INTRODUCTION

"If you want to learn about the health of a population, look at the air they breathe, the water they drink, and the places where they live."

- Hippocrates

The global environment is increasingly threatened by the excessive exploitation of our finite natural resources, taking place against a background of climate change and in parallel with the development of novel technologies, posing potential threats. Today more than ever, human health is vulnerable not only to individual sources of pollution, but frequently to the combined effect of pollutant mixtures. Scientists have traditionally worked to develop methodologies for the identification, understanding, monitoring and, importantly, mitigation of environmental hazards, whether anthropogenic or natural.

Climate change and global warming have been the most upcoming issues throughout the world. the prevalence of some diseases and other threats to human health depend largely on local climate. Neither developing countries nor the developed countries are spared from the effects of climate change. It is known to have impacts on the health which is clearly depicted by the number of deaths caused and the natural calamities faced due to the same. Climate change is not just an environmental issue but also a health issue. The potential health effects of climate change are enormous. Management of those health issues is a big challenge not only for developing countries but also for the developed countries.

An integrated and holistic political response is vital for good social, economic, and ethical reasons. The ability to adapt to the health effects of climate change depends on measures that reduce its severity i.e. mitigation measures that will drastically reduce carbon emissions in the short term, but also increasing the planet's capacity to absorb carbon. Climate change greatly influences the prevalence and distribution of the respiratory disease in general and asthma in particular. (Curson, 1993; Bohonos and Hogan, 1999; Engelthaler *et al.,* 1999 and Lancet commissions, 2009).

The predicted effects for the environment and for human life are numerous and varied. (Parry *et al.,* 2007). The main effect is an increasing global average temperature. From this flow a variety bof resulting effects, namely, rising sea levels (Roaf *et al.,* 2005; Dasgupta *et al.,* 2007 and McGranahan *et al.,* 2007) altered patterns of agriculture (Awuor *et al.,* 2008 and Bicknell *et al.,* 2009), increased extreme weather events, and the expansion of the range of tropical diseases (Epstein, 1996 and Krosnick *et al.,* 2000). According to World Health Organisation (WHO) estimates 300 million people suffer from Asthma, 255, 000 people died of Asthma in 2005 (WHO, 2004) and over 80% of Asthma deaths are reported from low and lower-middle income countries (Persky *et al.,* 1998; Mallol *et al.,* 2000 and Braman, 2006). Asthma is these days becoming a primary factor creating a substantial burden on individuals and families as it is more often under-diagnosed and under-treated. (Rabe *et al.,* 2000; Adachi *et al.,* 2002 and Lai *et al.,* 2003).

Human health is strongly affected by social, political, economic, environmental and technological factors, including urbanization, affluence, scientific developments, individual behavior and individual vulnerability (e.g., genetic makeup, nutritional status, emotional well-being, age, gender and economic status). The extent and nature of climate change impacts on human health vary by region, by relative vulnerability of population groups, by the extent and duration of exposure to climate change itself and by society's ability to adapt to or cope with the change (Meehl *et al.,* 2000; Smith, 2000; Patz, 2001; McMichael and Kovats, 2000 and McMichael *et al.,* 2006).

According to The Intergovernmental Panel on Climate Change (IPCC, 2007). Human beings are exposed to climate change through changing weather patterns and indirectly through changes in water, air, food quality and quantity, ecosystems, agriculture, and economy. The effects are small but are projected to progressively increase in all countries and regions. Given the complexity of factors that influence human health, assessing health impacts related to climate change poses a difficult challenge.

Furthermore, climate change is expected to bring a few benefits to health, including fewer deaths due to exposure to cold. Nonetheless, the IPCC has concluded that, globally, negative climate-

related health impacts are expected to outweigh positive health impacts during this century. (McMichael and Haines, 1997; Pielke and Pielke, 1997; Kunkel *et al.,* 1999; Easterling *et al.,* 2000; Bernard *et al.,* 2001; Haines *et al.,* 2006 and Diarmid and Carlos, 2007).

There is growing concern about the links between the environment and health. Worldwide, and probably also in India, one quarter to one third of the burden of disease appears to be attributable to environmental factors. Vulnerability and exposure, however, vary markedly between different groups and areas, with children and the elderly being particularly at risk. There is reasonable understanding of cause-and-effect relationships between water, air pollution and human health. However, the health consequences of other environmental factors and exposures, such as those resulting from climate change and chemicals in the environment are a result of complex interactions between the environment and humans that are far less understood.

Environmental factors affect human health in important ways, both positive and negative. – Positive environmental factors sustain health, and promoting them is preventive medicine. And Negative environmental factors are threats to health, and controlling them is public environmental health.

Over the last 50 years, human activities – particularly the burning of fossil fuels – have released sufficient quantities of carbon dioxide and other greenhouse gases to trap additional heat in the lower atmosphere and affect the global climate. In the last 100 years, the world has warmed by approximately 0.75°C. Over the last 25 years, the rate of global warming has accelerated, at over 0.18°C per decade. (Hales *et al.,* 2002; Arnell, 2004; Robine *et al.,* 2008 and Zhou *et al.,* 2008). There has been an increase in the global mean temperature of about 0.6°C since the start of the 20th century and that this increase is associated with a stronger warming in daily minimum temperatures than in maximums, leading to a reduction in the diurnal temperature range (Easterling *et al.,* 1997).

