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Understanding and validating the traditional rainfall classification and forecasting system with its implication to agriculture in Kalimpong Hill of West Bengal

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The farmers in Kalimpong and Darjeeling hills mainly depend on agriculture for their livelihood and live in difficult geographic terrain. They devised their own weather and rainfall classification system based on local indicators. The present study was conducted in Kalimpong hill over a period of four years from 2015-2019 to understand the traditional wisdom of weather prediction and its implication in hill agriculture. Numerous surveys were conducted at villages namely, Ichey Gaon, Bong Basti, Algarah, Sangsey Basti, Lava, Loley, Kafer, Tindhurey and Gorubathan. The people classified the rainfall as *Sawney Jhari, Bhadurey Jhari, Sohrasaradey jhari, Bonsho jhari, Titey jhari, Sisney Jhari, Naurathey Jhari, Chuia jhari, Faprey jhari, Bhangera jhari, Makurey jhari, Kartikey jhari, Maghe jhari,* Ashwina based on time of rainfall. The farmers predicted this rainfall based on phenology of local plants, movement of animals or birds etc. It was found that the knowledge of this traditional rainfall helped them to take different farming decisions especially in scheduling irrigation for major crops. The traditional knowledge has been reviewed with 50 years climatic data and it was found that in most cases it conformed with their traditional belief.

Keywords: Forecasting, Rainfall pattern, Traditional knowledge

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Since a long time, the farming communities of Kalimpong hills observed different bio-indicators, atmospheric changes and phenological indicators for predicting seasonal rainfall in advance[1,2]. The majority of these ethnic dwellers, viz., *Limbo, Bhutia, Lepcha, Tamang,* live far away from the developed cities, earn their daily livelihood on farming practices in the difficult geographical areas and collect forest products from undulating inaccessible terrain of Kalimpong hills. The tribal communities grew up in nature's lap, interacted with the natural environment and acquired a body of rich knowledge on ecological indicators for their survival. In the course of time, they developed their own rainfall classification system and identified several indicators of weather forecasting for taking any farming decisions. They combined their local forecasting knowledge based on empirical ecological observations and subsequent weather predictions through regular monitoring of the biological or phenological pattern of plant response and behavior of birds or animals. Their acquired knowledge base often helps them in prediction of forthcoming weather conditions and increases their farming resiliency through adaptation and mitigation options for minimizing the impact of any weather aberrations on standing crop. Despite the presence of modern meteorological weather advisory services, the local people in Kalimpong still rely on their traditional weather classification system for taking up any farm activities. People in the region predicted the weather for a very long time through phenology of certain plants and behavior of certain animals as an indicator for the advent of wet or dry year. However, their acquired knowledge is still not documented and validated with sufficient climatic or metrological observations. Therefore, it is an urgent need to authenticate the various traditional methods of weather prediction, especially rainfall forecasting, and its role in determining the efficiency of hill agricultural practices. Till date, very few scientific studies have been conducted on the rationale of these traditional beliefs and knowledge.

In this context, the present study was conducted to understand and document the traditional rainfall classification system and weather forecasting system developed by the ethnic tribal communities of

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Kalimpong hills with their supportive implications in hill farming system.

Methodology

The present study was conducted in Kalimpong hills, a part of Darjeeling Himalaya in West Bengal. Numerous surveys were conducted at *Ichey Gaon, Bong Basti, Algarah, Sangsey Basti, Lava, Loley, Kafer, Tindhurey and Gorubathan* village from Kalimpong district of West Bengal. The participatory survey was conducted in an exploratory manner, followed by supportive literature review and cross validation with daily rainfall observations received from India Meteorological Department (Pune, India). The study relied on the structured and unstructured interviews comprising of semi-structured and open-ended questions, followed by in-depth discussions. A probing technique was used to get in-depth information on farmers' knowledge on weather conditions and supportive farming decision criteria. Initially, a snowball sampling technique was used to identify the experienced resource person who had full knowledge of traditional weather system. Thereafter, 10-20 farmers with age above 35 years were randomly selected from the village for further interviews. Thus, data were collected from 116 respondents over a period of 4 years from 2015-2019. The finding in the study was supplemented by general observations during this period. The climatic data of last 50 years (1969-2018) were collected from Indian Meteorological Department (IMD) to validate the traditional knowledge of farming communities on rainfall pattern. The data were analyzed to observe the average rainfall pattern against each traditional knowledge. We classified the daily rainfall observations into extreme rainfall (≥50 mm), heavy rainfall (20≤ to<50 mm), moderate rainfall (7.6≤ to<20 mm), light rain (2.5-7.5 mm) and very light rain (0.1-2.4 mm) using standard approach of IMD[3] and Hajani & Rahman (2018)[4]. Further, data were analyzed through chi-square test to validate the knowledge of farmers by comparing real rainfall with expected rainfall (i.e., mean score of each rainfall category).

