Testing of Traditional Methods of Weather Forecasting in Gujarat Using the Participatory Approach

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Abstract

Saurashtra, located in the western part of the state of Gujarat, is predominantly a dry land farming area. Since the early seventies, it has been identified as a drought prone area. The farmers of this region place a lot of importance on the prediction of the onset of the monsoon since the choice of cropping pattern depends on it. Early showers would enable a farmer to go in for long duration crops such as groundnut (spreading type) and cotton.

Considerable progress has been made by Indian satellite technology. However, the predictions made by the India Meteorological Department do not help farmers very much when they have to make choices related to cropping patterns because the Department only makes long-range predictions for the nation as a whole. In the case of specific regions, the predictions are short range in nature, i.e., for a period of three days only. As a result, farmers in the dry land regions of India rely mainly on indigenous meteorological beliefs and knowledge to make predictions regarding the monsoon. The farmers' traditional meteorological beliefs are quite strong. Traditional meteorologists use methods and principles evolved by eminent astronomers and astrologers such as Varahmihir (700–800 AD), Bhadri (1000–1200 AD), Poet Ghagh (1200–1300 AD) and Unnad Joshi (1350–1400 AD). Many of the principles were contained in cultural and religious books or passed on from generation to generation by word of mouth. In this paper, we present our experience of participatory meteorological assessment and prediction with the farmers of Saurashtra, on the basis of the traditional beliefs and principles of the region. The process initiated in 1990 has taken the form of an informal network of local experts and formal scientists that provides voluntary service to the people of Saurashtra by making predictions on the basis of collective assessment.

Biological indicators of the monsoon have also been well documented and are extensively used by local experts. Pisharoty (1993) reported that the tree Amaltas or golden shower (Cassia fistula) is a unique indicator of rain. It bears bunches of golden yellow flowers in abundance about 45 days before the onset of the monsoon. This is also mentioned in "Brahad Samhita" written by Varahmihar (circa 8th century). The results will be discussed. We documented various tree species that have been used as indicators of the monsoon by local communities.

Observations on the behaviour of specific birds and animals have also been used as indicators of rain. As many as 500 ancient beliefs were documented from the text as well as from the experiences of old people. To overcome time and resource constraints, eight beliefs were short-listed on the basis of their popularity in the region. These have also been recorded by academics in Gujarati, the vernacular language.

Apart from validating these beliefs across the whole of the Saurashtra, the study has helped to restore the confidence of the people in their traditional knowledge and skill. The resulting knowledge network has brought together the expertise of the region, cutting across formal and informal systems. Such a network helps individual experts pool their knowledge and learn from each other. It enables

the group as a whole to make a collective judgement and to provide the farming community with a valuable service that helps farmers make decisions.

Our group has already acquired a high degree of credibility because of the successful predictions it has made over the past 11 years. In 1993, we got more than 500 observations on wind directions on Akshya Tritya and Holi. As a result, we were able to make very accurate predictions. We even predicted the likelihood of a locust attack. This prediction came true and added to our credibility.

It is this service and the resulting support and appreciation of the farming community that keeps the network going. The network emerged spontaneously and has experienced an organic growth. It exists because of the need that it helps meet. The experimentation and prediction are likely to continue without the help of external support. In the process, valuable meteorological data will be generated and additional beliefs will be tested. We believe that such a network can serve as a model for farmers of other dry land areas who rely on traditional experts for predictions of the monsoon.

Introduction

Saurashtra, located in the western part of the state of Gujarat, is predominantly a dry land farming area. Since the early seventies, it has been identified as a drought prone area. The occurrence of drought has become a regular phenomenon of the region and other adjacent parts of the state. The monsoon (from June to September) is characterized by irregular, erratic and uneven showers.

The farmers of this region place a lot of importance on the prediction of the onset of the monsoon since the choice of cropping pattern depends on it. Early showers would enable a farmer to go in for long duration crops such as groundnut (spreading type), cotton and sesamum. On the other hand, a delayed monsoon would mean restricting the choice to pulses, pearl millet, castor and the bunch type of groundnut.

Although Indian satellite technology has made considerable progress since independence, the monsoon predictions made by the India Meteorological Department are not very helpful to farmers in making choices related to cropping patterns. This is because the Department only makes long-range predictions for the nation as a whole. In the case of specific regions, the predictions are short range in nature, i.e., for a period of three days only. As a result, farmers in Saurashtra (as in many other dry land regions of India) rely mainly on indigenous meteorological beliefs and knowledge to make predictions regarding the monsoon. They base their crop-mix decisions on the predictions made by local experts.

The farmers' beliefs in traditional meteorological beliefs are quite strong. The local experts use methods and principles evolved by eminent astronomers and astrologers such as Varahmihir (700–800 AD), Poet Ghagh (1200–1300 AD), Unnad Joshi (1350–1400 AD) and Bhadli (1000–1200 AD). Many of the principles were contained in cultural and religious books or passed on from generation to generation by word of mouth.

The Junagadh Campus of Gujarat Agricultural University (GAU) is located in the heart of the Saurashtra region. The University has been contributing to the development of agriculture in the region since 1960. In this paper, we present our experience of participatory meteorological assessment and prediction with the farmers of Saurashtra on the basis of the traditional beliefs and principles of the region. The process initiated in 1990 has taken the form of an informal network of local experts

and formal scientists that provides voluntary service to the people of Saurashtra by making predictions on the basis of collective assessment.

