Rainfall Forecast of Gujarat for Monsoon 2011 based on Monsoon Research Almanac

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Gujarat state receives annual rainfall of 828 mm in 35 rainy days with coefficient of variation of 50 %. There is large spatial and temporal variation in rainfall of the state (Anonymous, 2000). The low rainfall areas receiving less than 500 mm rainfall are comprised of Kutch district and western parts of Banaskantha and Patan district and parts of Jamnagar, Rajkot and Surendranagar districts. These are also characterized by arid climate. The high rainfall (> 1000 mm) receiving areas (Dang, Valsad, Navsari and Surat districts) are characterized as sub humid climate. The rest part of the state receives rainfall between 500-1000 mm and generally fall under semi-arid climate (Shekh, 1989).

Considering the abnormality of weather particularly rainfall during the monsoon, Anand Agricultural University, Anand has prepared almanac predicting district wise daily rainfall from monsoon 2007 to 2011 for beneficiaries for the farming community as well as planners. The observed and predicted rainfall was then analyzed for its validity.

Astrological methods of rain prediction:

The various astrological methods for rainfall prediction were discussed in great detail in the proceedings of seminar held at Centre of Advanced Studies in Agricultural Meteorology (CASAM), Pune (MS), on 2-2-2002 (Varshneya and Vaidya, 2002) and in a lead paper presented in International Conference on 'Agricultural Heritage of Asia' by (Bhat *et al.*, 2005) in which the techniques of rainfall prediction were thoroughly discussed. The planetary chart of time and date of *Chaitra Pratipada* (Ashwini nakshatra) was laid, which indicate overall weather pattern for the year. Such planetary charts are prepared for the time when sun enters each constellation (Nakshatra) and its each quarter, prediction for that Nakashtra is based on this planetary chart. Actual predictions are made using place of each planet and its angle with reference to other planets (Varshneya *et al.*, 2009).

Validation of rainfall forecast given in Monsoon research Almanac 2005-2010:

Validation of rainfall forecast, for the year 2005, was done on Yes/No skill score (%) basis, for different zones of Gujarat. The validation of this forecast on Yes/No basis indicated that accuracy ranged between 52 to 73% for various zones (Table 1). During the year 2006, Yes/No skill score (%) for different zones of Gujarat ranged between 49 to 53%.

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In August and September rainfall was well distributed spatially over Gujarat, hence, range of accuracy was less. During 2007 accuracy varied between 54 to 69% for various zones. The validation of rainfall for the year 2009, on Yes/No skill score basis for June, July, August and September month indicate that average accuracy was 46%, 56%, 49% and 52% for four regions viz. Middle Gujarat, South Gujarat, North Gujarat and Saurashtra respectively. On an average 51% accuracy was observed for 2009 for Gujarat state. During 2010, on an average 71.3% accuracy was observed which was highest amongst last six years (2005-2010).

The validation of rainfall forecast on Yes/No basis indicated that average accuracy varied between 37% (2008) to 71.3% (2010) for state as a whole. Overall state average skill score was **56%.** Among the four regions average accuracy was highest in South Gujarat (59.1) and lowest in North Gujarat (52%) for the period of six years from 2005-2010.

Table 1: Validation of Yes/No Skill Scores of occurrence of Rainfall

Sr. No.	Name of Region / SAU	2005	2006	2007	2008	2009	2010	Average
1	Middle Gujarat	58	52	63	36	46	75	55.0
2	North Gujarat	52	53	59	35	49	64	52.0
3	South Gujarat	64	52	69	41	56	74	59.3
4	Saurashtra	73	49	54	35	52	73	56.0
	State Average	**62**	**52**	**61**	**37**	**51**	**72**	**55.8**

Validation of Rainfall Projection:-

Rainfall intensity was predicted for the first time in AAU Monsoon Research Almanac-2007 and has been predicted till 2010. The rainfall projection on monthly basis for each district of Gujarat state was given in Calendars. The validation was done with actual rainfall for each district. The percent deviation from actual rainfall for each zone and state as a whole was studied and presented in Table 2. The data reveals that in years 2007, 2008 and 2010, we had correctly predicted the above normal rainfall with more accuracy. The error was below 10%. For the year 2009 we have successfully predicted below normal trend. From the year 2007 to 2010 the average error was -4.3% for state as a whole. The most accurate prediction was done for 2010 monsoon with only 1.1% error.

Average error was lowest in south Gujarat (-0.8%), while it was highest in Saurashtra (-13.1%). In the year 2010, we were successful in predicting above normal monsoon rainfall which came true when compared with actual. The validation showed that during 2010 monsoon season the AAU's Monsoon Research Almanac has predicted above normal rainfall (i.e. 31.2%) for June to September months, whereas, actual rainfall occurred (June to Sept. months) was 29.8 % above normal for Gujarat state as a whole which was quite accurate(Vaidya *et al.,* 2010).

Table 2. Validation of rainfall projection for four regions of Gujarat.