Although global warming may bring some localized benefits, such as fewer winter deaths in temperate climates and increased food production in certain areas, the overall health effects of a changing climate are likely to be overwhelmingly negative. Climate change affects the fundamental requirements for health – clean air, safe drinking water, sufficient food and secure

shelter. (Woodhouse and Overpeck, 1998; Zwiers and Kharim, 1998; Diaz *et al.*, 2000; Viner *et al.*, 2000 and McMichael *et al.*, 2006)

The role of carbon dioxide in warming the Earth's surface via the natural greenhouse effect was first proposed by Swedish scientist Svante Arrhenius more than 100 years ago. Arrhenius suggested that changes in carbon dioxide might explain the large temperature variations over the past several hundred thousand years known as the ice ages. Carbon dioxide appears to have acted like a feedback during these cycles, reinforcing temperature changes initiated by natural variations in Earth's orbit (Revelle, 1983; Raval and Ramanathan, 1989; Rodhe, 1990; Rosenzweig and Solecki, 2001 and Royer *et al.*, 2007). In contrast, carbon dioxide levels were nearly constant during the past several thousand years until human activities began emitting large amounts of carbon dioxide into the atmosphere, amplifying the natural greenhouse effect. Thus, while carbon dioxide may have acted as a feedback in the past, it is acting as a force in the current climate (Sawyer, 1972; Scheffer *et al.*, 2006 and Ruddiman, 2006).

The direct effects of Climate change on human health are increasing due to increase in average temperature. Such increases may lead to more extreme heat waves during the summer while producing less extreme cold spells during the winter. Rising average temperatures are predicted to increase the incidence of heat waves and hot extremes. In the United States, Chicago is projected to experience 25 percent more frequent heat waves and Los Angeles a four-to-eight-fold increase in heat wave days by the end of the century. Particular segments of the population such as those with heart problems, asthma, the elderly, the very young and the homeless can be especially vulnerable to extreme heat. (Gubler *et al.*, 2001; Braganza *et al.*, 2004; Robine *et al*, 2008 and Rocklov *et al.*, 2010)

The increasing temperature results into the heat related stress, which thereby increases the short term mortality rate due to the heat stroke (Kovats and Ebi, 2006). In 2003 the heat waves in Europe lead to 70 000 deaths, mainly from respiratory and cardiovascular diseases (Robine *et al.*, 2003). Urbanization is also listed as one of the main factor causing global warming resulting in the climate change (Manu *et al.*, 2006 and Lebasi *et al.*, 2010). Rural areas are the minor victims of climate change as compared to the urbanized areas as a result of which they are more adversely affected and vulnerable to climate change, with special reference to the people with a

pre-existing respiratory disease (McMichael *et al.,* 2008). The California heat wave of 2006 (Schwartz, 2004 and Lebassi *et al.,* 2010) showed large increases in admissions to hospitals from cardiovascular and other illnesses, and the heat wave in Germany in 2003 (Kysely and Kriz, 2003) increased mortality rates, especially from respiratory causes. Modelling of climate change in the Gulf predicts increased mortality rates due to cardiovascular and respiratory illnesses, thermal stress, and increased frequency of infectious vector-borne diseases in 1970–99 (Husain and Chaudhary, 2008).

Extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease. Urban air pollution causes about 1.2 million deaths every year. Pollen and other aeroallergen levels are also higher in extreme heat. These can trigger asthma, which affects around 300 million people. Ongoing temperature increases are expected to increase this burden.

Extreme temperatures can lead directly to loss of life, while climate-related disturbances in ecological systems, such as changes in the range of infective parasites, can indirectly impact the incidence of serious infectious diseases. In addition, warm temperatures can increase air and water pollution, which in turn harm human health (McMichael *et al.,* 1996; Hulme *et al.,* 1999; WHO, 2000; Rogers and Randolph, 2000; Kovats *et al.,* 2001; Guerrant, 2002 and Curriero *et al.,* 2002).

There are various factors that influence the climatic conditions of a region. The extreme weather events are experienced by the combination of all these meteorological parameters resulting into a natural disaster. Some of them viz., Extreme Heat, Floods, Hurricanes, Tornadoes, Tsunamis, Extreme Winter Weather, etc.

Extremities such as heat waves, cold waves, storms, floods and droughts are human induced climate changes and can be controlled or prevented. Though predicting changes in these types of events under a changing climate is difficult but understanding vulnerabilities to such changes is a critical part of estimating vulnerabilities and future climate change impacts on human health, society and the environment.

As defined by EPA, changes in weather patterns can result from abrupt changes that may occur impulsively due to interactions between the atmosphere-ice-water bodies. (Meehl *et al.,* 2007). In a warming climate, changes in the frequency and amplitudes of these patterns might not only evolve rapidly, but also trigger other processes that lead to abrupt climate change (NRC, 2002). Examples of these patterns include the El Niño Southern Oscillation (ENSO) and the North Atlantic Oscillation/Arctic Oscillation (NAO/OA).

