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Sunrise AndSunset Time Prediction Ina Specific Latitude

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Abstract: *In this companion paper we have to determine the time of sunrise and sunset in any specific terrestrial latitude. Also it has been predicted about the sunrise and sunset in 2017(June - December). Although in this work there are some small errors at different situation but it does not effect on actual time of sunrise and sunset. So this is a good way to determine the time of sunrise and sunset in specific latitude. The result of our calculation is found to be good agreement to the other investigation.*

Keywords: *Anomaly, Declination, Latitude, Longitude, Time.*

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I. Introduction

Times of sunrise and sunset at specific locations often are important influences on daily operations. The change of heating of slopes and terrain at sunrise and sunset affects temperature, air density, and wind. The times of sunrise, sunset, and twilight at any particular location depend on such factors as latitude, longitude, time of year, elevation, and heights of the surrounding terrain. Earth is moving continuously around the Sun in the elliptic path in its own orbit. The Earth takes 23 hours, 56 minutes and 4 seconds to move on its own orbit for a single time. In the moving time of the Earth, the part of the Earth which faces the Sun, the light prevails in that part. That time of this part is generally called day and the part which remains on the opposite side of the Sun generally becomes dark and that time of this part is generally called night. A variety of phenomena may be seen during a day. The sun appears above the horizon, this time is known as sunrise time and the sun goes below the horizon, this time is known as sunset time. This work developed by various recorded data, many items of astronomical data recorded in different periods and different forms of historical records were surveyed, collected, or republished (Beijing Astronomical Observatory 1988)[1]. Such effort has even extended to the ancient literature of other East Asian countries (Xu et al. 2000)[2]. Current studies on ancient Chinese celestial records are not limited to eclipses (Liu 2002)[3], comets (Strom 2002), calendars (Zhang 1990; Li et al. 1998)[4] or secular variations of Earth's rotation (Han et al. 2003; Li et al. 1997)[5], rather, they cover almost all aspects of ancient astronomy (The researching group for the history of Chinese astronomy 1981; Chen 2003)[6]. This paper based only the sunrise and sunset time prediction depends upon the various astronomical terms. We have compared our data with August and November to December 2012 observed data. This compare can make a good agreement. According to the good agreement we may predict sunrise and sunset time at specific location, Jessore, June to December 2017.

II. Mathematical Formulation

1.1 Equation of Time

The difference between the apparent (true) solar time and the mean solar time is known as the equation of time.

Then, ξ = apparent solar - mean solar time

$= H.A.(true\ sun) - H.A.M.S.$

Again identifying δ with true sun (S) and mean sun,

$LST = H.A.S + R.A.S$

$LST = H.A.M.S + R.A.M.S$

or, $R.A.M.S - R.A.S = H.A.S - H.A.M.S = \xi$ the equation of time at any moment can be expressed as

ξ = R.A.M.S - R.A.S

The equation of time is positive or negative according as the apparent sun transits

1.2 **Sun Rise and Sun Set Time calculation**

This sunrise and sun set time calculation in this paper fully depend on astronomical formula and computation device like calculator or computer. We have use some various astronomical formula like solar noon, mean solar anomaly, equation of center, ecliptical longitude of the sun etc. Finally combining all through formula we may find this formula given below.This equation calculates the sunrise time in Julian date. After finding the Julian date we may convert the time in general form. These equations are in the complex form. We may use in different equation partially. This process is given below. First, we may introduce some related variables

J_{date} = Julian date
l_w = West Longitude (75W = 75, 45E = -45)
l_n = North Latitude (35N = 35, 25S = -25)
$M = Mean\ Solar\ Anomaly$
n = Julian cycle since Jan 1, 2000
C = Equation of center
λ = Ecliptical longitude of the sun
δ = Declination of the sun
H = Hour Angle (half the arc length of the sun)
$J_{transit}$ = Julian date of solar noon on cycle n
J_{rise} = Julian date of sunrise on cycle n
J_{set} = Julian date of sunset on cycle n

First, start by calculating the number of days since January 1, 2000. Add that number to 2451545 (the Julian day of January 1, 2000). This will be variable J_{date}.
The next step is to calculate the Julian cycle. This is not equal to the days since Jan 1, 2000. Depending on your longitude, this may be a different number.

