The Pennsylvania State University

The Graduate School

Department of Architecture

TOWARD SUSTAINABLE DESIGN -THE EXCLUDED ISSUES

LEED RATING SYSTEM IN INDIA

A Thesis in

Architecture

by

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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Architecture

December 2009

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ABSTRACT

Due to the recent emphasis on ‘Green’ buildings around the world, LEED (Leadership in Energy and Environmental Design), a voluntary certification program, has emerged as one of the major internationally recognized standards to quantify sustainability in building design and performance. The LEED rating system, which is primarily based on the American context, is also considered as a Green design guideline. It is now accepted in many countries, including India, and is being promoted as a universally applicable model for Green building certification. With its wide array of climatic, social, and economic variations, India poses a stark contrast to the American context and consequently presents different challenges for its Green buildings.

The present version of LEED India for New Construction (NC), however, fails to take these contextual variations into account, resulting in a superfluous recognition of generic and readymade design solutions that disregard the traditional sustainable building practices in the country. This thesis proposes additions and/or modifications to the LEED India NC rating system to address certain critical issues in the current LEED format as they apply to the Warm-Humid climate zone. The broader intent of this research is to ensure that a Green building certification system provides appropriate guidance to the designer who wishes to employ a design approach that is compatible with indigenous context. These proposals can be considered as suggestions toward a new version of LEED India NC in future.

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ACKNOWLEDGMENTS

I would like to begin by thanking my advisor, Professor Jawaid Haider for his guidance, patience and understanding. It was a great pleasure working under him where research became a pleasant learning experience. I am extremely grateful for his constructive suggestions which always made me think and look for better. I would also like to express my heartfelt gratitude to my committee members, Professor Lisa Iulo and Professor Ute Poerschke. Their comments and insights helped structure, improve and refine my thesis to the next level.

For the motivation and moral support, I would like to extend my thanks to my fellow classmate Suhas Bambardekar. I appreciate the support from my friends Siddharth Advani, Pooja Nadkarni, and Pratik Bang.

Last of all, I would like to thank all my family and friends, especially my parents for always being there for me with the constant support and unconditional love.

I dedicate this thesis to India, as a tribute and contribution to the people of my country and beyond.

Chapter 1

INTRODUCTION

Green buildings are going to play a significant role in defining our future on this planet. The design approach for such buildings thus has a major impact on the very sustainability of our civilization. In response to this challenge, at present we have certain standards and rating systems in different parts of the world to define and quantify sustainable aspects of buildings of different categories and scale. LEED (Leadership in Energy and Environmental Design) developed by the US Green Building Council (USGBC) is one such Green building rating system widely accepted around the world. The major goals of LEED are to define Green buildings by establishing a common standard of measurement and to promote integrated, whole-building design practices[1]. Though the rating system was originally developed considering the American context, it has been gradually accepted in more than 13 countries, including India. In India, before the advent of LEED there existed a number of national and international building standards and codes which fulfilled the requirement of a sustainable design guideline and rating systems in a discreet manner. The official certification of LEED for Indian buildings started in November, 2003, when the US Green Building Council (USGBC) certified the CII Sohrabji Godrej Green Business Centre, Hyderabad with the highest "Platinum" certification level under its LEED Rating System (Version 2.0) which was followed by subsequent Indian versions. At present, there are 18 LEED certified and 80 LEED

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[1] US Green Building Council, 2008

registered projects in India with an expectation of 1000 more buildings to be certified by 2012[2].

Although certain amendments for the Indian version have been proposed to fit into the context by the steering committee appointed by IGBC, the guideline for India is virtually identical to the US version with its standards and definitions based on the American context; for instance, there are few modifications to the ASHRAE[3] standards. But India has a very different architectural and climatic context compared to USA and has its own set of priorities in design. Thus, standards for sustainable buildings in India also vary from the US version.

The rich and complex background of Indian environment-conscious architecture has evolved from its geographic, climatic and multi-cultural roots. Based upon those roots and principles, the selection of design techniques, choice of materials and space planning were further developed by some of the renowned Indian and international architects post-independence. This development followed the theory of “Critical Regionalism”[4] to a certain extent, which promoted a localized approach toward architecture. Hence, even before the advent of the term “Green buildings”, India showcased appropriate examples of interplay between contemporary styles and traditional techniques under diverse contextual variations (Fig.1.1).

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[2] Indian Green Building Council, 2007

[3] The American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2007

[4] Frampton Kenneth,2002

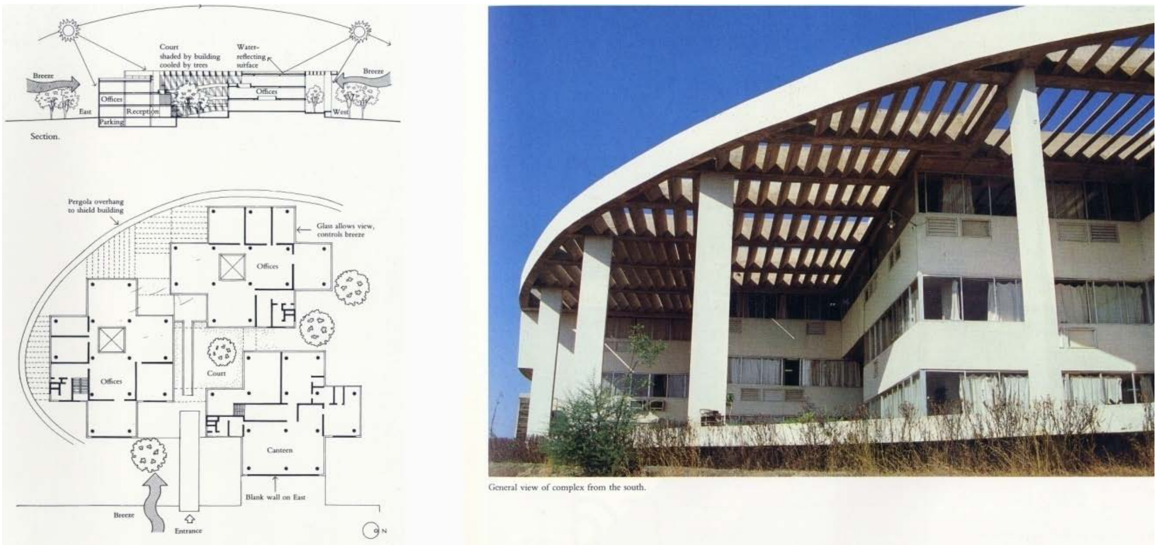

Figure 1.1: ECIL Office Complex, Hyderabad, India, 1968, Charles Correa: Use of extended pergola to protect window glazing from heat and glare. Sliding windows and spaces oriented to wind direction allow for natural ventilation.

Image Courtesy: Charles Correa & Associates

This approach encourages the choice of suitable design techniques and language based on local character. It seems odd to observe growing enthusiasm for the newly LEED-certified and other Green buildings, which incorporate readymade, generic design solutions heavily depending on mechanical systems disrespecting the unique problems of different contexts. There are few exceptions, but most of these buildings showcase enclosed spaces with building skins that lack the consideration of solar, wind and other climatic conditions; they are artificially controlled boxes. Yet, these buildings manage to receive LEED certification for being good examples of sustainable design. This situation indicates the incapability of the LEED rating system since it allows builders to bypass the major local design concerns and yet achieve sufficient credit points from LEED to obtain a high rating (Fig. 1.2). Buildings designed with particular aspects of their context taken into consideration usually require much more attention and rigor than the ones which come with generalized and readymade systems. It is simple to design an enclosed space installed with standardized mechanical ventilation systems. It is more difficult to include natural ventilation as a component of a ventilation system; this requires a careful study of wind flow, space, and opening allocation. In an urban environment, use of mechanical ventilation is sometimes inevitable, considering the air and sound pollution levels. However, any such design must first consider the use of passive methods coupled with modern technologies (such as noise barrier and dust screens) as any active system, however efficient it is, will always use more energy than the passive alternative[5]. Similarly, extensive use of glazing in façades increases heating load and glare. Use of reflective coatings can reduce these effects, but increases the production and operational expenses. For a large portion of the Indian population, financial limitations do not permit expensive technologies; designers are thus strongly advised to consider the less expensive passive shading and daylighting elements that are effectively used in many building projects (Fig. 1.3). Another major concern with these highly sophisticated techniques is the lack of industrial support in the Indian context, which still heavily relies on labor-intensive manual construction processes. If the abrupt incorporation of technically dependent systems, which can escalate the project cost instantly, cannot be recovered over the life cycle of a project, the claim of sustainability must be called into question.

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[5] Yeang, Ken, 2006

Figure 1.2: ITC Green Center, Gurgaon, India, 2005, LEED New Construction Platinum rating: Insulated glazing is used to minimize solar heat gain, External air economizer draws fresh air in mechanically, but the building skin lacks additional external shading elements to counter the high solar angle and depends entirely on a mechanical HVAC system without any provision for natural ventilation. Image Courtesy: Neha Gupta

Figure 1.3: Indian Institute of Management, Bangalore, Balkrishna. Doshi,

Figure 1.4: India International Center, New Delhi, Joseph Allen Stein: Use of Pergola and *Jali* (Lattice) to allow sunlight while restricting the heat and glare.

