CHAPTER 1

INTRODUCTION

1.1 GENERAL

India has a lot of variety and complexity in Cultures, Traditions and Climate. Architecture in every region is a deep rooted phenomenon. Climate conscious concepts, adopted in buildings originated in the Pre-Industrial Era before the introduction of space conditioning and electric lighting. (Oliver 2003) rightly defined vernacular houses as those "related to their environmental contexts and available resources, they are owner or community-built, utilizing traditional technologies . . . , built to meet specific needs, accommodating the values, economies and ways of life of the cultures that produce them".

Each region of the world employs its own techniques and designs in its buildings that are best suited to that particular region and climate that encompass the traditional cultural patterns. This is more commonly known as Traditional Architecture. Rappoport clearly explains the difference of vernacular architecture and the traditional architecture, he says, “the Vernacular architecture is the opposite of high traditional architecture which belongs to the grand tradition (e.g. palace, fortress, villa, etc.) and requires special skills and expertise which an architect must have knowledge of and for which he enjoys a special position” (Rappoport 1969). The Traditional Architecture grows out of the practical needs of the inhabitants of a place with respect to the constraints of the site and climate.
As the famous Indian architect B.V. Doshi said, “historically built environment was a result of the responses to many factors in the society; at the physical level it included the knowledge regarding orientation, climate, building material and construction technique, at the spiritual level, the built-form was inter-woven with the lifestyle in all the daily as well as seasonal rituals” (Doshi 1985).

Different civilizations have produced their own architectural styles based on their local conditions. Research is being done to study the climate responsiveness of traditional buildings in different parts of the world. The relationship between architecture and climate is being explored as an important component in the recent architectural studies. These studies mainly focus on qualitative description of the relationship between the building types, materials, finite construction and the local climate and lack enough field tests and quantitative analysis.

1.2 ENERGY CRISIS, GLOBAL WARMING AND THE ROLE OF CONTEMPORARY AND TRADITIONAL BUILDINGS

There is an intact relation between energy use in buildings and the resulted environmental damage. This is because of energy intensive solutions that are employed in buildings to attain comfort conditions in terms of mechanical cooling, mechanical ventilation and artificial lighting. This has caused severe depletion of non-renewable energy resources and environmental degradation. The utilization of passive methods and techniques in modern buildings to achieve thermal comfort allows the possibility of decreasing the dependence on fossil energy as much as possible and realizes sustainability (Doshi 1985).

In the present days, energy constraints and global warming are the biggest challenges confronting the planet. In the modern world, energy is a
vital part of every aspect of life. Demand for energy is rising rapidly. The analysis carried out by the US Energy Information Administration (EIA) estimates that, by 2030, global energy consumption will have grown by over 70%. Total world energy use rises from 505 quadrillion British thermal units (Btu) in 2008 to 619 quadrillion Btu in 2020 and 770 quadrillion Btu in 2035 (EIA-International Energy Outlook-2011). The world population, which has increased more rapidly than ever before over the last 50 years indicates huge future demand for houses and the energy to run them.

The building sector is one of the major energy consumers in the world. Building sector in developing countries accounts for one-third of the total energy consumption and consumes more than half of the electricity consumption (Synnefa et al 2007).

As Robertson said “The proportion of total energy use attributable to buildings generally ranges from 10 - 15% in undeveloped countries to more than 40% in the developed countries” (Robertson 1992). And as per the findings of Roaf “In UK, building’s use currently accounts for 46% of total energy consumption and it has been calculated that this energy could be almost halved if the existing building stock were adequately insulated”. Also, as stated in the proceedings of IFCO 2007 report “In India, statistics showed that buildings account for about 39% of total energy consumption” (Ahmadreza Foruzanmehr and Nicol 2008). Using and wasting energy, air-conditioned energy-dependent buildings result in more emissions of greenhouse gases that drive global warming.

Global warming, or specifically global climate change, is the most high-profile and urgent sustainability issue (CIBSE 2007). Global warming is one of the most critical components of environmental degradation. Global temperature which has risen by over 0.7°C in the last 300 years is predicted to rise by up to 8°C by 2050 which will present a worse global warming scenario
The Inter-governmental Panel on Climate Change (IPCC 2007) indicated in its report that warming of the (world) climate system is unequivocal and that world temperatures could rise by between 1.1 and 6.4°C during the 21st century (IPCC 2007, Climate Change 2007).

The increase in summer average temperatures can be intensified in urban areas, where cities replace natural land-cover with man-made materials and structures. On hot summer days, according to the U.S. Environmental Protection Agency (EPA), urban air can be 2-6°C hotter than in the surrounding countryside. Furthermore, added waste heat from vehicles, factories and air-conditioned buildings increases the need for air conditioning. Therefore energy demand and cost, green-house gas emissions, air pollution levels and thus heat-related illnesses and mortality also rises. The IPCC report lists barriers to adopting building technologies and practices that reduce GHG (green house gas) emissions (IPCC 2007, Climate Change 2007). Thus, there is a need for urgent action, and in such action, buildings are (Roaf 2004) the ‘front line of our defense and must be designed to shield us from the effects of climate change and global warming’.