$$n_* = (J_{date} - 2451545 - 0.0009) - (l_w/360)$$
$$n = round(n_*)$$

Now, it is time to approximate the Julian date of solar noon. This is just an approximation so that we can make some intermediate calculations before we calculate the actual Julian date of solar noon.

$$J_* = 2451545 + 0.0009 + (l_w/360) + n$$

Using the approximate value, calculate the mean solar anomaly. This will get a very close value to the actual mean solar anomaly.

$$M = [357.5291 + 0.98560028 * (J* - 2451545)] \bmod 360$$

Calculate the equation of center

$$C = (1.9148 * \sin(M)) + (0.0200 * \sin(2 * M)) + (0.0003 * \sin(3 * M))$$

Now, using C and M, calculate the ecliptical longitude of the sun.

$$\lambda = (M + 102.9372 + C + 180) \bmod 360$$

Now there is enough data to calculate an accurate Julian date for solar noon.

$$J_{transit} = J_* + (0.0053 * \sin(M)) - (0.0069 * \sin(2 * \lambda))$$

To calculate the hour angle we need to find the declination of the sun

$$\delta = \arcsin(\ \sin(\lambda) * \sin(23.45)\ )$$

Now, calculate the hour angle, which corresponds to half of the arc length of the sun at this latitude at this declination of the sun

$$H = \arccos(\ [\sin(-0.83) - \sin(l_n) * \sin(\delta)] / [\cos(l_n) * \cos(\delta)]\ )$$

If H is undefined, then there is either no sunrise (in winter) or no sunset (in summer) for the supplied latitude.
Now, time to go back through the approximation again, this time we may use H in the calculation

$$J** = 2451545 + 0.0009 + ((H + lw)/360) + n$$

The values of M and λ from above don't really change from solar noon to sunset, so there is no need to recalculate them before calculating sunset.

$$J_{set} = J_{**} + (0.0053 * \sin(M)) - (0.0069 * \sin(2 * \lambda)) \quad \text{..(1)}$$

Instead of going through that mess again, assume that solar noon is half-way between sunrise and sunset (valid for latitudes < 60) and approximate sunrise.

$J_{rise} = J_{transit} - (J_{set} - J_{transit})$ ………….(2)

Equation (1) and (2) give the sunset and sunrise time in any specific Longitude & Latitude.

III. Result and Discussion

We may find the result can be a good agreement with the observed sunrise and sun set data. The result of sunrise and sunset is displayed in minute but on the figure the result is in decimal form. We opine based on our research that the observed result and the model results are in good agreement. The following figure represents the agreement accuracy.

This model is applicable for any longitude and latitude in any specific location for the whole year. For an example or sample we have given for six months sunrise and sunset time prediction data. Here we have used the longitude and latitude of Jessore.

