CHAPTER 1

INTRODUCTION

1.1 GENERAL

Technology advancement has enormous benefits to the humankind, but at the same time it has its own destructions also. Lifestyle of people across the globe has changed from their own ancestral lifestyle with respect to their needs. While we adapt ourselves to the present needs we tend to forget the glory of the past which our ancestors had taught us. Around 150 to 200 years back, their life style was 100% sustainable (capable of being continued with minimal long-term effect on the environment). This shows the concern of our ancestors towards us and the future generation. The definition of sustainable livelihood and “Sustainable architecture is the architecture that utilizes environmentally conscious design techniques” (Maria 2009). In the present years, the earth is facing the danger of “global warming” and there is a perpetual worry of the depletion of fossil fuels (Helena 1998). Hence, production of more energy or reduction of energy consumption will be the priority for many countries. In India, the energy crisis is huge and as the population grows day by day, it becomes more problematic in the future. More than any other country, India has to worry much to find out the possible, sustainable and viable solutions to this crisis. Many researches are taking place across the country to find an answer to this query, but, yet there is a long way to find an appropriate answer. As architects and builders here is an
attempt to search the best possible solution to reduce energy consumption in building sector.

1.2 BUILDINGS AND ENERGY CRISIS

We generally acknowledge, that the building sector consumes about one-third of the total energy consumption worldwide and this data may vary according to building type and location (Olesen 2002). In 2010, the building sector in India has occupied about 20% to 24% of the total national energy consumption and this portion is expected to increase significantly (International Energy Agency 1998). Reducing energy use, especially energy used by occupants of buildings is an important issue in India as the country is constantly in the state of energy crisis. Research to reduce energy consumption in the building sector through climate responsive strategies without compromising human comfort is essential (Nayak 2006). Vernacular architecture is widely accepted as a real-world, operative and widespread solution. Sustainable development recommends that architects and engineers must seek solutions from vernacular buildings for the design of low energy consumption, environmental friendly and localized identities while utilizing modern materials and techniques (Paul Oliver 1997). Increasing concerns about global warming present the building industry with a challenge to cut its energy consumption. In India building sector consumes of order 40 - 50% of the total delivered energy. Of this, climate control systems, namely ventilation, cooling and heating can account for as much as 70% of the total energy use. However, this part of the energy consumption can be reduced significantly by employing passive environmental solutions instead of mechanical ones. For example, a well-designed naturally ventilated building can consume only one third of the energy consumed by an air-conditioned building, while arguably providing a comparable level of comfort. This is
because passive design allows buildings to adapt more appropriately to their local climates and take better advantage of natural energy resources, such as wind and thermal buoyancy, to help condition their interior environments. Furthermore, passive, naturally ventilated buildings have potential to provide more pleasant and healthier environments for the occupants compared to their mechanically ventilated counterparts. In these days, the energy resources for heating, cooling and lighting of buildings accounting for about 45% of total global energy consumption and this is a major contributing factor to global environmental pollution and global warming (Arvind Krishnan (2009). These environmental damages (environmental pollution) are caused because of unlimited and unwarranted use of energy in buildings so as to achieve comfort conditions by mechanical means of ventilation, artificial lighting and cooling which has led to severe depletion of non-renewable energy resources and ended up in environmental degradation (Sayigh 1998).

1.3 VERNACULAR ARCHITECTURE AND STUDY RELEVANCE

Vernacular buildings are usually built on their own or with the help of family and native builders of their tribe. Vernacular architecture provides shelter and comfort with the evolution of craft passed down through generations. Vernacular structures and techniques are easy to learn and understand. They are mostly built up of local materials. They merge with local climate, flora, fauna and ways of life in ecological means. Vernacular buildings have good concern on the environment rather than serving as self-proclaiming design statements. They are human in scale. There are many wonderful building styles from all over the world inform us their shapes, materials, arrangements, decorations, concept for heating and cooling etc. (Paul Oliver 1997).
The typical vernacular houses that have existed with a sloping roof surface to bear the rainfall or a circular house form to combat cyclonic winds or a thick flat mud roof that keeps out the heat of the sun or an inner courtyard are all born out of their own building knowledge of the people and of the society as a whole. The building knowledge is developed by trial and error and handed down the generations through local traditions. Vernacular buildings are continuously being evolved over a period of time to reflect the environmental, cultural and historical context in which they exist. Understanding of the locally available materials which suits climate of that region and the architectural detailing are evident in such architecture. This invites the researchers and scientists to have an extra knowledge in Vernacular architecture (Indraganti 2007). The researchers intend to examine these buildings qualitatively and quantitatively. The qualitative approach involves the assessment of the environmental performance of different elements of buildings in relation to the prevailing climatic conditions (Kim et al 2007), whereas the quantitative approach is based on in situ measurements with the help of the instruments by doing the experimental investigation of different climatic parameters outside and inside the examined buildings, which leads to conclusions concerning the thermal performance of the houses (Krishnan et al 2011).

