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Theoretical framework to introduce rainfall index-based futures contracts in India

Dileep N
University of Mysore, Mysuru, Karnataka, India
dileepn@commerce.uni-mysore.ac.in
G. KOTRESHWAR
University of Mysore, Mysuru, Karnataka, India
kotreshwar@commerce.uni-mysore.ac.in

Abstract. *The proposed study is attempted to frame a theoretical framework for Rainfall Index Based Futures (RIBF) contracts. The study explains the evolution and present status of rainfall risk market in India. The paper contains the detailed theoretical framework for RIBF contracts. Along with this paper elucidate the contract specification to trade the RIBF contracts. The paper show the flow of hedging the rainfall risk of various stakeholders like farmers, insurance and reinsurance companies, banking and financial institution, construction, manufacturing and other who directly or indirectly affected by the rainfall. Eventually the study identify the why the RIBF contracts are not yet developed so for and what are the essential police, regulation required for the design and development of full-fledged rainfall index-based futures contracts in India.*

Keywords: weather derivatives, RIBF, rainfall risk markets, hedging, contract specification and CME.

JEL Classification: G11, G14.

1. Introduction

The rainfall risk market plays an important role in achieving sustainable economic growth in the economy. Farmers and financial investors are impacted directly or indirectly by rainfall losses, whether scarce or abundant (Cabrera et al., 2013**)**. Abhijit (2008) concluded that weather risk causes a great amount of loss for weather-sensitive industries like power generation and hospitality. Therefore, weather derivatives are a tool to hedge the financial risk of industries that are affected by weather variables like temperature, rainfall, snowfall, etc. Vashishtha et al. (2007) concluded weather derivatives were the new tool that overcame the deficiency of insurance and had the features of a low-cost, flexible, and sustainable tool. Although in a country like India, with a large population dependent on agriculture and most of the power generation dependent on weather factors like rainfall, wind speed, and temperature, the demand for weather derivatives exists. Okemwa et al. (2013) opined that weather risk is an uncontrollable and unmitigated source of financial losses in developing economies. Some studies have shown that traditional insurance markets are unable to adequately address the problem of rainfall risk. Therefore, rainfall risk must be securitized to reduce the losses through the rainfall derivatives. Farmers, insurance and reinsurance companies, banking companies, speculators, investor and others who want to hedge and trade rainfall risk can participate in this market. Therefore, there is a need of versatile financial tool to effectively absorb the rainfall risk. The deregulation of the financial and insurance markets provided the avenue for the development of monsoon derivatives. The monsoon derivatives market is 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 Kanakasabai, 2006). Rainfall Index-based Futures (RIBF) represent an innovative financial product introduced by the Chicago Mercantile Exchange to effectively absorb the rainfall risk of various industries. These are short-term contracts, and can be made available for full season or for a specific month. The structure of the RIBF contracts is presented using standard metrics such as Excess Rainfall Days (ERDs) and Deficit Rainfall Days (DRDs). It is for many agribusiness participants, as well as industries that are equally affected by rainfall variability. RIBF contracts are the pioneers of developing a global rainfall risk market pool. It supports the emergence of an ART (Alternative Risk Transfer) product, which leads to the development of a sustainable, full-fledged, rainfall risk market. These products facilitate various opportunities like investment, hedging and speculation of rainfall by rainfall dependent industries.

2. Review of literature

Skees (2001) concluded that weather index derivatives were in their infancy and that weather risk markets would be in demand to mitigate weather risk. Vashishtha (2007) concluded that the agriculture and power sectors in India were vulnerable to weather factors. Rainfall had an impact on agriculture, and both rainfall and temperature have an impact on the power sector. So, there is a need for an adequate, sustainable weather risk management system for the Indian economy. Seth et al. (2009) assessed the farmer's willingness to pay for weather derivatives to hedge the weather risk. The author came to the conclusion that weather derivatives could be used even if the government didn't pay for

it. Karyl (2007) opined that many business firms were unaware that the risk associated with seasonal weather fluctuations could now be hedged. For that, the author demonstrated the use of weather derivatives to hedge the firm's unmanageable risk events caused by natural phenomena such as excessive rainfall. The author found that the purchase of weather derivatives will improve the owner's ability to forecast revenue and assure expenditure coverage for a small business. Chengyi et al. (2018) concluded that weather index insurance and futures can be used to better protect not only the agriculture industry but also other industries like the energy and utility industries. For these weather index-based futures to be used, the government had to take action on the availability of data, give subsidies to people who wanted to buy these contracts, and set rules for the weather risk market.