Results

We recorded 14 categories of rainfall classification among the ethnic communities of the region based on the nature of rainfall, time of rainfall and duration of rainfall (Table 1). Each type was named in their local

Table 1 — Traditional rainfall classification system

S N	Name of the rainfall	Time of rainfall	Duration of rain	Perceived rainfall intensity	Forecasting criteria
1	*Sawney Jhari*	Start from first week of July	15-20 days (5-7 days continuous rain in 2-3 intervals)	Mostly moderate to heavy	Dark cloud formation
2	*Bhadurey Jhari*	Mid-August to Mid-September	20-25 days (2-3 days continuous rain intermittently)	Mostly moderate to heavy	Dark cloud & lightening
3	*Sohrasaradey jhari*	First week of September	2-4 days	Light to medium rain	One month before Dushera festival
4	*Bonsho jhari*	Middle of September	2-3 days	Light rain	Flowering of *Bonsho (Bambusa sp)* herb
5	*Titey jhari*	Beginning of October	2-3 days of	Light	Flowering of *titeypati (Artemisia vulgaris)* plant
6	*Sisney Jhari*	Toward the end of first week of October	2-3 days	Very light	Flowering of *Sisnu* (*Urtica dioica*) plant
7	*Naurathey Jhari*	7-15Th October	2-5 days	Light	Dushera festival
8	*Chuia jhari*	Beginning of third week of October	1-2 days	Very light	Migration of chuia bird (pippit, *Anthus sp*.)
9	*Faprey jhari*	End of third week of October	1-2 days	Very light	Migration of Faprey bird (common hoopoe)
10	*Bhangera jhari*	20th October onwards	1-2 days	Very light	Migration of Bhangera bird (house sparrow)
11	*Makurey jhari*	Last week of October	1-2 days	Light rain and fog	Webbing spider net at field, forest & home
12	*Kartikey jhari*	Mid November	2-3 days	Medium	Diwali
13	*Maghe jhari*	Mid February	2-3 days	Medium	Makar Sankranti
14	*Ashwina*	March-April	3-4 times with hailstorm and heavy wind	Medium to heavy	Heavy flowering of fruit crops-mandarin, movement of crane and eagle bird.

dialect. In most cases, the influence of phenology, animal behavior and local cultural festival were prominent in the nomenclature of rainfall. The major rainfall events, time of rainfall, duration of rainfall, intensity of rain and its forecasting criteria are presented in Table 1.

Discussion

Farmers developed the vast traditional knowledge base on rainfall pattern and classified them based on their local culture. They classified 14 types of year-round rainfall pattern for the location, based on their perceived intensity (Table 1). The local traditional names of the rainfall are generally influenced by the time of rainfall, popular plant's phenology, migration pattern of birds and other animals etc. This knowledge immensely helped them in planning different farm activities. The major traditional knowledge on rainfall classification, prediction criteria, role in farming decision are discussed in details in the following section.

