Traditional Predictors of Monsoon in Rajasthan

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Abstract :- Economy of Rajasthan is based on agriculture; according to census of India 2011; 62% of its total population is directly or indirectly based on agriculture. 70% of total agricultural land is rainfed here. Summer monsoon contributes 80% of total rainfall. Approximate total kharif crops are dependent on monsoon. Quantity, uncertainty, delay and gap of monsoon deeply affects kharif crops; even quantity affects rabi crops too. Prediction of monsoon plays most important role in selection of crops and to determine the time of sowing seeds for farmers. India Meteorological Department is continuous trying to improve the systems of forecasting the monsoon but still there is no method with 100% accuracy. So we need to overview the traditional methos of prediction of monsoon which were developed in thousands of years by thousands of experienced persons. This study is a overview of both scientific and traditional methods of forecasting the monsoon similarly.

Key words :- SST = Sea Surface Temperature, LRF = Long Range Forecast, IMD = India Meteorological Department, AISMR = All India Summer Monsoon Rainfall, LRSF = Long Range Summer Forecast,

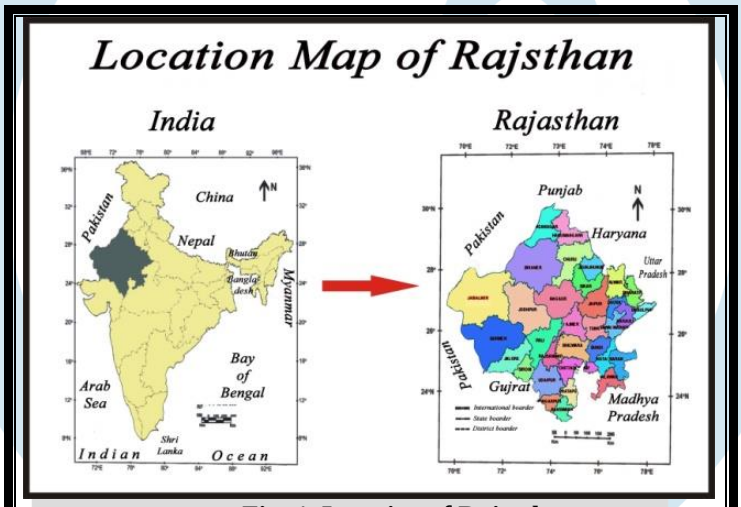


Fig.-1. Location of Rajasthan

Study Area:- Rajasthan is situated in North-East part of India among 23º3'N to 30º12'N and 69º30'E to 78º17'E in shape of irregular rhomboid and 10.41% of the country. It is five times larger than shri Lanka, three times of Czechoslovakia, seventeen times of Israel, more than two times of England and little bit smaller to Japan.

Rajasthan can be divided into four physical divisions like Western desert, Aravalli mountains, Eastern plains and South-eastern plateau, five climatic zones like wet, humid sub humid, semi arid and arid, nine soil zones like Sandy soil, Brown sandy soil, Alluvial soil, Red-yellow soil, Medium black soil, Red-black soil, Red-loamy soil and Brown sandy alluvial soil and into ten Agro-climatic zones.

Aravali mountain chain is dilated from south west to north east in the state. Ever flowing Chambal and Mahi and Luni, Banas, Kothari, Kali sindh, Jakham, Som, Ahu, Parvati, Banh ganga, Ghagghar, Western banas, Sukadi, Jojadi, Parvan, Khari, Rupangarh, Mendha etc. are seasonal rivers in the state. Lunkaransar, Sambhar, Pachbhadra, Degana, Parbatsar are saline and Jaysamand, Rajsamand, Talabsahi, Gebsagar, Annasagar, Kaylana, Kolayat, Foysagar, Narayansagar, Silisedh etc. are sweet water lakes scattered in the state. Only 1% underground water of the nation is found in Rajasthan.

Maximum average temperature of western Rajasthan is 36.1ºC and 33.3ºC in eastern part. Minimum average temperature is generally found between 17.7ºC to 21.1ºC. Average annual rainfall of the state is 57 cm. It lays in BWhw and BShw type climatic zones according to Koppen's climate classification. Land use of the state is as follows- net cultivated area is 51%, gross irrigated area is 43% out of which 67% area is irrigated by wells and tubewells. 17% land is uncultivated and 11.36% is fallow land. Average holding size in the state is 3.38 hactare and per capita available agriculture land is 0.49 hactare.