Before the advent of the industrial age, and the invention of mechanical heating and cooling, bio-climatic means were exclusively used to achieve moderately comfortable climate inside buildings. Bioclimatism is a concept that integrates the micro-climate and architecture with the human thermal comfort conditions (Sayigh and Marafia 1998). Today, active heating and cooling devices ensure interior comfort, but require major energy inputs. However, given the dual challenge of a growing fuel crisis and concerns of global warming, the amount of energy used to provide thermal comfort levels will become unsustainable.

Sustainable, ecological, and climate-adaptable architecture offers possible solutions to these challenges. Many architectural publications
advocate that traditional and vernacular homes form the basis of an environmentally conscious design. Increasing population and rapid urbanization in India in recent years has also affected the quality of life in cities. Even smaller cities are facing huge problems in accommodating the growing population and this in turn, has resulted in rapid replacement of heritage and traditional buildings with modern construction.

To mitigate the problem, the practice of sustainable developments has taken a front seat. “Sustainable development is that, which meets the needs of the present without compromising the ability of the future generations to meet their own needs” (The Brundtland Report 1987).

1.3 RESEARCH PROBLEMS ON COMFORT IN BUILDINGS.

The natural world has an immense amount to tell us about how to achieve sustainability. It uses energy far more efficiently and effectively and is capable of producing materials and structures that are far more benign than anything we have achieved in the industry (McDonough 2004). The assessment of energy and comfort conditions in buildings is very important in the design - decision making phase of the Architectural projection process. Incorporating energy efficiency, renewable energy, and sustainable green design features into all building types has become a top priority in recent years for designers and others. Energy efficient buildings reduce both resource depletion and the adverse environmental impacts of pollution, generated by energy production and it is often considered to be the basis of sustainable design.

The use of materials with large thermal resistance, such as mineral wool, glass fiber, expanded clay, and cellulose, can reduce both heat gains and heat loss indoors and minimize daily temperature fluctuations (Baker and Lugano 1999).
Vernacular architecture shows the combination of local climate conditions, available materials, design techniques, living style, traditions and socioeconomic conditions of the region (Sozen and Gedik 2007).

This type of Architecture addresses the local climate constraints and shows maximum adaptability and flexibility. The perfect knowledge of various design principles in vernacular buildings and the construction techniques employed and materials used in traditional architecture can be immensely useful in contemporary architecture if these are judiciously adopted by exchanging with suitable modern materials and technology. In recent days, the awareness among architects and engineers in the above referred technical understanding about the value of the traditional construction system is prevalent. Therefore there is concern among architects and engineers in providing energy efficient and sustainable solutions in designing modern buildings.

Recent studies on traditional buildings conclude that bioclimatism is an integral part of traditional architecture and a deciding parameter towards achieving sustainability in modern architecture. In the absence of precise temperature control measures, the role of the settlement/building design in mitigating the effects of wind and weather is extremely important in providing indoor comfort.

Understanding of traditional architecture in terms of heat, humidity, air movement and light with respect to the physical environment, provides vital lessons for the present design endeavors. In many traditional buildings, both primitive and vernacular, some ingenious solutions to the architectural problems of resisting extremes of weather and maintaining comfortable indoor climate can be seen (Sangkertadi 2008).
Climatic design lessons can be learned and inspiration can be sought by observation of the long tradition of vernacular architecture. These are important especially in the context of energy concerns from all around the world, and the alarming increase in air conditioning usage in the recent years. Building energy consumption in India is the highest among all Asia Pacific partnership countries.

With growing pressure from various interest groups, more and more buildings in India are being designed in aluminium and glass, only to be air conditioned, least concerning about the climate or context. As a result, the buildings relinquishes all their local character and wear the same building envelope, be it in the hot climate of Rajasthan or the cold climate of Himalayas.

The traditional dwellings of Chettinadu in Tamil Nadu, India represent the principle of climate oriented architecture. These are naturally ventilated buildings and are in accordance with the traditional lifestyles. Socio-economic background and traditional lifestyle have considerable effect on the occupant’s thermal comfort perception. Our advanced technical capability and cultural context prevent us from returning to these old-fashioned architectural forms. But we can learn a lesson from the approach of the builders who acknowledged the interdependence of human beings, buildings and physical environment (Helena 1998).

