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Application of Actuarial Methods in Crop Insurance Designing

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Abstract: Crop insurance, as well as strategies for designing, managing, running, and sustaining such programmes, are introduced and reviewed in this study. Crop insurance can be classified as property, causality, life, or health insurance. Throughout this study, crop insurance programmes are referred to as "agricultural insurance." Before being implemented, crop insurance plans must be thoroughly developed and tailored to the unique circumstances of individual countries and localities. Insurance systems that are poorly constructed will fail, resulting in losses for all parties involved as well as a lack of trust among producers and the broader public. In fully benefited programmes, all stakeholders must have a high level of trust.
Transparency is one of the most important criteria in establishing and maintaining trust in agricultural insurance schemes. Only if all plan participants are informed of the insurance procedure can this transparency be achieved. Clear communication enables stakeholders to develop programmes that meet the needs of their customers while avoiding long-term problems. Crop insurance transparency is emphasised throughout this research, from farmers to private insurers through government agencies that support and regulate programmes.

Key Words: Agriculture, Insurance, Crop Insurance, Transparency, Insurance process, Underwriting

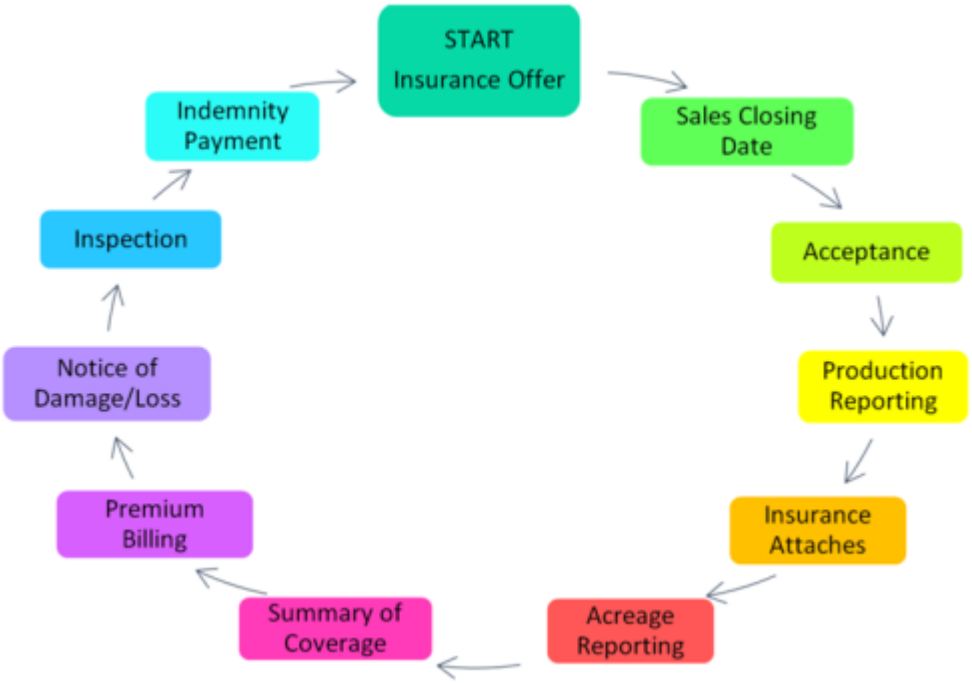
1. INTRODUCTION:

India's economy is primarily based on agriculture. Agriculture provided roughly 18% of the country's GDP and 50% of the country's jobs. Cultivation, on the other hand, is a difficult undertaking because each step is reliant on natural calamities. Droughts, heavy rains, floods, storms, and other natural calamities wreaked havoc on the farming community. In light of this, the government has implemented a range of general insurance policies known as crop insurance programmes to protect farmers from various types of financial damage. Crop insurance, on the other hand, has had mixed results in various parts of the world. Crop insurance has been used by policymakers in various forms at various times. Given the unique nature of Indian agriculture and the inequitable socioeconomic status of Indian farmers, crop insurance has been

a resounding failure. Despite several adjustments of the programmes and enormous support in the form of premium subsidies for farmers, crop insurance has failed to deliver the expected benefits. Despite the fact that crop insurance has been in some form or another for decades, only a small percentage of farmers have used it. The researcher demonstrates how to create crop insurance plans based on a variety of criteria and what factors actuaries consider when creating crop insurance policies. Actuarial methods are typically used to develop all sorts of life and general insurance plans. (2014, Watts"). In the same way, actuarial methods are used to design crop insurance for a variety of static factors that affect crop cultivation.
This article covers a wide range of subjects, including programme structure, participation incentives, the role of insurance and reinsurance enterprises, and government engagement in crop insurance and subsidy support, using various instances.

