Chapter - II

Review of Literature and Theoretical Background

2.1 Introduction

Review of literature is indispensable in gaining clear comprehension of the previous research studies conducted on similar lines, which creates a sound base for scientific investigation. It also gives new ideas and approaches for evaluating research efforts in comparison with similar efforts done by others. In this chapter an attempt has been made to demonstrate the theoretical and empirical information concerning the present investigation under the following heads.

2.1.1 Growth pattern of pesticide usage in agriculture in India and Karnataka

Mukund Joshi (2005) in his book ‘Perils of Pesticides’ has explained growth of pesticides consumption in agriculture as follows: Improvement in yield, which is key to long term growth, depends on a host of factors including technology, use of quality seeds, fertilizers, pesticides, micronutrients, and irrigation. Each of these plays a role in determining yield level and in turn augmentation in the level of production. Prior to 1940, the consumption of pesticides was negligible and restricted to a few inorganic pesticides. During World War II, large-scale use of synthetic pesticides began with the invention of DDT. Since then, the consumption of pesticides has increased steadily.

Md.Wasim Aktar., et.al., (2009), In their study found that, pesticide production Started in India in 1952 with the creation of Industry for the production of BHC at Calcutta. India Ranks 12th globally and second largest manufacturer of pesticides in Asia. The technical grade production of pesticide in India was 5000 metric tones in 1998. India captures 2 percent of the total pesticide market.

Abhilash and Nandita Singh, (2009), In their study found that, agricultural development is the most important objective of India’s planning and development. In the process of agricultural development one of the inputs pesticides acts as an important tool in minimizing diseases and maximizing output. However, exposure to pesticide residues occupationally and environmentally causes many health problems among farmers. India is the largest producer of pesticides in Asia presently. The vast
majority of population are dependent on agriculture and hence exposed to pesticide residues in the process of cultivation. Though, average pesticide used in India is low compared to developed countries pesticides related problems are high in India. Even pesticides use adversely affected the export of agricultural commodities. Hence, regulation of pesticides and strategies to implement rational application of pesticides to minimize health and environmental problems are suggested.

Shetty P K and Marium Sabitha, (2009) Found that, pesticide consumption in India differs based on cropping pattern, intensity of pests and diseases and regions. Even crop wise and state wise consumption varies. Since majority of the former poses small land holding it is very difficult to ascertain the quantity and quality of pesticides used by farmers. However, consumption of pesticides between 1955 and 2006 shows that, pesticides used was highest during green revolution and was in peak in the year 1988-89. Pesticide consumption declined from 75 to 43 metric tones between 1988 and 2000-2001 due to the ban of DDT and BHC in country. Another reason for decline was removal of subsidy on pesticides consequently, pesticide use between 2001-2002 showed slight increase.

Muthusamy Murugan., et al., (2010) Consumption of pesticides remained high in the initial years of Green Revolution and reached a peak in the year 1988-89. Illustrates the pesticide consumption trend in India since 1955-56 to 2003-2004. Between 1999-2000 and 2000-2001 there was a significant decline in pesticides use from 75,418 to 43,584 tones. This decline began with the banning of few organochlorine insecticides such as DDT, BHC for use in agriculture. BHC represented 30% of India’s total pesticide consumption. Yet, the consumption of pesticides between 2001-02 and 2003-04 showed a slight increase for various reasons. Among the states increasing trend of pesticide consumption was not iced in Arunachal Pradesh and Nagaland while no trend had been noticed in Punjab, Haryana and Rajasthan. Interestingly declining trend was observed in major consumers including Andhra Pradesh, Gujarath, Karnataka, Tamil Nadu, Pondicherry, Kerala and Sikkim. From this survey we found reasons that farmers often apply pesticides very frequently in very high doses. It was common for farmers to use pesticides over many times in one season. The spray solution used was a mix of numerous insecticides, fungicides and bio-insecticides even on crops such as vegetables and fruits. This increasing trend
of pesticide application therefore would aggravate the socio-economic and environmental and human health problems.

**Indira Devi P (2010)** Analysed that, the consumption of pesticides steadily increased from 1950-51 onwards, with the cropped area of 30 percent treated with pesticides. The cropped area later increased from 2.4 hectares to 137 million hectares (1950) treated with pesticides. The use of pesticide was at its peak during 1984 due to spiraling effects of green revolution. Decline in the pesticide consumption in the latter part was due to the awareness among farming community about the negative externality, reduction in the subsidy given to chemical pesticides and introduction of new harmful pesticides which are supposed to be used in lesser quantities.

**Wen Jun Zhang, et al., (2011)** Discussed that, consumption pesticides throughout the globe is increasing in terms of variety and quantity due to the rise in population and production. In the process of increasing production misuse of pesticides in Agriculture has caused many human health and environmental problems. Therefore, Pollution due to pesticide use across the globe especially in China is reviewed and documented in the study. In their study they found that, worldwide pesticide consumption has undergone significant changes since 1960s. The share of herbicides increased compared to insecticides across the world. China emerged as the largest exporter and producer of Pesticides in the world.

**Sachin Kumar, et al., (2013)** Examined that, pesticide use is slowly decreasing from 1994-2006, Punjab and Haryana are the largest consumers of Pesticides. India consumes 76 percent of insecticides as against world (44%) major pesticide receiving crops of the nation are cotton followed by Paddy and wheat.

**Sitaramaraju S, et al., (2014)** Analyzed the global use of Pesticides. Herbicides ranked first among the categories of pesticides between 2007 and 2008 followed by fungicides. Europe followed by Asia are the major pesticides consumers in the world. China, USA, Brazil and Japan are the major producers and consumers of pesticides, fruits and vegetables are largest pesticide demanding crops around the world. Whereas herbicides are used in larger quantities to cultivate maize in developed countries. In India there is a tradeoff between crop production and pollution relating to soil air and water which have caused many health complications due to pesticide use. Although in India per hectare consumption of pesticide is low compared to
developed countries, problems relating to pesticides are high in India. Unfortunately, India is still using some of the chlorinated pesticides like lindane and DDT which is a very serious cause of concern.

Murugan M and Shetty P K., et al., (2014) Conducted surveys with regard to pesticide use on Cardamom and tea during 2009-2012. The survey found that, Cardamom consumed 26 Kg. per hectare pesticides compared to tea (8 kg per hectare). As a result pesticide residue present in the soil in Cardamom growing region found to be highest leading to pesticide poisoning. Therefore study suggested that pesticide use in Cardamom and tea growing regions have to be taken care of seriously to safeguard agro forestry ecosystem.