Figure 1.5: Vedic Hotel Proposal, Kolkata, C. P. Kukreja & Associates, Figure 1.6: World Bengal Tower Proposal, Kolkata, RMJM – Globalized approach to architecture

Image Source: Indian Skyscraper Blog

Considering the builder- and customer-dominated building industry in India which hardly allows the design teams to explore design possibilities, it is evident that more and more projects will follow the shorter route to sustainability with acknowledgements in the form of LEED certification (Fig 1.4). This trend undermines the very fundamental objective of sustainable design in India which ignores the development of environment-friendly architecture through the ages. Hence, the argument of this research is that the LEED rating system fails to respond to the essence of Indian sustainable architecture, thus misleading the design process. Immediate attention thus needs to be given to particular sections of the LEED India version to ensure priority for contextual design aspects and traditionally developed design techniques before the LEED guideline can be accepted as the new measure for sustainable design in India.

1.1. Background of LEED in India

Before the arrival of LEED in India, there existed a number of national and international building standards and codes which partially fulfilled the requirements for a Green building rating system in a discreet manner. As mentioned before, the official certification of LEED for Indian buildings started with certification of the CII Sohrabji Godrej Green Business Centre. The first Indian version, referred as LEED India Version 2.0 was launched in October 2006. The current version, known as LEED India NC (for new construction) Reference Guide Version 1.0, was released in January 2007.This version is applicable to all new commercial buildings and residential buildings with four or more habitable stories and is the primary focus for this research. There is another version available named LEED India for Core & Shell, which certifies those kinds of buildings where the owners or developers do not control every aspect of the buildings, such as rentable spaces in Information Technology parks.

Though a number of amendments are incorporated for the Indian version to fit into the context as a part of the initiative by IGBC, the basic structure of the guide remains almost the same as the US version in all aspects. Because India is very much different in terms of climate, economy, and culture, a false notion of sustainability is generated by the use of US standards for new buildings. Hence, there is a requirement to identify the problems and provide appropriate modifications for the LEED rating system itself.

1.1.1. Thesis Statement

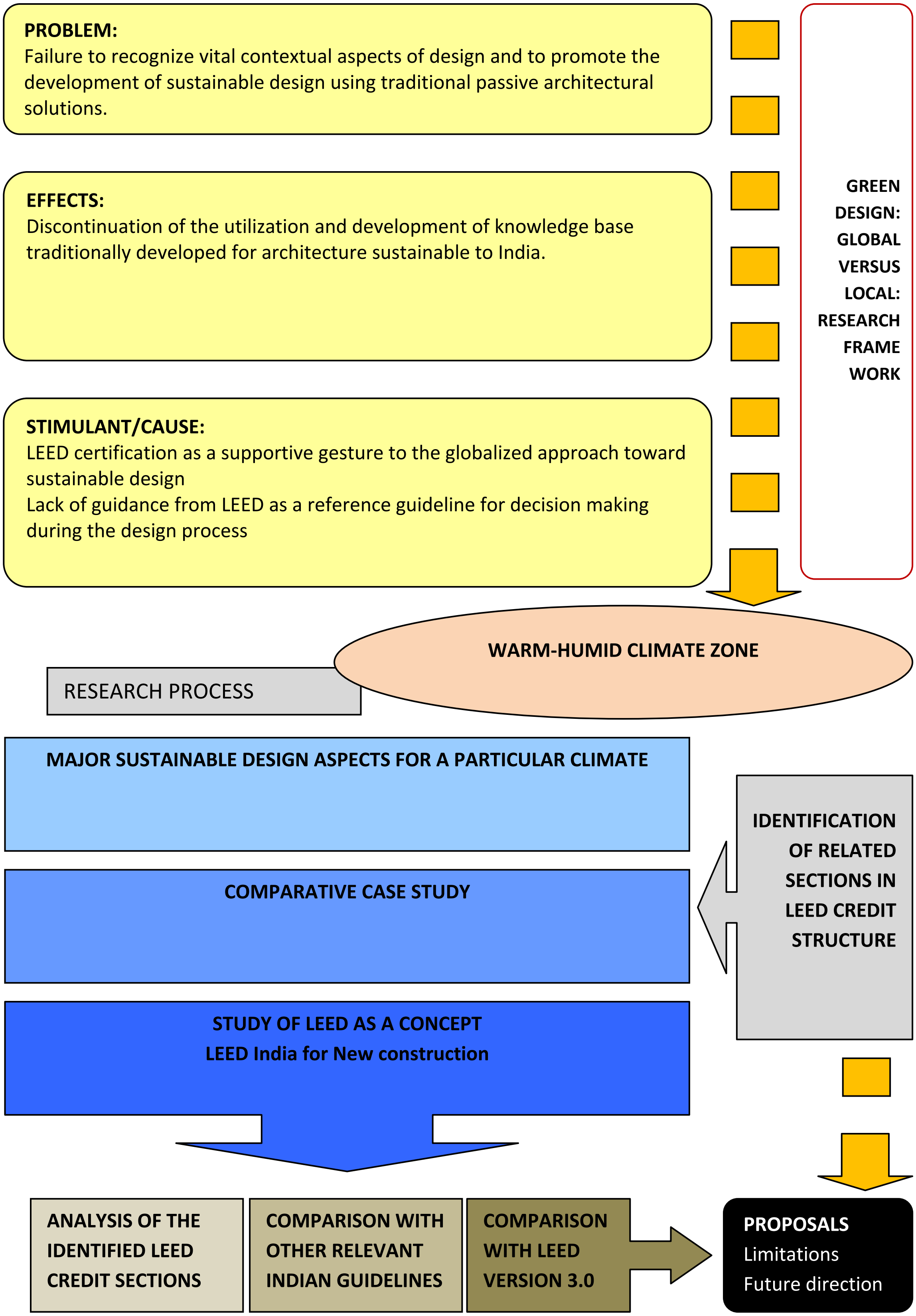
The purpose of this thesis is to identify the issues excluded or condoned in the LEED India NC Version 1.0 rating system that are essential to the design of sustainable buildings specific to the unique context of India and suggest further amendments for the next version to promote a context sensitive passive design approach.

1.1.2. Research Questions

1. What are the critical issues with regard to sustainability in the LEED rating system as sustainable design guideline while designing for a particular context in India?
2. How has the current version of LEED India guideline addressed the major contextual differences and/or requirements?
3. What is the best possible method to make the guideline structure more effective and particular for the Indian sustainable design context?

1.2. Methods of Inquiry: Research Framework

The research framework is based largely on literature review, case studies and comparative analysis. However, these methods are frequently applied together and sometimes in phases based on the development of the LEED rating systems over time. The overall purpose of the methods can be described as below:



PROBLEM:
Failure to recognize vital contextual aspects of design and to promote the development of sustainable design using traditional passive architectural solutions.

EFFECTS:
Discontinuation of the utilization and development of knowledge base traditionally developed for architecture sustainable to India.

STIMULANT/CAUSE:
LEED certification as a supportive gesture to the globalized approach toward sustainable design
Lack of guidance from LEED as a reference guideline for decision making during the design process

Figure 1.7: Research Methods

1.2.1. Review of Sustainable Design Aspects in India

India presents tremendous diversity in terms of climate, location, and culture. Regional factors prohibit one from prescribing a single model for all the situations. The area selected for this review is a single context chosen (the Warm-Humid climate zone). Thus the study consists of the requirements of climate specific design problems and their traditional solutions with development over time. This provides a good understanding of the context in terms of architectural requirements and helps in prioritizing a number of criteria for sustainable design under the chosen context.

1.2.2. Critical Analysis of LEED Rating System

The primary method for this research is critical review of the LEED rating system and analysis of the same as a sustainable design guide with respect to the design aspects identified for the Warm-Humid climate zone in India. The study examines the origin and basis of LEED rating system while the analysis looks deeper into the credit structure for LEED for New Construction (both USA and India version) and its relation to other design standards and guidelines.

1.2.3. Identification of Major Issues with LEED Rating System

Based on the literature review, a list of criteria is put forth. This is followed by a detailed review of the point based credit structure of the existing version of LEED rating system in India is scrutinized to determine the importance of these criteria in the credit structure. On the basis of this study the framework is finalized as the benchmark for the research procedure. The next step is to review the LEED India guidelines with respect to the addition and modifications applied by the Indian Green Building Council (IGBC) to make it more applicable to the Indian context. It is also important to mention here that a LEED India guideline also incorporates input from other existing Indian design guidelines. This leads to the study of all other existing or parallel national and/or international design guidelines which may or may not apply to the LEED system. This list includes study of the National Building Codes in India, TERI design guidelines and ASHRAE guidelines. The framework remains incomplete till the LEED version 3.0, launched in 2009 is included in the research framework. The criteria short-listed through the literature review thus become the areas of concentration in the entire credit structure as the scope of work for this research. Table 1.1 provides an overall comparison between the US and Indian version of LEED NC which shows the changes made to the Indian version so far. The area of concentration is defined as the shaded portion which includes the Water Efficiency, Energy & Atmosphere, Material & Resources, and Indoor Environment Quality.