Vernacular architecture is believed to integrate certain building features that were developed in a long process of adaptation and adjustment and therefore may embody valuable solutions for maintaining desirable indoor conditions. This claim, however, should not be taken for granted and must be critically examined in different contexts and settings. The Vernacular Architecture in the coastal region of Tamilnadu is an example of an vernacular architecture that may prove to contain applicable design strategies in confronting the hot and humid climate of the region's coastal plain. The
research proposes an assessment method for performing an indicative measurement of the environmental features of various building typologies in the coastal plain through the integration of Architectural and historical survey with instrumental experimentation and computer Aided simulation techniques.

The architectural and historical phenomenon of the traditional houses in the coastal region of Tamilnadu was researched in the past focusing on its cultural and typological aspects, while it’s more technical facets were almost neglected and therefore it's still technically remains relatively unknown.

This study focuses on coastal regions of Tamil Nadu, in an attempt to detect, document and analyse the design principles and the elements of its traditional architecture found in the four different building typologies of the traditional or vernacular residences. The analysis of this research is being carried out in two modules, the first one being the research on architectural aspects and followed by the research on bioclimatic aspects. The architectural aspect includes building typology, form, materials and construction techniques, whereas the analysis of bioclimatic aspects involves the thermal behaviour of building shell. In addition to the thermal behaviour, as a supporting study aural and visual comfort conditions of these vernacular residences are also analysed. The aim of the study is to document and assess thermal performance of the traditional residences both qualitatively and quantitatively. As said earlier, to reinforce further research, aural and visual behaviour of the same houses were also analyzed. In this thesis, different aspects of the vernacular architecture, namely typology, form, building materials, thermal, visual and aural behaviour are qualitatively documented and analysed for the sample study houses with respect to their study area and the climatic zone.
1.3.1 Significance of Vernacular Techniques

Application of the passive architectural design solutions from the old vernacular buildings into the modern buildings of day to day life towards achieving thermal comfort (orientation, shading, passive cooling etc) will be a greater answer to all these questions. So as to achieve this, in various part of the world, investigations on natural and passive ventilation systems in buildings providing thermal comfort are being explored in the form of continuous evaluation of vernacular buildings. Passive means of attaining thermal comfort (stalk ventilation and reverse stalk ventilation, venture effect etc) inside the buildings are the absolute solution to deliver a healthy and energy efficient built indoor spaces. This is of supreme importance for buildings in the tropics where mechanical systems with high energy consumption are used to condition the indoor environment for thermal comfort (Hassan Fathy 2005). These passive methods are found to be absent in day to day modern building designs where people are forced to depend on artificial systems for controlling the indoor environment. In many cases, it is found that the failure to provide required thermal conditions has resulted in discomfort, ill health and efficiency loss (Madhavi Indraganti et al). Presently, there is a constant need to evaluate the thermal conditions of indoor environments to learn further and proceed with research in passive design.

Many of the early studies of vernacular architecture has failed to pay much attention to the way in which should have been (Vellinga (2006) contributed to the creation of future built environment. Even in developed countries, the way in which vernacular knowledge and experience may be used to respond to 21st century challenges has so far not been the subject of many discussions (Oliver, 2003, p.14). Research projects that explicitly address the application and use of vernacular knowledge and skills in contemporary architectural practice are rare (Vellinga, 2006). Few attempts
have been made to investigate the vernacular architecture. Most of the existing literature in this field does not deal with vernacular traditions in terms of the application of vernacular strategies to a modern development context. Moreover, there is no comprehensive study on the relationship between temperature increase resulted from global warming and the effectiveness of passive-cooling systems. The extent to which traditional systems could provide comfort conditions in the buildings are not been the subject of studies and the way buildings can withstand extreme hot summer temperatures are not been well addressed.

