

CLIMATE CHANGE AND OPTIMAL DESIGN PROBLEM OF AGRICULTURAL INSURANCE FOR DEVELOPING COUNTRIES

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Abstract: *This paper discusses the agricultural damage managing problems in the aftermath of a climatic disaster with particular focus on the progress of agricultural insurance in developing countries. There are numerous barriers to design an accurate (optimal) insurance plan in developing countries which reduce the efficiency of insurance contracts. Farmers in developing countries produce under multiple risks and their revenues are not sufficient to cover agricultural credit debts and insurance premium. This paper proposes a simple approach to mitigate agricultural risks through insurance by taking farm revenue on its center. The contribution of the paper is to show how optimal insurance plans could be designed for sustainable farm revenues in developing countries.*

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Keywords: *Climate change, damage managing, agricultural insurance, developing countries.*

1. INTRODUCTION

The effects of climatic variability and change on agriculture have become an important area of research since the early 2000s. The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as “the degree, to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes” [1]. Vulnerability means, as defined by the IPCC [1], openness to multiple exposures that could adversely affect livelihoods, ecosystems, environmental services, resources, and infrastructures.

Over the twentieth century, world agriculture has evolved under a variety of climatic regimes. As the climatic change debate gained academic and scientific priority several scholars began to pay special attention to the climate change and public adaptations issues Congleton [2], Shughart [3], Gawel and Lehmann [4] are among those scholars who help create a rich literature in the field.

Generally speaking agricultural production faces multiple sources of risks. Among others two major risks are of serious concern to the agricultural economy. These are price risk and production risk. The first is caused by potential volatility in prices due to liberalization of trade while the second results from uncertainty about the level of production caused by the effects of climate change. Due to global warming it is likely that production risk will increase in coming decades.

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Present study has particular focus on the progress of agricultural insurance in developing countries. Based on an examination of specific experiences and difficulties of developing countries, it aims to reveal the role of public support policies and private institutions in mitigating agricultural risk through insurance.

2. RESEARCH METHOD

The research method used in this study is a comparative analysis of practices and experiences of the developing countries using different agricultural insurance models with regard to specific barriers such as public policies, government support, agricultural credits facilities, and bureaucracy etc. to formulate an efficient contract both on the public and private side. On the basis of these specific barriers, the paper proposes a simple approach to agricultural insurance by taking farm sustainability as a sustainable revenue problem which combine agricultural credit and agricultural insurance problem in the core of the farmers' concerns.

3. AGRICULTURAL DAMAGE MANAGING PROBLEM

Historically, agriculture is a risky economic activity and producers face various types of risks and uncertainties such as production risk, yield risk, price risk, storage risk, market risk, financial and credit risk. Under uncertainties, all unpredicted agricultural risks cannot be mitigated fully; however, they can be minimized up to certain level with the help of insurance. Under uncertainty, expectation from insurance would be to cover farm income losses under adverse weather conditions. There are continuous efforts among the developing countries to manage the agricultural risks through differentiating insurance products against various risks. Risks faced by farmers are numerous, varied and specific to the area and climate. Some major risks faced by farmer are shown in Table 1.

Table1. Some Major Risk Faced by Farmers

Risk	Nature	Impacts
Adverse weather events	Rainfall, extreme temperature variability	Loss of partial or total product, lower yields, lower income
Biological risks	Disease, pests, contamination	Loss of partial or total product, lower yields, lower income
Price risks	Price volatilities in the markets, low prices,	Loss of income because of lower prices
Political risks	Regulatory changes, political upheaval, trade war	Restrictions to the market access, changes in costs and taxes.
Health risks	Illness contamination, death	Loss of farmers and productions, loss of income

Source: Author

Although, the main difficulty for developing countries is that the livelihood of a large proportion of their population depends on agriculture on small size holdings with little revenues. It is also very common structural weakness in developing countries that small producers having limited resources cannot access directly to the agricultural insurance without the support of governments. The problems of small producers in developing countries can be summarized into two points: First, low level revenues in small sized farming cannot allow to them cover agricultural insurance premiums and second, insurance schemes in developing countries are limited and provide only a basic risk cover plan. However, other risks related to farming, such as plant and animal breeding, crop and animal husbandry practices as well as precautionary prevention measures against adverse weather events and farming planning for managing need also to be covered.