Sawney jhari

The term "*Sawney*" has been derived from the Nepali word "*Sawan*", i.e., *Shravan* month in Indian calendar and "*Jhari*" mean rainfall in Nepali dialect. The *sawney jhari* is the main rainfall of monsoon season and starts from July onwards during normal monsoon year. All the farmers under the present survey (100%) confirmed that the rainfall continued for 20-25 days in 2-3 intervals. The farmers predicted the onset of this rainfall through formation of heavy dark cloud in the sky. Chinlampianga (2011)[5] also reported similar observations of local rainfall prediction system based on the colour, time and direction of clouds among the tribal inhabitants of Mizoram. In similarity, Sarkar *et al.* (2015)[6] reported that farmers of Rajasthan forecasted good to moderate rainfall events by observing the variation of pale to yellow colour of the moon. Farmers reported moderate to high intensity rainfall on most of the days in this month. The analysis of supportive rainfall observations (Table 2) during 1969-2018 revealed that the maximum rainfall event was moderate with mean rainfall days of 10.64 followed by light rain (9.72), very light rain (4.98), heavy rain (3.80) and extreme rain (0.52). Thus, our analytical reports were in similarity with the farmers' traditional wisdom regarding distribution pattern and intensity of rainfall. Though the farmers perceived the rainfall as heavy in this month but meteorological data revealed the moderate intensity rainfall events mostly occurred during July in Kalimpong hills. This may be due to the differences in perception of local communities about the intensity of rainfall with scientific measurement that needs to be updated with their traditional knowledge base towards further upgradation of their existing knowledge repository.

The farmer respondents (92%) explained that the timely *sawney jhari* was highly critical for farming communities of Kalimpong hill as majority of their farmland still relies on the rainfed cultivation of rice, black gram, soybean, finger millet, rice bean, bean, ginger etc. The farmers started field preparation for transplanting *kharif* rice after this rainfall. The farmers also completed harvesting of zaid maize, looping of branches of shade tree in large cardamom fields, pits filling for new plantation of Darjeeling mandarin, planting of suckers of large cardamom, staking and mulching in large cardamom field before onset of this rainfall. The farmers (45%) from *Laval*, *Tindhurey* and *Looley* informed the beneficial role of the rainfall on the flower initiation and bearing habits of large cardamom (cultivar: *varlangey*) during *Sawney jhari*.

Bhadurey Jhari

The term "*Bhadurey*" has been derived from Nepali word "*Bhadau*" month, i.e., *Bhadra* month in Indian calendar. This *bhadurey jhari* continued for comparatively longer duration from 15-20 days in 3-4 intervals and intensity declined towards the end of the month. The farmers reported intermittent continuous rain for 2-4 days during this period. The intensity of the rainfall is moderate to heavy and considered as highly beneficial for the growth of *amon* paddy. The findings in Table 3 revealed that 8.16 days moderate rainfall was observed whereas

Table 2 — Rainfall pattern of July month of 50 years (1969-2018)

Mean monthly rainfall (mm)	10.77
Mean days with extreme rain	0.52
Mean days with heavy rain	3.80
Mean days of moderate rain	10.64
Mean days of light rain	9.72
Mean days with very light rain	4.98
Mean days with no rain	0.82
Chi square calculated value	870.97
Chi square p value (p)	<0.01
Max rain/day (mm)	218 mm
Min rain/day (mm)	0 mm
SD (mm)	13.34
CV (%)	123.84

2.40 days heavy rainfall incidence was witnessed in last 50 years in August month. This partially supported the farmer's perception on rainfall prediction. However, majority days (11.64) in this month experienced light rain as per the meteorological record of last 50 years (1969-2018). The chi-square test was significant at 1% level indicating that observed rainfall and expected rainfall were not significantly different and this further validated the traditional knowledge of farming communities.

Majority of the farmers (79%) reported that *bhadurey jhari* was highly critical for recharging the perennial and seasonal spring. This rain helped to continue the irrigation in the paddy fields. If this rain happened in fewer amounts, then farmers predict imminent drought situation and immediately takes contingency measures for supplemental irrigation. The rainfall is critical to ensure sufficient moisture during the fruit setting of large cardamom.

Sohrasaradey jhari

The name *sohrasaradey jhari* has come from the traditional *sohrasaradey* festival of Nepali community. The farmers reported that *sohrasaradey jhari* happened at the beginning of September month generally one month before the Dushera festival. They observed that the rainfall continued for 2-3 days in medium intensity. The findings in Table 4 revealed that maximum rainfall was observed in first week (7.21 mm) during 1969-2018. The majority days (2.18 days) witnessed very light rain followed by light rain (1.96 days), moderate rain (1.92 days), heavy rain (0.3 day) and extreme rain (0.10 day) in first week of September. This aligns with the traditional belief of farmers about rainfall pattern. The chi-square test was significant at 1% level and statistically validated the farmers' traditional perception on existing rainfall pattern.