Sr. No.	Name of Region	Rainfall Projection (% deviation from actual)				Average
		2007	**2008**	**2009**	**2010**	
1	Middle Gujarat	6.1	16.2	-25	10	1.8
2	North Gujarat	37.4	6.6	-43	-19.6	-4.7
3	South Gujarat	-37.6	11.0	-15	38.3	-0.8
4	Saurashtra	49.6	-19.4	-45	-37.5	-13.1
	State	**4.6**	**6.3**	**-29**	**1.1**	-4.9

Amongst four regions, AAU's Monsoon Research Almanac has predicted above normal rainfall ranging between 14.6% for middle Gujarat to 46.2% for south Gujarat. The trend was positively predicted for all the regions while rainfall occurred above normal in all four regions of Gujarat. The rainfall was comparably less in Middle Gujarat (4.2% above normal) followed by south Gujarat (5.7%) where rainfall was just above normal. Only Saurashtra has recorded very heavy rainfall (107.8%) due to very heavy rainfall in the months of June, July and September. The above normal rainfall was also recorded in Kutch district in North Gujarat. Out of 26 districts of Gujarat state, 22 districts have recorded above normal rainfall. Amongst the months we have predicted less rainfall in June which came true. AAU's Monsoon Research Almanac-2010 gave forecast of above normal rainfall projection with good distribution in Gujarat which came true in most districts of Gujarat (Vaidya *et al.,* 2010).

Methodology Used for preparation of Monsoon Research Almanac-2007-2011:

1. *Nakshatra Pravesh* of Sun: The Kundali at the time of Sun's entry into each Nakshatra is casted for each required place (*i.e.* district) for the period of Rainy Season. This gives average rainfall for a period of 12-13 days for that Nakshatra, at that place (Varshneya *et al,* 2008).
2. *Nakshatra Charan Pravesh* of Sun: The Kundali at the time of Sun's entry into each Nakshatra Charan is casted for each required place (i.e. district) for the period of Rainy Season. This gives average rainfall for a period of 2-3 days for that Nakshatra Charan, at that place. Daily rainfall was predicted by using Chandra Nakshatra.
3. A finer astrological technique of *shashthansha* ($1/60^{th}$ part of Rashi) kundali was used to distinguish planetary positions/aspects between two adjoining districts.
4. From each Kundali, various aspects like *Mandal* of the *Lagna*, Planets in *Saptanadi chakra*, *Vedhas* amongst the planets, and different aspects between planets like *Yuti, Pratiyuti, Navapancham Yoga, Kendra Yoga,* etc., are taken into

account. Importance is given if a planet changes its direction (*Vakri* or *Margi*), changes Rashi or Nakshatra, or becomes *Asta* or *Udita*.

5. Similarly, *Poornimanta* and *Aamanta* Kundalis were prepared for predictions. Kundalis were also prepared for eclipses. Effects of sighting comets were also considered.

Meteorological inputs used in Monsoon Research Almanac-2007-2011

1. Rainfall probability of getting ≥ 10 mm rainfall in standard meteorological week (SMW) was calculated by Markov chain model, is given for each district (Data of weekly rainfall for 50-100 years was used for analysis).
2. Monthly normal rainfall is given along with projected rainfall for each month for each district.
3. Monthly normal Maximum and Minimum temperature for each district were also given.

Computation of Rainfall Projection: The predicted rainfall intensity on daily basis viz. No rainfall, Low, Medium, Heavy and Very Heavy for each district (26) of Gujarat state from June to October month was used to quantify the rainfall amount of the state. Criteria for quantifying daily rainfall from qualitative prediction for districts under each Agricultural University of the respective region was decided based on frequency analysis for given rainfall intensity and used in the calendar as mentioned in Table 3.

Table 3. Criteria for quantifying daily rainfall from qualitative prediction in different regions of the state.

Sr. No.	Name of Region / SAU	Daily Rainfall quantification (mm)				
		No Rain	Low	Medium	Heavy	Very Heavy
1	Middle Gujarat (AAU, Anand)	0	2	10	35	75
2	North Gujarat (Sardar Krishinagar Dantiwada Agricultural University, SDAU, Dantiwada) and Saurashtra (JAU, Junagadh)	0	2	10	30	50
3	For Kutch district*	0	1	6	25	50
4	South Gujarat (Navsari Agricultural University (NAU, Navsari)	0	6	25	70	100

* Since the rainfall recorded in Kutch is very low, therefore, separate intensity was considered for this district in North Gujarat region.

By using above criteria for each district of the respective region, the monthly rainfall projection was computed and it is given in calendar against the normal monthly rainfall.

Rainfall Forecast – 2011

Salient features of rainfall prediction for Gujarat State-2011

1. Overall monsoon rainfall (June to October) will be above normal by **27% and 24%** (June to September**)** for the state as a whole, except for Kutch (-41%), Tapi (-17% and Panchmahal (-6%) districts during June to October, 2011 (Table 4).
2. This year there will be late onset of monsoon starting from 4th week of June (in North Gujarat, Saurashtra and Middle Gujarat) after 27th June while in South Gujarat it will start from 1st week of July.
3. One or two dry spells observed in most of the districts in this monsoon which will affect the crops.
4. Chances of getting pre-monsoon rain at many places in May 2010.
5. There will be less rainfall in June, 2011 (-68% for state as a whole).
6. There will be highest rainfall in South Gujarat, i.e. +44.5%, followed by Saurashtra with +32.2%.
7. Between June and September, September will get highest amount of rainfall (+85% followed by August (77%). In October month there is good possibility of rainfall which will be helpful for *rabi* crops.
8. Sufficient drinking water will be available till next summer i.e. till June 2012.

Table 4. Rainfall projection for four regions of Gujarat for 2011 (June-October)

Sr. No	Region	Rainfall Projection (June-Oct.) (mm)	Normal Rainfall (mm)	Rainfall Projection (% departure from normal)
1	Middle Gujarat	915.0	796.6	15
2	North Gujarat	720.0	575.5	20
3	South Gujarat	1685.0	1433.7	27
4	Saurashtra	829.0	580.4	47
	State	1037.0	846.5	**27**

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