Weather Risk Mitigation Strategies: A Contemporary Review and Its Application in India

Mahuya Basu* and Tanupa Chakraborty**

ABSTRACT

The corporate world has been hedging its risk exposure for decades. One of the most important systematic risk to which majority of the businesses is exposed to is weather. Weather not only affects agricultural output, but also the performance of majority of businesses in varying degree. With growing integration of capital and insurance market worldwide, innovative financial instruments are now available to hedge weather risk exposure successfully. With growing competition, corporates are also concentrating in managing these risks through several traditional as well as innovative risk management techniques including securitisation of both regular weather fluctuation and extreme weather events. The complexity and uniqueness of weather risk call for a detailed analysis of different mitigation strategies that are in use, and their applicability and acceptability in India. Accordingly, this paper focuses on the nature of weather risk and its unique characteristics and at the same time aims to review the use and effectiveness of several risk mitigation techniques.

Keywords: CAT risk, Weather risk, Crop and plot diversification, Contract contingency, Weather insurance, Weather derivatives.

1.0 Introduction

‘Everybody talks about the weather but nobody does anything about it’ – Mark Twain. Weather continues to be a major determinant of several economic activities even in this technology driven era. Almost all the businesses are exposed to the weather risk factor in a varying degree. In a 1998 testimony to Congress, former Commerce Secretary of United States of America, William Daley, stated, “Weather is not an environmental issue; it is a major economic factor. At least $ 1 trillion of the $ 7 trillion U.S. economy is weather-sensitive”.

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The similar statistics for India is not expected to show any different trend; rather the dependency of Indian economy on weather is expected to be far more intensive in nature. A low monsoon not only affects the agricultural production of India adversely, but also leaves a gloomy impact on the economy as a whole. Sectors like power, energy, entertainment, tourism, construction are largely weather sensitive in their performance. The degree of impact of weather on business can be classified under two broad categories (Brockett, Wang and Yang 2005). The regular fluctuation of weather condition causes fluctuation in the revenue and profit of a company, like an entertainment park has less than normal number of visitors on a rainy weekend or a power company faces lower power demand on a comparatively cooler summer day. This needs to be differentiated from the catastrophic weather events (known as ‘CAT risk’) like tornado or tsunami that causes extreme damages to property and life. The earthquake and tsunami that occurred in Japan in March 2011 caused physical damage that may range from $250 billion to as large as $309 billion (Source: CSR Report to US Congress, March 2011), a figure that matches the GDP of Greece approximately and twice that of New Zealand. The first type of risk however specifically concentrates on the fluctuation of firm’s profit due to normal weather fluctuation and is termed as ‘weather risk’. Such fluctuations are frequent but not devastative. ‘Weather risk’ also needs to be differentiated from ‘climate risk’, i.e the uncertainty that the companies are likely to face because of climate change and concern for global warming which may induce them to change their technology or take up financial contracts, commonly known as climate trading or carbon trading, to manage the emission of green house gases. However global warming may lead to both of more volatility in weather condition as well as increased number of extreme weather events thereby enhancing both ‘weather’ and ‘CAT risk’. Weather affects different industries in different manner and often in a conflicting manner. As the nature of the risk differs across industries, some of the industries and the nature of their exposure are listed below (Table 1).

Weather may have a direct and/or indirect impact on business and agriculture. The direct impact comes as a decrease in volume of sales or increase in cost due to increased volume of raw material consumption. The indirect impact appears in its correlation with price. The nature of such exposure is more complex. Weather condition often reduces the volume of sales for many industries like beverages or entertainment. In a cool summer although the price of ice-cream remains unchanged, the negative impact will come from lower sales volume. These are direct impact of weather risk which is purely volumetric. However in some other industries, demand may have influence on price also. During a cold winter, not only the demand for gas increases, but price of gas also rises.
Table 1: Illustrative Links between Weather Indexes and Financial Risks

