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Exploring the Rainfall Index as a Unique Asset Class for Investment, Hedging and Speculation

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Abstract

The proposed study is an attempt to explore the rainfall index as a unique asset class that can be used as part of a portfolio investment. Therefore, the present study considered the monthly monsoon rainfall data for the period from 1991 to 2020. The study employed the correlation matrix to know the relationship between the rainfall of one MSD and the rainfall of the other MSDs in India. For these, the study used the rainfall data of all MSDs in India for the study period. The correlation analysis shows that there is a negative and weak correlation between one MSD and other MSDs for the study period. That means the rainfall in one MSD is not strongly correlated with the other MSD. Therefore, it is a distinct and unique asset class for a portfolio investment. The rainfall index based futures (RIBF) contracts are the best tool to hedge, speculate and invest in the rainfall index. According to the author's knowledge, this is the first exploratory study to explore the rainfall index as a unique asset class, and it is used for investment, hedging, and speculation.

Keywords: Rainfall Index; Unique Asset; Hedging, Speculation and Rainfall Index Based Futures.

1. Introduction

India is a country with wide geographical diversity and different weather conditions for each distinct geographical location. There are some industries like agriculture, banking, manufacturing, construction, transportation, tourism, power generation companies, and other weather-dependent industries that are economically supported for the Indian economy and for the sustainable development of the country. As a result, the Indian economy is weather-dependent and is influenced by weather variables such as temperature, rainfall, snowfall, wind speed, and so on. Rainfall plays a vital role in the development of a developing economy like India. The recent occurrence of rainfall has revealed major floods and droughts in various parts of our country. This leads to adverse effects on the revenue of businesses, the price of FMCG goods, employment scarcity, and other problems for the people of a country. Therefore, it must be mitigated for the smooth operation of business and to avoid loss due to adverse rainfall occurrences. There are some insurance companies that have come out with a few plans for crop and index insurance, but these are not an effective way to manage the rainfall risk of our bio-diversified country. So, there is a need of capital market Alternative Risk Transfer (ART) products to hedge, speculate and invest on the rainfall. According to industry sources, around 10,000 crores of rupees were bet on monsoon rainfall. Therefore, ART instruments like rainfall index-based futures (RIBF) and option contracts provide a diversified opportunity to invest, hedge, and speculate on the rainfall. Therefore, the present study is undertaken to determine whether the rainfall index may be a distinct asset class or not. Because unique asset classes are helpful for all investment activity, like stock indices, those are not strongly correlated with other financial assets. The next section deals with the existing literature on the present study. In the continuing section explains the methodology of the study. In the next section, shows the empirical analysis of the study. Eventually, a study will reveal the findings and conclusions of the present study.

2. Review of Literature

Shivakumar and Kotreshwar (2013) developed the monsoon outcome index (MOX) and conducted statistical analyses of its properties. The test showed that geographically nearer subdivisions had a moderate correlation, while distant subdivisions had close to zero or a negative correlation. So, this weak and insignificant correlation shows the chance of creating portfolio diversification to control the rainfall risk. The coefficient of variation was very high for some subdivisions, and it shows the MOX values can be an excellent speculation instrument for speculators. Therefore, the MOX can be traded on the exchange. **Kotreshwar (2015)** study made an attempt to securitize rainfall risk as the basis for the creation of a rainfall derivatives market in India. The author proposed a unique index for rainfall variability, i.e., excess rainy days (ERDs) and deficit rainy days (DRDs). The statistical measures like mean, standard deviation, coefficient of variance, and value at risk showed that DRDs and ERDs time series data reveal a unique risk profile for each MSD and indicated that there was a vast scope for launching a wide range of derivative instruments for weather risk markets. **Bharath and Kotreshwar (2020)** proposed a new set of rainfall indices to explore the excess rainfall risk profile of the Indian subcontinent. It shows high volatility and persistence levels in the ERD values. The value of the correlation showed that it was weaker and more negative among the MSDs. It was concluded that there was a large potential for trading ERD index-based financial derivatives to hedge excess rainfall. These indices could serve as building blocks for the development of rainfall derivatives. **Harendra and Anil (2020)** prepared the rainfall index, explored the potential of the index as an alternative asset class, and suggested trading the index to mitigate the rainfall risk. Based on the statistical properties of the rainfall index and commodity price index, the rainfall index appears to be an excellent tool for hedging and speculating on rainfall risk. The rainfall index was a distinct asset class, and it could be listed on the exchanges as a tradable commodity. If it is launched on the exchanges, it will attract speculators and hedgers for their exposure to risk. **Dileep and Kotreshwar (2022)** investigated the interrelationship between the rainfall index and the Nifty index for the period from 1991 to 2020. The empirical analysis revealed that there was no relationship and no causal relationship between the variables chosen. Further, the GARCH (1,1) model depicts that there is no effect of the rainfall index on the Nifty index. Therefore, the rainfall index is a unique and distinct kind of asset that is not associated with the Nifty index, and it can be used as part of a portfolio investment as well as for diversification of investment.

Varangis et al. (2002) believe that developing countries can use weather derivatives to hedge their weather risk in the capital market. **Veeramani et al. (2005)** developed the basic mechanism for the operation of rainfall index insurance and rainfall derivatives. The coefficient of variation values show 47.22% in June, 35.43% in July, 36.41% in August, 34.61% in September, and 51.22% in October. The results concluded that the relative risk of rainfall for the above months was higher, and as a result of the widespread nature of rainfall risk, insurers seek to mitigate it through the use of rainfall derivatives. **Kotreshwar and Kanakasabai (2006)** attempted to design and present call and put option structures by considering the monsoon rainfall index (millimeter rainy days, MRDs) as an underlying asset. The deregulation of the financial and insurance markets provided the avenue for the development of monsoon derivatives. The monsoon derivatives market was critical for the development of the insurance market because it provided the opportunity to expose their monsoon risk to the monsoon derivatives market. **Kotreshwar and Arunkumar (2006)** developed a conceptual framework for securitizing monsoon risk through a monsoon option. This monsoon option facilitates the transfer of systematic risk to capital markets. **Bharath and kotreshwar (2022)** proposed the unique DRD and ERD rainfall index approaches to capture rainfall variability. The author computed the DRD and ERD values for 36 meteorological subdivisions in India and analyzed the statistical properties of the empirical data. The use of rainfall derivatives to hedge rainfall risk and concluded that, like CAT bonds, rainfall derivatives are potentially a distinct asset class that investors can add to their portfolios to enrich it.