2. MATERIAL:

Figure 1: Risk Management and the Crop Insurance Value Chain



Source: Federal Crop Insurance business

Quality assurance procedures and approaches

For successful crop insurance programmes, sign-up, verification, premium payments, loss adjustment, indemnity payments, and notifications between reinsurers and government regulators are all required processes and procedures.

Sign-up:

Crop insurance schemes involve a number of steps. Each phase is crucial in the establishment of a successful crop insurance policy. Before signing (purchasing) crop insurance contracts, farmers must research previous programme results and issues. Farmers' problems and needs must be documented and classified, which will need the creation of processes. If the concerns are real and well-founded, the programme should be changed to reflect this. Take a peek at this before you join up:

- Modification of the program details, including premium rates if necessary;

- Review data and other operations systems;
- Developing the plan with the support of collected informational materials.

Prescribed procedures must be in place for managing common situations and information must be available to the farmers. Farmers must understand the services that are provides to them in exchange for their premium payments; Review risk bearing strategy and agreements including risk distribution and responsibilities of primary insurance companies, reinsurers, and governments. Finalize the insurance policy with the details of prior information to the sign-up period. During the contract term the farmers should understand the program including premium calculations. The premium calculations including the farmers choices, Record the farmers information (e.g., name, address), the cultivation information (e.g., crops, acreage, location) ,Sign insurance agreements and provide both parties with copies , Collect farmers comments, concerns, and recommendations.

Later the contract sign-up period, it is necessary to enter sign-up information into a database. There should be an electronic method for entering this information while contracts are being signed. It is sometimes preferable to enter such data after the sign-up period to allow for corrections to be made if transmission is interrupted;

- Provide the details of the other users of the crop insurance with information (how many acres were insured, liability, which crops);
- Fulfil regulatory requirements, particularly on reporting;
- Starr signed agreements in a filing system;
- Record producers' comments and recommendations;
- Ensure that data are stored redundantly in several backup locations;

Notify producers of final date for contract modification (contract modifications may include acreage adjustment just prior to planting, but after the insurance contract is signed);

- Enter producer modifications into a database;
- Notify other risk bearers of required information;
- Fulfil regulatory requirements;
- Perform and record any required field inspections.

Calculation of Premium Payments:

In most cases, farmers pay insurance premiums when a contract is purchased. But most of the countries allows farmers to delay premium payments until later in the year. However, the foreign countries have cross compliance for premium payment with many other government programs, which minimizes payment default. To receive premium payments, it is necessary to confirm the accuracy of premiums quoted at sign-up. Contracts should specify the procedures to be followed if farmers do not provide sufficient minimum payments;

- The producers of premium amounts and provide invoices;
- Receive premium payments;
- Record payment or non-payment;
- Record the farmers payment receipt;
- Farmers of a policy cancellation if premium payments are not received
- Regulators and other risk bearers as required.

Loss Adjustment:
It refers to the process of verifying that actual harvest yields are below indemnity trigger yields. This is one of the most important factors in developing a successful crop insurance program. All users must be involved: (2016," Ministry of Agriculture & Farmers Welfare")

- Review the loss adjustment procedures, operations, infrastructure, and personnel;
- Inform the farmers about loss notification procedures;
- Provide the mechanism to receive the farming society requests for loss adjustment;
- Delineate and implement field inspections if required;
- Adjust, document, and record losses;

Indemnity Payment:
When actual harvest yields (or revenues) are below the indemnity triggers, an indemnity payment is owed. Indemnity payment amounts are determined by the difference between actual yields (or revenues) and the indemnity trigger multiplied by the price at which the commodity is valued. Several procedures for distributing indemnity payments must be followed:

- Review, document, and record indemnity calculations based on loss adjustments;
- Pay indemnity to producers;
- Notify and invoice risk-bearing partners;
- Receive payment from risk-bearing partners;
- To Record the payment from risk-bearing partners in database;
- Record the farmers indemnity payment in database

Final Steps:
A variety of mechanisms are need to be followed annually for the successful completion of a crop insurance cycle.

- Fulfil the regulatory requirements which is frame outed by the official board.
- Analyse the performance of the crop insurance
- Preparing the reports for informative purpose.