Handbook of Agriculture (2015) highlighted that, more than 2.6 million tons of active ingredients of pesticides are used worldwide. Roughly 85% of this consumption is used in agriculture. About three-quarters of pesticides are used in developed countries, mostly in Europe and Japan. India’s consumption of pesticides is only 2% of the total world consumption. The consumption of pesticides in India has increased several hundred, folds from 2,353 metric tons (MT) in 1955-56 to 75,000 MT in 1990-91. Thereafter, their consumption steadily declined to 43,584 MT primarily due to: (i) banning of high dose persistent organochlorine pesticides such as DDT, aldrin, heptachlor, etc and (ii) introduction of new generation pesticides such as neo-nicotinoid, that are effective at doses as low as 20 g a.i./ha. The per hectare consumption of pesticide in India is 381 g which is low as compared to the world average of 500g. Low consumption in India can be attributed to fragment land holding, low level of irrigation, dependence on monsoons, low awareness among farmers about the benefits of usage of pesticides etc. India, being a tropical country, the consumption pattern is also more skewed towards insecticides, which accounted for 64% of the total pesticide consumption in 2006-07. Fruits and vegetables consume the highest amount of pesticides (26%) in the world, followed by cereals (15%), maize (12%), rice (10%) and cotton (8.6%). In India, however, 45% of the total pesticide consumption is on cotton-crop, followed by rice (22%), vegetables (9%) and pulses (4%) and the trend is now changed after the introduction of transgenic cottons. The area under plant protection is continuously increasing, but still only 25-30% of total cultivated area is under pesticide cover. The approach to control pests and increase the yield of crops in developed countries is by controlling weeds that
compete with crop for nutrients and harbor insect pests and diseases. Therefore, out of the total pesticide used, 36% are herbicides, whereas insecticides are 25% and fungicides 10%. In developing countries, however, insecticides constitute a major portion of pesticide consumption but only 12% herbicides are used.

**Khanday Arshid Ahmad et al., (2015)** Observed that, compared to world consumption of pesticides India consumes 62 percent of insecticides as against 44 percent across the globe. This is followed by fungicides (19 percent), herbicides (141 %) and other pesticides (4 %) during 1995 to 2005. Paddy and Cotton are the major crops treated with pesticides accounting for 28 percent and 20 percent respectively out of total pesticide consumption. Three states namely Andhra Pradesh, Maharashtra and Punjab consume about 50 percent of the pesticides in India although there is a dealing trend observed in the pesticide consumption from 75,000 metric tons to around 41,000 metric tons is 2009-10, India produces 2 percent of the total pesticides marketed in India.

### 2.1.2 Economic impact of pesticide application in Agriculture

**Farrell M.J (1957)** In his study observed, the problem of measuring productive efficiency of an industry is crucial for both theorists and economic systems which are subjected to empirical testing. He further examined economic planning with an industry, it is important to know how far an industry is expected to increase its production by boosting its efficiency without procuring further resources. In his study he also attempted to construct “indices of efficiency” in which weighted average of inputs is compared with output.

**Aigner D.J., and S.F. Chu (1968)** Examined that, technical efficiency of an individual firm in the sample is the function of level of input variables in the stochastic frontier, in addition to technical efficiency effects. This empirical application is exhibited using cross sectional data on Ethiopian farmers. Hence, no technical efficiencies of production of null hypothesis among these farmers were accepted.

**Kalirajan K P et al., (1983)** In his empirical analysis employed stochastic frontier production function approach to measure technical efficiency of 79 paddy farmers in Philippines to explain the variation in paddy output by taking several input variables.
By the method of maximum likelihood, the parameters of the model were estimated. Whereas, for farm level data analysis Cobb-Douglas production function was found to be in appropriate. The individual technical efficiencies of the model found to be ranged from 0.38 to 0.91. It was found from the result that, seeds, fertilizer, years of farming and number of extension contacts had significant influence on the variation of the estimated farm technical efficiencies.

David Zilberman et al., (1991) Conducted a study on regulation of pesticide application in USA and economics of pesticide use. The study found that, the use of pesticides expanded agricultural production, by simultaneously increasing environmental and human health problems. These problems justify government regulation which was considered as a crucial topic of discussion in the society. Banning pesticide use were the primary regulatory tools enforced in U.S.A. The economic consequence of such bans depends on the availability of substitutes. Absence of substitutes will result in reduced crop production level and increased cost of production thereby causing substantial loss for both producers and consumers. They also found that, by establishing standards and Markets food safety aspects could be addressed effectively for pesticide differentiated commodities. But direct control by government is required in case of worker safety and clear water supply. Finally pesticides use fee was found to be efficient compared to bans on pesticides as a tool to attain environment and health safety goals.

Battese G.E and T.J. Coelli (1992) In their study estimated technical efficiencies of individual firms of an industry by employing frontier production functions which plays a very important role in the prediction of technical efficiencies. The best predictor of technical efficiency, of an individual firm at a specific time period is represented for the time varying model. As the best empirical example is presented employing agricultural data for paddy farmers in India.

George E. Battese (1992) in his study on Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics observed that, in microeconomics production function is stated as the maximum output that can be produced from a specified set of inputs, given the existing technology available to the firms involved. However, up until the late 1960’s, most empirical studies used traditional least-squares methods to estimate production functions. Hence the
estimated functions could be more appropriately described as response (or average) functions.

**Kishore (1994)** estimated external cost arising out of pest resistance of pesticide use in cotton cultivation by employing simulation model. It indicates that, annual external cost could be greater by an amount of 66 crores which increased the existing cost of cotton cultivation by an amount of 52 percent whereas, the annual expected value of catastrophic losses due to complete crop failure accounts for 13 crores with the increase in the cost of cotton cultivation by 10 percent.

**Mark L Teague et al., (1995)** In their study employed random co-efficient model to determine pesticide productivity trend of the marginal value product of pesticides and estimated pesticide productivity in agriculture in 10 states of USA for the period 1949-91. Study found, down word trend in pesticides productivity in two states namely Lowa and Texas. However, there was no declining trend observed in California State.

**Battese G.E. and Coelli T.J (1995)** in their study observed that panel data model is an extended form of recently proposed models for inefficiency effects in stochastic frontiers for cross-sectional data. An empirical application of the model is obtained using up to ten years of data on paddy farmers from an Indian village. The null hypotheses, that the inefficiency effects are not stochastic or do not depend on the farmer-specific variables and time of observation, are rejected for these data.

**Coelli Tim and George Battese (1996)** In their study estimated stochastic frontier production function to study the production and productivity of Indian farmers by incorporating the model for technical inefficiency effects, the variables included in the model for the inefficiency effects are the age and educational level of the farmers, land holding and the year of observation. The results of the model found that above factors did not significantly influenced inefficiency effects of farmers in two of the three villages taken.

**David Widawaska et al., (1998)** Conducted a study, in their study reported that, host-plant resistance productivity was more compared to pesticide productivity and indicated negative returns to pesticide use at the margin. The results of the study found that, host plant resistance was found to be effective alternative to Pesticides and
reduction in the use of pesticides could be attained substantially without any loss in paddy production, through betterment in host-plant resistance. The result indicated that pesticides were over used and host plant resistance was under used in China. Hence they came to the conclusion that, policy towards pesticide use was observed to be wrong in the view of negative externalities associated with pesticides use.

