^2\phi'),$$

$$T16 = \frac{1}{120v^5\cos\phi' k_0^5}(5+6e'^2\cos^2\phi'+28\tan^2\phi'$$
$$-3e'^4\cos^4\phi'+8an^2\phi' e'^2\cos^2\phi'+24\tan^4\phi'-4e'^6\cos^6\phi'$$
$$+4\tan^2\phi' e'^4\cos^4\phi'+24\tan^2\phi' e'^6\cos^6\phi'),$$

$$T17 = \frac{1}{5040v^7\cos\phi' k_0^7}(61+662\tan^2\phi'+1320\tan^4\phi'$$
$$+720\tan^6\phi'),$$

then the latitude ϕ and longitude λ can be found by formulas

$$\phi = \phi' - (\Delta E)^2 T10 + (\Delta E)^4 T11 - (\Delta E)^6 T12 + (\Delta E)^8 T13,$$

$$\lambda = \lambda_0 - \Delta E T14 - (\Delta E)^3 T15 + (\Delta E)^5 T16 - (\Delta E)^7 T17.$$

The coordinate UTM (E, N) = (768936.08, 9967996.45) in zone 49 M will be converted into geographical coordinate with the following steps. Because the location in zone 49 M, i.e. in the Southern Hemisphere then it is obtained

M = -32016.3565426178,
e^2 = 0.00669438,
e'^2 = 0.0067397,
μ = -0.0050281291,
e_1 = 0.0016792204,
$T11 = -6.423472123 \times 10^{-31}$,
$T12 = -6.450735067 \times 10^{-45}$,
$T13 = -6.4019633487 \times 10^{-59}$,
$T14 = 1.5685032305 \times 10^{-7}$,
$T15 = 6.4748986901 \times 10^{-22}$,
$T16 = 3.9878759867 \times 10^{-36}$,
$T17 = 2.8273808024 \times 10^{-50}$,

so that the result of latitude coordinate is ϕ = -0.289287 and the longitude coordinate λ = 113.416170. Thus the result is the same as the previous geographical coordinate.

Based on the recent paper, this following procedure can be used to convert the geographical coordinate into the UTM coordinate more briefly that the previous procedure. Let the geographical coordinate (ϕ, λ) where ϕ representing latitude coordinate and λ representing longitudinal coordinate [5] :

a = 6378137 (semi-major axis),
f = 1/298.257223563,
k_0 = 0.9996

$$n = \frac{f}{2-f},$$

$$A = \frac{a}{1+n}\left(1+\frac{n^2}{4}+\frac{n^4}{64}+\ldots.\right),$$

$$\alpha_1 = \frac{n}{2}-\frac{2n^2}{3}+\frac{5n^3}{16},$$

$$\alpha_2 = \frac{13n^2}{48}-\frac{3n^3}{5},$$

$$\alpha_3 = \frac{61n^3}{240},$$

$$t = \sinh\left(\tanh^{-1}\sin\phi - \frac{2\sqrt{n}}{1+n}\tanh^{-1}\left(\frac{2\sqrt{n}}{1+n}\sin\phi\right)\right),$$

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$$\xi' = \tan^{-1}\left(\frac{t}{\cos(\lambda-\lambda_0)}\right),$$

$$\eta' = \tanh^{-1}\left(\frac{\sin(\lambda-\lambda_0)}{\sqrt{1+t^2}}\right),$$

such that the Easting coordinate is

$$x = E = E_0 + k_0\, A\left(\eta' + \sum_{j=1}^{3}\alpha_j \cos(2j\xi')\sinh(2j\eta')\right),$$

and the Northing coordinate is

$$y = N = N_0 + k_0\, A\left(\xi' + \sum_{j=1}^{3}\alpha_j \sin(2j\xi')\cosh(2j\eta')\right).$$

The coordinate A_1 is (-0.289287, 113.41617) can be converted by using the procedure given in paper [5]. In this case, a = 6378137, f = 1/298.2572235605 and it is obtained

n = 0.0016792204,
A = 6367449.1458234154,
α_1 = 0.0008377318,
α_2 = $7.6084969587 \times 10^{-7}$,
α_3 = $1.2034877876 \times 10^{-9}$,
t = -0.0050152533,
ξ' = -0.0050196738,
η' = 0.0421820949,

(in meter) such that the obtained Easting coordinate is E = 768936.0776497596 ≈ 768936.08 and the Northing coordinate is N = 9967996.4484222736 ≈ 9967996.45. The location is in zone 49 M. The procedure given in paper [5] is more briefly and the result can be considered same as the first procedure.