According to administration point of view there are 33 districts, 289 blocks, 295 panchayat samities and 314 tehsils in the state.

Introduction :- According to census 2011; 54.6% of total workforce of India is engaged in agricultural and allied sector activities and accounts for 17.8% of country's Gross Value Added (GVA) for the year 2019-20 (at current price). In the state, there are 62% of total population is dependent on agriculture and accounts 26% of SDP. Indian agriculture is the gamble of monsoon. 52.58% of total area (342239 km^2) is under agriculture; of which, only 23.3% is net irrigated, 30.93% is gross irrigated and rest is dependent on monsoon. There are three agriculture seasons; kharif, rabi and jayad starts from July, which is the first month of

agriculture calendar. The soils are coarse and poor in fertility and cropping intensity is only 138.8% (2015-16). 70% agriculture land is rainfed while approx total kharif crops are dependent on monsoon only. In this way the monsoon deeply affects the life of folks.

Monsoon :- Al Masudi, Al- Balkhi, Halley, Flohn, M.T.Yin, Gilbert Walker, Smith and so many others have widely described the mechanism of monsoon. The common thing is that it is the opposite flow of air in a calendar; for six month it flows from south-west to North-East direction and for the rest six months reciprocally.

India is the first country to start operational seasonal prediction. The first forecast was issued on June,4 1886 based on the inverse relationship between the Himalayan snow cover and Indian summer monsoon rainfall (ISMR). In early 1900s Gilbert Walker made significant contributions to the Long Range Forecasting (LRF) system in India. He introduced the concept of correlation and regression approach in LRF. Since 1988 A.D. the India Meteorological Department (IMD) has been issuing forecasts based on 16 parameters power regression and parametric models. In 2k, four new promising predictors were introduced in the operational models. In spite of serious efforts by the modelling groups, there are still problems in the dynamical predictions of Indian monsoon. There are apparent four seasons based on monsoon in India:-

i. North-East monsoon season = from December, 1st to March, 15th
ii. Dry summer season = from March, 15th to June, 15th
iii. South-West monsoon season = from June, 15th to September, 30th
iv. Retrieving of monsoon season = from October, 1st to November 30th

In 2k, four predictors whose relationship with ISMR has weakened were replaced from the 16 parameter model. The four predictors removed from the model are :-

a. April 500 hPa ridge position
b. North India temperature (March)
c. 10 hPa zonal wind
d. Spring Darwin pressure

This revised model was used in 2000 for the operational Long Range Forecast of monsoon rainfall over the country as a whole. The new four predictors used in the revised model are :-

a. Arabian sea SST (November to January)
b. South Indian Ocean SST (February + March)
c. Europe pressure gradient (January)
d. Darwin MSL pressure tendency (April-January)

List of 16 parameters :-

1. El-Nino (same year)
2. El-Nino (previous year)
3. South Indian Ocean SST (February + March)
4. East coast Indian temperature (March)
5. Arabian sea SST (November + December + January)
6. temperature of central India (May)
7. NH temperature (January + February)
8. Darwin pressure tendency (April-January)
9. NH Pressure (January-April)
10. Southern oscillation index (March-May)
11. Indian ocean equatorial pressure (January to May)
12. Europe pressure gradient (January)
13. Argentina pressure (April)
14. 50 hPa east-west ridge extension (January + February)
15. Himalayan snow cover (January to March)
16. Euratian snow cover (December)

At this time, the IMD issues LRSF for the ensuring south-west monsoon rainfall spanning the four months period (June to September) over the country as a whole as well as for three homogeneous regions, viz- North-West India, North-East India and peninsular India. Models developed by IMD to forecast the monsoon are mentioned below :-

1. Operational models :-

i. Parametric models :- This model provides qualitative forecast and utilizes the signals from 16 antecedent global and regional land-ocean-atmospheric parameters. Analysis of the signals from these parameters indicates that this year, 63% of them are favourable for a normal monsoon. The seasonal rainfall for the country as a whole is thus expected to be normal (defined as ±10% of the long period average value).

ii. Power regression model :- This model provides quantitative forecast and is based on the physical relationship of monsoon rainfall with 16 different individual parameters. According to this model, the total amount of rainfall over the country as a whole during the monsoon season from June to September 2001 is likely to be 98% of its Long Period Average (LPA), with as estimated model error of ±4%.