1. Structure of the paper

Methodology

The paper is divided into four sections. After providing a brief review of the traditional meteorological knowledge and principles of the area, the beliefs that were chosen for validation and systematic assessment are described. Then, the details of the process by which local experts got involved in the systematic scaling up and refinement of their techniques are given and, finally, the conclusion is presented.

Traditional principles: A brief review of the literature

Bhadli (circa 12th century) described ten "chieftains" (variables) responsible for the development of the "ethereal embryo" of rain. These are wind, clouds, lightning, colours of the sky, rumbling, thunder, dew, snow, rainbow and occurrence of an orb around the moon and the sun. Bhadli considered the interactions of these variables with interplanetary, stellar systems during each of the 12 lunar months to characterize rainfall patterns through out the year (names and dates of constellations are given in Appendix 1).

Raman (1960) identified general atmospheric situations as indicators of a healthy conception of the "ethereal embryo" – that which leads subsequently to rain. Some of these are listed below:

1. Gentle and agreeable wind from the north, north-east and east
2. Clear sky
3. Soft, white deep halo around the moon or the sun
4. Dark-coloured sky – as dark as a crow's egg
5. Sky overcast with huge, bright dense clouds
6. Needle-shaped or sword-shaped clouds
7. Blood-red clouds
8. Rainbow in the morning or in the evening
9. Low rumblings of thunder
10. Lightning
11. Appearance of a "mock sun"
12. Planets and stars shining in full form and with soft light

Similarly, Golakia (1992) collected local beliefs regarding the occurrence of drought on the basis of meteorological observations:

1. If the sky acquires a faint yellow colour, there is less hope of rain.
2. If crow-coloured clouds are observed throughout the day while the night sky remains clear, a drought is indicated.
3. If the velocity of wind is not high during the *Mrighirsh* constellation and high heat is not experienced during the *Rohini* constellation, a drought can be expected to follow.
4. If it does not rain in *Adra* and no winds occur in *Mrighirsh*, then a drought will occur.

5. If the wind blows from the east during the month of *Shrawan* and from the south-west during the month of *Bhadrapad*, a severe drought can be expected.
6. Occurrence of wind with velocity on the fifth day of the first fortnight of the month of *Shrawan* is indicative of severe drought.
7. Occurrence of rain in the presence of sunshine is an indicator of poor rainfall in the near future.

Biological indicators of the monsoon have also been well documented and are extensively used by local experts.

Kanani *et al.* (1995) documented various tree species that have been used as indicators of the monsoon by local communities (see Table 1).

Table 1. Flowering and foliage of tree species as indicators of rain

Name of Species	Indicator	Expected outcome
Mahuda, *Madhuca latifolia*	Good foliage	Good monsoon
Bamboo species	Good foliage	Drought, rat attack
Ber, *Zyzyphus mauritiana*	Heavy flush of fruit	Average monsoon
Darbha grass *Eragrostis cynosuroides*	Appearance of good foliage	Good monsoon
Billi, *Aegle marmelos*	Good foliage	Subnormal monsoon
Pipal, *Ficus religiosa*	Good foliage	Adequate rain
Khejro, *Prosopis cineraria*	Heavy foliage	Drought
Kothi, *Limonia acidissima*	Good growth	Stormy rain
Neem, *Azadirachta indica*	Heavy flush	Drought

Observations on the behaviour of specific birds and animals have also been used as indicators of rain, as reported by Savalia *et al.* (1991) and Golakia (1992) (see Table 2).

Table 2. Behaviour of birds and animals as predictors of rain

Indicator	Expected outcome
Sparrow bathing in dust	Good rain
Kachinda (chameleon) climbs the tree and assumes black-white-red colours	Immediate rain
Frogs start singing in the initial days of *Jayestha* (May)	Early rain
Batairs (a bird) sing in pairs	Certainty of rain
Peacocks cry frequently	Rain within a day or two
Crows cry during the night and foxes during the day	Severe drought

Titodi or lapwing bird lays eggs during the night, especially on river banks	Heavy rains
Klheu/Bapaiya (a bird) sings songs early in the morning	Rains within a day or two
Snake climbs up on trees	Drought
Camel keeps facing the north-east direction, goat does not browse, crow scratches its nest	Immediate rains
Birds take bath in the dust on the full moon day of *Jayestha* (May)	Plenty of rain

Pisharoty (1993) reported that the tree *Amaltas* or golden shower tree (*Cassia fistula*) is a unique indicator of rain. It bears bunches of golden yellow flowers in abundance about 45 days before the onset of the monsoon. This is also mentioned in *Brahad Samhita* written by Varahmihar (circa 8th century)**.** The results of an observation of this tree as an indicator of the monsoon are given below (see Tables 3 and 4).

