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Indigenous knowledge based abiotic indicators used in weather prediction by farmers of Wayanad, Kerala, India

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The paper presents twenty abiotic indicators used by farmers for weather prediction in Wayanad district, Kerala. These indicators were based mainly on the appearance of sky, color and patterns of cloud, moon, wind, rainbow and temperature. The popularity of these indicators among farmers was measured using use validity score (UVS) based on purpose of use, extent of use and perceived reliability. With this score, we categorized the indicators into high, medium and low popularity classes. Five indicators were assessed as high popularity, four as low popularity and the remaining, medium popularity.

Keywords: Indigenous knowledge, Kerala, Weather indicators, Use validity score (UVS)

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Weather is the most important determinant of the success or failure of agricultural enterprises, with a profound influence on crop growth, development and yield[1]. The vulnerability caused by weather uncertainty is embodied in the Indigenous Technical Knowledge (ITK) systems of farmers. ITK is the sum total of knowledge and practices based on people's accumulated experience in dealing with problems related to various aspects of life[2]. ITK is unique to a culture. Largely undocumented and generally passed on from generation to generation through experimental learning processes and word of mouth, ITK-based weather forecasting practiced by humans for millennia helps to reduce uncertainty in agriculture. Before the advent of modern weather forecasting methods, rural communities used ITK, mostly based on observations of atmospheric conditions, astronomic and relief features, to predict weather over short and long periods. Accuracy of predictions was dependent upon the correct interpretation of indicators, which were in turn developed through experience, skills and insights of people over generations. This paper presents indigenous knowledge of abiotic indicators used by Wayanad farmers for weather prediction, validated through farmer participatory processes.

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Methodology

Study area: Wayanad district in Kerala, between North latitudes 11º26′ to 12º00′ and East longitudes 75º 75′ to 76º 56′, at altitudes of 700 to 2100 meters above mean sea level, was purposefully selected for the this study (Fig. 1), since the district represents one of the four climate change hotspot districts in Kerala. Moreover, this district was considered a rich repository of indigenous knowledge in agriculture, with impressive ethnic diversity of population with ten indigenous tribal groups. Thus all sources of Indigenous Knowledge are represented here.

Sampling: Exhaustive sampling was followed to include all the four Blocks of the district viz. Kalpetta; Mananthavadi; Sulthanba therry; and Panamaram. Purposive sampling based on area under cultivation and reported crop damage through natural calamity for the period 2014-2016 was used to select one panchayat from each of the four blocks. The panchayats selected for the study were Padinharethara (Kalpetta block); Vellamunda (Manathavadi block); Nenmeni (Sulthanbatherry block); and Mullankolly (Panamaram block). Twenty-five farmers from each panchayat were randomly selected, for a total sample of 100 farmers. In addition, 20 key informants were purposively selected from the officers of the Department of Agriculture Development and Farmers Welfare, and 10 major Non-Governmental

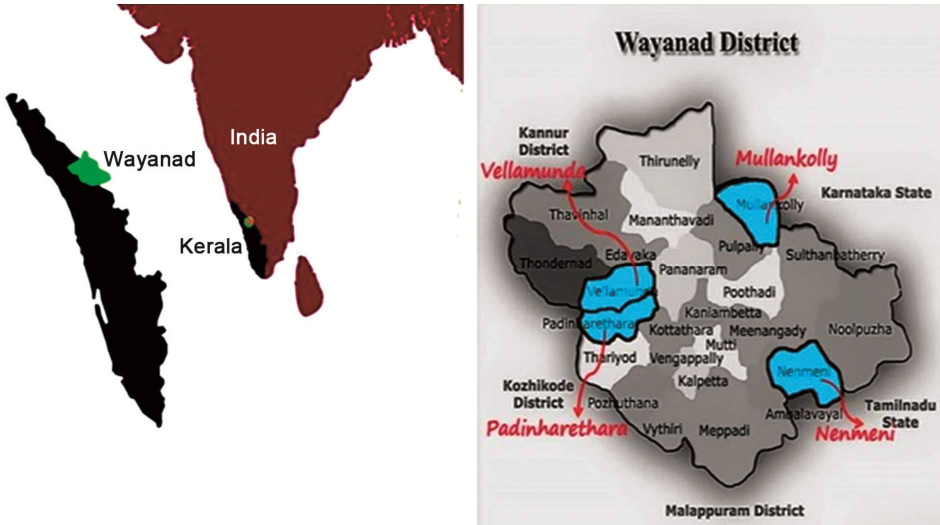

Fig. 1 — Map of Wayanad district showing the panchayats selected for the study

Organizations (NGOs)/farmer associations working with tribal groups in the area.