Venkat et al. (2003) concluded that agriculture and stock markets play a vital role in the development of the economy. But these were adversely affected by the rainfall variability. As a result, the authors proposed that rainfall index-based derivatives were an effective tool for hedging the variability of rainfall, and these tools reduced moral hazard, adverse selection, and high margin money payments to initiate the contract. Geyser (2004) assessed the feasibility of introducing rainfall derivatives to manage agricultural production risk in South Africa. The study showed that there was a strong positive relationship between average rainfall and maize yield for the study period. So, this positive relationship indicated the need for rainfall yield derivatives for the maize farmers in South Africa. Kotreshwar and Arunkumar (2006) expressed that insurance markets were not developed to curb the monsoon risk, and insurance markets were inadequate and ineffective in dealing with the monsoon risk. For that, they developed a conceptual framework for monsoon derivatives by securitizing monsoon rainfall. These monsoon derivatives allow systematic risk to be transferred to the capital markets. 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 authors concluded that monsoon derivatives were perfect for the Indian environment. It is the perfect opportunity to design the monsoon derivatives to absorb the monsoon exposure. The monsoon derivatives can be used not only by farmers but also by commodity traders, agro-processing industries, energy companies, and insurance companies. Leggio (2007) demonstrated how to use rainfall derivatives to hedge the golf course firm's excessive rainfall risk. The statistical analysis shows that the golf firm can reduce its 80% revenue volatility by using rainfall derivatives. Kotreshwar (2015) 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 variation, and value at risk show that DRDs and ERDs time series reveal a unique risk profile of each MSD and indicate that there is a vast scope for launching a wide range of derivative instruments for weather risk markets in India. Volpi Jacopo (2019) evaluated the effectiveness of rainfall derivatives to hedge the rainfall risk in the wine sector. For this author, study the relationship between rain and profitability in the Italian wine regions of Franciacorta and the province of Trento. The profit of companies that had used rainfall derivatives was higher than the profit of companies that didn't use rainfall derivatives. So, the author suggested that the wine industry use rainfall derivatives to reduce the effect of rain on the

wine industry's ability to make money. Bharath and Kotreshwar (2020) proposed a new set of rainfall indices to explore the excess rainfall risk profile of the Indian subcontinent. Based on the statistical properties, the authors concluded that there is a large potential for trading ERD index-based rainfall derivatives to hedge excess rainfall. These building blocks could be used to create rainfall derivatives that are similar to the HDD and CDD underlying temperatures. 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. Finally, the author suggested using 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 their portfolio.

3. Evolution of rainfall risk markets in India

The ecosystem of the rainfall risk market comprises three complementary and interdependent components: crop insurance, rainfall index-based insurance, and rainfall index-based derivatives. Crop insurance schemes were started during the 1930s in Japan and the US. In India, the General Insurance Corporation (GIC) introduced a crop insurance programme in 1972-1973 in Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, and West Bengal. The pilot crop insurance scheme was launched by the GIC in 1978-1979 based on the area approach. Following that, Kharif's (1985-1986) first national-level scheme, a comprehensive crop insurance scheme (suggested by Dandekar in 1976), was implemented in 15 states and two union territories. This scheme operated until Rabi 1999.

