Chapter 4
RAINFALL RISK MANAGEMENT IN INDIA

4.1. Introduction
The monsoon rainfall is critical for the development of economy of India. In view of this understanding the behaviour of the monsoon rainfall of India is necessary. In this chapter an attempt has been made to know about Indian Meteorological Department (IMD), rainfall data, pattern, anomalies of distribution of rainfall, effect on economical sectors, rainfall risk mitigation and management, advantages and limitations of traditional insurance and index insurance.

4.2. Monsoon of India
For Indian subcontinent rainfall occurs during monsoon period and is monitored by Indian Meteorological Department (IMD). According to IMD, Monsoon is defined as the seasonal reversals of the wind direction along the shores of the Indian Ocean, especially in the Arabian Sea, that blow from the southwest during one half of the year and from the northeast during the other half. Monsoon is categorised as

- South-West Monsoon (SW Monsoon)
- North-East Monsoon (NE Monsoon)

Based on the time of the year that these winds bring rain to India, they can also be categorised in two seasonal periods called:

- the Summer monsoon (May to September)
- the Winter monsoon, (October to December)

The complexity of Monsoon as a weather phenomenon of India is not yet completely understood, making it difficult to accurately predict its behavior in terms of quantity, temporal and spatial distribution of the accompanying precipitation. It involves winds blowing from the south-west direction (known as South-West Monsoon) from the Indian Ocean onto the Indian landmass during the months of June through September. These are generally rain-bearing winds, blowing from sea to land, and bring rains to most parts of the subcontinent. They split into two
branches, the Arabian Sea Branch and the Bay of Bengal Branch near the southernmost end of the Indian Peninsula. Subsequently later in the year, around October, these winds reverse direction and start blowing from a north-easterly direction. Given their land to sea flow, from subcontinent onto the Indian Ocean, they have less moisture and bring rain to only limited parts of India like Andhra Pradesh and Tamil Nadu. This is known as the North-East Monsoon. This mechanism completes the annual Monsoon cycle of the Indian subcontinent.

4.2.1. Unique features of Monsoon

a. "Bursting" of Monsoon Rains

Bursting of Monsoon implies the onset of the sudden change in weather conditions in India (typically from hot and dry weather to wet and humid weather during the SW Monsoon) due to abrupt rise in the mean daily rainfall. Similarly the burst of NE monsoon marks an abrupt increase in the mean daily rainfall over the affected regions.

b. Monsoon Rain Variability ("Vagaries")

One of the most commonly used phrases to describe the erratic nature of the Monsoon of the Indian subcontinent is "vagaries of monsoon", In some years, it rains too much causing floods in several parts of India, in others it rains too little or not at all causing droughts. In some years when the rain quantity is sufficient, its timing may be arbitrary. In some years, in spite of average annual rainfall, its daily distribution or the areal distribution might be substantially skewed. Such is the variability in the nature of Monsoon rains and weather.

Every year the normal onset of SW Monsoon is expected to "burst" onto the western coast of India (near Thiruvananthapuram) around 1st June covering entire India by around 15 July. Its withdrawal from India typically starts from 1st September onwards and completes by around 1st October. Similarly the NE Monsoon is expected to "burst" around 20 October and last for a period of about 50 days before withdrawing.
However, a rainy Monsoon is not necessarily a normal Monsoon. A normal Monsoon is expected to perform close to its statistical averages calculated over a significantly long periods. Therefore, a normal Monsoon is generally accepted to be the Monsoon that has near average quantity of precipitation over all the geographical locations (mean spatial distribution) under its influence and over the entire expected time period of its influence (mean temporal distribution). Further the arrival date and the departure date of both the SW and NE Monsoon should be close to the mean dates.

A Monsoon with excess rain can cause floods in India, Pakistan and Bangladesh and one with too little rain can lead to widespread drought, food shortage, famine and economic losses. Therefore, a normal Monsoon with mean performance is the most desirable Monsoon.

4.2.2. Indian Meteorological Department Model

IMD has tried to forecast the Monsoon for India since 1884, some unsuccessfully but till 2011 is the only official agency entrusted with making public forecasts about the quantity, distribution and timings of the Monsoon in India. However, following the 2009 drought in India (worst since 1972), IMD decided in 2010 that it needed to develop an indigenous model to further enhance its prediction capabilities.

4.2.3. Regional and sub-divisional Rainfall anomalies

Based on the data from the Indian Institute of Tropical Meteorology (IITM) for rainfall for the period, 1871-2000, the time series of seasonal rainfall anomalies (expressed as a percentage difference from normal) for all India and select few subdivisions illustrated in figure 4.1 to 4.9.
Figure 4.1: Time series of seasonal rainfall anomaly for All India

Source: web site http://www.monsoondata.org

Figure 4.2: Time series of seasonal rainfall anomaly for Punjab (PUNJB) subdivision

Source: web site http://www.monsoondata.org

Figure 4.3: Time series of seasonal rainfall anomaly for Gujrat (GUJRT) subdivision

Source: web site http://www.monsoondata.org
Figure 4.4: Time series of seasonal rainfall anomaly for Gangetic West Bengal (GNWBL) subdivision

Source: web site http://www.monsoondata.org

Figure 4.5: Time series of seasonal rainfall anomaly for West Uttar Pradesh (WUPPL) subdivision

Source: web site http://www.monsoondata.org

Figure 4.6: Time series of seasonal rainfall anomaly for Vidarbha (VDABH) subdivision

Source: web site http://www.monsoondata.org
Figure 4.7: Time series of seasonal rainfall anomaly for North Interior Karnataka (NIKNT) subdivision

Source: website http://www.monsoondata.org

Figure 4.8: Time series of seasonal rainfall anomaly for Rayalaseema (RLSMA) subdivision

Source: website http://www.monsoondata.org

Figure 4.9: Time series of seasonal rainfall anomaly for Kerala (KERLA) subdivision

Source: website http://www.monsoondata.org
4.3. **Effect of monsoon on Indian Economy**

The monsoon accounts for 80 per cent of the rainfall in India. Even if the monsoon is delayed by few days, it can have an adverse effect on the economy as it affects the GDP growth of agriculture, industry and as well service sector. In view of lesser agricultural output food inflation will increase. The agri export will come down and import has to be increased consequently the current account deficit will increase creating cascading effect on the secondary economic sectors and the overall economy. Monsoon is a key to determine agricultural output, inflation, consumer spending and overall economic growth.

4.3.1. **Monsoon effect on agriculture**

India, historically and primarily an agrarian economy, has recently seen the service sector overtaking the farm sector in terms of GDP contribution. However, even today agriculture sector contributes 14.5% of GDP and is the largest employer in the country with about 51% of people dependent on it for employment and livelihood and live in rural India. Since over half of these farmlands are rain-fed, Monsoon is critical to the food sufficiency and quality of life for the country. Despite progress in alternative forms of irrigation, agricultural dependency on monsoon is far from insignificant, even today. Therefore, the agricultural calendar of India is governed by Monsoon. Any fluctuations in the time distribution, spatial distribution or quantity of the monsoon rains may lead to conditions of floods or droughts causing the agricultural sector to adversely suffer. This has a cascading effect on the secondary economic sectors, the overall economy, food inflation and therefore the overall quality and cost of living for the general population in India.

With 75 per cent of Indians directly or indirectly dependent on agriculture, each and everyone in India looks forward to the monsoon season. Good rains will also boost the output of several commodities, reducing the burden on imports.

India is the second largest producer of rice and wheat in the world. These two crops are staple food of population of India and shortfall in crop has castrating effect in consumption and food industry. A good monsoon will boost the ailing agriculture
sector, resulting in bumper crops; bring down the prices of vegetables, cereals and essential commodities. It will remove the export ban on several commodities and reduce the country's dependence on imports.

As per IMD, South-West monsoon (Jun-Sept) accounts for 73% of the country’s rainfall. The North-East monsoon occurs on coastal areas of Peninsular India. This rainfall accounts for 13% of the rainfall. The broad distribution of Seasonal rainfall in India as per IMD is given in the Table 4.1.