3. Research Methodology

This study aims to explore how the rainfall index can be a unique asset that can be used for investment, speculation, and hedging by the various stakeholders. For this, the study considered the monthly monsoon rainfall data of 30 years, from 1991 to 2020. The study considered only monsoon rainfall which occurs in the month of June, July, august and September, because India get the maximum amount of rainfall in this months and rainfall dependent industries are awaiting for the good monsoon rainfall. The study used the monthly monsoon rainfall data of all 36 subdivisions, which were divided into four regions (table 1). The study collected the rainfall data from the IMD website and IMD annual reports. The study assumed one rainfall index was equal to one millimeter of rainfall. The other specific objectives and hypotheses are listed below:

Objectives

a) To know how 36 meteorological subdivisions are correlated with each other.
b) To examine the scope of RIBF contracts in providing diversified investment opportunities to the investing community.

Hypotheses

a) Ho: "The rainfall occurrence among the 36 MSDs in India is not strongly correlated"
   H1: "The rainfall occurrence among the 36 MSDs in India is strongly correlated"
b) Ho: "RIBF contracts based on MSDs do not provide the diversification advantage for the investing community."
   H1: "RIBF contracts based on MSDs does provide a diversification advantage to the investing community."

Table 1: Selected MSD and its Regions

Region	MSDs	Region	MSDs
East/North East	Arunachal Pradesh Assam & Meghalaya Nagaland, Manipura, Mizoram and Tripura. Sub-Himalaya, West Bengal & Sikkim. Gangetic West Bengal Jharkhand Bihar	**Central India**	Odisha West Madhya Pradesh East Madhya Pradesh Gujarat Region Saurasthra & Kutch Konkan & Goa Madhya Maharashtra Marathwada Vidarbha Chhattisgarh
North-West India	East Uttar Pradesh West Uttar Pradesh Uttarakhand Haryana, Chandigarh and Delhi Punjab Himachal Pradesh Jammu and Kashmir West Rajasthan East Rajasthan	**South Peninsula**	Andaman and Nicobar Islands Coastal Andra Pradesh and Yanam Telangana Rayalaseema Tamil Nadu, Pandicherry & Karaikal Coastal Karanataka North Interior Karnataka South Interior Karnataka Kerala & Maharastra Lakshadweep

Source: IMD, Complied by research scholar

The study used correlation analysis to analyse the empirical data. The correlation is used to know if there is any relationship between the monthly monsoon rainfall of one subdivision and that of other subdivisions. The study used SPSS software to analyse the selected data. The detailed analysis of empirical data is explained in the next section.

4. Empirical Analysis of Data

The correlation analysis conducted to know how the monsoon rainfall of 36 meteorological subdivisions is correlated with each other and to know how the RIBF contracts are providing diversification advantages to the investing community. The stated objective and hypotheses are analysed with the help of the following tables: 2 to 5.

Table 2: Correlation between the East/North East and other 3 Region's Monsoon Rainfall

MSDs	Arunachal Pradesh	Assam & Meghalaya	NMMT	SHWB & Sikkim	Gangetic West Bengal	Jharkhand	Bihar

East & North-East India							
Arunachal Pradesh	1						
Assam & Meghalaya	**0.597*** 0.000	1					
NMMT	**0.486*** 0.007	0.208 0.271	1				
SHWB & Sikkim	**0.489*** 0.006	**0.758*** 0.000	-0.128 0.501	1			
Gangetic West Bengal	**-0.056*** 0.006	**0.308**** 0.098	0.061 0.501	0.207 0.272	1		
Jharkhand	-0.107 0.575	0.277 0.138	-0.009 0.964	0.207 0.272	**0.780*** 0.000	1	
Bihar	0.117 0.537	**0.507*** 0.004	-0.171 0.366	**0.656*** 0.000	**0.542*** 0.002	**0.631*** 0.000	1
North-West India							
East UP	-0.47 0.805	-0.164 0.388	0.035 0.855	-0.034 0.858	-0.059 0.758	0.029 0.880	0.111 0.560
West UP	0.050 0.793	0.265 0.157	-0.197 0.298	**0.407*** 0.026	-0.043 0.820	-0.005 0.978	0.231 0.220
Uttarakhand	**-0.328**** 0.077	-0.152 0.423	**-0.416*** 0.022	0.084 0.661	-0.029 0.879	-0.185 0.329	0.091 0.631
Har. Chd and Delhi	0.303 0.103	0.241 0.200	0.296 0.112	0.142 0.453	-0.117 0.539	-0.069 0.717	0.011 0.952
Punjab	-0.028 0.882	0.151 0.426	-0.028 0.883	0.075 0.695	0.094 0.622	0.088 0.643	0.142 0.454
Himachal Pradesh	-0.085 0.654	**0.425*** 0.019	-0.186 0.325	**0.422*** 0.020	0.015 0.937	0.162 0.391	0.253 0.177
J&K	**-0.425*** 0.019	**-0.195*** 0.019	0.036 0.850	**-0.336**** 0.070	0.087 0.646	0.059 0.756	-0.282 0.131
West Rajasthan	0.165 0.382	**-0.360**** 0.051	**0.650*** 0.000	**-0.485*** 0.007	-0.256 0.173	-0.250 0.182	**-0.522*** 0.003
East Rajasthan	-0.141 0.458	**-0.390**** 0.051	0.132 0.486	**-0.382*** 0.037	-0.166 0.382	-0.135 0.478	-0.298 0.110
Central India							
Odisha	-0.262 0.163	**-0.345**** 0.062	-0.146 0.440	**-0.438*** 0.016	0.102 0.591	0.276 0.140	0.009 0.204
West MP	-0.187 0.323	-0.290 0.120	-0.067 0.726	-0.219 0.246	0.071 0.710	0.118 0.536	-0.049 0.797
East MP	-0.223 0.237	-0.161 0.396	-0.158 0.404	-0.081 0.670	-0.071 0.709	0.153 0.420	0.081 0.672
Gujarat Region	-0.191 0.312	**0.394*** 0.031	-0.085 0.656	**-0.312**** 0.094	-0.109 0.565	-0.018 0.925	-0.082 0.667
Saurasthra & Kutch	0.074 0.699	**-0.493*** 0.006	**0.543*** 0.002	**-0.559*** 0.001	**-0.327**** 0.077	-0.302 0.105	**-0.447*** 0.013
Konkan &Goa	-0.284 0.129	-0.004 0.985	**-0.575*** 0.001	0.313 0.092	0.120 0.527	0.042 0.826	**0.404*** 0.027
Madhya Maharashtra	-0.114 0.549	**-0.370*** 0.044	-0.053 0.782	-0.158 0.403	0.028 0.885	0.052 0.785	0.063 0.739