The Intergovernmental Panel on Climate Change (2007) has forecasted that there occur impacts on the human health/mortality with the change in the environmental factors with particular reference to the changes in the temperature. For heavy precipitation events: frequency increases over most of the areas and has an impact on the infectious diseases, allergies (Cashel *et al.,* 2004; Moreno, 2006; Agnieszka and Aneta, 2008). This will have pressure on urban and rural infrastructure and will lead to societal distrubances.

Climate change is generally related to the two potential changes in environment viz., increased temperature (Houghton *et al.,* 2001) and the frequency of rainfall events associated with flooding (Christensen and Christensen, 2003). Flooding triggers the increased risk of water borne diseases and spreading of pathogens (Koelle *et al.,* 2006). It also leads to certain gastrointestinal illnesses due to spread of infectious pathogens (Rose *et al.,* 2001; Patz *et al.,* 2008 and Jones *et al.,* 2008).Infectious diseases can cause rapid population declines or species extinctions. Many pathogens of terrestrial and marine taxa are sensitive to temperature, rainfall, and humidity, creating synergisms that could affect biodiversity (Daszak *et al.,* 2001). Climate warming can increase pathogen development and survival rates, disease transmission, and host susceptibility. (Harvell *et al.,* 2002 and Semenza and Menne, 2009).

Climate is defined as the sum of atmospheric elements and the variations occurring in them through parameters viz.: solar radiation, temperature, humidity, clouds and precipitation (type, frequency, and amount), atmospheric pressure, and wind (speed and direction) which are the main meteorological parameters.

Meteorology is the interdisciplinary scientific study of the atmosphere. Meteorological phenomena are observable weather events which illuminate and are explained by the science of meteorology. Those events are bound by the variables that exist in Earth's atmosphere; temperature, air pressure, water vapour, and the gradients and interactions of each variable, and how they change in time. In 350 BC, Aristotle wrote meteorology. Aristotle's *Meteorologica* (c.340 B.C.) is the oldest comprehensive treatise on meteorological subjects. Although most of the discussion is inaccurate in the light of modern understanding, Aristotle's work was respected as the authority in meteorology for some 2,000 years. In addition to further commentary on the *Meteorologica,* this period also saw attempts to forecast the weather according to astrological events, using techniques introduced by Ptolemy.

As speculation gave way to experimentation following the scientific revolution, advances in the physical sciences made contributions to meteorology, most notably through the invention of instruments for measuring atmospheric conditions, e.g., Leonardo da Vinci's wind vane (1500), Galileo's thermometer (c.1593), and Torricelli's mercury barometer (1643). Further developments included Halley's account of the trade winds and monsoons (1686) and Ferrel's theory of the general circulation of the atmosphere (1856). The invention of the telegraph made possible the rapid collection of nearly simultaneous weather observations for large continental and marine regions, thus providing a view of the large-scale pressure and circulation patterns that determine the weather.

Aristotle is considered the founder of meteorology. One of the most impressive achievements described in the *Meteorology* is the description of what is now known as the hydrologic cycle. The Greek scientist Theophrastus compiled a book on weather forecasting, called the *Book of Signs*. The work of Theophrastus remained a dominant influence in the study of weather and in weather forecasting for nearly 2,000 years. In 25 AD, Pomponius Mela, a geographer for the Roman Empire, formalized the climatic zone system.

Meteorology, the science of studying the observable changes in the weather is often overlooked when dealing with health and yet it is one of the most critical elements of Primary health care (Simon, 2009). Meteorology is considered as a key to understand the causes of air pollution in an

area. The degree to which air pollutants discharged from various sources concentrate in a particular area depends largely on meteorological conditions. Even though the total discharge of contaminants remains constant from day to day; degree of air pollution may vary widely because of differences in meteorological conditions (Christian *et al.,* 2001). Generally, the degree to which air pollutants discharged from various sources, concentrate into a particular area depends on meteorological conditions. So, the knowledge of these meteorological parameters which influence the dispersion process of air pollutants will give certain results like whether the air pollutants will be diluted in to the atmosphere or they just simply tend to concentrate on to the ground. The important meteorological parameters that influence the air pollution can be classified into primary and secondary parameters.

Primary parameters are:

1. Wind direction and speed.
2. Temperature.
3. Atmospheric stability.
4. Mixing height

Secondary parameters are:

1. Precipitation.
2. Humidity.
3. Solar radiation.
4. Visibility.

These parameters are known to vary widely as a function of latitude, season and topography. Air pollution is known to influence these meteorological parameters in several ways. Visibility may be reduced, fog frequency and duration may be increased and the incoming solar radiation may be decreased, particularly in the ultra-violet end of the spectrum (Pearce and Zawar-Reza, 2006 and Lantz *et al.,* 2009). Air pollution and meteorological parameters should be thus seen as a widespread public health problem, which can trigger admission and even death due to chronic obstructive pulmonary disease (COPD) (Hapcioglu *et al.,* 2006). According to Issever *et al.,* 2005 air pollution and meteorological parameters have a negative effect on various respiratory and cardiovascular parameters. Meteorology, along with emissions and atmospheric chemistry, is

well known as a major contributor to air pollution episodes. For that reason, the air quality in cities has been statistically correlated with the combination of the various meteorological factors in several studies over the past decade. (Akpinar *et al.,* 2006 and Baklanov and Korsholm, 2008).