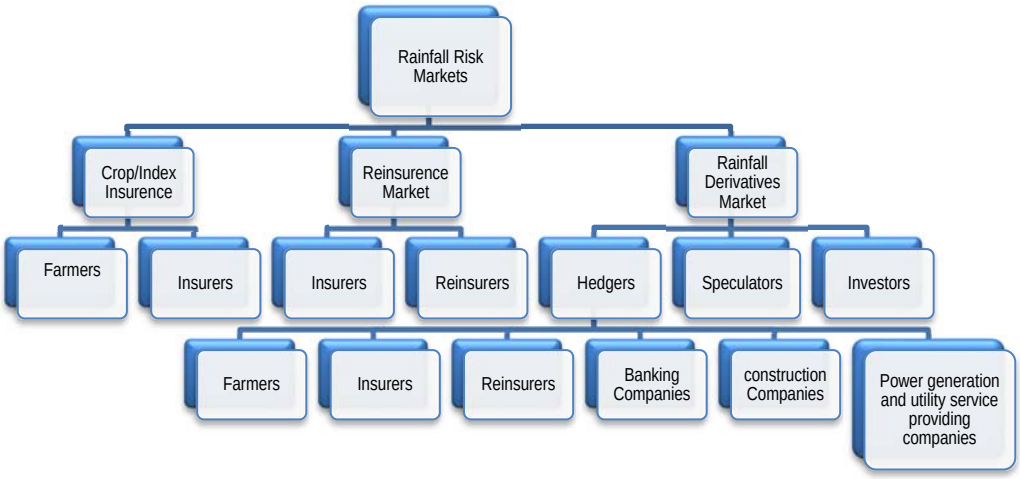
In order to cover more people, the Agricultural Insurance Company (AIC) changed the Comprehensive Crop Insurance Scheme into the National Agricultural Insurance Scheme (NAIS) starting with the Rabi season 1999-2000. After the pilot scheme of ICICI Lloyd General Insurance Company, IFFCO General Insurance Company, and AIC of India stepped forward in 2005-2006 for the commercialization of this rainfall index insurance, In 2005-2006, AIC sold weather index-based insurance policies to more than 125,000 farmers (Berry et al., 2007). From 2005-2006, Varsa Bima of AIC, Barish Bima of IFFCO TOKYO GIC, and the Rainfall Insurance Scheme for Coffee (RISC) were the ongoing schemes available to mitigate the rainfall risk. Since 2016, IFFCO TOKYO GIC has been offering Restructured Weather-Based Crop Insurance (RWBCI) to cover a variety of agricultural risks. Rainfall index insurance is superior because of its transparency, faster settlement, and low transaction cost.

Weather derivatives are a new set of weather risk mitigation tools that are widely accepted around the world. Weather derivatives are contracts between two parties to expose their weather risks, like rainfall, temperature, humidity, and snowfall. The value of these contracts depends on the underlying weather index, which is calculated based on the values measured in the stated geographical location. Weather risk affects approximately 70% of companies in the United Kingdom, and weather affects $1 trillion of the US economy. The most affected sectors included utilities, insurance, reinsurance, transportation, retailing,

and agriculture. Therefore, they listed the futures and options for the weather-sensitive commodities (John, 2003).

In 1997, the first weather derivatives contracts were undertaken by the Enron Corporation and Koch Energy Industries in the US for temperature variations. Furthermore, the Chicago Mercantile Exchange (CME) started weather derivatives in 1999 by listing the futures and options on temperature indices of ten US cities (Alieva and Viegas, 2010). In 2010, CME started trading rainfall futures for nine US cities by listing them on the exchange. CME Group is the world's largest and first exchange-traded market for weather derivatives. It is the market place where anyone can come and expose their weather risk. It is a combination of the CME, Chicago Board of Trade (CBOT), New York Mercantile Exchange (NYMEX), and Commodity Exchange, Inc. (COMEX) exchanges. These exchanges provide a variety of weather derivative products to help traders hedge their weather risk. According to the 2014 CME Group Report, CME lists more than 60 contracts like options and futures on rainfall, snowfall, and temperature. The London International Financial Futures and Options Exchange (LIFFE) was started in 2001 by offering temperature-related contracts for London, Paris, and Berlin. European countries are attempting to establish a European electronic exchange similar to LIFFE. Unfortunately, the LIFFE was acquired by EURONEXT in 2002 due to a lack of turnover and other structural issues. Because of the importance of weather derivatives, Romania, Mexico, Morocco, Mongolia, and Ukraine are gradually opening the door for weather derivatives (Anjali, 2012). This can be used not only by farmers, but also by others who are at risk of weather. It is currently needed for countries like India to absorb the rainfall risk, which affects the economy.

Figure 1. *Rainfall risk markets*



Source: Author compilation.

The ecosystem of the rainfall risk market is incomplete in the absence of a rainfall index-based derivative, i.e., a RIBF and options. RIBF is an innovative alternative tool that would facilitate hedging rainfall risk by a wide range of stakeholders. These are traded on the

Chicago Mercantile Exchange in the U.S. It launched standardized futures and option contracts in 2010. According to the CME Report (2011), CME initially offered derivatives based on rainfall to nine cities. At present, weather derivative contracts are traded in 25 cities in the US, 11 in Europe, 6 in Canada, 5 in Australia, and 3 in Japan. The CME Report 2020 showed a total notional value of $750 million in weather futures and $480 million in weather options traded on the CME.

