2.1. Introduction

Everyone knows that agriculture is an important sector in the developing countries from various economic standpoints. In different times the government of developing countries has taken various financial policies to improve the conditions in agriculture. In the developing countries most of the farmers are small and marginal and they face various risks such as flood, draught etc. In this situation crop insurance serves as an important instrument to safeguard the farmers against risk and uncertainty. It gives income protection, helps them to increase their production capacity and also encounter risk in production. Though the government has introduced various insurance policies (such as CCIS, NAIS, FIIS and rainfall, climatic relief fund) to ensure financial security and to encourage participation in insurance policy. But there is the negligence in case of risk sharing because they bear no risk Sinha (2004). Besides, the private insurers also come forward to help the farmers and bear the risks by introducing insurance in agriculture. But they also fail to give equal importance to all type of farmers (large, small and marginal). The farmers remain unable to get appropriate or perfect protection from agricultural risk and most of the farmers (small and marginal) depend on mercy of environment. So both the public and private insurer faces adverse selection, moral hazards and high administrative cost problems. But if the risk sharing agreement between public and private makes an appropriate design, it will be able to reduce the problems of moral hazard and adverse selections (Sinha 2004).

In this chapter, we shall present a brief review of existing literature on crop insurance. In this studies we come across various explanation about the pattern and structure of crop insurance, individual crop insurance, area yield crop insurance, problems of crop insurance (moral hazard, adverse selection, and high administrative cost), estimation of moral hazard and adverse
selection problem, in crop insurance, optimal area yield insurance and designs of optimal area yield crop insurance, subsidized crop insurance and conceptual explanation of crop insurance.

This chapter is organized as follows. Section 2.2 deals with the review of existence literature on crop insurance system in Indian agriculture. In section 2.3 we shall review the literature on crop insurance study asymmetric information. In section 2.4 we shall present review of literature on study on the demand for crop insurance. Section 2.5 is based on area yield crop insurance. The problem of crop insurance has been considered for review in section 2.6. In section 2.7 we have discussed about fertilizer use and it effects on environment and crop insurance. The studies of crop insurance for its effects on target yield level /coverage level have been considered for review in section 2.8. Finally, we present the conclusion of this chapter in section 2.9.

2.2. Crop Insurance System in Indian Agriculture

Indian crop insurance system has been analyzed in several studies by various economists with intention of giving appropriate protection from agricultural risk to the farmer.

According to Dandekar (1976) the agriculture is at the mercy of the vagaries of monsoon and this is the main source of income of majority of India’s population. Since various natural calamities hurting agriculture are beyond the control of the farmers, Dandekar (1976) has pointed out that the crop insurance is a vital technique to protect the farmers from crop loss. For this purpose he has recommended to introduce individual crop insurance in Indian agriculture but this insurance policy suffers from various problems such as moral hazard problem, adverse selection problem, and high administrative cost. Therefore, further, to overcome the problems of individual approach crop insurance policy he has recommended another crop insurance policy such as area approach crop insurance. The area approach crop insurance policy eliminates the moral hazard problem and reduces the scope or effectiveness of adverse selection problem and also reduces the administrative cost. He has pointed out that in the area approach scheme the area should be homogeneous either on the basis of the payment of premium, received indemnity, in relation to crop risk or in relation to agro-climatic conditions such as soil, Variety of the seeds used, farming practice. He proposes that the principal actuarial aspect of the crop insurance scheme varies year-to-year in crop yield and it depends on the terms and conditions on which
The indemnity becomes payable and determines the rate of premium. He suggested that less risk areas should be charged “slightly higher, but only slightly, higher premium than warranted” to subsidies more risk areas. He also argued in favour of direct subsidy in high-risk areas for small and marginal farmers.

Finally he points out that if the crop insurance scheme is compulsory for all farmers of an area, it will be not possible to collect the premium easily. In that situation he has suggested that the crop insurance may be linked to short-terms agricultural credit and the crop insurance scheme becomes a crop-loan insurance scheme. All crop loans should be compulsorily insured and premium should be deducted from the loan advance. Indemnities should be adjusted against recovery and any additional administrative cost may be raised.

**Dandekar (1985)** gives brief review of the crop insurance in India from 1976-85. Actually between 1979-80 the general insurance scheme introduced a crop insurance scheme (area approach or area yield crop insurance) in 26 areas in Gujarat, 23 areas of West Bengal and 17 areas of Tamil Nadu in collaboration with the State Government and this insurance scheme further has been extended to more areas of many more states. The central goals of this review is to trace the methodological modifications made from time to time in the original crop insurance scheme and identify certain outstanding problems followed by suggesting of provisional solutions. Finally in this paper he suggests that crop insurance scheme should be made compulsory to all borrowing farmers or for a specific section of the borrowing farmers such as the small farmers defined by their (small farmers) credit eligibility. He points out that crop insurance will be integrated with the crop loan insurance and there will be no need to issue separate policy to each insured farmer.

**Iftt (2001)** analyzed the true story of crop insurance in India in the paper “Government vs. Weather”. In India widespread crop insurance scheme started by introducing the Comprehensive Crop Insurance Scheme (CCIS) in 1985. The said scheme suffered from a lot of problems-a) high percentage of claims to premium; b) high administrative cost (5-7%) typically; c) mandatory for loanee farmers; d) acting as “bank insurance”; e) 22 states/union territories participate in the CCIS. In order to solve these problems, in 1999 it was replaced by the National Agricultural
Insurance Scheme (NAIS). The NAIS is reported to suffer from the main defects of the goal of financial viability, mandatory nature, and failure to address adverse selection; arbitrary premium rates and the area yield approach. Over all Government crop insurance policy becomes failure, but the Indian Government have ignored both its own failure and the failure of the other countries. Though, internationally, the private crop insurance is not highly developed but different types of private crop insurance program do exist. Jennifer Iftt (2004) remarked that if India withdrew from crop insurance schemes, it could still support the farmer through an income guarantee scheme or a risk management tool or investment in infrastructure.