Note that all points on the earth's surface are mapped into the plane by dividing it into 60 zones with each zone having a width of 6 degrees longitude. Longitude 0° to longitude 180° in Eastern part of the earth have zone numbers from 31 until 60. The rest have zone numbers from 1 until 30. Furthermore, zone C to zone M zone lies in the southern hemisphere, each zone has a width of 8° except the zone C which has a width 12°. Zone N up to zone X are located at Northern hemisphere and each zone has width 8° except zone X which have width 12°. More information can be found in [8] and [2].

If the UTM coordinates (E, N) and the zone of the location are known then to obtain the geographical coordinates can be used formulas [5] :

$$\phi = \chi + \sum_{j=1}^{3}\delta_j \sin(2j\chi),$$

$$\lambda_0 = zone \times 6^o - 183^o,$$

$$\lambda = \lambda_0 + \tan^{-1}\left(\frac{\sinh\eta'}{\cos\xi'}\right),$$

where

$$\delta_1 = 2n - \frac{2}{3}n^2 - 2n^3,\quad \delta_2 = \frac{7}{3}n^2 - \frac{8}{5}n^3,$$

$$\delta_3 = \frac{56}{15}n^3,$$

$$\xi = \frac{N-N_0}{k_0 A},\quad \eta = \frac{E-E_0}{k_0 A},$$

$$\beta_1 = \frac{n}{2} - \frac{2n^2}{3} + \frac{37n^3}{96},$$

$$\beta_2 = \frac{n^2}{48} + \frac{n^3}{15},$$

$$\beta_3 = \frac{17n^3}{480},$$

$$\xi' = \xi - \sum_{j=1}^{3}\beta_j \sin(2j\xi)\cosh(2j\eta),$$

$$\eta' = \eta - \sum_{j=1}^{3}\beta_j \cos(2j\xi)\sinh(2j\eta),$$

$$\chi = \sin^{-1}\left(\frac{\sin\xi'}{\cosh\eta'}\right).$$

To check that the UTM coordinates of Easting 768936.08 and Northing 9967996.45 with zone 49 M will have the previous coordinates like all then the following steps are used. Since the location is in zone 49 M i.e. in the Southern Hemisphere then it is obtained

δ_1 = 0.0033565514,
δ_2 = 0.0000065719,
δ_3 = 0.0000000177,
ξ = -0.0050281291,
η = 0.0422529794,
$\beta_1 = 8.3773216408 \times 10^{-4}$,
$\beta_2 = 5.9061108637 \times 10^{-8}$,
$\beta_3 = 1.6769911794 \times 10^{-10}$,
ξ' = -0.0050196735,
η' = 0.0421820952,
χ = -0.0050152110,

(in radian) such that the result of latitude coordinate is ϕ = -0.289287 and longitude coordinate is λ = 113.41617. The result is the same as the original geographical coordinates.

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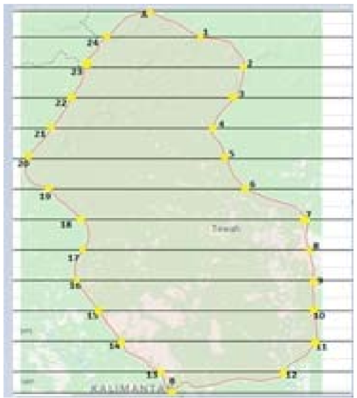

Figure 1: The boundary points of Gunung Mas Regency.