Table 3. Details of observation/prediction of monsoon on the basis of the flowering of the *Amaltas* or golden shower tree (*Cassia fistula*)

S. No.	Assessment year	Date of flowering in *Amaltas*	Date 45 days after flowering (as per text) (1)	Actual date of onset of the monsoon (2)	Difference between (1) and (2)
1	1996	29th April	13th June	14th June	+1
2	1997	20th April	4th June	1st June	-3
3	1998	22nd April	6th June	9th June	+3
4.	1999	30th April	14th June	17th June	+3
5	2000	26th April	10th June	8th June	-2
6	2001	29th April	13th June	14th June	+1
7	2002	23rd April	7th June	16th June	+9
8	2003	25th April	9th June	16th June	+7

Table 4. The details showing the observed and expected frequencies of the golden shower tree

Class	Observed frequencies	Expected frequencies	Proportion observed	Proportion expected
1	46	45	.7188	.7031
2	42	45	.6563	. 7031
3	48	45	7500	.7031
4	48	45	.7500	.7031
5	43	45	.6719	.7031
6	46	45	.7188	.7031
7	54	45	.8438	.7031
8	52	45	.8125	.7031
Total	379	360	5.9219	5.6250

Chi-Square = 3.622 Probability = .7276

The χ^2 value was found to be non-significant. This indicated that there was no real difference between the expected and observed frequencies. This means that since 1996, the year this study was undertaken, whatever dates the monsoon was expected on, on the basis of the flowering of the Amaltas (*Casia fistula*), were in agreement with the actual onset of the monsoon.

Participatory validation, assessment and prediction

Trigger

In 1990, the Meteorological Department had predicted normal monsoons for the nation as a whole. Although the monsoon was normal in the rest of the country, it eluded the region of Saurashtra till the month of July. The farmers of the region were anxious, since the time for sowing the long duration crops had already passed by. It was during this time that I had the occasion to meet two local meteorological experts.

The first was Devji bhai Jamod, of Jetalsar village, an engine driver employed with the Indian Railways. He was deeply interested in rainfall predictions as a hobby and used to record meteorological observations in his diary on a daily basis. Devji bhai was emphatic that there was no possibility of monsoon that year till the 15th of August. His assertion was based on the traditional belief that

"If there is a rain, accompanied with lightning and "roaring of clouds" (mild thunder), on the second day of *Jayestha*, there will be no rain for the next seventy-two days" (Bhadli, circa 12th century).

Jadhavbhai Kathiria of Alidhra village, a farmer and school teacher, made precisely the same prediction on the basis of the same observation.

We were intrigued by their observations and predictions and were curious to see the efficacy of this knowledge. To our surprise, their predictions came true. Exactly

after 72 days, on 15th August, Saurashtra experienced heavy showers, enabling farmers to plant late season crops.

So impressed were we by the successful predictions of these local experts that we decided to publicize the details in the local press. Their success was reported by almost all the local dailies such as *Phoolchhab, Sandesh, Gujarat Samachar* and *Akila.* An appeal was also made to readers to send information on other such local meteorological experts in Saurashtra. Many farmers wrote back suggesting that the University should take up systematic research on the topic. This was the genesis of the project on systematic validation of traditional meteorological beliefs and principles.

2. Belief chosen for validation

In 1990, we initiated a research project at the Department of Extension, Junagadh Campus, to take up selected meteorological beliefs for scientific validation. The following beliefs were short-listed on the basis of their popularity in the region. These have also been recorded by academicians in Gujarati, the vernacular language (Trivedi, 1986; Adhvaryu, 1974).

1. If there is rain at the beginning of the *Rohini* constellation with lightning accompanied by "roaring of clouds" (light thunder), there will be no rain for the next 72 days.
2. If there is rain during the *Adra* constellation, there will be rain during the next three constellations, viz., *Punarvasu, Pushya* and *Ashlesh.*
3. If there is rain during the *Punarvashu* constellation, there will definitely be rain during the *Pushya* constellation.
4. If rain occurs on second and fifth day of the first fortnight of *Ashadh*, there will definitely be more rain in the second fortnight of *Ashadh* and in the first fortnight of *Shravan,* respectively.
5. If the 11th day of the month of *Ashadh* (known as *Dev Podhi Ekadashi*) falls on a Sunday, Saturday or Tuesday, then food grains will be costly and there will be "rainy hazards" (losses on account of thunder storms and natural calamities).
6. If on the 12th day of the month of *Kartika*, the sky is clear at night with a bright moon (known as *Pushpa bandh yog*), the ethereal embryo will develop in the forthcoming monsoon.
7. Observations of the wind direction on *Holi*, in a period starting about half an hour before the lighting of the *Holika* to about half an hour after it has been lit, can be used to forecast the rainfall for the year (see Figure 1 for the various wind directions and associated outcomes).
8. Observations of the wind direction on *Akshya Tritiya* from 3 am to 6 am can be used to predict the rainfall pattern and expected crop yield for the year (see Figure 2 for the various wind directions and associated outcomes).

