

Crop Insurance in India: Evolution, Issues and Way Forward

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Received: 05 May 2020 Revised: and Accepted: 15 July 2020

ABSTRACT: Though India has achieved self-sufficiency in food grain production through the advancement of modern technologies the incomes of the farmers have not improved much and unstable because of natural catastrophes and price fluctuations. Farmers primarily face yield risk due to weather variability. The resource-poor farmers and landless agricultural laborers who have extremely limited means and resources are vulnerable in the absence of insurance mechanisms. Therefore, crop insurance is needed to address the issue of yield risk in the farm sector. The history of crop insurance in the pre-independence period goes back to the Dashuri tax introduced by the Mughal emperor Akbar. Few schemes were operated from 1920 to 1947 and were discontinued due to financial constraints. After independence, pilot crop insurance schemes were tried during 1972-78. Since then various schemes like Comprehensive Crop Insurance, Experimental Crop Insurance Scheme, Pilot Scheme on Seed Crop Insurance, National Agricultural Insurance Scheme, Weather-based Crop Insurance Scheme, Modified National Agricultural Insurance Scheme, Other crop-specific insurance schemes, National Crop Insurance Programme were tried till 2016. From 2016, the “Pradhan Mantri Fasal Bima Yojana” crop insurance scheme is in operation. This paper presents the evolution of crop insurance in India and the challenges encountered in each scheme from pre-independence times to the present day. Finally, based on the shortcomings reported and experiences learned, suggestions for effective implementation of the crop insurance schemes are presented.

KEYWORDS: Agricultural Insurance, Crop Insurance, India, Insurance, PMFBY, Risk in agriculture, Weather index insurance.

I. INTRODUCTION

Agriculture and allied sectors share 15.87% of the country's GDP in 2018-19 [1]. Its economic contribution was more than the world's average (6.4%) [2]. About 70 percent of its rural households depend on agriculture and allied sectors for their livelihood [3]. The World Bank report [4] reveals that there is a decreasing trend in employment in agriculture. In 2008 it was 53.1 percent and declined to 43.9 percent in 2018. In India, from 138 million operational farm-holdings in 2010-11, it increased to 146 million in 2015-16 *i.e.*, an increase of 5.33 percent [5]. Among the farming community in India, 82 percent are small and marginal farmers who possess less than two hectares (5 acres) of land [3]. Even though they are the majority, only 47.3 percent of the crop area is owned by them. There is a declining trend in the average landholding size from 1.15 hectares in 2010–11 to 1.08 hectares in 2015–16 [5].

Despite these, the food grain production in India was increased over the years and attained self-sufficiency through the adoption of modern scientific technologies. But, farming is subjected to natural calamities and price fluctuations as a result the situation of the farmers has not been improved and it remains unstable [6]. Frequent failure of crops, lack of remunerative prices for produce, and poor return on investment are the major problems in the agricultural sector [4].

The liberalization of economic policies after 1991 opened the economy to global market forces which encouraged the commercialization of agriculture. Commercialization leads to change in cultivation from staple crops to highly remunerative cash crops that made farming more capital intensive [7]. The report of All India Debt and Investment Survey (AIDIS) [8] revealed farmers are trapped in the debt compared to others not engaged in farming [9]. Farmers' suicide was reported as 39 percent in 2015. The main reason for farmers' suicide was indebtedness arises through increased cost of cultivation from commercial cropping to meet the market requirements due to globalization [10].

II. Need for Crop Insurance

Extreme temperature and rainfall shocks caused a decline in crop yield during both Kharif and Rabi seasons [9]. Climate change affects agricultural productivity [11]. Two types of risks are common in Indian agriculture [12] – yield risk (uncertainty of crop yield) due to weather variability [13; 12] and price risk. Even though farmers practice traditional risk management methods [14; 15; 16] by diversifying less risky and less profitable crops by The resource-poor farmers and landless agricultural laborers who have extremely limited means and resources [13] are vulnerable in the absence of insurance mechanisms [18; 19; 20; 21; 22; 23; 24]. The compensations in the form of relief packages given by the government during natural calamities suffered severe limitations [12]. Therefore, crop insurance is needed to address the issue of yield risk in the agricultural sector.

What is Crop Insurance?

Crop insurance is an arrangement of pooling risk based on the principle of 'large number'. The insurance company collects premiums from all policyholders and compensates for the persons who incurred loss [25]. Thus, the risk is managed in two ways. One through distributing across space that means the losses of farmers in one area is compensated by the farmers in other areas. Second, distributing across time by compensating with the reserves of the insurance company that are accumulated through premiums collected in normal years [26]. The corpus fund is created by the government and is supplemented by the insurer through the interest income accrued by investing the resources gainfully [25].

III. Benefits of crop insurance

The attitude of the farmer is changed when he insured the crop [27] and permits him to take risks in farming which he would not have taken if not insured [17] because taking risks affects capital investment in farming through allocating the resources sub-optimally [14]. Thus, access to formal insurance helps the farmers to protect the losses from risks, safeguard, and increase farm income [26].

The compensations received in case of crop failure help the farmer to pay the loans obtained through formal credit institutions in time. Thus, crop insurance increases the credit rating of the farmer by preventing him becomes a defaulter of loan [28; 29; 30]. Moral hazard incentives associated with insurance sometimes led insured farmers to use fewer chemical inputs [31], decrease nitrogen fertilizer applications [32], and influenced maize farmers' chemical use decisions [33]. Thus, a properly structured and executed crop insurance scheme avoids fluctuations and brings stability in the farm incomes [34] and bridges the gap between income and consumption requirements during periods of crop losses or crop failures [35].

IV. MATERIALS AND METHODS

The method of data collection entirely relies on secondary sources. It includes a wider range of subjects at various levels for its completeness and comprehensiveness. For this purpose, the relevant literature including past and recent were reviewed and organized thematically into the evolution of crop insurance and issues encountered in each scheme and way forward. The evolution of crop insurance and challenges encountered in each scheme from pre-independence times to present-day were explained for clear understanding by suitably categorized each scheme.

