Modeling and Designing of Rainfall Derivative Contract in India

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Abstract

There has been a prolonged discussion on the use of rainfall derivatives in the Indian conditions. The use of rainfall derivative instruments that could empower the ecosystem of trading and absorbing rainfall risk. The study adopted a unique approach of designing the rainfall indexation based on proposed metrics which is DRD/ERD index, this could be used as building blocks for designing rainfall derivatives similar to HDDs/CDDs underlying temperature derivatives. DRD/ERD values are computed for 36 meteorological subdivisions of India. The basic rainfall future contract structure is defined and analyse how it can reduce the rainfall risk. Like CAT bonds and weather derivatives, rainfall derivatives constitute potentially a distinct asset class and hence could be an added arsenal in the hands of investors for enriching their portfolios.

Key words: Rainfall risk, Indexation, Rainfall Derivatives, Deficit, Excess, Rainy Days.

1. Introduction

The use of derivatives markets for hedging weather-related risk has been around for over 25 years. The Chicago Mercantile Exchange (CME) to list the very first standardized weather futures contracts based on weather indexes. Currently, there are nine US cities, two European cities, and one Japanese city listed at CME. Weather derivatives contracts are used by a wide variety of agricultural, energy and financial based entities from around the globe to help manage localised exposure to weather-related impact risk. The sustained growth of weather derivative market needs development of other segments of weather risk, particularly the rainfall risk which adversely impacts the economics of tropical countries like India.

An increasing focus on weather-related risks in India has become a major driver of the demand for weather related derivatives products offering protection to adverse outcomes related to weather change. Extreme weather events are costing India $9-10 billion annually and climate change is projected to impact agriculture productivity with increasing severity from 2020 to the end of the Century (Vishwa Mohan, 2017). Indian Council of Agricultural Research's (ICAR) official highlighted that the "Indian will have to suffer a major loss due to rising temperature and uneven distribution of rainfall. If all the losses are compounded, Indian will be a major victim of climate change." The rainfall derivatives model is an initiative towards development of full-fledged rainfall risk markets in India. These markets would help to various enterprises, ranging from agriculture, energy, insurance, constructions and others sectors. The study aims to explore the plausibility of bundling the monsoon (rainfall) risk and transmitting it to the capital markets via rainfall derivatives. The study is mainly concerned with the conceptualization of rainfall parameter on par with HDDs/CDDs underlying temperature derivatives.

2. Rainfall Derivatives in India

Rainfall derivatives are new and emerging financial instruments in the derivatives market. Organizations or individuals can use it as part of a risk management strategy to reduce the risk associated with adverse rainfall conditions. Just as traditional contingent claims, whose payoffs depend upon some fundamental price, a rainfall derivative has an underlying measure as rainfall index. The difference from other derivatives is that the underlying asset has no value, and it cannot be stored or traded.

Rainfall derivatives are instruments that can manage the effects of rainfall risk on agricultural production and other industries. In recent years, the interest in and the use of rainfall risk transfer products in the agriculture sector have increased significantly worldwide. The Enterprises engaged in insurance, energy, banking, and agriculture are the potential users of rainfall derivatives. In agriculture, rainfall derivatives are used as a form of insurance against the adverse effect of rainfall events such as droughts and floods. Skees and Barnett (1999) opined that weather patterns tend to exhibit positive spatial correlation, making losses more volatile from the insurer's perspective, increasing the cost of maintaining adequate reserves to cover potential losses from systemic events. Thus, insurance may not be the optimal mechanism for providing efficient risk-sharing. Turvey (2001) demonstrated that rainfall options could be used as insurance against crop production risk. Woodard and Garcia (2008) further tested the application of precipitation derivatives at higher levels of spatial aggregation and found it effective in reducing systemic weather risk. Seth et al. (2009) evaluated the use of weather derivatives among small farmers in India. The study found that 98% of farmers were worried about adverse rainfall and also felt that weather derivatives schemes would help them mitigate rainfall risk. Chokshi (2012) discussed the emergence of rainfall derivatives as a hedging tool and studied the feasibility of weather derivatives contracts in the context of risk management issues in agriculture.

Shivkumar et al. (2014) and Kotreshwar (2015) opined that rainfall derivatives can be a potential tool for hedging and speculation. Sutanuka Ghosal (2020) suggested that monsoon-based indices will be a great boost to help the agriculture value chain and it can be used as a hedging tool to mitigate rainfall risk.