AGRICULTURAL INSURANCE AS A FORM OF RISK MANAGEMENT

As a form of risk management agricultural insurance may help farmers to hedge against a contingent loss during their agricultural activity. So, they transfer risk of loss from themselves to another entity in exchange for a premium or a guaranteed and quantifiable loss to prevent a large and possibly devastating loss. Agricultural insurance mainly may include crop insurance and also livestock insurance, and aquaculture. Crop insurance is the most developed sub-line of agricultural insurance market, accounting nearly for 90 percent of the global premium underwritten worldwide.

In developed countries three factors contributed to the growth in agricultural insurance. The first factor was the increase of the agricultural insurance premium volume by the increase of the number of the insurance contracts. The second factor was the increase of the demand for insurance against raising climate risk in agriculture. The third factor was the increase of public sector support in agricultural insurance market. According to the World Bank classification, there are three main groups in agricultural insurance scheme.

Table 1: Agricultural Insurance Products and Payouts

<i>Type of Agricultural Insurance Product</i>	<i>Payouts</i>	<i>Availability</i>
Index Based Agricultural Insurance*		
<i>Area-Yield Index</i>	Area-Yield Loss	USA, India, Brazil
<i>Crop Weather Index Insurance</i>	Weather Index Payout Scale	USA, CANADA, Mexico, India, Malawi
<i>NDVI' Index Insurance ***</i>	NDVI Index Payout Scale	Mexico, Spain, Canada
<i>Livestock Mortality Index Insurance</i>	Livestock Mortality Index Payout scale	Mongolia
<i>Forestry Fire Index Insurance</i>	Burnt area Payout Scale	USA, Canada
Indemnity Based Agricultural Insurance**		
<i>Named Peril</i>	Percentage of Damage	Widespread
<i>Multiple Peril</i>	Yield Loss	Widespread

Source: World Bank, 2009. [5]

*Insurance payouts calculated on the actual loss at the insured unit level

** Insurance payouts based on the actual loss at the insured unit level

*** NDVI: Normalized Deviation Vegetation Index

Generally speaking an indemnity based agricultural insurance contract provides a farmer insurance against a named peril or multiple perils. Concerning named peril insurance, the name of the suggested injured case is made explicit in the insurance list. The calculation of the damage is based on the production cost or on the expected crop revenue. The level of the loss in production is determined as a percentage of the damage occurred by the insurer expert after the damage occurs.

As an example, we presume that a farmer signed a named peril insurance contract with conditions specified below:

Insured Peril: Hail

Sum Insured: US\$ 30.000

Indemnity Limit: Full Value

Aftermath of Disaster Loss Control by the Insurer:

- 50 % of the insured unit with 0% damage

- 50 % of the insured unit with 40% damage

Total Damage Calculation: $50\% \cdot 0\% + 50\% \cdot 40\% = 20\%$

Indemnity Calculation: Percentage of damage = 20% *US\$ 30,000

INNOVATIVE INSURANCE PRODUCTS

There are a number of new innovative insurance methods which propose to cover producers against uncertainty of income with the support of public and private sector. Among others, there are rainfall, livestock, and seed crop and crop-revenue insurance plans.

Crop- Revenue Insurance Plan

This type of insurance product combines the production and price risk. This insurance plan takes into account of the quantity losses in the aftermath of a climate disaster by valuation of farmer's loss on the basis of the market price or target price.

Rainfall Insurance Plan

Rainfall insurance is frequently in use in some large countries. In India, for example, this insurance product has been developed by an insurance company and some banking and non-banking financial institutions are related in its effective application.

Index- based Insurance Plan

Index-based insurance as the most appropriate insurance is highly associated with the losses of crop and livestock. Compared to others this product is highly diversified and allows some special innovative products, namely *Area Yield Index*, *Satellite Vegetative Index*, *Mortality Rates for Livestock*.