V. DISCUSSION

Evolution of crop insurance in India

Pre-independence period

The origin of crop insurance in the pre-independence period goes back to the Dashuri tax introduced by the Mughal emperor Akbar and times when land revenue was suspended or canceled during crop failures [25]. In 1920, a rain insurance scheme for the then Mysore state was drafted by J.S. Chakravarti [30; 25] which was area-based and rain-gauge station-specific. In 1943, in Dewas at Madhya Pradesh, a compulsory insurance scheme was introduced [25]. Besides, private agencies also sold insurance products to tea growers [36]. The situation of indebtedness prevailed in Madras during 1946 necessitated Narainswami Naidu to recommend a crop insurance scheme based on the U.S.A model [37]. The lack of financial resources did not allow the state of Madras to implement the scheme [25].

Proposed Pilot Schemes

The Government of India (GoI) appointed an officer on special duty in 1948 to formulate experimental insurance schemes for crop and cattle. The GoI drafted two pilot insurance schemes and instructed all States to implement it. The states did not implement the scheme for a lack of financial resources. [38]. Again in October 1965, the Government of India prepared a Model Scheme of Crop Insurance and circulated among all the States for review. There was no consensus on the draft among the States and the views of the States differ from the GoI. Therefore, the GoI formed an expert committee as Dr. Dharm Narain as chairman in March 1970 and referred the Bill and the Model Scheme of Crop Insurance for review. In 1971, the committee recommended not to implement the crop insurance scheme immediately because of the financial burden on the public exchequer [38]. Further, the committee reported that the existing and proposed formal credit institutions and the guidelines of Reserve Bank of India were sufficient to meet and enhance credit availability and compensate for the crop loss of the farmers due to natural calamities [25].

Experimental crop insurance schemes 1972-1978 (First Individual Approach Scheme)

The failure of the government at the farmers' level to protect and compensate the crop losses of the farmers paved way for the voluntary evolution of crop insurance [25; 38]. In 1970-71, the '4-P-Plan' of practices and plant protection on the potato crop, and in 1971-72, Hybrid-cotton introduced needed input-intensive cultivation practices that need more credit. Therefore, the Gujarat State Fertilizer Company (GSFC) along with Life Insurance Corporation (LIC) of India and the Bank of Baroda facilitated loans to meet the credit requirement, and insurance coverage for the farmers to protect the loss of income from crop failure. Subsequently, the scheme was transferred to General Insurance Corporation of India (GIC) for execution [39; 40; 13; 41; 42]. The scheme was based on the "Individual Approach". The scheme continued till 1978-79. The scheme was found to be non-viable because it had a total premium collection of Rs. 4.54 lakhs against claims of Rs.37.88 lakhs. The claims exceeded the total premium collection. It was non-popular since it covered only 3110 farmers [43]. Rashtriya Chemicals and Fertilisers Company also introduced a crop insurance scheme for cotton during 1978-79 in Gujarat, Madhya Pradesh, and Maharashtra that covered 909 farmers.

General Insurance Corporation of India (GIC) executed all the schemes on an experimental basis across the states from the beginning of 1973 to 1976 that included cotton, wheat, groundnut, and potato crops with a total of 2,154 farmers [38]. These schemes stipulated the participation of the farmers is purely voluntary. The assessment of losses was at the individual farmer level. The financial performances of these schemes were not satisfactory at all [25]. The evaluation of these schemes revealed that the assessment of the losses at the individual farmer level throughout the nation was impractical [38].

Pilot Crop Insurance Scheme - PCIS (1979-84)

GIC came up with a scheme following the suggestions of Professor Dandekar. The scheme differed from the previously followed individual approach by adopting the area approach. This scheme was introduced in 1979-80 as a pilot scheme in three states only. In the year 1984-85, it was expanded to twelve states. Farmers were not compelled to insure the crops and it was left to their choice. The crop can be insured for the entire crop loan amount. Later it was increased to 150 percent of the crop loan amount [26; 25; 45; 43]. The premium rate charged to the farmers ranged from 5 to 10 percent. Small and marginal farmers are allowed for a 50 percent subsidy on the insurance premium amount. The subsidy component was shared by the State and Central Governments equally. The scheme adopted the "Area Approach". The scheme covered cereals, millets, oilseeds, cotton, potato, and gram. The scheme was meant for loanee farmers alone on a voluntary basis. The risk was shared by the General Insurance Corporation of India and State Governments in the ratio of 2:1. This scheme

was in place till 1984-85. From its inception to closure 6.27 lakh farmers insured their crops, paid Rs.196.95 lakhs as premium, and claimed Rs.157.05 lakhs as compensation [43].

The major issue in this scheme was that majority of the small and marginal farmers could not avail of this scheme due to lack of access to institutional credit as the crop insurance scheme was linked to crop loan. The low awareness of crop insurance scheme, a large unit of insurance, and non-inclusion of major cash crops like cotton and sugarcane were the other reasons for the failure of this scheme. Besides, the major part of the premium *i.e.* 79.83 percent was utilized for claims settlement [40].

Comprehensive Crop Insurance Scheme - CCIS (1985 - 1999)

So far the crop insurance schemes were designed and executed on an experimental and or pilot basis *i.e.* in a small geographical area and in an isolated manner. In 1985-86, CCIS was introduced on a nation-wide scale [38]. It is different from the PCIS in the sense that this scheme was compulsory for the farmers who availed short-term loans from cooperative agencies, regional rural banks, and commercial banks [40]. The premium was deducted from the loan amount by the bank and was paid to GIC. Thus, insurance was an integral part of the loan. The premium rates were low [30; 46; 13; 12].

The scheme operated on the 'homogeneous area' basis [30]. The insurance scheme became credit insurance instead of crop insurance since it was linked with short-term crop loans [43]. This scheme covered five crops *viz.*, rice, wheat, millets, pulses, and oilseeds [45]. The crop was insured for the crop loan amount subject to a maximum ceiling of Rs.10, 000 per individual farmer [43]. The sum assured was stipulated as 150 percent of the crop loan amount. A uniform premium rate of 2 percent of the insured sum for cereal crops and 1 percent for pulses and oilseeds crops was stipulated throughout the country. [45; 12]. Small and marginal farmers were benefitted through a 50% subsidy component [47] that was shared by the state and central governments in the ratio of 1:2 [43].

During 1998-99, only 5.6 percent of the farmers availed crop insurance. The area under crop insurance was 5.6 percent of the gross cropped area [38]. The total number of farmers insured their crops from the inception till Kharif season 1999 revealed the non-viability of the scheme even though the insurance scheme was popular [43]. The defects of this scheme reported by Jain [48] were adoption of area-based approach, insurance coverage for farmers who have obtained loans from institutional sources, uniform premium rate fixed throughout the country, included only a few crops for insurance coverage and delayed payments of claims. Shortages in the number of crop cutting experiments (CCEs) contributed to delay and some cases non-payment of claims because of the delay in merging two or three defined areas to assess the indemnity [38].