3. METHODS:

In order to explain the term Simple Crop Insurance, we need the basics of the following terms:

- **Expected Yield:** A farmer's average historical yield;
- **Price:** Price per unit of output used to calculate premiums and indemnity payment;
- **Deductible:** A percentage of loss absorbed by a farmer prior to qualifying for an indemnity payment.
- **Coverage:** The portion of the crop that is insured:

Coverage = 1 - Deductible

- **Indemnity Trigger:** The yield level that triggers an indemnity payment:

Trigger Yield = Expected Yield x Coverage

- **Liability:** The maximum indemnity payment:

Liability = Trigger Yield x Price

- **Pure Risk Premium Rate:**

Expected indemnity payments as a fraction of liability.

- **Loading Rate:**

Additional cost needed to provide insurance than the actual pure risk premium rate.

- **Total Premium Rate:**

Total Premium Rate = Loading Rate + Pure Risk Premium Rate

- **Total Premium:** The total cost of insurance:

Total Premium = Liability x Total Premium Rate

- **Production Premium:** The producer's cost of insurance:

Production Premium = (1 - Subsidy Rate) x (Total Premium)

- **Subsidy Rate:** The fraction of total premium paid by the government;
- **Indemnity:** Compensation for yield before indemnity trigger.

Illustration:

Consider the following data in correspondence to a yield-based insurance product:
Deductible = 40%
Pure Risk Premium Rate = 0.87%
Loading Rate = 3%
Subsidy Rate = 25%
Price of Output (wheat) = 1.0 (1 hectare is insured)

Indemnity of the insurer is based on the expected return from the field. Suppose that the producer has the following production history:

Table: 1 Historical Yield

Year	Historical yield (per tons)
1	3
2	4
3	3
4	4

In this case, The expected yield = 3.5 tons/ha (Average)

Expected yields are sensitive to sample size. Many countries use as little as four years of data, while others use as many as ten or more years to calculate expected yields. A few years of data are subject to outlier (extreme) observations. It is highly necessary to account for yield trends outcome due to technological change due to large sample test.

Example:

Liability = (*Price*) * (*Area*) * (*Expected Yield*) * (*Coverage*)
= (3.5 *tons* / *ha*) * (1 - 0.4) * ($1 / *ton*) * (1.0 *ha*)
= 2.1

Total Premium Rate = (*Loading Rate* + *Pure Risk Premium Rate*)
= (3% + 6%) = 9%

Total Premium = (*Liability* * *Total Premium Rate*)
= (2.1) * (0.09) = 0.189

Subsidy = (*Subsidy Rate*) * (*Total Premium*)
= (0.25) * (0.189)

= 0.04725

Producer Premium = (1 - *Subsidy Rate*) * (*Total Premium*)
= (0.75) *(0.189)
= 0.14175
Trigger Yield = (*Coverage*) * (*Expected Yield*)
= (1 - 0.4) * (3.5 *tons/ha*)
= 2.1 *tons/ha*

If actual yield is greater than the indemnity trigger, no indemnity will be paid. In our example, if the actual yield is 2.0 tons/ ha, then an indemnity is not generated. If actual yield is less than the indemnity trigger, however, then an indemnity is due. Suppose that the actual harvest yields total 1 ton per hectare. Then, the indemnity payment would is calculated as:

Indemnity = (*Trigger Yield - Yield Outcome*) x (*Price*) x (*Area*)
= (2.1 *tons/ha* - 1 *tons/ha*) x ($1/*ton*) x (1.0 *ha*)
= 1.1

Actuarial Calculation:

Actuarial Methods refer to the processes by which insurance premiums or rates are established. These premiums must be sufficient to compensate insurers and reinsurers for expected indemnities, costs of providing insurance services, business risk, and profit. Assume that a farmer is interesting in purchasing a crop yield insurance product with the following characteristics:

Acre = 1 *hectare*
Cost (Price) =1 INR *per ton*
Deductible = 40%

Suppose the Farmer has the following yield history, for which the indemnity trigger and the payments are: (Yield outcomes are randomly generated)

Table: 2 Simple Rating Example for yield Insurance

Year	Yield out come	Indemnity Trigger	Indemnity Payment
1	3.40	2.1	0.00
2	1.70	2.1	0.40
3	3.26	2.1	0.00
4	4.20	2.1	0.00
5	4.20	2.1	0.00
6	4.73	2.1	0.00
7	0.32	2.1	1.78
8	3.77	2.1	0.00
9	3.10	2.1	0.00
10	1.82	2.1	0.28

This results in:

Expected Yield = *Mean Yield* = 3 and

Coverage = (1 - *deductible*) = 60%

Pure Risk Rate:
Liability represents the maximum possible indemnity payment in any given year. In this case, the liability is calculated as:

Liability = *Indemnity Trigger* x *Price*
Given that Price = 1.0,
Liability = 1.8 x 1.0
The **Pure Risk Rate** is calculated as the quotient of the expected indemnity payment and the responsibility of the insurer. It should be noted that this example is demonstrated only for illustrative purposes. Only ten observations is a very small sample size and also it is an insufficient sample size for calculating pure risk rates. In cases of small samples, other methods are also used to determine pure risk rates, and easily used the result to find out the expert justification, experimental data, and easily compare with other crops and regions.

Loading factor and Total Premium Rates:
Loading factor are additions to pure risk rates that compensate insurers additional costs and risks. Consequently, loading factor are specified with each products. Because more risk may be associated with different crops or even different farmers. Crops that are highly seasonal, possess small market shares, have little historical data. Loading factors are commonly included in premiums to offset against the additional losses.

Rating confidence:
Loading factor are increased for insurance products that have been rated using low-quality data or questionable methodologies.

Insurance servicing:
Loading factor are larger for products requiring high monitoring costs, frequent review, audits, and smaller insurance markets.

Political, judicial, and other hazards:
Loading factor are larger in regions in which clear and enforceable property rights are problematic;

Structural change:
Loading factor are larger for products and commodities subject to policy or technological changes. Loading factor are sometimes a function of cost estimates that are based on contract servicing and historical performance of other insurance products. However, loading factor often result in subjective judgements of those involved in actuarial rating. Loading factor can be applied to premium rates either as a proportion of a premium rate or as a fixed addition to a premium rate:

Proportional loads:
The rates are added to a pure risk rate as:
Total Rate = (*Pure Risk Rate*) x (1 + *Loading factor*)

Fixed addition loads:

The rates are calculated as:
Total Rate = (*Pure Risk Rate*) + (*Rate of loading factor*)

Rating Methods:
Many existing methods are used to rate crop insurance products including empirical, parametric, combined, and spatial smoothing approaches. In general, the quantitative and qualitative of historical data are used to the rating method.

Empirical Rating Method:
It is using the historical data to calculate premiums. The preceding example used an empirical rating method.

Parametric Rating Method:
It is use specific probability distributions rather than empirical distributions (actual data) to establish premium rates. Parametric rating methods are often used in cases where historical data are not of sufficient quantity or quality to allow the use of empirical rating methods. The most common probability distributions used to rate insurance products include normal distributions, uniform distributions, and extreme value distributions.

Combined Approach.
Empirical and parametric rating methods are often combined to develop premium rates when data are available. After using each method, the outcome rates are compared. If both methods provide similar results, then insurers can be comfortable with the rating procedures. May the uniform distribution can be used to develop an upper bound premium rate.

Rating Methods with Limited Data:
Historical data are very limited, so the other methods may be used to establish premium rates. These rates usually include relatively high loads. These methods include rates from similar crops, rates from different regions with similar growing conditions, use of relative parametric approaches, and opinion of crop insurance experts. In general, it becomes difficult and expensive to reinsure risks if high- quality data are unavailable.

Data Management and Accounting:
Data collection, analysis, and management are important to the success of any insurance program. Data are used to evaluate and predict the rate of products, reinsurer's risk, to detect fraudulent activities, adjust public policies, and measure success.

- Data and educational efforts are required by:
- Farmers and farm organizations;
- Private primary insurance providers;
- Reinsurance companies;
- Government agencies managing the crop insurance programs;
- Regulatory agencies and/or oversight boards;
- Policy makers.

Farmers:
Farmers and farm organizations need data and information to:

- Decide whether they want or not agricultural insurance products;
- Select which products to use with the coverage levels, and deductibles;
- Determine eligibility and size of indemnity payments;
- Meet sign-up deadlines and respond to loss adjustment requests;

From the above information's the farming community to evaluate the performance of insurance products over time and assess whether they provide sufficient risk protection.

Primary Insurance:
Primary insurance Providers need data to:

- Service products;
- Establish premium rates;
- Pay indemnities;
- Establish performance benchmarks and monitor performance;
- Monitor the individual farm losses to identify fraud and high-risk producers;
- Conduct research, to develop new products, and modify the existing products;
- Provide product and financial information for internal and external audits;
- Receive government reimbursements for service costs and premium subsidies;
- Meet the information and performance benchmark requirements of reinsurance companies;
- Resolve disputes.