Climate and Environmental conditions are highly important parameters in a building design. Buildings are designed to achieve or to create a suitable atmosphere for human comfort. Comfort may be defined as the sensation of the complete physical and mental well being of a person within a built environment. Traditional builders used limited resources to achieve maximum comfort and climate which was the major determinant in traditional building techniques.
With the advancement in the building technology, heating and cooling in buildings have become easy for modern buildings; there is less concern with climate and environment in maintaining comfortable indoor conditions. Modern buildings in Tamilnadu follow the National standards with little response to local climate. Building construction methods have changed greatly in the last two to three decades and modern designers often choose to ignore fundamental aspects such as climate.

Climate has a major effect on the performance of the building and its energy consumption. Reducing energy consumption, using natural resources and providing comfortable, healthier and sustainable living spaces are the aims of a climatically responsive sustainable building design (Hui 2000). Climate responsive architecture is the architecture developed across a region in a selected climatic zone which is climatically receptive so as to make the inhabitants to have comfortable living conditions. Climate of a region has a direct influence on the settlement pattern and in its built form. Any good building should relate and respond to the climate it is situated in. A built form is designed for the beneficial aspects of the climate and to reduce the impact of unfavorable conditions. The layout, orientation and scale of buildings and settlements should therefore be controlled in relation to the climatic zones (Krishnan et al 2001).

Architecture and climate build an intimate bond in any traditional shelter form. Knowing and learning them in detail helps designers plan sustainable settlements in future, especially in the present days of energy debate. The climate responsive design of Tamilnadu traditional architecture calls for a comprehensive and quantitative study to understand better, its efficiency in terms of energy efficient and sustainable design solutions, which has given a thermally comfortable indoor living conditions.
The influence of climate in the evolution of form is evident from various styles of architecture that we see today. The layout, orientation and scale of buildings and settlements should therefore be controlled in relation to the climatic zones. The climate presents a challenge to the architect not satisfied with substituting mechanical equipment for good design (Cowan 1959).

The different variables of climate to which a building needs to respond are temperature, humidity, wind, rain, radiation and light. As part of the enhanced interest in design with climate, traditional architecture is widely being reviewed as an inspiration for contemporary design. As a consequence, researchers have made extensive studies on the thermal performance of traditional buildings in different parts of the world. The Chettinadu traditional dwellings of Tamilnadu perfectly demonstrate the principle of climate oriented architecture. Therefore it is decided to do a research to bring out the essence of climate responsive architecture, hidden in the traditional architecture of Chettinadu region which falls within the warm humid climatic zone.

1.4 SCOPE OF STUDY

An embedded understanding of vernacular architecture may serve as a model for sustainable design in response to climate, energy use and notions of environmental quality (Asquith, l. and Vellinga, M. 2006). An energy efficient building will provide the desired internal conditions by relying on natural means where possible. The study focuses upon the understanding and assessing the climate responsive techniques and methods that the traditional Chettinadu houses have. To achieve this, the following stages of works were carried out.
At first, the prevailing external climate as well as the local microclimate around the building are identified and understood. External climatic data from meteorological stations is collected and analyzed. This analysis provides the necessary understanding of the inherent climatic elements that affect thermal performance and comfort in the region.

Secondly, the experimentation process and the measurement techniques for both qualitative assessment and quantitative assessment of traditional and contemporary houses in a field study are carried out.

Finally, the performance of existing building fabrics, the analysis of their interaction with human comfort and external climate are examined on comparative basis. And the results shall be arrived at.

To carry out the experimentation process and comparative analysis of traditional and contemporary housing, a typical sample of houses representing both types were selected. The comparative study includes design, methods of construction, materials, patterns of use, layout planning, and methods of achieving comfortable internal conditions, etc.,

1.5 PURPOSE AND OBJECTIVES OF RESEARCH

Thermal comfort is defined as the condition of mind which expresses satisfaction with the thermal environment, related to air temperature, humidity and wind speed (Feriadi and Wongm 2004).

The techniques and principles of traditional architecture which were designed with thermally comfortable techniques are vanishing in these days, as modern methods prevail. This is unfortunate since most of the old buildings employ natural materials and simple concepts that are energy efficient.
Most of the buildings which are constructed today have not taken into account of the green concepts used in the traditional buildings. Therefore, there is a need for studying the green concepts used in traditional buildings and adopting the same in our present and future design.

This research aims to explore and assess the climate responsive architecture and design techniques that promote thermal comfort in traditional Chettinadu houses located in the warm humid climatic zone of the state of Tamil Nadu in India.

The study of these houses provides useful insights for designing energy efficient houses that promote thermally comfortable conditions. An analysis of these houses in Chettinadu region provides a context for the field research.

A typical chettinadu traditional house is shown in Figure 1.1 so as to understand its typical architectural features and magnanimity at façade level. These houses are huge in size and built with natural means of architecture with sustainable principles adapted in it.