Table 3 — Rainfall pattern of August month of 50 years from 1969-2018

Mean monthly rainfall (mm)	8.21
Mean days with extreme rain	0.28
Mean days with heavy rain	2.40
Mean days of moderate rain	8.16
Mean days of light rain	11.64
Mean days with very light rain	6.7
Mean days with no rain	1.06
Chi square calculated value	1043.37
Chi square p value (p)	<0.01
Max rain/day (mm)	132.50 mm
Min rain/day (mm)	0 mm
SD (mm)	10.57
CV (%)	128.72

The farmers from Kalimpong (25%) told that this rain happened during the reproductive phase of paddy and timely rainfall determines the panicle initiation to successful flowering of paddy. Similarly, farmers (14%) from low altitude areas like Gorubathan informed that harvesting of large cardamom needs to be completed before this rain. Jha & Jha (2011)[7] highlighted the similar role of traditional folklore, norms and belief system of ethnic community in understanding the nature and climate.

Bonsho Jhari

Bonsho (*Bambosa* sp) is a traditional grass and grown in waste lands of Kalimpong hills. Farmers predicted this rainfall seeing the flowering of *bonsho* grass during mid-September. If the flowering event gets delayed, then rainfall may follow the same to synchronize and predicted to be deficit occurrence for that year. The rainfall started mid-September onwards and continued for 2-3 days in light intensity. It can be deduced from Table 4 that the rainfall in second and third week was 6.20 mm and 5.76 mm with majority of the days (2.4) in second week witnessed light rain while third week witnessed very light for maximum days (2.70). The chi-square test was significant at 1% level; thus, it validated the traditional knowledge on rainfall pattern in the region. Almost half of the farmers (47%) confirmed the bumper paddy harvest if this rain event happens at milky stage of paddy. The rain event seems to be helpful for the farmers for the rabi season cultivation of wheat, mustard, rai, potato, pea, cabbage, cauliflower, radish and carrot. Singh &

Table 4 — Rainfall pattern of September month during 1969-2018

Mean rainfall in mm	Week	Weekly average rainfall (mm)	Days with extreme rain	Days with heavy rain	Days of moderate rain	Days of light rain	Days with very light rain	Chi sq (p)
5.84	First	7.21	0.10	0.3	1.92	1.96	2.18	<0.01
	Second	6.20	0.08	0.34	1.26	2.4	2.00	<0.01
	Third	5.76	0.08	0.36	1.02	1.82	2.70	<0.01
	Fourth	4.55	0.12	0.20	0.90	2.46	3.48	<0.01
Max	138 mm		Min	0 mm	SD	10.43	CV	178.46

Singh (2011)[8] reported similar findings from Rajasthan where people used *kair* and *kachri* (*Cucumis melo var. agrestis*) plants as the climate change indicators. However, farmers (45%) perceived that over the time the rainfall pattern was changed under changing climatic condition and the *bonsho jhari* was witnessed towards the end of the September month for most of the year. This need to be further investigated with trend analysis to calibrate the farmers' knowledge in the context of climate change.

Titey jhari

The *titey jhari* name came from a local medicinal herb *Titepati* (*Artemisia vulgaris*). The plant flowered between September to October from low altitude to high altitude. The farmer reported that flowering of *titepati* plant coincided with the successive light rainfall event. They opined that the rain happened in first week of October for 2-3 days. Thus, farmers predicted the light intensity rainfall from phenology of *titepati* plant and accordingly took decision for different farm activities. Similar findings are evident for other crop species. Acharya (2011)[9] similarly found that the flowering of *Nyctanthes arbor-tristis* was a good indicator for prediction of short- and long-range precipitation in Tripura. Chinlampianga (2011)[5] reported that if peach or plum flowers grow from the basal region to the terminal of the tree in flowering season, it is predicted that there will be a good rain and higher crop production than in other years. Hoa *et al*., (2021)[10] in their study in Vietnam reported that rainfall happened when one of the local wildflowers (*biyooc khao*) in the forest bloomed with a nice aroma. Similarly, if the Bo De's leaves (local name: *Bo De*) turned upside down with white color, then rainfall happened within 1 to 3 h. The average rainfall data of last 50 years (Table 5) revealed that first 4 days of the month received 3.53 mm rainfall in last 50 years with majority days (1.82) receiving very light rain followed by light rain (0.58 day). Though they were not able to differentiate between light and very light rain but the climatic data supported their perception of light rain in this month for most of the year. The farmers (43%) reported that that the amount of this rainfall has declined over the period and their distribution become highly skewed and this become the major concern for hill agriculture as the success of *rabi* season crop depends on this rainfall. This rain was highly beneficial for winter vegetables like beans, peas and radish and also helped in grain filling of paddy.