4. BARRIERS TO AN EFFICIENT INSURANCE PLAN IN DEVELOPING COUNTRIES

There are several difficulties in writing agricultural insurance. First, the definitions of the nature of the risks in the contract should be clear. Second, the coverage of the damage should also comprise the geographical dispersion of agricultural production and the complexity of the biological process of production. The both should be defined clearly to eliminate all potential asymmetries of information in the future. Third, there should be enough support from public funds.

From the point of agricultural insurer, verifying and valuation of catastrophe claims requires special attention and technical expertise. A thorough valuation of catastrophe claims is very important and claims should neither be magnified nor minimized. Insufficient technical expertise may generate incorrect decisions about the level of damage. Non technical experts are unable to distinguish between high-risk and low risk producers.

From the point of producer, if a non adequate expert set premiums on the basis of averages, he/she may attract only high-risk producers and, thus, generate asymmetries of information. In such cases low-risk producers, thinking that they may be considered as high –risk producers, may use less fertilizer or plant in less fertile areas or plant out of season.

Another difficulty on agricultural insurance contracts is setting the geographical dispersion of agricultural lands. Geographical dispersion generates huge operational and administrative costs if an agricultural land is widespread and products are not standard.

PROBLEMS ON INSURANCE SCHEMES IN SOME DEVELOPING COUNTRIES

Latin American Countries

Drought and floods are common as devastating perils that affect agricultural production in almost all Latin American countries. Hailstorms are frequent in southern countries, in Central America and in Western Mexico. Winter storms are common in Argentina, Chile and Uruguay. Tornadoes damage agricultural production in eastern Mexico and Baja California peninsula. Tropical storms affect agricultural production in Mexico, Central America and the Caribbean. Tsunamis have devastating effect on agricultural production in the Coastal area of the Pacific and Caribbean region [6].

Argentina

In Argentina nearly 25 percent of the total crop lands are highly open to hail risk and they are insured against hailstorms risk. Among others, wheat, soya bean, sunflower, maize and grapevines are under insurance program as important crops. Private sector insurance companies are growing and nearly twenty five companies compete in the sector. However, insurance sector needs to be diversified against multiple risks [6].

Brazil

Agriculture sector is very important for the Brazilian economy and provides various agricultural commodities to the world economy. Government subsidizes the crop insurance but the share of covered crop production in comparison to total crop production remains low. According to some experts, present government insurance program has some weaknesses and needs to be revised. Brazilian insurance system is based on a simple coverage package which includes too much risk with a weak coverage [6].

Asia - Pacific Countries

China

China is affected every year by huge natural disasters and agricultural sector faces enormous financial losses. On average 45 million hectares of crop area is affected by drought, flood and rainfall. According to the FAO reports, these natural disasters and other damaging factors, namely insects, pests and crop and animal diseases, cause a loss of nearly 12.5 billion US dollars in China. Crop production is more adversely affected than husbandry production. Agricultural insurance system has shown a significant development since 1982. Chinese government supports insurance companies. [6].

India

Agriculture is the primary sector which employs 70 percent of Indian population and contributes nearly 20 percent of Indian national GDP. For Indian people agricultural insurance is vital but it remains mostly insufficient [7].

First, crop insurance scheme was started under the Life Insurance Corporation of India (LIC) in 1972 in Gujarat for cotton (H-4 Cotton). However, cotton is not the only agricultural product affected from disasters. In India, the selection of covered product is based on “*Individual approach*” or on the initiative of government. Cotton insurance scheme was implemented in Gujarat, Maharashtra, Tamil Nadu, Anthra Pradesh, Karnataka and West Bengal but covered only a limited number of farmers. Afterwards, the scheme included some other products, namely groundnut, wheat and potato up to 1980 [7].

In the 1980's, a Pilot Crop Insurance Scheme (PCIS) based on *Homogenous Area Approach* which included oilseeds, cereals, millets, cotton, potato and gram was implemented in 13 states of the country. Within this scheme government supported 50 percent of the premium.

