Scientific Perspective of Traditional Long-term Weather Forecasting System of Hindus in Sri Lanka

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Abstract

Weather forecasting is becoming complicated due to the rapid and unpredictable climate changes in many countries. Hence various groups of people use numerous weather forecasting systems worldwide. Many countries have promoted their local and indigenous knowledge in all sectors towards sustainable development in recent times. In this context, Sri Lankan Hindu Tamils follow the sentential almanac (*Ragunathaiyar Suththa Vaakkiya Panchangam*) for long- or short-term weather forecasting. This study attempts to identify the scientific perspective of the relationship between long-term weather prediction indicated in the almanac and actual weather observations and measurements. All weather-related data (annual total and average) for fifty years from 1970 were collected from the Department of Meteorology for 16 stations. The almanac was also gathered from the same years. The collected data were analyzed using the correlation analysis method, which indicated a strong positive correlation between the observed annual total rainfall and the almanac predicted malai marakkal. According to the almanac, when mars is the ruling planet of a year, that year has a scanty rainfall, and when the moon is the ruling planet, rainfall is very heavy; thus, the rainfall varies based on the minister planet. Also, the rainfall varies based on the megathipathi planet of each planet. The average temperature was very high during the Kandavanam period. The almanac and actual weather phenomena disclosed a strong relationship, and the almanac predicted weather forecasting is more accurate and reliable for the short-term and long-term weather forecasting usage. However, the reliability in weather prediction of the almanac primarily depends on the accurate and appropriate reading and writing of the literature. A correctly explained almanac could be a reliable source for long-term weather forecasting and planning and development activities.

Keywords: Almanac, Weather, Correlation, Reliability, Forecasting

1. Introduction

Weather and Climate influence human life to a great extent. Every activity of human survival depends on various weather phenomena such as rainfall, temperature, wind, evaporation, and solar radiation. Several instruments help to collect weather data in several weather observation centers worldwide, and a meteorologist uses many

methods to analyze and forecast a location's present and future weather conditions (Praveen et al., 2020).

Weather forecasting, specifically long-term weather forecasting, is essential for human beings' planning and implementation activities. Domestic life and economic activities depend on the weather forecasting reports. Hence, weather forecasting reports are becoming a vital part of day-to-day life. The agricultural sector constantly seeks long-term forecasting to plan cultivation activities (Sivappragasam & Kanagasabai, 2008).

All governments have prioritized weather forecasting to avoid unnecessary human life loss and property damages. Most countries have made many initiations to make accurate weather forecasting in the context of climate change (Wu et al., 2016) but still face difficulties in long-term weather forecasting. Short-term weather forecasting is easy to observe, analyze, and forecast compared to long-term weather forecasting, which is difficult due to sudden changes in weather parameters.

Nevertheless, many organizations attempt to make their weather forecasting more effective and efficient (Angchok & Dubey, 2006), and worldwide, many methods are practiced to forecast weather (Kothawale & Rajeevan, 2017). Most of these methods are associated with modern technologies.

Weather forecasting commenced in the mid-19th century (Knoesen, 2012) and developed with modern information and communication technologies. However, some communities or groups still follow traditional weather forecasting methods. They have set up their lifestyles based on their traditional weather forecasting knowledge (Vanadeep, Sada Siva Murty & Krishnaiah, 2012).

Tamils are the second majority ethnic group in Sri Lanka. Most Tamils follow the Hindu, the oldest religion and the major religious group in India. Sri Lankan Tamils have unique and specific cultural identities, and they have specific customs and values. More than 85% of the Sri Lankan Tamils strictly follow the almanac (Sivappragasam & Kanagasabai, 2008).

Almanac has a powerful influence on every stage of the life cycle (Piratheeparajah, 2016). For three thousand and five hundred years, Tamils, especially the Hindus, used a very high Almanac (Panchangam) system for their holy, ritual, and personal purposes. Tamils, especially farmers and fishers, have been using the *Panchangam* for their meteorological, weather, and climatic purposes for a long time. They have constructed their lifestyle based on the *Panchangam* prediction (Piratheeparajah, 2015).