<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
<th>% of Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Monsoon</td>
<td>March-May</td>
<td>10.40</td>
</tr>
<tr>
<td>Monsoon</td>
<td>Jun-Sept</td>
<td>73.40</td>
</tr>
<tr>
<td>Post-Monsoon</td>
<td>Oct-Dec</td>
<td>13.30</td>
</tr>
<tr>
<td>Winter rains</td>
<td>Jan-Feb</td>
<td>2.90</td>
</tr>
</tbody>
</table>

Source: Indian Meteorological Department, Government of India

4.3.2. Distribution of Rainfall in India

Although the monsoons affect most part of India, the amount of rainfall varies from heavy to scanty on different parts. There is great regional and temporal variation in the distribution of rainfall. Over 73% of the annual rainfall is received in the four rainy months of June to September. The average annual rainfall is about 125 cm, but it has great spatial variations.

a. Areas of Heavy Rainfall (Over 200cm):
   The highest rainfall occurs in west coast, on the Western Ghats as well as the Sub-Himalayan areas in North East and Meghalaya Hills, Assam, West Bengal, West Coast and Southern slopes of eastern Himalayas.

b. Areas of Moderately Heavy Rainfall (100-200 cm):
   This rainfall occurs in Southern Parts of Gujarat, East Tamil Nadu, North-eastern Peninsular, Western Ghats, eastern Maharashtra, Madhya Pradesh, Orissa, the middle Ganga valley.

c. Areas of Less Rainfall (50-100 cm):
This less rainfall occurs in Upper Ganga valley, eastern Rajasthan, Punjab, Southern Plateau of Karnataka, Andhra Pradesh and Tamil Nadu.

d. Areas of Scanty Rainfall (Less than 50 cm):

This Scanty rainfall occurs in Northern part of Kashmir, Western Rajasthan, Punjab and Deccan Plateau.

The significant features of India's rainfall is that in the north India, rainfall decreases westwards and in Peninsular India, except Tamil Nadu, it decreases eastward.

**Table 4.2: Distribution of crop area in various ranges of rainfall**

<table>
<thead>
<tr>
<th>Rainfall range</th>
<th>Classification</th>
<th>% distribution of crop area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 750 mm</td>
<td>Low rainfall</td>
<td>33</td>
</tr>
<tr>
<td>750 mm-1124 mm</td>
<td>Medium rainfall</td>
<td>35</td>
</tr>
<tr>
<td>1125mm-2000mm</td>
<td>High rainfall</td>
<td>24</td>
</tr>
<tr>
<td>More than 2000mm</td>
<td>Very high rainfall</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture, Government of India

The cropped area falling under various ranges of rainfall is shown in the Table 4.2. An overwhelming majority of cropped area (around 68%) falls within medium to low rainfall range. Thus, large areas are affected by the monsoon outcome. A Table depicting the deficient rainfall effect on Kharif crop output during draught years is given below (Table 4.3).

**Table 4.3: Deficient rainfall effect on Khariff crop during draught years**

<table>
<thead>
<tr>
<th>Deficient rainfall years</th>
<th>Monsoon rainfall (% departure from normal)</th>
<th>Rainfall in July (% drop)</th>
<th>Kharif crop production (% decline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972-73</td>
<td>-24</td>
<td>-31</td>
<td>-6.9</td>
</tr>
<tr>
<td>1975-76</td>
<td>-12</td>
<td>-4</td>
<td>-12.9</td>
</tr>
<tr>
<td>1979-80</td>
<td>-19</td>
<td>-16</td>
<td>-19.0</td>
</tr>
<tr>
<td>1982-83</td>
<td>-14</td>
<td>-23</td>
<td>-11.9</td>
</tr>
<tr>
<td>1986-87</td>
<td>-13</td>
<td>-14</td>
<td>-5.9</td>
</tr>
<tr>
<td>1987-88</td>
<td>-19</td>
<td>-29</td>
<td>-7.0</td>
</tr>
<tr>
<td>2002-03</td>
<td>-19</td>
<td>-49</td>
<td>-19.1</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture, Ministry of Finance, Economic Survey 2002-03, Government of India
4.3.3. Monsoon effect on other sectors

- Economic Sector
The economic significance of monsoon can be aptly summed up by former Finance minister Sri Pranab Mukherjee's statement that “monsoon is the real finance minister of India”. A good monsoon resulting in improved agriculture and brings down prices of essential food commodities and reduces their imports overall reducing the food inflation. Further improved rains result in increased hydroelectric production. All these factors initiate positive ripple effects throughout the economy of India.

- Social sector
Sri Subbarao (then, Governor of Reserve Bank of India), during a quarterly review of the monetary policy, highlighted that lives of Indians depends on the performance of Monsoon. His own personal career prospects, emotional well being and the performance of his monetary policy were all a hostage to monsoon like it was for most Indians.

Farmers, rendered jobless due to failed Monsoon rains tend to migrate towards cities. This results in crowding of the city slums and further aggravates the job, infrastructure and sustainability of city life. Such is the magnitude of effect that monsoon casts on the lives of Indians.

- Environment
The Monsoon is the primary source of fresh water to bodies of water in the area. The Peninsular/Deccan Rivers of India are mostly rain-fed and non-perennial in nature depending primarily on the Monsoon for water supply. Similarly, most of the coastal rivers of Western India are rain-fed and Monsoon dependent. As such, obviously the flora, fauna and the entire ecosystem of these areas are heavily dependent on the Monsoon. It has both positive and negative effects also.

The summer monsoons roar onto the subcontinent from the southwest. The winds carry moisture from the Indian Ocean and bring heavy rains from June to September. The torrential rainstorms often cause violent landslides. Entire villages have been swept away during monsoon rains. Despite the potential for destruction,
the summer monsoons are welcomed in India. Farmers depend on the rains to irrigate their land. Additionally, a great deal of India’s electricity is generated by water power provided by the monsoon rains.

Meteorological data compiled over the past century suggests that the earth is warming. In keeping with this, for India as a whole mean annual temperature shows a significant warming trend of 0.51 degrees Celsius per 100 years during the period 1901-2007 (Kothawale et al., 2010). Similarly, global projections of temperature and for precipitation augur a warmer and wetter world. Simulations with regional climate models project similar trends for both variables for India—by 2030’s annual mean temperatures and summer monsoon rainfall are both expected to increase on average.

- **Energy**

A fall in rainfall leads to shortage of water supply for production of power and electricity. Electricity shortage has an adverse effect on all sectors of the economy. A rise in rainfall can bring power to thousands of households and small factories across India. The effect of insufficient monsoon rains is likely to create power outages. The Electricity demand will also be higher because due to insufficient rains summer heat of May and June will be higher and the demand from air conditioners and cooling systems stays high. Currently, about 26 percent of installed power generation capacity in India is based on hydropower. The limited addition, fall in hydropower generation in south India and higher demand for electricity in summer have resulted in a severe power crisis. The monsoon rains are thus vital for hydropower generation across the country.

As of April 2008, the total installed power generation capacity of the country stood at 0.143 million mega-watts. India’s power sector suffers from capacity shortages, frequent power failures, poor reliability and deteriorating physical and financial conditions. As a public policy, the government is encouraging environment-friendly sources like hydro and wind energy. Weather factors like rainfall, snowfall and wind speed will play a critical role in power generation through these sources.
- **FMCG Sector**
  Most of the FMCG companies depend on the rural market as villagers account for two-thirds of India's booming population. A poor monsoon impacts consumer companies in two ways, a demand squeeze, especially in rural areas, and high input cost. The impact could be significant on these companies’ financials, as well as stock prices. Rural sales, which form 40-50 per cent of most of FMCG companies’, will be hit due to the reduced purchasing power of consumers. FMCG stocks will under-perform in years of poor monsoon.

- **Banks**
  The performance of banks will be affected as public sector banks will be compelled by the government to support the farmers in the rain-deficit areas with concessional assistance, this will further affect their performance as already they are facing the heat on advances to the farm sector. Deteriorating asset quality and rising NPA will further worsen by the increase in lending to the drought hit farm sector.