Research design: Ex-post facto design was employed in the study. Primary data were collected during six months of field work conducted in the months of January to December, 2017. The information was collected from the key informants with prior informed consent. Personnel interviews using open-ended schedules were used for farmers. In order to ensure the collection of meaningful information, participatory tools like focus group discussions involving key informants were also used. The collected information analyzed and synthesized using Statistical Package for Social Sciences (SPSS. Version 16.0) and MS Excel computer programmes.

Validation of ITK Systems: Documented ITKs were validated through farmer participatory process using Use validity scores (UVS) developed for the purpose. Use validity was measured on three dimensions viz. purpose of use (PU); extent of use (EU); and perceived reliability (PR). The subclassification and scores assigned are diagramatically presented in Fig. 2. The inter correlations between PU, EU & PR were determined using Spearman Rank Correlation. The use validity score was developed as a weighted average sum of the three components, as given in equation (1):

*UVS = (Wpu * PU score) +(Weu * EU score) + (Wpr * PR score)* *Eq. (1)*

The score was calculated for each farmer and the average of the scores for the sample was used as validity scores of a particular indicator.

The weigh to feach component was calculated based on the logic that the variables highly correlated with others should receive higher weight. The formulae used to calculate the weights for PU, EU and PR are given as equation (2), (3) and (4) respectively.

$$W_{pu} = \frac{r_{pu.eu} + r_{pu.pr}}{2\,(r_{pu.eu} + r_{pu.pr} + r_{eu.pr})} \quad \ldots (2)$$

$$W_{eu} = \frac{r_{pu.eu} + r_{eu.pr}}{2\,(r_{pu.eu} + r_{pu.pr} + r_{eu.pr})} \quad \ldots (3)$$

$$W_{pr} = \frac{r_{pu.pr} + r_{eu.pr}}{2\,(r_{pu.eu} + r_{pu.pr} + r_{eu.pr})} \quad \ldots (4)$$

Where, Wpu – Weightage of PU; Weu – Weightage of EU; Wpr – Weightage of PR

Results and Discussion

The study delineated 20 abiotic indicators related to weather forecasting. These were based on color and appearance of the sky, clouds, moon, wind, rainbow, thunder, lightning and fog. The details of collected ITKs are presented in Table 1. Scientific interpretation could be attributed to most of the documented indicators based on existing theories and published research as described below.

Clear sky, stars and moon for no rainfall (A & C): In a high-pressure system with no clouds, air tends to sink which inhibit the cloud formation and precipitation[3].