Table 1 presents the coordinates of the latitude and coordinates of longitudes of the boundaries of Gunung Mas district of Central Kalimantan province as described in Figure 1, whereas Table 2 presents the result of converting the latitude-longitude coordinate system into a UTM coordinate system. Using the rectangular method, the length of Gunung Mas Regency can be viewed as the distance between point A_1 and point B_1' which has coordinates (-1.653229, 113.416719) i.e. l = 150.8921 km (as a comparison, the Vincenty distance between two points is 150.8174 km).

Table 1: Latitude and Longitude on the Boundaries of Gunung Mas Regency.

No.	Latitude	Longitude
1	-0.382669	113.666658
2	-0.506262	113.751802
3	-0.629852	113.691378
4	-0.734214	113.652825
5	-0.844067	113.710604
6	-0.953917	113.814974
7	-1.028064	113.968782
8	-1.168114	113.985262
9	-1.275206	113.982515
10	-1.412497	113.999999
11	-1.500359	113.985262
12	-1.601065	113.883187
13	-1.559882	113.432748
14	-1.408871	113.284432
15	-1.274325	113.196542
16	-1.164487	113.213021
17	-1.062883	113.213021
18	-0.951254	113.117258
19	-0.860310	113.024218
20	-0.796007	113.040438
21	-0.716363	113.104982
22	-0.635345	113.154421
23	-0.530980	113.210726
24	-0.408761	113.267031

The width of Gunung Mas Regency can be obtained from the average distance of the points (1,24), (2, 23), (3, 22), (4,21), (5,20), (6,19), (7,18), (8,17), (9, 16), (10,15), (11, 14) and (12, 13) i.e. w = 72.8852 km. All points are in 1 UTM zone so that the distance calculation can directly use Euclid distance. Furthermore, the area of Gunung Mas Regency can be found by

$$A = (l)w = (150.8921)(72.8852)$$

i.e. 10997.80 km^2. This result is 1.78% larger than the reference area.

Table 2: The Boundaries of Gunung Mas Regency in UTM coordinate based on Table 1.

No.	Easting	Northing
1	796833.6	9957657
2	866313.4	9943978
3	799576.9	9930305
4	795286.3	9918760
5	801703.1	9906600
6	813319.9	9894435
7	830447.1	9886214
8	832267.6	9870712
9	831948.4	9858859
10	833877.5	9843661
11	832222.9	9833938
12	820838.3	9822808
13	752324.5	9957670
14	746050.4	9944001
15	739775.6	9930333
16	734265.7	9918792
17	727073.5	9906646
18	725260.9	9894497
19	735614.1	9886290
20	746264.6	9870791
21	744114.4	9858947
22	744406.6	9843761
23	754181.2	9834032
24	770680.7	9822873

3. RESEARCH METHODS

The described method in the literature review is used to convert the geographical coordinates into the UTM coordinates of the border

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of regencies in Kalimantan Tengah. The methods can be applied to all regencies except Kapuas Regency and Murung Raya Regency. The distance between two UTM coordinate points depends on position of points within one zone or within a different zone. In the results and discussion, it is proposed a method of determining the distance between two points if the two points of UTM coordinates are in two or four different zones. Furthermore, it is also proposed to determine the distance between two points if one is in the Northern Hemisphere and the other is in the Southern Hemisphere. By using the rectangular method, the results are then used in determining the area of Kapuas Regency located in 2 UTM zones and Murung Raya Regency located in 4 different UTM zones.

4. RESULTS AND DISCUSSION

In the results and discussion, it is proposed that the measurement of the distance between two points in the UTM coordinates whether they are in the southern hemisphere or in the northern hemisphere yet they are in different zones. For example point A_2 has latitude-longitude coordinates (-0.363641, 113.969798) and point B_2 has latitude-longitude coordinates (-3.436162, 114.343967). In the UTM coordinate, they are (Easting, Northing, zone) = (830606.61, 9959752.32, 49 *M*) and (244872.15, 9619786.07, 50 *M*), respectively. To determine the distance between point A_2 and point B_2 can be done by calculating the distance between point A_2 and zone border i.e. longitude line 114° *E* that can be approximated by the distance between A_2 and point D_2 (-0.363641, 113.999999) (see Figure. 2). Furthermore, the distance between point C_2 (-0.363641, 114.343967) that has the same latitude as point A_2 and the same longitude as point B_2, with the boundary of the border zone 114° *E* can be approximated by the distance between C_2 and point E_2 (-0.363641, 114.000001). In UTM coordinates, points D_2, C_2 and E_2 are respectively (Easting, Northing, zone) =