	LEED NC Credit & Point System Comparison	point removed		point/value changed	
	Credits	**Points**			
		LEED NC V 2.2 USA	**LEED NC V 1.0 INDIA**	**Comments**	
		Total 69	**Total 69**		
Sustainable Sites	Construction Activity Pollution Prevention	Prerequisite	Prerequisite		
	Site Selection	1	1		
	Development Density & Community Connectivity	1 **ID 1**	1 **ID 1**	NC1proposed to be removed	
	Brownfield Redevelopment	1	1		
	Alternative Transportation: Public Transportation Access	1 **ID 1**	1 **ID 1**		
	Alternative Transportation: Bicycle Storage & Changing Rooms	1 **ID 1**	0 removed	NC1 2 wheeler parking was proposed	
	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles	1 **ID 1**	1 **ID 1**		
	Alternative Transportation: Parking Capacity	1 **ID 1**	1 **ID 1**		
	Site Development: Protect or Restore Habitat	1	1		
	Site Development: Maximize Open Space	1	1		
	Storm water Design: Quantity Control	1	1		
	Storm water Design: Quality Control	1	1		
	Heat Island Effect: Non-Roof	1	1		
	Heat Island Effect: Roof	1 **ID 1**	1 **ID 1**		
	Light Pollution Reduction	1	1		
Water Efficiency	Water Efficient Landscaping: Reduction	1 for 50%	1 for 50%	NC1 no potable water for A/C cooling tower was proposed	**AREA OF CONCENTRATION**
	Water Efficient Landscaping: No Potable Water Use or No Irrigation	1 for 100%	1 for 100%		
	Innovative Wastewater Technologies	1 **ID 1**	1 **ID 1**		
	Water Use Reduction: Reduction	1 for 20%	1 for 20%		
	Water Use Reduction: Reduction	1 for 30% **ID 40%**	1 for 30%		
Energy & Atmosphere	Minimum Energy Performance	Prerequisite	Prerequisite	NC1 emission reduction in cooling plants/DG sets, safety prerequisite	
	Fundamental Refrigerant Management	Prerequisite	Prerequisite		
	Fundamental Refrigerant Management	Prerequisite	Prerequisite		
				NC1 ECBC 2006 standard addition	
	Optimize Energy Performance	1 to 10 **ID 1**	2 to 10 **ID 1**	v3 percent increase value change	
	On-Site Renewable Energy	1 to 3 2.5-7.5% **ID 17.5**	1 to 3 2.5-7.5% **ID 17.5%**	v3 percent increase value change	
	Enhanced Commissioning	1	1		
	Enhanced Refrigerant Management	1	1		
	Measurement & Verification	1	1		
	Green Power	1 **ID 1**	1 **ID 1**	NC1 proposed to be removed	
Materials & Resources	Storage & Collection of Recyclables	Prerequisite	Prerequisite		
	Building Reuse: Maintain of Existing Walls, Floors & Roof	1 for 75%	1 for 75%		
	Building Reuse - Maintain of Existing Walls, Floors & Roof	1 for 95%	1 for 95%		
	Building Reuse: Maintain of Interior Non-Structural Elements	1 for 50%	1 for 50%		
	Construction Waste Management: Divert From Disposal	1 for 50%	1 for 100%+50% internal		
	Construction Waste Management: Divert From Disposal	1 for 75%	1 for 75%		
	Materials Reuse:	1 for 5%	1 for 5%		
	Materials Reuse:	1 for 10% **ID 15%**	1 for 10% **ID 15%**		
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 10%	1 for 5%		
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 20% **ID 30%**	1 for 10%		
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 10%	1 for 20% manufacture		
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 20% **ID 40%**	1 for 50% extract		
	Rapidly Renewable Materials	1 for 2.5% **ID 5%**	1 for 6.5%		
	Certified Wood	1for 50% **ID 95%**	1for 50% **ID 95%**		
Indoor Environmental Quality	Minimum IAQ Performance	Prerequisite	Prerequisite		
	Environmental Tobacco Smoke (ETS) Control	Prerequisite	Prerequisite		
	Outdoor Air Delivery Monitoring	1	1		
	Increased Ventilation	1	1		
	Construction IAQ Management Plan: During Construction	1	1		
	Construction IAQ Management Plan: Before Occupancy	1	1		
	Low-Emitting Materials: Adhesives & Sealants	1	1		
	Low-Emitting Materials: Paints & Coatings	1	1	NC1 exterior paint inclusion proposed	
	Low-Emitting Materials: Carpet Systems	1	1	NC1 point for no carpet use	
	Low-Emitting Materials: Composite Wood & Agrifiber Products	1	1		
	Indoor Chemical & Pollutant Source Control	1	1		
	Controllability of Systems: Lighting	1	1		
	Controllability of Systems: Thermal Comfort	1	1		
	Thermal Comfort: Design	1	1		
	Thermal Comfort: Verification	1	1		
	Daylight & Views: Daylight	1 for 75% **ID 95%**	1 for 75% **ID 95%**		
	Daylight & Views: Views	1 for 90% **ID 1**	1 for 90% **ID 1**		
Innovation & Des. Pr.	Innovation in Design	1	1		
	Innovation in Design	1	1		
	Innovation in Design	1	1		
	Innovation in Design	1	1		
	LEED Accredited Professional	1	1		

Table 1.1: Overall Comparison of LEED USA NC V 2.2 and LEED India NC V 1.0 scorecard showing focus of study.

1.2.4. Comparative Case Study using Real World Examples

To examine the effect of the LEED rating system as a new sustainable design guideline for architecture in India and to verify the validity of the assumption made on the issues identified, two different buildings in the same context have been selected for study (Chapter 3). The first is a sustainable building designed before the advent of LEED certification but officially recognized as a Green building and the second is a LEED certified building with a similar function. This is an “apples to apples” comparison of a single LEED-certified and non-LEED-certified Green building built in the same context. Hence, this study provides a better understanding of the previously defined criteria in terms of real world examples.

1.2.5. Comparative Analysis with New Version of LEED and Other Guidelines

As mentioned earlier, in addition to the LEED India guideline itself, there exists other national and local design guidelines which are applicable to the issues related to the sustainable design under the research context. Some of these guidelines are meant for rating sustainable buildings and thus apply to the context in a manner similar to that of the LEED guidelines. Since these guidelines are written specifically for the building industry in India, there are certain variations from LEED guideline in terms of definitions and distribution of significance for different factors. Thus, it is valuable to make a direct comparison of LEED India and the comparable guidelines for sustainable design developed in India itself (Chapter 5).

This research began with a study of the credit structure of LEED India NC Version 1.0, which follows the LEED US Version 2.2 effective to date. However, all LEED guidelines are updated and revised from time to time. The US Green Building Council introduced the new LEED Version 3.0 in April 2009. This version offers a number of major changes including the distribution of credits under different categories depending on the situation and more regional credits. Hence, the comparative analysis between the version 2.2 and version 3.0 plays a critical role for the entire research. On the one hand it will provide validation for the research findings; on the other hand it will help to redefine the research outcome since the new version will still primarily apply to the American context and have to be adopted by the Indian LEED rating system for future versions.

1.3. Significance

Design for sustainable buildings demands additional priority for the methods and technologies employed depending upon the contextual differences in various parts of the world. The differences could be climatic, geographical, social, economic, and so on. These factors should play a very important role in any design for sustainability. Thus, it is necessary to improvise the rating systems while they are being applied to a totally different context. LEED has become a symbol of the Green movement and is recognized by many professionals associated with the building industry from different countries. This recognition calls for more responsibility as the credit points and certification for the buildings not only certifies the approach taken to design that single project, but also serves as a recommendation for a large number of future projects which are encouraged to follow the same path. Hence, if the rating system does not recognize those individual factors for a particular context, the entire effort to make a huge section of our society “Green” becomes invalid. Thus, it is absolutely essential to critically analyze and revise every sustainable design guideline and rating system for every single country and its contexts accordingly.

In the following chapter the context of India is discussed in terms of geography, climate and culture. This leads to the development of architectural practice, and consequently the indigenous concepts for sustainability within the country.

Chapter 2

SUSTAINABLE DESIGN CONTEXT IN INDIA

Sustainable design has a long tradition in Indian architecture. Though the word “Green” and “Sustainable” have entered the architectural vocabulary in recent decades, the fundamental concepts and their implications can be found in even the earliest examples of the Indian architecture. From the Vedic ages to Global village, architecture in India has been influenced by the geographical, climatic, social and political realities of the country. Most of the traditional architecture styles developed in different corners of the country rely on a climate-specific approach; sustainability is always related to human comfort in a given region. Hence, before analyzing the effect of modern techniques on Indian buildings it is necessary to understand the process of traditional sustainable design development in India following the contextual differences.