![Figure 1.1 View of a Typical Chettinadu House](image)
The above research is achieved by the following objectives

- To study how “Climate Responsive Principles” is effectively conducted in traditional architecture.

- To conduct the qualitative study (indeterminate), and quantitative study (measurable) through experimental investigation by selecting two sample houses from traditional and modern houses.

- To investigate the occupants, the thermal comfort levels through interviews and questionnaire in both traditional and modern houses.

- To compare the results of the experimental investigation to the existing thermal comfort standards and chart out the conclusion.

1.6 RESEARCH METHODOLOGY

The climatic aspects between the interior and exterior of the selected traditional houses has been calculated to see their application of traditional passive cooling systems and to assess the effectiveness of integrated traditional strategies and to compare and evaluate the consequences of various options in existing building types so as to meet the thermal comfort level. A summer field study was thus conducted to investigate the indoor environmental conditions in such housing.

The intention of the investigation was to understand the solar passive features in Chettinadu housing by qualitative and quantitative analysis of thermal comfort parameters. This was undertaken by continuously monitoring the indoor and outdoor climatic conditions using a custom made
instrument setup called the “Architectural Evaluation System” (AES) as shown in Figure 4.36 and the experimental setup methodology is explained in subdivision 4.12 of chapter 4.

The data obtained will be used for data analysis and the results will be compared with ASHRAE standards and with the Olgyay bio-climatic chart to find out the thermal comfort level in traditional buildings. The research involves the study of thermal performance through on-site monitoring of two Chettinadu houses of one category each (i.e. two traditional houses and two modern houses). The method of evaluating the Chettinadu residences for its response to the climate included following steps:

- Study of the climate of this region.
- Identifying various architectural elements evolved as response to the climate.
- Investigate the thermal comfort level by experimental set up.

In order to investigate the performance of such dwellings, field measurements in houses of each type were carried out. On site monitoring and recording of the thermal performance of the various spaces like courtyards, bed room, living halls and other spaces in the buildings were carried out. The temperature, relative humidity, Mean Radiant Temperature(MRT), Air velocity, were measured outside the building and in different indoor spaces for every one hour for a complete one-day cycle for the entire summer, i.e., from 15th March to 15th June for consecutive two years 2009 and 2010 for each building with the help of the instrumentation setup (AES).

The comparisons between the findings of the on-site measurements enabled to draw conclusions. To determine the comfort range in any particular house design and the assessment of comfort criteria, the indoor environment
of existing traditional and contemporary houses were employed as indicators. The whole process was accomplished by measuring environmental variables inside the houses and the results were then compared. The study focused on the findings of the thermal comfort in interior spaces governed by natural ventilation.

The houses selected for the field study were chosen to have the same microclimate. Appraisals on their background, usage and constructions were undertaken. The development of the research began by investigating the thermal performances of the houses taking consideration of their form, materials, orientations and construction. Concurrently, the environmental variables of houses were identified and measured, and general remarks as to occupancy, clothing and activities involved were recorded. In order to evaluate thermal comfort conditions, thermal comfort indices were derived from the measured variables. Also, assessment of occupant thermal sensation was gathered through interviewing. The data collection from the field studies involved, and the researcher's observation and the analysis of each building is described explicitly, and conclusions were drawn.

1.7 INTERDISCIPLINARY RELEVANCE

In this proposed research, it is clear that the study of such a large system requires a broad interdisciplinary research involving various areas and competencies such as thermal behavior of buildings, architecture, planning, climatology, construction materials, physiology, economics, social sciences, statistical analysis, etc. Similar type of research has been carried out in Iran for hot dry climatic zone and in Jharkhand - Bihar, India for composite climatic zone which is discussed in chapter II.
1.8 CONCLUSION

Sustainable development recommends that architects and engineers must seek solutions from traditional buildings for design of low energy consumption, environmental friendly and localized identities while utilizing modern materials and techniques (Wang and Liu 2002). The report of World Commission Environment and Department says that architects and engineers need to come up with building designs which “meet the needs of the present while not compromising the ability of future generations to meet their own needs” (The Brundtland Report 1987). In the absence of precise temperature control measures, the role of the settlement/building design in mitigating the vagaries of wind and weather is extremely important in providing indoor comfort (Saleh and Al-Alkhalaf 1999).

Therefore this research would become an attempt to re-explore the possibilities of bridging the gap of the traditional sustainable principles to today’s construction methods.

All observations of both the qualitative and quantitative investigation will be recorded and considered for analysis. The experimental investigation data will be compared with the traditional houses selected for study to that of the modern houses. The data obtained will be analyzed to understand the maximum and minimum temperature recordings and the days showing the maximum temperature will be considered for thermal comfort analysis for both the traditional and the modern houses. The results obtained will be compared with ASHRAE standards and the bioclimatic chart constructed by Olgyay to find out the thermal comfort in these houses located in warm humid climatic zone.