There was always a discrepancy in the net sown area reported by the government agencies and the area insured. The area insured was greater than the net sown area since the inception of crop insurance schemes [12]. This problem was prevalent in groundnut crop in some districts of Gujarat [38]. However, the issue of area discrepancy was rectified through the area correction factor by AIC [12].

As per MoA [38] the sum insured, premium, and indemnity during 1985–86 to 1999 totaled Rs 24,975 crores, Rs 403.5 crores, and Rs 2,319 crores, respectively. The losses were reported in 27 out of 29 seasons. Except in two Rabi seasons, the indemnity payment was more than the premium received during the period. The indemnity payment was six times the premium received. The loss cost and claims ratio was 9.29:5.75 percent. These show that the CCIS was financially unviable. The ceiling for the sum insured was fixed as Rs 10,000 per farmer, irrespective of the size of the loan and farm size. This was also considered as a defect by the farmers [38].

Experimental Crop Insurance Scheme (1997-1998)

Small and marginal farmers who do not avail of crop loans from institutional sources left out in the previous schemes were also included in this scheme. This scheme was implemented in 14 districts of five states. This scheme was operated with a 100 percent subsidy on the premium that was shared by the central and state governments in the ratio of 4:1. This scheme covered all small and marginal farmers. Otherwise, it was the same replica of CCIS [40; 43]. The claims paid were higher (Rs. 37.80 crores) than the premiums received (Rs. 2.84 crores). The scheme had on roll 454555 farmers with a total sum insured of Rs. 168.11 crores [43]. The scheme was withdrawn after implemented for a season due to administrative and financial issues [38].

Pilot Scheme on Seed Crop Insurance (1999 - 00)

This multiple-peril scheme was introduced during the 1999-2000 Rabi season to encourage the breeders/institutions/organizations/seed growers in seed production. The main purpose of this scheme was to cover the risks in seed production at the field level, compensate for the loss in seed yield, and post-harvest loss. The production of 'foundation' and 'certified' seeds for State Seed Certification Agency (SSCA) was included under the scheme. The production of 'breeder' seed was eligible only when it was carried out under the supervision of the designated monitoring committee. The sum insured was calculated based on the preceding three/five year's average seed yield. The sum insured may be enhanced up to 150 percent of the seed yield accrued after processing and tagging [39; 13; 49; 41; 38].

National Agricultural Insurance Scheme - NAIS (1999 - 2007)

After years of thinking, experiments, and experiences, and to solve the problems encountered during the execution of CCIS and to meet the expectations of the states regarding the enhanced scope and content of CCIS, a wider-scope National Agricultural Insurance Scheme (NAIS) was implemented in 1999-2000 Rabi season [43; 38]. Agricultural Insurance Company of India Ltd (AIC) incorporated in December 2002 and started working from April 2003 took over the execution of NAIS [40]. This scheme used an "area approach" to assess widespread calamities and "individual approach" for localized calamities such as hailstorm, landslide, cyclone, and floods [40].

This scheme was compulsory for the farmers who obtained a loan from institutional sources and it was optional for other farmers. There was a slight inclination towards the actuarial regime. The formula used to work out threshold yield was also changed [25; 12; 49]. The Threshold Yield (TY) or Guaranteed Yield for rice and wheat was estimated by multiplying the moving average of the past three years' average yield by the level of indemnity. For other crops, the moving average of five years' average yield was considered. Three levels of indemnity, viz., 90 percent, 80 percent, and 60 percent corresponding to low, medium, and high risk areas respectively were worked out using the coefficient of variation (C.V) of past 10 years' yield of all crops [49].

The premium subsidy started with 50 percent for small and marginal farmers in 1999 that was equally shared by the state and central governments, was reduced to 10 percent in 2007 [40]. If the farmer is interested the crop can be insured 150 percent beyond the threshold yield by paying a premium at commercial rates. The actuarial rates were applied. Crop yield was estimated based on crop cutting experiments [49].

The shortcomings of this scheme are presented as follows. In the beginning, only 3 percent of the farmers who have no loan obligations with institutional sources insured the crops under NAIS [40]. The main flaws of the NAIS were the scheme was financially not viable, compulsory for loanee farmers, no mechanism to prevent adverse selection, arbitrary premiums, and estimation of loss based on area approach [74]. Gulati, Terway and Hussain [12] reported that area discrepancy issue was not resolved in NAIS too. Further AFC [49] in its report mentioned that the adverse selection problem emerged as a result of the uniform premium rates even though there were differences in yield changes unpredictably in different regions and crops. The great differences in the functioning of the credit system contributed to the disparities in crop insurance coverage in different states. The average premium was higher (2.98 %) in NAIS than in CCIS (1.62%). The share to the premium and the indemnity achieved more balance in NAIS than in CCIS. In CCIS, a single crop namely groundnut had more share to indemnity (53%) than premium (19%) [38].

Weather Based Crop Insurance (WBCIS) - 2007

About 95 percent of the crop loss claims in India during the period 1985-2003 were attributed to rainfall issues. Of which 85 percent of them were due to a shortage of rainfall and 10% by excess rainfall [25; 12]. It was reported that 50 percent of the variations in crop yield was due to variations in rainfall [50]. Apart from rainfall, the other parameters responsible for affecting crop production are soil moisture, sunlight, and temperature. In 2003-04, the higher temperature at the time of critical stages of cultivation and germination incurred a loss of approximately 4 million metric tonnes of wheat production [25].

Weather index-based crop insurance was another insurance instrument developed to cover losses in crop yield triggered by adverse weather parameters [43; 41]. The loss was estimated and compensated by adopting an area approach. For crop loss assessment, a Reference Unit Area (RUA) deemed to be a homogenous area was framed and linked with a Reference Weather Station (RWS). The claims were assessed based on the weather parameters observed and recorded by the RWS. The adverse weather conditions determine the pay-out based on the weather trigger mentioned in the 'Pay-out Structure' and the other guidelines of the scheme. The claim settlement was

automated as per the weather observations recorded in the RWS. The pay-out assessed in a RUA was the same for all the farmers under the same RWS [43; 38].