Marathwada	0.178 0.346	-0.246 0.189	0.180 0.340	0.097 0.611	-0.225 0.233	-0.282 0.132	-0.064 0.736
Vidarbha	-0.266 0.156	**-0.385*** 0.036	0.005 0.979	**-0.308**** 0.097	-0.125 0.512	-0.076 0.690	-0.294 0.114
Chhattisgarh	0.028 0.885	-0.252 0.180	**0.356**** 0.053	**-0.359**** 0.052	-0.135 0.476	0.150 0.429	-0.183 0.334
South Peninsula							
A&N Island	-0.142 0.453	-0.214 0.266	-0.064 0.736	-0.205 0.278	-0.012 0.950	-0.011 0.953	-0.187 0.322
Coastal AP and Yanam	0.238 0.206	0.057 0.764	0.219 0.245	0.268 0.152	-0.215 0.254	-0.252 0.180	0.053 0.780
Telangana	0.022 0.910	**-0.375*** 0.041	0.125 0.511	-0.084 0.658	**-0.346**** 0.061	**-0.384*** 0.036	-0.202 0.285
Rayalaseema	0.283 0.130	-0.025 0.897	**0.499*** 0.005	0.009 0.962	-0.071 0.708	-0.207 0.272	0.023 0.905
TN, Pudu & Karaikal	**0.340**** 0.066	0.188 0.320	**0.422*** 0.020	0.085 0.657	-0.238 0.204	**-0.371*** 0.043	-0.071 0.710
Coastal Karanataka	-0.164 0.387	-0.223 0.236	0.033 0.861	**-0.338**** 0.068	-0.026 0.893	0.085 0.655	-0.096 0.613
N.I. Karnataka	0.166 0.381	-0.208 0.271	0.281 0.133	-0.137 0.470	-0.134 0.482	-0.274 0.143	0.087 0.649
S.I. Karnataka	-0.055 0.773	-0.085 0.655	0.076 0.688	-0.237 0.208	-0.033 0.863	-0.188 0.321	-0.082 0.665
Kerala & Mahe	-0.147 0.437	-0.183 0.334	0.005 0.981	-0.301 0.106	0.064 0.738	-0.048 0.803	-0.118 0.535
Lakshadweep	**0.358**** 0.052	0.179 0.344	**0.362*** 0.049	0.122 0.522	0.071 0.708	-0.073 0.703	0.040 0.835

**Correlation is significant at 0.1 level

* Correlation is significant at 0.05 level

Source: SPSS output, computed by researcher

The correlation between East and North-East MSDs and the other three regions' MSDs in India is shown in Table 2. The correlations assess the strength of the relationship between two subdivisions. The study carried out a pair-wise correlation analysis between seven subdivisions and the other 29 subdivisions. It is found that the correlation values range between a minimum of -0.575 and a maximum of +0.780. There are 224 pairs, with 51 being significant at the 5% and 10% levels. Out of 51 pair-wise interrelationships, 28 pairs have a weak or moderate positive correlation, and 23 pairs are negatively correlated.

Table 3: Correlation between the North-West and other 3 Region's Monsoon Rainfall

MSDs	East UP	West UP	Uttarakhand	Har. Chd and Delhi	Punjab	Himachal Pradesh	J&K	West Rajasthan	East Rajasthan
East & North-East India									
Arunachal Pradesh	-0.047 0.805	0.050 0.793	**-0.328**** 0.077	0.303 0.103	-0.028 0.882	-0.085 0.654	**-0.425*** 0.019	0.165 0.382	-0.141 0.458
Assam & Meghalaya	-0.164 0.388	0.265 0.157	-0.152 0.423	0.241 0.200	0.151 0.426	**0.425*** 0.019	-0.195 0.301	**-0.360**** 0.051	**-0.390*** 0.033
NMMT	0.035 0.855	-0.197 0.298	**-0.416*** 0.022	0.296 0.112	-0.028 0.883	-0.186 0.325	0.036 0.850	**0.650*** 0.000	0.132 0.486