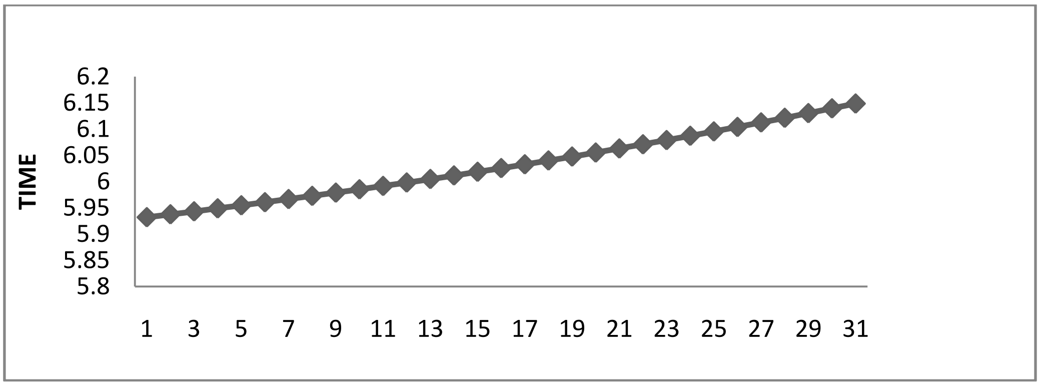

Figure 1. Shows The Predicted Sunrise Time in June 2017

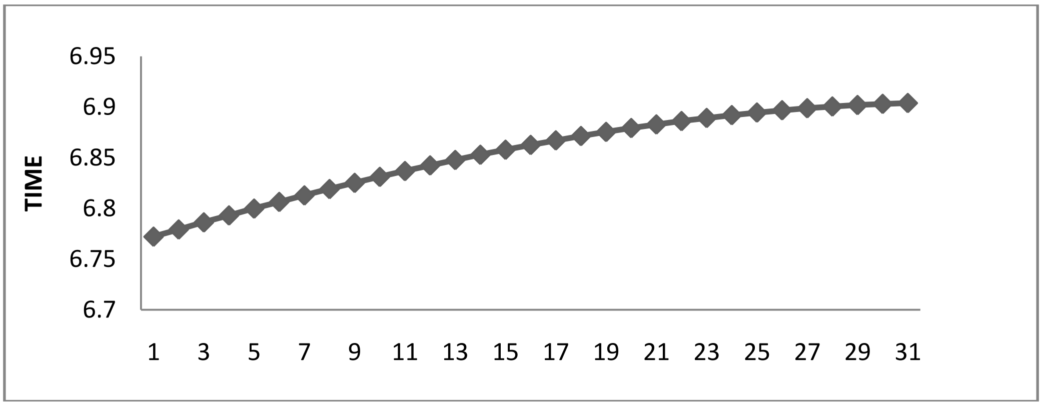

Figure 2. Shows The Predicted Sunset Time in June 2017

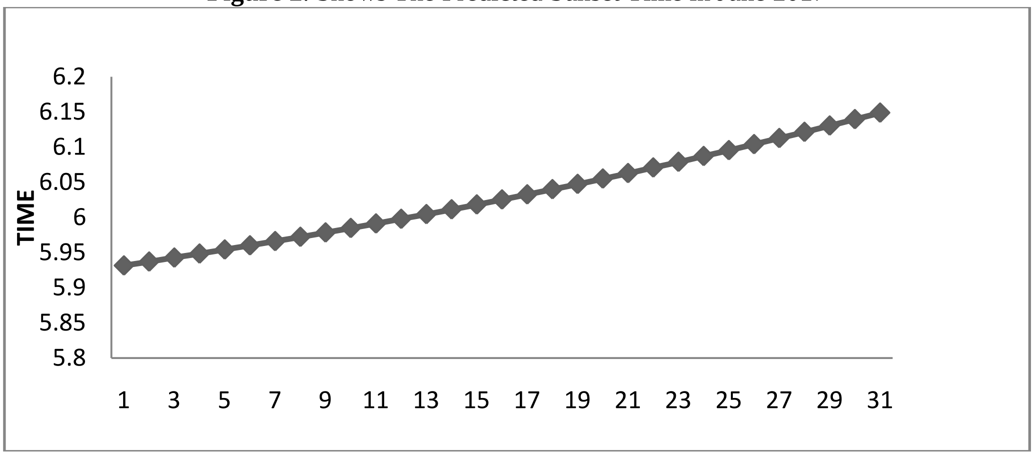

Figure 3. Shows The Predicted Sunrise Time in July2017

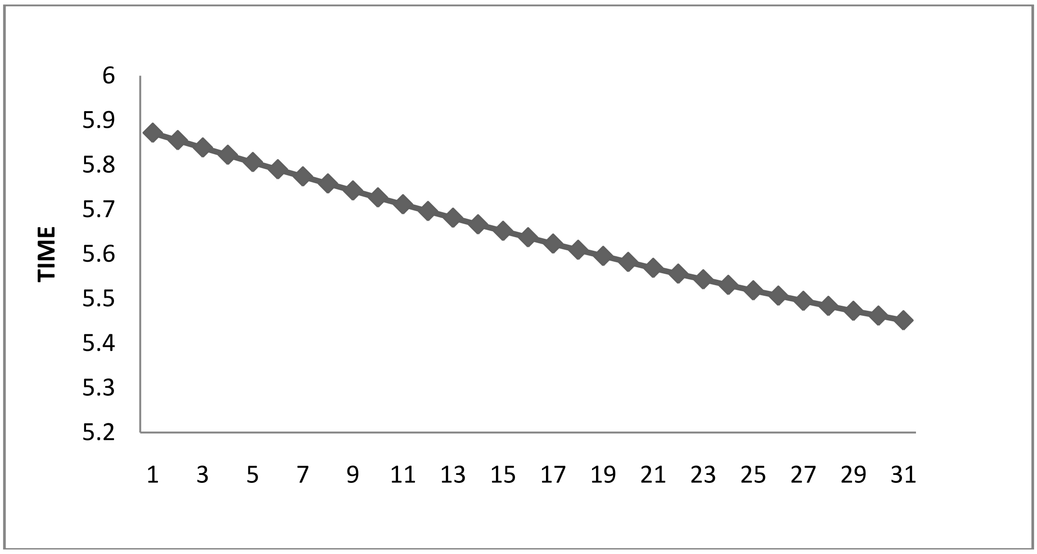