There is a need to study the general framework of securitization of rainfall risk to create a rainfall derivatives market in India. Indian stock and derivatives market is well developed; trading in rainfall derivatives as a risk mitigation tool seems to be a viable proposal for India. Therefore, the proposed study is stated with a broad objective of measuring the rainfall indices for securitization of rainfall risk and study the feasibility for the creation of a rainfall derivatives market in India.

3. Literature on Designing Rainfall Indexation

The rainy day indices are the most common types of rainfall derivatives contracts. A rainy day is defined as the deviation of average rainfall from a pre-determined level. There are some definitions of 'rainy days' that are in use. The following definitions are discussed below:

Skees, et al., (2001) developed a season-based rainfall index based on average monthly payment percentages. The method for calculating the payment of percentage is as shown below:

$$\text{Payment percentage (drought)} = \frac{Strike\ Rain - Actual\ Rain}{Strike\ Rain} \quad (1)$$

$$\text{Payment percentage (flooding)} = \frac{Actual\ Rain - Upper\ strike\ Rain}{Actual\ Rain} \quad (2)$$

In equation (1) & (2) above was supported and adopted by Veeramani, et al., (2003).

MuBhoff et al. (2006) opined that daily precipitation derivatives model could be derived from relevant weather index. The authors concentrated on two important aspectsfor developing a weather index. Firstly, the daily precipitation model used is very flexible within the scope of a daily simulation. Basically, all yield relevant events like the sum of precipitation for different accumulation periods, dry spells, or extreme precipitation can be determined for any period of time. Therefore, the direct estimation of the precipitation index distribution is usually only valid for a particular index. Secondly, the accuracy of precipitation index is based on daily data of larger number of observed values.

The following character of precipitation model:

The probability of rainfall occurrence obeys a seasonal pattern. Ex. Rainfall in Europe is more likely in winter than in summer.

1. The sequence of wet and dry days follows an AR process. The probability of a rainy day is higher if the previous day was wet.

2. The amount of precipitation on a wet day varies with the season. Ex. Rainfall in Europe is more intensive in summer than in winter.

3. The volatility of the amount of rainfall also changes seasonally. Ex. Europe is higher in summer than in winter.

The proposed precipitation model was based on binary event 'rainfall and dryness'. The following method was used:

$$x_i = \begin{bmatrix} 0, & \text{if day } t \text{ is dry} \\ 1, & \text{if day } t \text{ is rainy} \end{bmatrix} \quad (8)$$

Where, is a random variable and assumed that follows a first-order Markov chain. The probability that it will rain on day t can be calculated as:

$$P_t = P_{t-1} \; x \; q_t^{11} + (1 - P_{t-1}) \, x \, q_t^{01} \quad (9)$$

Where, t= 1,2,..............n

q_t^{01}=describes the transition probability of rain on day t and dryness on the previous day t-1.

q_t^{11}=stands for the transition probability between two successive rainy days.

Kotreshwar (2006), Kotreshwar & Kanakasabai (2006), Kotreshwar and Rekha (2006) explored the conceptual framework for rainfall derivatives based on Millimeter Rainy Days (MRDs) index; this index was based on daily average rainfall (in millimeters). The average daily rainfall was serving as the reference level (R_x). The following methods were adopted to generate MRDs.

For Call Options MRD_i = Max. $\{R_x - R_i, 0\}$ ...... (10)

For Put Options MRD_i = Max. $\{R_i - R_x, 0\}$ ...... (11)

Where R_x indicates a reference level, R_i represents the rainfall measured in terms of millimeters on a daily basis.

Ravikumar (2007) has proposed a rainfall index based on historical cumulative rainfall. The methodology of estimation of rainfall index is discussed below:

$$RI_{location} \frac{\sum r_{it}}{\sum R_{it}} X \text{ scale value} = \text{......} \quad (12)$$

Where r_{it} represents actual rainfall of i^{th} day of the t^{th} season; R_t represents long period average daily rainfall of i^{th} day of the t^{th} season; scale or multiplier value was assumed 1000 (rainfall was measured equivalent to 1/1000th of a met, i.e., in millimeter). $RI_{location}$ indicates what percentage of cumulative normal expected rainfall is realized, which means higher the rainfall index value than the cumulative average rainfall up to the date of index, more rainfall. Based on his methodology National Commodity & Derivative Exchange (NCDEX) launched on First Rainfall Index for Mumbai city in the year 2005, followed by indices for Belgaum, Erode, Guntur, Karimnagar, Ganganagar, Kottayam, Murshidabad, Rajkot, and Ujjain in 2006.