Sinha (2004) undertook a study of interstate comparison with respect to the effect of crop insurance policy. He has explained the agricultural insurance system in India and expressed the views, which are different to a great extent from those of the previous authors. In India the General Insurance Corporation (GIC) managed crop insurance, which was delivered through rural financial institution. But later the newly formed Agriculture Insurance Company (AIC) of India has taken over the role of the implementing agency (IA) from the General Insurance Corporation (GIC). In India different types of crop insurance schemes have been introduced one by one. These schemes are National Agricultural Insurance Scheme (NAIS) replacing Comprehensive Crop Insurance Scheme (CCIS) and Firm Income Insurance Scheme (FIIS) replacing NAIS. Besides, the Calamity Relief Fund (CRF) and the Rain Fall Insurance (RFI) also are introduced in agriculture.

From the analysis he shows that under the NAIS the participation rate is low but claim to premium ratio is high. The NAIS has covered only about 10 percent of gross cropped area and the claims to premium ratio were about 4.17 in Kharif crop till 2002. Sinha (2004) has rightly considered this phenomenon of low participation with high claim as something paradoxical. Interstate analysis of Sinha (2004) shows that Gujarat (43%) tops the list of total claims followed by five state (Maharashtra, Andra Pradesh, Madha Pradesh, Orissa and Karnataka which jointly account for 48%) and remaining state (Chhathisgarh, Tamilnadu, W.B, Uttar Pradesh, Bihar and other states which jointly account for 9%). This indicates a problem of adverse selection induced by the general uniform rates. For inadequate monitoring and control the program suffers from problems of moral hazard.
He also explains the activities of a new Farm Income Insurance Scheme (FIIS), which is strictly ‘crop’ income insurance and not ‘farm’ income insurance as it is designed to protect the income from a particular crop. In the FIIS the indemnity is measured by income shortfall and not just by yield shortfall. The origins of the FIIS lie in the attempts to reform the minimum support price (MSP) based procurement of food grains. As the MSP would be the basis for calculations of the indemnity on insurance.

Further he points out the activities of calamity funds and rainfall insurance. In the calamity relief funds (CRF) the center and state contribute to this fund in the ratio of 75:25. The CRF is to be used for meeting the expenditure for providing immediate relief to the victims of cyclone, drought, earthquake, fire, flood and hailstorm. On the other hand the rainfall insurance policy makes payments if the cumulative rainfalls during the season falls below the historical average. The rainfall insurance is able to eliminate the moral hazard problem completely.

From this analysis it has been shown that if the crop insurance system is managed by the government (AIC) then we observe some disadvantage as it bears no risk and gives poor internet in controlling moral hazard and adverse selection. But if private insurer manages the crop insurance system, they bear all the risk. But it has also disadvantage as it pays more attention to larger farmers. According to him there is possibility of public-private risk sharing between these two extremes. And if the risk sharing agreement makes an appropriate design, it will be able to reduce the problems of moral hazard and adverse selection.

Kalavakonda and Mahul (2005) analyzed the activity of crop insurance of India’s second largest driest state Karnataka and pointed out the weakness in product design, implementation challenges and operational problems. From the analysis they have found that the running crop insurance scheme failure to attain both of its explicit (risk management) or implicit (safety net and containment of both the central and share governments’ contingent liability) hypothesis, as a result the insured coverage acreage and number of insured farmer and also the financial activities were not satisfactory. Therefore, they provide a crop insurance design on the basis of cost effective risk management technique. Finally, they provide new ideas to improve the crop
insurance scheme and sketch the alternative-crop insurance scheme on the basis of an area–yield approach.

**Veeramani, Maynard and Skees** (2005) have assessed empirically the risk management potential of a rainfall based insurance index and rainfall options in Andhra Pradesh, Kanataka, India. In this study they have used historic monthly rainfall data for the Costal Andhra Pradesh subdivision for 130 years from 1871 to 2000. For the empirical analysis the rainfall insurance is performed over the three different revenue elasticity level (0.4, 0.5 and 0.6). They found that relative risk of rainfall for the Kharif season is lower [coefficient of variation (CV) is 19.63%] than the relative risk for individual months (CV in June 47.22%, July CV 35.93%, August CV 36.41%, September CV 34.61%, October CV 51.22%). They have shown that after accounting for the elasticity of revenue with respect to rainfall, the actuarial premium rates is relatively higher than the current crop insurance premium level. The higher actuarial premium rates are consistent with the rainfall insurance. The higher premium rates discourage participation in the crop insurance program. But if an optimization technique is used, there will be the way to get lower premium rates. Even risk swapping between localities can reduce the premium rates.

They have noted that put rainfall options would be appropriate for the farmer who wants to protect against drought and call rainfall options would be appropriate for the farmer who wants to protect against flooding. Since agriculture occupies a significant part of the economy adverse deviation in rainfall can affect the stock markets and traders can protect themselves by hedging their stock with rainfall options. They have concluded that although higher premium rates identified in this article may discourage the demand for insurance products, rainfall based crop insurance products are quite attractive to institutional investors and have vast potential in encouraging private participation in crop insurance.

**2.3. Crop Insurance Studies related to Asymmetric information**

**Miranda and Glauber** (1997) analyze the systematic risk, reinsurance and failure of the crop insurance market by using an empirical model of the U.S.A crop insurance market. There is the reference of a half-dozen conditions for a class of risks to be insurable. But they have analyzed two conditions, which are particularly relevant. First, the risk should be very nearly
stochastically independent across insured individuals. Second, the insurer and the insured should have very nearly symmetric information.

To measure the systemic crop loss risk faced by the U.S.A crop insurer, they have developed a stochastic simulation model of farm level crop insurance indemnities. By using this model they have computed the variability and systemic risk ratios of the crop insurance portfolios of the ten largest crop insurer in U.S.A. From the empirical analysis they have remarked that the systemic risk is substantial and the systemic risk ratios indicate that U.S crop insurers face portfolio risks anywhere from 22 to 49 times larger than if indemnities were independent. They have also shown that the crop insurers faced ten times larger portfolios risk than the private insurers.

In order to avoid the systematic crop loss risk they have considered crop reinsurance, area yield reinsurance contracts or area yield options contracts, which are more advantageous than government insurance program and private crop insurance program. The area yield options contracts offer a potential solution to the systemic loss risk problems and also offer protection against regional yield short fall and the catastrophic losses from widespread natural disasters and it reduces the variation in crop insurance company.