But in India, these markets have not yet developed so far because of a lack of research and the absence of regulatory support. The government must take steps to amend the regulation, provide infrastructure facilities like rain gauge stations, make rainfall data available for free, support transaction costs, and fund research in the area of rainfall risk markets. The NCDEX had tried to launch the weather derivatives in 2004, but it failed. After that, it sent a letter to SEBI to get permission to launch the weather derivatives. However, the SEBI has now formed a committee to recommend a fruitful product (Business Standard 2019). The Indian monsoon poses a high degree of risk, so it is the perfect opportunity to design monsoon-related derivative products (Sandor, 1995).

4. Rainfall derivatives

Rainfall derivatives are part of weather derivatives. These rainfall derivatives are used to overcome the losses due to adverse rainfall over a period of time. Rainfall derivatives include contracts like futures and options. Rainfall derivatives are financial instruments used to hedge the risk associated with the variability of rainfall. The contracting parties are paid based on the strike value and actual value of the rainfall index for the specific location and period. Rainfall derivatives are a tool for cross-hedging agricultural income variability when its revenue and cost are significantly correlated with the rainfall weather event (Spaulding et al., 2010). According to Hess et al. (2002), the best methods for developing rainfall derivatives are careful design, reliable weather data measurement, efficient market players, and transparency. The rainfall derivatives cannot change the rainfall pattern or variability, but they can help to manage rainfall risk in a more efficient way. The design of rainfall derivatives is effective where the correlation between the rainfall index and yield is significant.

4.1. Rainfall index-based option

The rainfall options contract is an agreement between two parties to buy or sell an underlying asset, which is the rainfall index, at a specified price on or before the specified date. According to the *Securities Contract (Regulations) Act 1956*, a contract for the purchase or sale of a right to buy or sell, or a right to buy and sell, securities in futures. A rainfall index-based option is a weather derivative that gives the holder the right to buy or sell the value of an underlying rainfall index. The rainfall options are always cash settled on the date of maturity or before the maturity period. The rainfall index-based options comprise the call and put options. The call option holder has the right to buy or sell, but the writer of the call option has an obligation to buy or sell. The option contract needs the initial payment as a premium to the seller of the contract and to maintain the maintenance margin in the account.

4.2. Rainfall index-based futures contracts

RIBF are contracts between two parties to buy or sell the rainfall index at a particular time in the future at the present predetermined price to hedge their rainfall risk. The payment is based on the level of the rainfall index at the maturity date of the contract. There are two positions available, like stock index futures. They are long positions to buy the rainfall index and short positions to sell the index at a predetermined time for a predetermined tick value. This rainfall index is calculated using the standard and actual rainfall of the location where they want to hedge their rainfall risk. These RIBF are short-term contracts, and it can be designed either for months or for one full season. Rainfall derivatives are a versatile tool for mitigating rainfall risk. It is for a large number of agricultural business participants as well as industries that are equally affected by rainfall variability. RIBF is the forerunner for the development of a global rainfall risk market pool.

The rainfall derivatives can be used to transfer precipitation risk to the capital market (Cabrera et al., 2013). The capital markets give the buyer an opportunity to reduce their exposure to precipitation risk, which helps to make a profit from weather uncertainties and stabilize cash flows and earnings for the business. The buyer of the rainfall derivatives receives the payout if the predetermined rainfall event occurs. The seller of the rainfall derivatives eliminates the moral hazard and avoids the higher administrative and loss compensation expenses of insurance companies. CME offers the market price of rainfall derivatives for both over-the-counter and exchange-traded derivatives. The CME acts as a clearing agent for the CME. It works as a seller for every buyer and a buyer for every seller, thus ensuring that each party fulfills their financial obligation.

a) Features of RIBF contracts

- The RIBF contracts are like stock index futures contracts. In the case of stock index futures, the underlying asset is a particular or selected stock index. But in the case of RIBF, the underlying asset is a rainfall index, either ERDs or DRDs. The pay out of the contract is based on selected rainfall index variability, just like stocks.
- The RIBF contract does not require any payment or premium to undertake the contract; rather, both parties need to maintain the margin money, like the initial margin and maintenance margin.
- The RIBF can be taken by anyone. It is not only for farmers but also for other stakeholders who face the rainfall risk. A speculator or other investor can take this contract to trade and make a profit out of the rainfall variability. RIBF can be used by insurance and reinsurance companies to hedge the pooled public rainfall risk.
- Exchange-traded RIBF contracts, like stock index futures traded on the stock exchange, can be publicly traded in the weather risk market. For traders in the weather risk market, the RIBF provides a marking to market facility. This means that the daily changes in the rainfall index values will be easily accessible to traders on the exchanges.
- The RIBF covers low-rainfall-risk events with a high probability of occurrence. This means the rainfall risk for hedgers is lower but the occurrence of the rainfall risk event is high. The risk of rainfall can occur routinely every year due to rainfall variability. But the rainfall risk of hedger is lower compared to other rainfall risk mitigation tools.