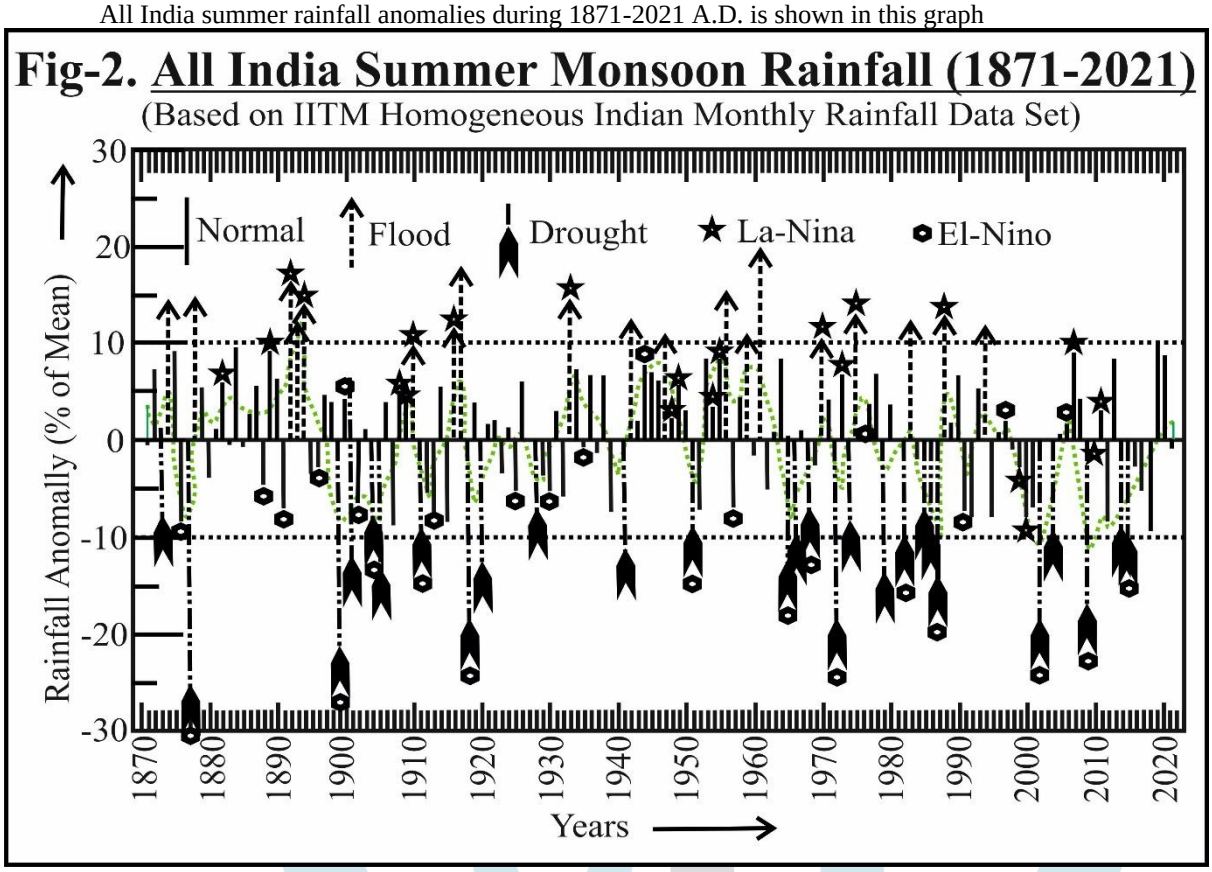
2. Experimental models :- These are written below –

i. Multiple regression model with 6 parameters.
ii. Dynamic stochastic transfer model with east coast India minimum temperature.
iii. Power transfer model with 10 parameters.
iv. Principal component regression model with 8 parameters.

v. Artificial neural network model with 8 parameters.

The forecasts obtained from different models are 101% of LPA from the multiple regression model, 101% of LPA from the principal component regression model and 100% of LPA from the neural network model.