<table>
<thead>
<tr>
<th>Risk Holder</th>
<th>Weather Type</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy industry</td>
<td>Temperature</td>
<td>Lower sales during warm winters or cool summers</td>
</tr>
<tr>
<td>Energy consumers</td>
<td>Temperature</td>
<td>Higher heating/cooling costs during cold winters and hot summers</td>
</tr>
<tr>
<td>Beverage producers</td>
<td>Temperature</td>
<td>Lower sales during cool summers</td>
</tr>
<tr>
<td>Building material companies</td>
<td>Temperature/Snowfall</td>
<td>Lower sales during severe winters (construction sites shut down)</td>
</tr>
<tr>
<td>Construction companies</td>
<td>Temperature/Snowfall</td>
<td>Delays in meeting schedules during periods of poor weather</td>
</tr>
<tr>
<td>Ski resorts</td>
<td>Snowfall</td>
<td>Lower revenue during winters with below-average snowfall</td>
</tr>
<tr>
<td>Agricultural industry</td>
<td>Temperature/ Precipitation</td>
<td>Significant crop losses due to extreme temperatures or rainfall</td>
</tr>
<tr>
<td>Municipal governments</td>
<td>Snowfall</td>
<td>Higher snow removal costs during winters with above-average snowfall</td>
</tr>
<tr>
<td>Hydroelectric power generation</td>
<td>Precipitation</td>
<td>Lower revenue during periods of drought</td>
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The profit and revenue of such industries are directly as well as indirectly affected by weather condition. The profitability of a firm may also get indirectly affected through the enhanced price of raw material or utilities which are weather dependant. For example, increased price of coal during heavy rain may enhance the cost of power production and at the same time the firm may generate less volume due to wet coal problem. Figure 1 reflects a graphical representation of the weather exposure of a firm.

Given the fact that ‘weather’ cannot be an overlooked area of concern for businesses even in this electronic age, the remainder of the paper is organized as follows. Section 2 enumerates the objective and rationale of the study. Section 3 conceptualizes weather risk in terms of its characteristics. The various kinds of strategies for weather risk mitigation, including that of weather derivatives, have been elaborated in Section 4 in special reference to India. Finally, Section 5 concludes the study by making a critical assessment of the weather risk mitigation strategies.
Figure 1: Possible Weather Conditions and their Impact on Company Costs and Revenue


Note: Here,

\( P_P - P_A \) = Planned and obtained price of sale; partially related to weather

\( Q_P - Q_A \) = Planned and actual volume of sales; directly related to weather

\( AVC_A - AVC_P \) = Obtained and planned value of resources used for production, partially related to weather

\( q_P - q_A \) = Planned and actual volume of resources used for production; directly related to weather.

2.0 Objective and Rationale of the Study

Although the effect of weather on economy and industry has been a known fact for long, companies are still categorising weather as an unmanageable source of risk especially in a developing country like India. A quick glance in Rallis India’s annual report shows; “FY12 was a challenging year for the domestic pesticide industry on account of adverse weather conditions. At the same time, it was one of the strongest
growth years for the global pesticide industry. Domestic industry is estimated to have declined in FY12 and in line with the same, Rallis’ domestic pesticide sales have shown de-growth (~2% YoY) in FY12” (Source: Annual Report: Rallis India 2011-12). The reason cited in the Economic Survey Report of 2010 for the negative growth rate of (-) 7.4% of Hydropower during April to December in 2009 as compared to 2008 is poor monsoon of 2009 (Source: Economic Survey Report 2010). However, with increasing competitiveness across industries, ‘adverse weather’ may not continue to appear as an acceptable excuse for bad performance of the companies. Assessment and quantification of this risk along with its diverse mitigation strategies are required to be explored simply for survival reasons. Accordingly the major objective of this paper is to understand the nature of weather risk and several weather risk mitigation strategies that have been adopted by many countries to mitigate such risk. The study also concentrates on the review of available strategies in the context of their effectiveness and applicability in India.

3.0 Weather Risk and its Characteristics

‘Weather risk’ can formally be defined as the financial exposure of a company’s earnings and cash flows attributable to weather deviations from “normal.” It includes the impact of temperature, rainfall, snowfall, and wind level’ deviations from “normal” on the level of business activities. This volumetric systematic risk differs in its nature from other type of enterprise risk and needs different tools for its understanding and management. The nature of this systemic risk is described as follows:

a) Unlike other risk, weather normally affects the volume or unit demanded or produced rather than unit price. Even though the firm enjoys a fixed price or can hedge the price risk successfully, such fluctuation in volume will result in fluctuation in revenue and profit. In this sense, weather risk is unique in nature and has to be mitigated separately. Available price risk management system is not enough to mitigate weather risk.

b) Weather Risk is localized. Hence firms belonging to same geographical location and engaged in similar business are exposed to the same kind of risk at a given time.

c) Weather is completely beyond human control. It cannot be influenced, modified or manipulated by regulation or speculation. Even weather cannot be predicted successfully beyond a very short time period to support commercial decision. It is a pure systematic risk.
d) Weather for almost all businesses is a non-core risk. Non-core risk can be interpreted as a risk which is not related to the core business of the firm and a risk that a firm should try to eliminate.