Rajasekharan P et al., (1999) in their study on Technical Efficiency of Natural Rubber Production in Kerala: A Panel Data Analysis observed that the share of area under natural rubber in total cropped area showed a consistent increase in Kerala and it occupied 14.64 per cent of the gross cropped area in 1995-96. Almost 86 percent of national area and 94 per cent of production was concentrated in the state. The additional land availability for natural rubber cultivation in the state is very limited and once the frontier for extensive cultivation is reached, further increase in production has to come only from improvement in productivity of the crop. In this context, technical efficiencies in production assume paramount importance. This study was taken up with the twin objectives of estimation of technical efficiencies and to identify its determinants in natural rubber production in the estate sector of Kerala.

Mythili G. and Shanmugam K.R (2000) in their study on Technical Efficiency of Rice Growers in Tamil Nadu: A Study Based on Panel Data attempt has been made to measure the farm level technical inefficiency which can be a dominant factor in explaining the difference between potential and observed yields of the crop, rice, for a given technology and input levels. In particular they employ frontier production function technique to measure technical inefficiency using farm level data for the state of Tamil Nadu.

Kim (2000) Analyzed economic and environmental impact of pesticide use on vegetable production in Korea. The result found that to increase spring Cabbage production, it pesticide application cost increases by 1%, the level of income declines by about 0.14 % as per the Cobb-Douglas production function analysis. This indicates that, the marginal productivity of pesticides is just 0.06 with an additional use of pesticide cost did not increase marginal revenue at all. However, with every one percent increase in pesticide cost leads to the increase in the income from & pinach production by only 0.22 % which can be justified based on the law of variable proportions.
Clevo Wilson and Clem Tisdell (2001) Analysed the reasons for indiscriminate and unscientific use of pesticides which is posing threat to health, environment and sustainability issues. The study reported pesticides of course helped in the boosting agricultural production on the one hand and increased negative externalities is the form of damaging environment, soil health, fisheries fauna and flora. The use of pesticide also results in unintentional destruction of organisms present in the soil which otherwise would have contributed positively towards crop production. These pesticides related problems are common especially in developing countries like ours. The cost from this externality largely affects the returns of the farmers. However, despite high cost of production and lower income generated, farmer continues to apply pesticides with higher doses.

Muhammad Iqbal et al., (2002) In their study found that, additional cost incurred by the farmers of cotton zones of Punjab due to increased application of pesticides owing to the development of pest resistance account, for about 11,000 Rupees per hectare. This amounts to 5667 million extra plated to 1.7 million hectares of cotton cultivation, similarly a loss of Rs. 379 million occurs due to the destruction of bio-diversity with excessive use of pesticides. They indicate that the use of pesticides increases the cost of cultivation manifold by raising external cost.

Erdal N Yrdim et al., (2003) The study estimated economics of pesticide use on the processing of tomatoes. Study found that, among herbicides, fungicides and insecticides, fungicide treatments in tomatoes processing resulted in greater yields than insecticides regime only, whereas, fungicide and herbicide regimes were found to be more effective compared to insecticide only.

Jikun et al., (2003) In their study found that the average income obtained by the farmers of paddy cultivation in China from the use of pesticide was greater. The result indicates that, yield loss in paddy cultivation due to pest related diseases accounting for about 40 percent if plant protection chemicals are not applied in paddy farming. On the other hand, as shown in the study that, the contribution of pesticide in rice production was significant by reducing crop losses whereas the marginal contributions of pesticides used recorded steep decline with additional use of pesticides and reached to zero in paddy cultivation. Thus the result indicates that with the use of pesticides
crop yield losses can be minimized owing to pasts and diseases. But any additional use will reduce the marginal contribution of pesticides used and it approaches to zero.

**Bhavani and Thirtle (2005)** In their study analysed pesticides use in cotton cultivation in south Africa. They found that, farmers overused pesticides. They substituted pesticides with BT technology. By providing natural substitute for pesticide, BT technology enabled the small holders to overcome the credit and labour constraints associated with pesticides application. The technology significantly minimized pesticide use but influenced the yield mildly.

**Huang et al., (2005)** Conducted survey on the productivity and health implications of the insect resistant G.M. Paddy in the land holdings of farmers in China. The survey found that, small and poor farm households benefitted by adopting GM paddy by an amount of 6.9 % and reduced the use of Chemicals by 80 percent, which contributed in the form of better health. Full adopters reported that they were not severely affected by pesticide. While, those who adopted only Non-Gm. method adversely affected.

**Selvarajah et al., (2007)** to estimate the impact of chemical use on crop productivity; a multiple regression approach was used. The dependent variable, level of pesticide used by farmers, was measured by a ratio of actual amount of pesticides used to recommended level. The farmers’ pesticide use level was hypothesized to depend on various socio economic, crop and chemical price variables. Such information was useful not only for a better understanding of farmers’ behavior on pesticide use, but for deciding a suitable strategy on improving present pest and pesticide management techniques.

**Md. Wasim Aktar, et al., (2009)**, Examined benefits and hazards of pesticides use in forestry, public health and the domestic sphere and, of course, in agriculture, a sector upon which the Indian economy is largely dependent. Food grain production, which stood at a mere 50 million tons in 1948-49, had increased almost fourfold to 198 million tons by the end of 1996-97 from an estimated 169 million hectares of permanently cropped land. This result has been achieved by the use of high-yield varieties of seeds, advanced irrigation technologies and agricultural chemicals (Employment Information: Indian Labor Statistics, 1994). Similarly outputs and productivity have increased dramatically in most countries, for example wheat yields in the United Kingdom, corn yields in the USA. Increases in productivity have been
due to several factors including use of fertilizer, better varieties and use of machinery. Pesticides have been an integral part of the process by reducing losses from the weeds, diseases and insect pests that can markedly reduce the amount of harvestable produce.

**Indira Devi P et al., (2010)** In her study found that, every 1 percent increase in quantity of pesticides will result in 0.37 percent decline in the value of total Agricultural production. The result indicates that, 1 percent increase in pesticide application in case of food grain production index reduces the food grain production by 0.08 percent. Similarly one percent increase in pesticide use in case of non-food grain the production reduced by 0.19 percent. The result indicates that pesticides contributed positively in case of non-food grain production compared to food grain production.

**Shende et al., (2013)** Estimated production function using Cobb-Dougllass production function, the result revealed that for every one percent additional use of all inputs (namely laborers, manures, quantity by pesticides) simultaneously farmers tend to get the output less the one percent due to the operation of decreasing returns to scale. It means it farmers increases the seed by one percent farmer realizes the gross income by 0.3489 % and every one percent increase in pesticides will result in the increase in gross income by 0.0287 percent. In case of fertilizer and manure one percent increase in the said factors will decrease the gross income by 0.0276 percent it is true of labour also. Thus the result is justified based on theoretical expressions.