Comprehensive Crop Insurance scheme which started in 1985 in 15 states and 2 union territories covered 76.28 million farmers [7].

A National Agricultural Insurance Scheme (NAIS) was established in 1999 and it was implemented in 23 states 2 union territories. Three remarks can be made concerning this national scheme: First, the national system is based on homogenous area approach; second, the yield guarantee approach is in application; and third, system covers all borrowing farmers. This nationwide system covers the food crops, oilseeds, as well as commercial horticultural crops. In 2000's, India started to implement in 38 districts the Farmer Income Insurance Scheme (FIIS), being one of the most frequent risks, rainfall also was introduced in agricultural insurance scheme.

Mongolia

Livestock sector is the backbone of the Mongolian economy. It supports nearly half of the population in rural areas and accounts for 87 percent of agricultural GDP which constitutes around 14.6 percent of the national GDP [8]. The share of agriculture in the export is around 5.9 percent. Existence of variety of risks in this sector makes it to be considered uninsurable. Therefore, an Index based Livestock Insurance Project began to be implemented in the country as a solution. This project received a mutual financial assistance from IDA, World Bank and Japanese Government between 2005 and 2010 [8].

Although agriculture is still important for Mongolian economy, a strong growth in mining industry in the past few years, with a contribution of only 11.7 percent into GDP in 2003 to 22 percent in 2015, has had serious implications for agriculture sector mainly due to migration of labor from agriculture to the mining industry. Only one important agricultural product, cashmere, became an export product. Cashmere retail provides the main export revenue while the importance of other agricultural products diminishes and their coverage against climate change with an insurance scheme reduces [9]. According to the experts in the field, without agriculture growth there is little chance of diversifying the Mongolian economy and breaking its dependence on mineral export for reducing poverty and hunger. On the other hand, as a result of a harsh climate it is difficult to promote cultivation. One possible solution proposed from FAO and ISFB is to promote a labor intensive production around the urban areas of the major cities by creating arable or horticultural lands [9].

Malaysia

In Malaysia agriculture sector is divided between big and small farmers. There are large numbers of small scale producers and, unfortunately, they have very feeble interest in purchasing of insurance because of low revenue problem. But, the large scale producers are more interested in insurance coverage contract. The crop insurance include palm oil, rubber, cocoa, tropical fruits such as durian, mango and mangosteen. It is clear that crop insurance program is more common than livestock insurance in Malaysia. So, a crop insurance program is undergoing a development facing diverse risks including climate change [9].

Philippines

Every year, Philippines suffer around 22 cyclones and also endure risks of drought and pests attack. For managing these risks, Land Bank of the Philippines, as a prime public bank for

agricultural sector, started a crop insurance program in 1981. Since 1984, a nationwide crop insurance company “Philippines Crop Insurance Corporation” offers risk management support to producers. Especially for maize and rice, there is a compulsory involvement of farmers in the crop insurance scheme because these are the most important export products. So, in this country export products receive more support than others and they also have some other types of incentives by the government [9].

5. AGRICULTURAL INSURANCE IN TURKEY

In Turkey, transformation of the farms into large scale lands is expected to improve land use with potential benefits for agricultural productivity and water resource management. Another key concern is that water scarcity, water quality and soil erosion become more and more significant as a result of climate change [10].

In Turkey, traditional agricultural insurance has been available only for hail since 1957; however, only 0.5 % of agricultural areas were insured until 2000s. Therefore, in 2005 an agricultural insurance pool “TARSIM” was created in Turkey, as a public-private partnership in agricultural insurance. TARSIM is responsible body for managing all works and procedures of this pool. It provides insurance coverage for catastrophe risks like drought and frost that cannot be covered by a single insurance company but also provides standardization in insurance contracts which cover the risks under the scope of the law [11].

In crop insurance TARSIM provides a wide range of covers for every type of crop regardless of the region. The pool realized an expansion into drought insurance based on a pilot scheme and also into epidemic diseases for livestock insurance. In livestock insurance, the use of smart glasses in loss adjustment for taking audio and video recordings started in some areas on the basis of pilot projects [11].