SHWB & Sikkim	-0.034 0.858	**0.407*** 0.026	0.084 0.661	0.142 0.453	0.075 0.695	**0.422*** 0.020	- **0.336**** 0.070	**-0.485*** 0.007	**-0.382*** 0.037
Gangetic West Bengal	-0.059 0.758	-0.043 0.820	-0.029 0.879	-0.117 0.539	0.094 0.622	0.015 0.937	0.087 0.646	-0.256 0.173	-0.166 0.382
Jharkhand	0.029 0.880	-0.005 0.978	-0.185 0.329	-0.069 0.717	0.088 0.643	0.162 0.391	0.059 0.756	-0.250 0.182	-0.135 0.478
Bihar	0.111 0.560	0.231 0.220	0.091 0.631	0.011 0.952	0.142 0.454	0.253 0.177	-0.282 0.131	**-0.522*** 0.003	-0.298 0.110
North-West India									
East UP	1								
West UP	**0.578*** 0.001	1							
Uttarakhand	0.299 0.108	0.303 0.103	1						
Har. Chd and Delhi	**0.354**** 0.055	**0.557*** 0.001	0.029 0.880	1					
Punjab	**0.308**** 0.098	**0.508*** 0.004	0.161 0.395	**0.763*** 0.000	1				
Himachal Pradesh	0.089 0.640	**0.702*** 0.000	0.067 0.725	**0.544*** 0.002	**0.651*** 0.000	1			
J&K	-0.027 0.888	-0.018 0.924	0.111 0.561	0.300 0.108	**0.391*** 0.033	0.272 0.146	1		
West Rajasthan	0.185 0.329	-0.191 0.313	-0.237 0.208	**0.353****0.056	0.101 0.597	-0.203 0.281	**0.361*** 0.050	1	
East Rajasthan	0.277 0.139	-0.048 0.802	-0.098 0.607	0.166 0.381	0.262 0.161	-0.013 0.947	**0.438*** 0.016	**0.634*** 0.000	1
Central India									
Odisha	0.239 0.204	-0.172 0.364	0.075 0.695	0.010 0.958	0.229 0.223	-0.116 0.541	0.158 0.403	0.149 0.431	0.244 0.193
West MP	0.205 0.277	0.028 0.884	-0.075 0.693	-0.037 0.845	0.147 0.437	0.061 0.749	0.312 0.749	**0.331**** 0.074	**0.748*** 0.000
East MP	**0.486*** 0.006	**0.421*** 0.020	0.063 0.741	0.170 0.369	0.237 0.207	**0.332**** 0.073	-0.040 0.832	0.115 0.545	**0.450*** 0.013
Gujarat Region	0.174 0.358	0.008 0.966	0.175 0.355	0.283 0.130	0.265 0.157	-0.008 0.967	0.280 0.134	**0.343**** 0.063	**0.356**** 0.053
Saurasthra & Kutch	0.235 0.212	- **0.319**** 0.085	-0.189 0.317	0.184 0.330	0.001 0.997	**-0.399*** 0.029	0.153 0.419	**0.879*** 0.000	**0.589*** 0.001
Konkan &Goa	0.039 0.837	0.302 0.104	**0.499*** 0.005	-0.174 0.358	0.128 0.500	0.230 0.221	-0.034 0.858	**-0.427*** 0.019	0.172 0.365
Madhya Maharashtra	0.089 0.639	-0.061 0.749	-0.039 0.838	0.035 0.856	0.080 0.674	-0.185 0.327	-0.012 0.948	0.169 0.373	**0.333**** 0.072
Marathwada	0.212 0.261	0.271 0.145	0.000 1	**0.327**** 0.078	0.096 0.614	-0.009 0.964	-0.090 .638	**0.321**** 0.083	0.149 0.432
Vidarbha	0.303 0.103	0.147 0.438	0.222 0.239	0.039 0.838	0.032 0.866	0.043 0.821	0.277 0.139	**0.425*** 0.019	**0.409*** 0.025
Chhattisgarh	**0.475*** 0.008	0.062 0.746	-0.146 0.443	**0.324**** 0.081	0.139 0.463	0.017 0.930	0.234 0.212	**0.677*** 0.000	**0.618*** 0.000
South Peninsula									

A&N Island	0.012 0.949	-0.096 0.615	-0.073 0.701	0.066 0.730	0.220 0.242	0.072 0.705	**0.353**** 0.056	**0.379*** 0.039	**0.726*** 0.000
Coastal AP and Yanam	0.154 0.417	0.140 0.460	0.043 0.821	0.273 0.145	0.038 0.842	0.009 0.964	0.086 0.652	**0.311*** 0.09	0.207 0.272
Telangana	**0.504*** 0.004	0.262 0.162	0.187 0.322	0.277 0.139	0.130 0.495	-0.082 0.667	0.111 0.560	**0.484*** 0.007	**0.388*** 0.034
Rayalaseema	0.190 0.315	-0.049 0.799	-0.108 0.571	0.336 0.846	0.037 0.846	-0.242 0.197	0.115 0.544	**0.494*** 0.006	0.243 0.195
TN, Pudu & Karaikal	0.157 0.407	0.151 0.424	-0.153 0.419	**0.337*** 0.068	0.109 0.565	-0.031 0.870	0.038 0.843	**0.361*** 0.050	0.284 0.129
Coastal Karanataka	0.085 0.656	-0.040 0.833	-0.136 0.474	0.042 0.825	0.125 0.511	0.048 0.803	0.111 0.559	**0.350**** 0.058	**0.534*** 0.002
N.I. Karnataka	-0.063 0.742	-0.228 0.226	-0.212 0.260	0.046 0.810	-0.127 0.502	**-0.415*** 0.022	-0.079 0.680	**0.340**** 0.066	0.265 0.157
S.I. Karnataka	-0.113 0.550	-0.137 0.470	-0.212 0.260	-0.045 0.815	-0.041 0.829	-0.189 0.316	-0.026 0.893	0.118 0.535	0.122 0.522
Kerala & Mahe	-0.111 0.561	-0.094 0.622	-0.090 0.635	0.002 0.994	0.157 0.408	-0.015 0.939	0.090 0.635	0.153 0.419	**0.325**** 0.079
Lakshadweep	-0.147 0.439	-0.211 0.264	0.197 0.296	-0.006 0.973	-0.006 0.973	-0.115 0.547	0.066 0.730	**0.420*** 0.021	**0.383*** 0.036

**Correlation is significant at 0.1 level

* Correlation is significant at 0.05 level

Source: SPSS output, computed by researcher

Table 3 shows the correlation matrix between the North-West MSDs and the other 3 regions' MSDs in India. The study carried out a pair-wise correlation analysis between nine subdivisions and the other 27 subdivisions. It is found that the correlation values range between a minimum of -0.485 and a maximum of +0.879. There are 279 pairs, 67 of which are statistically significant at the 5% and 10% levels. Out of 67 pairs with pairwise correlation, 54 pairs have a weak or moderately positive correlation, and 13 pairs are negatively correlated with North-West MSDs in the Indian region.