Hence, this research is focused on experimenting the vernacular passive-cooling strategies used amongst the vernacular residential buildings in coastal areas. The coastal area is preferred because of the availability of different house typologies along the coastal line of Tamilnadu as well as to study and compare the performance of varied traditional buildings in same climatic conditions and to find out the best performing traditional techniques. These buildings are located in the area where the sea and the land meet with scorching sun and high humidity and sudden rainfall with medium and heavy wind blow. The overall aim of the research is to find out the useful techniques that can be successfully incorporated into existing modern buildings to improve their energy performance, carbon reduction, cultural acceptance and thermal comfort of occupants. Hence there is an urgent need to undertake the research in areas of natural means of energy use and energy management in vernacular buildings.

1.4 VERNACULAR BUILDINGS VERSUS MODERN BUILDINGS

As mentioned earlier, there is a need to search vernacular design solutions that are prevailing in vernacular buildings which will make the occupants thermally, aurally, and visually comfortable. In warm and hot
climates, most of 20th century buildings are not suitable for present day climatic conditions. They are dependent on air-conditioning systems and electricity, reliant on fossil fuels and increasingly unable to adapt to a warming climate (Sayying et al 1998). A large proportion of modern buildings are poorly designed for prevailing climate, leading to extreme use of electrical equipment and energy to maintain desired indoor conditions (Kimura 1994). In contrast to modern buildings, vernacular architecture in these regions is more adaptable to the environment in many ways. Traditionally, builders used knowledge passed from generation to generation to ensure that their buildings could modify the impact of a hostile outdoor environment (Giovini 1981).

Vernacular buildings, in general, are equipped with thick high walls, courtyards, and vaulted chambers according to the changes developed over generations. They used local construction materials, passive cooling, passive heating and renewable energies. Vernacular resources, technologies and forms are generally seen to be well adapted to local climatic conditions and are often considered an appropriate base for environmental design (Feriadi 2004). However, it is important to note that the materials, techniques, etc varies with respect to the various climatic zones.

1.5 BUILDING PHYSICS PHENOMENON IN THE VERNACULAR HOUSE TYPOLOGIES AT GLOBAL LEVEL

Bioclimatic design, by definition, satisfies the needs of human beings (thermal, luminous and acoustics). It considers climatic conditions, also uses techniques and materials available in that region and attempts to integrate the building with its surroundings. Building physics exhibits ability and knowledge of allowing sunlight, heat, and airflow through the building envelope when necessary, at certain moments of each day and month of the
year (Maria 2009). Vernacular architecture may also be categorized as bioclimatic as, traditional builders understood the bioclimatic concepts, aspects of building physics, and the strong relationship between site, climate and building. This made people aware of the consequences of design choices. Vernacular architecture which considers the effect of climatic condition on the building’s envelope suggests knowledge of the building physics at an experimental level. Efforts have been made by many researchers world-wide to explore the possibilities of evaluating the green principles in vernacular architecture (Do-Kyoung Kim 2006). Maria (2009) conducted a study to evaluate a sustainable Greek vernacular settlement by using subsequent analysis based on two major steps: a study concerning the evolution of built environment (typological analysis, site planning, construction materials and techniques) and an evaluation of specific vernacular dwelling types and their response to climate based on passive design principles (Maria 2009). The vernacular settlement demonstrated an economical use of local building resources adapting to climatic conditions without using much energy and providing human comfort. Canas & Martin (2004) employed statistical method to gather data about vernacular Spanish buildings and categorised them into different bioclimatic strategies based on their locations. By doing so, they found the most frequently used a strategy which corresponds to the building locations and local climate. They had made it clear that the vernacular settlement demonstrates an economical use of local building resources, adapting to climatic conditions without using much energy and providing human comfort (Canas & Martin 2004).