Crop insurance based on a composite rainfall index for Groundnut and Castor crops was introduced by ICICI–Lombard General Insurance Company during 2003-04 in Mahboobnagar district in Andhra Pradesh. ‘Varsha Bima’, was a rainfall-based insurance scheme introduced by Agricultural Insurance Corporation (AIC) during the southwest monsoon season in 2004. This scheme had five different options namely sowing failure, rainfall distribution index, seasonal rainfall index, agronomically optimum rainfall, and catastrophe cover. The compensation was paid when the actual rainfall in a season falls short of the stipulated percentage of normal rainfall of the area. In 2004, IFFCO-Tokio General Insurance Company (ITGI) introduced ‘Barish Bima’ an index-based weather insurance scheme in nine districts in Andhra Pradesh, Karnataka, Gujarat, and Maharashtra. The loss in crop yield due to excessive and deficit rainfall in a particular area was compensated under this scheme [25; 13].

The cost of expected inputs to be used in the cultivation of crops was covered. The sum insured was calculated based on the cost of inputs and therefore it was pre-determined per unit area. The AIC declares the amount before the onset of each season for various crops in different RUA. The premium to be paid by the farmers was fixed at 1.5% or actuarial rate, whichever was less for wheat and 2.0% or actuarial rate, whichever was less for other cereals, millets, pulses and oilseeds [43]. The premium rates were determined by the actuarial rate in WBCIS that was different from the premium rate estimation followed in NAIS [12].

There was a decline in the area insured (88%) under WBCIS from 11.1 million hectares in the 2012 Kharif season to 1.3 million hectares in Kharif season 2016. [12]. More number of farmers did not insure their crops under WBCIS because of the high premium rate, a complex procedure in the computation of index-based weather products, and low density of weather stations [51]. Gulati, Terway and Hussain [12] reported that the insurance product was faulty in design as there was no relationship between temperature and other weather parameters and yield. Insurance companies speculated more chances of compulsory payout and increased the actuarial rates to 70 percent to recover their losses.

Mukherjee and Pal [41] reported that higher crop loss was noticed when the crop was insured than otherwise. This was prominent when farmers insured voluntarily. This might be due to problems of moral hazard, adverse selection and increased transaction costs. The incidence of crop loss was higher when crops are insured than when not insured, and the problem was more acute when crops are insured voluntarily due to moral hazard and adverse selection problems, and higher transaction costs [52; 13]. In few districts unethical practice of altering temperature observations recorded in the weather stations to stimulate ‘trigger’. Sometimes the settlement of claims was delayed beyond the subsequent cropping season [12].

The salient feature of this scheme was that there was no need to submit a claim form or evidence to prove crop loss. The insured farmer put additional effort to obtain a better yield since the compensation to crop loss was decided by weather data [43].

Modified National Agricultural Insurance Scheme - (MNAIS) 2010

MNAIS was introduced during the 2010–11 Rabi season on a pilot basis in selected 50 districts as per the recommendations of the GoI Joint Group. Loanee farmers are registered compulsorily and for others, it was optional [53]. The salient features of MNAIS were: premium rates were charged on actuarial rate, 75% subsidy in premium to all the farmers, sharing of premium subsidy equally by the central and state government, claim liability was vested with the insurance company, the unit area was redefined to village panchayat for major crops, compensation for prevented sowing/planting risk and for post-harvest losses due to cyclone (in coastal areas), payment of 25% of expected claims as immediate relief, realistic threshold yield calculation, minimum compensation level increased to 70% from 60% under. The other features of this scheme were the presence of a competitive environment due to private sector participation in crop insurance, the establishment of the catastrophe-relief fund at the national level with an equal share of central and state governments, protection to insurance companies when premium to claims ratio exceeds 1:5 at the national level [38]. Farmers monitored the crop cutting experiments (CCEs) in real-time as the details of video recordings of CCEs with GPS-tagged footage were sent to the farmers by SMS [54].

In MNAIS, the premium rates were capped. If the actuarial premium rate is higher than the capped rate, the total protected would get diminished to a similar extent. This prompted lower installments on account of the catastrophe despite of higher premium rates. There was variety in premium rates starting with one area then onto the next and subsequently, farmers expressed that it was hard to know the premium rate they need to pay [55].

The subscription of MNAIS was low due to unreasonably expensive high premium rates, capping of premium, and less sum assured. As a deviation from the NAIS in the fixing of the premium rate, under MNAIS it was decided on an actuarial basis [12]. The actuarial premium rate was followed because of risk-based pricing. As a result, the premium considered the commercial cost in providing the coverage. These high costs were paid by the farmers and the government to the insurance company at the onset of the crop season [56]. Then sum insured per hectare was diminished proportionately to the capped premium rates and this prompted the low total guaranteed for a large number of crops. In numerous regions, the guaranteed sum in specific cases was inadequate to match even the cultivation expenses for the vast majority of the covered crops because of high actuarial premiums. The capped premium rates were 11 percent for food crops and 9 percent for oilseed crops during Kharif and Rabi seasons. As a result of capping, the guaranteed sum was very less and the premium rate was more in MNAIS [12].

Other Insurance Schemes

Apart from these major crop insurance schemes some other crop insurance schemes were also implemented side by side *viz.*, Farm Income Insurance 2003-04, KBS pilot scheme for soybean cultivators in Ujjain, Rajasthan government insurance for orange crop, Sookha Suraksha Kavack (Drought Risk Insurance), Wheat Insurance (Weather and Biomass), Rabi Weather Insurance, Potato crop insurance, Poppy insurance, AIC coffee rainfall index and area yield insurance, Bio-Fuel Tree or Plant Insurance, Pulp Wood Tree Insurance (Agroforestry Plantation Insurance), Coconut Insurance, Rubber Plantation Insurance, and Mango Insurance.

Farm Income Insurance, 2003-04

This insurance was a revenue-based insurance scheme [49] commenced on a trial basis for wheat crop in 18 districts from 10 states and for paddy crop in three districts from three states in 2003-04 [43] to safeguard the crop income of the farmers by insuring yield and the market risks through proper changes in the design of insurance product [40]. NAIS focused on income concerning individual crops, and not the farm income [38]. The scheme was mandatory for loanee farmers and others it was optional. The sum insured was the product of the average yield of the past 7 years \times indemnity level \times minimum support price (MSP) of the current year. A subsidy of 75% was given on the actuarial premium rate for small and marginal farmers and for other farmers, it was 50% and the subsidy component was fully paid by the Government of India. The Scheme operated on an "Area Approach" basis [49]. The central government bore the cost of claims over the premium amount after deducting the administration and marketing expenses. Rural agents obtained a commission of 5 percent of gross premium paid by non-loanee farmers. All farmers had to pay a service charge of 2.5% to the banks [43]. The plan was ceased on the suggestion of the Joint Group [38].