**Abedullah et al., (2014)** In their study compared BT and Non-BT farmers of cotton and found that, Bt cotton adopter in Pakistan experienced fewer cases of acute pesticide poisoning than non-adopters of the technology. It is also found that the yield of cotton is greater by an amount of 26 percent in case of BT farms due to more effective pest control compared to not BT farm. Even the use of pesticide, is lower in BT farms compared to non BT farms. Hence, the study found that BT cotton cultivation was observed to be most profitable.

**Khanday et al., (2015)** In their study found that, fertilizer and pesticides are very important inputs of crop cultivation to bridge the yield gap between the potential yield and realized yield. Pesticides that act against pests and diseases play an important role
in the enhancement of crop production. As the study found that, higher the level of application of pesticide greater will be the crop yield and Vice-versa.

2.1.3 Negative Externalities of Pesticide Use

**Els Wynes and Geoff Edwards (1990)** In their study tried to examine the benefits and costs, private and external, arising out of a partial shift from Conventional farming to chemical free farming. The study found that, private net returns observed to be same for both types of farmers. Another favorable change world is net externalities due to the movement from chemical farming to chemical free farming in the study area. Therefore, policy implications would be to tax the use of pesticides in agriculture.

**Agnes C. Rola and Pingali (1993)** In their Unique study examined the impact of prolonged use of pesticides on human health. In their study they tried to identify health problems faced by the farmers due to the long term exposure to pesticides during the course of cultivation and also tried to quantify health impairments relative to the use of pesticides. Econometric analysis also showed that, health problems and health costs are positively associated with pesticide exposure when health effects are explicitly considered, net returns of pesticide use has negative sign.

**John M Antle et al., (1994)** Examined impact of pesticide use on farmer’s health and impact of farmers health on productivity in two paddy cultivating areas of Philippines. The results found that, pesticide use had positive implications on productivity and negative impact on farmer’s health and suggested to reduce insecticide use in agriculture. They also estimated regression analysis taking health impairment as dependent variable and age, nutritional status, weight / height ratio, alcohol consumption, number of times pesticides are applied as independent or explanatory variables.

**Rajendran S (2002)** Highlighted Kasargod type of pesticide episode. Even in the case of Padre Village in Kerala, formers in these areas suffered many problems ranging from minor to sever like many farmers become mentally retarded, cancer cases and endosulfan residue found in the blood samples of sample farmers. Some people as reported in the study areas committed suicide due to lack of money for treatment and owing to unable to bear the trauma caused from pesticide exposure.
Rajendran S (2003) In his study found that, banned pesticides are still being used in the country due to the loopholes in the existing pesticide acts. As a result pesticides are used indiscriminately in our country. Therefore, social cost is more than the user cost as the farmers incur expenditure only to buy pesticides, while government has to spend huge amount of resources on pesticide related public health programmes which is referred to as social cost.

Shetty P K (2004) conducted study in four states of India to assess socio-ecological implications of pesticide use. His study revealed that, most of the respondents in the study were less informed about the importance of insecticide formulation, were guidelines and dosage details on the insecticide labels. It was observed that, illiterate farmers or agricultural laborers are a vulnerable group as they cannot identify the warming symbols on the label, are often subjected to the risk of poisoning. Majority of the respondents in the study area did not follow any of the recommended safety measures while handling pesticides, such as wearing gloves, shoes facemask and other protective clothing they found these protective measures uncomfortable in the hot weather and also as a hindrance to their work. Persons who are involved during spraying indulge in extremely dangerous practice of smoking, chewing tobacco, and eating, which have led to several unintentional poisoning cases in these regions.

Susmita Das gupta et al., (2005) In their study conducted in Bangladesh Mango formers found that 47 percent of the farmers were observed to be using excessive pesticides in Mango cultivation with only 4 percent are trained about handling practices of pesticides. Over 87 percent of the farmers reported to have not wearing protective gadgets at the time of pesticides praying, probit model was estimated to assess the health impairments as the function of amount of pesticides used, toxicity of chemicals and perception of farmers about pesticide use etc.

Selvaraja and Thiruchelvam (2007) reported that, illnesses due to spraying were recorded only among six farmers in the study sample. Common illnesses were fainting; vomiting, eye irritation, headache fever and diarrhea, except in the case of fainting three other farmers undertook homemade treatment by drinking thick squeezed coconut milk. They did not go for private treatment. When they feel ill after spraying, they chew betel to diagnose whether their body has been poisoned by the symptoms such as heavy body sweating and uneasiness is throat. Average health cost
among the affected farmers was Rs 2.325 per year. The danger posed to humans by long term effects of pesticide is currently suspected to cause various diseases like cancer and Kidney ailments.

**Indira Devi P and Sai Jyothi (2007)** analyzed the pesticide use and handling pattern in an environmentally sensitive rice ecosystem in Kerala, India and assess farm worker health cost and then estimate the financial aspects of IPM. Improper market regulation, imperfect and inadequate information wrong perceptions and poor monitoring leads to unscientific use of the pesticides and its careless handling. The pesticides used in rice included those which were banned/restricted for use in rice and without proper registration. On an average the use of chemicals were higher by 17.233% and of water was less by 58% than the recommended levels. The average expected health cost from pesticide exposure is Rs 38 per day which is one fourth of the average daily earnings. Dose reductions are a feasible strategy for farmers in Kerala and can be achieved either by restricting the quantity of pesticide used or by diluting the amount sprayed with more water.

**Suresh Sachdeva (2007)** analyzed several incidents of non-fatal poisoning because proper safety measures are not followed while spraying in his study conducted in Kerala. The country with an average literacy rate of about 50 percent, a complete awareness regarding ill effect of pesticides, guidelines of dosage etc. they are not aware of the re-entry intervals and safe techniques of spraying. Health related problems like headaches, dizziness, skin, eye irritation are quite common. There may be many unforeseen serious long term health implications as well.

**Shetty P K and Marium Sabitha (2009)** Analysed the reasons for increase in the use of pesticides, The result found that, farmers investment on inputs such as seeds, fertilizer, irrigation labour go in vain if investment on pesticides is not incurred because pesticides acts as the protective umbrella for other inputs, while pesticides are essential to save crops from pests and diseases, its indiscriminate use, has caused socio-economic and ecological problems across the world.

**Indira Devi P (2009)** Conducted a study with regard to the awareness level among farmers about the use of pesticides, their toxicity levels, reading instructions given in the pesticide container etc. The result found that, one third of the farmers reported they read the instructions on the pesticide container by themselves or through the
help, while only 3 percent reported that, they followed instructions, whereas, 99 percent of the farmers reported to have unaware of toxicity colour symbol present on the pesticide container or Bottle.