Sisney Jhari

Sisney jhari is low intensity rainfall during flowering of *sisnu* plant (*Urtica dioica*) towards the end of first week of October for 2-4 days intermittently. The flowering of *sisnu* plant started from September in lower hills to October in mid hills to November in upper hills. The majority (78%) of the people from Kalimpong mid hill observed the *sisney jhari* towards the end of first week of October. The climatic data of last 50 years (Table 5) revealed that 2.69 mm rainfall was received between 4 to 7 days of October month. The very light rain was witnessed for most of the days (1.50 days) followed by light rain (0.88 day) with 4-7 days of this month. This was also the flowering period of *sisnu* plant in Kalimpong and thus validated the farmers' traditional knowledge of *sisney jhari*. The rain happened during grain filling of paddy and locally called as "*Tisra pani*". This rain lowers the seasonal temperature over the hill region.

Singh (2011)[11] reported the similar uses of plant phenology to predict weather events and found that the rainfall in a season was predicted by observing the flowering pattern of *Hibiscus cannabinus* Linn. plant. If the plant bears a large number of flowers, it was presumed that the rainfall for the year would be good. If the color of the vegetative parts of the staghorn fern plant was dark green, it was an indicator of imminent rainfall, whereas if the colour was dull, no rainfall was expected in the immediate future.

Table 5 — Rainfall pattern of October month during 1969-2018

Monthly mean rainfall in mm	Days	Average rainfall (mm)	Days with extreme rain	Days with heavy rain	Days of moderate rain	Days of light rain	Days with very light rain	Chi sq (p)
3.53	1-4 day	3.53	0.08	0.04	0.22	0.58	1.82	<0.01
	4-7 day	2.69	0.02	0.08	0.30	0.44	1.50	<0.01
	7-15 day	2.89	0.06	0.14	0.44	0.88	3.22	<0.01
	15-20 day	1.87	0.02	0.12	0.34	0.28	1.78	<0.01
	20-24 day	0.94	0.00	0.02	0.18	0.26	1.06	<0.01
	25-31	0.49	0.00	0.04	0.06	0.16	1.18	<0.01
Max	286	Min	0	SD	10.07	CV	523.29	

Naurathey Jhari

This is very light rain continued for 2-5 days during *Navaratri* before Dusshera (Tig) festival mostly in second week of October month. It is difficult to correlate with climatic data as the time of festival varied from year to year. However, the climatic data in second week revealed that very low intensity rainfall (2.89 mm) was received during the period 1969-2018. This conforms to farmers' belief of *naurathi jhari*. The seed of *dalley chilli* is sown after this rain and land preparation is started for potato, pea, rai, radish etc. After this rain, the sky becomes clear and vegetation in the field and forest looks green. Sharma and Rai (2012)[2] found similar findings from Sikkim where farmers used to classify the rainfall events in different season as per their local culture.

Chuia jhari

The ethnic communities were keen observers of migratory patterns of different birds and their correlation with climatic conditions. They found that migration of *chuia* (pippit, *Anthus* sp) birds from high altitude to low altitude was associated with a splash of rainfall. This rain increases the cold and indicates starting of winter season. As per the people's observation, very light rain happened for 1-2 days during the beginning of third week of October after *Naurathey jhari*. The climatic data of last 50 years (1969-2018) revealed that (Table 5) the average rainfall between 15-20th days of October month was 1.87 mm with majority of the days (1.78 days) received very light rain. Thus, climatic data and statistical value of chi-square test (significant at 1% level) also validated the traditional belief of people about *chuia jhari*. In this context, Sparks *et al.*, (2002)[12] also reported that the birds can predict changing weather or climate and accordingly they migrate from one region to another.