Figure 4. Shows The Predicted Sunset Time in July2017

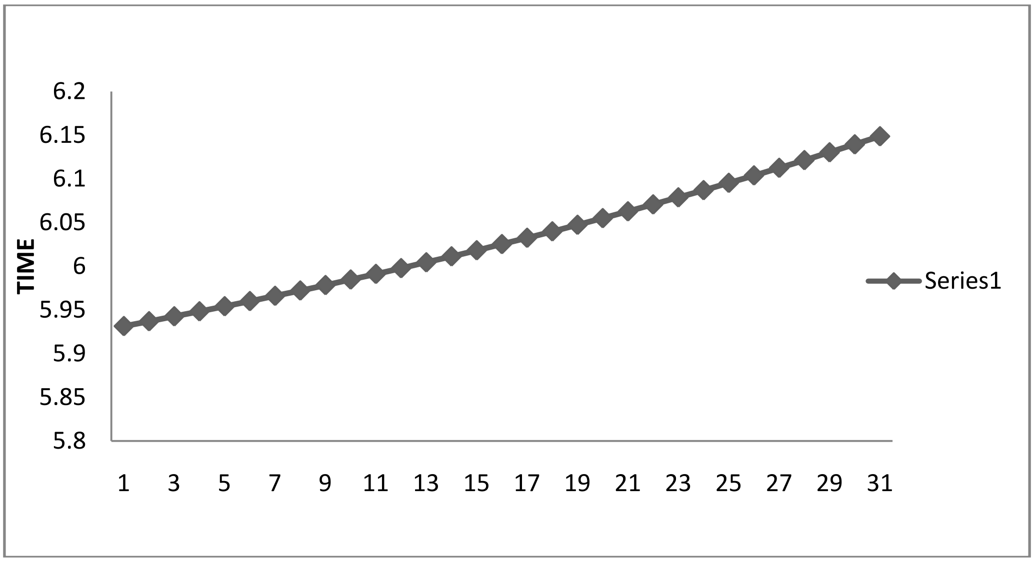

Figure 5. Shows The Predicted Sunrise Time in August 2017

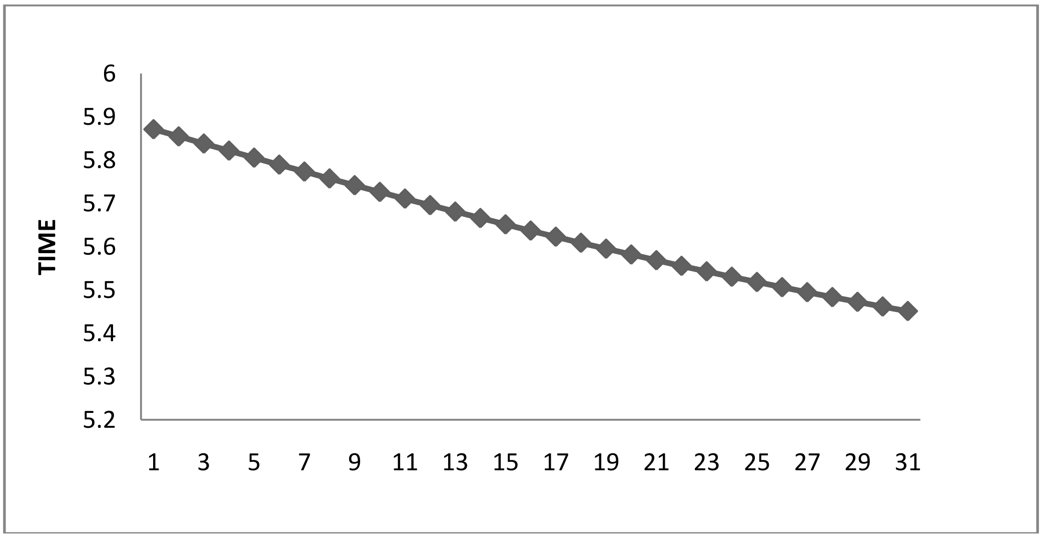

Figure 6. Shows The Predicted Sunset Time in August 2017

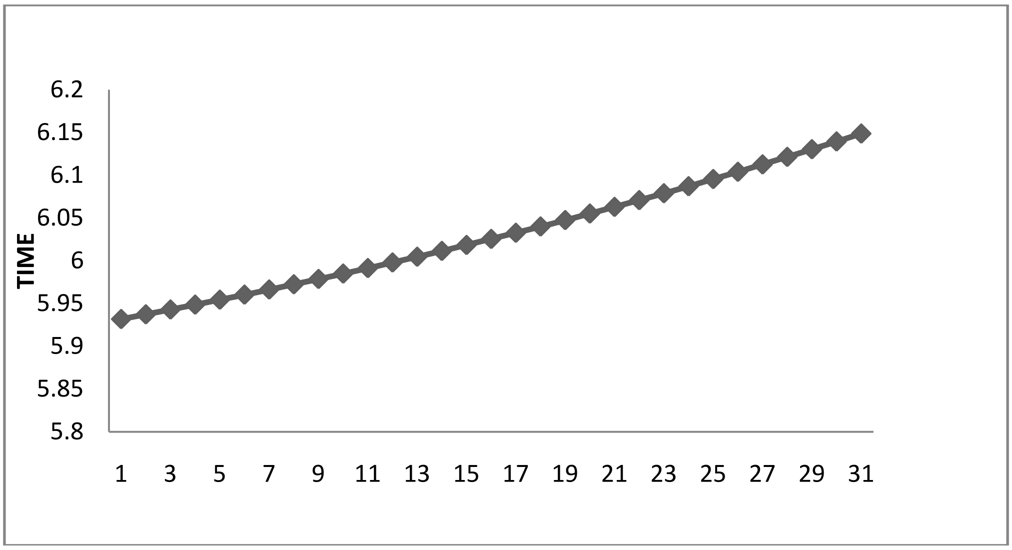