1.6 STATEMENT OF THE PROBLEM

As stated above, a large proportion (70%) of modern buildings are poorly designed without any concern on existing environmental and climatic factors. The modern buildings in this coastal region of Tamil Nadu are
dependent on air-conditioning systems and electricity, reliant on fossil fuels and increasingly unable to adapt to a warm climate. A large proportion (70%) of these modern buildings are not designed considering prevailing climate, leading to extreme use of electrical equipment and energy to maintain desired indoor conditions. These buildings, without enough insulation, un-shaded, tight-skinned and with inefficient air-conditioning, are using vast amount of energy to provide thermal comfort, especially when weather conditions are harsh and extreme. Development in many hot climate countries, including India, is badly hindered by the crippling high cost of energy. At a point of time brown-outs and black-outs are predicted and noted due to high consumption levels; problems in electricity production and the increasing summer temperature, people will not be able to stay inside building, if the electricity fails particularly during daytime. In hot climates, if the air-conditioning goes off, buildings become hard to occupy at a quicker rate (Roaf 2004), and in a short time such structures will have soaring internal temperatures in summer. In contrast to modern buildings, vernacular buildings in coastal areas are equipped with thick high walls, courtyards and vaulted chambers, according to principles evolved over many generations, these principles include physical functionality, beauty, low-energy use, comfort, durability and affordability. Such buildings uses local construction materials, passive cooling and heating, and renewable energies. Vernacular resources, technologies and forms are generally appear to be well adapted to local climate conditions and are often considered as an appropriate base for environmental design. Vernacular architecture across the world had the concern on environmental and climatic factors (Hassan Fathy 2005). The research originated from the assumption that, the historical phenomenon of the different house typologies in the coastal regions of Tamilnadu may embody practical strategies and features that were conceived for tackling the climatic needs for the builders. The earlier vernacular residences which were found in the hills have slowly speeded to the plains and coastal regions.
However, predominant vernacular residences were found all along the eastern coast of Tamil Nadu stretching from Chennai to Kanyakumari. In contrast to the modern buildings, the vernacular architecture in this coastal region is more adoptable to environment in many ways. Many researchers have proved that vernacular architecture are more climate responsive than modern architecture. However in coastal belt of Tamil Nadu, it is found that there are many typologies amongst the vernacular residences. These residences with different typologies do not behave similar with respect to thermal comfort, visual comfort and aural comfort. This research intends to find out the best demonstrating vernacular residence amongst these vernacular residential typologies found along the coastal line of Tamil Nadu. All the four typologies are analysed qualitatively and quantitatively during summer as well as winter to assess the behaviour of these residences with respect to the thermal comfort, as a supporting research, the visual and aural comfort. Research is also supplemented to fulfil the building physics phenomena. The four different building typologies and their study area and sampling houses are briefed in the third chapter.

1.7 SIGNIFICANCE OF RESEARCH

The most important contribution of this present research is that it discloses hidden and elapsed techniques and technology from the traditional practice to design product in terms of indoor comfort. The proposed research is used to design energy efficient residential buildings in warm humid climates of coastal regions of Tamil Nadu which will reduce the energy consumption in modern buildings which in turn will reduce the energy consumption in the society. This similar type of research may be carried out for different climatic regions like hot humid regions, hot and dry regions, cold and cloudy regions etc. Buildings account for 45% of worldwide energy use and hence significant amount of green house gas emissions to the
environment is related to this energy use (Singh et al 2009). To meet the increasing energy needs, particularly in developing and less-developing countries, the climate responsive buildings or solar passive buildings with advanced active systems seem to be most appropriate and efficient solutions to this problem (Kumar et al 1994). In general, human beings are relying on finding out new means of technological solutions to overcome the crisis born out of energy or environment. The energy consuming equipments viz air-conditioners, refrigerators, mixer, wet grinders, washing machine, utensil washer, etc have become a necessary commodity to contemporary houses. Architecture of olden days was built along with nature and not against the nature, that is why this architecture remains even today as examples of low energy consuming buildings. By the end of the 20th century, a pro-environmental or ecological architectural trend began to appear (Do-Kyoung Kim et al 2006). The architects and builders today started realizing this problem but unable to give appropriate solutions. No doubt that Architecture needs to be synchronized with nature. What is needed is to rediscover the methods to improve the coexistence between nature, architecture, and human being. In particular, the solutions from vernacular architecture across the world had given exemplary solution to build buildings along with nature. With respect to this research, the architecture of the coastal regions of Tamil Nadu in its approach to ‘‘harmony with nature,’’ which had evolved traditionally over a period of time has formed a unique architectural culture. During the process of research, it is found that, the features seen in vernacular buildings of these coastal regions are more of green architecture, because of their planning and construction techniques, energy efficient materials, solar passive elements etc and they blend with nature. However, it is needed that they have to be proved scientifically. This is achieved by carrying out various experiments as explained in the research methodology.
In order to overcome, these researches are important so as to find out the hidden sustainable principles of vernacular architecture. In Warm humid climatic zone of the coastal regions of Tamil Nadu, the vernacular architecture evolved is of with four distinct typologies. In this connection, it is also necessary to explore which amongst these four are truly climate responsive, and which among these consumes less energy on day-to-day basis. Such principles can be directly or indirectly be used in the modern buildings so as to reduce energy demand. The results of this experimental study reveals that the vernacular architecture in the selected study area is built along with nature which encompasses the solar passive techniques embedded with the bioclimatic principles. Vernacular architecture of the coastal regions of Tamil Nadu under the warm humid climatic conditions is necessarily built with climate responsive principles. A greater essence from this architecture can very well be utilized for modern or contemporary buildings so as to overcome the energy and environmental crisis occurring in these days. Therefore, this research has become an authentic solution provider to modern builders and building designers, as to make them incorporate the traditionally used design principles based on the climate responsive architecture to the modern buildings with respect to the context and climatic zone.