**Indira Devi P (2010)** Analyzed externalities associated with pesticide use in Kerala In her study she found that, indiscriminate pesticide application has not only damaged the ecosystem but also caused human health problems in the study area. She further observed that, the victims of unintentional pesticide application are often children and women. Careless storage and disposal of pesticide containers lead to accidental pesticide poisoning. Even farmers were unaware of re-entry internal concept leading to inhalation of pesticide residues due to occupational exposure.

**Tholkappian and Rajendran S (2011)** Analyzed the excess the use of pesticides application which damaged environment and resulted in many human problems. Due to the effectiveness of endesulfan pesticide, Plantation Corporation of Kerala encouraged farmers to apply pesticides on cashew, cereals, oil seeds vegetables, coffee and tea, that exposed farmers to succumb many health problems like skin problem, cancer and lung problems etc.

**Shetty P K et al., (2011)** Conducted a study on negative externality of pesticides use. The results of the study found that, consumption of pesticide observed declining trend since 1990. In his study he found that about 19 percent of the farmers experienced negative side effects due to occupational pesticide exposure. Many farmers are well aware of possible routes of pesticide absorption. They make short term assessments of pesticides and apply pesticides without taking any precautionary measures. Case sheets with regard to pesticide poisoning cases were available only in few Government hospitals. But private hospital does not keep any records relative to pesticide poisoning cases.

**Leela Solomon (2011)** Observed that Aerial spraying of the pesticide endosulfan on Cashew plantations at Kasargod district of Kerala. In her study she found that despite the ban of endusultan in Kerala (after the tragedy that occurred, in Kasargod) it is still continues to be sold in the state itself and in different parts of the country. India is the major exporter of endosulfan despite its adverse effects in agriculture which needs to be addressed in the view of sustainability, food security; environmental conservation and health of farmer’s issues are concerned.
Dhanraj A Patil and Ravasaheb J Katti (2012) In their study the found that, indiscriminate and unscientific handling practices of pesticides has not only damaged environment but also caused many human health problems in agriculture. It causes 14 percent known injuries and 10 percent fatal complications. The study found that in Maharashtra cash crop zone the relationship between extents of pesticide used and health complications among farmers were assessed. The result revealed that 75 percent of the labourers used either moderately hazardous pesticides or highly hazardous pesticides are classified by world health organization (WHO). However 88 percent of the labourers who were involved in the spraying activities did not wear any protective clothing thereby exposed to pesticide residues.

Amoako P.K et al., (2012) Conducted a study on pesticide usage in cabbage in Ghana. The results found that, only 25 percent of the respondents applied recommend doses of pesticides, while majority of 55 % used more than the recommended level of pesticides and 20 percent sprayed pesticides below the recommended dosages to control pests and diseases in cabbage cultivation. Even 67 percent of the Cabbage farmers reported that the adopted protective measures at the time of pesticide spraying, while 33 percent of the respondents reported that they did not wear any protective clothing at the time of pesticide spraying.

Lavanya Kumari and Giridhar Reddy (2013) The study highlights some of the problems experienced by the sample respondents and farm workers were skin rash, headache, excessive sweating, and diarrhea. As reported in the study most often self-reported health problems are skin rash (90 %), Headache (48.2%) excessive sweating (22.4%) and diarrhea (21.4%). Finally they found that, there is a strong correlation between toxicity symptoms and practice score for protective measures.

Tulsi Bharadwaj and Sharma (2013) Observed that, application of pesticides adversely affects non target species in the environment such as plants, fisheries, birds and wildlife. They also found that excessive use of pesticides pose potential risk to humans and cause many side effects to the environment. Hence, the major victims are children. Some of the acute health problems noticed among respondents include cancer, neurological problems, reproductive risk etc.
Day and Dutta (2013) In their study carried out in three districts of Barak valley of Assam found that farmers in the study area used pesticides ranging from highly hazardous category to extremely hazardous category which are considered to be highly dangerous by world health organization (WHO). Various signs and symptoms were reported by the farmers, it was found to be very, severe. It is also found that, lack of precautionary measures taken by the farmers was observed to be significant factors for the poor state of health of farmers in the study area.

Subhashchandra et al., (2014) Conducted a study on persistence pattern of pesticides on “Brinjal” and found that, an estimated 85-90% of pesticides in human bodies are received through foods, vegetable are of direct concern with respect to the buildup of pesticides residues from point of hazards to consumers, as they are consumed afresh immediately after field harvest without giving much time for dissipation of residues. With the growth of pesticide use in developing countries, the case of poisoning and occurrence of environmental hazards are also likely to increase. In most countries, governments are endeavoring to regulate pesticide usage and increase farmers’ awareness of hazards, while at the same time trying to promote the use of environmental friendly alternatives such as integrated pest management practices.

Indranil Banerjee et al., (2014) conducted a study and their study reveals that, alpha – cypermethrin (46%) was the most commonly used pesticide in the study area, followed by methyl parathion (25.6%), imidacloprid (16.4%) dichlorros (7.8%) and phorate (4.2%). The farmers experienced headache (29.8%) followed by nausea (26%), burning sensation in eyes (9.8%), cough (9.2%), muscle cramps (2%). Regarding the personnel protective measures taken by the farmers for spraying, covering nose, mouth with cloth combined with bath after spraying was the most common practice (27%). When asked about suggested actions to be taken if anybody becomes sick following exposure to pesticides, 86% of farmers prefer consulting a doctor.

Abedullah et al., (2014) In their study estimated and quantified health and environmental effects of pesticide use in an economic perspective for BT and Non BT farmers of cotton in Pakistan. The result found that, farmers who adopted BT farms have greater Cotton production with small quantity of pesticide used and least environmental pollution. This increased environmental efficiency of BT, forms by 37
percent. Whereas, in case of conventional non Bt farms, to reduce negative health and environment implications incurred the expenditure of US $ 54 per acre in terms of foregone yields and revenues. These results indicate that, BT farm adaptors emerged as most economical and environmental friendly.

**Deviprasad et al., (2015)** conducted a survey on pesticide usage pattern in four districts of Karnataka.” Survey reveals that, few of farmers knew that there are harmful effects of the pesticides on human beings the farmers who are actively involved in the pesticide usage were asked whether they experience any health related problems during or immediately after pesticide spraying days and non-spraying days. Many signs and symptoms were reported by a large number of farmers. Skin problems are the most common health problem linked to pesticide use, eye irritation symptoms, breathing problem, dehydration/ vomiting cramps and diarrhea were also reported for which these people either go to doctor or hospital. It was found that agricultural farmers are relatively free from illness during non-pesticide spraying days. It is pertinent to note that due to bad smell, eye irritation, throat infection and many other reasons, majority of the farmers chewed tobacco, gutka or smoke while spraying and farmers expressed the fact that they consume country liquor/wine during spraying to avoid smell and adverse effects of pesticides.