(833971.75, 9959751.21, 49 *M*),
(204349.33, 995963.22, 50 *M*),
(166028.25, 9959751.21, 49 *M*).

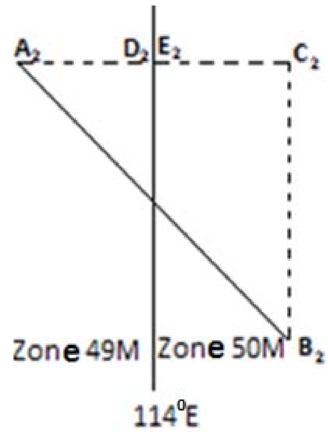

Figure 2: Method of Calculating Distance Between 2 Points located in different zones and located in the same hemisphere.

Since point A_2 and D_2 are located in one zone it can easily be obtained the distance between point A_2 and D_2 by using a distance of Euclid i.e. 3.3651 km. Furthermore, the distance between point E_2 and point C_2 is 38.3211 km and the distance between points B_2 and C_2 is 339.9776 km. Finally, by using the Pythagoras theorem it can be obtained the distance between point A_2 and point B_2 is 342.5237 km (as a comparison of Vincenty distance i.e. 342.2867 km). The difference between the two methods is only 0.2370 km or 237.0 meters.

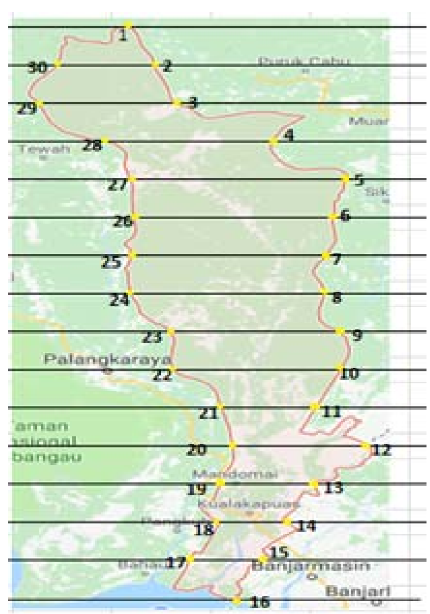

Figure 3. The boundaries of Kapuas Regency Region.

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The proposed method can be applied to determine the area of Kapuas regency, Central Kalimantan. Table 3 presents the coordinates of Kapuas regency boundaries as shown in Figure 3. The length of the Kapuas district area can be considered as the distance between point 1 (or point A_2 in the above example) and point 16 (or point B_2 in the above example) and can be approximated by the distance between point 1 and point 16′ (-0.363641, 114.343967) i.e. l = 340.0695 km.

The area width of Kapuas Regency can be obtained from the average distance of the points (2,30), (3, 29), (4, 28), (5,27), (6,26), (7,25), (8,24), (9,23), (10, 22), (11,21), (12, 20), (13,19), (14,18) and (15, 17) i.e. w = 52.3378 km. Furthermore, the area of Kapuas Regency can be found by

$A = (l)w = (340.0695)(52.3378)$,

i.e. 17798.4835 km^2. This result is 18.66 % more than the reference area.

Another case appeared when one point is in the Northern Hemisphere while the other is in the Southern Hemisphere. It will be determined the distance between point A_3 (0.798250, 114.907438) and point B_3 (-0.857881, 114.246885). In the UTM coordinate system, they are respectively obtained (Easting, Northing, zone) =

(267120.58, 88289.93, 50 N),
(193562.65, 9905068.01, 50 M).