HOLI PREDICTION

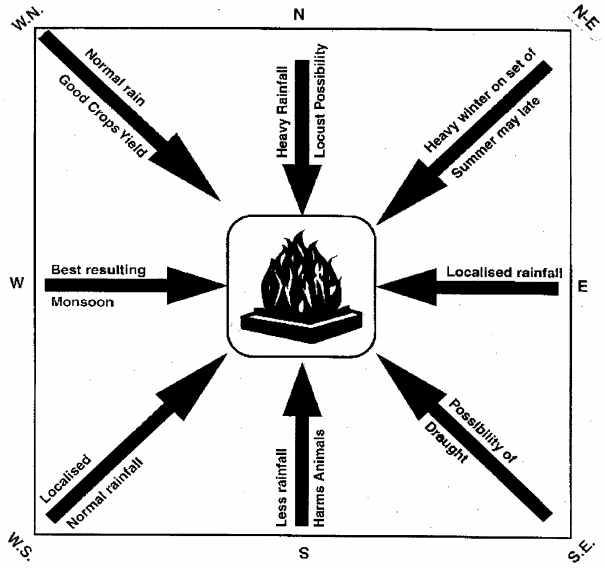

Fig. 1 Prediction of rainfall / Year through direction direction of wind on the day *Holi* Observation time : Before and after half an hour at the time of enlighting the *Holi*

AKSHAY TRITYA PREDICTION

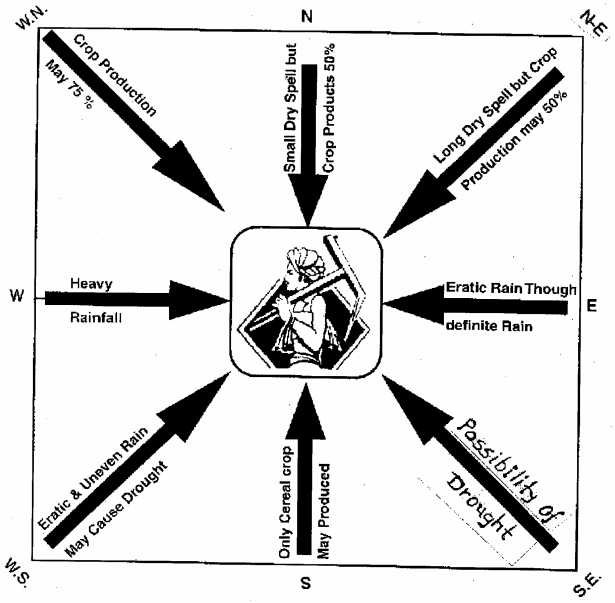

Fig. 2 Prediction of rainfall / Year through direction of wind on the day *Akshaya Tritya* (observation time : 3.00 – 6.00 a.m)

The last two of these beliefs are based on Bhadli's couplets and are perceived as the most reliable indicators by a majority of the local experts. These beliefs are based on the direction of the wind on two specific days, viz., *Akshya Tritya* and the day of the *Holi* festival. Predictions could be made not only about the ethereal embryo of the monsoon but also on secondary outcomes such as intensity of diseases and pests and expected crop yields.

Emergence of knowledge network

To enable farmers record the observations on the last two beliefs, we developed diagrams (Figures 1 and 2) providing instructions on how to make systematic observations of the direction of the wind. These diagrams were developed after extensive consultation with local experts. In 1992, these were published, for the first time, in the local dailies with an appeal to farmers and local experts to send their observations to the GAU. The editors of all the local dailies decided to publish these diagrams free of charge. They felt it was an important experiment for the region and were only too happy to provide this service to the farming community, which constituted its main readership. They continued to provide this support in subsequent years, in the same spirit, and have published the charts every year.

In response to the initial appeal in 1992, we received more than 200 letters from farmers all over Saurashtra. The responses were classified according to the districts and talukas from which they came. We needed collaborators from the entire region, and this classification would help us in selecting potential collaborators. Two hundred collaborators were selected from the six districts of Saurashtra as follows: Junagadh (61), Amreli (45), Rajkot (37), Jamnagar (32), Bhavnagar (17) and Surendranagar (8).

3. The participative research and the prediction process

The collaborators were sent a questionnaire in which they were expected to record observations on various parameters such as velocity and direction of wind, humidity, occurrence of a rainbow, occurrence of an orb around the moon and sun, occurrence of dew etc. These observations were to be made for 195 days from the 1st day of *Kartika* to the 15th day of *Chaitra*. Collaborators were also expected to make observations on fixed days (for beliefs 7 and 8) as advised through the local press. The observations recorded by the participating experts were tabulated each year and analyzed on the basis of criteria given by Bhadli.

On June 16, 1997, the first seminar on Ancient Methods for Studying Rain Phenomena was organized at Junagadh in which about 60 traditional meteorologists participated. The GAU sponsored the seminar, and each local expert was allowed to present his/her findings and make predictions. The predictions were documented in the proceedings and carried to the people by the local press.

The seminar was a great success and resulted in the formation of an Ancient Rain Prediction Network. The seminar became an annual feature. The participation from local experts has been increasing each year. Participants come from all over Saurashtra at their own cost. Only network members are invited to present their predictions for the forthcoming monsoon. In subsequent years, local experts get a

chance to review their previous predictions and make suitable improvements in their techniques. Their peers hold experts who have made accurate predictions over the years in high esteem.

In terms of gender, the participation of women was weak with only four women participating in the seminar. These women came from nearby villages. They had earlier attended a training programme at the Farmers' Training Centre, run by the GAU. When they came to know about the seminar, they decided to attend.

However, the low participation by women does not mean that women are less interested in the subject. One of the women participants brought to the seminar a Gujarati publication on Bhadli's *Vakya* and made it accessible to other members of the network.