A similar estimation method of rainfall index was proposed by Multi Commodity Exchange (MCX) and Weather Risk Management Services Pvt. Ltd. (WRMS). They have jointly developed rainfall indices based on historical annual cumulative rainfall, and it is adjusted with excess and deficit of actual cumulative rainfall, as mentioned in the specific data. The adjustment factor takes into account the impact of historical and actual rainfall during the period.

Woodard and Garcia (2008) developed an accumulative growing season precipitant index. This index is defined similarly to the temperature derivatives. Cumulative precipitation (CP) was denoted by:

$$CP^{M,N} = \sum_{d=m-n} P_d$$

d = M-N,……M …… (13)

Where, P is daily precipitation measured in inches. M-N is the first day of the contract period. M is the expiration date.

Patni (2008) proposed a cumulative rainfall index is a total rainfall received in a region from a reference base date to the date of exercise of an option. It can be defined as:

$$R_C = \sum_{t=1}^{n} r_i \quad \text{…… (14)}$$

Where = cumulative rainfall index

Rainfall on ith day from a reference date.

n = number of days from reference date to current date.

Weighted rainfall index: Cumulative rainfall index takes only total rain over a period of time.

$$R_{WD} = \frac{\sum_{i=1}^{n} w_i r_i}{\sum_{i=1}^{n} w_i} \quad \text{…… (15)}$$

Where, W_i= weight of rainfall for i^{th} day from a reference date. R_{WD}= Daily weighted rainfall index.

The different aspect of this method is estimation of weights for different days. Weights can be assigned based on bucket period instead of individual days. The size of bucket should not be too large reducing effectiveness or too small making it difficult to estimate the value for all weights. The index for period weighted index can be calculated as:

$$R_{Wp} = \frac{\sum_{i=1}^{n/k} w_i \ \sum_{i=i\,k-k+1}^{ixk} r_j}{\sum_{i=1}^{n/k} w_i} \quad \text{… (16)}$$

Where, k= number of days per period, = period WRI

Odening et al. (2007) and Musshoff et al. (2011) developed two different types of rainfall indexes defined as a cumulative rainfall index and a deficit index.

i). the cumulative rainfall index (or rainfall sum is the sum of daily rainfall amount in a certain accumulation period:

$$I^c = \sum_{t-1}^{x} y_t \quad \text{… (17)}$$

Where, x denotes the length of the accumulation period.

ii). Rainfall deficit index (defined as:

$$I^d = \sum_{t-1}^{x} min \left(0. \sum_{i=(t-1)x\,X-1}^{T=5} y_t - y^{min}\right)$$

… (18)

Where, this index measures the shortfall of the rainfall sum in a 5 days period relative to a reference level y min this shortfall is cumulated over Z periods. This construction principle is quite similar to that of degree-day indexes. = average precipitation in the respective accumulation period. The rainfall sum and rainfall deficit are calculated for four accumulation periods like June 1 to September 30. The number of CCDs for a single day is defined as the amount by which the average temperature is above the reference temperature, 65° Fahrenheit.

Shivkumar & Kotreshwar (2013) proposed the process of rainfall indices based on a ticker value defined as Monsoon Outcome Index (MOX) and estimated their statistical properties of MOX series across time and subdivisions, and the study examined the potential of MOX as a new asset class for inclusion in the portfolio for risk hedging. The following method was used to measure the MOX index.

$$MOX = \frac{\sum R_{it}}{\sum R_{ct}} X\ 1000 \qquad \text{...... (21)}$$

Where, R_{it} indicates cumulative rainfall for the end of i^{th} month of the t^{th} season; R_{ct} indicates historical average cumulative monthly rainfall for the t^{th} season, and 1000 is the multiplier value (where rainfall is measured equivalent to 1/1000th of a meter, in millimeters).

Basu (2016) proposed two rainfall indexes that are used to measure the rainfall risk. Cumulative rainfall index also known as called rainfall sum index. It measures the sum of daily rainfall amount in a certain accumulation period and can be expressed as:

$$x = \sum_{i=1}^{n} R_i \qquad \text{... (22)}$$

Where, R_i represents the total rainfall during a particular day.