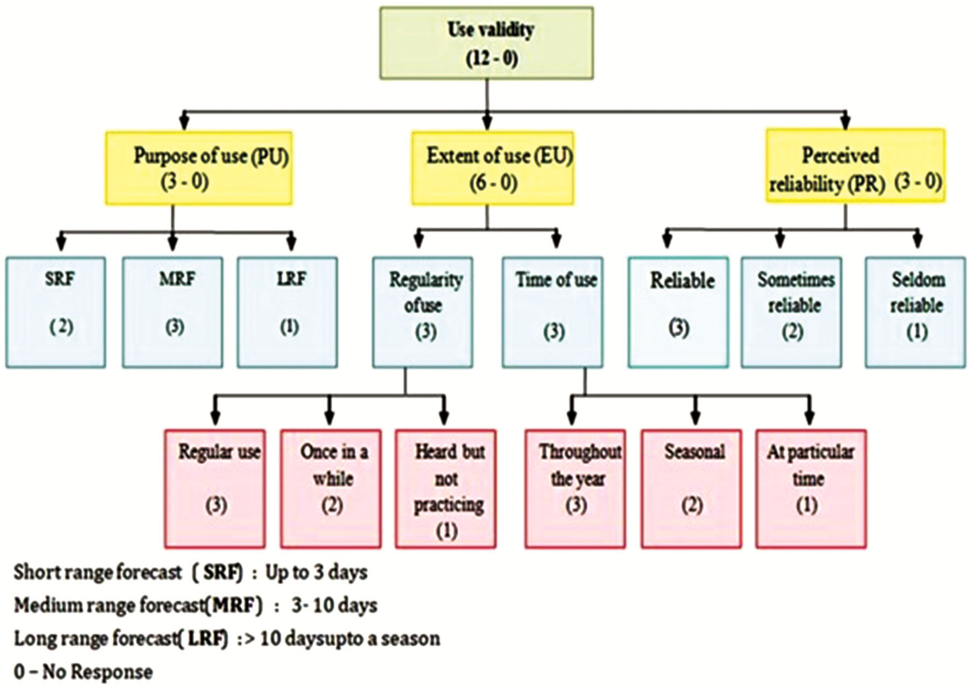

Fig. 2 — Flow diagram showing scores assigned to the dimensions of Use Validity Score (UVS)

Table 1 — List of abiotic indicators used in weather prediction

Code	Indicator	Associated weather indication
A	Clear sky	No rainfall
B	Red sky	No rainfall
C	Clear stars and clear moon	No rainfall
D	Dark rolling clouds with cool breeze	Heavy rainfall
E	Red clouds (Fig. 3)	No rainfall
F	Widespread cloud cover (Fig. 3)	Lighter showers on and off over several hours
G	Clouds with vertical development (Fig.3)	Thunderstorm, lighting and heavy rainfall
H	Halo around the moon (Fig.3)	Good rainfall
I	Cool breeze along with moisture	Upcoming rain
J	Warm breeze in February- March	Upcoming rain
K	Whirlwinds or dust devils	On set of dry season
L	Rainbow in the West during S-W monsoon	Upcoming rain
M	Rainbow in the east direction Indicate (Fig. 3)	Absence of rain/ less rainfall
N	Thunder and lightning	Upcoming rain
O	Thunder sound during night	Onset of N- E monsoon
P	Black fog in early morning, White fog with water drops indicate	Rain No rain/ good weather
Q	Drop in temperature at night/ coldness at night	Starting of dry season
R	Increasing temperature during day	Triggering of rainfall
S	Occurrence of rain in presence of sunshine indicates	Absence of rain innear future
T	Reduction in water level in swamps, lagoons and *Kenies*	DroughtI Drought

Red sky/ red clouds indicate no rainfall (B&E): High concentration of dust and particles in air scattered light with the longest wavelengths more making sky appear red. Therefore red sky indicates dry dusty air devoid of condensation nuclei in the atmosphere with no chance for precipitation[4]. Red color clouds are associated with high pressure system therefore good weather is expected[5].

Dark rolling clouds with cool breeze indicate heavy rainfall (D): A cloud gets thicker and denser as it gathers more water droplets and ice crystals which indicate good rainfall. When thickness of cloud increases light reflection and scattering also increases resulting in less light penetration into the clouds making rain clouds appear grey/ black[5,6,7].

Widespread cloud cover indicate lighter on and off showers over several hours (F): Widespread cloud cover include stratus, stratocumulus and nimbostratus clouds, which develop horizontally and are uniform and flat, producing a gray layer of cloud cover which cause periods of light precipitation[8].

Clouds with vertical development associated with thunderstorm, lighting and heavy rainfall (G): In conditions of atmospheric instability, moisture and lift, strong updrafts can develop cumulus cloud leading to mature, deep cumulonimbus cloud. It results in thunderstorm producing heavy rain. In addition, cloud electrification occurs within cumulonimbus clouds due to collisions between charged water droplets, graupel (ice-water mix), and ice crystal particles, resulting in lightning and thunder[9].

Halo around the moon, indicates good rainfall (H): High, thin clouds get lower and thicker as they pass over the moon and ice crystals are reflected by the moon's light, causing a halo to appear[5,9,7]. Hence the ring around the moon indicates an advancing warm front (precipitation).

Cool breeze with moisture and warm breeze in February-March indicate upcoming rain (I&J): Cool winds with moisture trigger saturation of already existing clouds resulting in heavy rains.

Whirlwinds or dust devils indicate onset of dry season (K): Whirlwinds are clear indication of the onset of dry season as it normally occur during clear, hot days over a dry surface[5].