In the seminar held on the 6th July 1999, a resolution was passed to establish a professional body called the "Ancient Rain Phenomena Association". The names of the executives of this association are given in Appendix 2. The procedure to get the Association registered has been initiated. An executive body with members representing different parts of Saurashtra has been established. The rules and norms are now being evolved. The annual membership fee is Rs.75, while the life membership fee has been fixed at Rs.525.

4. Validation of traditional meteorological beliefs in Saurashtra: Summary of findings

Testing of the eight beliefs (treated as hypotheses) has been carried out since 1990. Each year the results were presented to the Agricultural Research Committee at the GAU, in order to get feedback from researchers and extension workers.

The observations taken over a period of 14 years, from 1990 to 2003, indicated that seven out of the eight hypotheses have not been proved untrue so far (see Tables 5.1 to 5.9). The results indicate that many of these beliefs are likely to be reliable indicators of the monsoon.

Table 5.1. Hypothesis: If there is rain at the beginning of the *Rohini* constellation with lightning accompanied with "roaring of clouds" (light thunder), there will be no rain for the next 72 days

Inference: The belief has proven to be true since 1990.

Year	Occurrence of condition specified	Rainfall
1990	Condition observed on 25/5/90	Rainfall recorded exactly after 72 days, i.e., on 16th August 1990
1991	Condition specified did not occur	Monsoon was regular
1992	Condition specified did not occur	Monsoon was regular
1993	Condition specified did not occur	Monsoon was regular
1994	Condition specified did not occur	Rain was recorded during 72 day period

1995	Condition specified did not occur	356 mm rainfall recorded during 72 day period
1996	Condition specified did not occur	642 mm rainfall recorded during 72 day period
1997	Condition specified did not occur	514 mm rainfall recorded during 72 day period
1998	Condition specified did not occur	681 mm rainfall recorded during 72 day period
1999	Condition specified did not occur	312.4 mm rainfall recorded during 72 day period
2000	Condition specified did not occur	341.8 mm rainfall recorded during 72 day period
2001	Condition specified did not occur	529.7 mm rainfall recorded during 72 day period
2002	Condition specified did not occur	537 mm rainfall was recorded in 23 rainy days
2003	Condition specified did not occur	1280 mm rainfall was recorded in 43 rainy days

Table 5.2. Hypothesis: If there is rain during the *Adra* constellation, there will be rain during the next three constellations, viz., *Punarvasu, Pushya* and *Ashlesha*

Inference: This was found to be false in 1995, and hence, it can be considered a reliable indicator of rain.

Year	Occurrence of condition specified	Rainfall (in mm)
1990	35.5 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 30.2, *Pushya* – 18.4, *Ashlesha* – 21.3
1991	13 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 241.05, *Pushya* –148, *Ashlesha* – 43.08
1992	35.6 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 15.4, *Pushya* –351.6, *Ashlesha* – 103.7
1993	34.4 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 95.8, *Pushya* – 2.8, *Ashlesha* – 10.9
1994	258 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 434, *Pushya* – 117, *Ashlesha* – 55
1995	No rains observed during the *Adra* constellation	*Punarvasu* – 361.9, *Pushya* –258.7, *Ashlesha* – 22.1
1996	18 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 33.2, *Pushya* –285.3, *Ashlesha* – 30.7
1997	152.8 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 117.9, *Pushya* –163.4, *Ashlesha* – 23.9

1998	362.9 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 83.4, *Pushya* –93.2, *Ashlesha* – 94
1999	67.3 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 200.2,*Pushya* –18.48, *Ashlesha* – 21.5
2000	156.3 mm rainfall recorded during *Adra* constellation	*Punarvasu* –152.6, *Pushya* –0.6, *Ashlesha* – 94.3
2001	30.6 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 114.3, *Pushya* – 84.2, *Ashlesha* – 153.4
2002	277.2 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 12.9, *Pushya* –32.9, *Ashlesha* – 24.1
2003	58 mm rainfall recorded during the *Adra* constellation	*Punarvasu* – 422.3, *Pushya* – 78.3, *Ashlesha* – 396.4

Table 5.3. Hypothesis: If there is rain during the *Punarvasu* constellation, there will definitely be rain during the *Pushyai* constellation

Inference: This belief has been found to be true every year since 1990, except in 2000.

Year	Occurrence of condition specified	Rainfall (in mm)
1991	*Punarvasu* – 30.28	*Pushya* – 18.42
1992	*Punarvasu* – 241.05	*Pushya* – 148
1993	*Punarvasu* – 95.8	*Pushya* – 2.8
1994	*Punarvasu* – 434	*Pushya* – 117
1995	*Punarvasu* – 361.9	*Pushya* – 258.7
1996	*Punarvasu* – 33.2	*Pushya* – 285.3
1997	*Punarvasu* – 117.9	*Pushya* – 163.4
1998	*Punarvasu* – 83.4	*Pushya* – 93.2
1999	*Punarvasu* 200.2	*Pushya* 18.48
2000	*Punarvasu* 152.6	*Pushya* 0.6
2001	*Punarvasu* 114.3	*Pushya* 84.2
2002	*Punarvasu* 12.9	*Pushya* 32.9
2003	*Punarvasu* 58	*Pushya* 422.3

Table 5.4. Hypothesis: If rain occurs on the second and fifth day of the month of *Ashad*, there will definitely be more rain during the second fortnight of *Ashadh* and the first fortnight of the month of *Shravan*, respectively.