2.1. Context

While designing for a specific context, one needs to consider the geographical, climatic, economic, and social aspects of that particular context. These aspects are closely related to each other and thus each of them affects the design solution. Discussed below are three major contextual aspects of sustainable design processes in India: Geography, Climate and Culture.

2.1.1. Geography

In terms of topography and geological features, India is a very diverse country. While the northern regions are part of the great Himalayan range and valley, the other three sides are bounded by oceans, encompassing the Indian Plate. Rivers, desert and rainforests make the context even more complex.

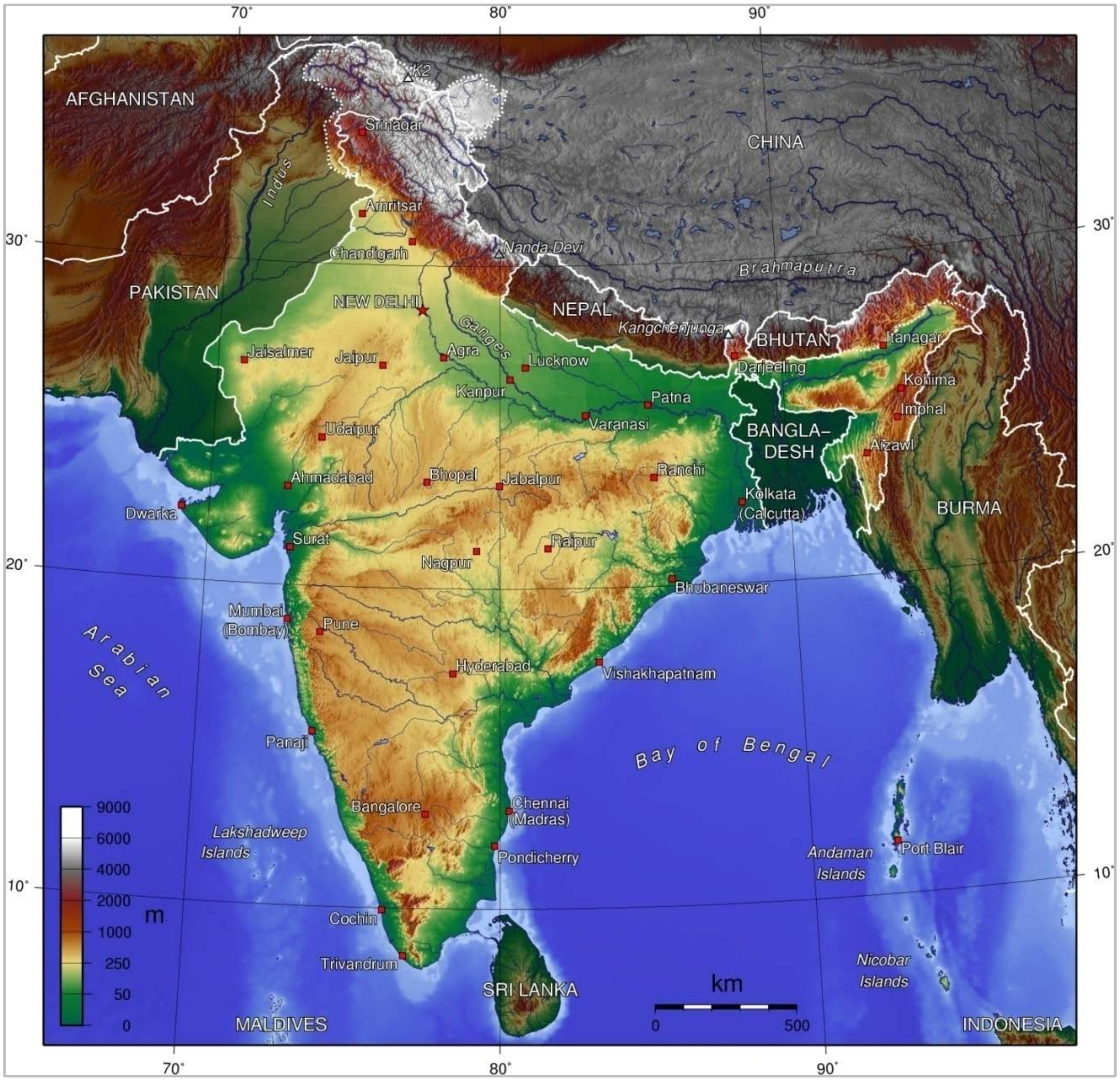


Figure 2.1: Geographic map of India. Image Source: www.wikimedia.org

India is divided into seven physiographic regions. They are

1. The Northern Mountains, including the Himalayas, which include the Kuen Lun and the Karakoram ranges and the northeast mountain ranges.
2. The Indo-Gangetic plains
3. The Thar Desert
4. The Central Highlands and Deccan Plateau
5. The East Coast
6. The West Coast
7. The bordering seas and islands

The variation in the geographical context has a great impact on sustainable design decisions in terms of choice of materials, structure, and form. For example, adobe and brick are traditionally building elements along the Gangetic Plain, because of the readily available clay. On the other hand, stone is a major building element in the desert and hilly regions which provide good thermal mass as a protective layer from the external environment (Fig. 2.2).

Figure 2.2: Stone Architecture in Jaisalmer, Desert zone, Figure; 2.3: Brick Vaults in Maldah, Indo-Gangetic Plain

The structural framework and form of the buildings also vary significantly depending on the terrain. This defines the life cycle of the buildings, which is one of the important factors while in considerations of sustainability.

Figure 2.4: Brick and wood structure, Gangtok, Highlands

Figure 2.5: Clay tile and Brick structure, Chennai, Deccan Plateau

2.1.2. Climate

Climate is one of the major factors in determining methods and techniques in a sustainable design process. Often, the climate and geographical characters complement each other in the emergence of architectural styles. As a very large and geographically diverse country, India has more than one climate zone. Most of the country is in the Tropical zone, rest being Subtropical humid and montane climate zones. Some of the major characteristics of the tropical and subtropical climates are hot summers, significant amounts of rainfall, and moderate winters. By Contrast, the climate of much of the USA is temperate (Fig. 2.6 and 2.7).

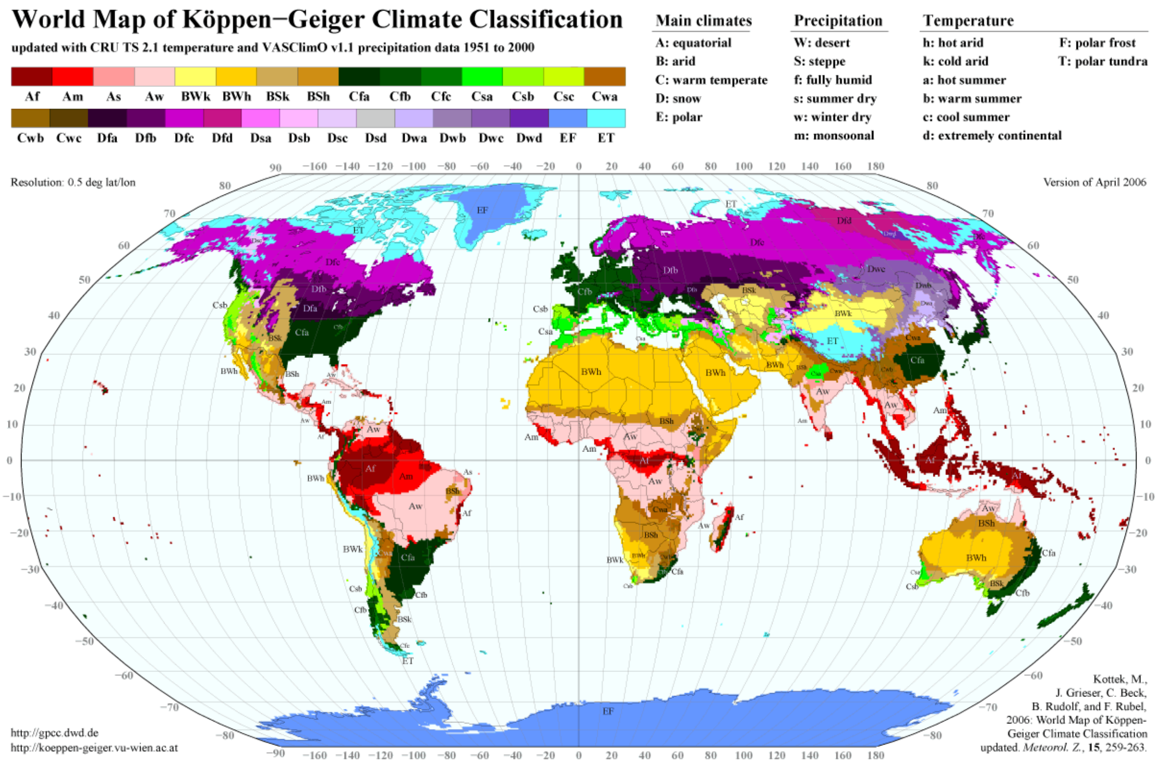


Figure 2.6: World Climate Classification. Image Source: Köppen-Geiger Classification