Rainbow in the west during S-W monsoon predict upcoming rain and in the east indicate absence (L&M): Rainbow appear opposite to the direction of sun. More depth and heavy coverage of sky cause rainbow to appear in the west which is considered as an indication of the onset of S-W monsoon. If the sun is in the western side and if there is a drizzle/light rain, then rainbow occur in the eastern side[10].

Thunder and lightning indicate upcoming rain and thunder during nights in October/ November indicate onset of N- E monsoon (N&O): As water vapor condenses into clouds and rises to colder upper regions of the sky, some of it turns into ice crystals having positive charge, and some becomes water droplets, with negative charge. When the charges are strong, electricity is discharged in the form of lightning. Some lightning precedes rain and some occurs as downdraft starts and rain or other precipitation falls[5]. N-E monsoon is due to the confrontation between two different types of air masses, which leads to the formation of thunder clouds.

Drop in temperature at night indicates commencement of dry season (Q): Cloudless skies and subsequent radiation cooling results in lowering of temperature. If it prolongs, it is an indication that the upcoming days will be hotter with clear skies.

Day time increase in temperature indicate triggering of rainfall (R): Higher temperatures lead to more water vapor in the atmosphere, which increase the chance of heavy showers[8].

Occurrence of rain in presence of sunshine indicates absence of rain inner future (S): Synchronized occurrence of rain and sunshine leads to end of rainy season.

Reduction in water level in swamps, lagoons and *Kenies* leads to drought (T): Decreased ground water level and increased evaporation and transpiration leads to reduction in water level in swamps and *Kenis* located on wetlands. Due to abandoning of paddy fields and deforestation, the water table is recede leading to drought[11,12]

The distribution of different weather forecast indicators related to various abiotic factors are presented in (Fig. 3). Out of these documented indicators, a maximum of 20% were related to clouds. Those related to wind accounted 15% and those related to moon, sky, rainbow, thunder and lightning, temperature and water had two indicators each accounting for 10% each of the total indicators. The indicator related to fog contributed only 5% of the documented factors. The maximum number of documented indicators was related to clouds. We found that farmers are close observers of cloud color, movement and pattern. Indicators for wind reflect frequent observations of changes in wind. Moon, sky, rainbows, thunder and lightning, temperature, water and rainfall indicators, all have equal importance to the farmers, with fog being least important. Out of these 20 abiotic indicators documented, an equal number (10) is related to prediction of rain and onset of dry season/absence of rainfall. Some of the common abiotic indicators are given as Fig.4.

Popularity of indicators among farmers: Popularity of indicators among farmers are presented

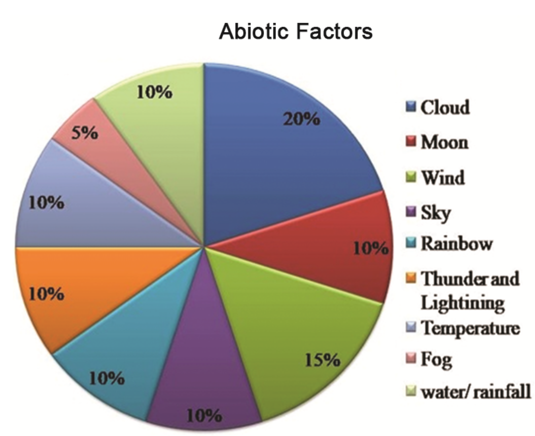

Fig. 3 — Distribution of weather forecast indicators in relation to abiotic factors

in three classes (Table 2) based on mean and standard deviation of UVS as High (≥2.604), Medium (2.604–0.75) and Low (≤0.75). Out of the 20 abiotic indicators, five indicators had high popularity (≥2.604) among farmers (Table 3). Clear sky, clear stars and clear moon at night were features that indicated no rainfall. Dark rolling clouds along with cool breeze, cool breeze along with moisture and thunder and lightning indicated heavy rainfall. Eleven indicators had medium popularity scores between 2.604 and 0.75 among farmers. These included black fog in early morning, increasing temperature during daytime, rainbow in the western sky during S-W monsoon, warm breeze in February, March and halo around the moon that forecasted upcoming rains. Clouds with vertical development associated with thunderstorms, lighting and heavy rainfall also had only medium level of popularity among farmers. White fog along with water drop in the morning, drop in temperature at night/coldness at night, reduction in water level in swamps and lagoons and Kenies (small well-like structures located on wetlands), red sky and clouds in the evening and rainbow in the east indicated absence of rain or onset of dry season. These were also rated with only medium level of popularity among farmers.