- In the case of the commodity market, there is a spot market, and this spot market is supportive for identifying the future prices of commodities. In the case of rainfall derivatives, there is no spot market, and it takes time and good methodology to calculate future prices.
- Rainfall futures contracts don't have any spot market to easily price the contract, and it can't be settled in physical form; it is settled only through cash. The trader can't exchange the rainfall index for their settlement; they can only get it in cash.

b) Significance of RIBF contracts

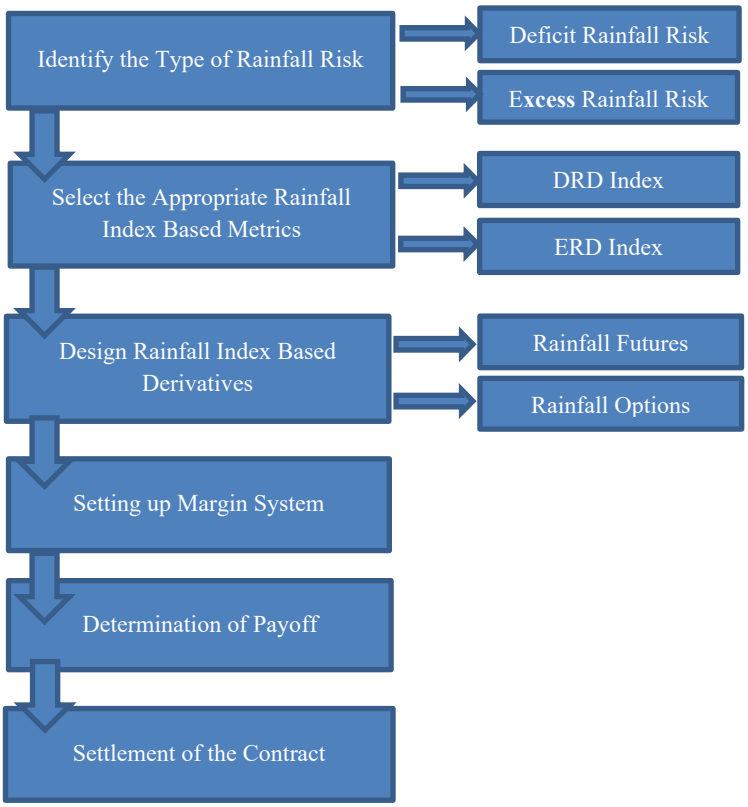
The rainfall is one of the important factors that determine the economic prospects of the country. A great majority of sectors, including agriculture, are impacted by rainfall. Therefore, the Indian economy has a fear of adverse rainfall. Weather derivatives are a new instrument for hedging rainfall risk. Anjali (2012) opined that India's agriculture and power sectors were the main pillars for the economy and that these sectors were dependent on rainfall. So there is a need for adequate, sustainable weather derivatives to manage the weather risk. These weather derivatives are low-cost, flexible, and sustainable options to hedge the weather risk in India. Weather is the most critical factor impacting the construction industry. The rainfall index-based derivatives are not only restricted to agriculture; it can also be used by those who suffer a loss of revenue due to rainfall variability (Zarrad et al., 2017) and (David et al., 2020). Jones (2007) opined that the introduction of weather derivatives helps industries that are weather-sensitive.