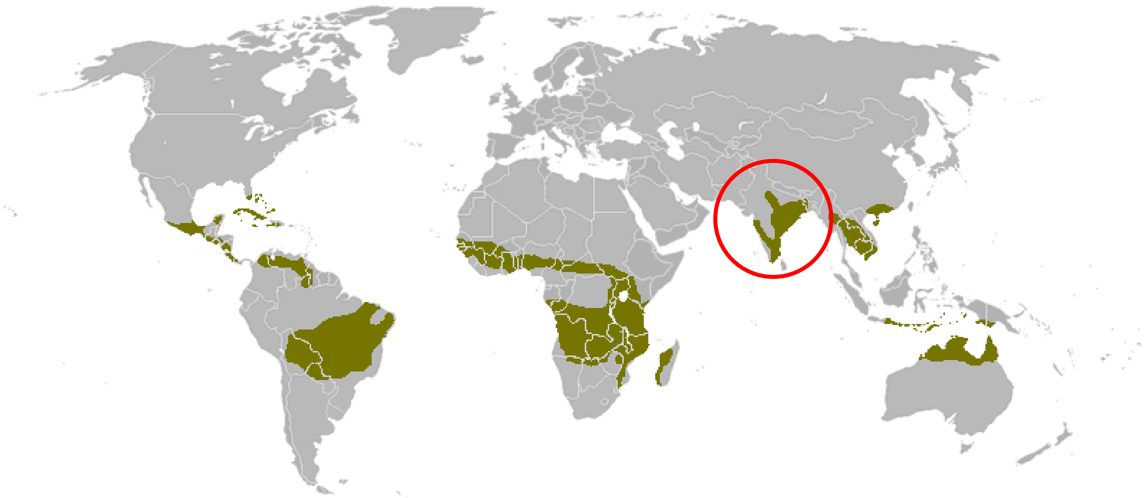


Figure 2.7: Worldwide Tropical wet and dry Climate zones. Image Source: www.wikimedia.org

The climatic regions of India can be subdivided further. According to the National Building code of India[1] there are five major climatic zones in India:

1. Hot-Dry
2. Warm-Humid
3. Composite
4. Temperate
5. Cold.

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[1] Bureau of Indian Standards, 2005

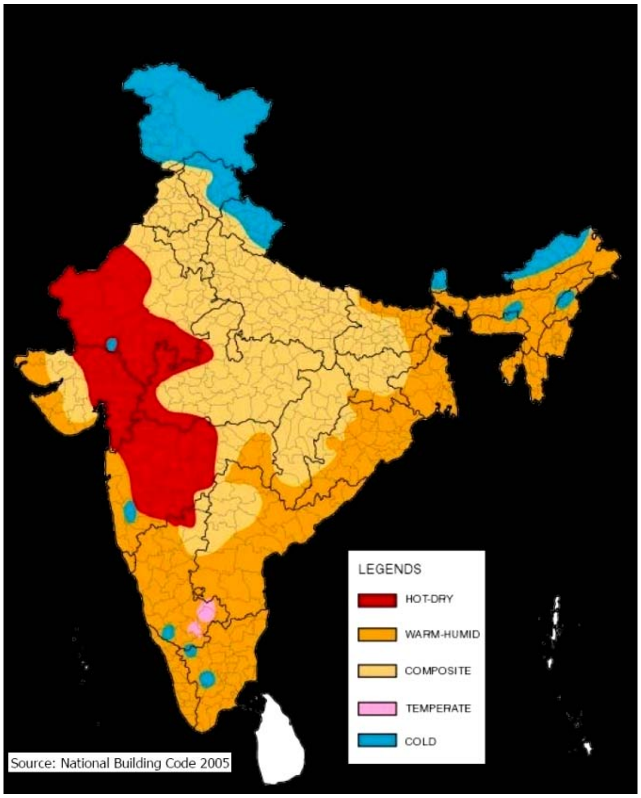

Figure 2.8: Climate zones in India. Image Source: National Building Code of India

This climatic variation is one of the major driving factors behind the diversity in traditional architecture in different parts of the country. The architectural methods and techniques that have been developed in various regions are responsive to the regional patterns of solar radiation and sun path, humidity, and wind direction throughout the year (Fig. 2.9 & 2.10).

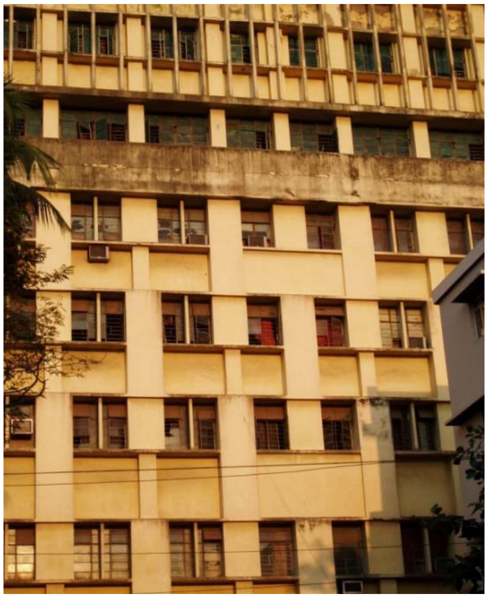

Figure 2.9: Openings to allow airflow while preventing direct exposure from sun: IIM Ahmadabad, Hot-Dry climate

Figure 2.10: Operable windows to allow airflow with shading protection from sun and rainwater: Jadavpur University, Kolkata, Warm-Humid climate

From the previous discussion it becomes evident that every climate zone would require a different set of priorities for a truly sustainable design that relates to other local contexts. Hence, for research purposes a single major climate zone will be considered to reflect on LEED India and related guidelines. The warm- humid climate zone encompasses a major portion of the country and is one of the difficult contexts to handle, due to excessive humidity during summer and the monsoon season, combined with a high sun angle. Major cities like Mumbai, Kolkata, and Chennai are located in this zone and have a significant impact on the building industry and the environment. Focusing on the climatic zone for this study allows for comparisons between buildings of similar function that have been recognized either by LEED and/or by other organizations as Green buildings. The characteristics of the warm-humid climate are discussed in the next chapter.

2.1.3. Culture

India is one of the most diverse countries in the world in terms of culture and demographics. The country consists of twenty-eight states and seven union territories, most pf which are different in terms of language, custom, and cultural practices. This diversity is made even more complex by the absorption of influences from other cultures, such as the Mughal, British, French, and Portuguese.

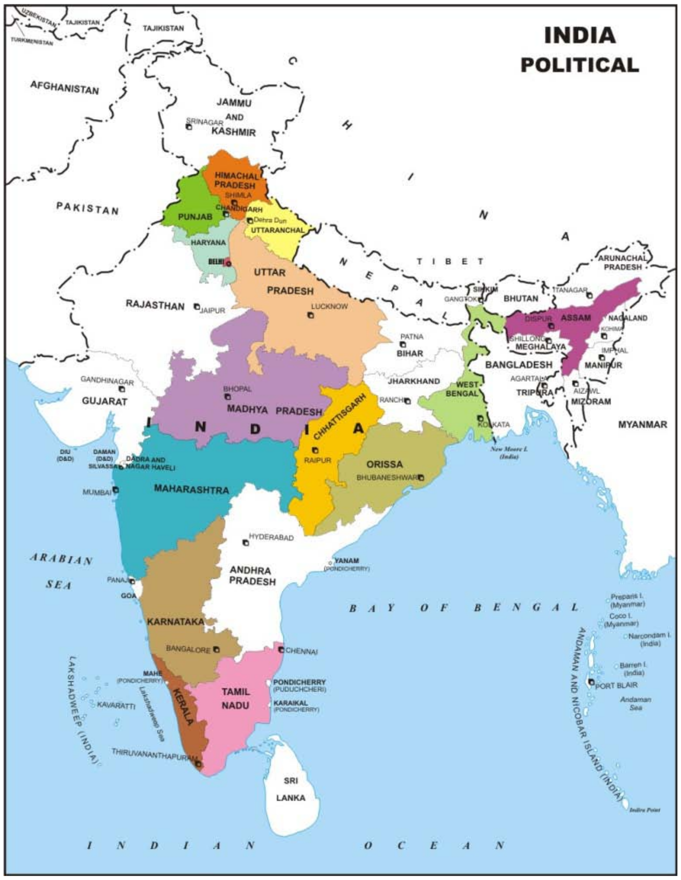

Figure 2.11: Political states of India: states representing different cultural aspects

Image Source: Government of India

The different regions of India have developed different architectural responses to their climatic and cultural conditions. The beginning of architecture can be traced back to Third millennium BC, to the Indus Valley civilization. With the advent of Aryans, a new tradition in architecture started heralding the Vedic era. “*Vaastu Shastra”’* (the science of building and orientation) can be considered one of the earliest traces of sustainable concepts in Indian architecture.[2]

Figure 2.12: Brick as regional material, The Great Bath of Mohenjo-Daro

Image Source: www.harappa.com

Following are some of the major architectural styles developed with different cultures and societies.