Meteorology has a major influence on the initial dispersion of plumes, fugitive emissions and area sources, and on the movement of air parcels containing air contaminants. Therefore, meteorological measurements are an essential complement to air quality measurements. The meteorological phenomena exert a critical influence on air quality (Kassomenos *et. al.*, 1999; Elshout *et al.,* 2008 and Hajek and Olej, 2009;).

At times the meteorological conditions are such that the pollutants when dispersed into the atmosphere from any source stay in the same condition in and around the area as they were dispersed into the atmosphere. They do not disperse into the atmosphere and hence no dilution of pollutants into the atmosphere occurs. In meteorological terms it is well defined as the sub-adiabatic or the negative lapse rate (inversion). Under such conditions, if the concentration of pollutants increases in an area, it may adversely affect the air quality of the area and lead too serious health problems (Shahgholian and Hajihosseini, 2009 and Wallace *et al.,* 2010). The atmosphere can as such assimilate a certain amount of air contaminants without its ill effects. Dilution of air contaminants into the atmosphere is an important process in preventing undesirable levels of pollutants in the ambient air. Air pollution results from the combination of high pollutant emissions and unfavourable weather. Air quality is strongly dependent on meteorological conditions, and is therefore expected to be affected by long-term changes in weather statistics, i.e., climate change (Tai *et al.,* 2010).

Atmospheric dispersion of air contaminants into the atmosphere is the result of ventilation, atmospheric turbulence and molecular diffusion. However, gaseous and particulate air contaminants are entered into the ambient air through wind action and atmospheric turbulence, much of which is on microscale level. High levels of pollutants are generally connected to low wind speed conditions in winter at Night time and early morning. This is because of poor vertical mixing and low horizontal transport out of the source area (Guastella and Knudsen, 2004). Rainfall removes dust and gasses from the atmosphere. Humidity levels are high in summer,

frequently reaching over 100%, while lower levels are recorded during winter, with a minimum of 20%. The higher relative humidity during summer also means that chemical transformations which require water vapour (e.g. conversion of SO2 to sulphate aerosols) are performed more efficiently and therefore airborne pollutants are removed more rapidly than during drier conditions in winter. Air temperature ranges from daily averages of 16.6°C in winter to 24.6°C in summer, with extreme ranges of 3 to 40°C. – Coastal area (Boesch *et al.,* 2000 and Seetharam and Jeena, 2002).

Sulphur dioxide (SO2) is a recognised indicator pollutant as it is associated with industrial fuel burning. Elevated SO2 concentrations are known to cause respiratory problems. The Council for Scientific and Industrial Research (CSIR) initiated a country-wide system for measuring SO2 (by means of bubbler instruments) and smoke (using a soiling index) during the 1960's.Certain meteorological factors, which affect the air quality and the dispersion of contaminants into the ambient air, are Lapse rates, Pressure system, Wind and Moisture (Peavy *et al.*, 1985; Pandey *et al.,* 2005; Ho *et al.,* 2007 and Bell *et al.,* 2008).

Climate modifications by urban areas are due to the process of urbanization, which significantly alters the natural surface conditions and atmospheric properties of a locality. Such modifications involve the transformation of the radiative, thermal, moisture, and aerodynamic characteristics of the surface and its immediate overlying atmosphere. These, in turn, alter the natural energy, momentum, and hydrological balances, resulting in the formation of distinct urban climates. The urban–rural temperature difference known as the "urban heat island" (UHI) is a well-documented human-induced climate modification.There exists an inter-relationship between the air pollution and meteorological conditions. As described earlier meteorological conditions may become a cause for air pollution, it can be vice-versa, too. Air pollution also in its own ways hampers the meteorological conditions. Reduced visibility, altered precipitation and the UHI effect are among the changes in weather that have been attributed to air pollution with particular reference to urbanization (Alexander *et al.,* 2007 and Rizwan *et al.,* 2008).

The potential effect of human activities on the temperature of earth must be carefully assessed. Human activities are partly responsible for changing the meteorology of earth (Karl and

Trenberth, 1999; Newton *et al.,* 2001; Ogden and Stewart, 2002 and Hik, 2002). These activities are:

- Deforestation and depletion of forest cover.
- Shifting of surface water and ground water in massive amounts.
- Release of heat from energy-producing sources.
- Emission of particles and trace gases into the atmosphere.
- Release of carbon dioxide into the atmosphere by combustion of fossil fuels.
- Effect of transportation system on land surface and effect of their emissions on lower and upper atmosphere.

From ancient times weather forecast has been major source for a layman to understand the atmospheric conditions. Based on these forecasts, one used to schedule his day-to-day activities and work accordingly. Earlier these forecasts were based solely upon the observations of sky. Today, meteorologists rely heavily on computer models (numerical weather prediction), it is still relatively common to use techniques and conceptual models that were developed before computers were powerful enough to make predictions accurately or efficiently (Krosnick *et al.,* 2000 and Shively and Sager, 1999).