Purpose of use: The purpose of use explained whether the farmer uses an indicator for short range forecast (SRF), medium range forecast (MRF) or long-range forecast (LRF). Purpose of use of indicators based on farmers' perceptions are given in Table 4. Out of the 20 listed indicators, farmers used most (14) of the indicators for short range forecast, 04 indicators for medium range forecast and 02 indicators for long range forecast. The most commonly used indicators for SRF were clear sky (60%), clear stars and clear moon (45.45%), red evening sky (55.71%), whirl winds (50%), white fog along with water drop in the morning (56.52%) and rainbow in the east (55.56%) for absence of rain. The SRF method used for rainfall prediction included dark rolling clouds with cool breeze (70.97%); widespread cloud cover (90%) indicating light showers intermittently over several hours; halo around the moon

Fig. 4 — Common abiotic indicators used in weather prediction by farmers

Table 3 — Popularity of indigenous abiotic indicators in weather prediction among farmers

Sl. No.	Indicator code*	Use Validity Score (UVS)	Popularity among users
1	C	3.326	High
2	D	2.932	High
3	A	2.764	High
4	I	2.757	High
5	N	2.725	High
6	P	2.128	Medium
7	Q	2.119	Medium
8	T	1.953	Medium
9	B	1.644	Medium
10	R	1.569	Medium
11	L	1.568	Medium
12	E	1.476	Medium
13	J	1.471	Medium
14	G	1.361	Medium
15	H	1.35	Medium
16	M	1.132	Medium
17	F	0.535	Low
18	K	0.364	Low
19	S	0.276	Low
20	O	0.093	Low

*For details see Table 1

Table 2 — Classification of indigenous abiotic indicators of weather prediction based on UVS

Mean	Std. deviation	Maximum UVS= (Mean+Std. deviation)	Minimum UVS= (Mean - Std. deviation)	Popularity score		
				High	**Medium**	**Low**
1.68	0.93	2.60	0.75	≥ 2.6	2.6 – 0.75	≤ 0.75

Table 4 — Purpose of use of indigenous abiotic indicators in weather prediction (N=100)

Sl. No.	Indicator code*	Purpose of Use						Non response frequency
		SRF		MRF		LRF		
		Frequency	%	Frequency	%	Frequency	%	
1	A	57	60.0	21	22.1	17	17.9	05
2	B	39	55.7	17	24.2	14	20.0	30
3	C	45	45.4	34	34.34	20	20.2	01
4	D	66	70.9	17	18.3	10	10.8	07
5	E	19	31.7	27	45.0	14	23.3	40
6	F	18	90.0	2	10.0	0	0.00	80
7	G	11	21.6	33	64.7	7	13.73	49
8	H	27	54.6	17	34.0	6	12.00	50
9	I	66	72.5	21	23.0	4	4.40	09
10	J	42	71.2	12	20.3	5	8.47	41
11	K	9	50.6	1	5.6	8	44.44	82
12	L	36	54.6	20	30.3	10	15.15	34
13	M	25	55.6	13	28.9	7	15.56	55
14	N	51	60.7	32	38.1	1	1.19	16
15	O	1	33.3	2	66.7	0	0.00	97
16	P	39	56.5	23	33.3	7	10.14	31
17	Q	22	29.3	13	17.3	40	53.33	25
18	R	26	41.3	21	33.3	16	25.40	37
19	S	3	27.2	7	63.6	1	9.09	89
20	T	22	28.9	9	11.84	45	59.21	24

*For details see Table 1

(54%); cool breeze with moisture (72.53); warm breeze in February-March (71.19%); rainbow in the west (54.55%); thunder and lightning (60.71%); and increasing temperature during the day time (41.27%).