1.8 STRUCTURE OF THE THESIS

The purpose of the study is to establish potential strategies for contemporary buildings that passively promote thermal comfort in these buildings, thereby reducing the need for external energy inputs and increasing the quality of life for occupants. This research intends to seek ways to document the traditional vernacular principles to promote a sustainable community. To conclude, the study intends to test the assumption of, vernacular houses in coastal regions that have high thermal comfort levels, visual comfort levels and acoustic comfort without using any mechanical
Sample vernacular houses are chosen with the age of around 200 years old along the coastal line of Tamil Nadu located at Parangipettai, Tharangambadi, Nagappattinam and Thoothukudi which are incidentally being age-old harbour towns of Tamil Nadu. These houses were undergone experimental study during consecutive summer (April, May and June of the year 2009 and 2010) and winter (December and January of the year 2009 and 2010). The in-situ experiments were conducted with the help of instruments setup called as AES (Architectural Evaluation System – Emcon-cochin) for thermal comfort study and light meter (Lux meter) visual comfort study and, in addition, the simulation was also carried by using the software (Ecotect) to further reinforce the visual comfort study. The aural comfort study of all the houses has been carried out with the help of sound level meter. This instrument is designed to make acquisition of the related environmental, climatological and behavioural parameters of architectural/structural buildings using 18 sensors and 20 channel data system. The system consist of eighteen nos sensors, 20 channel electronic meter to make digital display of the data, memory module to store the data with real time, software for operating the system in automatic mode, sensor brackets, 12V battery and battery charger. There are 18 sensors attached with the system. They belong to parameters pertaining to air inside, air outside, deformation, shifts of structures. The remote operation facility of the sensors up to certain lengths enables integrated measurements and centralised monitoring for making effective studies. The Relative humidity sensors which are positioned inside the buildings measure the RH of that place. The sensor should be positioned free from the direct hit of water spray and solar radiation. The Relative Humidity Sensors which is place outside is provided with a protective screen to prevent the direct hit of solar radiation and rain on it. This is kept outside either directly or preferably at some shades. The Air Temperature inside sensors is to be kept at the required position using suitable supports to get the temperature at the position. The Air temperature outside sensors is provided
with a special screened cover to prevent the direct influence of rainfall or solar radiation. The wind velocity sensors are provided with the stand and it may be kept vertical for designing the wind velocity at that place or may be kept in rooms, halls etc.

This research proposes a new approach for analysing and evaluating vernacular dwellings in coastal region of Tamil Nadu in terms of building physics. A survey has been conducted among the residents of the villages of the study area to know the occupant thermal comfort range. The data obtained were fed in different models and the results were arrived. This approach includes six subsequent steps. It is also expected that both qualitative (indeterminate) and quantitative (measurable) analysis encompassed in this research will reinforce the result findings. This thesis is divided into six chapters. The first section is about literature review that discusses the significance and background for this research. This section is subdivided into three chapters. Chapter 1 deals with Introduction, background of the research problem, Introduction of vernacular architecture and thermal comfort, aim and objectives and thesis structure. Chapter 2 focuses on the complete comprehensive literature review. Chapter 3 describes about the climatic conditions of coastal regions in Tamil Nadu and discusses the qualitative analysis of the four different typology of vernacular architecture in coastal region. The second section of the thesis encompasses an in-depth research study of specific cases of vernacular architecture in the coastal regions of Tamil Nadu. This section is divided into three chapters. Chapter 4 describes the experimental investigation set up and experimental methodology carried out in four different typology of vernacular houses in Thermal, Visual and aural Comfort. Chapter 5 comprises of synthesis of data and analysis of results and discussions. Chapter 6 concludes the research and suggests ways of traditional or vernacular architecture principles to promote and apply in today’s construction and future studies that could broaden the results drawn from this study, contains the analysis and conclusions of the research.