One of the significant effects of the TARSIM on agriculture sector is that the producers start to apply modern agricultural techniques because of the insurance requirements. For example, for hail risk insurance, farmers have to build modern greenhouses. Another important effect of TARSIM is that the insurance penetration is significantly increased from % 1 in 2006 to 15 % in 2016. In this insurance pool there are nearly 25 insurance companies. Insurance market had a positive reaction to the system.

Only registered farmers may apply for the insurance. For a valid application, farmer’s land and crop information for the pertinent year should be updated in Farmer Registration System (FRS). Later, farmers make their application to one of TARSIM’s member insurance companies or their agencies. The insurance company or its agency will conduct relevant queries on the farmers’ information via TARSIM’s online system. In the aftermath of a natural disaster, loss adjustment is carried out by loss adjusters (experts) appointed by TARSIM. After completion of the claims file, finalized indemnity amount will be paid by TARSIM within 30 days to the insured through a bank [11].

The insurance covers any losses on crop, livestock, garden plants, poultry, aquaculture and greenhouses (cover construction, technical equipment and crop) after risk assessment due to hail, storm, flood, whirlwind, fire, earthquake, and snow and hail weight. Producers should present their claims notification within 24 hours directly or via an agency to TARSIM. There is 50% premium subsidy by the government for all covered products.

6. OPTIMAL DESIGN PROBLEM OF AGRICULTURAL INSURANCE

HOW CAN WE DESCRIBE THE SITUATION OF A SMALL SIZE HOLDING PRODUCER IN REGARD TO OPTIMALITY OF HIS INSURANCE CONTRACT?

We assume that farmers produce under normal supply and demand conditions. If they encountered a production shortfall in crop, they might expect this to result in a rise in price. To some extent, such a rise will cancel out the financial loss of the farmers who suffers a production shortfall. But this will only be the case, if they harvest sufficient crop and sell it at sufficient premium over the expected price. Unfortunately, if the reason of the shortfall is a climate disaster, there would not be sufficient crop. Therefore, crop-revenue insurance provides a guaranty of the revenue in the case of a shortfall in revenue from crop sales.

Proposition: A Basic Model- Small Size Farmer Facing Climate Change Challenge

Risks faced by farmers are numerous, varied and can be specific to the area and climate. Some major risks faced by farmers are shown in the Table below.

Table 3. Some Major Risks Faced by Farmers

<i>Risk</i>	<i>Nature</i>	<i>Impacts</i>
Adverse weather events	Rainfall, extreme temperature variability	Loss of partial or total product, lower yields, lower income
Biological risks	Disease, pests, contamination	Loss of partial or total product, lower yields, lower income
Price risks	Price volatilities in the markets, low prices,	Loss of income because of lower prices
Political risks	Regulatory changes, political upheaval, trade war	Restrictions to the market access, changes in costs and taxes.
Health risks	Illness contamination, death	Loss of farmers and productions, loss of income

Source: Author

Under volatile supply and demand conditions a farmer may encounter following prices:

Grower's Price: Producer's price on the harvested area (1)

Expected Market Price: It represents the equilibrium point where demand and supply meet in the market place. New information such as product failure, widespread disease outbreak, and a major revision to previous production estimate may alter the expectation of the buyers and sellers in the market. (2)

Farmer's Expected Selling Price: It represents the maximum sales price objective on the anticipated total cost of farmer. (3)

Farmer's Effective Selling Price: Depending open the competition and price offered in the market, farmer's selling price. (4)

If expected market price is higher than grower's price, a farmer's effective selling price would be approximately close to the market price.

If the effective harvested quantity is almost reached to the expected maximum harvested quantity farmer's brut revenue will reach to the maximum level as on expected by the farmer.