Hindus in India, Sri Lanka, Nepal, Thailand, Malaysia, Myanmar, Bhutan, France, Germany, America, the United Kingdom, Switzerland, the United States of America, and Singapore use several kinds of almanacs (Anurathan, 2016). Some differences could be identified among these almanacs considering the calculation source, the method, interpretation, and time zones. In Sri Lanka, Hindus mostly use two types of *Panchangam;* one is the "sentential almanac" (*Suththa Vaakkiya Panchangam*), and the other is the "mathematical almanac" (*Thirukkanitha Panchangam*). Generally, Tamils use both, though some time differences could be identified between these two types. The Thirukkanitha Panchangam is based on planetary and astrological calculations (Vanadeep et al., 2012), whereas the Sentential almanac on the sentences provided by pries in the ancient period. The mathematical almanac is based on planets' movement, including the moon (Ragunathaiyar, 2006).

This study primarily focuses on sentential almanac widely used by Tamil Hindus in Sri Lanka. The sentential almanac is based on the statements provided by the various Hindu yogis in various periods and started by Rishi '*Akaththiya'* and Rishi '*Parasara'* and then '*Vedanta Jyothis'* made some modifications. He published a revised 'Vaakiya panchangam' between 1400 - 1300 B.C. *'Brihat Samhita Varahamhira'* rewrote this sentential in 505 A.D. Rishi '*Birhat Samhita*' introduced many meteorological aspects in this new version of sentential almanac (Sivapragasam & Kanagasabai, 2008).

The sentential almanac has a sixty-year cycle, and each year in the almanac has an individual name. After sixty years, one name (year) will reappear. The sixty years is comprised of five major divisions, and each division contains 12 years. This sentential almanac is related to the meteorological aspects and has many weather phenomena described. In this almanac, Rishi 'Parasara' indicated the amount of rainfall (indicated as 'Marakkal'), angle of Sun and temperature (indicated in the phase of *'Kandavanam'*), wind direction changes ('Ketpoddam'), cloud types, amount of clouds, and the number of rainy days. Birhat Samhita noted that the meteorological aspects depend on the ruling planet, the minister planet, and other '*Athipathi'* planets. The sentential elaborated long-term weather forecasting, especially rainfall and rainy days, in the early stage of the year, sometime before the beginning of a particular year (Regulagedda Akshay, 2007).

Climate change is an emerging issue, and everyone is thinking and talking about the climate change impacts. Many policymakers and development planners seek possible ways to predict the climate change impacts in advance because it helps them to design and prepare their plans (Piratheeparajah, 2015), (Malmgren et al., 2003)**,**

(Basnayake et al., 2003), (De Costa, 2010). In this context, the present study examines the reliability and accuracy of the weather forecasting by the almanac as compared to actual situations that prevailed during this period.

Studies on the local indigenous or traditional weather forecasting methods worldwide are limited, and only a few have investigated the Hindu's almanac in Sri Lanka (Basnayake et al., 2003). This study's main objective is to identify the reliability of the climatic prediction of the Hindu almanac and define the relationship between the climatic forecasts of almanac rainy days, temperature, and wind.

2. Data

The Northern region of Sri Lanka, located in the northernmost part of the country, was the study area chosen for the investigation. The Palk Strait, Arabic Sea, Bay of Bengal, and the Northcentral provinces are the region's boundaries (Figure 1). The actual daily, monthly, and annual rainfall and rainy days' data for the Northern Province, for fifty years from 1970 to 2020 (a majority of Hindus live in this province), were collected from the Department of Meteorology.