4.0 Weather Risk Mitigation Strategies (with special reference to India)

Weather risk mitigation process is not always straightforward, and it is usually an iterative process. There are few steps that are common to all risk management strategies with natural exposure to weather like identification of the critical weather variables, identification of the impact of the weather variables on revenue, profit or cost, identification of a reliable source of historical data, identification of the period during which the weather variables influence the financials of the company, quantification of the relationship between changes in the weather variables and changes in the financial parameter affected by weather, and establishment of sensitivity to the changes in financial parameter and translating the sensitivity in terms of the weather variable.

World Bank (2001) has classified the strategy for risk mitigation as informal and formal strategies. Informal strategies are identified as “arrangements that involve individuals or households or such groups as communities or villages,” while formal arrangements are “market-based activities and publicly provided mechanisms”. Both industries and agriculture have been using traditional risk management techniques which have been able to partly offset the weather risk also. There are several ART (Alternative Risk Transfer) mechanisms that have evolved recently and with growing importance many more are yet to come. A few of these tools are convenient and have specific industry application, but many of them are costly and insufficient in nature. The following sub sections review the few traditional as well as innovative weather risk mitigation mechanism under practice.

4.1 Risk diversification

Especially in agricultural sector, farmers may protect themselves from weather related risk through various structural mitigation measures, for example supplementary irrigation system to offset the risk of insufficient rainfall or construction of dams to control flood etc. The production strategy selected is also an important means of mitigating the risk. Traditional cropping systems in many places rely on ‘crop diversification’ i.e. using the same plot of land to produce more than one type of crops over the year, and ‘plot diversification’ where different plots of land are used to produce different types of crops. Apart from altering agricultural production strategies, households may also smooth income by diversifying income sources- typically crop
income and some livestock or dairy income, and thus minimizing the effect of a negative shock to any one of them. Off-farm seasonal labour, trade and sale of handicrafts are also common alternative income sources for agricultural family. Buffer stock accumulation of crops and the use of credit are some other means of households’ smooth consumption practiced. Crop-sharing arrangements in land renting and labour hiring are also few effective ways of sharing risks between individuals, thus reducing producer risk exposure (Agriculture and Rural Development Department, World Bank 2005).

Companies relying heavily on the production of weather sensitive product can mitigate the impact of weather on their revenue and/or cost using product and geographical diversification. For example, a ski resort may introduce water sports for their summer guests. For companies that have diversified their sales across regions, locations, products and services are protected by the nature of their business i.e. they are naturally hedged. Natural hedge is however much more difficult to achieve through geographical diversification because the feature of negative correlation between meteorological elements in different locations is often difficult to achieve. Although this can partially offset the losses incurred when the weather turns against the company in a particular region, but it cannot eliminate them. Moreover such diversification as a strategy could be extremely costly to implement.

4.2 Contract contingency

In some sectors, it is under practice to transfer the weather related risk to customer through contract contingency. Some construction companies may pass the weather related cost fluctuation to their customers through individual project contract. Such a strategy may operate during boom time when property price normally flourish. However during slow growth or recessionary period, contract contingencies might be hard to accept for customers. Moreover, contract contingencies effectively transfer the risk of weather related delays from one party to another, but do not provide compensation for losses incurred.

Power is one sector which is highly sensitive to weather fluctuation. In the absence of any other weather risk management mechanism, Indian power sector mostly depends on long term contract for risk mitigation. In India, the power price payable by the bulk customers has two components- ‘capacity cost’ which is based on the declared capability (DC) of the generator and ‘energy charge’. Even though the demand fluctuates due to weather condition, once bulk customers have agreed on the declared capability and cumulative DC is equal to or more than agreed norms, the generators recover the entire agreed declared capacity cost from the bulk customers in case of lower demand thereby transferring the capacity loss risk to the customer. However here also, even though the
risk is transferred, one party to the contract still retains the risk and weather related losses are not compensated.