Government:
The Government Agencies need data to service and operate the programs, to regulate the issuing agencies and reinsurers. Use the data set to research the development of the improved products. The government also wants to establish the product performance benchmarks. The data are used for internal and external audits and to calculate and disburse premium and service subsidies.

Actuaries need data:
Actuaries are in need of the data to establish the performance of benchmarks for program participation among farmers and to analyse the budgetary expenditures, evaluate crop insurance plans performance and to determine and monitor the subsidy funding levels and related expected expenditures.

Collecting Data:
Data sets are collected from several entities including the farm level, primary insurance providers, and private and public third parties.

Farm-Level:
Individual farm level yield and revenue insurance products require a great deal of data including: Crops produced, areas planted to specific crops, crop production practices, field locations, and yield histories, farm locations, names of insured farmers or landowners, and farm or farmer identification codes, insurance product choices, including the farm coverage levels, price elections, deductibles, co-payment choices, reseeding options, quality riders, and prevented to planting the types of crops

Primary Insurance Providers:

They must collect and manage data on:

- Program and product participation.
- Premium rates and revenues;
- Current year crop production by farm, program, product, and region;
- Indemnity payments by product and region;
- Retained risk and reinsured risk;
- Retained earnings;
- Surplus position of accounts;
- Product and program service costs.

Private and Public Third Parties:

Government agencies, international organizations, universities, research institutes, and other private companies gather data. Farmers and insurance providers often access third-party data that may have been collected for non-crop insurance reasons. In the foreign countries collect data on Historical production data by countries and region (often needed to establish premium rates and for other actuarial purposes);

- Weather and other proxy index data (for area-based insurance products);
- Experimental plot data for crops.

Storage:

Crop insurance programs are fully depending on past data, so data storage is important for maintaining program integrity. Ideally, all insurance information should be stored and managed at a central location that are trusted by all stakeholders. Farm-level crop production performance, and company performance data should be collected and maintained for all years. Storage issues that must be addressed include:

- Where will data be stored?
- Where will multiple data backups be stored?
- How will data security be managed?
- How will data be formatted for storage and accessibility?
- What security measures need to be implemented?
- Who will have access to data?
- What quality control measures will be used when entering data?

Access:

Data confidentiality must be strictly maintained and access limited to relevant parties. Storage excess is essential to prevent data loss resulting from accident or natural disaster. There is trust between government, private insurance companies, farms, and farm organizations are at issue, then storage must be provided by a trusted third party (Inc. "Watts",2014). If data are stored at a central location, then all program participants should be granted access to summary data and to their own confidential data, but not to other participants' confidential data. Oversight boards and regulatory agencies should have access to such confidential data as has been agreed to by all parties. Confidentiality rules must be strictly adhered to under penalty of law.

Business Operations:

Document Storage and management are important aspects of insurance programs. Details to be considered include:

- Who is going to store the insurance contracts?

- Will insurance contracts include references to other documents or will they be self-contained agreements?
- Documents must be signed and stored, and duplicates should be maintained in a separate secure place.

Business Processes:
Building confidence in crop insurance programs requires the development and adoption of solid business processes. Businesses must educate the farmers so that they understand products prior to purchase and recognize and minimize hidden costs to farmers, auditors, and managers and to reduce unnecessary costs.

Underwriting and Loss Adjustment:
Underwriting and loss adjustments are the important activities of successful agricultural insurance programs. Underwriting refers to the details involved in preparing crop insurance contracts including definitions, processes, rating, and dispute resolution issues. Loss adjustment refers to the processes used to report, verify, measures, and document losses resulting from covered perils.

4. CONCLUSION:

The development, implementation, and success of crop insurance programs require much coordination, cooperation, and shared visions. Financial sustainability depends upon offering products desired by Farmers. In addition, appropriate premiums must be charged and transparent business management systems must be employed. By using the actuarial methods, the actuary easily assesses the value of the risk, and easily predict the future loss and frame out the actual indemnity to meet out the losses, which is faced by the farmers. In many cases, government involvement is necessary in terms of providing regulatory services and/or financial reserves or subsidies. In addition, human resources with specific expertise must be developed before implementing an insurance program. Substantial human capacities are required in government ministries, insurance regulators, private insurance companies, and farmer's organizations. Many of these skills are specific to the agricultural insurance sector. Also, the cooperation among disparate groups must centre on a common vision and outcome.

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