Table 3. Latitude and Longitude of the Boundaries of Kapuas Regency.

No.	Latitude	Longitude
1	-0.363641	113.969798
2	-0.525685	114.054949
3	-0.786593	114.151073
4	-0.978831	114.461436
5	-1.182041	114.711375
6	-1.431915	114.664683
7	-1.673525	114.593272
8	-1.822067	114.623633
9	-2.039462	114.705203
10	-2.194726	114.685781
11	-2.516846	114.545948
12	-2.718616	114.604212
13	-2.93199	114.534295
14	-3.319837	114.441073
15	-3.319837	114.359504
16	-3.43616	114.343967
17	-3.35861	114.126449
18	-3.14145	114.235208
19	-2.92423	114.223555
20	-2.73414	114.305125
21	-2.5052	114.309009
22	-2.26047	114.215763
23	-2.03815	114.130619
24	-1.81817	113.981306
25	-1.51344	113.962830
26	-1.35182	113.985926
27	-1.19018	113.981306
28	-0.95465	113.888923
29	-0.75835	113.664892
30	-0.54972	113.744335

It means that both points are in different zones since point A_3 is in the Northern hemisphere while point B_3 is in the southern hemisphere, however both points have longitude between 114° E and 120° E. To determine the distance between A_3 and B_3, it can be used the auxiliary point C_3 (-0.857881, 114.907438) i.e. the point that has the same latitude as the latitude of the point B_3 while the longitude equals the point A_3, point E_3 (0.000001, 114.907438) and point D_3 (-0.000001, 114.907438) (see Figure. 4). In UTM coordinates, points D_3, C_3 and E_3 are (Easting, Northing, zone) =

(267124.06, 9905114.61, 50 M),
(267098.11, 9999999.89, 50 M),
(267098.11, 0.11, 50 N).

In other words, point A_3 and E_3 are located in one zone therefore the distance between those points can be calculated by using Euclid distance, i.e. 88.2898 km. Similarly the points C_3 and D_3 are in 1 zone with a distance of 94.8853 km and point C_3 and B_3 are in 1 zone with a distance of 73.5614 km. Furthermore, the distance between A_3 and B_3 can be obtained with the Pythagoras theorem i.e. 197.3940 km (compare to the Vincenty distance i.e. 197.3363 km).

In addition, the distance between A_4 points (0.798250, 114.907438) and B_4 (-0.326447, 113.208677) will be determined. In the UTM coordinate system, respectively it is obtained (Easting, Northing, zone) =

(267120.58, 88289.93, 50 N),
(745827.78, 9963890.79, 49 M).

It means that the two points are in different zones since the A_4 point is in the Northern hemisphere and the longitude is greater than the 114° E (the border of zone) while the point B_4 is in the Southern hemisphere and has a longitude smaller than the 114° E. To determine the distance between A_4 and B_4, it can be used the auxiliary point C_4 (-0.326447, 114.907438) i.e. the point that has latitude equal to point B_4 and longitude equal to longitude of point A_4, point D_4 (-0.000001,

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114.907438), point E_4 (0.000001, 114.907438), point F_4 (-0.326447, 114.000001) and point G_4 (-0.326447, 113.999999) (see Fig. 5). In UTM coordinates, the points D_4, C_4, E_4, F_4 and G_4 respectively are (Easting, Northing, zone) =

(267098.11, 9999999.89, 50 *M*),
(267101.87, 9963893.55, 50 *M*),
(267098.11, 0.11, 50 *N*),
(166026.95, 9963867.94, 50 *M*),
(833973.05, 9963867.94, 49 *M*).

In other words, point A_4 and E_4 are located in one zone with the Euclid distance is 88.2898 km. Similarly point C_4 and D_4 are in 1 zone with distance 36.1063 km, point C_4 and F_4 are in 1 zone with distance 101,0749 km and point G_4 and B_4 are in 1 zone i.e. zone 49 *M* with distance 88.1453 km. By using Pythagoras theorem, the distance between A_4 and B_4 can be determined as 226.4479 km (in comparison, Vincenty distance is 226.3296 km).