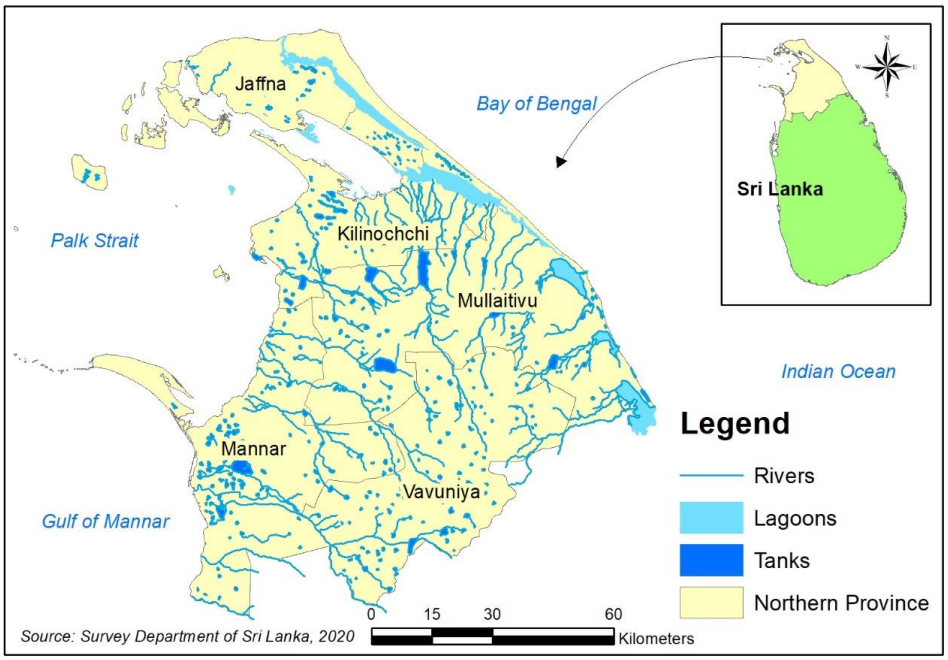

Figure 1. Map of the Northern region of Sri Lanka

2.1. Almanac Data

The Northern region of Sri Lanka can be generalized for the *Panchangam* predicted weather phenomena because most Northern provinces use the almanac for all their activities and fix dates for their holy or ritual initiations. Over 71% of the Northern Province of Sri Lanka population use a sentential almanac (*Ragunathaiyar Suththa Vaakkiya Panchangam)* for various purposes. Hence this almanac is considered as the vital source of a document to obtain almanac data.

The almanac indicates the weather details based on the sentences provided by earlier pries using poetry lyrics. This study acknowledged fifty years from 1970 to 2020. The almanac has a 60-year cycle from 'Dhathu' to 'Yuwa,' and every year has a separate Tamil name. Each name will return after sixty years. Every year has a different name, and one name will reappear after sixty years, which is a cyclic pattern. Rishi 'Birhat Samhita' proposed the name of a particular year in the 5th century. According to this almanac, the year starts in April (14th of April), and the almanac per particular year indicates and commences the facts on the specific date.

The almanac years in Table 1 signify the almanac predictions of the quantity of rainfall and rainy days, Kandavanam, and Ketpoddam, by Pancahnagam (Regulagedda Akshay, 2007).

Table 1. Almanac Years

No.	Almanac Year	No.	Almanac Year	No.	Almanac Year
1	Dhathu	21	Avilambi	41	Pingala
2	Eswara	22	Vilambi	42	Kalayukthi
3	Vegudanya	23	Vikari	43	Chitharthi
4	Pramaathi	24	Saarvari	44	Routhri
5	Vikrama	25	Pilava	45	Thunmathi
6	Vishu	26	Subakirudhu	46	Thundhubi
7	Chitrabanu	27	Sobakiruthu	47	Ruthrothkari
8	Subanu	28	Krothi	48	Rakthakshi
9	Tharana	29	Visuvavasu	49	Krodhana
10	Parthiba	30	Akshara	50	Akshaya
11	Viya	31	Parabava	51	Prabhava
12	Sarvachithu	32	Pilavanga	52	Vibhava
13	Sarvathari	33	Keelaga	53	Sukhila

14	Virodhi	34	Sowmiya	54	Pramodhuda
15	Vikruthi	35	Sadharana	55	Prjothpathi
16	Kara	36	Virodhikirudh	56	Aangirasa
17	Nandhana	37	Paridhabi	57	Srimuga
18	Vijaya	38	Piramadheesa	58	Paava
19	Manmadha	39	Anandha	59	Pirabava
20	Dhurmugi	40	Rakshasa	60	Yuva

Source: Sivappragasam & Kanagasabai, (2008)

The almanac elaborates a unique system about the weather. Only specific weather parameters are indicated in the almanac: rainfall, extreme temperature, wind direction. The Panchangam denotes the following for every year:

1. The Ruling planet (the main planet for the particular year and upon which the fundamental aspects of the year are calculated based on its unique characteristics),
2. The Minister planet (the second dominant planet in the solar system which is supporting the ruling planet for the particular year),
3. The Megathipathi planet (the planet which determines the entire weather system of that particular year), and
4. The yogis classify Megam (the kind of cloud), and this panchangam says rainfall and rainy days are determined as per this classification.

In the almanac, rainfall is given under the name of 'Malai marakkal*,'* and its amount is mentioned in the Marakkal scale. Marakkal is one of the measuring tools used by the ancient Hindus for a long time to measure grains and liquids. The scale of received rainfall is indicated in the number of marakkal in the almanac: One marakkal is equal to 300 mm rainfall. However, that amount is reported for the whole year. The Almanac year will start in April and end in March. The almanac indicates the total amount of rainfall when it is published in April.