Inference: Except for 1995 and 2001, the hypothesis was found to hold.

Year	Occurrence of condition specified	Rainfall (in mm)
1990	Rainfall observed as follows: 2nd day of *Ashadh* – 5 mm 5th day of *Ashadh* – 22.34 mm	2nd fortnight of *Ashadh* – 37.5 1st fortnight of *Shrawan* – 59.7
1991	2nd day – 118 mm 5th day – 53.7 mm	2nd fortnight of *Ashadh* – 117 1st fortnight of *Shrawan* –50.2
1992	2nd day – 10 mm 5th day – 6 mm	2nd fortnight of *Ashadh* – 246.5 1st fortnight of *Shrawan* –219.4
1993	2nd day – 25 mm 5th day – No rain	2nd fortnight of *Ashadh* – 127 1st fortnight of *Shrawan* –1
1994	2nd day – 21 mm 5th day – 80 mm	2nd fortnight of *Ashadh* – 45 1st fortnight of *Shrawan* – 60
1995	2nd day – 10 mm 5th day – no rain	2nd fortnight of *Ashadh* – 443.7 1st fortnight of *Shrawan* – 155
1996	2nd day – 1.9 mm 5th day – 1.2 mm	2nd fortnight of *Ashadh* – 36 1st fortnight of *Shrawan* – 39.9
1997	2nd day – 6.3 mm 5th day – 0.2 mm	2nd fortnight of *Ashadh* – 164.1 1st fortnight of *Shrawan* – 25.9
1998	2nd day – 20.80 mm 5th day – 63.8 mm	2nd fortnight of *Ashadh* – 117.4 1st fortnight of *Shrawan* –139.4
1999	2nd day 100.5 mm 5th day 0 mm	2nd fortnight of *Ashadh* – 21.3 1st fortnight of *Shrawan* –4.80
2000	2nd day 13 mm 5th day 97 mm	2nd fortnight of *Ashadh* – 1.1 1st fortnight of *Shrawan* –85.7
2001	2nd day 0 mm 5th day 0 mm	2nd fortnight of *Ashadh* – 141.7 mm 1st fortnight of *Shrawan* –56.8 mm

Table 5.5. Hypothesis: If the 11th day of the first fortnight of *Ashadh* (*Dev Podhi Ekadashi* – DPE) falls on a Sunday, Saturday or Tuesday, natural hazards due to excess rainfall may occur, causing food grain prices to shoot up

Inference: This hypothesis was found to be true, except in 1995, when it was found to be only partially true.

Year	Occurrence of condition specified	Rainfall pattern and natural calamities
1990	DPE was on a Tuesday (3/7/90)	Heavy rainfall recorded in Kutch and Banaskantha, resulting in floods. Food grain prices were unusually high.
1991	DPE was on a Thursday(22/7/91)	No natural calamities
1992	DPE was on a Friday (10/7/92)	No natural calamities
1993	DPE was on a Wednesday (30/7/93)	No natural calamities
1994	DPE was on a Tuesday (11/7/94)	Heavy rainfall was recorded all over Gujarat. The plague occurred in South Gujarat. Food grain price were high
1995	DPE was on a Sunday (9/7/95)	No natural calamities; however, food grains prices were observed to be high.
1996	DPE was on a Saturday (27/7/96)	A cyclone occurred with heavy rain, causing extensive damage to standing crops and trees. Food grain prices were high.
1997	DPE was on a Wednesday (16/7/97)	Heavy rains in North Gujarat; prices of food grain were stable.
1998	DPE was on a Sunday (5/7/98)	Severe cyclone in the coastal area of Saurashtra on June 8, 1998; floods in Surat city due to the heavy rainfall. Prices of food grains, potatoes and onions were very high.
1999	DPE was on a Saturday (24/7/1999)	Localized rain observed and the price of food grains was high.
2000	DPE was on a Wednesday (12/7/2000)	Irregular rain observed, but the price of food grains was stable.
2001	DPE was on a Monday (1/7/2001)	Rainfall was satisfactory
2002	DPE was on a Thursday (10/7/2002)	Rainfall was satisfactory
2003	DPE was on a Saturday (20/7/2003)	1280 mm of rainfall was recorded in 43 rainy days; natural hazards occurred

Table 5.6. Hypothesis: If on the 12th day of the month of *Kartika*, the sky is clear at night with a bright moon (known as *Pushpa bandh yog*), it is believed that the ethereal embryo will develop in the forthcoming monsoon

Inference: This belief has proven true since 1990.

Year	Occurrence of condition specified	Rainfall pattern
1990	Clear sky on the specified day	Monsoon was satisfactory
1991	Cloudy sky	Monsoon was erratic and uneven
1992	Very clear sky	Normal monsoon, evenly distributed
1993	Cloudy sky	Erratic rainfall
1994	Clear sky	Regular and adequate monsoon
1995	Cloudy sky	Erratic rainfall
1996	Clear sky	Regular monsoon
1997	Clear sky and bright moon	Regular and adequate monsoon
1998	Clear sky and bright moon	Regular and adequate monsoon
1999	Cloudy sky and dull moon	Monsoon was irregular in nature
2000	Cloudy sky and dull moon	Monsoon was irregular in nature
2001	Very clear sky	Regular monsoon
2002	Cloudy sky and dull monsoon	Rain was irregular and uneven
2003	Clear sky	Monsoon was regular

Table 5.7. Hypothesis: The direction of the wind approximately half an hour before and after the lighting of the *Holika* on the day of the *Holi* festival can be used to forecast rainfall for the year. A set of eight hypotheses has been proposed on the basis of the eight wind directions, as shown in Figure 1

Note: This belief was pre-tested between 1990 and 1993 and gave positive indications. During this time, the diagram shown in Figure 1 was developed to facilitate systematic recording of wind direction by farmers. Since 1994, recording has been made with the help of this diagram.