Makki and Somwaru (2001) examine factors that influence farmers’ decision to participate in the agricultural risk insurance market, and analyze the choice of insurance contracts under various economic and policy scenarios. They also discuss different ways of creating incentives to increase and diversify the insured pool of participants in the yield and revenue insurance market. To examine these criteria they have used artificial neural network models. In this study they have collected data for the years 1995-1999 from Risk Management Agency (RMA) in the USA Department of Agriculture, which maintains individual record. From an empirical analysis they point out that the important factors that affect the decision to participate in the crop insurance program and the choice of the contract include the availability of new revenue insurance products, the level of risk, premium rate, the level of subsidy and the design of the contract. Finally they have pointed out that the premium subsidy is an important incentive for participating in the crop insurance program. Even though lower premium rates through increased subsidies increases participation, it may also create a perverse incentive to assume
more risk. According to them increased participation or the interest of the farmer in the insurance program can be sustained by offering more product in more areas to meet the needs of different farmers, setting premium rates proportionate to risk and judicious use of premium subsidies.

**Sherrick, Barry, Ellinger and Schnitkey** (2004) have observed that the various studies by Gardner and Kramer, Goodwin and Smith, Knight and Coble, Makki and Somwaru have disclosed the effects of many factors (such as the costs and returns of insurance, yield and other business risk, financial risk, farm size, enterprise and other form of diversification, coverage levels, and relationships to adverse selection and moral hazard) on crop insurance purchase decision by using the data from USDA’s Risk Management Agency (RMA).

They have examined farmers’ choices among alternatives crop insurance and determine how the level of risk, risk management practices, production, and financial factors influence these choices. They have used two-stage process to evaluate the farmers’ decisions to purchase crop insurance and their choices among alternative crop insurance products. In this study they have included the factors that are level of risk, importance of risk management as a modifier of risk, financial structure, wealth (tenure), attitudinal attributes implied by age and education, and expected yields as an indication of management ability and return level, farm size, livestock enterprises and off-farm income.

From the survey results, they have pointed out that the averages of farm size, debt use and leverage, leasing land, self-assessed probability of receiving yield indemnities, and number of landlords of crop insurance users exceed than nonusers. Again the average values of farm size, debt use, and leverage, and intended expansion of insurance use are highest for crop revenue insurance users and lowest for hail insurance users. The revenue insurance users are younger have higher level of education and earn more off-farm income.

Further, shown that the insurance users are greater important than the insurance nonusers to risk management. In case of revenue insurance the risk management important scores are highest, and intermediate for yield insurance and lowest for hail insurance.
From the empirical analysis they have also supported that the insurance users have significantly larger acreages, older ages, higher debt-to assets ratios, greater leasing of farmland, higher perceived risk, higher expected yields and greater importance attribute to risk management. Among the insurance users, intentions to increase acreages are positively and significantly associated with use of both yield and revenue insurance relative to hail insurance.

Finally they have remarked that the crop insurance serves as an increasing important instrument of agricultural policy. They concluded that among three alternative crop insurance policies such as, hail insurance, yield insurance and revenue insurance, the revenue insurance policy is more attractive relative to the hail and yield insurances to the farmers’. The probability of using revenue insurance increase, and the probability of using yield insurance decreases and the probability of using hail insurance is constant.

2.4. Studies on the Demand for Crop Insurance

Goodwin (1993) analyses the demand for multiple peril crop insurance of the Iowa Corn Producers by taking 99 Iowa counties for the period 1985 to1990. There are several factors such as, yield, loss risk, characteristic of the farm operation, land values, premium rate etc., which affect the soundness and profitable of crop insurance. Before this study the empirical analysis of the demand for multiple perils crop insurance has received limited attention. Thus the objective of this study is to evaluate and quantify how these factors affect farmers’ demand for multiple peril crop insurance.

He sets up an empirical model to analyze the demand for multiple peril crop insurance. In this model he derives the demand for crop insurance function for producers, by maximizing the expected utility of profit yields, and considers the loss risk term to evaluate the effects of premium changes on the demand for insurance.

He finds that most of the parameters are generally statistically significant and have the correct sign. But the percentage of full time farmers and not irrigates farmers and relative livestock are not statistically different from zero. By estimation of the data, he finds out that the elasticity of demand for relative acres is –0.32 and –0.73 for liability per planted acre, that is the liability
equation is much more price elastic than the relative acres equation. This reflects the facts that insurance purchase can be adjusted by changing yield and price election as well as by canceling coverage altogether. He seeks out the relationship among loss-risk, price elasticity and premium rate, and also between land value and price elasticity, characteristics of the farm operation and price elasticity of demand for crop insurance. He shows that as relative loss risk increases, the price elasticity of demand falls significantly, and this is indicated by the significant positive coefficients on the premium risk interaction terms in each demand equation.

Also, he represents, that counties with low loss-risk have considerably more elastic demand for crop insurance than those counties where producers typically collect high indemnities relative to their premium payments. This suggests that increasing premiums rates for all producers would increase aggregate loss-risk levels among the pool of participants as cancellation occurred among low-risk producers at a significantly higher rate than high loss-risk producers. In this respect if premium rates will rise the problem of adversely selected pool of participant may be aggravated and as a result the overall industries loss-ratio may be raised.

He finds out from his empirical analysis, that the land values have significant positive effects on insurance purchases. He has shown that the counties with more land in tenancy and rental arrangement are more likely to participate in insurance programs.

Again farm operation characteristics are regarded as a significant determinant of participation in insurance programs. Consequently, proportion of farm acreage is operated by corporation rises and participation rises. And large farmers are also more likely to purchase insurances.

Finally from the evaluation of count-level loss ratios, he observed skewness of the distribution, which suggests the presence of adverse selection in current and pervious premium rates.

Sakurai and Reardon (1997) have examined thoroughly empirically, using farm household data in Burkina Faso, the demand for formal drought insurance of developing countries, in the drought prone zone of the West African Semiarid Tropics (WASAT). Before, this study, there were very rare analysis of demand for formal drought insurance in the developing countries. In the developing countries informal self-insurance policy is observed. But there are exist certain
defects of informal Self-insurance, such as-a) most informal strategies do not fully self-insure in the case of drought, which affects all household within a village or even over large areas and it also unable to fulfill the required demand of the household during severe drought; b) for not having experience drought simultaneously few informal risk sharing mechanisms face a moral hazard problem to household which is discoursing self-insurance or the purchase of formal insurance polices; c) the informal self-insurance is costly. Therefore formal insurance policy is needed to overcome these defects of informal insurance. The formal insurance can pool risk across agro-climatic zones and will be less costly than the informal insurance. They have distinguished between self-insurance and formal insurance equilibrium, which help to develop a novel estimation method for potential demand for drought insurance as a function of the premium rate.