Faprey Jhari

This rain happened when *Faprey bird* (common hoopoe) started migrating from high altitude to low altitude. The rainfall happens towards the end of third week and often overlaps with *bhangera jhari*. The average rainfall data of last 50 years revealed that the average rainfall during 0.94 mm. The rainfall happened in very light intensity and strengthened the onset of winter season. This type of traditional early warning systems played a crucial role especially in deciding adaptation and coping strategies in agriculture sector.

Bhangera jhari

This is the light rain after mid October and happened when the *Bhangera* (house sparrow) bird start migrating from high altitude to low altitude. This rainfall occurred mostly after third week, i.e., after chuia *jhari* and faprey *jhari*. This rain intensified the cold in the region. The findings in Table 5 revealed that average rainfall between 20 and 24 days was 0.94 mm with mainly very light rain for majority of the days (1.06). Thus, climatic data also supported the farmers' belief about *bhangera jhari*. Jha and Jha (2011)[7] also reported that the *Lepcha* community of the hill predicted the rainfall from birds' movement pattern. They believed that if the birds are silent, rain and storms are due. They believed that *Mayel fo* (migratory birds) brought messages sent by *Mayel* Gods to inform people of the right time to sow, weed and harvest crops.

Makurey jhari

The farmers of the region very closely observed the behavior of spider (locally name *makurey*) and correlated their behavior with weather condition. The farmers (67%) of the region reported that a rainfall happened when the spider starts making webs on agricultural fields, forest or home at the end of October. The climatic observations revealed that the very low intensity rainfall (0.49 mm) happened between 25-31 days of the month. Mainly very low intensity rainfall continued for shorter duration (1.18) 1-2 days in with the fog. The chi-square test was significant 1% level and validated the farmers' knowledge about *makurey jhari*. Chinlampianga (2011)[10] reported similar findings from Mizoram where the people predicted weather events through observation of insect and animal behavior, viz., if a cricket brought new soil particle out of its hole during the dry season, it is thought that rain was coming soon. When there were a number of ants moving along a path carrying their food items with them, a heavy rain was expected on the same day or within 1 or 2 days. Similarly, David *et al*., (2020)[13] mentioned that agropastoral smallholder farmers of Uganda adapted to draught using their traditional weather forecasting knowledge based on the visibility of flowering of wild plants, blowing of strong winds and appearances of flying and crawling insects.

Kartikey jhari

This rainfall happened in the middle of November for 2-3 days in medium intensity after *Diwali*. This rain lowers the temperature significantly in the region.

The farmers started constructing *pandal* or shade arrangements at high altitude to protect large cardamom suckers from low temperature and frost. The climatic data (Table 6) revealed that 0.25 mm rainfall was received between 8-22 days of the month. The majority of the days (1.58) received very light rain followed by light rain (0.18 day) and medium rain (0.1). The findings did not support the farmers beliefs about medium intensity rainfall during this period as majority of days witnessed (1.58) very low rain. The chi-square test (0.80) was also non-significant and indicates that there was significant difference between observed and expected rain. However, this does not mean that farmers' knowledge was void as they were only wrong in estimating the intensity of rainfall. Hence, this knowledge needs to be rectified in the light climatic data for more precise forecasting and decision making. The rain helped in providing additional water in the field of winter vegetables, large cardamom and Darjeeling mandarin field.

Maghe jhari

This happened during the middle of February for 2-3 days in medium intensity and brings down the temperature sharply. The rain is highly beneficial for rabi crops and pre-kharif maize in the region. This rainfall fulfills the irrigation need of large cardamom and mandarin field. The climatic data (Table 7) of last 50 years revealed that very low intensity rainfall (0.43 mm) happened between 7-21 days. The Table 7 shows that very low intensity rainfall was experienced for 2.8 days followed by light rain (0.26 days) during this period. However, their perception of medium intensity rainfall was not supported by climatic data (0.43 mm) and the chi-square test was non-significant which indicated that there was significant difference between observed and expected rainfall. Hence, data was further analyzed and it was found that rainfall event over the time shifted from mid to end of February. The ethnic communities of the region opined that recently their climatic prediction or forecasting often failed in winter season as per their traditional criteria under the changing climatic scenario.