Sacred Hindu Architecture: The religious architecture of Hinduism has a span of more than a thousand years and consists of diverse temple forms ranging from rock-cut

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[2] Thapar, Bindia, Suparna Bhalla, 2004

temples to immense temple cities. It features a heavy building mass surrounding small sacred spaces for worshiping.

<u>Sacred Buddhist Architecture:</u> The concept of Buddhism deviated from Hindu roots with Gautama Buddha, the founder of the religious movement. *Stupas* and rock-cut cave temples are the prominent examples of Buddhist architecture.

Figure 2.13: Kandariya Mahadeva Temple, Khajuraho: Sacred Hindu Architecture

Figure 2.14: Ajanta Caves: Buddhist Architecture. Image Source: www.wikimedia.org. Use of thermal mass

<u>Dravidian Architecture:</u> The Dravidian or Southern style is a branch of Sacred Hindu architecture, and presents a stark contrast with Northern style in terms of form and elements which are often developed indigenously.

<u>Islamic/Mughal Architecture:</u> From the tenth century onwards, with the invasion of Muslim forces in the form of the Sultanate and Mughal Empire, a completely new style found its place in India. The cultural and social variety added with the advent of Islamic architecture opened up new possibilities in terms of space organization, building elements, and aesthetics. Islamic architecture introduced extensive use of *jali* (lattice screens) as a form of solar shading yet allowing natural ventilation. Mughal forts are of the good examples of use of the sunken courtyards and roof terraces to create comfortable micro-climates.[3]


Figure 2.15: Rooftop court, Agra Fort, Agra: Mughal Architecture

Colonial Architecture: Western influences, such as the British, French, and Portuguese who first intervened in the Indian Territory first as traders and gradually transformed into political forces, changed added more facets to the Indian architecture. Colonial architecture, introduced a completely new building vocabulary to India through new administrative buildings which eventually became the face of the British Empire for two hundred years. Roman and Gothic elements merged with the indigenous architectural styles of India, producing a new kind of architectural style. The bungalows and courtyard houses in Bengal are instances in which the climate and style are balanced effectively.

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[3] Correa, Charles, 1996

Figure 2.16: Kolkata Metropolitan Corporation: British Colonial Architecture

Various other styles of architecture have developed in different parts of the country, based on influences from the major styles and vernacular methods such as the Nagara style, Sikh and Jain Architecture, etc.

2.2. Contemporary Indian Architecture and Passive Design Techniques

Toward the end of the British rule in the Indian subcontinent, the process of combining the traditional Indian style with the traditional Western forms resulted in a hybrid architecture known as the Indo-Colonial style. Edward Lutyens's design for the Parliament Complex and the President's House in New Delhi are good examples of this approach. After Independence, international architects like Le Corbusier and Louis I. Kahn were invited to design extensive projects, including the Chandigarh administrative complex and the Indian Institute of Management in Ahmadabad; such projects opened the door for development of contemporary architecture in India.

Figure 2.17: Light shelves and recessed windows: Chandigarh Secretariat, Le Corbusier

Image Source: www.wikimedia.org

These architects made an honest approach to understand India as a very different context for design and inaugurated the interaction between the clean, geometric open planning systems and traditional systems that had developed to deal with high solar angle, heat gain and natural ventilation. Meanwhile, a number of young Indian architects, who had studied modern Western architecture took this process very seriously and developed a contemporary language for Indian architecture that is still deeply rooted to the traditional ideas and systems.[4] Achyut Kanvinde, Charles Correa,

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[4] Bhatt, Vikram & Scriver, Peter, 1992

Raj Rewal, and Balkrishna V. Doshi are a few of these pioneers who defined the early framework for a context friendly architecture in the Indian subcontinent.

Figure 2.18 and 2.19: Use of brick and concrete façade integrated with light wells and deep corridors to create spaces with natural light and natural ventilation: IIM Ahmadabad, Louis I. Kahn

Working with different traditional architectural styles around the country, the new revolution in Indian architecture has thus attempted to incorporate appropriate passive designs that are harmonious with the vernacular building techniques. The techniques vary in nature depending on the climate, landscape, available materials, and social structure but they all address the following issues:

1. Solar heat gain/loss
2. Ventilation
3. Light

The passive design techniques are applied to address these issues in a holistic fashion that takes into account the interrelation between them. These techniques work on simple principles and are flexible enough to be adapted to a variety of local and renewable materials. Hence, it is easy to understand the effort of many contemporary architects to adopt these techniques with necessary modifications and improvements. The following images site examples of such approaches in different parts of the country.

Figure 2.20: Combination of brick walls, concrete and thatched roof, and window projections to provide solar protection: ISCON Housing; West Bengal, Laurie Baker

Figure 2.21 and 2.22: Use of small openings to allow daylight and air while blocking the heat, an examply of synergy of techniques: The Centre for Development Studies, Trivandrum; Kerala, Laurie Baker. Image Source: www.laribaker.net

Figure 2.23: Operable louvers allowing control over sunlight penetration and airflow: Gandhi Smarak Sangrahalaya, Ahmadabad; Charles Correa

In the last twenty years, architecture in India, particularly in the commercial sector, has been significantly influenced by the corporate culture which compelled the architects to seek for influence from modern international architectural movements in terms of building form, materials and aesthetics. The introduction of glass as a major building material can be considered greatly responsible for a major shift in the language of Indian architecture. Large amount of glazing in building facades have provided more open, flexible spaces, on the one hand; but they have also had the unwelcome effect of making the buildings more vulnerable to heat and glare. Architects are thus challenged to solve these new problems in an effective manner (Fig. 2.24).

Figure 2.24: Combination of traditional stone and modern glazing in façade with solar protection added by overhead space frame acting as shading device – LIC Building, New Delhi; Charles Correa

With constant pressure from the client and limited scope to explore design techniques, architects for the majority of modern Indian buildings have to choose readymade solutions, such as artificial ventilation systems rather than natural ventilation. This approach generated buildings which drew visual inspiration from Western countries but lost the connection to the development of context-specific architecture discussed above (Fig. 2.25). With rapid economic growth and support from the developers and owners, for whom profit is of greater importance than true sustainability, it became a common practice everywhere in the country.

Figure 2.25: Extensive use of aluminum cladding and glazing with little consideration for the heat and ventilation: Cinema 89, Kolkata. Image Source: Bengal Ambuja Pvt. Ltd.

However, a constant parallel effort to formulate solutions for the design problems of modern corporate buildings in the Indian cultural and climatic context has resulted in some successful buildings that combine traditional passive techniques and space planning with modern built forms (Fig.2.26 & 2.27).

Figure 2.26: Use of modern building materials following traditional screening system on façade – ITC Sonar Bangla Hotel; Kolkata, Kerry Hill. Figure 2.27: Detail of facade

In this context, LEED, not only as a Green building rating system, but as an international marketing tool thus carries great responsibility to define the future of Indian architecture. It can drive the building industry to make a choice between these two approaches: developing sustainable buildings that respect the indigenous building practices or blindly following definitions of sustainability derived from a completely different background.

Chapter 3

MAJOR ASPECTS OF SUSTAINABLE DESIGN: GUIDELINES FOR AN INDIAN CONTEXT

Sustainable design guidelines and rating systems formulated by different voluntary organizations are applied to different parts of the world today. The rating systems are intended to measure or quantify the sustainable features of the design solutions for buildings and their performance during their lifecycle. Most of the criteria are based on basic concepts of sustainability which focus on conservation and utilization of natural resources and minimization of the use of non-environment-friendly products. However, the rating systems individually vary in their emphasis on particular criteria and the way they are measured. In India, there are a number of design guidelines, rating systems, and building codes (both national and international) currently in use. The subject of this chapter is to identify the major aspects an architect must consider while referring to any of these guidelines to ensure context specific design. The discussion will focus on the LEED rating system and applicable guidelines are considered in relation to other guidelines. Building examples are cited to highlight the real-world effects of these guidelines.

3.1. Definition of a Sustainable Design Guideline

Generally Green buildings are intended to minimize depletion of resources during their lifecycle. Other aims of Green building design are to minimize the demand on nonrenewable resources, maximize the efficiency of these resources when in use, and maximize the reuse, recycling, and utilization of renewable resources. Green design and construction maximizes the use of efficient materials and construction practices; optimizes the use of on-site sources; uses efficient equipment and minimal fuel to meet its lighting, air-conditioning, and other needs; maximizes the use of renewable sources of energy; uses efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions[1]. The architect, landscape designer, and the air conditioning, electrical, plumbing, and energy consultants work as a team to address all aspects of building and system planning, design, construction, and operation. This 'integrated' design team critically evaluates the impacts of each design decision on the environment and arrives at viable design solutions to minimize the negative impacts and enhance the positive impacts on the environment. A sustainable design guideline thus evaluates the following aspects of the building design in an integrated way:

- Site planning, landscaping and connectivity
- Building envelope design
- Building systems design: HVAC (heating, ventilation, and air conditioning), lighting, electrical, and water heating
- Integration of renewable energy sources to generate energy onsite.
- Water and waste management
- Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential, etc.).