From the empirical estimation of parameters of the production function they have observed that the crop diversification has not always a negative effect because both output and risk decrease in a drought year and increase in a good year.

There is effective demand for the hypothetical formal drought insurance in all zones. There is unequal access to off-farm employment because of substantial entry barriers for the poor and very unequal distribution of assets, especially livestock. Such demand is much correlated with agro-climatic zone because drought risks differ over zones.

From the analysis of the determinants of demand for drought insurance, they have shown that the demand for drought insurance depends on how households manage risk ex ante and ex post so there is much heterogeneity within an agro climatic zone. But the drought does not occur simultaneously over zone. It is possible to avoid co-variability and then the drought insurance scheme is feasible. Again the demand for drought insurance is less for the wealthier households who are more self-insured and they suffer from small income shocks from drought. In some cases initial assets allow the household to take risk decisions that lend to demand for insurance.
Again they found that public food aid has a significant negative effect on insurance demand in the sahelian zone and it may cause moral hazard and discourage self-insurance or formal drought insurance and also smoothes income.

The negative significant effect of off-farm income and livestock holdings on demand for formal insurance supports the hypothesis that those who do not have self-insurance mechanisms demand more drought insurance because they tend to suffer large income shock from drought. The result shows that it is true not only for the upper livestock-holding stratum but also middle livestock holding stratum and lower livestock holding stratum. The formal drought insurance can substitute for livestock holding. Finally, they have pointed out that the formal drought insurance is only one policy tool to an unmet need for insurance against risk in the West African Semiarid Tropics (WAST). According to them another potentially promising approach is to facilitate self-insurance by public policy to reduce entry barrier for the poor to enter nonfarm employment through micro credit and training programs.

We point out that the demand for crop insurance purchase has significant effect on the land value. The more self-insured farmer demand less drought insurance as they suffer from small income shocks from drought. On the other hand, the farmers have no self-insured mechanisms demand more drought insurance because they tend to suffer large income shock from drought.

2.5. Studies on Area Yield Crop Insurance

Miranda (1991) has analyzed area yield crop insurance theoretically and empirically with the help of linear additive model about the western Kentucky Soybean producers of the USA. In the linear additive model he shows the relationship between average yield of individual producer’s (dependent variable) and the average yield of a surrounding geographical area (independent variable) and a random error term, which is uncorrelated with the aggregate area yield. The linear additive model decomposes individual yield into a systematic component that is perfectly correlated with the area yield and a non-systematic component that uncorrelated with the area yield. Before area yield crop insurance program the individual yield crop insurance program has been introduced in agriculture. In this case of individual crop insurance program indemnity is paid to the insured farmers on their own yield loss. In the individual crop insurance program
three important problems will arise; namely adverse selection, moral hazard and high administrative cost. These problems weaken the actuarial performance of the crop insurance program and fail to attract large number of farmers. In that situation Miranda gives assurance for accepting area yield crop insurance program. In this insurance program, in the insured area, the farmers receive the same amount of indemnities per insured acre due to crop loss and pay the same premium to the insurer. Area yield crop insurance program significantly reduces adverse selection problems and substantially reduces the administrative cost and finally eliminates moral hazard problems. So he pointed out that area yield crop insurance is an important risk-reducing tool in agricultural insurance policy. Theoretically he pointed out that if the area yield falls below critical yield ($y_c$, expressed both in bushels per acre and as a percentage of the normal or expected area-wide yield of 30.7 bushel per acre), then in the insured area the farmers receive an indemnity per insured acre. The area yield insurance is risk reducing for agricultural producer if individual beta ($\beta_i$, it measures the sensitivity of the producer’s individual yield to the systemic factors that affect the area yield) exceeds the critical beta ($\beta_c$ it measures the sensitivity of the critical yield to the systemic factors that affect the area yield). Again he shows that if both the producer’s yield and area yield is more highly correlated and the higher a producer’s yield variance then area yield crop insurance is the greater risk reduction contract than the other agricultural insurance policies.

The critical beta varies directly with the critical yield (Critical yields are expressed both in bushels per acre and as a percentage of the normal or expected area wide yield of 30.7 bushel per acre). At the sufficiently low value of the critical yield, the critical beta reaches its minimum. Again for sufficiently high value of critical yield, the critical beta reaches its maximum of one-half (0.5). Under the full coverage area yield plan, the actuarially fair premium rises with the critical yield. The area-yield insurance is completely ineffective at the sufficiently low critical yields then the actuarially fair premium is zero. Again if the critical yield level is sufficiently large (high), the area yield insurance is effective and then the actuarially fair premium raises and the average optimal coverage level is equal to 100%. In that situation the betas’ distribution possesses a regular bell shape, which is centered on one and exhibits no discernable skewness.
Finally he compares among the individual-yield plan (IYP), full coverage and optimal coverage area-yield plans (AYP). Under the IYP, the actuarially fair premiums are based on individual yield experience and this is how varying among producers. Under full coverage AYP the premium is based on the area yield experience and it is the same for all producers. In case of the IYP and full coverage AYP the average premium paid by the producer is 27% of the normal area yield. Again under the optimal coverage AYP the optimal level of coverage per planted acre varies among producers. And the average optimal coverage level across producer is 160%.

From the comparison of the relative performance of three alternative crop insurance plans (IYP, FAYP, OAYP) he points out that on average, the risk reduction is greater in case of the optimal coverage area yield plan than the IYP or the full coverage AYP. Again the producer with highest beta (individual) tends to enjoy the greatest relative risk reduction in case of the optimal AYP. The producers with the highest yield variance tend to enjoy the greatest relative risk reduction in case of IYP. He notes that both the small and large producers will tend to prefer the optimal AYP to the IYP. And the large producers enjoy the greatest benefit from the AYP.