KBS pilot scheme for soya farmers in Ujjain, 2003

BASIX (Bhartiya Samruddhi Investments and Consulting Services Limited)/KBS (Krishna Bhima Samruddhi Local Area Bank Limited (Samruddhi Bank) designed a policy for soybean cultivators in Ujjain, Madhya Pradesh in 2003. The insurance component was integrated in the crop loans availed from banks. If the cumulative weighted rainfall was below 80% of the average recorded at the time of critical crop growth stages, then the policyholders got a concession of Rs. 10 per mm of deficit rainfall on the bank interest charges for the loan availed. But, the banks charged higher interest rates for the crop loans since the insurance component was integrated [57].

Rajasthan government insurance for the orange crop, 2004

ICICI Lombard General Insurance Company went into a joint effort with the state government of Rajasthan in June 2004 to give rainfall-indexed insurance to orange producers in Jhalawar district and surrounding areas. Insurance protection was given when there was a deficit in rainfall that prevented flowering and dry period at the flowering stage with premiums of Rs. 415 and Rs.315 respectively. The premium was subsidized at 50% for small and marginal farmers. The policy was sold through branches of the Land Development Bank and Jhalawar Cooperative Bank, rural branches of Commercial Banks in Jhalawar, Jan Mitra kiosks, and direct sales agents of ICICI Lombard. Guaranteed amount settlement was to be done inside 30 days of the expiry of the policy period [58;59].

Bio-Fuel Tree or Plant Insurance, 2004

The trees/plants included in this policy were *Jatropha curcas* (Jatropha), *Pongamia pinnata* (Karanja), *Azadirachta indica* (Neem), *Bassia latifolia* (Mahua), *Calophyllum inophyllum* (Polanga) and *Simarouba glauca* (Paradise Tree). The compensation was given for the cost of the inputs incurred in case of total loss or damage of the trees/plants due to natural shocks due to natural shocks like a flood, cyclone, storm, frost, and pest and diseases, *etc.*, either in separately or simultaneously. The compensation amount was based on the cost of inputs incurred per unit area that varies with the type and age of the tree/plant and can be extended up to 125% or 150% of the input cost [82].

Drought Risk Insurance (Sookha Suraksha Kavack), 2005

This new scheme to compensate losses occurred due to drought for popular crops like guar, bajra, maize, jowar, soybean, and groundnut was implemented in 12 districts of Rajasthan from 2005 Kharif season onwards. The premium charged ranged from 5 to 8 percent. Threshold deficiency percentage of the weighted actual rainfall index was used to estimate the compensation against the commonly used normal rainfall index. If the trigger was greater than or equal to the threshold deficiency percentage of the weighted actual rainfall index, insured farmers can claim for compensation. Through the automatic claim settlement process, the claim amount will be transferred to the beneficiary's bank account. The insured farmers who didn't avail of crop loans from institutional sources had to produce the insurance proof [43].

Wheat Insurance (Weather and Biomass), 2005

This plan is a distinctive agriculture technology-based instrument that joined crop vigor/biomass (Normalized Difference Vegetative Index-NDVI) and weather (temperature) parameters. This scheme was introduced in 2005. This insurance scheme was operated during peak wheat crop growth stage, more particularly during parts of February and March. AIC collected the past 10 years of satellite images [43] during the 3rd week of January and 2nd week of February and estimated the average values of NDVI and revealed that it was significantly correlated with the final yield. Based on this relationship the triggers were fixed as 95 to 85 percent of the past 10 years' average. The costs of procurement of historical images and its processing were very high and there was a lack of ground realities in the calculation of the current season's NDVI [60].

Potato crop insurance, 2005

This insurance product compensated for the financial loss by taking into consideration the cost of inputs. The loss incurred as a result of death/total damage of the plants leading to reduction of the plant population below the threshold number due to natural shocks like flood, cyclone, storm, frost and pest and diseases (except late blight), *etc.* either in isolation or concurrently during the period of insurance were compensated [83].

Poppy insurance, 2005

Sengupta and Himatsingka [61] reported that Indian Tobacco Company Ltd (ITC) and Agriculture Insurance Company of India (AIC) together introduced poppy insurance to some 70,000 registered and licensed poppy growers in Madhya Pradesh, Rajasthan, and Uttar Pradesh.

AIC coffee rainfall index and area yield insurance, 2005

This scheme was introduced on a trial basis in three prominent coffee plantation districts of Karnataka state. The rainfall index and yield parameters are considered. Approximately two-thirds of the compensation was determined considering the rainfall at the critical stages of coffee growth *i.e.* blossom and backing periods as well as excess rains during the monsoon months of July and August in Karnataka and the residual risk based on coffee yield at harvest time. Coffee growers can choose the premium [62].

Coconut Insurance

This insurance was introduced to help small and medium coconut growers. Under this scheme, the subsidy component was shared by the Coconut Development Board, state government, and farmers in the ratio of 2:1:1

respectively. For the age group between 4 and 15 years palm, the insured sum shall be Rs. 900 per palm and the premium payable per plant per year was Rs.9. For the age group between 16 and 60 years, the insured sum was Rs. 1750 per palm and the premium payable per plant per year was Rs.14. The scheme covered storm, hailstorm, typhoon, cyclone, tornado, flood, and heavy rains; pest attack that leads to irrecoverable damage to the coconut palm; forest fire, bush fire, accidental fire and lightning that destroys the palm completely; earthquake, tsunami, and landslide; a severe drought that can lead to death and turn the palm unproductive. Claims are not allowed for the losses that occurred because of robbery, civil war, revolt, insurgency, natural death, or uprooting under the scheme [84].