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[1] www.grihaindia.org, 2009

- Indoor environmental quality (maintains indoor thermal and visual comfort and air quality).

3.2. Objectives of a Sustainable Design Guideline

A sustainable building rating system provides verification of the sustainable features of a building project. However, the rating system and related design guideline provide background information to assist the owner, the design team, and the contractor in understanding how to prioritize various design and construction aspects while making decisions and implementing them throughout the entire project. The role of such guidelines is noteworthy during the design phases, because most of the design decisions in this stage dictate the development of the other aspects of the project and hence, the overall performance. It is also important to understand that while following a guideline under such rating systems, the aim is not just to achieve credits or certification by any possible means but to achieve the best possible design solution through well-judged decisions which can be verified by the rating system. The former approach, often referred as “point chasing”, can mar the foremost objective severely, making the rating system certification just another marketing tool. Any sustainable design guidelines thus should

- Be comprehensive with the evaluation framework for sustainability
- Indicate the priority for sustainable design aspects considering the project and the context
- Establish the synergy and tradeoffs between different aspects

3.3. Design Guidelines and Rating Systems in India

Before the advent the Green Building movement, The Indian building industry had a number of national and international building codes and standards, which partly contributed to the sustainable design approach in terms of development density, building footprint, water management, basic energy performance and indoor air quality. The major standards are:

The National Building Code: The National Building Code of India (NBC), a comprehensive building Code, provides guidelines for regulating the building construction activities across the country. It serves as a model code for adoption by all agencies involved in building construction works including public works departments, other government construction departments, local bodies, or private construction agencies. The code contains administrative regulations, development control rules and general building requirements; fire safety requirements; stipulations regarding materials, structural design and construction (including safety), and building and plumbing services. The Code was first published in 1970 at the instance of the Planning Commission and then revised in 1983. The comprehensive NBC 2005 contains 11 parts some of which are further divided into sections, totaling 26 chapters.

ASHRAE standards: The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) is an international technical society for all individuals and organizations interested in heating, ventilation, air-conditioning, and refrigeration. The NBC refers to the ASHRAE standards 62.1 (for Indoor Environment Quality), 55 (for thermal comfort) and 90.1 (for building energy performance).

Local Building Regulations: In addition, every state and municipal board of India has individual building regulation systems designed to control the ratio of building footprints to open land.

Before the adoption of the LEED rating system and guidelines by Indian building industry, institutions such as Tata Energy Research Institute (TERI) had been working on developing a framework for sustainable design suitable for the Indian context and identifying good examples of sustainable building projects. Currently, there are three major sustainable design guideline and rating systems available in India:

LEED: The Leadership in Energy and Environmental Design (LEED) rating system developed by USGBC was adopted for Indian context by IGBC (Indian Green Building Council) in 2003 and was published as LEED India version in 2006. LEED is so far the most successful Green building rating system in India in terms of general acceptance and number of certified buildings.

ECBC: The Energy Conservation Building Code (ECBC), launched in 2006, is a document that specifies the energy performance requirements for all commercial buildings that are to be constructed in India. Buildings with an electrical connected load of 500 kW or more are covered by the ECBC. The ECBC has been developed by India's Bureau of Energy Efficiency. The ECBC provides design norms for:

- Building envelope, including thermal performance requirements for walls, roofs, and windows;

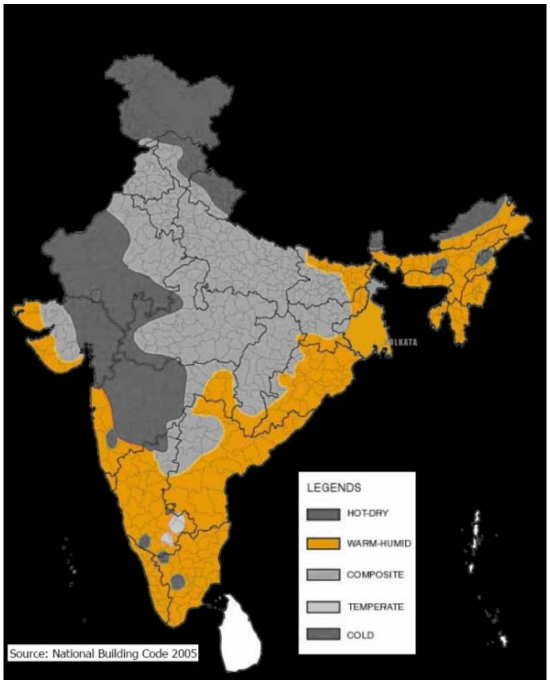
- Lighting system, including daylighting, and lamps and luminaire performance requirements;
- HVAC system, including energy performance of chillers and air distribution systems;
- Electrical system
- Water heating and pumping systems, including requirements for solar hot-water systems.

TERI GRIHA: Green Rating for Integrated Habitat Assessment (GRIHA) is a new national sustainable rating system and design guideline developed by Tata Energy Research Institute (TERI) in 2008. The objective of this system is to identify the issues critical for sustainable design in India, taking into account the decentralized and diverse character of the building industry which might not be recognized by any other international rating system.

These new sustainable design rating systems and guidelines also refer to each other and the above mentioned standards from time to time. Hence, none of these new guidelines can be considered as standalone systems. This makes them difficult to refer as design guidelines as it becomes a very time consuming complicated process unless proper coordination and guidance are provided. This difficulty discussed in detail in chapter 5.

3.4. The Warm-Humid Climate Zone: Key Design Aspects

The warm-humid climate zone encompasses a major portion of the Indian Territory, and will serve as the focal area of study.



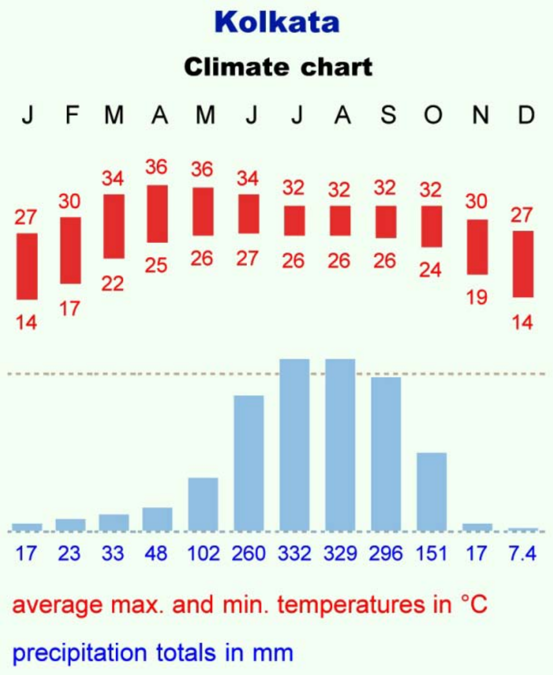


Figure 3.1: The warm-humid climate zone in India. Image Source: National Building Code of India

Figure 3.2: Climate Chart for Kolkata: high temperature and humidity in summer demands cooling with dehumidification. Image Source: www. wikipedia.org, www.imd.org

From the climate chart (Fig. 3.2), it is clear that combination of solar radiation and precipitation increase the temperature and humidity during most of the year with the peak in summer. The combination of heat and humidity in the summer requires extensive cooling and dehydration of the air inside the buildings. Winters are dry and much more comfortable in terms of temperature, reducing the demand for heating.

Some of the major concerns for a climate-responsive approach in Green building design; relevant to India's Warm-Humid climate are the indoor environment quality, water management, and use of material resources. These factors are very closely related and together cause the overall performance of the building. The following discussion describes the particular concerns for these criteria under this climate zone in India.

3.4.1. Indoor Environmental Quality

Air: The indoor environmental quality largely depends on air temperature, humidity, air flow, and the quantity and type of dust particles present in the air. The human body maintains its core temperature through interactions with the surrounding environment which include transfer of heat (heat flow/loss) by evaporation, radiation, and convection. Other factors, like clothing and pollution, also have significant impact. Generally, the comfort temperature range is 68-77°F (20-25°C) under conditions of minimal wind flow.[2] Comfort level is not a very simple attribute to determine; it depends upon the satisfaction of at least 80 percent of the occupants of a building, and can vary under different circumstances. If other conditions are satisfied, the comfort temperature could go beyond 82°F (28°C) for certain hours of the day.[3]

In warm and humid environments, where the air temperature exceeds 80°F (26.6°C) with more water vapor present in air, the human body has to depend more on evaporative methods than on convection or radiation to lose heat for comfort. Hence, it can be argued that under warm-humid conditions, the building indoor environment requires more air movement to maintain a comfortable temperature.

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[2] Emmanuel, M. Rohinton, 2005

[3] Carbon Trust, 1999

The architectural solution to this problem is provision for adequate cross-ventilation across the building. Thus while designing for the warm-humid climate, considering the strong South-West wind during summer (Fig 3.3), the choice of natural ventilation or mixed mode ventilation (balancing natural and mechanical methods) should be strongly considered over mechanical ventilation.

