The socio-economic impacts of air pollution are subjects of public concern in developing countries. Despite resistances from environmental movements and international compulsions for safe environmental practices for industrialisation, many developing nations are still using 'pollution generating' technologies for the sake of ensuring economic well-being to the large sections of their labouring classes and poor communities. Although some of these countries, as part of liberalization packages, have been adopting 'environment-friendly technologies' during the last couple of decades, sufficient progress has not been achieved so far due to their own structural problems. The existing scenario of Indian industrialisation also raises similar concerns and very few attempts have been so far made to study how pollution externalities influence the process of the country's industrialisation and its drive towards sustainable economic development\(^1\). The issue of environmental degradation and the need for evolving a self-sustaining industrial sector has been the primary concern in India and the Government has formulated various legal codes and regulatory regimes to control pollution. Although a number of studies have been recently conducted on the impacts of industrial pollution on public health and the economy of India, no such

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serious studies exist in the state of Kerala. This neglect arises from the general feeling with in the bureaucracy that the State does not experience serious contradictions in the use and allocation of its environmental resources for industrialisation. The neglect of environmental issues in the early writings of the apostles of the Kerala Model of development has already been exposed by many scholars recently\(^2\).

Our study is a humble attempt to examine the economic impacts of air pollution on the human health and property values in the industrial capital of Kerala. We observed that the process of industrialisation in Kerala and the increase in air pollution created damages to human, natural and economic resources in the State. The manner in which civil society and the affected households in particular, reacted to their welfare loss varied significantly across different regions and various groups of people and an understanding of such human responses are essential for evolving an environment-friendly approach towards industrialisation. This study was organised to understand this behaviour and to estimate and present information on welfare losses of households affected by air pollution in Cochin industrial agglomeration.

\(^2\) The so-called ‘Kerala model of development’ has become part of the broad global debate about development in the ‘third world’. Alexander (1994) has gone so far as to recommend Kerala as a sustainable and eco-friendly model for the whole world in the twenty-first century (Tharamangalam). Franke, (1995) has also raised serious concerns about the environmental degradation as a major problem in Kerala. See footnote number 7 in chapter 1.
The study began by documenting the extent of air pollution and applied econometric approaches to estimate economic impacts of air pollution on human health and property values. Welfare losses for the local households due to air pollution were estimated using Observed Behavioural and Hypothetical Market Survey Methods. 'Marshallian Consumer Surplus' measures were also estimated for obtaining welfare loses in property values due to air pollution. The methods detailed in the introductory chapter, presented the economic models and estimation procedures adopted in this study.

The thesis is organized into six chapters. After introducing the study and the methodology in chapter 1, an attempt was made to review the relevant literature on the impact of air pollution on human health and property values in the second chapter. In the third chapter we outlined the status of air pollution in the Cochin industrial agglomeration. The fourth chapter provided an analysis of the influence of air pollution on human health and chapter five focussed on a detailed analysis of the impact of air pollution on property values.

The brief review of studies undertaken by social scientists in different parts of the world was presented in chapter two. The survey helped to examine the complex relationship between air pollution, public health and property values both in the developed and developing nations and enabled us to understand the major theoretical
and conceptual issues raised especially by environmental economists in studying such relationships. These surveys revealed clearly that air pollution affected public health and the prices of their property both in the developed and developing nations alike. The recent attempts by scholars to study the environmental issues related to industrialisation has helped to formulate sound economic policies for good environmental governance.

The third chapter presented the air pollution scenario of Kerala and provided some scientific evidences on health-air pollution relationship. Air pollution is a serious problem in the industrial capital of the state due to the heavy concentration of air polluting industries and their inability to install sufficient pollution abatement mechanisms. The city of Cochin has witnessed the remarkable deterioration in the quality of air due to early localisation of a variety of air polluting industries and the growth of vehicular traffic. The available data revealed that air pollution exceeded the tolerance limits in many locations near the industrial agglomeration. The results established that, contrary to the general belief, air pollution did matter in the state of Kerala, especially in areas where industries are concentrated.

The immediate target group affected by the high incidence of air pollution has been the local human population. As argued in various chapters of this thesis, both their health and property were directly ruined due to this externality produced by the industries.
Chapter four therefore focussed on estimating their loss in welfare due to air pollution using established methods in environmental economics.