Kandavanam indicates the extreme temperature and the hottest days in a particular month as defined period and certain days. Almanac suggests that the Kandavanam would start on this particular day and end on this specific day; the period between these two specific days is called the *Kandavanam period*. Panchangam points out that this period will be the hottest day of every year. The comparative analysis attempted to identify whether the Kandavanam period is the hottest day of the year.

2.2. Observed weather data

The observed rainfall, temperature, and wind data were collected from the Department of Meteorology for fifty years, starting from 1970. The almanac indicates only the annual rainfall amount. Hence, the total yearly rainfall was collected for this study to compare the almanac predicted and observed rainfall. There is no particular rain gauge station for the almanac. The almanac indicates weather details for the entire region. Therefore, this study considers the average values of sixteen stations functioning in the Northern Province of Sri Lanka. First, the annual total rainfall for the fifty years was collected from the sixteen stations, followed by summarizing and obtaining the average annual total rainfall for the Northern region of Sri Lanka. The temperature data for the entire region were collected from two stations only such as Thirunelvely and Vavuniya and summarized to obtaine the average value for the study area.

3. Methodology

The Pearson correlation analysis method was used to identify the relationship between the actual rainfall and the Panchangam predicted rain. The concept of correlation is a method to examine the relationship between two variables, and correlation analysis involves various methods and techniques used to analyze and measure the extent of the relationship between the two variables. The coefficient correlation method was applied for this study.

Correlation analysis techniques are the most efficient and widely used statistics for many researchers. The “r” measures the association of degree between the two different values provided in the data set.

The following formula gives the coefficient of correlation “r”:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}$$

The coefficient correlation analysis was performed using Microsoft Excel software. The analyzed results were figured using a Microsoft Excel worksheet, and results were interpreted in the results and discussion part.

4. Results and Discussion

The almanac indicates a ruling planet, minister planet, megathipathi, and megam details, which describe the weather forecasting details in the almanac. Table 2

elaborates the ruling, minister, megathipathi, megam, and annual total rainfall details.

Table 2. Details of the almanac year, ruling and minister planets, and almanac predicted and observed rainfall

No.	English Year	Almanac Year	Ruling Planet	Minister Planet	Magathi pathi	Megam	Marakkal in number	Observed rainfall in mm
1	1970-71	Sadharana	Mars	Moon	Moon	Varuna	2	1420
2	1971-72	Virodhikirudh	Saturn	Mercury	Mars	Neela	1	1204
3	1972-73	Paridhabi	Jupiter	Jupiter	Mercury	Kaala	4	1502
4	1973-74	Piramadheesa	Mercury	Venus	Jupiter	Drona	3	1289
5	1974-75	Anandha	Sun	Saturn	Saturn	Pushkala	1	996
6	1975-76	Rakshasa	Saturn	Moon	Sun	Samvartha	1	1320
7	1977-78	Pingala	Sun	Mercury	Mercury	Dhamo	1	1256
8	1978-79	Kalayukthi	Saturn	Jupiter	Jupiter	Vaayu	1	1428
9	1979-80	Chitharthi	Jupiter	Saturn	Venus	Varuna	4	1178
10	1980-81	Routhri	Moon	Sun	Saturn	Neela	3	1245
11	1981-82	Thunmathi	Sun	Moon	Moon	Kaala	1	1290
12	1982-83	Thundhubi	Venus	Mars	Mars	Drona	4	1310
13	1983-84	Ruthrothkari	Jupiter	Jupiter	Mercury	Pushkala	4	1304
14	1984-85	Rakthakshi	Moon	Venus	Jupiter	Samvarta	4	1607
15	1985-86	Krodhana	Venus	Saturn	Saturn	Avarta	4	1392
16	1986-87	Akshaya	Jupiter	Moon	Sun	Dhamo	4	1429
17	1987-88	Prabhava	Moon	Mars	Moon	Vaayu	3	1209
18	1988-89	Vibhava	Venus	Mercury	Mars	Varuna	4	1147
19	1989-90	Sukhila	Venus	Jupiter	Jupiter	Neela	4	1321
20	1990-91	Pramodhuda	Mars	Saturn	Venus	Kaala	2	1006
21	1991-92	Prjothpathi	Sun	Sun	Saturn	Drona	1	956
22	1992-93	Aangirasa	Saturn	Moon	Sun	Pushkala	1	1065
23	1993-94	Srimuga	Mercury	Mars	Mars	Samvarta	3	1153
24	1994-95	Paava	Mars	Jupiter	Mercury	Avarta	2	1280
25	1995-96	Yuva	Moon	Venus	Jupiter	Dhamo	1	1420
26	1996-97	Dhathu	Jubiter	Moon	Saturn	Kaala	3	1175
27	1997-98	Eswara	Sun	Saturn	Sun	Drona	2	1028