Rainfall Deficit index measures the shortfall in rainfall sum over a 'S" day period relative to a reference level of minimum rainfall. This shortfall is cumulated over 'Z' period. The principle of formulation of the index is quite to that of degree day index which is widely used in temperature market. The index (ID) can be defined as:

$$Id = \sum_{T=1}^{Z} \min\left(0, \sum_{(T-1)(S+1)}^{T.S} R_t - R_{min}\right) \qquad \text{...... (23)}$$

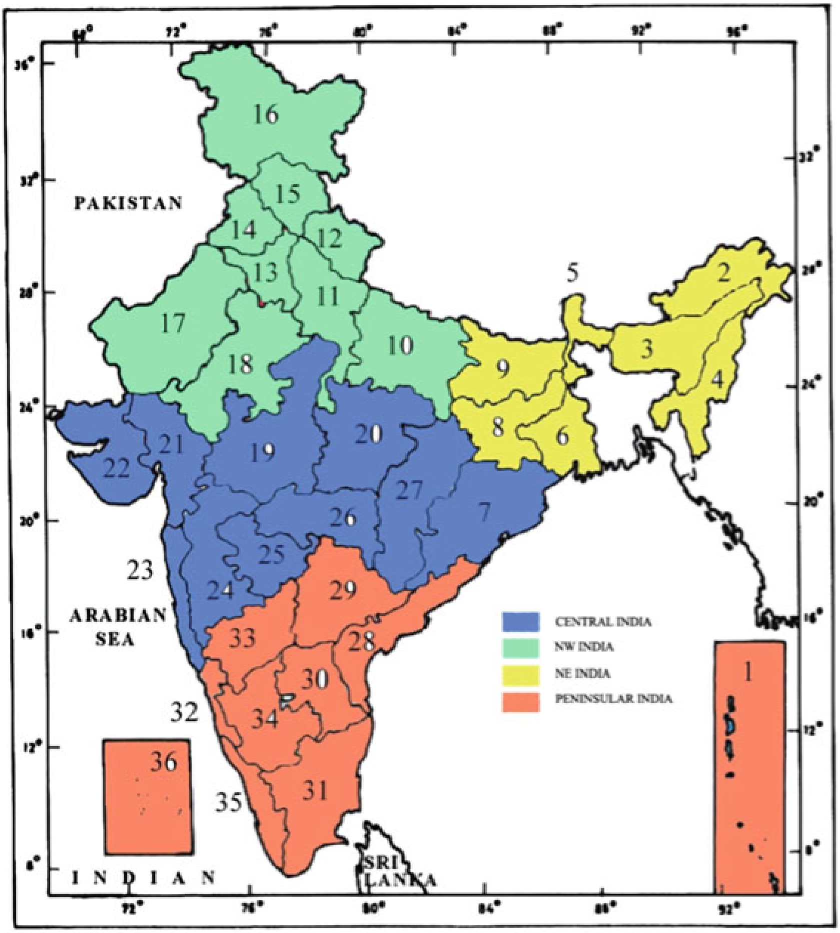
Shah (2017) modelled the daily rainfall in monsoon season (June to Sept.).

$$R_t = \frac{1}{n} \sum_{i=1}^{n} P_{it} \ \ldots \qquad (24)$$

Where, daily rainfall (R_t) in the location is a simple average of daily rainfall (recorded at the each of the n rainfall stations at time (t).

National Commodity and Derivatives Exchange (NCDEX) (2020) has launched two national-level rainfall-based indices that track the country's systematic rainfall movement. The two indices will only be representative rainfall indices in the country and were not available for trading. There are two models which are Indian Monsoon Index (Cumulative Monsoon Index) and Indian Rain Index (Monthly Cumulative Rainfall Index). These models are based on rainfall and it captures the deviation in rainfall from normal value. The following methodology is used to calculate the index value.

Figure 1: Identified Homogeneous Regions and Meteorological Sub-divisions



1. Andaman & Nicobar Island
2. Arunachal Pradesh
3. Assam & Meghalaya
4. N M M T
5. S H W B & Sikkim
6. Gangetic W. Bengal
7. Orissa
8. Jharkhand
9. Bihar
10. East U P
11. West U P
12. Uttaranchal
13. Har Delhi Chandigarh
14. Punjab
15. Himachal Pradesh
16. Jammu & Kashmir
17. West Rajasthan
18. East Rajasthan
19. West M P
20. East M P
21. Gujarat Region
22. Saurashtra & Kutch
23. Konkan & Goa
24. Madhya Maharashtra
25. Marathwada
26. Vidarbha
27. Chhatisgarh
28. Coastal A P
29. Telengana
30. Rayalseema
31. Tamil Nadu
32. Coastal Karnataka
33. North Interior Karnataka
34. South Interior Karnataka
35. Kerala
36. Lakshdweep

Source: Indian Meteorological Department (IMD)

Indian Monsoon Index = Σ (Actual Rainfall – Normal) ......(27)