- **Rural Consumption**
  Rural consumption is likely to slump due to low purchasing power with the consumers as rural income depends on the agriculture and allied sectors. The automobile, textile, Consumer durables, FMCG products sales will be lower due to low off take. Banks will restrict lending to the rural customers which again has cascading effect for the economy.

- **Effect of government action on economy due to monsoon deficiency**
  Fiscal, administrative and trade policy tools are usually the first line of defense in tackling a drought-like situation. Authorities may monitor local shortages more strictly and crack down on hoarding, since the gap between wholesale and retail prices will be wide. The government can also reduce import duties and ban exports, impose stock limits on commodity traders, and impose margins on, or ban, futures trading if prices rise too Sharply. Such government policy will have different impact on the economic sectors.
4.3.4. Monsoon effect on Stock market

During a normal monsoon, agro raw materials for the industry will be available for cheaper rate and beneficial for agro industry. A good monsoon increases their purchasing power whereas a drought can lead poor income and an additional burden on the government coffers with an increase in subsidies for the poor. FMCGs, automobile, textile industry revenue will be affected due to poor monsoon.

The behaviour of BSE for the last 12 years (2001-2013) published in “Business Line” is given in the Table (4.4), which surprises general perception about Sensex movement correlating to rainfall.

**Table 4.4: Monsoon and the Indian Stock market**

<table>
<thead>
<tr>
<th>Year</th>
<th>Monsoon</th>
<th>Sensex Change in %*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>Below Normal</td>
<td>-4.48</td>
</tr>
<tr>
<td>2002-03</td>
<td>Drought</td>
<td>-2.46</td>
</tr>
<tr>
<td>2003-04</td>
<td>Near Normal</td>
<td>75.76</td>
</tr>
<tr>
<td>2004-05</td>
<td>Drought</td>
<td>36.41</td>
</tr>
<tr>
<td>2005-06</td>
<td>Near Normal</td>
<td>67.98</td>
</tr>
<tr>
<td>2006-07</td>
<td>Near Normal</td>
<td>25.71</td>
</tr>
<tr>
<td>2007-08</td>
<td>Above Normal</td>
<td>7.56</td>
</tr>
<tr>
<td>2008-09</td>
<td>Near Normal</td>
<td>-40.86</td>
</tr>
<tr>
<td>2009-10</td>
<td>Drought</td>
<td>19.85</td>
</tr>
<tr>
<td>2010-11</td>
<td>Near Normal</td>
<td>14.76</td>
</tr>
<tr>
<td>2011-12</td>
<td>Near Normal</td>
<td>-5.94</td>
</tr>
<tr>
<td>2012-13</td>
<td>Below Normal</td>
<td>16.14</td>
</tr>
</tbody>
</table>

*Between Jun 1 - March 31  
(Source: Badrinarayanan, Business Line)

There is a widespread perception that a deficit monsoon will impact the economic activity and result in a slowdown of the economy. A weak economy in turn will impact the stock markets directly. On the other hand, normal and timely rainfall will increase agriculture productivity which will check inflation. This will also leads a higher disposable income at the hands of the rural folk.

However, equity markets do not always move in tandem with the weather. An analysis of monsoon data between 2001 and 2013, suggests a limited correlation
between monsoon and Sensex. The country faced monsoon deficit in 2009-10 of 25%, but Sensex posted almost 20% gains. Monsoon was normal in 2008-09, but global slowdown impacted Indian markets too, the Sensex slumped by 41%.

However as the monsoon accounts for 80 per cent of the rainfall in India, even if the monsoon is delayed by few days, it can have an adverse effect on the economy as about half of India's farm output comes from crops sown during the June-September rainy season. Monsoon is a key to determine agricultural output, inflation, consumer spending and overall economic growth.

While a normal rainfall signals growth and prosperity, a below normal rainfall could spell disaster making food more expensive, aggravating the power, water shortage, hitting industrial production which in turn will put more pressure on the government's kitty. A good monsoon will boost the ailing agriculture sector, resulting in bumper crop, bring down the prices of vegetables, cereals and essential commodities. It will remove the export ban on several commodities and reduce the country's dependence on imports. Good rains will boost the output of several commodities, reducing the burden on imports. A good monsoon increases their purchasing power whereas a drought can lead poor income and an additional burden on the government coffers with an increase in subsidies for the poor.

As for investors, a normal monsoon can positively impact the stock markets too. It will boost hydroelectric industries and improve the power situation. Raw materials for the industry will get cheaper. Monsoons thus act as an economic lifeline for India.

Debroy and Srinivas (2012) deals with the prediction of rainfall by IMD, as IMD forecast can go wrong and hence the unpredictability of Monsoon is high. What is the risk to the economy due to failure of monsoon? Agriculture’s direct share in GDP is down to 17%, though 50% of work force is employed in agriculture. Only 55% of agriculture area is irrigated. Aggregate levels of rainfall are misleading, what matters is its temporal and spatial spread, sequence
of rains. Due to deficit rainfall 0.25% GDP may be affected. The South-West Monsoon is erratic in one out of four years. With wide variations in agro-climatic zones, drought is guaranteed somewhere in the country each year, affecting about 50 Mn people. Changing weather pattern have accelerated drought attacks. There were six droughts between 1900 and 1950 and twelve in the following fifty years and already faced three droughts between 2000 and 2009. But reports need not to worry due to following reasons.

- Country had learnt to manage: After 2002-03 drought, the government developed a standard operating procedure to tackle water shortage for humans, cattle and crops, rescheduling farm loans, creating more jobs, hike in food allocation etc
- Ample food availability: Government is holding enough Rice, wheat more, import of pulses and edible oil. But consumer may have to pay more for vegetable, milk and meat
- Better technology for the help of farmers: Agro–metrological advisory services for weather, soil, pest and disease information in 550 districts, Resource conservation technology for rice intensification, drip irrigation, going for short duration and drought resistant crops etc
- Off farm income: Alternative nonfarm jobs, rising commodity price compensate for smaller harvest
- Resilient system: Even if normally drought prone Maharashtra, Andhra Pradesh and Karnataka take a hit, the eastern states like Bihar, West Bengal and Orissa are better equipped to pick up the slack.

In the sixties, over 2/3rd food output came from Kharif (South-west Monsoon rain), in recent past both Kharif and Rabi have contributed in equal parts. Rice, coarse cereal, tur and ground nut are main Kharif crops, while wheat, gram and sun flower are Rabi crops. A bad monsoon doesn’t equally impact all food and non food crops, making country’s overall agriculture output fairly resilient to the monsoon performance.
However, India Inc’s fortunes have been inextricably linked to monsoon rains. A good year means more money in the hands of rural consumer to spend. For corporate India, this has grown on consumption theme during the last couple of years, mainly in rural and semi-urban markets, monsoon has great implications. Weak and inadequate rainfall eat into rural income of many companies in the sectors such as fertilizer, seeds, agrochemicals, automobiles, consumer goods and finance and can have a ripple effect on the economy.

Even though a country can able to manage drought year it certainly affects the economy, GDP, farmer income, rural economy, inflation etc and hence there is need to de-risk the rainfall deficiency.

4.4. Weather Insurance in India

Since independence, policy makers in India have understood the importance of providing agriculture insurance to the majority of the Indian population whose livelihood is directly or indirectly dependent on agriculture or allied sectors. With the General Insurance Corporation of India (GIC) making pioneering efforts, crop insurance products have ranged from individual claim assessment products, area-yield index insurance covers to the recent weather-indexed products. The Agriculture Insurance Company of India (AIC) took over the role as the implementing agency from the General Insurance Corporation. AIC was granted “the overriding authority and overall responsibility in the operation of the public agriculture insurance schemes in India” (Sinha, 2007).