Table 4: Correlation between the Central India and other 3 Region's Monsoon Rainfall

MSDs	Odisha	West MP	East MP	Gujarat Region	Saurashtra & Kutch	Konkan &Goa	Madhya Maharashtra	Marathwada	Vidarbha	Chhattisgarh
East & North-East India										
Arunachal Pradesh	-0.262 0.163	-0.187 0.323	-0.223 0.237	-0.191 0.312	0.074 0.699	-0.284 0.129	-0.114 0.549	0.178 0.346	-0.266 0.156	0.028 0.885
Assam & Meghalaya	- **0.345**** 0.062	-0.290 0.120	-0.161 0.396	- **0.394*** 0.031	**-0.493*** 0.006	-0.004 0.985	**-0.370*** 0.044	-0.246 0.189	**-0.385*** 0.036	-0.252 0.180
NMMT	-0.146 0.440	-0.067 0.726	-0.158 0.404	-0.085 0.656	**0.543*** 0.002	- **0.575*** 0.001	-0.053 0.782	0.180 0.340	0.005 0.979	**0.356**** 0.053
SHWB & Sikkim	- **0.438*** 0.016	-0.219 0.246	-0.081 0.670	- **0.312**** 0.094	**-0.559*** 0.001	**0.313**** 0.092	-0.158 0.403	0.097 0.611	- **0.308**** 0.097	**-0.359**** 0.052
Gangetic West Bengal	**0.102*** 0.016	-0.219 0.246	-0.081 0.670	- **0.312**** **	**-0.559*** 0.001	**0.313**** 0.092	-0.158 0.403	0.097 0.611	- **0.308**** 0.097	**-0.359**** 0.052

				0.094						
Jharkhand	0.276 0.140	0.118 0.536	0.153 0.420	-0.018 0.925	-0.302 0.105	0.042 0.826	0.052 0.785	-0.282 0.132	-0.076 0.690	0.150 0.429
Bihar	0.009 0.963	-0.049 0.797	0.081 0.672	-0.082 0.667	**-0.447*** 0.013	**0.404*** 0.027	0.063 0.739	-0.064 0.736	-0.294 0.114	-0.183 0.334
North-West India										
East UP	0.239 0.204	0.205 0.277	**0.486*** 0.006	0.174 0.358	**0.235*** 0.0212	0.039 0.837	0.089 0.639	0.212 0.261	0.303 0.103	**0.475*** 0.008
West UP	-0.172 0.364	0.028 0.884	**0.421*** 0.020	0.008 0.966	**-0.319**** 0.085	0.302 0.104	-0.061 0.749	0.272 0.145	0.147 0.438	0.062 0.746
Uttarakhand	0.075 0.695	-0.075 0.693	0.063 0.741	0.175 0.355	-.189 0.317	**0.499*** 0.005	-0.039 0.838	0.000 1	0.222 0.239	-0.146 0.443
Har. Chd and Delhi	0.010 0.958	-0.037 0.845	0.170 0.369	0.286 0.130	0.184 0.330	-0.174 0.358	0.035 0.856	**0.327**** 0.078	0.039 0.838	**0.324**** 0.081
Punjab	0.229 0.223	0.147 0.437	0.237 0.207	0.265 0.157	0.001 0.997	0.128 0.500	0.080 0.674	0.096 0.614	0.032 .866	0.139 0.463
Himachal Pradesh	-0.116 0.541	0.061 0.749	**0.332**** 0.073	-0.008 0.967	**-0.399*** 0.029	0.230 0.221	-0.185 0.327	0-.009 0.964	0.043 0.821	0.017 0.930
J&K	0.158 0.403	**0.312**** 0.093	-0.040 0.832	0.280 0.134	0.153 0.419	-0.034 0.858	-0.012 0.948	-0.090 0.638	0.277 0.139	0.234 0.212
West Rajasthan	0.149 0.431	**0.331**** 0.074	0.115 0.545	**0.343**** 0.063	**0.879*** 0.000	**-0.427*** 0.019	0.169 0.373	**0.321**** 0.083	**0.425*** 0.019	**0.677*** 0.000
East Rajasthan	0.244 0.193	**0.748*** 0.000	**0.450*** 0.013	**0.356**** 0.053	**0.589*** 0.001	0.172 0.365	**0.333**** 0.072	0.149 0.432	**0.409*** 0.025	**0.618*** 0.000
Central India										
Odisha	1									
West MP	0.222 0.237	1								
East MP	0.222 0.239	**0.595*** 0.001	1							
Gujarat Region	**0.575** 0.001	**0.386*** 0.035	**0.378*** 0.040	1						
Saurasthra & Kutch	0.230 0.221	**0.338**** 0.068	0.150 0.428	**0.970*** 0.030	1					
Konkan &Goa	-0.005 0.980	0.274 0.142	**0.331**** 0.074	0.216 0.251	**-0.390*** 0.033	1				
Madhya Maharashtra	**0.361*** 0.050	**0.350**** 0.058	0.295 0.113	**0.752*** 0.000	**0.318**** 0.087	**0.398*** 0.029	1			
Marathwada	-0.272 0.145	0.086 0.650	0.121 0.523	0.295 0.114	**0.328**** 0.077	0.124 0.514	**0.560*** 0.001	1		
Vidarbha	0.224 0.235	**0.482*** 0.007	**0.527*** 0.003	**0.429*** 0.018	**0.439*** 0.015	0.135 0.476	**0.340**** 0.066	**0.369*** 0.045	1	
Chhattisgarh	**0.466*** 0.009	**0.543*** 0.002	**0.616*** 0.000	**0.495*** 0.005	**0.625*** 0.000	-0.227 0.227	0.218 0.247	0.060 0.753	**0.509*** 0.004	1