Indian Rain Index = Σ (Actual Rainfall – Normal) ......(28)

The term Normal value of a particular day represents average rainfall for previous 30 years on that particular day. The normal value is calculated as sum of 30 years of rainfall data divide by 30 years. The calculation of both indices is based on the daily surplus/deficit rainfall data. The Indian Monsoon index is a seasonal index, this index would track rainfall on the basis of deviation from actual rainfall for which cumulative monsoon rainfall i.e. from 1st June to 30th September every year. On 1st June every year the index will be reset to zero. While Indian Rain index is a monthly cumulative rainfall index, this index shows the daily variations in the value depending on actual rainfall across the country. The value of the Indian Rain Index may turn positive in case of excess/surplus rainfall, if it turns negative in case of a deficit/drought. The index starts from zero as their base value every month.

4. Objectives

1. To study the framework for standardisation of measures of rainfall indices for securitization of rainfall risk.
2. To derive empirical values of rainfall indices for all the 36 Meteorological Sub-divisions of India.
3. To suggest a model rainfall derivative contracts.

5. Data and Methodology

The study covers all the dimensions of securitization of rainfall risk except the pricing issue. The present study is proposed to measure rainfall indices using empirical data of all 36 Meteorological subdivisions of India. For determining empirical values of rainfall indices, South-West monsoon rainfall data for the past 50 years (1970 to 2019) has been considered for all the 36 Meteorological Subdivisions of India. Indian These 36 MSDs are divided into four regions: East and North-East India, North-West India, Central India, and South Peninsula. East & North-East India has 7 sub-divisions. North-West India region has 9 sub-divisions, Central India and South Peninsula have 10 sub-divisions (fig 1). The study covers 50 years (1970-2019) of South-West Monsoon Season's rainfall data (June to September) of all 36 MSDs for the analysis. The rainfall data is collected from Indian Meteorological Department (IMD).

5.1 Methodology

The proposed methodology to compute rainfall index is based on the defined metrics Deficit/Excess Rainy Days (DRD/ERD). This approach appears to be more relevant to define and evaluate rainfall variability using DRD/ERD measures as standard metrics. The present study is based on the new approach for rainfall indexation.

Deficit/Excess rainfall at a given location needs to be quantified using a standard metric. For this purpose, the historical daily average rainfall for the selected location would serve as the 'base' rainfall for calculating the metric. The rainfall at a location equivalent to being below a defined normal rainfall by one millimeter for one day can be denoted as 'Deficit Rainy Day' (DRD). Similarly, rainfall at a location equivalent to being above a defined normal rainfall by one millimeter for one day can be denoted as 'Excess Rainfall Day' (ERD).

The underlying variable being rainfall, let R_i denote the rainfall (in millimeters) measured on i^{th} day, and R_x denotes the average daily rainfall (in millimeters). The average daily rainfall, R_x, should serve as the reference level for rainfall in millimeters. The value of R_x is based on the past rainfall data for any chosen length of the period. The standard underlying variable would be simply the difference between the daily average value of rainfall (in millimeters), i.e., R_x, and the actual value of rainfall (in millimeters) on i^{th} day, i.e., R_i. The DRDs generated on a given i^{th} day then is given by:

$$DRD_i = \text{Max.} \{R_x - R_i, 0\} \qquad (1)$$

Similarly,

$$ERD_i = \text{Max.} \{R_i - R_x, 0\} \qquad (2)$$

In equations (1) and (2) above, it can be seen that the number of DRDs / ERDs for a specific day is just the number of millimeters that the rainfall deviates from a reference level. The methodology adopted in this paper comprises the following steps:

Estimation of reference level of rainfall for each of the selected meteorological sub-divisions(MSDs) in India

i. Estimating the DRDs/ERDs for each month of the south-west monsoon

ii. Taking the sum of DRDs/ERDs for all the four months

The number of accumulated DRDs (D_n) for a period of 'n' days can be determined as follows:

$$D_n = \sum_{i=1}^{n} DRD_i \qquad (3)$$

Similarly, the number of accumulated ERDs (E_n) for a period of 'n' days can be determined as follows:

$$E_n = \sum_{i=1}^{n} ERD_i \qquad (4)$$

Monthly DRDs/ERDs facilitate capturing the element of variability in each month of the south-west monsoon. The DRDs/ERDs values were computed based on equations (1), (2) & (3) for the all 36 MSDs.