Following the causality demonstrated between revenue losses in agriculture and weather in India, a greater interest in developing weather-indexed insurance products resulted. Weather-index contracts make payments if the cumulative rainfall during the season falls below (or above) the historical average. The rainfall insurance is then a put (call) option on this index with a strike price and premium amount. This is a viable alternative to the traditional crop insurance market and has the potential to extend beyond the farming sector into the corporate end-user market. The key to unlocking such markets lies in developing an appropriate index.
In 2003 an attempt was made to offer insurance products in which payouts are based on a rainfall index, with a pilot scheme launched in Mehboobnagar district, Andhra Pradesh, by the private general insurer ICICI Lombard General Insurance Company and BASIX, a microfinance institution. Following this pilot, three risk carriers, ICICI Lombard General Insurance Company, IFFCO Tokio General Insurance Company and Agricultural Insurance Company of India (AIC), stepped in and started to offer weather products commercially. End-users who purchase weather insurance include farmers, corporations engaged in contract farming, tea, coffee and sugar producers, wind farms, salt producers and bio-diesel plantations.

3Surjit and Jogi (2011) made an effort to bring out the reasons for not succeeding Weather Insurance Schemes in Rajasthan in terms of coverage.

- Limited knowledge with farmers about how the scheme functions. There is hardly any effort in terms of extension to build awareness. There are different signals given by various players in the field. Payout is a major issue that takes away farmers.
- Farmers do bear basis risk due mainly to the distance between his plots and the reference weather station.
- Follow up of crop failure is not prompt. Farmers expects visit from the field staff, which are rare. Farmers are not made to understand the relation between their crop loans and crop insurance.
- Database is still weak. Weather indexed insurance requires information on temperature and rainfall closer to farmers.
- Investment in rain gauge stations should of outmost importance.
- Insurance companies need to understand that farmer’s perceptions and expectations may not coincide with the historical data, which as stated is lacking in India.

4.4.1. How is weather insurance different from conventional crop insurance in India?

Conventional crop insurance provides coverage by assessing losses that have resulted from named peril events as specified by the policy. This requires insurance
companies to use loss assessors to determine the magnitude and value of losses. India's primary conventional weather insurance program is the National Agricultural Insurance Scheme (NAIS). It is an area-yield based Multi-Peril Crop Insurance (MPCI) scheme administered by the public insurance company AIC (Agricultural Insurance Company of India Ltd.). NAIS is the largest crop insurance program in the world.

Payouts in conventional crop insurance are based on actual yield losses to risks covered under the scheme. The loss is determined by comparing the yield with historical crop yield in the area. The risks covered in India are natural fires and lightning, storms, hailstorms, cyclones, floods, landslides, droughts, etc. Accurate crop yield data is central to effectiveness.

Index-based weather insurance products are contingent claims contracts for which payouts are determined by an objective weather parameter (such as rainfall, temperature, or soil moisture) that is highly correlated with farm-level yields or revenue outcomes. Rainfall can be used as a good proxy for the actual losses incurred by farmers when rainfall patterns at the local weather station are similar to the farm-level yield patterns. In other areas, farm incomes can be indexed to temperature indicators for production sensitive to heat or frost, such as horticulture. The underlying index used for an index insurance product must be correlated with yield or revenue outcomes for farms across a large geographic area.

Weather insurance, uses an index derived from the correlation of historical yield data and weather events. The correlation demonstrates how the weather variables have or have not influenced yield over time.

The properties for a suitable index are that the random variable being measured is: (1) observable and easily measured; (2) objective; (3) transparent; (4) independently verifiable; (5) able to be reported in a timely manner; and (6) stable and sustainable over time with good historical data.
One of the key disadvantages of index-based insurance is the higher probability of basis risk, i.e., the potential mismatch between actual losses and payouts. However, basis risk is also a consideration for area-yield based programs, such as the NAIS, for the individual farmer. In India index-based insurance is being offered through a number of private companies including MFIs, insurers, NGOs, and has recently been offered by AICI also.

4.4.2. Weather Index Insurance

In recent years, researchers and development organizations have been exploring the potential for using weather index insurance to provide risk management opportunities for the rural poor. Weather index insurance pays indemnities based not on actual losses experienced by the policyholder but rather on realizations of a weather index that is highly correlated with actual losses. In its simplest form weather index measures a specific weather variable (e.g., rainfall or temperature) at a specific weather station over a defined period of time. Weather index insurance policies specify a threshold and a limit that establish the range of values over which indemnity payments will be made. If the insurance policy is protecting against unusually high realizations of the weather variable (e.g., excess rainfall or extremely hot temperatures), an indemnity is paid whenever the realized value of the index exceeds the threshold. The limit is set higher than the threshold, and the indemnity increases as the realized value of the index approaches the limit. No additional indemnity is paid for realized values of the index that exceed the limit. Conversely, if the policy is protecting against unusually low realizations of the weather variable (e.g., drought or extremely cold temperatures) an indemnity is made whenever the realized value of the index is less than the threshold, and the limit is set lower than the threshold.

To illustrate how weather index insurance works, consider the following example of an index insurance policy that protects against insufficient rainfall over a three-month period, with rainfall being measured at a specific weather station. The threshold is set at 100 millimeters of rainfall and the limit at 50 millimeters. Assume the policyholder purchases $1,000 of insurance protection. If the realized rainfall at
the weather station is less than 100 mm, the policyholder will receive an indemnity equal to $20 for each mm less than 100 mm, up to a maximum of $1,000 for rainfall realizations of 50 mm or less. The indemnity does not depend on losses incurred by the policyholder but is based strictly on rainfall measured at the weather station. Relative to traditional insurance products

4.4.3. Advantages of weather Index Insurance

- The insurance contract is relatively straightforward, simplifying the sales process.
- Indemnities are paid based solely on the realized value of the underlying index. There is no need to estimate the actual loss experienced by the policyholder.
- Unlike traditional insurance products, there is no need to classify individual policyholders according to their risk exposure.
- There is little reason to believe that the policyholder has better information than the insurer about the underlying index. Thus, there is little potential for adverse selection. Also, there is little potential for ex-ante moral hazard since the policyholder cannot influence the realization of the underlying weather index.
- Operating costs are low relative to traditional insurance products due to the simplicity of sales and loss adjustment; the fact that policyholders do not have to be classified according to their risk exposure; and the lack of asymmetric information. However, start-up costs can be quite significant. Reliable weather and agricultural production data and highly skilled agro-meteorological expertise are all critical for the successful design and pricing of weather index insurance products.
- Since no farm-level risk assessment or loss adjustment is required, the insurance products can be sold and serviced by insurance companies that do not have extensive agricultural expertise.

An important limitation of index insurance is that policyholders are exposed to basis risk. In this context basis risk refers to the imperfect correlation between the index
and the losses experienced by the policyholder. It is possible for the policyholder to experience a loss and yet receive no index insurance indemnity. Likewise, it is possible for the policyholder to receive an index insurance indemnity and experience no loss. There are two potential sources of basis risk. First, losses may be caused by disease, insect infestation, or any number of factors other than the weather variable on which the index is based. Unless the index is based on a weather variable that is the dominant cause of loss in the region, basis risk will be unacceptably high. Second, the weather variable used to drive the index may not be highly spatially covariate. Thus, the measure of the weather variable at the farm or household may be quite different than the measure at the weather station. Basis risk can be reduced by offering weather index insurance only in areas where a particular, highly covariate weather variable (e.g., drought or extreme temperatures) is the dominant cause of loss.

4.4.4. Requirements for Weather Index Insurance

While the basic concept is simple, effective implementation of weather index insurance is not at all simple. The continuing availability of accurate historical weather data is critical (Barnett and Mahul 2007). It is also necessary to determine whether any of the available weather variables are in fact highly correlated with realized losses and if so, the time periods in which losses are most likely to occur.

4.4.5. Modeling Rainfall

Precipitation has been a subject of intensive research for more than twenty years. Several types of models have been developed: meteorological models which seek to capture the dynamics of the large scale atmospheric processes controlling precipitation, multi-scale models which use multifractal cascades to describe rainfall statistical models which use purely statistical techniques to fit the rainfall data to well known distribution types with little emphasis on underlying physical processes and last stochastic processes based models which try to describe the rainfall behavior by a small set of physically meaningful parameters driving a stochastic process. Pavel (2003) proposed a model that falls in the last category but includes ideas from statistical models too.
All models strive for two goals, physical realism and mathematical tractability. The model of Pavel (2003) preserves the physical intuition of stochastic-process models while improving the mathematical tractability to the level of statistical models.