28	1998-99	Vegudanya	Venus	Mercury	Saturn	Pushkala	2	1175
29	1999-2000	Pramaathi	Venus	Jupiter	Mercury	Samvartha	4	1492
30	2000-01	Vikrama	Moon	Saturn	Saturn	Avarta	4	1320
31	2001-02	Vishu	Saturn	Sun	Venus	Dhamo	2	1140
32	2002-03	Chitrabanu	Venus	Moon	Sun	Vaayu	3	988
33	2003-04	Subanu	Sun	Saturn	Moon	Varuna	3	1160
34	2004-05	Tharana	Mercury	Jupiter	Saturn	Neela	3	1298
35	2005-06	Parthiba	Jupiter	Venus	Mercury	Kaala	4	1426
36	2006-07	Viya	Venus	Saturn	Venus	Drona	4	1238
37	2007-08	Sarvachithu	Jupiter	Sun	Saturn	Pushkala	3	1283
38	2008-09	Sarvathari	Moon	Saturn	Sun	Samvartha	4	1502
39	2009-10	Virodhi	Venus	Mercury	Moon	Avarta	4	1430
40	2010-11	Vikruthi	Saturn	Jupiter	Jupiter	Dhamo	3	1210
41	2011-12	Kara	Sun	Venus	Jupiter	Vaayu	3	1261
42	2012-13	Nandhana	Mars	Sun	Venus	Varuna	3	975
43	2013-14	Vijaya	Mercury	Moon	Sun	Neela	3	1045
44	2014-15	Jaya	Sun	Saturn	Moon	Kaala	3	1219
45	2015-16	Manmadha	Jupiter	Mercury	Saturn	Drona	3	1380
46	2016-17	Dhurmugi	Saturn	Venus	Jupiter	Pushkala	3	1290
47	2017-18	Avilambi	Mars	Saturn	Venus	Samvartha	2	982
48	2018-19	Vilampi	Venus	Mercury	Saturn	Avarta	3	1230
49	2019-20	Vihari	Jupiter	Sun	Moon	Dhamo	2	1180
50	2020-21	Sarvari	Sun	Saturn	Jupiter	Vaayu	3	1286

Source: Ragunathaiyar Vengadesakkurukkal Vaakkiya panchangam (1970-2020)

4.1. Actual and Almanac Rainfall relationship

A similar linear line pattern of almanac and observed rainfall pattern is noted in the Northern region of Sri Lanka. The almanac and observed rainfall patterns are similar, and the lines fall in the same curves. The same increase and decrease patterns could be identified in the almanac predicted and the observed rainfall pattern in the study area (Figure 2).

Correlation analysis techniques identified the relationship between the almanac, indicating total rainfall amount and the recorded actual rainfall amount. 'X' values show the almanac rainfall in *Marakkal*, and the 'Y' value indicates the actual rainfall**.**

The average of the marakkal for ninety years is 3.03, as indicated in the almanac, and the actual average rainfall of the study area is 1251 mm. The r-value of the correlation analysis between the almanacs indicated marakkal. The actual rainfall is 0.7816, which is a strong positive correlation. In other words, there is an accurate prediction of annual total rainfall by almanac every year (Figure 3).

A highly positive correlation has been identified between the almanac rainfall and the actual rainfall. If the almanac rainfall is more than three (03) *marakkal*, the actual rain is always above 1100 mm.