**Pujeri Pujor et al., (2015)** Conducted a study on an economic analysis of pesticide residue in vegetables in Vijayapura, Karnataka. The study found that, pesticide ensures high crop production and helps in post-harvest treatment of agricultural commodities. However, indiscriminate use of these chemicals have contaminated environment and resulted in short term/ long term chronic health problems like headaches, nausea, cancer, reproductive harm etc. The study further found that, presence of pesticide residues in food products.

**Greenpeace (2015)** In its report on “Pesticides and our health” finds how industrial farming and the use of chemical in particular is presently adversely affecting farmers health and their family. The report also highlights on pesticides residues found in food and human breast milk, cancer development in children etc.
2.1.4 Determinants of pesticide use in the study area:

Gilles Forget (1991) Pointed out that a high proportion of pesticide intoxications appear to be due to lack of knowledge, unsafe attitudes, and dangerous practices. The technology available to small farmers of pesticide application is often inappropriate: faulty sprayers, lack of protective equipment adapted to tropical conditions, nonexistent first-aid provisions. Agricultural extension is often not oriented to the transfer of information relative to the dangers inherent in the use of pesticides. The lack of information at all levels may be one of the most important causative factors of chemical intoxication in developing countries.

Sivayoganathan C et al., (1995) Conducted a study on Sri Lankan farmers with regard to pesticide usage and influence of education on pesticide use. In their study they found that Sri Lankan farmers use large amounts of pesticides to control the pests affecting their vegetable crops. Improper use of pesticides by farmers has resulted in poisoning of occupational origin. They recommend that protective materials adapted to the climate and socio-economic conditions of farmers be developed, and that farmers be encouraged to use their protective materials through appropriate educational efforts and incentives.

Guy Blaise Nkamlu et al., (2000) In their study on determinants of input use in peri-urban lowland systems found that, the educational level of the head of the household has a positive relationship to the decision to use chemical fertilizer. The coefficient of education is positive and significant at 10%. Although having the expected signs, it is found that the level of education is not significantly related to the adoption of pesticides. As expected, the coefficient is positive confirming the fact that chemical fertilizer is applied more in distant fields. In contrast, contact appears to be significantly related to pesticide use and not related to fertilizer use. In inland zones of Cameroon, it is observed that a part of chemical fertilizer, animal manure and/or composting, are frequently used. In contrast, chemical pesticide does not have so many substitutes. This may explain the fact that chemical fertilizer is used more on distant fields and the relative importance of extension contact in the adoption of pesticides. Concerning land tenure rights, results show that land tenure rights are significant in either the chemical or pesticide sub-model. As expected, farmers with permanent land rights have the lowest probability of fertilizer and/or pesticide use.
Sanzidur Rahman (2003) In his study found that, farm size was found to have significant influence on pesticide use. However, it is not clear which form size categories use more pesticides. Age and education level of farmer as explanatory variables are common in the literature. These variables, acting as a group or separately, are expected to have an influence on pesticide demand in the following ways. For instance, education is used as surrogate for a number of factors. At the technical level, access to information as well as capacity to understand the technical aspects related to farming may influence crop choices and hence pesticide use. Age of the farmer is incorporated to account for the maturity of the farmer in his/her decision making ability related to pesticide use.

Shetty P K (2004) In his study observed that, education plays an important role as it exposes farmers to the various aspects and opportunities related to agriculture. It also enables them to read and understand instructions in the package of practices and the labels on pesticide Containers. It was observed that, farmers with education have high awareness of various developments in agriculture recommended practices, and ill effects of toxic chemicals. Awareness in the farming community is the net result of their education, involvement in Programmes conducted by the government and pesticide industry, exposure to media, and interaction with other progressive farmers. Illiterate farmers or agricultural laborers are a vulnerable group as they cannot identify the warning symbols on the label and are often subjected to the risk of poisoning. Medium and large farmers have greater access to information on agriculture, and often take the risk of adopting innovative agricultural practices.

Jayanthi and Kumbairaju (2005) In their study highlighted the factors about farmers perception on the quantity of pesticide being used by them as to its adequacy, under use or over use and reasons for the same. Quantity of pesticide currently used is enough to control pests was the main reason as per the perception of adequate use of pesticides with 56.41 percent farmers. About 34.62 percent responses reasoned the use of this quantity of pesticides for getting higher returns, while 8.97 percent applied it on the recommendations of pesticide dealers. Those farmers who reported over use of pesticides reasoned out that, higher pest incidence (41.3), followed by ineffectiveness of pesticides (19.8%) as the major reasons for their overuse. Some farmers (19.01) felt the necessity of over dose because of overuse of pesticides by their neighbors. About 12.40 percent responses were in favor of higher returns from
the over-use. Pest resistance (7.44 percent) also made the farmers to use over doses to control pests. The major reasons stated by the farmers for less use of pesticide were lack of funds (38.4%), low pest incidence (38.4), and lack of knowledge about prophylactic dose (23.1).

Susmita Dasgupta et al., (2005) In their study empirically analyzed the farmers perception of pesticides, that can be shaped by a variety of factors including potential health implications, formal education, and pesticide training. Farmers misperception include, age, education, training and location. Farmers’ overuse of pesticides was specified as a function of farmer misperception, toxic use, age, income, education, farm size, ownership, training, practicing IPM and location.

Selvarajah and Thiruchelvam (2007) Conducted a study on factors effecting pesticide use by farmers in vavuniya district. In their study they estimated the impact of chemical use on crop productivity; a multiple regression approach was used. The dependent variable the level of pesticide used by farmers was measured by a ratio of actual amount of pesticides used to recommended level. The farmers’ pesticide use level was hypothesized to depend on various socio- economic, crop and chemical price variables. Such information was useful not only for a better understanding of farmers’ behavior on pesticide use, but for deciding a suitable strategy on improving present pest and pesticide management techniques. It was the perceived view that amount of pesticide use can be influenced by farmers education, farming experience, farming system, income and type of labor involved in spraying, that is own family labor or hired labor and chemical price thus, it was hypothesized that better educated and experienced farmers apply recommended quantities of chemicals. Farmers with higher income may use more chemicals then lower income farmers. It was also hypothesized that a low quantity of the chemical is used when its price is increased.

Subashiny Nagenthirarajah and S. Thiruchelvam (2008) Examined in their study– Similar to many developing countries, pesticide related issues in Sri Lanka have become a major concern in the recent past. Many researches were conducted to evolve technical alternatives for eco-friendly agriculture, but very less emphasis was given to the knowledge and behavior of the farmers. Having recognized the need, present study was conducted to assess the farmers’ knowledge level on pest management practices and socio-economic factors influencing the existing pest
management practices. Ordered probit model was used to analyze the data from 50 vegetable farmers who were randomly selected from Pampaimadu, Agricultural instructor range in the Vavuniya district. Nearly 605 of the farmers had medium level of knowledge of plant protection practices. Only 6% of the farmers had good level of knowledge towards the recommended plant protection measures. Almost all the farmers depended on chemical pesticides for the management of pest and disease but at 35% higher concentration than recommended level. Farming experience and social participation were positive and significantly contributed to farmers’ knowledge on safe pesticide use. Education, income, age and family size of farmers had showed no relationship with the knowledge level of pest management.