Rubber Plantation Insurance

This scheme was a collaborative project of the Rubber Board and the National Insurance Company. This scheme covered both well grown mature and immature plantations. For immature plantations, the policy can be availed for 7 years from the last day of the month of planting. Compensation was estimated by adding the replacement cost of the plant with the present value of future returns arising out of the loss/death of the plant. Compensation can be claimed from the second year onwards. The mature plantations from the 8th year onwards can be insured for 3/2/1 year(s). All the input costs and expected yield were added and recurring maintenance costs were subtracted from that in the process of computation of compensation. Natural calamities like fire, lightning, riot, strike and malicious damage, bush fire, forest fire, flood, storm, tempest, inundation, landslide, rockslide, earthquake, and drought were covered under this scheme only when the block/taluk was notified officially as drought-affected by the state government. The loss incurred due to road/rail/vehicles and wild animals were also included for claims. If the incurred loss was 75 percent or more in one hectare then the loss was treated as a total loss [85].

Mango Insurance

The crop was insured on a hectare basis. The premiums of Rs. 5,200 and Rs. 9,200 were fixed for young and old plantations respectively with a 50 percent subsidy shared equally by the state and central governments. This insurance scheme covered the crops from losses incurred due to excess and unseasonal rains between January 1 and February 29, temperature variation between January 1 and March 15 and against damages due to wind between March 1 and May end [86].

Pulp Wood Tree Insurance (Agroforestry Plantation Insurance), 2013

The United India Insurance, Chennai, had introduced an extensive 'Agroforestry Plantation Insurance' scheme for tree plantations. The pulpwood trees such as *Casuarina*, *Eucalyptus* (pulpwood), *Melia dubia* (plywood), *Ailanthus*, *Gmelina* (matchwood), and *Leucaena* and *Dalbergia sissoo* (Indian rosewood) are included for coverage. The basic premium rate was computed as 1.25 percent of the input cost per one-acre plantation. The premium rates ranged from Rs. 300 to Rs. 600 based on the input cost incurred for tree cultivation. The amount insured was based on the input cost, the age of the tree, and their type [63]. A farmer can increase the sum insured to 125% of the initial costs or 150% of the same [64]). The plantation was insured against forest and bush fire, lightning, riot and strike, storm and cyclone, flood and inundation, and loss due to wild animal attack.

National Crop Insurance Programme (NCIP), 2013

Various components under the previous schemes were improved considering the recommendations of evaluation studies, insights from the execution of various crop insurance schemes, and the demands of stakeholders for designing farmer-friendly insurance products namely NCIP. This consisted of three components: the MNAIS, WBCIS, and the Coconut Palm Insurance Scheme (CPIS). This scheme was effective from 2013-14. A maximum subsidy was provided at the rate of 50% in WBCIS and 75% in MNAIS. For different crops and seasons, the premium rates were capped accordingly. In situations where the actuarial premium rates were higher than the capped limit, the total guaranteed for such crops was diminished concerning to the cap level. NCIP was mandatory for the crop loan availed farmers and others can opt either MNAIS or WBCIS component [65; 38].

Plappallil [66] reported the issues noticed in the MNAIS component were: time lag in providing yield data and sharing of funds by the state governments; lack of awareness and publicity among farmers; lack of accuracy of crop-cutting experiments, timeliness, and reliability. Further, excessive work burden of India Meteorological

Department, lack of regulatory mechanisms in the government and private sector, inadequate redressal mechanisms to settle disputes, and litigation were the hurdles in the efficient operation of the scheme.

According to the industry experts, some states didn't have village-level data on weather and agricultural yields, most of the insurance products focused on extreme weather shocks, lack of adequate awareness campaigns, no transparency in data and data sharing amongst various stakeholders, dysfunction between many parameters, reducing the size and decreasing the actuarial premium rates together were the issues impeding the successful implementation [67].

Rabi Weather Insurance, 2015

AIC introduced a scheme that protects against adverse weather shocks like frost, heat, rainfall, *etc.*, during the Rabi season. The crop losses incurred due to a maximum temperature ($^{\circ}\text{C}$) above the trigger level and/or deviation in the temperature range from the normal above the trigger value and/or minimum temperature ($^{\circ}\text{C}$) below the trigger level and/or minimum temperature below 4°C resulting frost and/or rainfall above the trigger levels (calculated on daily/weekly/monthly basis) and/or bright sunshine hour below the trigger level were indemnified. The advantage of this scheme according to Singh [43] was that the causal events like adverse weather shocks can be independently confirmed and estimated.

Pradhan Mantri Fasal Bima Yojana (PMFBY), 2016

The NAIS and MNAIS were supplanted with a new multi-hazard crop insurance scheme by the GoI on 13 January 2016 to achieve 50% coverage by 2018 [41]. In this scheme provisions that are desired by the farmers and considered as farmer-friendly such as a reduction in the share of insurance premiums to be paid by farmers, claims for prevented sowing, and losses in the mid-season or post-harvest have been introduced to address additional risks faced by cultivators. The number of crops covered and the types of hazards have also been expanded [35].

The premium rates for Kharif and Rabi seasons are different. It is 2 percent of the amount insured for food crops and oilseeds in the Kharif season and 1.5 percent in Rabi season. For cash/horticultural crops the premium is declared as 5%. The premium subsidy is shared by the central and state governments equally. The amount insured by a single farmer is determined by multiplying the cost of cultivation by the area notified by the farmer under cultivation of the crop [12]. The important feature of this scheme is that there is no upper limit for government subsidy [27].

The significant advantages of this scheme over the previous schemes are: the stipulation on the number of crop cutting experiments (CCEs) is fixed as 4 for major crops and 8 for other crops at the village level; harnessing the advantage of mobile phone technology and GPS for enhancing the quality and quicker estimation of loss; involvement of other public and private insurance companies in addition to AIC; wider coverage of risks at different stages of crop growth and post-harvest losses incurred due to natural calamities [12].

The accomplishment of 41% inclusion of farmers inside a few years after the commencement of PMFBY seems noteworthy, especially when contrasted with 28% inclusion of farmers accomplished under three plans consolidated (WBCIS, NAIS, and MNAIS) before the execution of PMFBY [68]. Rajeev and Nagendran [35] reported that north-eastern states have scarcely observed any cropping area under the plan. Bhati [69] reported that this scheme fell short of the target of 50% coverage of the gross cultivation area as it covered below 30% despite numerous benefits and coverage than previous plans. However, GoI has claimed that coverage has increased to 30 percent of the gross cropped area (GCA) from 23 percent in 2015-16 under the previous schemes [70].

Rajeev and Nagendran [35] reported that the damage assessment mechanism that is not farmer-friendly and the documentation requirements indirectly affected the adoption of crop insurance. The process of registration for the non-loanee farmers is complex and requires a few more steps to complete the process of registration that may not occur most of the time. According to Rajeev and Nagendran [35], some insured farmers were dissatisfied with the scheme because if losses are even 74% in the case of prevented sowing (approved 75%) or 49% in the case of mid-season losses (approved 50%), no claims are paid.