For example, the given historical monthly average rainfall for June for a location is 10 mm, and if the actual daily average rainfall is 9 mm, we can approximate the DRD for June as 30mm (1mm x 30 days). A zero DRD means that June month recorded excess rainfall. For seasonal DRD, South-West monsoon season of 4 months (June-Sept) historical average found to be 10mm, 12mm, 15mm, and 18mm respectively for a location or meteorological subdivision. The DRD value for location/MSDs is approximately 182mm (Table 1). The number of accumulated DRD for a

Table 1: Calculation of Monthly DRD (MM)

Month	June	July	August	September	Total
Historical Average	10	12	15	18	
Actual rainfall	9	10	16	15	
	1*30days	2*31days	0*31days	3*30days	
DRD	**30**	**62**	**0**	**93**	**182**

Source: Computed by the author

South-West Monsoon is a minimum of zero and a maximum of 182 mm for a location/MSD.

The study applies to each sub-division rainfall data series to validate the proposed method, which allows predicting actual rainfall at each sub-division and comparing these estimates to the actual rainfall values. The DRD/ERD values are computed based on the equation of 3 and 4 for all 36 MSDs of India

6. Results and Discussion

The part is dealt with the discussion of proposed rainfall index parameters and rainfall futures contract specification. The use of rainfall futures contract has been discussed in the end.

Table 2: Proposed Rainfall Index Parameters of rainfall derivatives

	DRDs				ERDs			
Underlying symbol	**Strike value (Avg.)**	**Max.**	**S.D**	**CV (%)**	**Strike value (Avg.)**	**Max.**	**S.D**	**CV (%)**
East & North-East India								
Arunachal Pradesh	**215**	**552**	**158**	**73**	**215**	**1124**	**228**	**106**
Assam & Meghalaya	**215**	**618**	**169**	**79**	**215**	**1006**	**250**	**116**
NMMT	**159**	**493**	**135**	**85**	**160**	**1449**	**247**	**155**
SHWB & Sikkim	**201**	**602**	**137**	**68**	**201**	**578**	**16**	**82**
Gangetic West Bengal	**153**	**403**	**94**	**61**	**153**	**465**	**128**	**84**
Jharkhand	**130**	**384**	**83**	**64**	**136**	**500**	**119**	**88**
Bihar	**138**	**401**	**90**	**65**	**138**	**553**	**112**	**81**
North-West India								
East UP	**124**	**397**	**94**	**76**	**124**	**600**	**114**	**91**

West UP	**122**	**345**	**92**	**75**	**123**	**443**	**105**	**85**
Uttarakhand	**157**	**748**	**167**	**106**	**157**	**673**	**153**	**98**
Har. Chd & Delhi	**93**	**246**	**64**	**69**	**93**	**356**	**87**	**94**
Punjab	**95**	**279**	**66**	**70**	**95**	**624**	**110**	**116**
Himachal Pradesh	**111**	**334**	**89**	**80**	**111**	**472**	**108**	**97**
J & K	**94**	**259**	**63**	**67**	**94**	**398**	**98**	**104**
West Rajasthan	**68**	**189**	**46**	**68**	**68**	**246**	**64**	**94**
East Rajasthan	**104**	**356**	**82**	**79**	**104**	**417**	**86**	**82**
Central India								
Odisha	**124**	**350**	**82**	**66**	**124**	**482**	**124**	**98**
West MP	**137**	32	87	64	**137**	525	137	89
East MP	**257**	530	117	46	**133**	472	133	91
Gujarat region	**189**	557	145	77	**199**	663	199	86
Saurasthra & Kutch	**162**	448	112	69	**135**	443	135	122
Konkan & Goa	**338**	1028	255	75	**338**	1233	338	79
Madhya Maharashtra	**102**	287	74	73	**123**	486	123	80
Marathwada	**123**	334	71	57	**1024**	344	1024	99
Vidarbha	**135**	298.	87	65	**162**	1173	162	87
Chattishgarh	**119**	397	89	75	**119**	513	119	81
South Peninsula								
A & N Island	**201**	518	147	73	201	884	201	100
Coastal AP& Yanam	**82**	192	55	67	82	272	75	92
Telangana	**114**	291	76	67	118	508	120	102
Rayalaseema	**75**	169	45	60	75	287	73	97
TN,Pudu & Karaikal	**48**	167	34	72	48	141	42	87
Coastal Karnataka	**348**	902	229	66	348	1096	292	84
N.I. Karnataka	**76**	186	54	71	76	229	69	91
S.I. Karnataka	**86**	232	64	75	86	239	68	80
Kerala & Mahe	**261**	660	169	65	261	847	243	93
Lakshadweep	**158**	480	108	68	158	449	111	70