Ashwina

This happened during March-April in summer season on 3-4 occasions with heavy wind and hailstones. The first spell generally starts at the end of March month and intensified in April month. The climatic data revealed comparatively high rainfall towards the end of March month, i.e., 1.7 mm last week of March (Table 8). Then 2.06 and 2.52 mm in fourth and fifth weeks of April month. All the weeks of March and April month mainly witnessed very light rain followed by light rain. The climatic data revealed light to very light rain for most of the days in this month and nullify the farmers' perception of medium to heavy intensity rainfall in this month. But farmers reported that the rainfall last for very short period in this duration and happened in medium to high intensity. Therefore, the hourly rainfall intensity data may validate the farmers' knowledge on rainfall in this month more accurately.

This rain was highly critical in the region for irrigating the standing crops and fields. If this rain does not happen then it indicates a drought season and accordingly farmers make their agricultural decisions. The rain helped in growth of maize crops and Darjeeling mandarin. The farmers started digging pits for large cardamom plantation and they completed the filling operation by third week of April before pre-monsoon showers. This is the time for applying fertilizer and manure in large cardamom field for better growth and yield. The colletotrichum blight, phoma leaf spot, *chirkey*, *foorkey* and fungal disease appeared with the advent of these showers in April

Table 6 — Rainfall pattern of November month during 1969-2018

Monthly Mean rainfall (mm)	8-22 days average (mm)	Days with extreme rain	Days with heavy rain	Days of moderate rain	Days of light rain	Days with very light rain	Chi sq (p)
0.16	0.25	0.00	0.06	0.10	0.18	1.58	0.80
Max	1	Min	0	SD	1.51	CV	894.18

Table 7 — Rainfall pattern of February month during 1969-2018

Monthly mean rainfall (mm)	Average rainfall between 7-21 days	Days with extreme rain	Days with heavy rain	Days of moderate rain	Days of light rain	Days with very light rain	Chi sq (p)
0.35	0.43	0.00	0.04	0.18	0.26	2.82	0.76
Max	34.23	Min	0	SD	1.75	CV	493.64

Table 8 — Rainfall pattern of March and April month during 1969-2018

Month	Week	Average rainfall (mm)	Days with extreme rain	Days with heavy rain	Days of moderate rain	Days of light rain	Days with very light rain	Chi sq (p)
March								
Monthly mean rainfall (mm)	First	0.36	0	0	0.06	0.14	1.72	<0.01
0.35	Second	0.39	0	0	0.04	0.12	2.4	<0.01
	Third	0.52	0	0.02	0.02	0.32	2.16	<0.01
	Fourth	0.79	0	0	0.14	0.52	2.52	<0.01
	Fifth	1.7	0	0.02	0.16	0.40	1	<0.01
	Max	34.23	Min	0	SD	1.75	CV	493.64
April								
Monthly mean rainfall (mm)	First	0.98	0	0.04	0.16	0.52	2.66	<0.01
1.55	Second	1.16	0	0	0.22	0.66	2.66	<0.01
	Third	1.78	0	0.06	0.30	0.90	3.10	<0.01
	Fourth	2.06	0	0.06	0.42	1.16	3.16	<0.01
	Fifth	2.52	0	0	0.12	0.46	0.98	<0.01
	Max	35.11	Min	0	SD	3.23	CV	208.55

and progress rapidly during rainy season. Farmer also completed the trashing or tiding the suckers with rope to protect the large cardamom suckers from hailstorm. This is time of flowering of large cardamom and this rain is highly beneficial for fruit setting of large cardamom. The rain was highly helpful for mandarin plant as this was time for fruit set. In case of less rain, farmers ensured supplementary irrigation and mulching for good fruit setting.