The prime indicator of reduced health status of individual households was defined as Restrictive Activity Days, RAD. Estimation of the regression coefficient of pollution on restrictive activity days, (RAD), using the 'Household Production Function' approach, indicated that restrictive activity days’ coefficient in moderate polluted areas- Irumpam and Ernakulam North- was 12 percent higher than the least polluted areas- Port Trust and CSIR Complex- while restrictive activity days’ coefficient in highly polluted areas (Eloor and Ambalamugal) was 18 percent higher than the least polluted areas. This established clearly that the welfare losses due to air pollution were a very serious problem in the study areas.

Accordingly, we estimated the willingness to pay of the affected households using the household's production function and found that the mean willingness to pay, WTP, for high polluted stations- Eloor and Ambalamugal- were Rs.4414 and Rs.6274 respectively. For moderate polluted stations-Irumpam and Ernakulam North- the mean values were Rs.2997 and Rs.3617 respectively. The regression results also indicated that, when there was a change in air quality, people in moderate polluted areas were willing to pay Rs.3204 more than those in low polluted areas where as in highly polluted areas, people were even willing to pay Rs.4946 more than those in
low polluted areas. All variables (disease dummies for asthma, bronchitis, eye irritation, recurrent fever etc., education, smoking, and insurance) other than mitigating cost, monthly income and pollution dummies, showed a negative relationship.

Estimates of willingness to pay, WTP, based on hypothetical markets were also calculated using Contingent Valuation Method (CVM). This method involved asking people whether they would be willing to pay to reduce symptoms corresponding to a change in pollution. Results showed that for highly polluted areas (Eloor and Ambalamugal) the mean willingness to pay values were Rs.932 and Rs.1059 respectively. For moderate polluted areas (Irumpalam and Ernakulam North) mean WTP values were Rs.552.50 and Rs.636 respectively. For less polluted areas (CSIR Complex and Port Trust) the respective mean willingness to pay values were Rs.359 and Rs.481. The different willingness to pay values estimated by Contingent Valuation Method (CVM) method were then regressed with socio economic variables to find their influence on willingness to pay. The estimate indicated that monthly income, mitigating cost, pollution dummies and education dummy have positive and significant impact on willingness to pay. Income is highly significant and is positively related to the willingness to pay of the people, that is, unit increase in income increases willingness to pay by 0.10 units. Mitigating cost also had a positive impact on willingness to pay and was significant. In general, the two approaches provided
evidence that, households in the Cochin Industrial Agglomeration value health reduction due to change in air quality. Comparing the estimates of willingness to pay measures we noted a consistent upward bias in the bids obtained using Household Production Function approach than Contingent Valuation Approach. Hence both approaches provided evidence that households were willing to pay for health reduction due to change in air quality. There are two sets of evidence. First, the mean willingness to pay for high and moderate polluted areas were different as per the changes in the level of pollution. The second set of evidence comes from the estimated household production function model, where doctor visits and restricted activity days had significant positive coefficient on two pollution dummies. In both approaches, income is the major factor, which influenced willingness to pay.

The primary objective of chapter five was to establish the relationship between air quality and the residential property values in Cochin industrial agglomeration. This relationship was established by estimating the Hedonic Property Value model. Incorporating a number of structural, neighbourhood, environmental and socio economic variables as the determinants of the consumer’s willingness to pay for reduced air quality, we hypothesised that the major environmental variable SO2 was inversely related to the residential property values.
Adopting a two-stage estimation procedure to estimate these relationships, we found that, on an average, an increase in the level of SO₂ reduced the property prices in the study area by 0.45 percent. We estimated the marginal implicit price for reducing SO₂ as Rs. 5154. Estimates further revealed that the households are willing to pay an additional amount of 1.48 percent for a reduction in SO₂.

The average consumer surplus per person, for a ten percent reduction in SO₂ is Rs.53,006 and the range is estimated from Rs. 3850 to Rs. 606003. Although the consumer surplus in high polluted areas (Ellloor, Irumpanam) is lower than less polluted areas (Port Trust, Ambalamugal), the latter are more conscious about the impacts of SO₂ on their property values. In short, the analysis revealed a positive response of households in Cochin industrial agglomeration towards reduced air quality. The study also revealed that tree coverage, distance from industry, plinth area of the house, number of toilets, rooms, plot area, availability of electricity, water, fencing and passage were found to be positively related to property prices while distance from city and intensity of traffic are negatively related.