A low index of rainfall would be beneficial to the following industries:

- Insurance industry, in relation to rain-related claims such as property flood claims and motor accidents
- Recreation/Tourism industries, especially for outdoor events and tourism, because they will generally receive higher trades in dryer conditions
- Retail industry, especially clothing and gardening
- Construction industry is usually delayed by high levels of rainfall
- Airline industry is significantly affected by rainfall. One estimate states that when precipitation exceeds 0.025 inches at the destination airport, delays are more than doubled.

On the opposite side of the scale, a high index of rainfall would be beneficial to the following industries:

- Insurance industry, if during summer months, because could reduce risk of subsidence for the following year
- Industries utilising water
- Indoor recreation/tourism facilities, such as Center-Parks, etc.
- Energy industry (especially if heavily dependent on hydro-electrical power stations)
- Again, agriculture is often somewhere in the middle of the scale, but this depends on the exact type of crop being grown. One example often given is barley – which is damaged by excessive levels of rainfall at harvest time.

4.5. Risk mitigation for Agricultural Sector

There are two dominant types of crop insurance: 1) Peril, and 2) Multiple Peril. Peril insurance involves assessing losses based upon a specific risk or peril. By contrast, multiple peril crop insurance, which covers losses due to any of a large
number of risks, has rarely been offered without government subsidies. Implementation of multiple peril crop insurance becomes increasingly complex. If one is insuring for multiple perils, it is nearly impossible to first identify the “set of events” that may have created the losses and then perform a loss assessment that attempts to separate the actual loss by event. If there is crop loss, there is no clear way to tell if the loss is due to a weather event or to management practices. In North America, the “average” yield is estimated using individual farm records. If the yield is below a certain percentage of the “average” yield, a payment is made.

To provide weather insurance such as multiple peril crop insurance based on losses of individuals, an insurer must know a great deal about the individual who is being insured. There is almost always an imbalance of information. This asymmetric information creates the twin problems of adverse selection and moral hazard.

The costs that must be considered when establishing premiums for weather insurance such as multiple peril crop insurance are as below:

**Price of insurance** = Cost of the pure risk + Cost of information to control adverse selection + Cost of monitoring to control moral hazard + Cost of loss adjustment + Cost of delivery + Cost of ambiguity of risk + Cost of ready access to capital to pay for all losses

Most of the costs stated above do not vary greatly with the size of the insurance policy. Thus, for small insurance policies, such as one would expect with rural households in lower-income countries, these costs are quite large relative to the amount insured. The problem of small units makes it almost impossible for insurers to offer traditional agricultural insurance in lower-income countries that are dominated by large numbers of small farms. Due to the structure of agriculture in lower-income countries, commercial insurers may feel that the investment to develop and administer an insurance product will be higher than the potential income from a relatively small market volume and the costs associated with administering the product. So the cost of insurance is very high and applicable to country like India.
Most crop insurance has involved heavy subsidies to mitigate the expense of the premiums. For example, both the United States and Canada have three forms of subsidy: 1) a direct premium subsidy, 2) subsidy in the delivery costs, and 3) some form of government sharing for the most catastrophic risk. The world experience with multiple peril crop insurance has been particularly troublesome: the amount paid by the farmer is typically a fraction of the total cost of delivery and underwriting this form of insurance. However, because of poor actuarial performance—indemnities exceeding premiums—there have been unintended subsidies. Poor actuarial performance will most certainly accompany multiple peril crop insurance programs that do not invest significantly in trying to control adverse selection and moral hazard.

No country can afford to implement a crop insurance program fraught with problems that result in extremely poor actuarial performance. Furthermore, when there are large numbers of households that operate small units, it is increasingly expensive to control the adverse selection and moral hazard that lead to poor actuarial performance. Clearly, the focus must be on how to make weather insurance more affordable for lower-income countries.

Given that lower-income countries can ill afford to follow the path of higher-income countries in providing subsidies for weather insurance such as multiple peril crop insurance programs, it is important to develop new approaches that focus on lowering many of the cost items. In this regards index insurance is designed for that explicit purpose.

4.6. Present status of Agricultural Insurance in India

Agriculture accounts for around 14.5% of India’s gross domestic product. An estimated 65% of the population is engaged in agriculture and associated activities. Most of the agricultural production is small-scale. Of the more than 120 million landowners, 80% own parcels of less than 2 hectares. Weather risk is a major concern to agricultural producers and agribusinesses alike. It is estimated that rainfall variability accounts for more than 50% of the variability in crop yields.
Weather index insurance was first introduced in India in 2003. In collaboration with the microfinance institution BASIX, ICICI Lombard General Insurance Company began selling a rainfall index insurance product. BASIX holds no risk on the insurance policies but instead acts as an intermediary that receives commissions from selling the index insurance to its customers. Between June 2003 and March 2006, BASIX sold a total of 7,653 rainfall index insurance policies in six Indian states.

The parastatal agriculture insurance company AICI introduced a weather index insurance product in 2004. In 2005–06, AICI sold weather index insurance policies to more than 125,000 farmers. Most (98%) were sold to farmers in the State of Maharashtra. The World Bank has provided technical assistance to the Government of India and AICI in the development of weather index insurance. This assistance has focused on product design, rating, and large scale implementation.

There was an existence of risk management tools in terms of usage by farmers but was restricted to rich farmers own initiative signifying deficient role of government. The agricultural loans continue to be risky and agricultural lenders are increasingly emphasizing about credit quality and management of credit risk in their loan portfolios. Even the only practical and widely available option crop insurance has not proved to be a successful solution of the problem.

Crop insurance in India remained restricted to few crops in spite of India being an agrarian economy and accounts for less than 2 percent of income generated from agriculture in a year even after 25 years since the inception of agricultural insurance in India. A large part of the insurance, which is about 82 percent of the sum insured, occurs in the critical monsoon dependent khariff season (during which rice is the major crop). Most of the crop insurance schemes like Pilot Crop Insurance Scheme, Comprehensive Crop Insurance Scheme, Experimental Crop Insurance Scheme and National Agricultural Insurance Scheme have failed for one reason or another. The poor financial performance of these schemes is due to their utter failure in correctly estimating the probability of the risk covered, the total claims paid being
substantially in excess of the premium amount collected. Thus, the crop insurance schemes launched so far have failed to provide a sustainable solution to the risk-hedging problem in the Indian agriculture. There was also lack of Participation of private Players in agriculture insurance

4.7. Rainfall Insurance

The Indian exposure towards agricultural risk was assessed in a national survey carried out in 1991. One sixth rural households had loans from rural financial institutions as to finance their agricultural activities, but only 35% of the actual credit needs were met through these channels. The World Bank estimated then that moneylenders, the reduction in farming inputs, overcapitalization and over diversification of the activities have all led to a suboptimal asset allocation for Indian farmers. The challenge was therefore to innovate and find low-cost ways to reach farmers and help them to better manage their risk.

The arrival of rainfall insurance in India was spurred by two events. India has dramatically liberalized financial markets in the past decade, and in particular allowed new entrants into the field. Insurance companies, however, face a requirement to generate a certain share of revenue from rural areas. This has led to development in micro insurance, with companies offering health, life, property, and livestock insurance. Around the turn of the century, the International Task Force on Commodity Risk Management in Developing Countries conceived, and began to work out, the technical details for offering rainfall insurance.

The idea is relatively simple: an insurance contract agrees on a pre-specified amount of rainfall, usually the minimum needed to ensure successful growth of a given crop. If, during the growing season (which is also pre-specified), rainfall falls below a pre-specified threshold, the policy holder is eligible to receive a payment. The payment typically increases with the amount of the rainfall deficit, with a maximum payout at a threshold below which total crop failure are likely.

The World Bank / Commodity Risk Management Group first implemented rainfall insurance in the state of Andhra Pradesh, in India, in cooperation with BASIX, a
microfinance corporation, and ICICI Lombard, a private insurance company (see Hess, 2003). Within several years, sales had grown to tens of thousands policies, and at least one other private insurer entered the market.