4.3 Commodity derivatives

Another possible way to hedge the weather risk could be to enter into trading of commodity derivative. For example, a farmer may protect himself from a potential price fall due to bumper harvest resulting from sufficient rainfall by entering into a future trade and locking the selling price of product. Similarly, an electricity company can enter into a long term trade contract with a merchant power generator at a pre-fixed price to hedge against higher demand, hence higher price of electricity resulting from too high or too low temperature. Such a strategy, although capable of safeguarding against price fall, cannot offset loss of volume. Moreover, one important prerequisite of a viable derivative market is a vibrant spot market for the said commodity, which may not exist for many products. For majority of agricultural products a vibrant spot market may exist, however for electricity the existence of such active spot market is farfetched. This is one factor that explains the failure of electricity derivative markets globally.

4.4 Traditional insurance scheme

In principle, traditional insurance scheme can also be used as a risk mitigation strategy of adverse weather and in practice it is the most common strategy adopted against extreme weather events across sectors. Using insurance to prevent the impact of adverse weather is most popular in agricultural sector where crop insurance is widely used to mitigate weather risk. Crop insurances are generally developed based on one of the two approaches namely ‘individual approach’ and ‘homogeneous area approach’. Under a ‘homogeneous area approach’, individual farmers are treated as identical risks, and hence different agro-climatically homogeneous areas are dealt with as a single unit and individual farmers receive the same benefits while the premium also remains same. Under the ‘individual approach’, premium determination depends on individuals’ ex ante risk assessment, and ex post loss assessment is done to settle claim payments.

A beginning in crop insurance in India was made in 1972 by implementing an experimental scheme for hybrid-cotton in a few districts of Gujarat state. This scheme followed the individual approach and uniform guaranteed yield was offered to selected farmers. This scheme continued till 1979 and was phased out following the assessment that crop insurance schemes based on individual approach are not feasible and economically viable to implement on a large scale in a large developing country like India. The Pilot Crop Insurance Scheme (PCIS) based on an area approach was launched by the state owned General Insurance Corporation (GIC) in 1979. This was followed by
CCIS (Comprehensive Crop Insurance Scheme), introduced in 1985 which experienced major failure. As successor of the CCIS, the National Agricultural Insurance Scheme (NAIS) was introduced by the Indian government in 1999. This scheme is available to all states/union territories and covers food crops, horticultural crops, oilseed crops, and commercial crops.

NAIS provides greater coverage than CCIS in terms of number of farmers, crops, and risk. However according to Prachure (2002), “whether it was CCIS or NAIS, the performance of the crop insurance scheme in India can only be judged as disappointing on all counts; financial, economic and administrative”. Financially, the scheme has been incurring continuous losses. Till Kharif (i.e. monsoon season between June and September) 2010, NAIS covered 158.32 million farmers for a premium of Rs. 6,801.61 crores and finalized claims of Rs. 14,227.99 crores (Source: WBCIS Report; Ministry of Agriculture, Government of India 2011). The performance of the scheme in terms of the size of impact is also negligible. For instance, average per annum claims paid were Rs. 233 crores which, if compared to the sum-at-risk i.e. the agricultural output of the country worth Rs. 6,50,000 crores, is hardly 0.035% (Prachure 2002). Lastly in administrative form, it is very complex involving more than one central and state Government departments and organizations. The main flaws of NAIS include its mandatory nature, its failure to address adverse selection by non-loanee farmers, arbitrary premiums, and the inefficiency of the area approach.

All the crop insurance schemes introduced till now are subject to two major faults namely ‘adverse selection’ and ‘moral hazard’. Adverse selection exists when the insured has more information about the risk involved as compared to the insurer, and therefore can better decide on the fairness of the premium. Moral hazard occurs when the insured can enhance the probability of indemnity by his own action after purchasing the insurance. Both moral hazard and adverse selection affect the financial viability of the insurance scheme. Empirical research provides evidence of moral hazard in multi-peril crop insurance, as well as adverse selection (Sharma and Vashishtha 2007; Sinha 2007). Besides these reasons, there is a lack of participation of private insurance firms in agricultural insurance. It is worth mentioning that worldwide agricultural insurance suffers loss and is subject to government subsidy. Moreover insurance works with the concept of risk pooling i.e. it spreads the risk among policy holders who are having uncorrelated risk or unsystematic risk. But a major risk component in agriculture risk is the risk of natural disaster or weather variation which is geographically concentrated. Thus it is often not feasible for private insurance company to operate in multi-peril insurance scheme. The scale at which these schemes need to operate to diversify the risk
is often beyond the scope of private insurance company. Otherwise they have to charge premium high enough to make the scheme unattractive for the farmers.