**Williams, Carriker, Barnaby and Harper** (1993) have studied the “crop insurance and disaster assistance design for wheat and grain Sorghum” (name of the crop). In this study, they have compared the effectiveness of two crop insurance designs, two disaster assistance designs, a linked crop insurance and a government commodity programmed for reducing net returns risk. These insurance policies are evaluated by using primary farm level data for wheat and grain sorghum enterprises in a uniform production region in 45 south central Kansas and for wheat enterprises in a less uniform production region in 36 northwest Kansas. They employ the stochastic dominance analysis of the net returns distribution to identify the preferred design(s) over several risk preference intervals. For this reason they have examined six strategies- (a) participation in the government commodity program only (GCP); (b) participation in the government commodity program and purchase of individual crop insurance (GCP+CI); (C) participation in the government commodity program and purchase of area crop insurance (GCP+ACI); (d) participation in a linked government deficiency payment/crop insurance program (LDC); (e) participation in the government commodity program and receipt of assistance under an individual disaster assistance program (GCP+DIS); and (f) participation in the
government commodity program and receipt of disaster assistant under an area disaster assistance program (GCP+ADIS).

From the empirical analysis they have suggested that the wheat and grain sorghum producers would prefer either a crop insurance or disaster assistance program in addition to the government commodity program. They have also referred to that disaster assistance design is preferred to crop insurance policy.

The risk averse managers of both south central Kansas grain sorghum and north west Kansas wheat prefer individual crop insurance instead of area crop insurance for producing crops with relatively more risky yields. On the other hand, the farmers growing low risk crops (wheat) of south central Kansas are more likely to prefer area crop insurance. If adverse selection and moral hazard continue to be a problem for the current individual crop insurance program, then a subsidized area crop insurance plan may be an alternative. Because, the subsidized area crop insurance plan would prevent moral hazard and reduce adverse selection problems. Again the risk neutral and risk preferring farm managers prefer area crop insurance over individual crop insurance with a 10 percent subsidy of area crop insurance premiums. And also for higher subsidy level the more risk averse farm managers prefer area crop insurance over full-cost individual crop insurance.

In this study from the examination over the disaster assistance programs it is clear that the area disaster assistance design or program is more acceptable and would be less expensive than the individual disaster assistance program in areas with relatively more risky crop yields.

Wang, Hanson, Myers and Black (1998), examined the relative performance of individual yield crop insurance and area yield crop insurance programs. The performance of these crop insurance polices are measured by the farmer participation rates and farmer welfare. They analyzed different contract design features as yield index, trigger yield restriction, proportion of insured areas and insurance pricing scheme, which alter the performance and implementation cost of a crop insurance program. They have used two portfolios of risk management
instruments: (a) crop insurance alone and (b) crop insurance, future and options. To analyze the model they have finally used stochastic simulation and numerical optimization techniques.

From the empirical estimation they have found that in the presence of negative price yield correlation under restricted insured acreage the optimal trigger yield for area yield crop insurance (AYCI) is much higher than individual yield crop insurance (IYCI) when only crop insurance is used to manage income risk. This is because the AYCI premium is actually fair and there is the absence of natural hedge so the farmer can choose any coverage level without reducing expected profit. In that situations under the current trigger yield restrictions level when an individual index requires a thirty-five percent premium loading then IYCI is preferred to AYCI.

If the price-yield correlation is zero the optimal trigger yield increases for IYCI and it reaches the maximum level under AYCI. In the presence of the zero price yield correlation and current trigger yield restrictions; the IYCI is again preferred to with a willingness to pay (WTP) measure. However in the presence of negative price-yield correlation, and the coverage restriction for AYCI is removed then it is preferred to IYCI with a WTP.

Again if the correlation between price and yield is negative and there is no coverage restriction, the optimal trigger yield increases both for IYCI and AYCI compared to restricted coverage with negative price correlation. Again with no price yield correlation and no coverage restriction the level of insured acre tends to increase relative to the case of negative price yield correlation.

They have measured the participation level and willingness to pay for crop insurance, futures and options. They have examined from empirical analysis that with the futures and options in the portfolio the optimal trigger yield levels increase slightly with negative price yield correlation and it is expected to remain the same with no price-yield correlation. The addition of futures and options to the portfolio increases the WTP but it has little impact on the optimal trigger yield. In both situations under the current trigger yield restrictions IYCI is preferred to AYCI. And if the AYCI’s trigger yield restriction is removed then AYCI is preferred to IYCI at the current trigger yield restriction.
The level of yield basis risk is significant for the performance of IYCI and AYCI. If the yield basis risk is higher an area yield index does not allow a farmer to manage yield risk and an individual farm yield index is preferred with a significant premium loading. When area yield indices defined over a small geographically local region will reduce the yield basis risk and increase the ability to manage yield risk. However when the geographic region with area yields index is concentrated, the level of transaction costs, potential moral hazard and adverse selection problem increases.

Finally they have analyzed the impact of individual crop insurance premium loading on the participation levels and willingness to pay. If the IYCI premium loading is zero the AYCI is almost as valuable as IYCI in all portfolios. Again if the IYCI premium loading decreases and the optimal trigger yield increases then the performance of IYCI improves relatives to AYCI. With no premium loading or trigger yield restriction the IYCI is preferred to AYCI.

**Mahul (1999)** analyze the problem of the design of an optimal area yield insurance contract. He defines the optimal form of this contract in a more general framework, where the risk averse farmer is assumed to maximize the expected utility of net yield and the corresponding indemnity payment schedule is based upon the aggregate yield of a surrounding area.

His result shows that the optimal form of this insurance contract depends on the individual beta coefficient, which measures the sensitivity of farm yield to area yield. Again, when the beta coefficient is positive (negative), the optimal insurance contract acts as a put option (call option) and then the farmer received an indemnity if the realized area yield is lower (greater) than a critical yield (Critical yields are expressed both in bushels per acre and as a percentage of the normal or expected area wide yield of 30.7 bushel per acre). If the insurance premium is actuarially fair, the farmer purchases the area yield contract with full insurance and the optimal coverage level equals his or her beta coefficient. If the coverage level and the index of absolute risk aversion are fixed, a negative relationship exists between the optimal critical yield and the coverage level.

He also analyses the “ideal” area yield contract where the farmer is free to choose the coverage level and the critical yield. And the “almost ideal” area yield contract where the coverage level is
fixed to unity and the farmer selects only the critical yield. He has found from his analysis that both the contracts are identical and generate the same decrease in risk for the average farm and the optimal critical yield level is also the same in both contracts. But these contracts may generate significant differences in terms of yield risk reduction for the farms with beta coefficients different from unity.