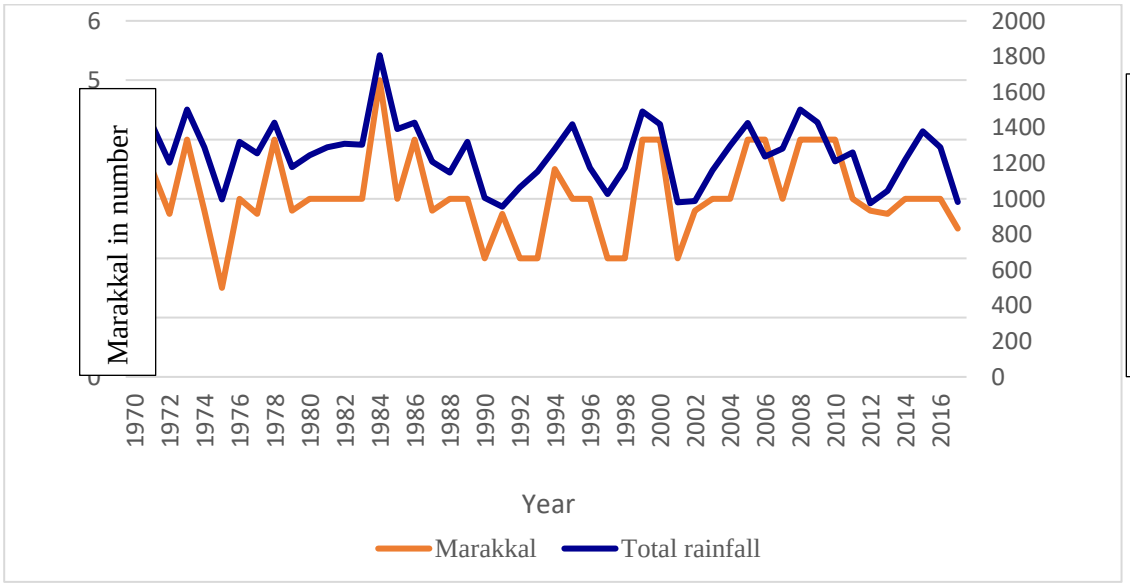

Figure 2. The trend of Observed Rainfall and Almanac predicted Rainfall (*Marakkal*)

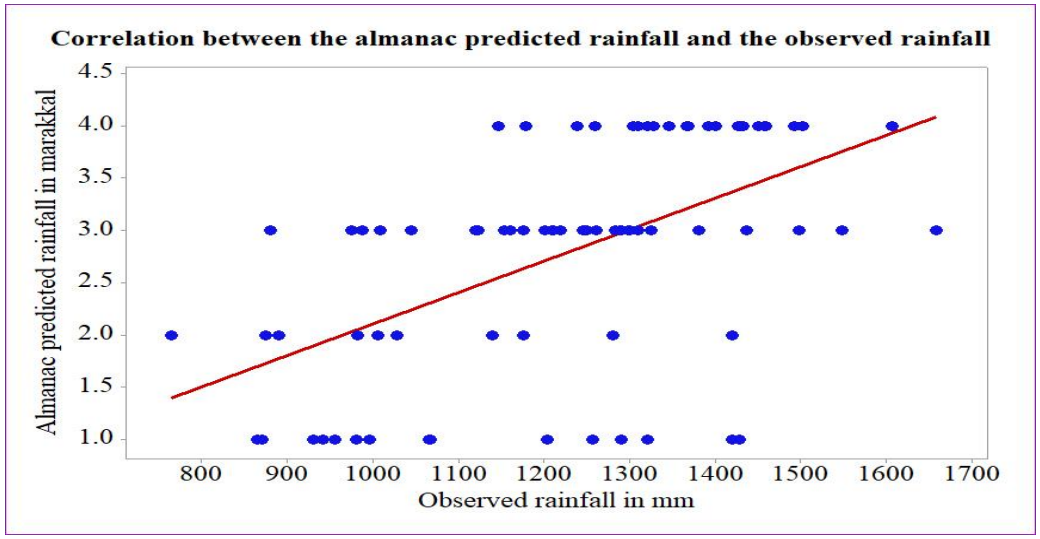

Figure 3. Correlation between the almanac predicted and observed rainfall in the Northern region of Sri Lanka

Comparing the almanac and actual rainfall in the line chart disclosed that the trend and the rhythms are in the same pattern. There is a strong relationship between the ruling planet and the rainfall. The rainfall is high when some specific planets function as the ruling planet, while others give a meager rainfall. In that way, if Mars is the ruling planet, the rainfall is scanty, and if the moon is the ruling planet, the region gets very high rainfall.

Table 3 indicates the relationship between the ruling planet and the rainfall. Compared to all other planets, 90% of the heavy rain is recorded when the moon is the ruling planet; on the other hand, 82% of the low amount of rainfall is recorded during the ruling period of Mars.

Table 3. Relationship between the ruling planet and rainfall

Ruling Planet	Rainfall
Mars	Scanty
Saturn	Very Low
Sun	Moderate
Mercury/Venus	Good
Jupiter	Very Good
Moon	Very Heavy

Also, we can see the different scales of rainfall in every planet when they act as the minister planet according to the almanac. If the minister is mercury, a high amount of rainfall is recorded, and if the minister is Saturn, the recorded rain is low. Table 4 indicates the relationship between the minister plant and the rainfall.