4.5 CAT bonds

A whole new class of weather linked financial instruments has been introduced in the recent past which can be clubbed together as CAT linked securities. CAT linked securities provide a mechanism to transfer the catastrophic risk to the capital market and provide an additional layer of protection over and above the traditional insurance and reinsurance process. These securities are primarily designed to mitigate the risk of catastrophic event and do not stand as a suitable mitigation strategy for non-catastrophic weather risk. The most prominent one in these class is catastrophic bond, or commonly known as CAT bonds. They were first used in mid 90’s after the hurricane Andrew and the Northridge earthquake struck United States. These bonds are normally floating rate bonds and inherently risky, issued by insurance companies with the consultation of an investment bank to evade some of the risk they would face in case a catastrophic event occurs which will create damage that they will not be able to cover with the premium they receive. The investors who have invested in a CAT bond continue to get the coupon as long as the catastrophe event does not take place. However in case the event does take place, a part of the principal and / or the coupon will be forgiven and the insurance company will use the money to pay the insurance claim. One well known experiment was ‘National Catastrophe Insurance Notes’, a transaction done between AIG(American International Group), Hannover Re. and USAA (United States Automobile Association) in the mid 1990s, where only 85% of return was promised if one earthquake occurred in the two-year bond life and only 40% if two earthquakes occurred. The investors prefer to invest in this class of securities as the return from CAT bond is largely uncorrelated with the return of other financial securities and hence gives an option for better diversification. These bonds also give more return than other type of corporate bonds.

4.6 CAT linked derivatives

Another alternative measure of catastrophic risk transfer is CAT linked derivatives, a derivative instrument where a catastrophic event acts as underlying. Over-the-counter instruments such as the Deutsche bank-sponsored event loss swaps or the NYMEX (New York Mercantile Exchange), the CME (Chicago Mercantile Exchange), and the IFEX (Insurance Futures Exchange) exchange-traded futures and options contracts are examples of more recent innovations in CAT-linked derivatives segment. The buyer of an event loss swap pays a premium to the seller of the protection, who then will be liable to pay the full notional value of the swap to the buyer in case the industry wise insurance
losses cross a prefixed threshold level. The event swap transaction issued by Deutsche Bank covers the risk for one year and covers windstorm and earthquake risks in the U.S. with threshold levels set at US$20 billion, US$30 billion, and US$50 billion for hurricanes and tornadoes, and at US$10 billion and US$15 billion for earthquakes. CME has introduced index based hurricane future and option, where the settlement is based on Carvill Hurricane Index (CHI), which is based on parametric feature of hurricane like maximum wind velocity and size. The contract expires as soon as the hurricane makes landfall.

4.7 Index based weather insurance

Recently, there has been increasing interest amongst various international organisations such as the World Bank and the International Monetary Fund (IMF) to investigate and test new and innovative products for risk sharing like index based weather insurance in the developing countries primarily in the agricultural sector. An index based weather insurance makes payment based on weather index primarily rainfall rather than loss incurred, where the protection is being given to the farmer if the crop in question receives less than required rainfall or excessive rainfall during harvesting period. The insurance amount is proportionately linked to the deficit or excess rain amount, generally arrived by multiplying the amount of deficit/excess rainfall with predetermined tick rate. The insurance generally comes with a cap of maximum payable amount. The rainfall insurance in India is a classic example of such insurance policy. The index based rainfall insurance was first introduced by ICICI Lombard General Insurance Company, with support from the World Bank and International Finance Corporation in Mahabubnagar, Andhra Pradesh in July 2003. The first year, 2003, was a pilot year, and the program was only targeting groundnut and castor farmers. The design of the insurance scheme was made by ICICI Lombard, with the technical support of the Commodity Risk Management Group (CRMG) World Bank, and consultation of BASIX, the objective being to protect the farmers from drought during the groundnut and castor growing season. The payout is based on three phases of crop production namely sowing, flowering and harvesting. The insurance payment is based on the accumulated rainfall in each phase measured at the nearby weather station. The payments of first two phases are linked with low rainfall whereas the third phase is linked with high rainfall. The year 2004 witnessed an extension of the first experience to 4 new weather stations in Andhra-Pradesh. In the third phase of the project in 2005, a total of 7685 contracts in 36 localities in India were sold by BASIX through the micro insurance channel, but more generally more than 2,50,000 farmers bought weather
insurance in the country directly from ICICI Lombard. The overall project has been a major success improving the financing condition of many small farmers in India.