Before discussing the advantages and limitations of rainfall insurance, it is useful to fix ideas. Two products, the first provided by ICICI, and sold by SEWA in 2006, the second provided by IFFCO-Tokio, and sold by SEWA in 2007 are brought here.

4.7.1. ICICI Lombard’s Product

The first year, 2003, was a pilot year, and the program was only targeting groundnut and castor farmers in the Andhra-Pradesh district of Mahbubnagar. The design of the insurance scheme was made by ICICI Lombard, with the technical support of the CRMG and the consultation of BASIX, the objective being to protect the farmers from drought during the groundnut and castor growing season, which corresponds to Khariff (the monsoon season, between June and September). The entire portfolio sold by BASIX was insured by ICICI Lombard with a reinsurance contract from Swiss Re. The marketing and sales were made in 4 villages selected by a local bank, according to their current involvement in microfinance. Workshops and presentation meetings were arranged by BASIX. 230 farmers (154 producers of groundnut and 76 of castor) bought insurance against drought during Khariff, and most of them were considered as small farmers, with less than 2.5 acres of land. The insurance contract bought by the farmers had only the name of insurance. It was indeed a financial derivative based upon a reference weather index. The index based upon rainfall has been carefully established by farmers and biologists as to represent the real impact of rain on the growth of either the groundnut or the castor (two indices were considered depending on the crop). The different stages of the growth were also taken into account by weighting differently the different sub periods of the considered season. If the rainfall was not sufficient, then the contracts would be automatically triggered, and the farmers would automatically receive their compensation. Because of this triggering mechanism, the costs of the overall scheme are lower than those of a traditional insurance programme, and the
compensation received promptly by the farmers, helping them to survive until the next season.

4.7.1.1. Payout structure

Different payoffs were considered depending on the size of the land, as to take into account scale effect. The year 2004 witnessed an extension of the first experience to 4 new weather stations in Khamman and Antapur, in Andhra-Pradesh. Existing contracts were slightly modified, following the feedback of farmers who bought them in 2003. In particular, more weight was put on the initial sowing period of groundnut in the computation of the rainfall index. New contracts were created for cotton farmers, targeting excess rainfall this time. 400 farmers bought these contracts from BASIX and 320 bought them directly from the insurance company ICICI Lombard, which did not buy reinsurance this time.

Further improvements were made in the third phase of the project in 2005: a total of 7685 contracts were sold by BASIX, through the microfinance channel, but more generally more than 250000 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. A long term question is certainly the study of the impact of these policies on the farmers’ behavior.

The product design was divided into three separate phases: the first two case of rainfall deficit, while the third in case of excess rainfall. The amount of payout is determined as follows: In Phase I, if rainfall is above 100mm, no payout is made. For each mm of deficit below 100mm, the policy holder is paid Rs. 5 / mm of deficit. If total rainfall is below 10 mm, the policy-holder is paid a single payment of Rs. 500. In financial terms, the contract may be replicated by buying 5 puts on rainfall at a strike price of 100, selling 5 puts at a strike price of 10, and buying an option that pays Rs. 500 if rainfall falls below 10mm.
Table 4.5: Rainfall Policy, 2006

<table>
<thead>
<tr>
<th>Phase</th>
<th>I Phase</th>
<th>II Phase</th>
<th>III phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>Deficit</td>
<td>Deficit</td>
<td>Excess</td>
</tr>
<tr>
<td>Target (Strike)</td>
<td>100</td>
<td>65</td>
<td>550</td>
</tr>
<tr>
<td>Rs/mm over target</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Exit</td>
<td>10mm</td>
<td>5mm</td>
<td>650mm</td>
</tr>
<tr>
<td>Policy Limit</td>
<td>Rs 500</td>
<td>Rs 500</td>
<td>Rs 500</td>
</tr>
</tbody>
</table>

Phase II works similarly (though with different strike prices), while Phase III pays out only in the event that rainfall is above 550mm, with a maximum payout of Rs. 500, if rainfall is above 650 mm.

The start date of Phase I was dynamically determined, based on the first date in June in which cumulative rainfall exceeded 50mm. Farmers plant seeds only after the soil has received some moisture. If cumulative rainfall did not exceed 50 mm by June 1st, the first day of Phase I would be July 1st. Phases I and II last 35 days each, while Phase III lasts 40 days. Because the soil has only a limited capacity to absorb moisture, any rainfall occurring in Phase I or II that exceeded 50mm in a single day, would count as only 50mm. Similarly, any day with rainfall less than 2mm would count as zero, because such small amounts would not be absorbed in the soil.

4.7.2. IFFCO-Tokio Product

Based on feedback received from the marketing team and consumers, SEWA elected to go with a simpler policy for 2007. This policy sets a target amount of rainfall over a four-month period, and pays out according to a schedule, if the total cumulative rainfall falls short. The schedule is reproduced in Table 4.6.

Table 4.6: IFFCO-Tokio Product

<table>
<thead>
<tr>
<th>% Deficiency</th>
<th>Claim payout (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>60</td>
<td>35</td>
</tr>
<tr>
<td>70</td>
<td>45</td>
</tr>
<tr>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>
4.7.3. Rainfall Insurance Scheme for Coffee (RISC)

Since the coffee industry plays a significant role in the Indian economy in general and Karnataka in particular, its development and sustenance is quite essential. It is exposed to many risks, among them rainfall is a major risk. The adverse rainfall affects the coffee production/yield. It puts the coffee growers in debt cycle. So Agriculture Insurance Company introduced the Rainfall Insurance Scheme for coffee growers in the year 2007. It is a unique rainfall insurance product specially designed for the coffee growers of Karnataka, Kerala and Tamilnadu. This product is designed in consultation with Coffee Board, Central Coffee Research Institute and the Coffee Growers of these states. RISC is expected to provide effective risk management aid to those coffee growers likely to be impacted by adverse rainfall. The most important benefits of RISC are:

a) Trigger events like adverse rainfall can be independently verified and measured.

b) Parameters considered in designing this insurance product are relevant, appropriate and to a large extent captures the rainfall induced risks affecting Coffee production.

c) Allows for speedy settlement of indemnities, within 45 days after the indemnity period.

The policy compensates the insured, against the likelihood of diminished coffee output / yield resulting from shortfall / excess in the actual rainfall (as the case may be) for different coverage options within a specific geographical location and specified time period, subject to a maximum of the Sum Insured specified in the policy under each of the coverage options Period of Insurance.

4.8. Rainfall risk management

The rainfall is critical factor for rain fed agriculture and its allied sector. Weather risk is often correlated risk, many people in an area are affected by a single event and all are likely to suffer loss. In many cases, the more severe the event, the wider is the geographic impact. For example, drought or excess rainfall can create widespread damage across entire communities and regions. Such correlated weather
risk can be a major constraint to the development of the formal rural and agricultural financial markets because a widespread, severe weather event may result in excessive loan defaults across the affected area.

To access input loans, the farmers would need to pledge their assets as collateral to banks or microfinance institutions. Most of these farmers do not have such assets. The lack of collateral and their high dependence on rainfall make small holder farmers high risks and most banks do not lend loans to them.

The rainfall risk can be managed through Rainfall Insurance Scheme. The rainfall based insurance indices and options are suggested as a replacement for the expensive area yield programs (Veeramani et al. 2005). Weather index insurance is a relatively simple concept that, under certain circumstances, can effectively transfer spatially covariate weather risks (Barnett and Mahul, 2007). Index insurance is transparent, inexpensive to administer, enables quick payouts, and minimizes moral hazard and adverse selection problems associated with other risk coping mechanisms and insurance programs (Gine, 2007).

Pauline, and Scaillet, (2010), focuses on innovation in weather insurance designed to fit the special circumstances of lower-income countries where rural and agricultural financial markets are largely underdeveloped. Weather insurance is important to the long-term economic development of lower-income countries as a means of spurring rural finance and agricultural and rural development. Weather insurance can also help alleviate chronic poverty. The lack of access to weather insurance can cause rural and farm households in lower-income countries to consume their assets to survive an extreme weather event or their assets may be destroyed, throwing these households into a cycle of poverty with no means of recovery. To be clear, the lack of weather insurance may be only one of several constraints that are slowing progress in economic development and rural financial markets in lower-income countries.