The RIBF is used to hedge the volumetric risk. The hedger can use the RIBF contracts to hedge either monthly or seasonal rainfall risk. In Chicago, the CME offered both monthly and seasonal rainfall futures. The type of contract taken by the participants depends on the pattern of rainfall risk or the type of crop for which they enter into rainfall futures contracts. The government provides the minimum support price for farmers to overcome the price risk. But they fail to overcome the volumetric risk faced by the farmers. The rainfall futures can be used to hedge the volumetric risk due to rainfall risk. Volumetric risk is the risk of an insufficient supply of volume, i.e., yield, to generate the required profit. Jones (2007) concluded that weather derivative contracts could be easily used to hedge agricultural yield risk and increase the revenue of farmers and other agri-related businesses. For example, a farmer can sell his crop at a good price, but due to adverse rainfall, he can't harvest a sufficient volume of output. This volumetric risk can be hedged through these rainfall futures contracts. If a farmer harvested not as much output compared to standard production, then he would compensate for the lesser production risk and the less produced output could be sold at the market price. Venkat et al. (2003) concluded that the presence of a high correlation between rainfall and crop losses makes rainfall index-based products an attractive option for insuring agricultural risk and rainfall index-based products reduced moral hazard, adverse selection, and the problem of extensive margin. The other advantages of these contracts are given below:

- The payout of these contracts is not based on farm yield or business loss. Rather, it is based on the predefined rainfall index. Therefore, it does not lead to moral hazard practices and minimizes adverse selection. Because the payment is based on the rainfall index and not on the yield or loss of business.

- The RIBF involves low administration costs because they do not require any field visits to determine the yield loss or inquire about the loss associated with the business activity or any underwriting issue. Therefore, there is no officer's appointment and no inquiry cost.
- Insurance and reinsurance companies have a wide range of opportunities to hedge the accumulated or pooled crop/index insurance risk of the public. Sometimes, insurers and reinsurers can also face huge losses due to the adverse rainfall. At this time, insurers and reinsurers can get the RIBF and hedge their pooled rainfall risk in the weather risk market.
- The RIBF contracts can be taken from anyone who is willing to trade the rainfall risk in the weather risk market. Even if he or she is not at risk of rain, he or she can use the RIBF for speculation purposes. The rainfall-dependent industries can use the contract to hedge the rainfall risk, and others can use the contract to make money out of the rainfall variability.
- RIBF contracts are very transparent. Because the contract involves an underlying asset such as a rainfall index, it is calculated based on the amount of rainfall that occurred. This rainfall can't be controlled or managed by human beings; it is a natural phenomenon. Spicka and Hnilica (2013) concluded that rainfall index-based derivatives are transparent contracts and correctly measured because weather variables cannot be intentionally modified by farmers or any other party to the subject.
- The RIBF can be designed either for one particular month or for any full monsoon season. This lets farmers and other business owners who depend on rain make contracts with flexible time frames.
- The payment procedures in RIBF contracts are speedy and accurate. These contracts are based on variations in the rainfall index, and these variations can be easily found and calculated. But in the case of insurance needs, the time and payment depend on the valuer/inspection officer, field visitor, or underwriter of the insurance company.
- RIBF does not allow any insider trading while trading the rainfall futures. Because it is based on the rainfall index, which is calculated based on natural rainfall patterns and is beyond the control of humans. The rainfall can't be stored for trading. That means there is no chance for the black market, or illegal market.
- RIBF contracts are low-cost and sustainable tools to mitigate the rainfall risk. These are designed on a monthly and seasonal basis, which helps rainfall-dependent industries undertake the contract seasonal basis. The claim is made when rainfall is above or below the strike level.

c) Hedging rainfall risk – the flow



Source: Author compilation.

d) Requisites of Good RIBF contracts

The RIBF contracts are standardized contracts that can be traded on the exchanges. The effective introduction of RIBF markets is a big challenge. It needs enormous research efforts and government support to build the public platform needed to hedge the rainfall risk. This platform can also be used by speculators to make money out of the differences in rainfall in different MSDs. Musshoff et al. (2009) opined that the effectiveness of a weather hedge depends on the contract design, i.e., whether it includes an index, a strike level, a tick size, and weather data. But the basis risk remains with the contracting parties. As a result, the essential requirements for sustainable and fully pledged rainfall risk markets are as follows.

Independent data collection centres with the area surrounded by 5 to 10 km.

- Transparency in rainfall data collection at the rain gauge stations.
- Evaluation of data that is collected for trading.
- The design of the contract should be based on area, crop, region, meteorological changes, the mindset of people, and environmental conditions in the areas where we undertake the contract.