All India summer rainfall anomalies during 1871-2021 A.D. is shown in this graph



The figure-2 shows the time series evolution of AISMR anomalies, expressed as percent departures from its long term mean, over more than a century in the past. Prediction of the future evolution of the monsoon activity, at least a season in advance, remains a difficult challenge. The study says that nearly 6 out of 10 droughts in non-Elnino years occurred during the Indian summer monsoon season in the past century.

Past data reveals that IMD's monsoon predictions are mostly not up to the mark although, at the same time, its long range forecasting skills are improving. IMD's first long range forecast (LRFs) of the monsoon are made in April, 2022 and carry a ±5 percentage point margin of error. Last year, the agency's first LRF of 98% seasonal rainfall was bang on, with the monsoon ending up at 99% of LPA. Such success, however, remained largely elusive in the previous decade (2011-2020), when monsoon rainfall was more than the forecasts margin of error in eight out of the 10 years. The two years when the forecasts came true were 2011 & 2017.

The average deviation of the forecast from the actual rainfall during 2011-2020 was 7.1 percentage point, higher than the error margin of the forecasts. This was an improvement over the previous decade (2001-2010), when the forecasts deviated from actual by 8.6 percentage point on average. During that decade, monsoon rainfall was within the forecast's 5 percentage point error margin on three years (another year, 2003, had a 6 percentage point deviation but both forecast and actual rainfall were in the normal range of 96% - 104%).

However, the three – four accurate forecasts in the 2001-2010 decade were offset by some spectacular failures. IMD's forecasts were out of range by 10 percent or more in four years, as opposed to one in 2011-2020. These included years 2002 and 2009, when the forecasts were off by 20 and 19 percentage points, respectively and 2004, when the forecast deviated by 13 percentage points. This led to a major overhaul of the forecast methodology in 2007.

It's often joked that the monsoon is the second most difficult prediction problem; the most difficult being predicting human behaviour. However, for the efforts and investments being made in monsoon forecasting we are not getting expected results and the improvements are not proportional.

Although the meteorologists are in search of more successive scientific methods to find more accuracy in the prediction of monsoon but we should at least once overview the traditional methods of forecasts; which were developed by experienced persons in thousands of years. Some of these are described below ;-

Traditional predictors :- Our ancestors have developed these predictors during thousands of years by a keen observation. Although IMD is still struggling to forecast of monsoon with 100% accuracy, similarly these traditional method are also not perfect but they are not worst to predict monsoon together. Today also old persons predict season with the help of nearby events in rural areas; modern science calls them biological indicators and these indicators become accurate many times. Some of these are described here :-

Fauna :- Birds and animals has some special god gifted powers to guess the upcoming weather as they are able to predict earthquake; with the senses like pressure sensitive eardrum etc.

- When in summers house sparrow (Passer domesticus) takes mud bath in dry soil is an indicator of heavy rainfall and when it sprawls in water means it will be a weak monsoon in upcoming rainy season.
- Birds tend to get very quite and stop flying before an upcoming cyclone or storm.
- Birds singing in the rain indicates fair weather approaching.
- If crows fly in pairs, expect fine weather; a crow flying alone is a sign of rough weather.
- The red-wattled lapwing (Vanellus indicus) is an Asian lapwing or large plover, a wader in the family Charadriidae. Like other lapwings they are ground birds that are incapable of perching. Their characteristic loud alarm calls are indicators of human or animal movements and the sounds have been variously rendered as did he do it or pity to do it leading to the colloquial name of did-he-do-it bird. Usually seen in pairs or small groups not far from water, they sometimes form large aggregations in the non-breeding season (winter). They nest in a ground scrape laying three to four camouflaged eggs. Adults near the nest fly around, diving at potential predators while calling noisily. The cryptically patterned chicks hatch and immediately follow their parents to feed, hiding by lying low on the ground or in the grass when threatened.