Table 4: Relationship between the minister planet and rainfall

Minister	Rainfall
Mercury	Very Good
Jupiter/ Venus	Good
Sun	Moderate
Saturn	Low

Megathipathi is vital to determine the rainfall. If the *megathipathi* is Moon or Jupiter, there will be a reasonable extent of rain; if the sun or Saturn is *megathipathi*, the rainfall is low (Table 5).

Table 5: The relationship between *megathipathi* planet and rainfall

Megathipathi	Rainfall
Moon	Very Good
Jupiter	Good
Mars	Moderate
Venus	Moderate

4.2. Kandavanam

Kandavanam is the crucial word in the almanac of Hindus because it is about the amount of solar radiation and the temperature. Almanac says not to involve in any new activity during the Kandavanam period because of the increased temperature. According to the almanac of Hindus, kandavanam will be eight to thirteen days' period (Figure 4). Whenever the almanac indicates any kandavanam that will be the highest temperature period, with the maximum received solar radiation period. Forty-seven out of 60 years' almanac accurately predicted the maximum temperature period during the last sixty years.

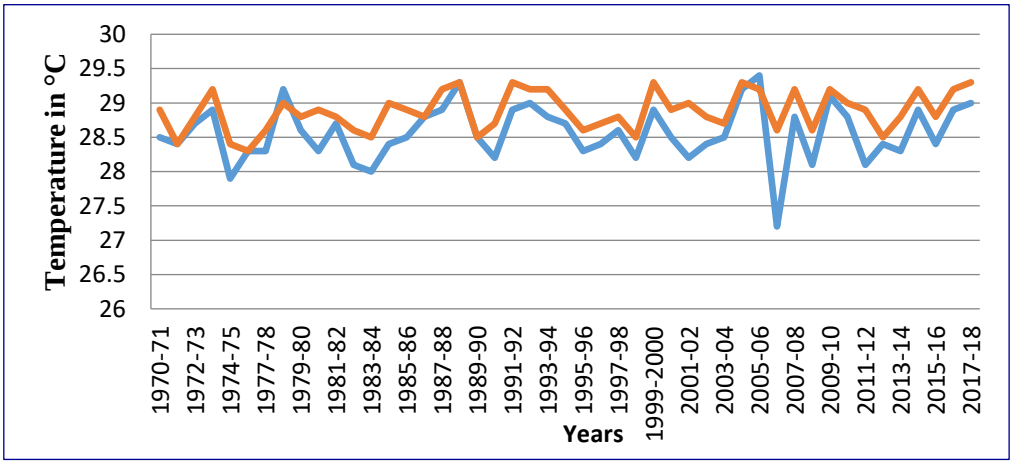

Figure 4. Observed Average Temperature (in Blue color) and *Kandavanam* predicted Average Temperature (in Red Color)

Several studies have been conducted in Sri Lanka related to weather and climate. Nevertheless, no studies related to almanac and rainfall or any other weather features are available. However, some findings explain the local indigenous knowledge on the weather pattern. A survey about the almanac-predicted weather system (Lacombe et al., 2019) describes the earliest methods related to weather forecasting. Balachandran (2001) explained the temperature and the kandavanam in the Jaffna region and revealed a strong relationship between the kandavanam and temperature; the current study also presents the same results.

The rainfall pattern of the northern region is fluctuating, and climate change affects the region's climatic pattern. Hence, the traditional system must be adapted to mitigate climate change (Malmgren et al., 2003). However, no study is directly related to the almanac and observed rainfall in any part of Sri Lanka.

The almanac predicted the total amount of rainfall for the entire region for the year. However, this kind of forecasting is not usable for farmers and other people who need weather forecasting. Nevertheless, all people consider the kandavanam and consider the kandavanam period to commence any new activity, including building a house, celebrating special events, and fixing new farming activities.

5. Conclusion

The almanac has had a tremendous system for weather prediction for a long time. Strong positive correlations have been identified when the almanac indicated rainfall was compared with the actual rainfall in the Northern region of Sri Lanka for the last ninety years. The almanac indicated rainfall as marakkal is more related to the actual rainfall.

Also, a strong relationship exists between the ruling planet and the total rainfall of the study area. When the Moon is the ruling planet, we experience heavy rainfall, and when Mars is the ruling planet, we receive deficient rainfall. A strong relationship is also present between the minister planet and the received total rainfall. The almanac indicated the Kandavanam period, during which the study area experienced the highest temperature.