BASIX also designed a weather insurance for soya farmers in Ujjain, Madhya Pradesh, which linked insurance to bank loans, where farmers receive interest payment relief of Rs 10 per mm of rainfall index deficit. Thus farmers pay a higher interest rate in normal years as the weather insurance premium, but receive much-needed relief in drought years. In 2004, rainfall insurance has been introduced in Rajasthan for orange grower on a pilot basis in Jhalawar, Baran and Kota districts. The pilot scheme of ‘Versa Beema Yojna’ has been implemented by Agricultural Insurance Company of India Ltd. as announced in the Union Budget of 2007-2008; it has been implemented at a larger scale covering twelve states. Rainfall insurance has also been introduced among the coffee growers of Karnataka, Kerala and Tamilnadu from the year 2008. The payment here also is tied with the phase of blossom shower, backing shower and monsoon shower.

It’s been more than a decade since the launch of first weather insurance contract in India. Lots have been said and discussed about weather insurance and their application in Indian agricultural sector. But the gaps related to the product are still manifold. Optimal product design and payment structure have a crucial role to play as success factors. Index needs to be developed in such a way that it has a high correlation with the crop loss due to monsoon failure and simple enough to have high acceptance. The indemnities in the existing product are concentrated at the extreme in case of adverse deviation of rainfall. It protects the farmer only in case of devastative events, thus generating a highly skewed payment distribution for the insurance company. The fund factor has also emerged as crucial in the success of the product, as the premiums are generally paid at the beginning of the season when fund requirement for the cultivator is at its maximum. The other important determining factor is the pricing issue. Both sustainability and success of the product requires charging of fair premium and a transparent subsidy policy if any, based on it.

Gine, Townsend and Vickery (2008) analysed the acceptance of the rainfall insurance product in a survey conducted in the World Bank Economic Review. The study estimated the cross sectional determinants of household insurance take up. In that survey, 24.9% of farmers explained lack of understanding of the product on their part as the principal reason for not taking up the insurance, whereas only 2.5% have expressed that the protection against varying rainfall is not required. The survey also identified the demographic characteristics of the target group for both takers and non-takers. The average education of the household head was found to be (in years) 5.3 for buyers and 3.17 for the non buyers (significantly different at 1% level of significance). 97% of them
have spent their entire life in the village, and 45% of the non-takers do not have any other insurance policy. These demographic characters partly explain the lack of understanding and awareness about the insurance product.

In another study conducted by Gine, Townsend and Vickery (2008) across fourteen different weather stations in Andhra Pradesh, the expected pay out was found out to be Rs. 29.7 against a premium of Rs. 100 considering the historical rainfall data of 1970 to 2006. It becomes eminent that the premium charged is far higher than the fair value. It is more significant as the premium charged was claimed to be grossly subsidized. It also estimated that payment is made in only 11% of the phases, and in 1% case the insurance pays the maximum indemnity of Rs. 1000, yielding an average return on the premium paid of 900%.

Figure 2 explains the major difficulties faced by the Indian market which directly or indirectly affects the growth and development of a weather insurance market in India. The three main causes identified are –

\begin{itemize}
\item \textbf{Delayed compensation}
\end{itemize}

One of the major hindrances in the development of the weather insurance market in India is lack of availability of reliable weather data and is also the main reason for the delayed compensation of claim where weather insurance is concerned. There are about 580 weather stations in the country run by the Indian Meteorological Department, out of which only a few have good historical weather data for a period of thirty continuous years or more.

\begin{itemize}
\item \textbf{High risk transfer cost and regulatory issues}
\end{itemize}

This is due to lack of product knowledge and product inefficiencies, as well as improper weather data and improper assessment of risk faced. The relationship between weather and crop yield is not always straightforward. The yield depends on various factors such as crop growth phase, soil texture, humidity etc. It is very important that weather insurance should be able to explain the actual presence of a clear relationship between weather factors and the production variability; otherwise it is no more an attractive tool for hedging weather risk.

\begin{itemize}
\item \textbf{Major of the farmers in India are small and marginal with very small landholding. The main problem is that weather contracts, insurance or derivatives cannot be written for small centre, they have to be written in major agricultural centre. The other problem is that there are not many reinsurers who are underwriting weather contracts.}
\end{itemize}

\begin{itemize}
\item \textbf{Lack of product knowledge}
\end{itemize}

In order to make weather product popular in the Indian market, it is very important that all the market participants such as the farmers and financial intermediaries become
properly educated and trained. They can benefit from weather insurance only if they understand the use and effectiveness of the product.