With respect to MRF, majority of the farmers used indicators such as the presence of red clouds in the sky (45%) and occurrence of rain in the presence of sunshine to indicate the absence of rain (63.64%) in near future. MRF also relied on indicators like clouds with vertical development to predict heavy rainfall (64.71%) and thunder during the night to indicate the onset of N-E monsoon (66.67%). LRF indicators were few compared to SRF and MRF. The most widely used LRF included a nighttime drop in temperature (53.33%) and reduced water level in the swamps, lagoons and *Kenies* (59.9%) to predict the incidence of dry season. In SRF method the indicators provide instantaneous outcome about weather, which help the farmer to make decisions about agricultural operations. Out of the 20 listed indicators, majority (14) were used as an SRF method which is in line with the findings of Shanker *et al.* (2008) [7]

Reliability: Reliability is the trustworthiness of an indicator in giving the desired outcome in the local situation as perceived by the farmer. Reliability of indicators expressed as percentage based on farmers' perceptions is presented in Table 5. Out of the 20 listed indicators, 06 were evaluated as reliable, 11 were rated as sometimes reliable and 02 were regarded to have low reliability. Results indicated that the night time temperature drop indicating the onset of the dry season was rated as reliable and sometimes reliable by equal numbers (49.3%) of respondents. Most of the indicators related to prediction of rain such as clear sky (40.66%), clear stars and clear moon at night (60.22%), clouds with vertical development (44.9%), halo around the moon (52.27%), thunder and lightning (60%) and thunder sound in the night (66.67%) were rated as reliable indicators.

However, a majority of 11 documented indicators were perceived to be only 'sometimes reliable'. These included red sky (70%) and red clouds (53.7%), whirl winds (53.3%), white fog in the morning (44.1%), rainbow in the east (65.9%) and reduction in water level (49.9%) which indicated absence of rainfall. Indicators rated as sometimes reliable for predicting rain were: dark rolling clouds (55.56%), widespread clouds (40%), rainbow in the west (68.9%), cool breeze with moisture (66.4%) and warm breeze in March (78.9%). The indicators perceived to have low reliability were increasing temperature during the daytime that triggers rainfall (51.52%), and occurrence of rain in the presence of sunshine, indicating absence of rain in the near future (54.55%).

Table 5 — Perceived reliability of indigenous abiotic indicators in weather prediction

Sl. No.	Indicator Code*	Perceived Reliability (N=100)						No. of non respondents
		Reliable		Sometimes Reliable		Seldom Reliable		
		Frequency	%	Frequency	%	Frequency	%	
1	A	37	40.66	35	38.46	19	20.88	09
2	B	11	18.33	42	70.00	7	11.67	40
3	C	56	60.22	33	35.48	4	4.30	07
4	D	27	30.00	50	55.56	13	14.44	10
5	E	12	22.22	29	53.70	13	24.07	46
6	F	6	30.00	8	40.00	6	30.00	80
7	G	22	44.90	17	34.69	10	20.41	51
8	H	23	52.27	17	38.64	4	9.09	56
9	I	14	15.22	62	67.39	16	17.39	08
10	J	7	12.28	45	78.95	5	8.77	43
11	K	3	20.00	8	53.33	4	26.67	85
12	L	7	12.07	40	68.97	11	18.97	42
13	M	6	13.64	29	65.91	9	20.45	56
14	N	51	60.00	29	34.12	5	5.88	15
15	O	2	66.67	1	33.33	0	0.00	97
16	P	29	42.65	30	44.12	9	13.24	32
17	Q	35	49.30	35	49.30	1	1.41	29
18	R	9	13.64	23	34.85	34	51.52	34
19	S	3	27.27	2	18.18	6	54.55	89
20	T	30	42.25	34	47.89	7	9.86	29

*For details see Table 1

Conclusion

Indicators of weather prediction have been woven into villager's folk culture, as revealed in the local sayings and indigenous knowledge. Moreover, most of the documented ITK could be validated based on existing theories and scientific rationale. Farming community are generally aware of the indigenous knowledge in their own region. Out of the 20 abiotic indicators documented in this study, 05 had high popularity among farmers. Clear sky, clear stars and clear moon at night were features that indicated no rainfall. Dark rolling clouds along with cool breeze, cool breeze along with moisture, and thunder and lightning indicated heavy rainfall. Four indicators had low popularity among farmers, and the remaining (11) had medium popularity. Farmers used most (14) of the indicators for short range forecast, 04 indicators for medium range forecast and 02 indicators for long range forecast. The farmers used 06 indicators as providing reliable weather prediction. Eleven were rated as sometimes reliable and 02 were rated as seldom reliable. The deep knowledge and traditions exist among farmers regarding estimation of coming weather and its management are slowly eroding. This knowledge is relevant and valuable, and there is a great need to collect and document it, not only in Kerala but wherever it exists.

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