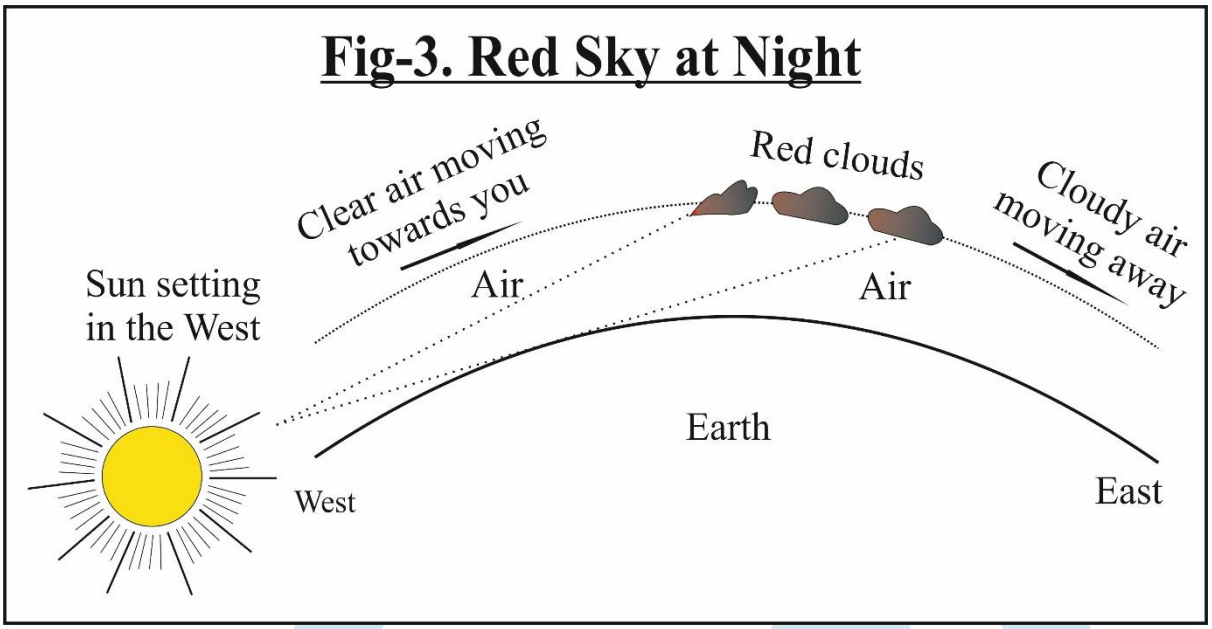
  It never sit on trees and always lays eggs in a nest formatted on the ground. If nest is found in a dry water logging area of pond or river, it means it will drought in coming rainy season. And if found afar from it on a comparatively high place, there will be heavy rainfall. If eggs are found vertical, it is supposed to be heavy rainfall and in case of horizontal it will be raining with intervals. If there are four eggs, indicate heavy rainfall and three eggs indicates drought to average rainfall. If two out of three eggs are adjoining and one is away from rest means there will two months of rainfall and one will be dry in coming rainy season.
- Hawks flying high indicates a clear sky. When they fly low, prepare for a blow.
- Geese fly higher in fair weather than in foul.
- Air pressure does indeed affect birds. For example, swallows have sensitive ears; when the barometric pressure drops, they fly as close to the ground as possible, where air density is greatest. Generally, low flying birds are a sign of rain; high flying indicates fair weather.
- Noise of frogs in the month of May is also an indicator of early monsoon.
- Even there is no any cloud in the sky but there is a noise of a pair of quails (partridges) together is a predictor of sure rainfall.
- Continuous noise of peacocks is also a guaranteed indication of rainfall within 2 or three days.
- If crows make noise late nights in the month of June indicates drought in upcoming monsoon season and the same indicator is crying of jackal during day.

1. Flora :-

- If there are so many leaves on mahuwa (Madhuca longiflora) in summers means very green mahuwa tree indicates good monsoon.
- Green bamboo leaves indicates weak monsoon.
- High quality of ber fruits on ber tree (Ziziphus mauritiana) indicates normal monsoon.
- If doob grass (Cynodon dactylon) is very green in summers than upcoming monsoon will be better to normal or much better.
- Lack of leaves on bel tree (Aegle marmclos) indicates little bit low to normal monsoon.
- More green pipal tree (Ficus religios) and high quantity of leaves indicates normal monsoon.
- Much green neem (Azadirachta indica) and high quality of its fruits indicate weak monsoon.
- If there are so many flowers like chandelier on golden tree (Amaltas; Cassia fistula); it means monsoon will start after 45 days.