Makki and Somwaru (2001) analyzed empirically the farmers’ choice of insurance contracts and present evidence of adverse selection in the crop insurance markets. The empirical results imply that the low and high-risk farmers choose different insurance contracts or products depending on their expected risk of loss. It implies that high-risk farmers prefer revenue insurance such as Crop Revenue Coverage (CRC), Revenue Assurance (RA), relative to yield insurance and also prefer individual insurance relative to group insurance, such as Group Risk Plan (GRP).

The farmers income and the cost insurance significantly affects the choice of insurance contracts or products and as well as the selection of alternative coverage levels. From analysis they point that high-income farmers prefer Crop Revenue Coverage (CRC) and Revenue Assurance (RA) contracts to the Actual Production History (APH) insurance contract relative to low income farmers with the same risk class or within the same risk category.

The farmers’ choice of coverage levels also depends on their expected risk of loss. They have shown that the farmers’ income and choice of coverage level is positive and significant for Actual Production History (APH), Crop Revenue Coverage (CRC), and Revenue Assurance (RA). The results imply that high-income farmers prefer greater coverage relative to low-income farmers. The ownership share and farm practice are negatively related with the coverage level. The loss frequency is positively related with the choice of coverage but non-significant for all contracts except for Group Risk Plan (GRP). There will exist positive relationship between the coverage level and the yield span that indicates the farmers with high-expected yield are more likely to buy higher coverage levels. The choice of insurance contract and the risk of loss are correlated that point out the presence of adverse selection in the crop insurance market.
Finally, empirical results shows that the low-risk farmers are overcharged that is, pay more than their competitive rates (competitive rate is equal the expected indemnity divided by liability) and the high-risk farmers are undercharged that is, pay less than their competitive rates for their respective (comparable) insurance contracts. And the actual premium rates fail to accurately reflect individual farmers’ probability of losses. Again at the extreme risk levels the disparity is high between the actual and competitive rates (that reveals asymmetric information in the crop insurance market).

2.6. Studies on the Problem of Crop Insurance

Skees and Reed (1986) have analyzed the relationship between expected yields and theoretical rates at the various granted coverage yield. They have traced on the differences in standard deviation (S.D) between farmers with the same expected yield that leads to inappropriate insurance rates. Since relative risk can be represented by coefficient of variation (C.V), standard deviation and expected yield but these are critical for ratemaking. Not only the farmers with higher expected yields have less risk in percentage terms and receive less protection in spite of paying the same premium but also need less for insurance than the farmers with lower expected yield. Again the farmers with higher expected yields are farming better and more expensive land. Indeed, the farmers with higher expected yields are farming better and more expensive land by taking greater financial risk than farmers with lower expected yields and less expensive land. Again if both the farmers have the same relative risk they should be charged same premium. But if both the farmers have similar yield dispersion and different expected yields values they also should be charged the same premium for a fixed level of protection and finally, it creates an adverse selection problem.

In this analysis they have identified two problems that lead to adverse selection: a) farmers with relatively high expected yields can only expect very small and infrequent indemnity payments when grantees (granted yields) are tied to some measure of expected yields, and b) Unadjusted Actual Production History (APH) yields reduce the expected indemnity payments.

Finally, they have come to the conclusion that accuracy in developing farm-level protection based upon actual farm-level expected yields is a key to avoiding adverse selection.
Quiggin, Kragiannis and Stanton (1993) have explained theoretically and empirically about the problems of moral hazard and adverse selection. Before this explanation various analysts have explained theoretically about these problems [such Ahsan, Ali, and Kurian (1982), Nelson and Loehman (1987), Chambers (1989)]. But there had been little empirical study of these problems, because of difficulties in the distinction between adverse selection and moral hazard. In this explanation, they have considered the joint impact of adverse selection and moral hazards and explained their predictions theoretically by considering a model of choice under uncertainty and empirically their predictions are tested by suitable production function. Here cross section study has made data (USA) by using USDA (US Department of Agriculture) and FCRA survey.

Therefore the production function can be written as –

\[ Y = f(Z, X, \theta) \eta(\xi \varphi). \]

Where

- \( Z = \) Final input
- \( X = \) Observable variable inputs.
- \( \theta = \) Unobservable inputs e.g. operator’s effect.
- \( \xi = \) Exogenous fluctuations.
- \( \varphi = \) Farm type i.e. land quality and Farmers skill.

In this model, moral hazard problem is explained by the variable \( \theta \) and the adverse selection problem is explained by the variable \( \varphi \). Therefore by using suitable expected utility function they have pointed out the following hypothesis–

1) If the firm type is worse-off then for any given insurance contract the insured farmers are gainer and the insurer are loser.

2) If the absolute risk aversion is given the farmers are taken out insurance when the firm type at the granted output level is better off or same as compared to the firm type at the actual output level. On the other hand, the farmer will not be taken out insurance if firm type of the actual output level is better-off compared to the firm type at the granted output level. This represents the case of adverse selection effect.

3) If the unobservable inputs to the actual yield level are better than the unobservable input to the granted yield level and the observable inputs to the actual yield level are better than the
observable input to the granted yield levels, then the insurance leads to a reduction both of observable inputs and unobservable inputs in the optimal level. This is the case of the moral hazard effect. Finally, the combinations of moral hazard and adverse selection effect imply that, on average, the insured farmer will have lower output than the uninsured farmers with similar observable characteristics and inputs.

Now for empirical estimation of the adverse selection and moral hazard effect a simple Cobb–Douglas type of function form is used.

From empirical estimation they have pointed out that, the absence of economizes of scale is a necessary condition for the success of a crop insurance scheme based on expected yield per acre of a surrounding geographical area. If large farmers who have higher yield than smaller farmers, will choose insurance, and large farmers choose self-insurance, which creates the adverse selection.

For empirical estimation they have remarked that the insured farmer uses less variable inputs to produce given level of output than the uninsured farmers. This implies that, the output for insured farmer is to be lower [20% lower] for a given vector of inputs than the uninsured farmers. It is favorable to moral hazard explanations and also it is consistent with adverse selection.