**Figure 2: Factors Affecting the Growth of Weather Insurance Market in India**

Data Deficiency
- Delayed Current Data
- Lack of quality Historical Data

Product Inefficiency
- Improper Risk Assessment
- Regulatory Restrictions
- Historical yield / production / sales data
- Low Landholdings

Inefficient Outreach
- Weather Information
- Farm Management

Customer / Risk Profile
- Large share of Rainfall Risk
- Single side Risks
- Major buyer segment is uneducated and ignorant

Delayed Compensation

High Risk Transfer Cost

Lack of Product Knowledge

Impacts Penetration Levels

Inhibits Market Development


### 4.8 Weather derivatives

Weather derivatives are the most commonly used weather hedging technique worldwide. A derivative is a financial instrument whose value depends on and is derived from more basic underlying assets. A weather derivative is a derivative based on an underlying index which is formed on a weather variable. The weather index is computed by quantifying the deviation of meteorological elements (temperature, rainfall, snowfall, wind speed, frost, etc.) from the selected reference level. The deviation is calculated
based on observations of actual weather condition in the specified climatologic stations. Weather contracts are based on the actual observations of weather at one or more specific weather stations. Most transactions are based on a single station. Also, contracts can be based on a weighted combination of readings from multiple stations and on the difference in observations from two stations. Then, to each degree of deviation, a certain monetary value is given, known as tick. Tick represents the fundamental parameter in building weather cover. A contract becomes valuable when the level of selected meteorological element falls below or rises above the predetermined threshold, depending on the position taken. In this way, weather has been converted into a tradable good. Payoff of a weather derivative is determined by the value of its underlying index. All contracts have start and end dates that define the period over which the underlying index is calculated.

A standard weather derivative contract is defined by the following attributes:

a) A contract period: A start date and end date of the contract during which the contract will be viable.

b) A measuring station: Normally a Meta station where the weather variable like temperature or rainfall will be measured.

c) A weather variable or a set of defined weather variables measured in a measurement station over the duration of the contract period which will act as the basis of the index.

d) An index which aggregates the weather variable over the contract period in some way.

e) A pay-off function which converts the index in money terms following a specific logic for the settlement of the contract at the end of the contract period.

f) For some type of contract a premium is paid by the holder to the writer of the contract.

Although weather derivatives can be written on several underlying, in any given year almost 80% of them are written on temperature. The indices most commonly in use for temperature-based contracts are degree day indices. A degree day is defined as the deviation of the average daily temperature from a pre-determined base level normally set at 18°C. There are two degree day indices which are in common use - Heating Degree Day (HDD) which is normally used in winter and is correlated to the electricity demand for heating and Cooling Degree Day (CDD) which is correlated to the electricity demand during summer as explained below.

(a) Heating Degree Day: HDD is a measure for energy required for heating and thus is a measure of how cold it is. The HDD is measured as the number by which the average
temperature of a day is lower than a prefixed temperature level, otherwise zero. Thus if $Z_i$ represents the HDD of a particular day, then

$$Z_i = \max (T_0 - T_i, 0)$$

\[\text{...............(1)}\]

where $T_i$ is the average temperature of the day and $T_0$ is the threshold temperature. In United States the threshold temperature is usually taken as $65^\circ \text{F}$ or $18.33^\circ \text{C}$ and in all other country it is taken as $18^\circ \text{C}$.

An index based on HDD over a period of a particular time is usually calculated as the sum of daily HDD over the specific time period. Hence a HDD index ‘$x$’ over $N$ day period will be defined as

$$x = \sum_{i=1}^{N} Z_i$$

\[\text{...............(2)}\]

HDDs are used in United States and Europe, but seldom in Japan.

(b) **Cooling Degree Day**: CDDs are used to measure the energy demand for cooling and thus is a measure of how hot it is. The CDD is measured as the number by which the average temperature of a day is higher than a prefixed temperature level, otherwise zero. Thus if $Z_i$ represents the CDD of a particular day, then

$$Z_i = \max (T_i - T_0, 0)$$

\[\text{...............(3)}\]

An index based on CDD over a period of a particular time is usually calculated as the sum of daily CDD over the specific time period just like HDD.