Human biometeorology refers to the relationship of human beings with the natural climatic conditions prevailing in the atmosphere. It studies influence of various meteorological parameters on man in health and disease, his adaptability to alteration in atmospheric environment and role that these changes play in triggering the onset of respiratory illness. Such studies are important because it directs us to implement policies that can improve air quality and help in understanding climatic changes which further facilitates us in humanizing the overall health condition and prevent respiratory illness by forming a proper management plan (Lahdensuo *et al.,* 1996; Haby *et al.,* 2001; Gibson *et al.,* 2002 and Slader *et al.,* 2006). Scientists do not know exactly what causes the development of asthma in individuals, nor is there a cure for asthma once it has developed. It is generally thought that some people are born with a genetic predisposition toward developing asthma, but environmental (and potentially societal) factors

play a role in the actual development of the disease (Roemer *et al.,* 2000). It is this knowledge that allows scientists to determine ways in which asthma attacks can be prevented or limited.

Respiratory illness is the term for diseases of the respiratory system. These include diseases of the lung, pleural cavity, bronchial tubes, trachea, and upper respiratory tract and of the nerves and muscles of breathing. Respiratory diseases range from mild and self-limiting such as the common cold to life-threatening such as asthma. 'Asthma' is a Greek word which means 'breathless' or 'to breathe with open mouth'. Asthma is a disease of the lungs in which the airways are unusually sensitive to a wide range of stimuli, including inhaled irritants and allergens (Cohn *et.al.*, 2004). This results in obstruction to airflow which is episodic - at least in individuals with early or mild asthma - and which causes symptoms of tightness and wheeziness in the chest. (Busse and Lemanske 2001)

The Global Strategy for Asthma Management and Prevention Guidelines define asthma as 'a chronic inflammatory disorder of the airways associated with increased airway hyper-responsiveness, recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night/early morning'. Airway inflammation produces airflow limitation through acute bronchocons- triction, chronic mucus plug formation and airway wall swelling or remodelling. These symptoms may be relieved either spontaneously or after treatment. Asthma can occur at any age. However, in half the cases the onset is before 10 years of age. Asthma is thought to affect about 3% of the population in most countries. The highest prevalence (almost 30%) is found in New Zealand. The prevalence in a number of countries falls in the range of 10%–17% (Murthy and Sastry, 2005).

Asthma is a chronic condition in lungs that occurs mainly due to two main components:

1. Constriction: The tightening of the muscles surrounding the airways.
2. Inflammation: The swelling and irritation of the airways.

Both these conditions lead to the narrowing of the airways, which result in symptoms such as wheezing, coughing, chest tightness, or shortness of breath. It is also believed, if left untreated, asthma can cause long-term loss of lung function. The factors which induce the inflammation or

swelling in the airways leading to lungs making it harder to breathe are defined as the triggers of asthma.

Asthma is a syndrome characterized by airflow obstruction that varies both spontaneously and with specific treatment. Chronic airway inflammation causes airway hyperresponsiveness to a variety of triggers, leading to airflow obstruction and respiratory symptoms including dyspnea and wheezing. Although asthmatics typically have periods of normal lung function with intermittent airflow obstruction, a subset of patients develops chronic airflow obstruction.

Some of the factors categorized as the risk factors of asthma are indoor air quality, health care, family history, and exposure to environmental tobacco smoke and other irritants. Air quality can be well related to both air pollution and the meteorological conditions prevailing in the area. It is observed that air pollution is a major cause for asthma either in its initiation or aggravation as studied and reported by various scientists all across the globe. (Holmen *et al.,* 1997; Norris *et al.,* 2000; Schwartz, 2004 and Agrawal *et al.,* 2006a).

In many parts of the world it is also found that asthma is highly affected due to weather and meteorological conditions which has been again discussed in many related studies (Fleischer and Asnani, 1978; Holmen *et al.,* 1997; Wong *et al.,* 1999; Burch and Levetin, 2002 and Agarwal *et al.,* 2006b).

Asthma is the most common occupational respiratory disorder in industrialized countries (Konstantinos *et al.,* 2000; Barraza-Villarreal *et al.,* 2001; Alexander *et al.,* 2005 and Bäcklund *et al.,* 2006). Occupations associated with a high risk of occupational asthma include farming, agriculture work, painting, plastic manufacturing, etc. Studies have shown that asthma is highly affected by meteorological factors like temperature, windspeed and rainfall. Though other factors such as relative humidity, pressure, evaporation, etc are taken into consideration for study purpose but the results reveal that not all have a strong correlation with the occurrence of asthma.

The prevalence of asthma has increased markedly over the past 30 years. In developed countries, approximately 10% of adults and 15% of children have asthma. Most asthmatics are atopic, and

they often have allergic rhinitis and/or eczema. The majority of asthmatics have childhood-onset disease. A minority of asthmatic pts do not have atopy (negative skin prick tests to common allergens and normal serum total IgE levels). These individuals, occasionally referred to as intrinsic asthmatics, often have adult-onset disease. Occupational asthma can result from a variety of chemicals, including toluene diisocyanate and trimellitic anhydride, and also can have an adult onset.(Xu *et al.*, 1996; Hedge *et al.*, 2002 and Bakerly *et al.*, 2008)

Also, poverty and unhealthy environment are strongly related to the respiratory disorders. Bronchitis and asthma recorded as leading cause, pneumonia and tuberculosis of the lungs ranked one of the five causes of deaths in rural India. Asthma and bronchitis prevalence rates in Karnataka, Gujarat, Haryana, Uttar Pradesh, Kerala and Madhya Pradesh are above national average. Bronchitis and asthma are recorded as leading cause of death between rural male and female and then pneumonia and tuberculosis are ranked as one of the five leading causes of deaths in rural India. Asthma afflicts 6% to 8% of the population, making it one of the most common chronic diseases in the country. The care of these individuals is often difficult from both a patient and provider perspective. Although some progress has been made in understanding the disease, considerable gaps remain to be filled.