The length of Murung Raya district can be considered as the distance between point A_4 and point C_4 that is 183.1751 km (see Figure. 6). The width of Murung Raya district can be approximated by using the average distance of the points (2.16), (3, 15), (4, 14), (5.13), (6.12), (7.11) and (8,10) that is l = 149.1407 km. Thus the area of Murung Raya Regency region is

$A = (l)w = (183.1751)(149.1407)$

i.e. 27318.8637 km^2. The result is 15.27% greater than the reference area.

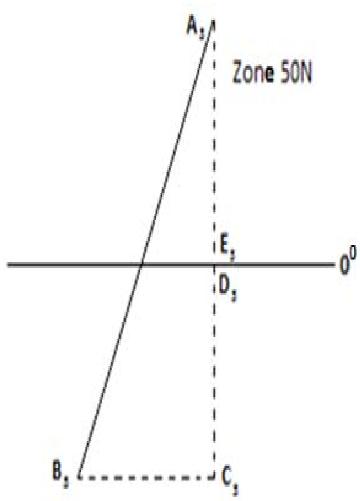

Figure 4. Method of Calculating Distance Between 2 Points, one in the Northern Hemisphere and one in the Southern Hemisphere.

Table 4. Latitude and Longitude of the Boundaries of Murung Raya Regency.

No.	Latitude	Longitude
1	0.798250	114.907438
2	0.545582	115.053007
3	0.334102	114.998075
4	0.111631	114.794828
5	-0.099856	114.912931
6	-0.275636	115.047514
7	-0.503597	115.025541
8	-0.723311	114.870359
9	-0.857881	114.246885
10	-0.745282	114.117796
11	-0.470639	114.021665
12	-0.326447	113.208677
13	-0.062777	113.406431
14	0.151456	113.400938
15	0.302517	113.451230
16	0.546956	113.727781

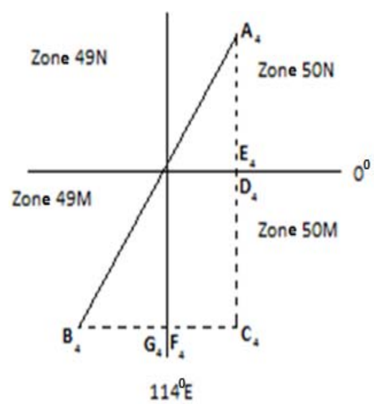

Figure 5. Method of Calculating Distance Between 2 Points, one in the Northern Hemisphere and one in the Southern Hemisphere and one on the left of the zone borderline and the other to the right of the zone borderline.

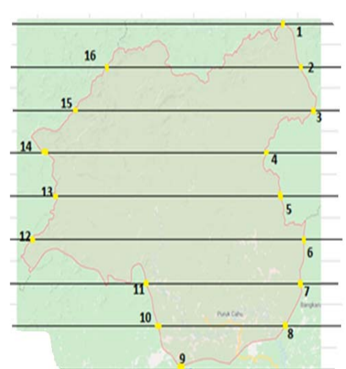

Figure 6. The boundary of Murung Raya Regency.

Table 5. Information of Used Data.

No.	Regency	The number of border points	Reference Area
1	Kotawaringin Barat	38	10759
2	Kotawaringin Timur	40	16796
3	Kapuas	58	14999
4	Barito Selatan	50	8830
5	Barito Utara	52	8300
6	Sukamara	38	3827
7	Lamandau	38	6414
8	Seruyan	54	16404
9	Katingan	54	17500
10	Pulang Pisau	38	8997
11	Gunung Mas	52	10805
12	Barito Timur	52	3834
13	Murung Raya	32	23700

Table 6. Result of Calculated Area.