Expected Brut Revenue = *Effective Selling Price per Unit* x *Effective Harvest Quantity* (5)

Net Revenue: *Expected Brut Revenue* – (*Farming Fixed Cost* + *Farming Variable Cost* + *Agricultural Credit Cost* + *Insurance Cost*) (6)

So, sales performances are essential for the sustainable revenues for farmers. First, sales revenues of the farmers should cover their agricultural credit debts. Second, because of unexpected weather events small farmers should purchase insurance contracts and could be able to pay their premium with their sales revenues.

Unexpected weather events are major threat to the resilience of farmers. In case of a catastrophic event, if farmers encountered total or partial losses of their products they may be covered financially if they had purchased insurance contracts before the event. On the whole, small farmers in developing countries are not able to purchase insurance contracts because of the revenue constraints. However, if there is no insurance they would not be financial resilient to continue farming in coming years. This may cause a permanent fall in supply and also unexpected increase in prices of related products. Therefore, government intervention to the national insurance system would be unavoidable because private sector insurance funds can not cover huge agricultural damages in a country. An optimal insurance plan should sufficiently cover farmers claimed injuries.

Crop–revenue insurance products entail the determination of loss on the basis of an area. For an accurate determination of product loss, governments should make use of some digital databases. For the correct calculation of the production and related revenue losses, it is important that the price element should have to be taken on the market-based price that is on future prices for the coming season.

The use of an alternative price, namely “a *target price*” by governments, could lead to a distortion of supply, if it is not reached to the market price of the coming season. In that case, it is unlikely that a crop revenue insurance based on a target price (i.e., non –market price) would find underwriting support. Target price model may be suitable if the development of local crop future markets is the case.

PROBLEMS AND CHARACTERISTICS OF FARMING IN DEVELOPING COUNTRIES

Problems and some characteristics of farming in developing countries may be summarized as follows:

1. In developing countries, farmers are processing with a low resources base and have small sales revenues because the grower’s price is less than the market price.
2. Developing countries have restricted financial resources for public expenditure as compared to developed countries.
3. The amount of fiscal resources remains insufficient for encouraging insurance market.
4. The size of agricultural enterprises is very small as compared to developed countries.
5. In developing countries due to the predominance of small size farming, risk bearing abilities and resource endowments remains insufficient.
6. Administrative costs for insurance products designed for smaller farms are significantly higher than that of the larger farms.
7. In developing countries livelihoods of population depends largely on agriculture and this generates insufficient income revenue and income transfer to public resources.

8. In developing countries, there is non-availability of a database to estimate the loss assessment on area or land basis.
9. In developing countries, there is significant weakness on necessary local expertise (on area base or land base).
10. Developing countries could not access to the satellite technologies for accurate risk assessment.

The risk-layering concept is useful for analyzing the optimal combination in an agricultural insurance product. Some less frequent losses are more manageable than the frequent and catastrophic losses. They cannot be managed through either on-farm risk management or mutual insurance scheme because they may cause huge financial losses. So these losses need to be transferred to commercial reinsurers.

7. CONCLUSION

In developing countries, farmers possess little resources and have small sales revenues as the grower's price is well below than that of market price. Sustainable farmer revenues are essential for maintenance of farming activity and of course food security policy in developing countries. Therefore, farmers need to be united under farmer's organizations to solve marketing problems of their products and improve their selling performances. Governments should work with farmer's organizations to make the insurance products sustainable in order to stabilize income. The role of governments is crucial for successful implementation of the crop insurance plans. On the other hand, private sector companies may also be encouraged, by the support of the governments, to take part in the insurance system. So that private sector may also provide various insurance products and contribute to the growth of agricultural insurance sector.

The risk-layering concept is useful for analyzing the optimal combination of an agricultural insurance product. Some less frequent losses are more manageable than the frequent and catastrophic losses. These cannot be managed through either on-farm risk management or mutual insurance scheme because they may cause huge financial losses. So these losses need to be transferred to commercial reinsurers. An optimal insurance plan should sufficiently cover farmers claimed injuries. Our finding is that the role of the government is vital for accurate risk assessment management in developing countries. Developing countries could not access to the satellite technologies for accurate risk assessment and could not collect strong database to estimate the loss assessment on area or land basis.

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