Figure 7. Shows The Predicted Sunrise Time in September 2017

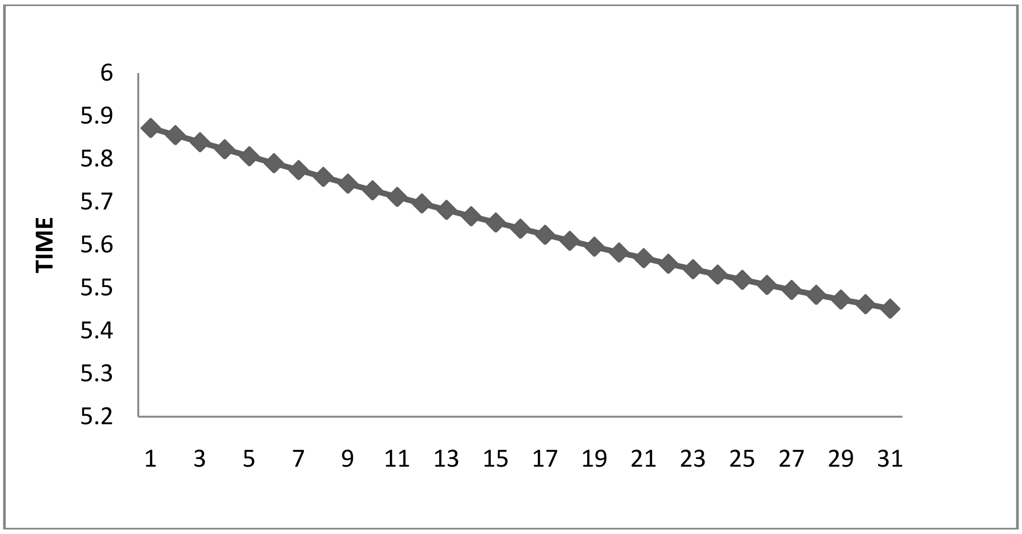

Figure 8. Shows The Predicted Sunset Time in September 2017

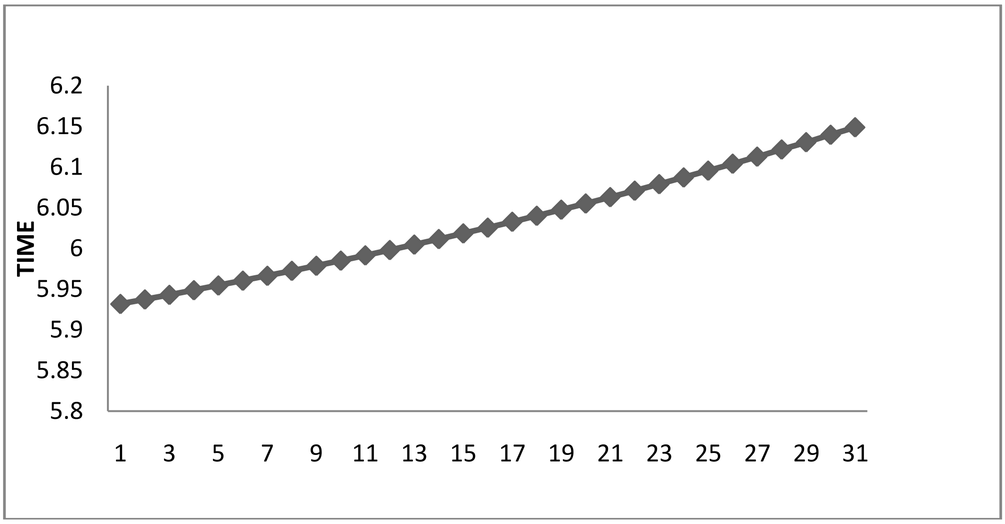

Figure 9. Shows The Predicted Sunrise Time in October 2017

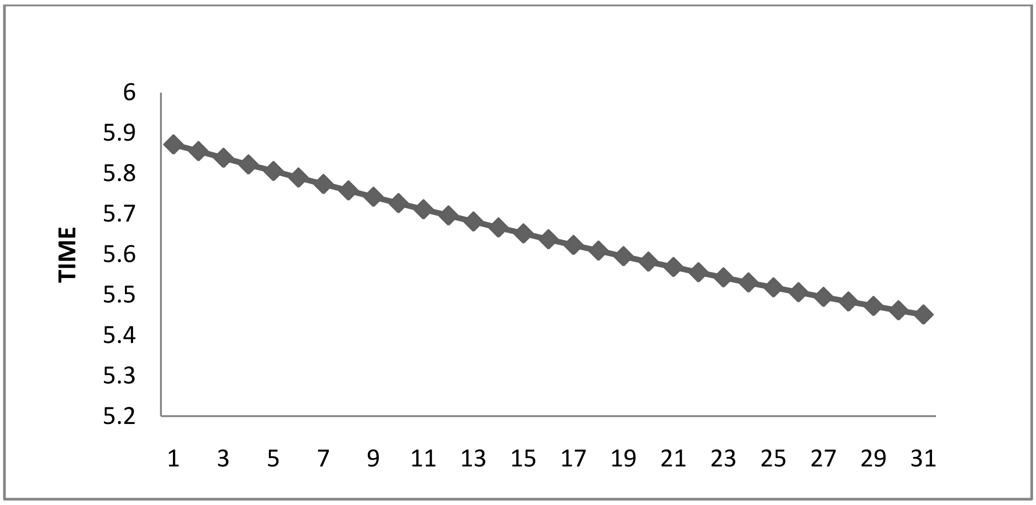