3. View of sky :- anyone can forecast the upcoming weather of the day or nearby future by observing the sky with a long time experience or getting advantages from experienced previous generations. Some of these are written below :-

- A sky darkened by large, rolling clouds is a very reliable sign of rain or thunderstorms ahead.
- In the case of the red sky, weather systems that move west to east filter sunlight through their clouds, causing the western sky to illuminate red or orange or pink as the storm recedes at sunset.
- The red eastern sky in the morning is an indicator that storm systems approaching from the east.
- A summer time fog produces dull, hazy yellowness in the sky. Take summer fog as a sign of good weather for the next day.
- On the other hand, winter fog indicates the meeting of air currents of different humidity, which often brings rain.
- Halo around moon and sun indicates heavy rainfall and cyclones but aura around these means; it is a dry day.



❖ Red sky at night, a farmers' delight. Red sky in the morning, farmers take warning.

4. **Flame of Holi :-** Holi is major festival of Sanatan religion. On this occasion Sanatanis Fire woods in the memory of Prahlad. By the flame of Holi farmers of the state predicts the upcoming monsoon like this :-
   - ✓ If the flame is straight in sky vertically and the weather is calm; is the sign of good monsoon in upcoming season.
   - ✓ If in the day of Holi; it is thundering, raining, storm or high speed wind is blowing than monsoon will have high rainfall.
   - ✓ If flame turns in East (if westerlies blow) than monsoon will be better to normal in forthcoming rainy season.
   - ✓ If flame turns in Agneya direction (wind blows from North-West to South-East) than it will be drought.
   - ✓ If flame turns to South direction (if winds blow from North to South direction) than it will be famine.
   - ✓ If flame turns to West (if winds blow from East to West) than monsoon will be normal.
   - ✓ If flame turns into North & Ishan (if winds blow from South & South-West to North & North-East) directions than rainfall will be more than average in upcoming monsoon.
   - ✓ If flame rotates in all directions, indicated heavy drought.
   - ✓ If flame turns to Nairitya (from North-East to South-West) direction also indicates famine.
   - ✓ If flame turns to Vayavya direction (if winds blow from South-East to North-West direction) than there is a high probability of cyclone and dust-devils.
5. **Earthen Pot (*Mataki*) :-** It may seem funny to someone but this parameter is being practiced by farmers of western Rajasthan for decades and mostly it proves true. In this process an earthen pot fully filled with water and tightly covered on its mouth has been put under ground on day of Holi festival. On the day of next Holi villagers get it out from that pit and observe the water level. If *mataki* is still filled fully with water indicates good monsoon; if half filled indicates normal monsoon and if it is empty means there will be drought in upcoming rainy season. And they put next earthen pot filled with water in the pit for forecasting the next years' monsoon.

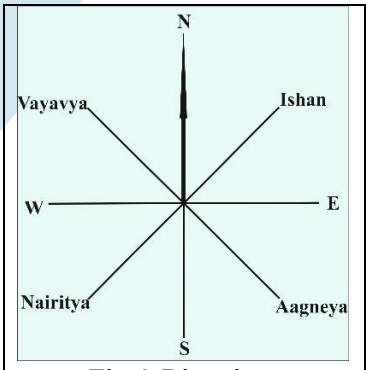


Fig-4. Directions

6. **Sanatan Calender :-** The Sanatan Calendar is based on the calculation of movement of moon and other celestic bodies. We can find out the date & time of solar and lunar eclipses for before and after thousands of years with 100% accuracy and so many others. Similarly these panchangs helps to forecast the monsoon and many times these forecasts become true.

Conclusion :- Monsoon is main determiner of the life of folks even before of Hadappan civilization. Both modern age scientific and traditional methods of forecasting the monsoon have equal importance. Scientific methods are based on data and analytical formulas and traditional methods are based based on experience and observations. These traditional methods cannot be neglected. Animals really have some god gifted power to predict earth quake, oxygen level, air pressure, monsoon etc.; similarly nature has given these powers to vegetations also. Men have observed and analysed these indicators from generation to generation and these traditional methods became parameters. Although till today these both scientific and traditional systems do not have adject accuracy but are being practiced by scientists and villagers respectively.

Suggestions :-

Although we are living in the era of science and technology. But we should not forget that present day prediction technologies of IMD are not accurate; these have low or high deviation from actual rainfall. And these traditional forecasting methods have been developed for thousands of years by thousands of wise persons with continuous deeply observations. So we shouldn't make jokes on these, rather than should deeply study and observe these and these traditional methods should be taught to students similarly with modern scientific methods.

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