South Peninsula										
A&N Island	0.131 0.491	**0.601*** 0.000	0.287 0.124	0.167 0.378	**0.379*** 0.039	0.216 0.253	0.119 0.533	-0.130 0.492	0.281 0.133	**0.368*** 0.045
Coastal AP and Yanam	-0.222 0.238	-0.041 0.831	-0.194 0.303	0.074 0.699	0.264 0.159	0.065 0.734	0.158 0.404	**0.481*** 0.007	0.148 0.436	0.042 0.825
Telangana	-0.013 0.947	0.262 0.162	0.262 0.162	**0.348**** 0.060	**0.510*** 0.004	0.107 0.573	**0.402*** 0.027	**0.720*** 0.000	**0.629*** 0.000	0.303 0.104
Rayalaseema	-0.188 0.319	0.035 0.854	-0.214 0.256	0.162 0.392	**0.536*** 0.002	-0.163 0.390	0.249 0.184	**0.511*** 0.004	0.087 0.646	0.171 0.366
TN, Pudu & Karaikal	-0.267 0.154	-0.039 0.838	-0.221 0.241	0.048 0.802	**0.348**** 0.059	-0.032 0.867	0.160 0.397	**0.322**** 0.082	-0.093 0.626	0.045 0.815
Coastal Karanataka	**0.443*** 0.014	**0.441*** 0.015	**0.390*** 0.033	**0.390*** 0.033	**0.424*** 0.020	0.173 0.360	**0.393*** 0.031	0.003 0.989	**0.481*** 0.007	**0.487*** 0.006
N.I. Karnataka	-0.117 0.539	0.055 0.774	-0.162 0.393	0.179 0.345	**0.509*** 0.004	0.046 0.808	**0.519*** 0.003	**0.540*** 0.002	0.145 0.444	0.007 0.970
S.I. Karnataka	0.096 0.613	-0.073 0.703	-0.107 0.575	0.179 0.343	0.292 0.118	0.076 0.691	**0.363*** 0.049	0.125 0.509	0.177 0.351	-0.061 0.747
Kerala & Mahe	**0.403*** 0.027	0.199 0.291	0.070 0.714	**0.395*** 0.031	0.250 0.182	0.214 0.255	**0.469*** 0.009	0.013 0.946	0.270 0.149	0.153 0.419
Lakshadweep	0.042 0.825	0.193 0.307	-0.065 0.735	0.245 0.192	**0.417*** 0.022	0.022 0.908	**0.317*** 0.088	0.217 0.249	0.134 0.480	0.258 0.168

**Correlation is significant at 0.1 level

* Correlation is significant at 0.05 level

Source: SPSS output, computed by researcher

Table 4 displays the correlation values between the Central MSDs and the other 3 regions' MSDs in India. The correlation is calculated between the 10 central subdivisions and the other 26 subdivisions. The correlation coefficient values range from -0.575 to +0.970. There are 305 correlations, but only 104 are statistically significant at 5% or 10%. Out of 104 pairs, 84 pairs are weak or moderately positively correlated, and 20 pairs are negatively correlated with the Central MSDs.

Table 5: Correlation between the South Peninsula and other 3 Region's Monsoon Rainfall

MSDs	A&N Island	Coastal AP and Yanam	Telangana	Rayalaseema	TN, Pudu & Karaikal	Coastal Karanataka	N.I. Karnataka	S.I. Karnataka	Kerala & Mahe	Lakshadweep
East & North-East India										
Arunachal Pradesh	-0.142 0.453	0.238 0.206	0.022 0.910	0.283 0.130	**0.340**** 0.066	-0.164 0.387	0.166 0.381	-0.055 0.773	-0.147 0.437	**0.358**** 0.052
Assam & Meghalaya	-0.214 0.256	0.057 0.764	**-0.375*** 0.041	-0.025 0.897	0.188 0.320	-0.223 0.236	-0.208 0.271	-0.085 0.655	-0.183 0.334	0.179 0.344
NMMT	-0.064 0.736	0.219 0.245	0.125 0.511	**0.499*** 0.005	**0.422*** 0.020	0.033 0.861	0.281 0.133	0.076 0.688	0.005 0.981	**0.362*** 0.049
SHWB & Sikkim	-0.205 0.278	0.268 0.152	-0.084 0.658	0.009 0.962	0.085 0.657	**-0.338**** 0.068	-0.137 0.470	-0.237 0.208	-0.301 0.106	0.122 0.522

Gangetic West Bengal	-0.012 0.950	-0.215 0.254	-0.346 0.061	-0.071 0.708	-0.238 0.204	-0.026 0.893	-0.134 0.482	-0.033 0.863	0.064 0.738	0.071 0.708
Jharkhand	-0.011 0.953	-0.252 0.180	**-0.384*** 0.036	-0.207 0.272	- **0.371*** 0.043	0.085 0.655	-0.274 0.143	-0.188 0.321	-0.048 0.803	0.073 0.703
Bihar	-0.187 0.953	0.053 0.780	-0.202 0.285	0.023 0.925	-0.071 0.710	-0.096 0.613	-0.087 0.649	-0.085 0.665	-0.118 0.535	0.040 0.835
North-West India										
East UP	0.012 0.949	0.154 0.417	**0.504*** 0.004	0.190 0.315	0.157 0.407	0.085 0.656	-0.063 0.742	-0.113 0.550	-0.111 0.561	-0.001 0.995
West UP	-0.096 0.615	0.140 0.460	0.262 0.162	-0.049 0.799	0.151 0.424	-0.040 0.833	-0.228 0.226	-0.137 0.470	-0.094 0.622	-0.147 0.439
Uttarakhand	-0.073 0.701	0.043 0.821	0.187 0.322	-0.108 0.571	-0.153 0.419	-0.136 0.474	-0.212 0.260	-0.212 0.260	-0.090 0.635	-0.211 0.264
Har. Chd and Delhi	0.066 0.730	0.273 0.145	0.277 0.139	**0.336**** 0.069	**0.337**** 0.068	0.042 0.825	-0.046 0.810	-0.045 0.815	0.002 0.994	0.197 0.296
Punjab	0.220 0.242	0.038 0.842	0.130 0.495	0.037 0.846	0.109 0.565	0.125 0.511	-0.127 0.502	-0.041 0.829	0.157 0.408	-0.006 0.973
Himachal Pradesh	0.072 0.705	0.009 0.964	-0.082 0.667	-0.242 0.197	-0.031 0.870	0.048 0.803	- **0.415**** 0.022	-0.189 0.316	-0.015 0.939	-0.115 0.547
J&K	**0.353**** 0.056	0.086 0.652	0.111 0.560	0.115 0.544	0.038 0.843	0.111 0.559	-0.079 0.680	-0.026 0.893	0.090 0.635	0.066 0.730
West Rajasthan	0.379 0.139	**0.311**** 0.094	**0.484*** 0.007	**0.494*** 0.006	**0.361**** 0.050	**0.350**** 0.058	**0.340**** 0.066	0.118 0.535	0.153 0.419	**0.420*** 0.021
East Rajasthan	**0.726** 0.000	0.207 0.272	**0.388*** 0.034	0.243 0.195	0.284 0.129	**0.534*** 0.002	0.265 0.157	0.122 0.522	**0.325**** 0.079	**0.383*** 0.036
Central India										
Odisha	0.131 0.491	-0.222 0.238	-0.013 0.947	-0.188 0.319	-0.267 0.154	**0.443*** 0.014	-0.117 0.539	0.096 0.613	**0.403*** 0.027	0.042 0.825
West MP	**0.601*** 0.000	-0.041 0.831	0.262 0.162	0.035 0.854	-0.039 0.838	**0.441*** 0.015	0.055 0.774	-0.073 0.703	0.199 0.291	0.193 0.307
East MP	0.287 0.124	-0.194 0.303	0.262 0.162	-0.214 0.256	-0.221 0.241	**0.390*** 0.033	-0.162 0.393	-0.107 0.575	0.070 0.714	-0.065 0.735
Gujarat Region	0.167 0.378	0.074 0.699	**0.348**** 0.060	0.162 0.392	0.048 0.802	**0.390*** 0.033	0.179 0.345	0.179 0.343	**0.395*** 0.031	0.245 0.192
Saurasthra & Kutch	**0.379*** 0.039	0.264 0.159	**0.510*** 0.004	**0.536*** 0.002	**0.348**** 0.059	**0.424*** 0.020	**0.509*** 0.004	0.292 0.118	0.250 0.182	**0.417*** 0.022
Konkan &Goa	0.216 0.253	0.065 0.734	0.107 0.573	-0.163 0.390	-0.032 0.867	0.733 0.360	0.046 0.808	0.076 0.691	0.214 0.255	0.022 0.908
Madhya Maharashtra	0.119 0.533	0.158 0.404	**0.402*** 0.027	0.249 0.184	0.160 0.397	**0.393*** 0.031	**0.519*** 0.003	**0.363*** 0.049	**0.469*** 0.009	**0.317**** 0.088
Marathwada	-0.130 0.492	**0.481*** 0.007	**0.720*** 0.000	**0.511*** 0.004	**0.322**** 0.082	0.003 0.989	**0.540*** 0.002	0.125 0.509	0.013 0.946	0.217 0.249