Weather index insurance is insurance that is linked to a weather index such as rainfall, rather than a possible consequence of weather, such as crop failure. This
subtle distinction resolves a number of fundamental problems that make traditional insurance unworkable in rural parts of developing countries.

4.8.1. Rainfall Index Insurance

Given the problems with some traditional crop insurance programs in developed countries, finding new solutions to help mitigate several aspects of the problems outlined above has become critical. Index insurance products offer some potential in this regard (Skees et al. 1999). These contingent claims contracts are less susceptible to some of the problems that plague multiple-peril farm-level crop insurance products. With index insurance products, payments are based on an independent measure highly correlated with farm-level yield or revenue outcomes. Unlike traditional crop insurance that attempts to measure individual farm yields or revenues, index insurance makes use of variables exogenous to the individual policyholder—such as area-level yield or some objective weather event or measure such as temperature or rainfall—but have a strong correlation to farm-level losses.

For most insurance products, a precondition for insurability is that the loss for each exposure unit be uncorrelated. For index insurance, a precondition is that risk be spatially correlated. When yield losses are spatially correlated, index insurance contracts can be an effective alternative to traditional farm-level crop insurance.

4.8.2. Basic characteristics of an Index

The underlying index used for index insurance products must be correlated with yield or revenue outcomes for farms across a large geographic area. In addition, the index must satisfy a number of additional properties affecting the degree of confidence or trust that market participants have that the index is believable, reliable, and void of human manipulation; that is, the measurement risk for the index must be low. A suitable index required that the random variable measured meet the following criteria:

- Observable and easily measured;
- Objective;
- Transparent;
Independently verifiable;
Reportable in a timely manner and
Stable and sustainable over time.

Publicly available measures of weather variables generally satisfy these properties. For weather indexes, the units of measurement should convey meaningful information about the state of the weather variable during the contract period, and they are often shaped by the needs and conventions of market participants. Indexes are frequently cumulative measures of precipitation or temperature during a specified time. In some applications, average precipitation or temperature measures are used instead of cumulative measures. New innovations in technology, including the availability of low-cost weather monitoring stations that can be placed in many locations and sophisticated satellite imagery, will expand the number of areas in which weather variables can be measured as well as of the types of measurable variables. Measurement redundancy and automated instrument calibration further increase the credibility of an index. The terminology used to describe features of index insurance contracts resembles that used for futures and options contracts rather than for other insurance contracts. Rather than referring to the point at which payments begin as a trigger, for example, index contracts typically refer to it as a strike. They also pay in increments called ticks.

In this context, a contract being written to protect against deficient cumulative rainfall during a cropping season may be considered. The writer of the contract may choose to make a fixed payment for every one millimeter of rainfall below the strike. If an individual purchases a contract where the strike is one hundred millimeters of rain and the limit is fifty millimeters, the amount of payment for each tick would be a function of how much liability is purchased. There are fifty ticks between the one hundred millimeter strike and fifty millimeter limit. Thus, if Rs50,000 of liability were purchased, the payment for each one millimeter below one hundred millimeters would be equal to Rs50,000/(100 – 50), or Rs1,000. Once the tick and the payment for each tick are known, the indemnity payments are easy to calculate. A realized rainfall of ninety millimeters, for example, results in ten
payment ticks of Rs1,000 each, for an indemnity payment of Rs10,000. The payout structure for a hypothetical Rs50,000 rainfall contract with a strike of one hundred millimeters and a limit of fifty millimeters.

In developed countries, index contracts that protect against unfavorable weather events are now sufficiently well developed that some standardized contracts are traded in exchange markets. These exchange-traded contracts are used primarily by firms in the energy sector, although the range of weather phenomena that might potentially be insured using index contracts appears to be limited only by imagination and the ability to parameterize the event.

4.8.3. Advantages of Rainfall Index Insurance

One key advantage of rainfall index insurance is that the transaction costs are low. This makes it workable under real market conditions – both financially viable for private sector insurers and affordable to small farmers. Unlike traditional crop insurance against crop failure, the insurance company does not need to visit farmers’ fields, to determine premiums or to assess damages. Instead the insurance is designed around rainfall data (for example). If the rainfall amount is below the earlier agreed threshold, the insurance pays out. Since there is no need for the insurance company to corroborate actual losses, payouts can be made quickly and distress sales of assets avoided. This process also removes the ‘perverse incentives’ of crop insurance, where farmers may actually prefer their crops to fail so that they receive a payout. With index insurance, the payout is not linked to the crop survival or failure, so the farmer has the incentive to make the best decisions for crop survival.

Weather index insurance is one of a number of index-based financial risk transfer products that have the potential to help protect people and livelihoods against climate shocks and climate risk. Others include weather options, weather-linked bonds, weather derivatives, and bundled products such as insured credit. Indexes are not limited to rainfall but can also be constructed around other variables (streamflow, temperature, onset of rains, etc). The advantage of index insurance for lower-income countries is that it can be simpler and less costly to administer relative
to traditional forms of insurance. Index insurance can control some of the cost factors associated with weather insurance in the following ways:

- **Simpler information requirements**
  Because index insurance indemnity payments are not tied to actual losses incurred, there is no need to classify potential policyholders according to their risk exposure. As already discussed, this a significant informational constraint on traditional agricultural insurance. It is unlikely that the information required for traditional agricultural insurance will be readily available in a lower-income country, and it would require a great amount of effort to develop or obtain the information. However, in the case of index insurance based on rainfall, no household-level information is needed. The risk assessment uses historic rainfall data to evaluate the impact and frequency of insufficient rainfall.

- **No loss adjustment**
  One of the significant challenges for traditional insurance products is the high cost of loss adjustment. As discussed, under a traditional insurance policy, the insurer has to determine whether each individual household has suffered an insured loss and, if so, the extent of the loss. This can be extremely costly, particularly in remote, rural areas. In the case of index insurance, there is no need to conduct household-level loss adjustment. Indemnities are based solely on the realization of the underlying index relative to the pre-specified threshold.

- **Reduction of moral hazard**
  Because the indemnity does not depend on the individual’s actual losses, the policyholder cannot change his or her behavior to increase the likelihood of receiving a payment.

- **Reduction of adverse selection**
  Index insurance is based on widely available information, which reduces the opportunity that informational asymmetries can be exploited or that the most risky individuals will be the primary purchasers of the insurance.
- **Low administrative cost**
  Indemnity payments are based solely on the realized value of the underlying index as measured by government agencies or other third parties. Without the need for individual risk assessments or loss adjustment, the costs to the insurer can be significantly less, particularly for individuals with very small units.

- **Standardized and transparent structure**
  Index insurance contracts can have simple and uniform formats. Contracts do not need to be tailored to each policyholder and so, again, administrative costs are lower. Thus, index insurance contracts should be more easily understood by the insured than many forms of traditional insurance.

- **Reinsurance function**
  Since index insurance pays for large correlated losses, it can also be used to protect local insurers against large losses from correlated weather risks. As mentioned previously, the potential for large financial losses from correlated weather risk is an inhibiting factor to the development of insurance markets. Using index insurance as reinsurance—insurance on an insurance portfolio—would make it easier for local insurers to offer traditional farm-level agricultural insurance without the threat of large financial losses that could result from a natural disaster.