Source: SPSS output, computed by the researcher

Table 2 shows the proposed rainfall index parameters of rainfall derivatives contract. The rainfall derivatives contracts payoff is based on an underlying index (DRD/ERD), which is observed from rainfall data at a specific geographic location. Based on this, the mean (strike) DRDs values for the selected regions would serve as the 'base' for calculating the contract's payoff. For example, from the above table-2, the mean DRD/ERD values of south-west monsoon season for N.I. Karnataka were 76 mm; this value indicates that every year N.I.Karnataka has been facing a minimum of 76 mm of deficit rainfall from the south-west monsoon season. The N.I.Karnataka region's DRD values would serve as a benchmark for designing rainfall options and futures contracts for trading in the markets.

6.1 Model of Rainfall Futures Contract

Basically a rainfall index future is a derivative contract whose value depends on the underlying index. The underlying rainfall index can be defined and measured in several ways. The present study examined alternative methods of measuring rainfall indexes and adopted the DRD/ERD indices as standard metric which can be used as building blocks for designing rainfall futures contracts.

A model rainfall index futures contract involves specification of the following terms:

1) **Contract size:** the underlying is simply on index number that needs to be converted into a monetary value by a 'Multiplier' which for instance is 50 for NIFTY. The 'multiplier' is called lot size of the contract. This is necessary for determining the value of a futures contract. The chosen multiplier may be a sum, say Rs.1000. this means that contract size is 1000 times the DRD/ERD index points. If the DRD index is 200 points, the contract value is Rs.2,00,000.

2) **Product Description:** Empirically derived values of DRD/ERD indices are the products for each specified MSD or any other region or city.

3) **Tick Size:** it is the predetermined decimal applied to each index point. For instance, if the decimal is decided to be 0.1, then the tick size of the contract will be 0.1 x multiplier (=Rs. 1000 x 0.1 = Rs.100 per contract)

4) **Mode of Settlement:** the mode of settlement is compulsory on cash basis. This is because DRD/ERD indices are not physically deliverable.

5) **Contract Months:** As core part of monsoon covers a period of 4 months from June to September, these months are ideal for trading rainfall Index futures contracts.

6) **Ticker symbols:** As the underlying for rainfall index futures is either DRD or ERD index, the ticker symbol could be DRDX or ERDX.

Based on the terms described above, a model rainfall index futures contract for North Interior Karnataka MSD can be designed as shown below:

Table 3 : A model Rainfall Index futures contract (specification)		
1	**Contract size**	Rs.1000 times the respective DRD/ERD index
2	**Product Description**	DRD/ERD (millimeters) of North Interior Karnataka MSD
3	**Tick Size**	0.1 Index point (= Rs.100 per contract)
4	**Mode of Settlement**	Cash Settlement : Final Settlement Procedures for monthly DRD/ERD futures
5	**Contract Months**	DRD/ERD = June, July, August and September (4 months)
6	**Ticker Symbols**	DRDX or ERDX
7	**Position Limits**	All months combined: 10,000 contracts
8	**Pricing Unit**	Rs. Per index point (1 index point = 1 mm of rainfall)

Source: Compiled by the researcher

6.2 Risk Management using DRD/ ERD Futures

A simple numerical example is presented here to illustrate the hedging application of DRD futures. Let us assume that ABC Bank finds that its agri-loan revenue is negatively correlated with the North Interior Karnataka subdivision. ABC bank is concerned about the possibility of adverse rainfall and would like to use DRD futures to hedge against the possibility of deficit rainfall than expected rainfall. In order to construct a hedging strategy, it will necessary to quantity the relationship between agri-loan and monsoon conditions. A statistical regression between revenues and rainfall is useful in assessing the quantitative relationships. Assume that, based on historical regressions, ABC bank finds that its agri-loan revenue is negatively correlated with the North Interior Karnataka subdivision DRD index with a sensitivity ratio of 0.70, i.e., a 1 percent change in DRD may give drive a 0.7 percent change in ABC's anticipated Rs. 5 crores in revenues. Assuming futures are trading at 186, the no. of futures contracts required may be calculated as follows:

No. of futures contract = (Revenues x Hedge ratio) / DRD index x Multiple

= (5,00,00,000 x 0.70) / 186 x 1000

= (3,50,00,000 /186000)

= 188 futures contracts

This suggests that ABC bank might buy 188 futures contracts to hedge the risks of deficit rainfall and lower than expected revenues.