The list of actual contracts in use is extensive and constantly evolving. Most of the weather contracts traded are swap and put/call option or a combination of these. The temperature related derivative instruments are swaps, futures and options on futures (i.e. an option written on a future contract which gives the holder the right to enter in the specified underlying future contract). They are either traded in Exchanges or in Over-The-Counter (OTC) markets. The OTC weather market is far larger in terms of volume than exchange traded market. The Chicago Mercantile Exchange (CME) is the pioneer and most prominent exchange trading weather derivatives. In September 1999, CME introduced trading in weather futures and options on futures on the weather index of ten cities in USA. At present, CME offers listing and trading of temperature based index futures and options on futures on average, seasonal and monthly weather based on CDD, HDD and CAT (cumulative average temperature) in 47 cities worldwide, 24 in US, 6 in Canada, 11 in Europe, 3 in Japan and 3 in Australia.
5.0 Conclusion

The application of traditional risk mitigation strategies has its own inherent limitations. Natural hedging, apart from being an expensive strategy, has its own limitation in terms of applicability across industries. On the other hand, contract contingencies can only transfer the risk to customers rather than hedging it. But weather derivatives in the case of adverse weather, besides risk transfer, provide a payment that can be used to pay consequential penalties or cover the additional cost. Both insurance and CAT securities are more suitable for handling the catastrophic risk rather than weather risk. CAT linked derivatives now act as an alternative to traditional re-insurance in order to help the insurance companies hedge its exposure to catastrophic risk such as typhoon and earthquake, and they are now traded both in exchange and over the counter market. The main difference between weather derivative and such insurance derivative is that in the former, the payout trigger is the weather event itself rather than the amount of financial losses arising out of the weather event. The holder of weather derivative need not prove the damages or submit a claim to be compensated. On the other hand, the holder of the insurance derivative has to verify the financial losses he or she has suffered due to extreme weather event as the payout trigger will be active if the indemnity pay by the insurance industry crosses a threshold limit due to extreme weather event. The process of submitting a claim can be lengthy and costly and may contain subjectivity that is not appreciated by the holders.

Another issue of constant debating is whether weather product like weather derivatives and CAT Bonds are to be introduced in India. Several researchers have suggested the introduction of weather derivatives in India in the context of growing privatisation of energy industry here. In an exploratory study, Sharma and Vashishtha (2007) have concluded that application of traditional risk-hedging tools and techniques in Indian agricultural and power sectors have proved to be costly, inadequate, and more importantly, a drag on the country’s fiscal system. They also suggested that an appropriate weather based derivative contract may prove to be a more flexible, economical and sustainable way of managing the volume-related weather risk in an economy like India having predominant agricultural and power sectors. Most of the basic requirements for introducing weather derivatives already exist in India. One such basic requirement is accurate past weather data of different localities, which are becoming increasingly available day by day. India is also having an active market for other derivative products, a fairly matured secondary market and stock exchanges. Accordingly, introducing weather derivatives will not call for huge infrastructural investment. Moreover, it will enable the insurance and reinsurance companies and even
financial institutions insuring and financing at a cheaper rate as there will be an available avenue for them to mitigate their weather exposure.

Weather insurances are perceived to be less risky as compared to the weather derivatives. There is no secondary market available for weather insurance, however weather derivative may be traded during the holding period. This makes it necessary to perform a regular re-evaluation of the hedging position in derivatives market unlike the insurance. Secondly, weather insurance can only be bought by an individual who is having an interest in the business that is exposed to weather risk, but in case of derivatives no such restriction is there. Another important difference is due to the more standardized and flexible features of weather derivatives, which increase its market liquidity and reduce its cost of hedging. In a derivative market, players with opposite weather exposures enter and meet in a contract which hedges each other’s risk. On the other hand, weather insurance lacks flexibility and ability to specifically match over. Additionally, weather contracts can be bought for speculative purposes, like any standard derivatives and hence it can be applied with several different type of hedging or speculative objective. For example, classical index based weather insurance can only protect the interest of farmers of a particular region in relation to their own crop, but not against the high yield of the competitors’ region which may lead to a dramatic fall in the market price of the farmers’ product in question unlike weather derivatives.

References


**Weblinks**