Most farmers were unaware of the computation method (including concepts such as threshold yield), and thereby feel "misled" when they do not receive compensation despite being insured and facing crop losses. This works to reduce their faith in the institution of crop insurance, and thus, reduced their willingness to participate in it. Farmers facing specific damage to crops that do not present over the entire area were not covered under insurance. More specifically, farmers were considered in blocks rather than individually [35].

Delays in releasing the results of crop cutting experiments, identifying farmers who faced losses, processing of claims burdened subsistence farmers as they have neither the crop income nor insurance claim during this period. Further, the insurance cover is often only for the crop loan amount (estimated on the cost of cultivation, not on the value of yield) and therefore, cannot provide cover for their potential income. Even for farmers getting insurance through the voluntary route, the insurance coverage is according to the scale of finance and not the value of output [35]. The scheme is mandatory for only those who availed crop loans from formal sources which was less than 33% of the total farmers and for other farmers it remained optional. The voluntary enrollment in crop insurance in India was extremely low [68].

According to PTI [71], GoI has a proposal to introduce an exhaustive insurance plan that covers agriculture and allied sectors including farm equipment. Thereby the total cost of the insurance policy will be reduced by protecting all the risks in farming. The farmers will have the choice to pick and choose the risk cover in the proposed scheme.

Bihar Rajya Fasal Sahayata Yojana, 2018

On June 5th, 2018 the state government of Bihar has launched Bihar Rajya Fasal Sahayata Yojana to provide crop insurance to farmers in replacement to PM Fasal Bima Yojana (PMFBY) which is effective for Kharif crops. In this scheme, the government estimate the crop loss and pay the compensation without any involvement of insurance company and collecting premium from farmers [72].

Table 1 Summary of Crop Insurance Schemes Introduced in India

S. No	Crop Insurance Name	Year	Salient Feature	Reason for Discontinuance/Issues noticed
1	Rain Insurance Scheme	1920	Area-based; Compensation based on rainfall data	Resource constraints
2	Compulsory Insurance Scheme	1943	Compulsory for all	---
3	Crop Insurance Scheme*	1946	To solve the problem of indebtedness	Financial constraints
4	Two Pilot Schemes for Crop and Cattle*	1948	---	Resource constraints
5	Model Scheme of Crop Insurance*	1965	---	Financial burden
6	Experimental Crop Insurance Scheme	1972 - 1979	First Individual approach scheme	Loss-making; Financial performance not satisfactory; Individual approach not suitable on the national level
7	Pilot Crop Insurance Scheme (PCIS)	1979 - 1984	First Area approach scheme; Participation was voluntary for loanee farmers	Crop insurance was integrated with crop loans and available only to loanee farmers
8	Comprehensive Crop Insurance Scheme (CCIS)	1985 - 1999	Pioneer crop insurance scheme implemented nationwide scale; Compulsory for loanee farmers; Homogeneous area basis approach	Integrated with short-term credit; Available to only loanee farmers
9	Experimental Crop Insurance (ECIS)	1997 - 1998	Small and marginal farmers were eligible with a 100% subsidy on premium	Administrative and financial difficulties

10	Pilot Scheme on Seed Crop Insurance	1999 - 2000	To cover the risks involved in seed production	---
11	National Agricultural Insurance Scheme (NAIS)	1999 - 2007	Both area-approach for widespread calamities & individual-approach for localized calamities were adopted	Financially not viable. Issues of adverse selection and area discrepancy were noticed
12	Weather Based Crop Insurance Scheme (WBCIS)	2007 to till date	Insurance covered weather triggers	High premium rate. Complex computational exercise. A low density of weather stations
13	Modified National Insurance Scheme (MNAIS)	2010 - 16	The unit area was shrunk to the village panchayat level. Private sector participation encouraged. The immediate partial payment system was introduced	High premium rate. Capping on premium rate and amount assured
14	National Crop Insurance Program	2013	Compulsory for loanee farmers. Three components viz., WBCIS, MNAIS, and Coconut Palm Insurance Scheme were included.	Lack of scientific evidence to relate weather to crop productivity. Overburden of India Meteorological Department. Lack of proper maintenance of rain gauges
Other Insurance Schemes				
15	Farm Income Insurance	2003 - 2004	Crop income protection to farmers by combining the system of insuring the crop yield and market risks	Discontinued on the recommendations of joint-group
16	KBS Pilot Scheme for Soya Farmers	2003	Linked insurance to bank loans. Interest payment relief based on rainfall index deficit	Farmers have to pay high-interest rate on crop loans
17	Rajasthan Government Insurance for Orange Crop	2004	Rainfall-indexed insurance. Only for orange tree planters	---
18	Drought Risk Insurance (Sookha Smaksha Kavack)	2005	Threshold deficiency percentage of the weighted actual rainfall index was used against normal rainfall index	---
19	Wheat Insurance (Weather and Biomass)	2005	Combined crop vigor/biomass and weather parameter	Huge costs incurred on the procurement of historical satellite images and their processing. Lack of clear guidelines in the computation of NDVI
20	Potato Crop Insurance	2005	Insured against the cost of inputs	---
21	Poppy Insurance	2005	Only for poppy growers	---
22	AIC Coffee Rainfall Index and Area Yield Insurance	2005	Rainfall index and yield parameters are blended during critical stages of crop growth	---

23	BioFuel Tree or Plant Insurance	2005	Insured in respect of the cost of inputs	---
24	Coconut Insurance	-	To help small and medium coconut growers	---
25	Rubber Plantation Insurance	-	Compensation is estimated considering the replacement cost of the plant and the present value of the future returns	---
26	Mango Insurance	-	Insured against excessive and unseasonal rain, temperature and high wind during the critical periods	---
27	Pulp Wood Tree Insurance	2013	Cost of inputs per unit area was considered in determining the amount of insurance	---
28	Rabi Weather Insurance	2015	Provided protection against adverse weather parameters during a particular period. The insured was compensated against the diminished crop output/yield due to adverse weather parameters	---
29	Pradhan Mantri Fasal Bima Yojana	2016 – to date	Reduction in the cost of the premium (Government contribution is five times that of the farmer)	---

Source: Author’s Compilation (2020)

List of Companies Providing Crop Insurance

Many countries are involving private insurance companies in crop insurance. [73]. Ifft [74] recommended the Government of India to include private companies in the implementation of crop insurance programs. In India, the imperfect information (high cost in information collection) and natural calamities severely damaging crops over a very vast area discouraged the participation of private agencies of regional nature in the crop insurance market because it will go bankrupt by paying huge compensations [40].