Table 4: Hedging with Rainfall Futures

		Revenues (without futures contract)	With Futures Contract
1	Now	Expected Revenue of Rs.5 crore	Buy 188 futures at 186
2	Later	Realised Revenue of Rs.4.64 crore	DRD futures settled at 205
		Revenue shortfall of Rs. 35.73 lakhs	Profit: 19 DRD x 1000 x 188 contracts
			= **Rs. 35.72 lakhs**
3	**Results**	**Net revenue realiwsed is the same as the Rs.5 crore. ABC bank revenue loss of Rs. 35.73 lakhs is off-set by profit on DRD futures contract.**	

Source: Compiled by the researcher

Assume that rainfall is scanty and DRD index settles at 205 DRD. This deficit implies 10.21 % (205-186 =19/186x100) increase in DRD and as a result revenues would fall by 7.147% (10.21% x 0.7) to Rs. 35.73 lakhs. The net revenue realised is the same as the Rs.5 crore. ABC bank revenue loss of Rs. 35.73 lakhs is off-set by profit on DRD futures contract**.** Proper use of rainfall futures contract not only enables ABC bank to stabilize revenue but may also be used to provide at least a partial hedge to the cost side of the equation.

The following case studies below are designed to illustrate some basic DRD-based transactions. Cumulative DRD for a period of 4 months (i.e., from 1st June to 30th September) comprising the south-west monsoon aggregated to give a quantitative measure of DRD/ERD index values over the season.

6.4 Application of Rainfall Futures

The following case studies below are designed to illustrate some basic DRD-based transactions. Cumulative DRD for a period of 4 months (i.e., from 1st June to 30th September) comprising the south-west monsoon aggregated to give a quantitative measure of DRD/ERD index values over the season.

Case Study 1: Difference in Expectations

The demand for power is significantly affected by deficit rainfall in the monsoon season. The power generation company estimated that the 50 year average is around 86mm DRD for South Interior Karnataka subdivision. Suppose a company plans to hedge the event of a drought. The power generation company buys a monthly DRD futures contract, the less rainy day in the month the greater the value of the contract. Suppose empirical value of DRD index for south-west monsoon is 86mm, and actual due to deficit rainfall is 110mm. It will receive a payout of Rs.24000 (24mm x Rs.1000). If rainfall is normal, the power generation will increase leads to increase in the revenue.

Case Study 2:
Correlation across MSDs

The study found that DRD values of North Interior Karnataka subdivision have a negative (-0.337) relationship with Odisha subdivision. This means it is quite likely that when Odisha subdivision reels under deficit rainfall, North Interior Karnataka subdivision experience excess rainfall. Buying or selling DRD futures on both Odisha and North Interior Karnataka subdivision simultaneously, the loss in one is offset by gain in another. A crop insures with maximum exposure in Odisha for a drought outcome can buy Odisha subdivision DRD and simultaneously sell the North Interior Karnataka subdivision DRD. This is particularly useful when DRD is used as a distinct asset class by building a diversified portfolio by insurance companies having sold rainfall-based index insurance policies across a wide geographical area.

Case Study 3:
Commodity Market and Rainfall Futures Market.

India is third largest wheat producing country. Largest wheat producing state is Uttar Pradesh, India. Weather conditions are the important factor influencing the wheat production. A wheat trader at NCDEX expects that coming monsoon in Uttar Pradesh region is more likely to be below normal and goes long position for the season. The trader can hedge his position with a short position in DRD futures on a traded rainfall deviation in the East and West Uttar Pradesh region. If it is below normal the trader markets significant money on the wheat position at the relatively modest loss on the DRD futures, netting out to a profit. If monsoon turns out to be normal than the trader expected, the trader will lose money on the wheat position, which will be compensated in whole or in part by the payout from the DRD futures.

7. Conclusion

The study has intended to designing the rainfall indexation based on proposed metrics which is DRD/ERD index, this could be used as building blocks for designing rainfall derivatives similar to HDDs/CDDs underlying temperature derivatives. DRD/ERD values are computed for 36 meteorological subdivisions of India. Rainfall derivative instruments that could empower the ecosystem of trading and absorbing rainfall risk. The monsoon-sensitive sectors can use rainfall derivatives to effectively hedge rainfall risk. Rainfall derivatives can be a n attractive tool for speculators to satiate their instincts by betting on adverse rainfall outcome. Like CAT bonds, rainfall derivatives constitute potentially a distinct asset class and hence could be an added arsenal in the hands of investors for enriching their portfolios.

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