Inference: This belief has proven to be true since 1993 and was found to be a reliable indicator of rainfall.

Year	Occurrence of Condition Specified	Rainfall pattern
1994	**Holi was observed on 26/3/94** Reported wind direction was north and north-west Normal rainfall was predicted with a strong **possibility of a locust attack**	Normal monsoon. **Locust attack caused** extensive damage to crops.
1995	**Holi was observed on 16/3/95** The wind direction was east to west, indicating localized rainfall	Localized rainfall in South Saurashtra zone

1996	**Holi was observed on 14/3/96** 153 observations were received from farmers; reported wind direction was east to west, indicating localized rainfall	Localized rainfall occurred
1997	**Holi was observed on 24/3/97** 143 observations were received. The wind direction in 52.5% of the cases was reported as being from the north-west and west. Good rainfall was predicted.	Good rainfall occurred
1998	**Holi was observed on 12/3/98** 111 observations were received. In 55.5% of the cases, the wind direction was indicated as being from the north-west and west. Good rainfall was predicted.	Good rainfall occurred
1999	From 1999, no observations could be made.	

Table 5.8: Hypothesis: Observations of the wind direction on *Akshya Tritiya* (third day of the month of *Vaishaka*) from 3 to 6 am can be used to predict the rainfall pattern and expected crop yield for the year. A set of eight hypotheses has been proposed on the basis of the eight wind directions, as shown in Figure 2

Inference: This belief has proven to be true since 1990 and was found to be a reliable indicator of rainfall.

Year	Occurrence of condition specified	Rainfall (in mm)
1994	***Akshya Tritiya* observed on 13/5/94** Responses were received from 504 farmers; 63% indicated the wind as being from the west, while 35% indicated a north-westerly direction for the wind. Heavy rain was predicted with 75% crop yield.	Prediction came true.
1995	***Akshya Tritiya* observed on 3/5/95**. Observations were received from 51 farmers; 40% indicated the wind as being from the west, while 30.5% indicated a north-westerly direction for the wind. Sufficient rain resulting in about 65% yield was predicted.	The prediction came true.
1996	***Akshya Tritiya* observed on 20/5/96.** Responses were received from 386 farmers. The wind direction was as follows: north-west (30%), west (24.5%) and north (13.2%). Sufficient rain with about 65% crop yield was predicted	This was found true.

1997	***Akshya Tritiya* observed on 9/5/97.** Responses were received from 243 farmers. The wind direction was as follows: west (52%), indicating good rainfall for all crops, and south-west (46%), indicating erratic rainfall. Moderate rainfall with 50% crop yield was predicted.	This was found true.
1998	***Akshya Tritiya* observed on 29/5/98.** Responses were received from 288 farmers. Wind direction: west and north-west (79%), indicating good rainfall for all crops, and south-west (13%), indicating erratic rainfall. A 75% crop yield was predicted.	Rains were sufficient in all areas except Northern Saurashtra, which experienced erratic rainfall.
1999	*Akshya Tritiya* observations could not be taken	Rainfall was only 431.3 mm in 30 rainy days
2000	***Akshya Tritiya* observed on 6/5/2000** Responses were received from 567 farmers. Wind direction: west and north-west (51%), indicating good rainfall for all crops, and south-west (33%), indicating drought, erratic rainfall and a 50% crop yield was predicted.	Rain was insufficient (594.80 mm) in 30 rainy days. The whole region experienced erratic and uneven rainfall.
2001	***Akshya Tritiya* observed on 26/4/2001** Responses were received from 418 farmers. Wind direction: west and north-west (71%), indicating good rainfall for all crops, while north-east and south-east (20%), indicating irregular rainfall. A 75% crop yield was predicted.	Rainfall was 848.60 mm in 51 rainy days.
2002	***Akshya Tritiya* observed on 15/5/2002** Responses were received from 122 farmers. Wind direction: west and north-west (70%), indicating good rainfall for all crops, while south-east and south-west (23%), indicating drought. A 60–65% crop yield was predicted.	Rainfall was 537.8mm in 23 rainy days.
2003	***Akshya Tritiya* observed on 4/5/2003** Responses were received from 149 farmers. Wind direction: west and north-west (69%), indicating good rainfall for all crops, while south (6%) and north- east (4%), indicating natural hazards. An 85% crop yield was predicted.	Rainfall was 1280.8 mm in 43 rainy days.

The data collected for the wind direction on *Akshya Tritya* for the years 1994 to 2003 (except for the year 1999) were utilized to obtain a prediction equation for future forecasting and to plan the cropping pattern.