**Juthathip and Ganesh (2009)** In their study conducted to investigate pesticide use and prevention practices of tangerine cultivators in Thailand found that about 36% tangerine farmers adopted recommended preventive measures at the time of pesticide use. Preventive measures as reported by farmers are farming experience and chemical use experience. Participating in training programmes found to be ineffective. Whereas education, training and research on harmful effects of pesticides on human health is desperately needed. In this regard extension workers proactive attempt to alter pesticide policy is essential rather than giving knowledge of pesticide use to the farmers.

**Joko Mariyono and Battharai (2009)** In their results show that, factors leading to higher doses of application of pesticides are- market price of chilly, number of insect pests on the field as observed by farmers, non –hybrid variety of chilly grown, and more frequency of spray in a season, cocktail method of pesticide spray, and production location. On the other hand, factors that contribute in less use of pesticides use are, increased prices of pesticide, higher level of farmers education and long years of farming experience, more number of diseases observed by farmers, and large acreage cultivated to chilly.

**Indira Devi P (2009)** Analyzed the level of awareness regarding pesticide use/handling has been reported in the farms of Kerala and the same has been compared with the adoption pattern and experiences of health risks episodes, is a society with high level of literacy. The understanding on various aspects of pesticide use has revealed better awareness in certain aspects and poor understanding in certain
others. The workers have not been given adequate training to understand the toxicity level by looking at the color code on the packet. Despite a high literacy level, most of them do not care to read the instructions and follow them. The study has found that a majority of the respondents are of satisfactory health status by the body mass index values. The study has highlighted the need for targeted trainings to farm Laborers Besides farmers on the scientific management of pesticides and undertaking of massive awareness generation programmes.

**Shetty P K et al., (2010)** In their study on Formers education and perception on pesticides eye and crop economies: In Indian Agriculture found that, Education plays very important role as it widens the vision of the farmers and exposes them to various aspects and opportunities related to agriculture and related fields. In this study nearly 15% of the farmers had either college level education or no education at all. Close to 40% of the samples had only primary level of education. The rest of the samples were having secondary education (30.8%). Regarding awareness of pesticides 70% of the illiterate farmers undertook spraying of pesticides themselves, while about 76% of the college educated farmers preferred hired laborers for spraying pesticides.

**Adeola S.S. et al., (2011)** Estimated determinants of pesticide using regression analysis. The result reveals that, pesticides used was taken as dependent variable and family size, sex, level of education, farm size, years of farming experience as independent variables. The result found that, co-efficient of family size was negatively related to pesticide use. It infers that, as the size of the family expands, the level of pesticides used decreases. While farm size is positively related to pesticide use. This indicates that, higher the size of land holding, lower will be the application of pesticides. Hence, family size and land size observed to be statistically significant variables in the model.

**Adeola, R.G. et al., (2012)** Conducted a study on perceptions of pesticide use of farmers in Nigeria. Findings revealed that, among the variables in the model age of the farmers had significant influence on the farmers’ perception. Because old farmers can better perceive the impact of pesticide on health of the farmers due to previous knowledge and experience gained in farming activities. Education also had significant influence on farmers’ perception. This is due to the capacity of the farmers to read and follow the guidelines on pesticide containers. Farming experience
was also found to have significant influence on farmers’ perception. The reason for this may be due to the awareness on pesticides hazards which the experienced farmers have gathered in the past years. Extension contact also had significant influence on farmers’ perception and this is due to the information gathered from the extension workers on the environmental consequences of pesticides. Other variables in the model are also influencing the perception of the farmers, but are not statistically significant.

Niklas Mohring, Robert Finger et al., (2012) Found that, most variation in pesticide use is due to individual and farm characteristics are confirmed. Their results show significant effects of socio-economic variables (as wealth, education and age), agronomic variables (as solid management) and farm characteristics (as farm type). Higher education, as well as mixed animal and crop farming are shown to be determinants for reduced pesticide use, for example, the effect of proxies for risk aversion on the other hand is difficult to distinguish, due to mixed results in significance and difficulties in interpretation. This might indicate a relatively small effect on pesticide use compared to stable use patterns, which can weather specific. Significance of the above determinants further differs for different types of pesticides.

Tijani and Sofolue, (2012) In their study on factors determining the pesticide use on cocoa farms in Nigeria found that, pesticide price is significantly directly related to pesticide use suggesting that, as the prize of the pesticide increases, the quantity of pesticides used for cocoa crop also increases due to the occurrence of black pod disease in cocoa cultivation, which cannot be destroyed if pesticides are not applied irrespective of the price of pesticides. Greater the farm size, the quantity of pesticide used also increases but in a diminishing manner owing to economy of scale on the amount of pesticides used on large farms. The amount of pesticide use is negatively associated with age, marital status, household’s size and access to loan. Education is positively associated with pesticide use indicating that highly educated people use more pesticides, consistent with high expectation.

Amoako P K et al., (2012) Conducted a study and the results show that, fifty one percent (51%) of the farmers interviewed did routine spraying of pesticides to control insect pest on their cabbage. However, forty nine percent (49%) of the respondents decided to spray pesticides against insect pests upon noticing their presence on their
cabbage forms, whether or not the numbers of insects are at the threshold. Majority of the farmers sprayed whether they saw insects on the crop, whether at the threshold or insects were not pests. Even though majority of the farmer sprayed in the mornings and evenings.

Magali Aubert and Geoffroy Enjolras (2014) In their study analyzed factors that encouraged French wine growers to use pesticides in order to protect or increase output. The study shows that, differentiating the inputs is the primary factor which must be taken into consideration to analyze whether a particular input stimulates the growth of plant or not. An input intensive farm size is characterized by small area, unfavourable climatic conditions are mostly governed by the application of plant protection chemicals and fertilizers. While, education and indebtedness are found to be insignificant factors influencing output of the French growers.

Lavanya Kumari P and Giridhar Reddy et al., (2013) In their study on knowledge and practices of safety use of pesticides among farm workers focused on level of Knowledge and Practice of safety pesticide use among various farm workers in agricultural field. Certain level of education and experience has contributed significant knowledge on safety use of pesticides which further has to make them to practice correct methods while applying pesticides. But no such practice has been identified which tells the need of special training to implement known safety measures rather than knowing further. Age and gender have not influenced their knowledge and practice on safety use of pesticides. Interestingly, farm workers who are working in closed farms had more knowledge than those of in open farms but both group of workers are practicing only half of the safety measures which are known to them. Hence, they extremely need a motivational programme rather than awareness programme.