Figure 10. Shows The Predicted Sunset Time in October 2017

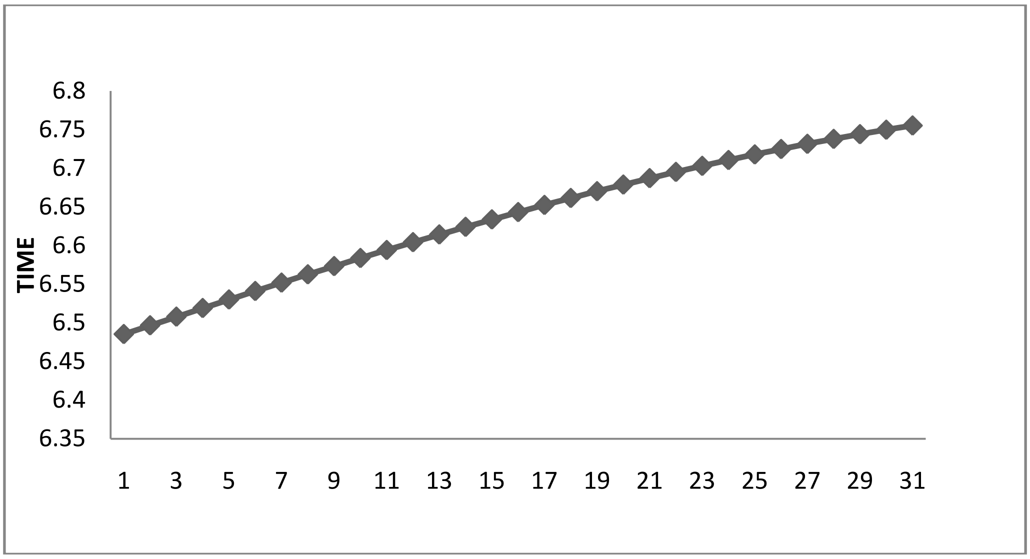

Figure 11. Shows The Predicted Sunrise Time in November 2017

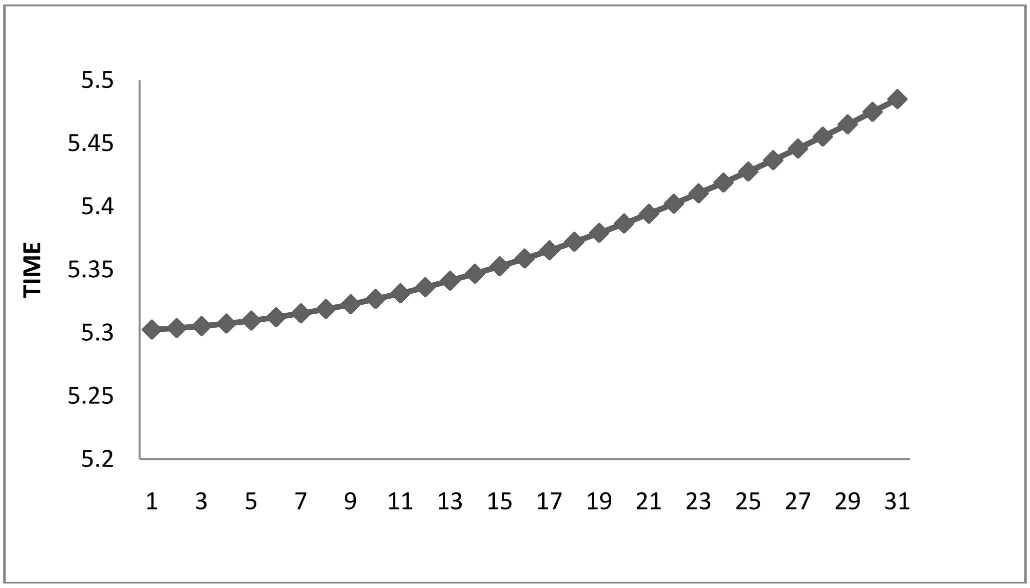

Figure 12. Shows The Predicted Sunset Time in November 2017

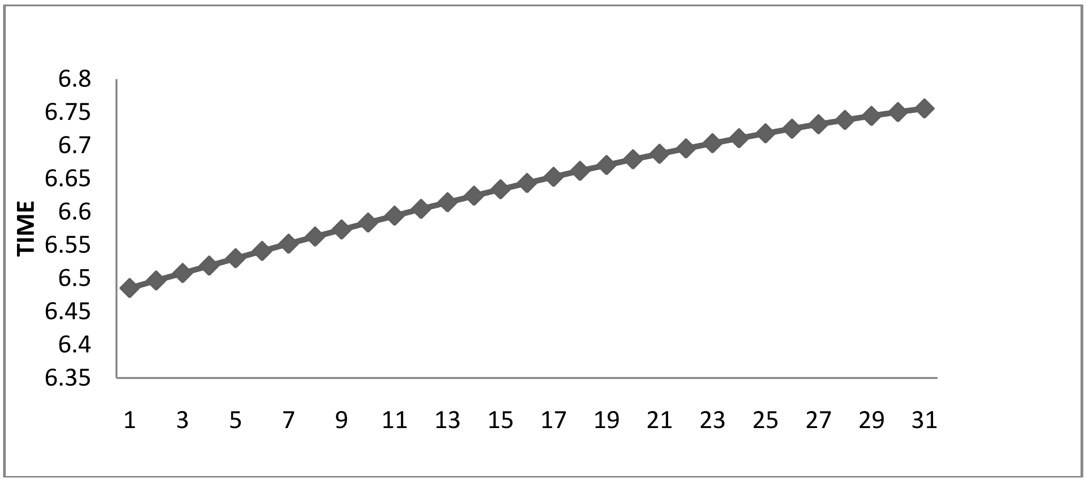

Figure 13. Shows The Predicted Sunrise Time in December 2017