- Transparency in data collection, index structuring, selection of location, parameters of the contracts, and other information regarding the contract.
- There is a need for a liquid market.
- There is a need for a regulated trading platform for trading in rainfall derivatives.
- Good and advantageous government policies to trade rainfall in exchanges.

e) Contract specification for RIBF contracts

The RIBF are the contracts to buy or sell the rainfall index at a predetermined index value today, to be settled at a future date. Basically, a RIBF is a derivative contract whose value depends on the underlying index. The present study examined alternative methods of measuring rainfall indices and adopted the DRDs/ERDs indices as standard metrics that can be used as building blocks for designing rainfall futures contracts.

Table 1. *Contract specification for the RIBF*

A model RIBF contracts (Specifications)	
1. Contract Size	Rs. 1000 times the respective DRD/ERD index.
2. Product Description	DRD/ERD of 36 MSDs of India
3. Tick Size	0.1 Index point (=Rs100 per contract)
4. Contract Months	DRDs= June, July, August, September (4 months)
5. Strike level	The level of rainfall favourable to hedger. Below or above the rainfall leads to the risk.
6. Reference rainfall station	Where hedger wish to hedge the rainfall risk
7. Settlement Procedure	Cash Settlement: Final Settlement procedures for months ERDs/DRDs futures
8. Position Limit	All months combined: 10000 contracts
9. Pricing Unit	Rs. Per index point (1 index point= 1MM of rainfall)
10. Pay off	Payoff based on: K(Strike Rainfall-Actual Rainfall) K(Actual Rainfall-Strike Rainfall)
11. Ticker Symbols	DRDX*

*A symbol for DRD Index.
Source: Author compilation.

The profit and losses would depend upon the difference between the rainfall index at which the contract position opened and the rainfall index at which it is closed.

f) Application of RIBF contracts

(1) Agriculture

Farmers who face revenue losses due to heavy or insufficient rain can use RIBF to mitigate the risk. If ERDs and DRDs futures contracts are traded on an organized exchange, a farmer can use them to hedge his rainfall risk. If the number of rainfall index points in the month or season turns out to be higher than the strike level where the contract was bought, the buyer gains on the contract. In a similar manner, anyone can sell a monthly or seasonal rainfall index-based future. If the number of indices in the month or season is lower than the index level, where contracts were sold, the seller gains on the futures contract.

Assume a cotton-growing farmer anticipates heavy rain in the near future; he can purchase ERDs to hedge against heavy rain. If there is excess, he will receive the payout from the long position because the ERD index would go up. If the rainfall is normal, he will likely harvest a normal yield of cotton and earn favourable revenue.

In the same way, DRDs' future can be used to hedge the risk of decreased revenue when deficit rainfall occurs. For example, if a maize farmer wishes to hedge his deficit rainfall risk, he can buy the DRDs future contract. If the rainfall is below normal and his crop yields go down, then the loss of revenue will be offset by the DRDs because the DRDs index would go up in the event of a deficit rainfall. However, if the rainfall is normal and his maize crop does well, then he will earn additional revenue from the maize crop.

(2) Power generation sector

Hydropower generation is one of the sources for generating power in India. Our hydropower generation needs rainfall. The rainfall from June to September generates 11.5% (Report of the Ministry of Power, Government of India, as of October 19, 2022) of our country's total power generation. Therefore, in the event of an unusually low rainfall, it affects the revenue of the power generation companies. The deficit rainfall leads to low generation of power and low revenue, and this low revenue is compensated through the DRDs futures contracts. In event of insufficient rainfall in the coming days, the hydropower generation company may take a long position in the DRDs futures contracts. In the case of a deficit rainfall, the DRDs index values go up, and power generation companies can compensate for the loss of revenue due to the deficit rainfall through DRDs futures contracts.

(3) Tourism/Amusement parks

The tourism and amusement park businesses face the problem of unusual rainfall in the business season. The unusual excess rainfall leads to a reduction in the revenue of the business by reducing the inflow of customers to tourist attractions and amusement parks. In the case of the months of June to September, there may be unusual and excess rainfall that leads to a reduction in the income of these businesses. Business owners can take a long position in the ERDs futures contracts because of the unusual rainfall risk. If there is unusual rainfall, the ERDs index values go up, and it helps to compensate for the loss of revenue because of the unexpectedly heavy rainfall. The amount of loss in business can be compensated through the ERDs' index values, which are higher than the strike value.