No.	Regency	Result of calculation	%
1	Kotawaringin Barat	8916	-17.13
2	Kotawaringin Timur	16087	-4.22
3	Kapuas	18372	22.49
4	Barito Selatan	7422	-15.95
5	Barito Utara	10139	22.16
6	Sukamara	4380	14.45
7	Lamandau	7280	13.5
8	Seruyan	17629	7.47
9	Katingan	18509	5.77
10	Pulang Pisau	10585	17.65
11	Gunung Mas	10569	-2.18
12	Barito Timur	3098	-19.2
13	Murung Raya	24480	3.29

Based on the described method, the area of regency region in Central Kalimantan province can be determined by using the rectangular method. The results are presented in Table 6 and compared to the reference area (Table 5). The calculation of the area shows that there are some regencies that is smaller than the reference i.e. Kotawaringin Barat, Kotawaringin Timur, Barito Selatan, Gunung Mas and Barito Timur, meanwhile other regencies show that their area are greater than the reference. The smallest absolute percentage error is found in Gunung Mas Regency while the largest absolute percentage error is found in Kapuas Regency. Based on these results, it can also be obtained that the mean of absolute percentage error (MAPE) is 14.45 %.

The difference in results obtained by using the rectangular method and the reference area is probably caused by the method used. Another possibility is also caused by the boundaries of territory provided by Google Maps that are not exactly equal to the administrative boundaries of regencies or cities in Kalimantan Tengah province (see in paper [9]). Other methods that can be used in land area measurement are Spherical Quadrilateral Approach Method (see in paper [7]) and polygon method (see in papers [8], [11], [12] and [13]).

5. CONCLUSION

In this paper we have presented how to use Google Maps and the UTM coordinates in land area measurement in different zone based on the rectangular method. The proposed method is then applied in determining of regional area of regencies in Central Kalimantan such as Kapuas Regency and Murung Raya Regency. The mean of absolute percentage error (MAPE) is 14.45 %. This research can be extended to determine regional area measurement by using other methods and the results are compared to the result of this method.

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REFERENCES:

[1] Kelly, K. M., *Coordinate Transformations : Universal Transverse Mercator/ Geographic*, The Association of Ontario Land Surveyors, 1989.

[2] Langley, R. B. The UTM Grid System, *GPS World, Feb. 1998*, pp. 46-50.

[3] Setiawan, A. & Sediyono, E., "A new Determination of regional Area by Utilizing Rectangular Approach Method and Google Maps", *ICITISEE, IEEE Xplore*, 2017, page 417-420.

[4] Hager, J. W., Behensky, J. F., Drew, B. W. "The Universal Grids : Universal Transverse

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Mercator (UTM) and Universal Polar Stereographic (UPS)" Defense Mapping Agency, Fairfax, VA, 1989.

[5] Kawase, K. "Concise Derivation of Extensive Coordinate Conversion Formulae in the Gauss-Krüger Projection", *Bulletin of the Geospatial Information Authority of Japan*, 60, pp 1–6, 2012.

[6] Vincenty, T., "Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations", *Survey Review*, 23 (176), 1975, page 88-93.

[7] Setiawan, A., Sediyono, E., "Using Google Maps and Spherical Quadrilateral Approach Method for Land Area Measurement", *ICI3INA IEEE Xplore*, 2017.

[8] Snyder, H. P. , " Map Projections – A Working Manual. U. S. Geological Survey Professional Paper 1395", United States Government Printing Office, Washington, D. C, 1987.

[9] Kumar, S. V. , "Are administrative boundaries in Google maps correct", *Coordinates* , December 2017.

[10] Karney, C. F. F., "Algorithms for geodesics", *J. Geodesy* 87 (1),2013, page 43-45.

[11] Pedzich P., M. Kuzma, "Application of methods for area calculation of geodesic polygons on Polish administrative units", *Geodesy and Cartography*, 2012,vol. 61, no. 2, page. 105-115.

[12] Sjoberg, L. E., "Determination of Area on the plane sphere and ellipsoid", *Survey Review*, 2006,vol. 38, no. 301, page. S83-S93.

[13] Gillissen, I, "Area Computation of a Polygon on an Ellipsoid", *Survey Review*, 1993,vol. 32, no. 248.