The responses of the respondents recorded from seven districts of the Saurashtra region were recorded. For various variables, viz., X_1, X_2, X_3 and X_4, the cropping yield potential was determined for each year.

An attempt has been made to obtain a prediction for the future cropping potential, Ý. All four variables (X_1 to X_4) were regressed on Ý, and the constants generated are given in equation 1. This equation provided considerable predictability, i.e., 95%.

Table 5.9. Details of dependent and predictor variables

Year	Fore casted crop yield (Ý)	Wind direction observed by the largest no. of respondents (X_1)	% response received for wind direction for X_1 (X_2)	Wind direction observed by the second largest no. of respondents (X_3)	% response received for wind direction for X_3 (X_4)	Total no. of respondents
1994	75	1.0	63	2	35	504
1995	65	1.0	40	2	31	51
1996	65	2.0	30	1	24.50	386
1997	50	1.0	52	8	46	243
1998	75	2.0	79	8	13	288
2000	50	2.0	51	8	33	567
2001	75	2.0	71	6	20	418
2002	60	1.0	70	8	23	122
2003	72	1.0	69	4	21	149

Prediction of rain on the basis of the wind direction on *AkshyaTtritya*, equation 1,

$Ý = 44.0119 + 4.6658\ X_1 + 0.6054\ X_2 - 3.3965\ X_3 - 0.1116\ X_4$ (R2 = 0.9541)

Where,

Ý = is the predicted value of the crop yield

X_1 = is the direction of the wind observed on *Akshya Tritya* by the largest number of respondents

X_2 = is the percent of respondents for variable X_1

X_3 = is the direction of the wind observed on *AkshyaTritya* by the second largest number of respondents

X_4 = is the percent of respondents for variableX_3

Conclusion

Apart from validating these beliefs across the whole of the Saurashtra, the study has helped to restore the confidence of the people in their traditional knowledge and skill. The resulting knowledge network has brought together the expertise of the region, cutting across formal and informal systems. Such a network helps individual experts to

pool their knowledge and learn from each other. It has predicted droughts and rat attacks for the farming community, a valuable service. In the past, the farmers were often faced with conflicting judgements and predictions made by local experts. Now, the widespread dissemination of the collective judgement of experts has made it easier for farmers to make their decisions.

Our group has already acquired a high degree of credibility because of the successful predictions it has made in the past nine years. In 1994, we got more than 500 observations of the wind directions on *Akshya Tritya* and the day of the *Holi* festival. As a result, we were able to make very accurate predictions. We even predicted the likelihood of a locust attack. This prediction came true and added to our credibility. Since 1996, the golden shower tree has been found to be the best indicator of the onset of the monsoon.

It is this service and the resulting support and appreciation of the farming community that keeps the network going. The network emerged spontaneously and has experienced an organic growth. It exists because of the need that it helps meet. The experimentation and prediction are likely to continue without the help of external support. In the process, valuable meteorological data will be generated and additional beliefs will be tested. We believe that such a network can serve as a model for farmers in other dry land areas who rely on traditional experts for predictions of the monsoon.

Appendix - 1
Names and dates of constellations

S. No.	Name	Approximate dates
1	*Kritika*	10–11 May
2	*Rohini*	24–25 May
3	*Mrigshirsh*	7–8 June
4	*Adra*	21–22 June
5	*Punarvasu*	5–6 July
6	*Pushya*	19–20 July
7	*Ashlesha*	2–3 August
8	*Magha*	16–17 August
9	*Purba Falguni*	30–31 August
10	*Uttra Falguni*	12–13 September
11	*Hasta*	26–27 September
12	*Chitra*	10–11 October
13	*Swati*	23–24 October
14	*Vishakha*	5–6 November
15	*Anuradha*	18–19 November
16	*Jayeshtha*	2–3 December
17	*Mool*	15–16 December
18	*Purvashadha*	28–29 December
19	*Uttarashadha*	10–11 January
20	*Shrawan*	23–24 January
21	*Dharishtha*	5–6 February
22	*Satatitha*	18–19 February

23	*Purva Bhadrapad*	4–5 March
24	*Uttara Bhadrapad*	17–18 March
25	*Revati*	30–31 March
26	*Aswini*	13–14 April
27	*Bharani*	26–27 April

Appendix - 2
Varsha Vigyan Mandal, Executive Committee, Junagadh

S.No.	Name	Designation
1	Dr. D.D. Malavia	President
2	Shri. Dhansukh bhai Shah (Pune)	Vice-President
3	Shri Jeram bhai Timbadiya	Vice-President
4	Dr. M.A. Munshi	Secretary
5	Dr. A.O. Kher	Add. Secretary
6	Dr. P.R. Kanani	Treasurer
7	Shri. R.M. Chandra	Member (Jamnagar)
8	Shri. Sajanbha Sumania	Member (Jamnagar)
9	Shri Mavajibhai Kesarabhai Patel	Member Kutch
10	Shri Ramnikbhai Vamja	Member Junagadh
11	Shri. Dipakbhai Malani	Member Amreli
12	Shri Hasmukhbhai Nimavat	Member Junagadh
13	Shri Jasmatbhai Surani	Member Bhavnagar
14	Shri Pravinbhai Vora	Member Rajkot
15	Shri Jayantibhai Patel	Member Rajkot
16	Shri Kantibhai Joshi	Member Porbandar

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