According to the reliability of the climatic predictions of Hindu calendars, a highly significant positive correlation is observed in the actual and almanac rainfall; the trend of rain also follows the same pattern. There is a similarity in the maximum temperature and the amount of received solar radiation as indicated by the almanac.

According to the analysis, scientific perspectives have been identified in the almanac-predicted rainfall amount and the temperature extremes compared with the absolute measurements and observations. However, the accuracy of the prediction mainly depends on the almanac interpretation. If written or explained in a certain level of accuracy, the prediction of rainfall and temperature of the Hindu almanac could act as a vital document source for long-term weather forecasting.

References

Angchok, D. & Dubey, V.K. (2006). The traditional method of rainfall prediction through Almanacs in Ladakh. *Indian Journal of Traditional Knowledge*, Vol.05 (01), 145-150.

Anurathan.K.L. (2016). India's traditional weather forecasting systems. *Indian Journal of Traditional Knowledge*, Vol.02 (02), 120-130.

Balachandran, S. (2001). *Applied Climatology*. Department of Geography, University of Jaffna.

Basnayake, B. R. S. B., Punyawardena, B. V. R., & Vithanage, J. C. (2003). An investigation of ambient air temperature trends at Hambantota – Angunakolapelassa and Nuwara Eliya - Thalawakele. *Proceedings of the 59thAnnual Session of Sri Lanka Association for the Advancement of Science (SLASS). Section E1*, 194–199.

De Costa, W. A. J. M. (2010). Adaptation of agricultural crop production to climate change: A policy framework for Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, *38*(2), 79–89. https://doi.org/10.4038/jnsfsr.v38i2.2032

Knoesen, D. M. (2012). Integrating hydro-climatic hazards and climate changes as a tool for adaptive water resources management in the Orange River catchment. *School of Bioresources Engineering and Environmental Hydrology*, *May*, 234.

Kothawale, D. R., & Rajeevan, M. (2017). Monthly, Seasonal and Annual Rainfall Time Series for All-India, Homogeneous Regions and Meteorological Subdivisions : 1871-2016. *Indian Institute of Tropical Meteorology (IITM) Earth System Science Organization, Ministry of Earth Sciences*, *02*, 1–164.

Lacombe, G., Chinnasamy, P., & Nicol, A. (2019). Review of climate change science, knowledge, and impacts on water resources in South Asia. Background Paper 1. In *International Water Management Institute*. https://doi.org/10.5337/2019.202

Malmgren, B. A., Hulugalla, R., Hayashi, Y., & Mikami, T. (2003). Precipitation trends in Sri Lanka since the 1870s and relationships to El Niño-southern oscillation. *International Journal of Climatology*, *23*(10), 1235–1252. https://doi.org/10.1002/joc.921

Praveen, B., Talukdar, S., Shahfahad, Mahato, S., Mondal, J., Sharma, P., Islam, A. R. M. T., & Rahman, A. (2020). Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. *Scientific Reports*, *10*(1), 1–21. https://doi.org/10.1038/s41598-020-67228-7

Piratheeparajah, N. (2016). Temporal and Spatial Variations of the Atmospheric Temperature in the Northern Province of Sri Lanka. *International Research Journal of Environment Sciences,* Vol. 5(5), 63-67

Piratheeparajah, N. (2015). Spatial and Temporal Variations of Rainfall in the Northern Province of Sri Lanka. *Journal of Environment and Earth Science*, Vol.5, No.15, 179-189

Ragunathaiyar Vengadesakkurukkal Vaakkiya panchangam (1935-2017), Saivapprgasa Iyanthira saalai, Kokkuvil, Jaffna, Sri Lanka

Regulagedda Akshay. (2007). Panchanga- Tantra: the Magic of the Indian Calendar System. *National University of Singapore*, Singapore, 1-45

Sivappragasam, S. & Kanagasabai, V. (2008). Traditional Almanac Predicted Rainfall- A Case Study. *Indian Journal of Traditional Knowledge*, Vol.08, (04), 621-625

Vanadeep, K. Sada Siva Murty, R. & Krishnaiah, M. (2012). Meteorological predictions preserved in the Panchangam versus real-time observations – a case study Tirupati region – a semi-arid tropical site in India. *Indian Journal of Science and Technology*, Vol. 5 No.4, 2491- 2509

Wu, H., Huang, M., Tang, Q., Kirschbaum, D. B., & Ward, P. (2016). Hydrometeorological Hazards: Monitoring, Forecasting, Risk Assessment, and Socioeconomic Responses. *Advances in Meteorology*, *2016*, 11–14. https://doi.org/10.1155/2016/2367939