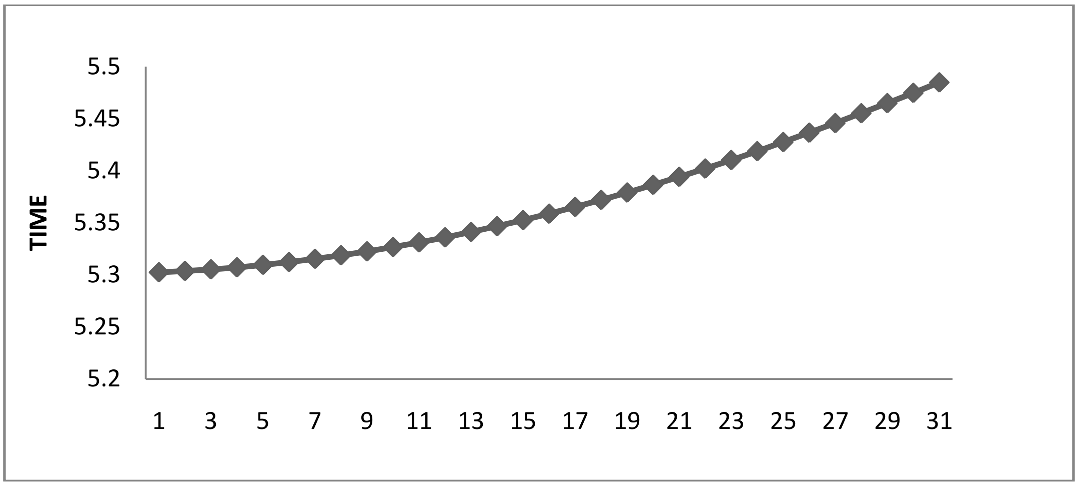

Figure 14. Shows The Predicted Sunset Time in December 2017

IV. Conclusion

We may conclude that our study on sunrise and sunset time calculation is more than 97% accurate with observed sunrise and sunset time in specific latitude (Jessore). This work is very useful for finding the Muslim prayer time calculation. The calculated Sunrise and Sunset time will be more accurate if we may use more effective factor, such like Anomaly, Node factor etc. Finally, this work is more efficient for finding the twilight timecalculation.

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