Vidarbha	0.281 0.133	0.148 0.436	**0.629*** 0.000	0.087 0.646	-0.093 0.626	**0.481*** 0.007	0.145 0.444	0.177 0.351	0.270 0.149	0.134 0.480
Chhattisgarh	**0.368*** 0.045	0.042 0.825	0.303 0.104	0.171 0.366	0.045 0.815	**0.487*** 0.006	0.007 0.970	-0.061 0.747	0.153 0.419	0.258 0.168
South Peninsula										
A&N Island	1									
Coastal AP and Yanam	0.117 0.538	1								
Telangana	0.124 0.515	**0.668*** 0.000	1							
Rayalaseema	0.164 0.386	**0.737*** 0.000	**0.571*** 0.001	1						
TN, Pudu & Karaikal	0.162 0.391	**0.597*** 0.001	0.306 0.100	**0.718*** 0.000	1					
Coastal Karanataka	**0.653*** 0.000	0.012 0.949	0.135 0.478	0.137 0.469	0.205 0.278	1				
N.I. Karnataka	0.267 0.154	**0.515*** 0.004	**0.464*** 0.010	**0.788*** 0.000	**0.624*** 0.000	**0.358**** 0.052	1			
S.I. Karnataka	0.283 0.129	0.215 0.255	0.159 0.402	**0.437*** 0.016	**0.540*** 0.002	**0.582*** 0.001	**0.727*** 0.000	1		
Kerala & Mahe	**0.461*** 0.010	0.087 0.647	0.074 0.699	0.183 0.334	0.294 0.115	**0.793*** 0.000	**0.452*** 0.012	**0.757*** 0.000	1	
Lakshadweep	**0.467*** 0.009	**0.478*** 0.008	0.245 0.192	**0.680*** 0.000	**0.618*** 0.000	**0.521*** 0.003	**0.635*** 0.000	**0.532*** 0.002	**0.471*** 0.009	1

**Correlation is significant at 0.1 level

* Correlation is significant at 0.05 level

Source: SPSS output, computed by researcher

The correlation matrix between the South Peninsula MSDs and the other three regions is shown in Table 5. The pair-wise correlation analysis between 10 subdivisions and the remaining 26 subdivisions has been carried out. The correlation range is between -0.415 and +0.788. Out of 305 pairs, 116 pairs are significant at 5% and 10%. Out of 116 pairs, 77 have a significant weak or moderately positive relationship with the South Peninsula MSD region, while 5 have a negative relationship.

5. Testing of Hypotheses

The above tables show that 30-year rainfall data on MSDs are not perfectly correlated with other MSDs in India. It can be seen that there are 1113 pairs of correlation matrices in the tables, ranging from 2 to 5. There are 338 significant correlation pairs at 5% and 10% of the total 1113 pairs, of which only 2 pairs are very strongly correlated, 40 pairs are strongly correlated, and the remainder are weak and negatively correlated with other subdivisions. The rainfall data for the majority of MSDs has a negative and weak correlation with the other MSDs, with some others being moderately correlated. Even MSDs within the same region are not perfectly correlated with each other. For example, Konkan/Goa and Madhya Pradesh belong to the Central Region, but both are negatively correlated with a value of -0.390. The East/North East Region includes Gangetic West Bengal and Arunachal Pradesh, both of which are negatively correlated with the value -0.056. The Panjab and East UP belong to the North-West India region, but these are weakly correlated with the value of 0.308. The Coastal Karnataka and N.I. Karnataka belong to the South Peninsula, but these are weakly correlated with a value of 0.358. The overall correlation matrix shows that the correlation range is between -0.575 and +0.970. This demonstrates that the subdivisions are not perfectly correlated with one another. Hence, it is inferred that

the null hypothesis, **"The rainfall occurrence among the 36 MSDs in India is not strongly correlated,"** is accepted and the alternative hypothesis, **"The rainfall occurrence among the 36 MSDs in India is strongly correlated,"** is rejected.