4.8.4. **Limitations of Index Insurance**

Index insurance addresses some of the factors that limit the development of traditional insurance in lower-income countries. However, it is not without its limitations. This highlights the importance of conducting a thorough feasibility study to determine if index insurance is appropriate. The sections on feasibility study, product design, and pilot development further discuss how to address these issues. Some of the challenges of index insurance are the following:

  a. **Basis risk**
  With an index insurance contract, there is basis risk, which is the chance that the indemnity payment a policyholder receives does not match the actual loss. The insured could suffer a loss and not receive any or enough indemnity to compensate
for the loss. It is also possible that an insured could receive an indemnity even when he/she has not suffered a loss. Too much basis risk will deter interest because individuals will feel that the index will not be representative of their loss experience and will therefore offer them poor protection against risk. While basis risk is an inherent problem with index insurance, basis risk can be minimized through product design and application.

b. Reliable and accessible data
For index insurance to be viable, it is critical that the underlying index is objectively and accurately measured. If data used for the index cannot be trusted or are not accurate, the system will fail. Making the data publicly available to both insurers and policyholders can help build confidence in the accuracy of the numbers. Whether provided by government or other third-party sources, index measurements must be widely disseminated and secure from tampering.

c. Education
Potential policyholders may have no previous experience with insurance or similar products. Educational initiatives are necessary to convey the concepts of index insurance and help users assess whether or not these instruments can provide them with effective risk management. Local insurers and government regulators are likely to require some education on index insurance.

d. Financing of large losses
In lower-income countries, local insurance companies typically do not have the financial resources to offer weather insurance without adequate and affordable reinsurance to protect against financial losses that could occur if many policyholders suffer losses from the same event. Effective financing arrangements must be made to ensure that some type of reinsurance is available for the insurer who offers index insurance, whether it is through international reinsurers, national or provincial governments, or international development organizations.
4.8.4.1. The trade-off between basis risk and transaction costs

Among the most significant issue for any insurance product is the question of the extent of monitoring and administration that is needed to keep moral hazard and adverse selection to a minimum. To accomplish this goal, coinsurance and deductibles are used so that the insured shares the risk and any mistakes in offering too generous coverage are mitigated. Considerable information is needed to tailor insurance products and to minimize the basis risk even for individual insurance contracts. Increased information gathering and monitoring involve higher transaction costs, which convert directly into the higher premiums needed to cover them. Index insurance significantly reduces these transaction costs and can be written with lower deductibles and without introducing coinsurance. When farm yields are highly correlated with the index being used to provide insurance, offering higher levels of protection can result in risk transfer superior even to individual multiple-peril crop insurance (Barnett, B.J., and Mahul, O., 2007).

The direct trade-off between basis risk and transaction costs has implications for achieving sustainable product designs and for outlining the role of governments and markets. These concepts also greatly depend on understanding the trade-off between basis risk and transaction costs. At every level of risk transfer, someone must accept a certain degree of basis risk if the products are to be both sustainable and affordable. In short, extremely high transaction costs must be paid for. The social cost of having products with some basis risk may be significantly lower than the social cost associated with the high transaction cost entailed in attempting to design products that have no basis risk.

4.8.4.2. Inappropriateness of Index Insurance

Index insurance contracts will not work well for all agricultural producers. Many agricultural commodities are grown in microclimates. For example, coffee grows on certain mountainsides in various continents and countries and fruits such as apples and cherries also commonly grow in areas with very large differences in weather patterns within only a few miles. In highly spatially heterogeneous production areas, basis risk will likely be so high as to make index insurance
problematic. Under these conditions, index insurance will work only if it is highly localized and/or can be written to protect only against the most extreme loss events. Even in these cases, it may be critical to tie index insurance to lending, since loans are one method of mitigating basis risk.

Over fitting the data is another concern with index insurance. If one has a limited amount of crop yield data, fitting the statistical relationship between the index and that limited data can become problematic. Small sample sizes and fitting regressions within the sample can lead to complex contract designs that may or may not be effective hedging mechanisms for individual farmers. Standard procedures that assume linear relationships between the index and realized farm-level losses may be inappropriate. While scientists are tempted to fit complex relationships to crop patterns, interviews with farmers may reveal more about the types of weather events of most concern. When designing a weather index contract, one may be tempted to focus on the relationship between weather events and a single crop. When it fails to rain for an extended period of time, however, many crops will be adversely affected. Likewise, when it rains for an extended period of time, resulting in significant cloud cover during critical photosynthesis periods, a number of crops may suffer.

Finally, when designing index insurance contracts, significant care must be taken to assure that the insured has no better information about the likelihood and magnitude of loss than does the insurer. Farmers’ weather forecasts are quite often highly accurate. Potato farmers in Peru, using celestial observations and other indicators in nature, are able to forecast El Niño at least as well as many climate experts. In 1988, an insurer offered drought insurance in the U.S. Midwest. As the sales closing date neared, the company noted that farmers were significantly increasing their purchases of these contracts. Rather than recognize that these farmers had already made a conditional forecast that the summer was going to be very dry, the company extended the sales closing date and sold even more rainfall insurance contracts. The company experienced very high losses and was unable to meet the full commitment of the contracts. Rainfall insurance for agriculture in the United States suffered a significant setback. The lesson learned is that when writing insurance based on
weather events, it is crucial to be diligent in following and understanding weather forecasts and any relevant information available to farmers. Farmers have a vested interest in understanding the weather and climate. Insurance providers who venture into weather index insurance must know at least as much as farmers do about conditional weather forecasts. If not, inter temporal adverse selection will render the index insurance product unsustainable. These issues can be addressed; typically, the sales closing date must be established in advance of any potential forecasting information that would change the probability of a loss beyond the norm. But beyond simply setting a sales closing date, the insurance provider must have the discipline and the systems in place to ensure that no policies are sold beyond that date.

4.9. Pricing precipitation derivatives
Pricing of precipitation derivatives poses a great challenge compared to the other types of weather derivatives let alone classical securities derivatives. Precipitation is most elusive one from the point of view of reliable statistical modeling. From the practical point of view precipitation can be quite a localized phenomenon. Theoretical difficulties lie in the fact that it is not easy to find a tractable mathematical model accurately representing the reality of the precipitation and intensive hydrological research has been conducted in this area for more than 40 years.

Currently, in developing countries weather derivatives are being considered as a means of risk management. Rainfall contracts have received significantly less focus, in terms of both the literature and the amount of trading activity, when compared to temperature based derivatives (Tindall, 2006). Primarily, this was due to the fact that the weather derivatives market was largely created from the needs of energy and utility companies whose major exposure was to temperature related weather variations. Adding to this, rainfall has proven significantly more difficult to model accurately, particularly where geographically small areas are concerned. This is primarily due to the discrete nature of rainfall; two geographically close recording
stations can produce widely different precipitation readings, something that is not encountered with temperature based statistics.

These difficulties manifest as geographical ‘basis’ risk in rainfall derivative contracts in that the situation of the risk must be relatively close to the measuring station for an effective hedge to be possible. This makes it increasingly hard to find the two (minimum) willing counterparties for the contract. Not only it is required to find someone who will be benefited and someone who will lose-out if rain fails but you also have to create an underlying rainfall index (i.e. weather station) that will protect both users. This has proven difficult to achieve in practice.

The fundamental problem of weather risk management whether in energy or agriculture industry is that of putting a price on the contracts whose payoffs depend on the evolution of some weather variable. Once a model for the precipitation has been established, the pricing problem arises: it is necessary to develop a pricing technique which can incorporate the precipitation. Since the inception of the classical Black-Scholes formula for pricing plain vanilla options, there has been constant improvement in approaches for pricing derivatives based on no-arbitrage arguments. The arbitrage pricing approach, however, only provides a unique price for the derivative in complete markets - in which the traded assets span all the sources of risk and the derivative securities are redundant. The traditional no-arbitrage pricing mechanisms used in financial derivatives pricing do not apply due to impossibility to buy and sell the weather variable - precipitation in our instance. Therefore alternative approaches need to be implemented. One of them, the utility indifference pricing seems to be particularly efficient (5Pavel, 2003)

4.10. Summary

The monsoon rainfall is critical for the development of economy of India. It is seen that monsoon effects on the performance of various economic sectors and stock market. The consistent rainfall without much variability is necessary for the agricultural sector but the distribution of rainfall and the deviation anomalies indicate the contrary. The traditional crop insurance has disadvantages and the
same are addressed in rainfall index insurance, but the limitations such as basis risk needs to be addressed. The modelling rainfall and pricing the rainfall derivatives are the challenging issues.

4.11. References