Asthmatics can develop increased airflow obstruction and respiratory symptoms in response to a variety of different triggers. Inhaled allergens can be potent asthma triggers for individuals with specific sensitivity to those agents. Viral URIs commonly trigger asthma exacerbations. β-adrenergic blocking medications can markedly worsen asthma symptoms and should typically be avoided in asthmatics. Exercise often triggers increased asthma symptoms, which usually begin after exercise has ended. Other triggers of increased asthma symptoms include air pollution, occupational exposures, and stress. (Nicas *et al.*, 2000; Etzel, 2003 and Seymour *et al.*, 2003).

As defined by WHO; Asthma attacks all age groups but often starts in childhood. It is a disease characterized by recurrent attacks of breathlessness and wheezing, which vary in severity and frequency from person to person. In an individual, they may occur from hour to hour and day to day. This condition is due to inflammation of the air passages in the lungs and affects the sensitivity of the nerve endings in the airways so they become easily irritated. In an attack, the

lining of the passages swell causing the airways to narrow and reducing the flow of air in and out of the lungs.

In 1989 the Global Initiative for Asthma (GINA) program was initiated with the U.S. National Heart, Lung, and Blood Institute, NIH and the World Health Organization (WHO) in an effort to raise awareness among public health and government officials, health care workers, and the general public with a preview that asthma trend was increasing day by day. The GINA program recommends a management program based on the best available scientific evidence to allow doctors to provide effective medical care for asthma tailored to local health care systems and resources.

This burden as defined by GINA on global scale is as summarized below:

1. Asthma is one of the most common chronic diseases in the world. It is estimated that around 300 million people in the world currently have asthma.
2. Asthma has become more common in both children and adults around the world in recent decades. The increase in the prevalence of asthma has been associated with an increase in atopic sensitization, and is paralleled by similar increases in other allergic disorders such as eczema and rhinitis.
3. With the projected increase in the proportion of the world's population that is urban from 45% to 59% in 2025, there is likely to be a marked increase in the number of asthmatics worldwide over the next two decades. It is estimated that there may be an additional 100 million persons with asthma by 2025.
4. The number of disability-adjusted life years (DALYs) lost due to asthma worldwide has been estimated to be currently about 15 million per year. Worldwide, asthma accounts for around 1% of all DALYs lost, which reflects the high prevalence and severity of asthma. The number of DALYs lost due to asthma is similar to that for diabetes, cirrhosis of the liver, or schizophrenia.
5. It is estimated that asthma accounts for about 1 in every 250 deaths worldwide.

6. The economic cost of asthma is considerable both in terms of direct medical costs (such as hospital admissions and cost of pharmaceuticals) and indirect medical costs (such as time lost from work and premature death).

This increasing trend of asthma and other allergic diseases have become now a major concern and challenge for the coming century and generation (Baena-Cagnani, 2001). With the projected increase in the proportion of the world's urban population from 45% to 59% in 2025, there is likely to be a marked increase in the number of Asthmatics worldwide over the next two decades. It is estimated that there may be an additional 100 million persons with Asthma by 2025. The highest Asthma prevalence rates are found in the United Kingdom (>15%) and New Zealand (15.1%) (Masoli *et al.*, 2004).

In Western Europe, the Asthma prevalence rate has doubled over the last decade and in Japan, the number of Asthma patients treated by medical facilities has tripled over the past 30 years (Masoli *et al.*, 2004).A wide variation in prevalence rates has been documented: studies of both children and adults have revealed low prevalence rates (2%–4%) in Asian countries (especially China and India) and high prevalence rates (15%–20%) in the United Kingdom, Canada, Australia, New Zealand and other developed countries (Janson *et al.*, 2001; Asher *et al.*, 2006 and Zock *et al.*, 2006).

The number of disability-adjusted life years (DALYs) lost due to Asthma worldwide has currently been estimated at about 15 million per year. (WHO 2004)Worldwide, Asthma accounts for around 1% of all DALYs lost, thus reflecting the high prevalence and severity of Asthma (Drazen and Weiss, 2002; Masoli *et al.*, 2004 and Yan *et al.*, 2005). Globally, the economic costs associated with Asthma exceed those of tuberculosis and HIV/AIDS combined (www.who.int/mediacentre/fact sheets).

The economic cost of Asthma is considerable both in terms of direct medical costs (such as hospital admissions and cost of pharmaceuticals) and indirect medical costs (such as time lost from work and premature death). Developed economies can expect to spend 1 to 2% of their health-care budget on Asthma (Masoli *et al.*, 2004).