The following insurance companies are involved in issuing crop insurance in India which includes private insurance companies too. Besides government agencies like Agriculture Insurance Company of India Ltd, State Bank of India, private companies like Reliance General Insurance Co. Ltd., Cholamandalam MS General Insurance Co. Ltd., IFFCO-Tokio General Insurance Co. Ltd., HDFC ERGO General Insurance Co. Ltd., ICICI Lombard General Insurance Co. Ltd., Future General India Insurance Company Limited., Bajaj Allianz General Insurance Co. Ltd., Universal Sompo General Insurance Company Limited are serving the farmers in crop insurance.

Challenges of Insurance in Indian Agriculture

A huge number of fragmented small and isolated landholdings, differences in climatic and soil types, inadequate baseline data, range of farm practices render it to operate the insurance plan on an ‘individual basis’. The majority of the farmers are resource-poor and illiterate. Due to these, farmers don’t have sufficient knowledge of the insurance plan and how it works. Therefore, it is very difficult to enroll all the farmers in crop insurance schemes [68]. Because of the severity of poverty among farmers, the non-loanee farmers could not afford to pay a huge premium at once [75]. Non-availability of adequate land records is hindering the registration of farmers in crop insurance schemes [35]. Lack of awareness, farmers could not take up insurance according to the value

of output, and dissatisfaction with the terms and conditions of insurance facilities were the major factors behind a lack of insurance adoption in India [35].

Use of Satellite Data for Crop Insurance

The pre-harvest production forecasts for rice and jute crops at the district/state/national level were generated by adopting optical and microwave remote sensing data through FASAL (Forecasting Agricultural output using Space, Agro-meteorology, and Land-based observations) project. The drought estimation in the agricultural sector was effected at the district/sub-district level through the collection of data from many satellites and other related parameters in the NADAMS (National Agricultural Drought Assessment and Monitoring System) project. CHAMAN (Coordinated Horticulture Assessment and Management using geo-informatics) project assessed the production of 7 major horticultural crops using satellite data. KISAN (C[K]rop Insurance using Space technology and Geo-Informatics) project used high-resolution remote sensing data for yield estimation through crop cutting experiments in crop insurance.

Remote sensing-based Information and Insurance for Crops in Emerging Economies (RIICE) project used the radar based-remote sensing data with high spatial resolution and temporal resolution to monitor the growth of rice at a resolution of 3 by 3 meters [12]. The actual cultivatable land can be determined using drones besides the extent of loss and the actual yield can be assessed during claims. The exact health of the crop can be assessed using drones fitted with high-precision cameras. As the drones cover the distances quickly, the time taken to settle the claims can be reduced significantly [76].

VI. WAY FORWARD

The report of the Ministry of Agriculture and Farmers Welfare [77] revealed that in a study conducted with 5,993 farmers, only 37% knew the insurance schemes and the premium rates, the types of risks included, claim procedure, the loss incurred, *etc.*, whereas the rest 63% did not have any knowledge of the insurance plans. This shows that the publicity was inadequate or ineffective. Farmers are not part of the scheme that is designed for their improvement in livelihood if they are ignorant of information regarding credit, insurance, premium deduction, yield-loss assessment, and non-payment of claims. Most of the farmers considered insurance as an investment mechanism. They did not know that it is meant for risk reduction. [67]. Therefore, large scale awareness should be created on the benefits of crop insurance among farmers using various outreach methods. It is revealed from the experiences so far that either PMFBY or WBCIS would not be sufficient to cover all the pure risks arising from agricultural activities. Instead, a total insurance package should be designed and offered for farmers' subscription [51]

There is a scope for manipulation of crop yield data assessed through crop cutting experiments by the private insurance companies for profit sake [27]. Therefore, to avoid this manipulation of yield data large scale use of remote sensing, drones, satellite imagery and digitization of land records should be encouraged at all levels for the successful execution of the PMFBY.

Private insurance companies invested huge money in the scheme reaped and continue to earn a profit. There should be transparency in claims processing and compensation settlement. A specific insurance company was assigned the responsibility of selling insurance at the cluster level. At present, the situation is a monopoly due to lack of competition. Therefore, there is little or no chance to improve or upgrade their products and introduce competitive pricing [27].

Time lag in settlement of claims was due to the delay in transmission of yield data by the concerned department, not timely transfer of premium subsidy by the state governments, disagreements over yield-data between insurance companies and the state governments, missing of bank account details of farmers due to miscommunication to credit the compensation amount, and NEFT related issues, *etc.* Specific changes in the operational guidelines should be framed to avoid delay in claim settlement so that the compensation to farmers is paid in time [27].

The latest technologies such as remote-sensing, simulation modeling, 3D imaging, and ICT tools should be used to improve accuracy and objectivity while estimating the crop loss based on weather index parameters. A solitary information storehouse ought to be made with all insurance-related information on weather and crop yield for quick access by all agencies involved in crop insurance [51]. The farmers who adopt climate-smart agricultural practices should be incentivized by insurance companies through designing insurance products at affordable rates and providing access to them [67].

The risks in crop insurance schemes are spatial, temporal, and crop-specific. This cannot be eliminated by a area approach; the individual approach is best suitable but economically infeasible. The “utmost good faith” in the compliance mechanism of material information disclosure by the insurance companies to the insured farmers did not happen always in agriculture insurance. The true reasons were the heterogeneity in farmers’ perceived risk attitudes leading to a varying degree of concern to pay for insurance premium, crop choice and income stream from agricultural activities, and level of financial literacy [78; 79;80]. Hence, multi-agency in insurance product design should be encouraged [51]. The GoI should frame an effective dispute and grievance settlement mechanism immediately for encouraging private insurance companies to actively take part in promoting crop insurance in rural agricultural markets [67].

Improved identification of losses can undoubtedly be beneficial because most of the farmers were unaware of loss computation methods (including concepts such as threshold yield) and damage assessment mechanisms are not farmer-friendly [35]. Hence, they feel “misled” when they do not receive compensation despite being insured and facing crop losses.

VII. ACKNOWLEDGMENTS

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