Therefore, the insurance implication of moral hazard and adverse selection can be easily explained by the coefficient of variation of both the probability of a pay-out and the expected value of pay out that is, calculated by suitable normal or log normal distribution and an insurance policy at various coverage levels. From the result they point out that the expected pay out and the probability of a pay out both are increased with increase in coverage level for the uninsured farmers. On the other hand, the expected pay out and the probability of a pay out both are also increased with increase in coverage level for the insured farmers but the loss ratio decreases [the ratio of pay outs to premiums]. But the loss ratio is greater for lower coverage level and higher for log-normal distribution. Finely, the probability of pay out for uninsured farmers is very low.
compared to insured farmers in both cases [for normal and log normal distribution] that help the insurer to charge low premium from the uninsured farmers.

The study “Weather Information and the Potential for Inter- Temporal Adverse Selection in Crop Insurance” by Luo, Skees and Marchant (1994) contributes to the research on adverse selection by identifying a different type of adverse selection in corn insurance: “intertemporal adverse selection”. They investigate the potential usefulness of early-season weather information to forecast corn yields for crop insurance purchase in the study region (Midwest-USA). There are three models, which are used to forecast low-yield years: a) a simple weather forecast model; b) a yield-weather regression model; and c) a yield-weather discriminant model. They have shown that each model has its own yield shortfall criterion.

The basic process of the study includes three steps. The first step helps to decide which year(s) to purchase crop insurance. A “low-yield” crop year forecasts a yield shortfall by a model. It helps the farmers to purchase corn insurance in selected years.

The second step of this study compares yields distribution from two types of behavior: (1) using early-season weather information to select low-yield years and buying insurance in only those selected years; and (2) not using weather information and buying insurance in all years over the entire sampling period (all year).

Third step is to identify the climate divisions in the Midwest with the most potential for intertemporal adverse selection in crop insurance. The farmers may use such information in deciding which years to purchase crop insurance and which years not to purchase insurance.

There are the ranks of weather variable contributions to yield forecasting such as- 1) seasonal rainfall forecast, 2) temperature forecast, 3) pre-seasonal water-supply conditions and 4) temperature conditions. This study presents procedures that would allow farmers to predict low corn yield before the purchasing deadline of corn insurance on 95 percent of planted acreage in the Midwest.
This is how these conclusions made by these researchers imply the possibility of *intertemporal* adverse selection in the multiple peril crop insurance (MPCI) programs and the need for policy design adjustments.

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Finally, empirical results shows that the low-risk farmers are overcharged that is, pay more than their competitive rates (competitive rate is equal the expected indemnity divided by liability) and
the high-risk farmers are undercharged that is, pay less than their competitive rates for their respective (comparable) insurance contracts. And the actual premium rates fail to accurately reflect individual farmers’ probability of losses. At the extreme risk levels the disparity is high between the actual and competitive rates (that reveals asymmetric information in the crop insurance market).

2.7. Survey of Studies on Crop Insurance on Use of Fertilizer and Effects on Environment

Horowitz and Lichtenberg (1993) examine how crop insurance affects Corn farmers’ fertilizer and pesticide use. There are many theoretical economic models, but these models do not discuss the effects of crop insurance on chemical use.

There are two factors, which affect chemical use. First the farmers paying share rent should apply less of variable inputs than cash renters. Yet nitrogen and potassium use per acre grew as the proportion of land operated under share rental increased. Second wealthier farmers tend to apply more inputs per acre. The wealthier farmers of low-risk aversion increase the use of nitrogen and pesticides.

From the empirical estimation, they have found results as follows. First, the crop insurance purchase which is more likely in areas with high corn yields (because the size of potential loss and premium subsidize are greater in those region) is less likely in areas where yields from alternative crops are higher. This implies that the crop diversification significantly is more profitable. Second, the farmers operating more acreage (may have higher yield variances) are more likely to purchase crop insurance.

In this empirical study the effect of crop insurance on use of nitrogen, pesticide, insecticide and herbicide has been found to be positive and statistically significant. The result shows that the insured farmers have increased nitrogen application per acre by 19%, pesticide expenditure per acre by 21%, herbicide acre-treatment by 7%and insecticide acre treatment by 63%. The crop insurance has a negative and statistically insignificant effect on other input uses (phosphorus and potassium use). It is believed that higher pesticides are risk reducing and therefore a substitute for insurance but in many circumstances these are risk increasing.
Theoretically, the analyst, Quggin (1993) suggests that moral hazard problem incentives to increase the use of inputs that raises the expected yields as well as the variance of yields. But on the other hand another two analysts (Horowitz and Liehtenberg, 1993) suggest that the farmer who purchases crop insurance use more chemical inputs than the farmers who do not purchase crop insurance.

Smith and Godwin (1996) in their study examined the relationship between chemical input use and crop insurance purchase decisions for sample of dry land wheat producer. They argue that input use and crop insurance decision are made jointly and as a result in this analysis simultaneous-equation estimation approach is appropriate. From the empirical result they have found that insured dry land wheat producers who purchase crop insurance use fewer agricultural chemical inputs than uninsured farmer. They also indicate that the farmers who use fewer agricultural inputs are more likely to be insured. But on the other hand, the farmers who use agricultural chemical inputs more intensively are less likely to purchase crop insurance. According to these analysts the results of this study confuse the environmental organizations.

Wu (1999) analyzed empirically the effect of crop insurance on cropping patterns and chemical use by using the area study data (Central Nebraska Basin, USA). The effect of crop insurance on chemical use has examined by the change in cropping patterns and application rates and it effects must be determined through intensive-margin (changes in acreage planted to specific crops) effect and extensive-margin (changes in the over all size of farms) effect. Before this study various analysist [Horowitz and Lichtenberg (1993), Babcock and Hennessy (1996), Smith and Goodwin (1996)] empirically examined the intensive –margin effect of crop insurance on chemical use but they have got contradictory result. Some analysist such as Horowitz and Lchtenberg (1993) states that, the crop insurance increases the chemical uses. Other respect, Smith and Goodwin (1996) have shown that the crop insurance reduces the chemical use.

In this analysis he pointed out four important questions: -Does crop insurance affect crop mix and chemical? How significant is the effect? Can this extensive-margin effect dominate the
intensive-margin effect of crop insurance on chemical use? And what is the environmental implication of the effect?

He examined these questions empirically by using cross-sectional, farm-level data of 235 farms at the Central Nebraska Basin (USA) in the year 1991. The data includes information on individual farm’s crop insurance, crop mix, land properties and farmers’ socioeconomic characteristics.