Severe Asthma is associated with disproportionately high costs in comparison with other degrees of Asthma severity, and the economic burden of the disease disproportionately affects those with the moderate to severe Asthma (Godard *et al.,* 2002). It was reported that in New Zealand 'high cost' asthma patients accounted for the use of 80% of the resources and their annual cost of treatment was US$ 2584 as compared to US$ 410 for others (Weiss *et al.,* 1992; Lai *et al.,* 2003 and Neffen *et al.,* 2005) and, accordingly, the cost of medication in India was estimated as US$ 30 per month (Weiss and Sullivan, 1993; Singh, 2004 and Accordini *et al.,* 2006).

The environmental problems in India are growing rapidly. The increasing economic development and a rapidly growing population that has taken the country from 300 million people in 1947 to more than one billion people today is putting a strain on the environment, infrastructure, and the country's natural resources. Industrial pollution, soil erosion, deforestation, rapid industrialization, urbanization, and land degradation are all worsening problems. Overexploitation of the country's resources be it land or water and the industrialization process has resulted environmental degradation of resources. Environmental pollution is one of the most serious problems facing humanity and other life forms on our planet today (Rathi and Vatsvani, 1999; Srivastava and Saraff, 2001; Chatterjee, 2001; Nagdeve, 2002; Rindfuss *et al.,* 2003 and Rahman and Agarwal, 2007).

India's per capita carbon dioxide emissions were roughly 3,000 pounds (1,360 kilograms) in 2007, according to the study. That's small compared to China and the U.S., with 10,500 pounds (4,763 kilograms) and 42,500 pounds (19,278 kilograms) respectively that year (Dharmendrasingh, 2011). The study said that the European Union and Russia also have more emissions than India. India has been ranked as seventh most environmentally hazardous country in the world by a new ranking released recently. (Kandilkar and Ramchandran, 2000)

In India, an estimated that 57,000 deaths were attributed to Asthma in 2004 (WHO, 2004) and it was seen as one of the leading cause of morbidity and mortality in rural India (Smith, 2000). Though effective screening, evaluation, and management strategies for Asthma are well established in high-income countries, these strategies have not been fully implemented in India as evidence had previously suggested that Asthma is not to be treated independently but fitted into the general

spectrum of respiratory diseases (Krishnakumar, 2003). Furthermore, even though medicines that treat Asthma effectively are available at affordable costs, they rarely reach more than one per cent of those who would benefit from it (Krishnakumar, 2003).

Several attempts have been made to study the trend of asthma in the developing countries. Being a developing country and several scientific drawbacks including lack of uniformity of methodology and analysis of data, a large scale data to establish the trend of Asthma in India is still lacking (Subbarao *et al.,* 2009). Asthma rates are quiet low in India as compared to other countries, although there is some recent evidence that the true prevalence is higher than previously thought (Aggarwal *et al.,* 2006).

According to the recently conducted cross sectional nationally representative National Family Health Survey (NFHS)-3, the overall prevalence of asthma among adult men and women in India is similar with 1,696 and 1,627 per 100,000 respectively (IIPS and Macro International 2007). The number of men and women with asthma increases steadily with age. Prevalence of asthma is higher in rural areas (1,719 per 100,000 for women and 1,799 per 100,000 for men) than for urban areas and that it is more common among women than men. Asthma among men is more prevalent in the lower wealth quintiles than among the higher wealth quintiles Moreover, prevalence is highest among those with less than five years of schooling (2,283 per 100,000 among women and 2,640 among men per 100,000), and among those with no education (1,914 among women per 100,000 and 2,440 among men per 100,000).

It is found that the majority (about 80%) of patients with asthma in India live in rural areas. As the magnitude of poverty is more in the rural set-up in India. Also, a considerable proportion of the population in the active and economically productive age groups suffers from this chronic disease. Further, the elderly (above 60 years of age) constitute the majority of cases (Murthy and shastry, 2005). In a study from Mumbai, Asthma prevalence in adults aged 20-44 years was reported to be 3.5% using clinician diagnosis' and 17% using a very broad definition (which included prior physician diagnosis and/or a positive bronchoprovocation test) (Chowgule *et al.,* 1998).

The population prevalence of Asthma reported in different field studies is variable and ranges from 2.4-6.4%. Among school children higher prevalence rates have been reported the prevalence ranges from 384 per 100,000 in Himachal Pradesh to 5,924 per 100,000 in Tripura among women and from 407 per 100,000 in Jharkhand to 5,086 in Tripura among men. The number of women with asthma exceeds 1,000 per 100,000 in 23 states and is exceptionally high (above 3,000 per 100,000) in five states: West Bengal (3,304), Mizoram (3,563), Kerala (4,037), Sikkim (5,150), and Tripura with the highest prevalence whereas this is true for men in only 2 states; West Bengal and Tripura. Overall, the Northeast Region stands out as the region exhibiting the highest prevalence levels of asthma (IIPS and Macro International, 2007).

There is limited Asthma research currently going on in India and they are far from adequate to address the emerging demand (corresponding increase in disease burden). National Asthma surveillance data collection is currently limited, and this presents perhaps the most significant gap in Asthma research in India. Therefore, to measure the extent of the problem in the entire population, there is a need for reliable population-based epidemiological studies in the context of its existing and potential economic impact.