(4) Insurance and reinsurance companies

By using RIBF, insurance and reinsurance companies can transfer their pooled rainfall risk to the capital market. If they are afraid of excess rainfall in the upcoming days, then they can take the ERDs futures contracts. Similarly, if they are worried about the deficit in rainfall, then they should go with the DRDs futures contracts. The insurance and reinsurance companies can predict future conditions based on their experience or on the pooled rainfall risk of the public. In the event of an unusual excess or deficit in rainfall, the insurance and reinsurance companies underwrite the loss. Because they need to pay the claim amount to the public who undertook the rainfall insurance. Therefore, this loss can be compensated through the ERDs and DRDs futures contracts. If the value of these indices goes up, then insurance and reinsurance companies get the payoff through the ERDs and DRDs contracts.

(5) Construction companies

The construction companies face the problem of adverse rainfall for their construction activity. The adverse effects of rainfall may delay the work of construction and require extra time to complete the work. Excessive rainfall also leads to the destruction of completed work. Therefore, the construction companies can take a long position in the ERDs futures contracts. If there is normal rainfall, there is no problem with delays in work or demolition of completed work. If there is continuous unusual rainfall, it makes construction work difficult, and the company must pay a fine or the customer may withdraw from the construction contract. Similarly, in the event of excessive rain, newly constructed works are demolished. Therefore, the ERDs futures contracts help to compensate the loss due to the unusual rainfall for the construction companies.

(6) Banking and financial institutions

The banks and financial institutions are providing loans to agriculture and other rainfall-dependent industries. The borrower repays the loan in the event of sufficient revenue from their business or agricultural activity. If there is unusual rainfall, it may be an excess or deficit, and it will affect his activity. If they are not in a position to repay the loan, they become insolvent. The banks face the problem of non-recovery of loans. As a result, banks can use the ERDs or DRDs futures contracts to compensate for the loan amount loss. This loss can be compensated for through the ERDs and DRDs RIBF contracts.

g) RIBF: Policy implications

Rainfall derivatives include rainfall futures, options, and swaps. In 2016, SEBI allowed trading in weather derivatives in the financial market **(Ishan and Girish, 2017)**. But there are some reasons why these markets are not yet developed:

- High initial investment for the development of infrastructure.
- High initial investment in the development of rainfall risk markets.
- Lack of awareness and product knowledge.
- Unfavourable government regulations and policies.
- Lack of reliable data from the meteorological subdivisions.
- Problem of basis risk.
- Lack of availability of weather data.
- Lack of willingness for the participants.
- The problem of pricing the rainfall derivatives.

5. Conclusion

Rainfall risk is a major issue for the Indian economy, and it is critical to the country's sustainable development. Some of the studies show that nearly 30% of the US economy depends on the weather. So, they started with temperature derivatives in 1999 and rainfall derivatives in 2011. So, they are successful in trading weather derivatives. Because rainfall is so important to the development of the Indian economy, India faces the same risk of rainfall variability as the United States. And the variability of rainfall is particularly noticeable in India's geographical location. There are some other countries keen on participating in the Indian weather risk market, but the Indian markets are not yet set up

with the proper platform for trading. All of this indicates that India requires a rainfall derivative market for long-term development. The feasibility of introducing rainfall index-based futures is relevant. Because the government is trying to insulate the farmers from the financial shocks due to crop failure. The developing countries, like India, need to address the weather vagaries through relief packages and compensation. But it is a burden for the government, and it needs a huge amount of capital. Some of the industry sources predicted that nearly 10,000 crores of betting would take place every year on the rainfall. So, it was advised to bring the unorganized transactions into the well-organized exchanges. Therefore, there is a need for a full-fledged and sustainable market to absorb this rainfall risk. The creation of a rainfall risk market provides an opportunity to hedge and speculate on the risk of rainfall. Rainfall risk markets allow traders to trade rainfall risk through futures and options based on rainfall indices. Therefore, the SEBI already requested the committee to suggest the good product to mitigate the rainfall risk. So, this product may be fruitful product to investors, hedgers, and speculators. But the development of these markets needs government support and research in this area.

6. Research implication

The present study yielded some useful inputs for policy making in respect of highlighting the implication of rainfall derivatives to create rainfall risk market for hedging opportunities for a wide range of stakeholders, particularly farming community.

7. Limitations and scope for further research

The present study presents a conceptual framework of rainfall risk market in India. It is important to study the perception of market participants and stakeholders for understanding feasibility of trading rainfall index-based futures. Therefore, there is a scope for further research in understanding market sentiment of target group consisting of risk managers, insurers, reinsurers, corporates, policy makers, financial experts, agriculturists etc.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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