From the empirical result, he suggest that if there is the high soil erosion in the cornfield, then the corn producers purchase possible more crop insurance and they shift land from hay and pasture to corn. And the extensive-margin effect on chemical use dominates the intensive-margin effect that finally increases in total chemical use and nonpoint environmental pollution problem also increases.

He found that the farmers who planted more Corn and Sorghum and fewer Soybeans, they purchased more Corn insurance. Again if the farmers planted more Soybeans and if crop diversification is possible, the farmers purchase less crop insurance. Besides this, the irrigated farmers purchase likely to more crop insurance than the dry land farmers. In this respect corn is high value irrigated crop so the corn producers purchase more crop insurance. The farmers who have more farming experience are more likely to purchase crop insurance. The farmers who have higher soil erosion rates in their cornfields purchase crop insurance more frequently than the farmers of lower soil erosion rates.

In the absence of crop insurance, the farmers with more cattle and farmers who work off the farm would allocate more acres to hay and pasture and fewer acres to corn. But with crop insurance, the farmers with more cattle and farmers who work off the farm would shift some land from hay to corn. The farmers of different sizes may react to crop insurance differently. The college education had significant effect on crop-mix. The farmers with some college education allocate more land to insured crop corn and soybeans than the other crops. The farmers with higher water holding capacity in their cornfield allocate more land for corn and less land to soybeans. With crop insurance small farmers increase land allocation to corn and soybeans and
reduce to hay and pasture. And without crop insurance small farmers does not take decision to plant high-value risk crop on their marginal land.

Finally, he concluded that the crop insurance would increase total chemical use that may exacerbate the ground water quality problem.

Agahi, Zarafshani and Behjat (2008) describe the effect of crop insurance on technical efficiency among insured and uninsured dry wheat farmers in Kermanshah province (study region of Iran). They have used the Corrected Ordinary Least Squares (COLS) to estimate both insured and uninsured dry wheat farmers’ technical efficiency. Using stratified multistage cluster sampling method 251 farmers were interview across three different regions: Tropical, temperate and cold during 2003-2004 crop years. From the empirical analysis they have shown that parameters intercept, seed, nitrogen fertilizer and pesticide are statistically significant (at 1% level of significant) in the cold regions. On the other hand all parameters have meaningful signs but labor, phosphate fertilizer and land are statically insignificant in temperate regions. Beside only land, nitrogen fertilizer and phosphate fertilizer are statistically significant in the tropical regions.

They have shown that there is a significant difference of technology between insured and uninsured dry wheat farmers in temperate and tropical regions but there is no significant difference in technical efficiency across cold regions. This result reveals that there is a positive effect of crop insurance in tropical and temperate regions but the farmers those are living in the cold regions may not fell the need to purchase insurance policy for their crops.

2.8. Studies of Crop Insurance for its Effects on Target Yield Level /Coverage Level

Ker and Coble (1998) analyze a potential policy change to setting multiple peril crop insurance (MPCI) premium rates in the USA agriculture. The USA Department of Agricultural Risk Management Agency (RMA) estimates the premium rate for a base coverage level (targeted yield level) and then uses multiplicative adjustment factor to recover rates at the other coverage levels. The risk management agency changes the base coverage level for the MPCI from the
65% coverage level to the 50% coverage level. Therefore the objective of this study is to analyze where such a change should or should not be carried out.

They have used conditional yield distribution function and simulation analysis to point out the actual feed back of the change in the base coverage level for premium rate setting. They have also used two counties (Shelby county in Western Central Iowa and Wheat from South-Central Kingman county and Kansas) to verify the changing base coverage level. From the analysis they have found that the conditional yield density for Shelby Corn is shown to be a negatively skewed and possibly bimodal density. But in the case of Kingman wheat the conditional yield density is mildly skewed and unimodal. By the simulation analysis if the empirical rate at one coverage level is given then they (Ker and Coble) derives the associated rate for the other coverage level using the initial level as the base. This enables to calculate the mean squared error of the estimated and derived rates at both coverage levels. From the estimated result they have suggested that higher coverage level rather than lower coverage level should be used as the best. This argument is appropriate for both counties. In that situation they have pointed out some intuitive logic. If the coverage level is increased the expected yield moves toward its mean value. As a result the estimated premium rate at higher coverage level is relatively more accurate. Finally they have recommended so that the USDA Risk Management Agency does not change its base coverage level from the 65% to the 50% coverage level.

**Goodwin, Vandeveer and Deal** (2004) have examined empirically the participation of the farmers in the crop insurance program and also examined the effects of crop insurance on acreage allocation among the competing crops in two relatively homogeneous growing regions (Corn Belt and Northern Great Plans, USA). The central goal of the study is to test the hypothesis that is the crop insurance had no distinguishable effect on land use. To evaluate the acreage and insurance decisions they have considered multiequational structural model of acreage response, insurance participation, Conservation Reserve Program (CRP), and input usage. From the empirical analysis, they have assessed that the demand for crop insurance is generally quite inelastic. Again they have pointed out some policies simulation such as insurance subsidies and insurance premium decrease that stimulate the farmers participation in the crop insurance program and land use patterns. From the analysis they have concluded that the
participation of the farmers in the crop insurance program increases and it finally arouses the statistically significant effect on acreage. But the effect of premium decreases on acreage is modest.

2.9. Conclusion
In this chapter we have reviewed various studies relating to crop insurance and its effects on agriculture. We have discussed the literature about the crop insurance system in Indian agriculture, asymmetric informations and the demand for crop insurance. We have analyzed the literature about the types and the problem of crop insurance. We have also discussed the articles about the contradictory effect of crop insurance on use of fertilizers and environment. Finally we have analyzed the effect of crop insurance on target yield and coverage level. From the review of literature we have come to one important point is that the crop insurance is ultimately a subsidized policy of the government of any country.

In our dissertation, we are concerned to focus the effect of crop insurance on participation, loss-ratio, indemnities, input usage, acres for crop, production and cost of the farmers. From the review of literature we have come to the conclusion to analyze the above points. We have used suitable econometric technique in order to estimate the participation of farmers into the crop insurance, loss-ratio, indemnities, input usage, acres for crop, production and cost of the farmers. A set of explanatory variables have been considered from sources and types of data as determinants of participation of farmers into the crop insurance, loss-ratio, indemnities, input usage, acres for crop, production and cost of the farmers. In all the cases, we have used generalized least square model to estimates the parameters of the above model.