Conclusion

The study successfully documented the different traditional weather forecasting mechanism of different ethnic communities of Kalimpong hill. The study showed the usefulness of traditional weather forecasting knowledge system despite the availability of modern macro-weather forecasting system. This traditional knowledge helped the farmers to mobilize their day to day farming activities, especially sowing, scheduling irrigation, fertilizer application, disease management and post harvesting operation. Proper scheduling of such activities helped in maximizing resource utilization, and providing a greater chance for additional income. Hence, the rural communities are likely to continue relying on their traditional methods of forecasting the weather. However, the study found that in many cases (*maghe jhari*, *ashwina jhari*) the traditional indicators failed to predict and classify the rainfall as per meteorological observations under changing climatic condition and they need to be calibrated against current climatic condition. Hence, a mechanism for integrating both traditional and scientific weather forecast systems can bridge these gaps. Therefore, the policy makers, academicians and research institutes should take local knowledge into consideration in designing any weather forecasting service for farming communities with community institutional mechanisms to adapt under changing climatic condition.

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Conflict of Interest

There is no conflict amongst the authors as it is evidence-based learning and collection of traditional knowledge from the farming community and old people involved, although nothing confidential.

Declaration

The authors declare that prior informed consent was taken from all the respondents for collecting the data for the present research work.

Authors' Contributions

SS: Investigation, data collection, writing original draft; RNP: Conceptualization, methodology, review and editing; SS: Data analysis, methodology, review and editing.

References

1 Ingty T, Climate change and indigenous peoples, In book: Climate Change in Sikkim Patterns, Impacts and Initiatives, Editors: Arrawati ML, Tambe S. Edition: 1, 17th chapter, (Information and Public Relations Department, Government of Sikkim, Gangtok), 2012, p. 275-290.

2 Sharma G & Rai L K, Climate change and sustainability of agrodiversity in trdaitional farming of the Sikkim Himalaya, http://www.sikenvis.nic.in/writereaddata / 12-Chapter _ Climate _ Change _ and _ Sustainability_ of _ Agrodiversity _ in _ Traditional _ farming. pdf. 2012.

3 MET Glossary-IMD. https://www.imdpune.gov.in/Weather/ Reports/glossary.pdf. Donloaded on 01.04.2021.

4 Hajani E & Rahman A, Characterizing changes in rainfall: a case study for New South Wales, Australia, *Int J Climatol*, 38 (3) (2018) 1452-1462.

5 Chinlampianga M, Traditional knwoeldge, weather prediction and bioindicators: A case study in Mizoram, Northeastern India, *Indian J Trdait Know*, 10 (1) (2011) 207-211.

6 Sarkar S, Padaria R N, Vijayragavan K, Pathak H, Kumar P, *et al*., Assessing the potential of indigenous technological knowledge (ITK) for adaptation to climate change in the Himalayan and Arid ecosystems, *Indian J Tradit Know*, 14 (2) (2015) 251-257.

7 Jha V & Jha A, Traditional knowledge on disaster management: A preliminary study of the *Lepcha* Community of Sikkim, India, *Indian J Tradit Know*, 10 (1) (2011) 173-182.

8 Singh D & Singh R K, *Kair* (*Capparis decidua*): A potential ethnobotanical weather predictor and livelihood security shrub of the arid zone of Rajasthan and Gujarat, *Indian J Tradit Know*, 10 (1) (2011) 146-155.

9 Acharya S, Presage Biology: Lessons from nature in weather forecasting, *Indian J Tradit Know*, 10 (1) (2011) 114-124.

10 Hoa H T, Son H N, Kingsbury A, Chi D T L, Tam N V, *et al*., The role of Tay indigenous knowledge in climate change adaptatation in the Northern mountainous region of Vietnam, *Indian J Tradit Know*, 20 (2) (2021) 459-472.

11 Singh H B, Plants associated in forecasting and beliefs within the *Meitei* community of Manipur, Northeast India, *Indian J Tradit Know*, 10 (1) (2011) 190-193.

12 Sparks T, Crick H, Elkins N, Moss R, Moss S, *et al*., Birds, weather and climate, *Weather*, 57 (2002) 399-410.

13 David M, Bernard B, Anthony E, Michael M S, James W, *et al*., The role of indigenous knowledge (IK) in adaptation to draught by agropastoral smallholder farmers in Uganda, 19 (1) (2020) 44-52.