With the increase in infrastructural and construction projects in the city and in peripheral towns, cases of asthma have been rapidly in 2009-10. Industrialization and urban growth are now occurring at an unprecedented rate in this previously agrarian society (Chowgule *et al.,* 1998). Both prevalence and mortality from asthma appear to have increased in many parts of the world during a time when better asthma medications have been available to more patients suffering from asthma (Suissa *et al.,* 2000; Juniper *et al.,* 2002 and Newman, 2005).

Striking geographic variations in asthma prevalence are evidence of important variations in asthma susceptibility and equally important - and often dynamic - environmental determinants of asthma. Surveillance of asthma in North America, Western Europe, and Australia has demonstrated recent increases in asthma prevalence and mortality. Application of a standardized asthma surveillance methodology in 48 centres worldwide, the European Community Respiratory Health Survey (ECRHS), allows the most valid available comparisons of asthma prevalence and of determinants associated with asthma, including patterns of asthma therapy.

Report submitted by the Union Ministry of Environment and Forests to the World Bank in August 1997, Gujarat, Maharashtra, Andhra Pradesh and Tamilnadu together comprise 60 per cent of the hazardous waste generated in the country. This report observes "Vadodara district generates the highest percentage of solid waste in Gujarat. It also noted that the bulk of the generated hazardous waste is not safely handled, treated and disposed, causing threat of serious contamination of groundwater resources, possibilities of health and vegetation impacts due to airborne emission of toxins and damage to the land.

Vadodara (Baroda) is one of the mega cities of the state and the financial and commercial center as well as a major industrial port. It is the state's most rapidly growing mega-city, with a projected population of 15 million in the year 2000. The city gains over 250,000 rural-to-urban emigrants annually. Vadodara lies on a narrow peninsula running north to south, connected to the mainland at the northern tip, constricting the geographic spread of its growing population. Situated at approximately 19 8 north latitude, the coastal city has the warm moist climate of a tropical savanna. Sulfur reductions in fossil fuels in recent years have helped reduce ambient sulfur dioxide levels, but the increasing density of motor vehicles contributes to rising concentrations of total suspended particulate. ''In the last few years the topography of the state has changed because of large-scale development works—laying of canals and railway tracks, construction of new colonies. The flash floods, we believe, were caused by changes in the topography,'' Vadodara city was once known as the City of Gardens.

The growing urbanisation and the demand for more housing and transportation have led to a decline in urban greens. The environment of a city is a critical determinant of the health of its inhabitants and consequently productivity. The problem of environmental pollution in the city has become a matter of concern in recent decades due to population explosion, industrialisation, urbanisation and increase in transportation. The pollution level in the city is determined by the air quality. The Gujarat Pollution Control Board (GPCB) is responsible for monitoring and air quality. The NOx and SO_2 levels have been below the GPCB prescribed standards throughout the period 1994-99. The suspended particulate matters (SPM) levels have always remained constantly above the prescribed limits for residential and rural areas. This can be mainly

attributed to the high concentrations of dust and other construction materials in most parts of the city. Unpaved margins of roads on the outskirts of the city on the highways are mainly responsible for the particulate matter in high concentrations. The SPM levels could be reduced in the residential areas of the city with effective maintenance of the margins of the roads through paving, regular cleaning etc.

Earlier studies conducted have shown that the quantity of SPM in some of the residential areas has regularly increasing over the period of time. Few of the environmental studies conducted in Vadodara have also reported that there is an increasing load of pollutant in the city (De, 2005; 2007a; 2007b and 2007c). However, there major aim was to record the pollutant load in Vadodara city. There is a lacuna as far as the inter-relationship of the environment and its impact on health is concerned. Hence the present study is an attempt to understand the relationship between the environmental factors and further to have an insight whether there exists any interdependence between the prevalence of the respiratory illness with particular reference to the meteorological factors in Vadodara city. Thus the present study aims the following objectives:

1. **A trend analysis study for 2005 – 2007: Correlation Between Air Pollution And Meteorological Parameters For Vadodara City, Gujarat was analyzed based on "Regression models", "Shaft Diagrams", "Wind Rose Diagrams" and "Isopleths derived from ISCST3 Modeling Studies" a comparison between asthma exacerbations, meteorological factors and pollution levels were studied to find the existing correlation (Chapter I)**

2. **Getting the trend analysis for meteorology and pollution in Vadodara City, prevalence of actual respiratory illness in general and asthma in particular was explored by questionnaires and depending on the clinical symptoms they were categorized for Rhinitis, COPD and Asthma. (Chapter II)**

3. **Further after knowing the Meteorological and pollution interaction and respiratory illness trend in Vadodara city, the economic burden of the respiratory illness prevailing, was analyzed on the basis of the sale of medications so as to interpret the existing trend of the illness in the Vadodara city. (Chapter III)**

4. **Stepping forward with the help of clinician, the selected patient's spirometry was taken and their lung functions were analyzed. Based on "Regression models", "Wind Rose Diagrams" and "Isopleths derived from ISCST3 Modeling Studies" a comparison between asthma exacerbations, meteorological factors and pollution levels were studied to find the existing correlation and further forecasting the future trend prediction. (Chapter IV)**

5. **The asthma patients were then monitored based on the suggested management plans given to them to find the effectiveness of the management strategies to reduce the trauma of the disease in the affected identified patients. (Chapter V)**