Omotayo Olugbenga Alabi. et al.,(2014) In their study examined probit model analysis of smallholder’s farmers decision to use agrochemical inputs in Gwagwalada and Kuje Area Councils of Federal Capital Territory, Abuja, Nigeria. Eight estimators, age; farm-size; education-level; extension services; access to credit; off-farm income; experiences in farming; in the Probit model were found statistically significant. Results show that the probability of using agrochemical inputs increases with age; farm size; family-size; education-level; extension services; experiences in
farming but decreases where they have off-farm income and access to credits. McFadden Pseudo-R gives 0.6866 and Probit model correctly classified 93%.

**Benjamin Tetteh Anang et al., (2015)** The study sought to investigate the factors which influence small holder rice farmers’ use of pesticides in rice farming in northern Ghana. The data was analyzed both descriptively and inferentially. A probit model was used to study the determinants of pesticide use. The study showed that farm size, farm income, mechanization, extension contact, distance to source of pesticide and production system were the influential factors in rice producers’ choice to use pesticide in rice farming. The study recommends extension education to farmers on pesticide use in order to avoid misuse and the risks factors associated with improper application.

**Himani Tyagi et al., (2015)** Found that, efficiency of the pesticide for pest was identified as the most important factor that influences the choice of pesticide by the farmers. More than 50% of the respondents (58%) agreed that pest control is the crucial factor behind selection of pesticide while 42% farmers pointed out cost of the production as the driving factor for the same. Maximum number of farmers (40%) revealed they normally apply pesticide either on the presence of pest or just before the pest occurrence period. Recommendation and advice of agro-chemical dealers (24%) and the following farmers (20%) were also major contributing factors towards deciding the time of application of the pesticide. However, a significant proportion of the farmers (16) confirmed the pesticide application on a regular basis throughout the crop season without considering the presence of pest or disease symptoms.

**2.2 Theoretical Background**

Externality has been defined by several economists in several ways. According to Boumol and Oates negative externality states that,

1. An action of one person (B) affects production/consumption activities of person (A) as a side effect.
2. Action of the person (B) is unintended or not deliberate.
3. There is no agreement between A and B governing the impact or the effect.
4. There is no price system (compensation is not paid for loss or benefit is not rewarded) between A and B due to the impact or the effect.
This is market failure as market fails to value the impact, which can be positive or negative.

**Theory of Economic Externalities.**

British economist A. C. Pigou propounded the theory of economic externalities, published in 1920. An economic externality is the result of an economic activity that is borne by a third party. The theory of economic externalities examines instances where the costs or benefits of activities extend beyond the parties directly involved and third parties are impacted. When the third party suffers the costs, it is a negative externality. The presence of negative externalities unduly affects economic choices, since neither of the involved parties is bearing the cost of the activities and thus they make wrong decisions.

The best example of a negative externality is a scenario where in the process of its manufacturing activities, a factory emits poisonous chemicals into the adjacent river. Residents of the town downstream fell ill from the polluted water, and living things in the river die from the factory's chemicals. These residents are third parties who are paying the costs for the factory owner's business decisions. Pigou propagated taxing the activities in such situations. The free market often fails to provide sufficient incentives to eradicate the negative implications of economic activities, such as the factory's pollution that resulted from its manufacturing. This theory offers the incentive when market economies do not. In the example above, a Pigovian tax, such as an emissions tax levied against the factory, would incentivize the factory owner to implement more environmentally friendly production processes.

**The Coase Theorem (The Problem of Social Cost)**

Cease’s main contribution was clarified in his article published in 1960 concerned with those actions of business firms which have harmful effects on others. The standard example is that of a factory the smoke from which has harmful effects on those occupying neighboring properties. The economic analysis of such a situation has usually proceeded in terms of a divergence between the private and social product of the factory. The conclusions to which this kind of analysis seems to have led most economists is that it would be desirable to make the owner of the factory liable for the damage caused to those injured by the smoke, or alternatively, to place a tax on the
factory owner varying with the amount of smoke produced and equivalent in money terms to the damage it would cause, or finally, to excluded the factory from residential districts (and presumably from other areas in which the emission of smoke would have harmful effects on others). It is my contention that the suggested courses of action are inappropriate, in that they lead to results which are not necessarily, or even usually, desirable.

There are two kinds of externalities, namely positive and negative externalities. The former arises when an action by an individual produces a beneficial result to the society or another individual. In our study some of the paddy farmers used bio pesticides like neem cakes, green manure etc in paddy cultivation. As a result of this severity of the health problems are less to the farmers who used bio pesticides (positive externality). Another beneficial externality is sample farmers were able to obtain good quality and quantity of yield of paddy per hectare. Whereas many of the sample farmers who used spurious chemical pesticides which are of category 1b and 2 category pesticides (as per WHO classification) in all the three crops caused severe health damage due to occupational exposure (Negative externality). This do not require admission to a hospital and are therefore not included in routine health statistics. There are no estimates or case sheets of the incidence of occupational poisoning in the government hospitals of the study area. It is based on the self-reported episodes by sample farmers.

Furthermore, proper assessment of health hazards due to pesticide use in the study area raises some difficulties as many minor poisoning cases are not reported to a doctor or there is no systematic monitoring of poisoning cases in these three taluks. It was observed that record on serious pesticide poisoning cases were available mostly in a few government hospitals in Mysore district, but such details were not accessible from private hospitals as pesticide poisoning incidences are subjected for medico-legal cases.

As the farmers incur expenditure in the form of private cost as the value of loss to pests and diseases (private cost) is invariably lower than the cost of treating pesticide related illness in the form of public health programmes which is referred to as social cost. Hence, private cost is less than the social cost in the case of negative externality.
**Frontier Production Function**

Frontier production functions have been applied in the analysis of farm-level data in a large number of developed and developing countries. Frontier production functions have permitted sophisticated analyses of technical efficiency. The stochastic behavior of the random variables involved in frontier production functions is obviously only part of the modeling exercise. The use of frontier production functions for the prediction of the technical efficiencies of farmers involves several problems which require further research. Although frontier production functions can be estimated by different methods (other than maximum likelihood, it appears that distributional assumptions are basic to obtaining predictions for technical efficiencies. The robustness of predictors when different distributional assumptions are made is an issue for further study. The precision of predictors for individual technical efficiencies is also an area requiring careful research.

The rather sophisticated nature of the econometric models for frontier production functions and the predictors for technical efficiencies is likely to discourage many researchers from applying them in empirical studies. However, the computer program, FRONTIER, can be readily used for estimating both time-invariant and time-varying models of technical efficiency with panel data or applied in the analysis of cross-sectional data (see Coelli, 1992. More general frontier models are being investigated and will be incorporated into the program, FRONTIER, as they are developed.

Hence, the present chapter reviews literature pertaining to the various aspects of pesticides uses, research issues and the theoretical background of production. The next chapter focuses on growth pattern of pesticide usage in agriculture in India in general and southern states in particular.