The empirical analysis of the correlation of MSDs over the past 30 years has shown that no subdivision is strongly correlated with any other subdivision. All the subdivisions have a weak to moderate correlation with the other subdivisions, and some of the subdivisions have a negative or no correlation with the other subdivisions. Even within the same region, some groups of subdivisions do not have a strong correlation with the other subdivisions. For example, there are 338 pairs of significant correlation, out of which only 40 pairs have a strong correlation, but other pairs of subdivisions are not perfectly correlated. As a result, this rainfall index is potentially a distinct and unique asset worth considering as part of a portfolio investment strategy. Diversifying the risk of assets with uncorrelated assets helps the investor offset the returns of one asset with the loss of other assets. The rainfall index can be considered a new kind of asset that can be used to construct an efficient portfolio of assets. Therefore, the hedger and investor can take advantage of this opportunity to hedge and speculate on the rainfall of 36 MSDs by observing weather conditions. The investor can make profit from variations in the rainfall among the MSDs and also use it for speculation activity. The hedgers who face the rainfall risk can hedge their risks with the others who want to trade the rainfall risk.

RIBF contracts are the financial agreement between the two parties to exchange the rainfall index in future predetermined period. It is like the stock index futures. The RIBF contracts can be used to hedge and speculate on the rainfall of 36 MSDs in India. If these instruments are introduced in the Indian capital market, anyone can trade the rainfall risk of any subdivision. For example, a hedger in N.I. Karnataka can hedge his rainfall risk with Rayalseema subdivision. Even the investor can trade the rainfall risk of any MSD regardless of where he/she lives. The RIBF is providing diversification in investment opportunities because traditional investments like gold, shares, debentures, and land are already available and there is a huge competition among them. Some of them didn't believe in the stock market. Therefore, the RIBF contract is one kind of diversification investment tool for the investor.

The above correlation study found that monsoon rainfall in the NIK subdivision has a negative correlation (-0.415) with the Himachal Pradesh subdivision. It denotes when the Himachal Pradesh subdivision experiences excessive rainfall while the NIK subdivision experiences deficit rainfall. The investor can buy ERD index-based futures contracts in Himachal Pradesh, which has more rainfall, and DRD index-based futures contracts in the NIK subdivision. Now investors can diversify their investment in ERD/DRD RIBF contracts by buying the ERD/DRD RIBF contract. In case of any increase in ERD/DRD indices over the strike ERD/DRD indices, the investor receives the pay-out from the RIBF contract. Therefore, investors can take this opportunity to diversify their investment portfolio by buying DRD and ERD futures contracts in the weather risk market. The contracts on DRD and ERD provide a diversified investment opportunity to invest in this kind of unique asset class and make money out of the rainfall variability. Therefore, the null hypothesis **"RIBF contracts based on MSDs do not provide the diversification advantage for the investing community"** is rejected, and the alternative hypothesis **"RIBF contracts based on MSDs provide the diversification advantage for the investing community"** is accepted.

6. Conclusion

The above theoretical and empirical discussion proved that the rainfall index of 36 MSDs is not strongly correlated, and RIBF contracts provide a wide range of opportunities to diversify the rainfall risk for the investing community. The empirical analysis has shown that monsoon rainfall over an MSD in India is not strongly correlated with the rainfall at other MSDs' monsoon rainfall in India. Therefore, it can be concluded that the monsoon rainfall index could be a unique asset class, and it can be used as a financial index similar to a stock index. The RIBF contracts can be used to hedge and speculate on the rainfall index, and it provide a diversified investment opportunity for the investing community. Theoretical observations and previous literature indicate that there is scope for RIBF contracts. Therefore, RIBF contracts could be effective special-purpose vehicles to hedge, speculate, and invest in the rainfall risk of the rainfall-dependent industries. The RIBF contracts are not only used as a hedging tool; it can also be used as a diversified investment avenue for the investing community.

References

Bharath, V., and Kotreshwar, G. (2022). Modelling and designing of Rainfall Derivative Contract in India. *KIIT Journal of Managemenet, 18*(1), 11-27. Doi:10.23862/kiit-parikalpana/2022/v18/i1/212343.

Bharath, V., and Kotreshwar, G. (2020). Evaluating Rainfall Risk Profile of Indian Subcontinent Based on Index Metrics. *Indian Journal of Finance and Banking*, ISSN 2574-6081, E-ISSN 2574-609X, *4*(2), 38-50. https://doi.org/I0.4628I/ijfb.v4i2.700.

Dileep, N., Kotreshwar. G. (2022). Interrelationship Between the Rainfall Index and NSE Nifty Index: An Empirical Study. *Journal of Applied Financial Econometrics*, E-ISSN 2583-374X, *3*(1).

Harendra Singh, and Anil Vashisht. (2020).Use of rainfall derivative to hedge rainfall risk in agriculture sector in India *Journal of Xi'an University of Architecture & Technology, 7*(5), p. 2280, Received from https://www.xajzkjdx.cn/gallery/237-may2020.pdf.

Kotreshwar, G., and Rekha Arunkumar. (2006). Monsoon Risk Securitization: Monsoon Option on Selected MET Subdivisions. 10th Capital Markets Conference, Indian Institute of Capital Market Paper. https://dx.doi.org/10.2139/ssrn.962322.

Kotreshwar,s G., and Kanakasabai, M., (2006) Design amd pricing of Monsoon Derivatives: A conceptual framework, A paper presented at international conference organised by Asia Pacific Risk and Insurance (APRIA), Tokyo, Japan.

Kotreshwar, G. (2015). Securitisation of Rainfall Risk in India: Designing Rainfall Derivative Contracts Based on Standard Metrics. Paper presented in International Conference on Emerging Trends in Finance Accounting, SDM-IMD, Mysuru, India, August 22, 2015.

Panos Varangis, Jerry Skees, and Barry Barnett. (2002). Weather Indexes for Developing Countries. Climate Risk and the Weather Market, World Bank, University of Kentucky and University of Georgia. https://www.researchgate.net/publication/238539596.

Shivakumar, D P., and Kotreshwar, G. (2013) Trading In Weather Risk Transfer Products- Reengineering Rainfall Indexation. *International Journal of Business and Management Invention, 2*(11) 33-41, ISSN: 2319-8029, Print: 2319-801X. www.ijbmi.org.

Veeramini, Venkat, N., Maynard, Leigh, J., and Skees. (2003). Assessment of the Risk Management Potential of a Rainfall Based Insurance Index and Rainfall Options in Andra Pradesh, India. *American Agricultural Economics Association*, 27-30. http://dx.doi.org/10.22004/ag.econ.22183