This study therefore, provided very clear evidence to establish the fact that air pollution created damages to human health and their residential property values in Cochin. The trade offs between pollution-health risks and pollution-residential property value damages raised in this thesis challenge the traditional wisdom produced
in the Kerala model of development that maintained an academic silence on the environmental concerns of the economy's industrialisation processes.³

It also provided the necessary theoretical and empirical support for initiating such modes of governance in Kerala. For instance, it provided useful tips on the welfare losses to various stakeholders rooted on strong environmental economic foundations. Similarly the estimates of willingness to pay measures are helpful in designing various fiscal regimes for environmental governance⁴. This case study is a modest attempt to indicate that policies need to be based on the material realities of the local areas.

In fact, the study provided enough bases for evolving a new development strategy of sustainable industrialisation by considering the environmental needs of the local population, especially to their health and property. In other words, the new Kerala

³ It is interesting to note that similar concerns had already been raised as the limitations of the Model. For instance, the inability of the model to discuss the socio economic and ecological concerns of marginalised communities like the fisher sand tribal communities, is well known (Kurien, 1992). Similar concerns had also been raised by various social movements and political parties in recent days. Environmental problem such as industrial or automobile air pollution has not accounted serious concern in the development thinking of Kerala People. Also environmental policies haven't made any serious negative or positive influence in the industrial growth of the state. Few environmental problems reported in and after 1980's were related to deforestation, paddy conservation and disruption of backwater ecosystem.

⁴ It is unfortunate to note that environmental policy making processes in developing countries had been influenced by western models and the experiences of industries in developed countries. Lack of enough case studies to the satisfaction of drawing meaningful guidelines and generalisations are pointed out as the major reasons for this policy mistake.
Model of development should necessarily incorporate its own environment as an important variable in the development discourse.\(^5\)

This is not to diminish or to negate the ongoing responses of various stakeholders\(^6\) towards air pollution and government's\(^7\) initiatives to regulate its negative impacts. As observed by Rene Veron (2000; 2001) local environmental actions in the state have been emerged mainly due to the conflicts in the regional use of natural resources like water, sand, fisheries, forests etc. and the responses to this environmental degradation came from various quarters. Many industries are facing severe public resistance against the negative impacts of industrialization. At the same time, pollution emitting firms face severe bottlenecks for undertaking abatement measures, especially due to a recent economic crisis evolved due to liberalisation. Government regulatory mechanisms are either not enforced or become ineffective even when enforced.

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\(^5\) The production trajectories needed to be redefined by introducing pollution as an explicit input variable vector. Increasing number of people's agitations against polluting factories indicate the need for sound pollution management methods in Kerala. Also pollution management should be localized by introducing the concept of participatory planning which comprises decentralized administration, participatory planning and the collaboration between the state, NGOs and civic movements.

\(^6\) Various local level institutions and NGOs such as Kerala Peoples Science Movement (Kerala Shastra Sahitya Parishat KSSP) have raised voice for serious environmental issues. People's struggles against the polluting industries, which directly affect their livelihood in Karimukal and Eloor of Cochin attracted national and international importance. These two strikes along with some other regional agitations have created a new environmental consciousness in the development model of Kerala.

\(^7\) Under the Indian federal system environmental management is generally organised by various government departments based on formal legal norms and policies crafted by the Central and State governments from time to time Kerala State Pollution Control Board is the official authority to monitor
This indicates towards the limitations of the modes of environmental governance adopted by the centralised bureaucracies for managing air pollution. We shall briefly mention these limitations in the light of this study. For instance, even if good estimates of welfare losses and corresponding willingness to pay measures were available, the governing agency would still require a variety of additional information on the behaviour of other stakeholders including the industry and civil society towards the production and consumption of air pollution. Second, there is the question of choice of an appropriate agency for governance as there is no guarantee whether the industry or the affected stakeholders cooperate in the process of management if measures are designed and enforced unilaterally by the state bureaucracy. Although such considerations are important for evolving good environmental management in areas affected by air pollution, economic valuation studies still merit attention as a guide towards good policy making.