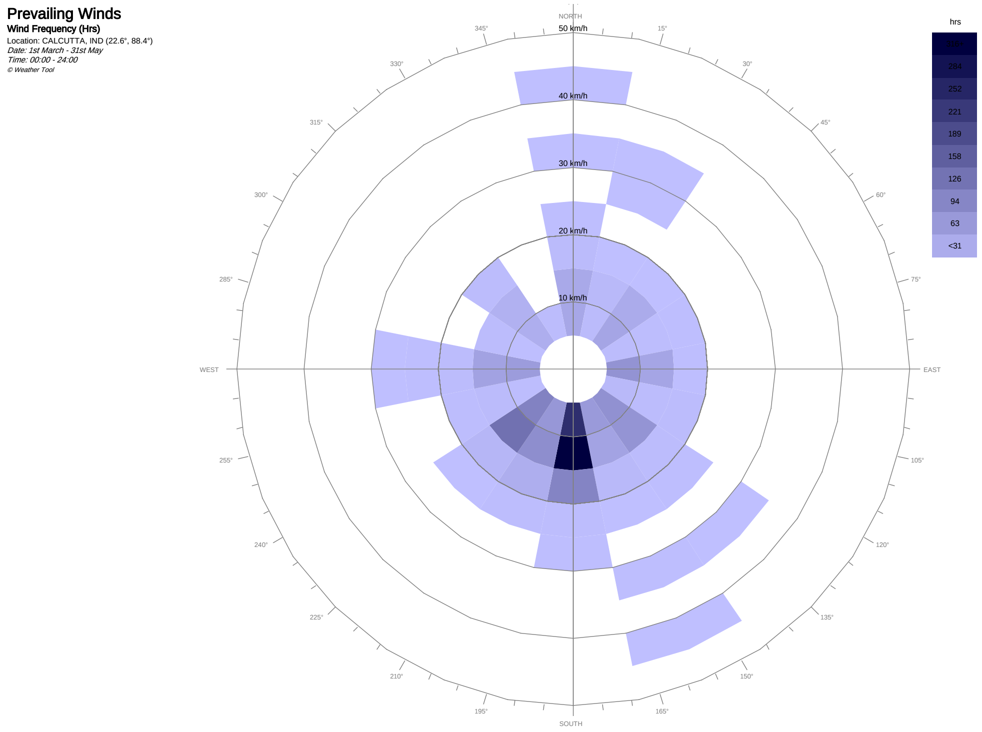
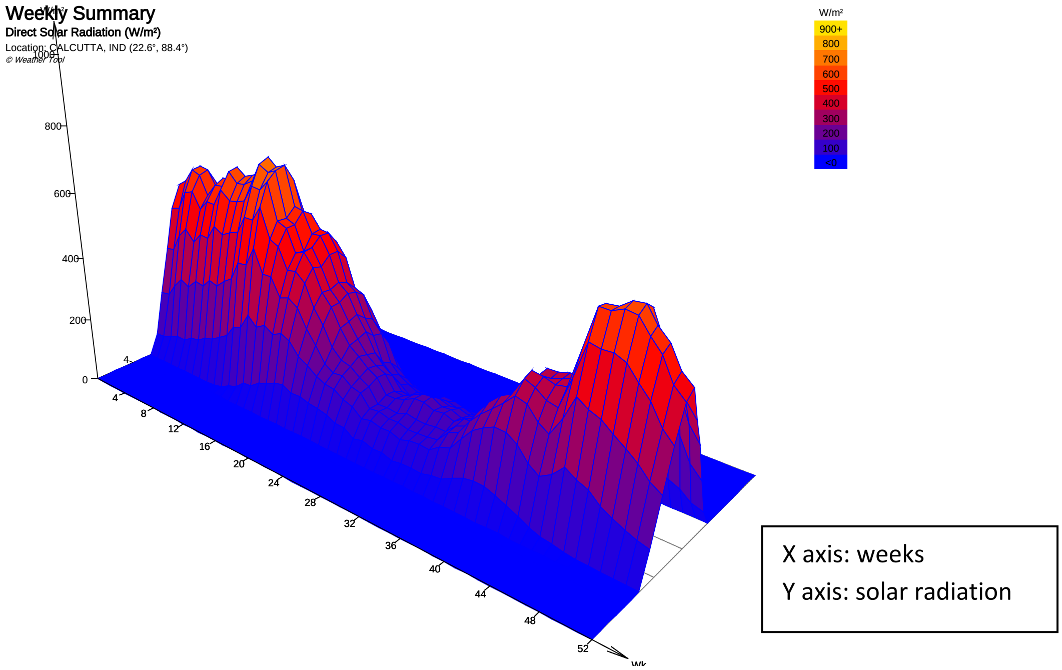


Figure 3.3: Summer Wind Frequency in Kolkata: Strong wind flow is favorable to natural ventilation

Image Source: Weather Tool, Autodesk Ecotect

The effects of solar radiation upon a building can be divided into the following categories:

Heat Gain: The sun is the primary source of heat on this planet. Without artificial heating or cooling, the intensity of solar heat gain largely controls the temperature within a building throughout the day. The intensity depends upon the angle of incidence of the sun's rays, which vary in predictable daily and annual patterns in a given locations. With the knowledge of solar movement in a particular place, we can determine which portion of a building will have maximum solar incidence. In a tropical warm-humid climate zone, the angle of solar incidence will be much higher than colder climates zones (for example, temperate) throughout the year, especially in summer (Fig.3.4). In winter, the heat gain is insufficient to provide optimum comfort levels, but the average temperature is not extremely low, as it is in more northerly climate zones (Fig. 3.5). Thus, the buildings should be designed minimize the heat gain during summer and prioritize heat gain enhancement during winter, through the use of building orientation, façade systems, and the selection of building materials appropriate to these conditions.



X axis: weeks
Y axis: solar radiation

Figure 3.4: Weekly Direct solar radiation, Kolkata

Image Source: Weather Tool, Autodesk Ecotect

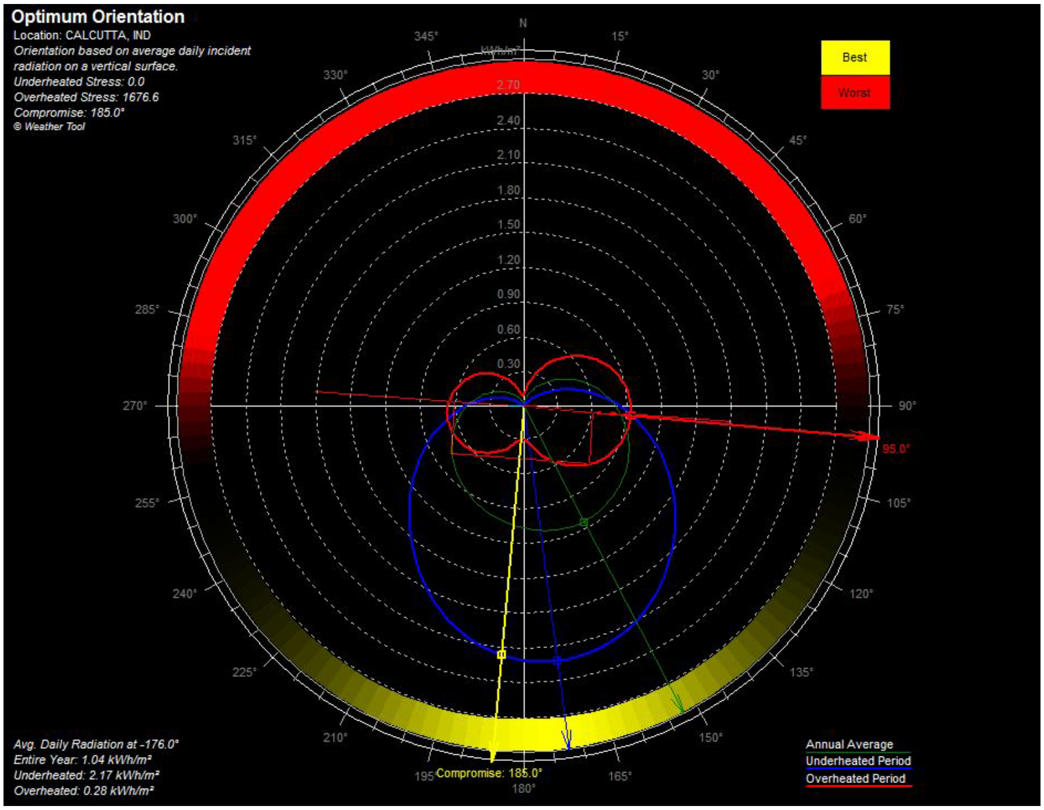


Figure 3.5: Optimum building orientation for Kolkata. Image Source: Weather Tool, Autodesk Ecotect

Daylighting: The use of natural light instead of artificial is a key factor to any sustainable building for minimizing energy consumption. In a country like India, one can expect much more sun light than most western countries and it is essential to exploit this opportunity as much as possible while minimizing the effects of sun glare and heat gain. This could be achieved by the careful selection of shading devices, limitation of floor width, and choice of appropriate materials. Daylighting therefore is one of the critical issues that should be emphasized in any sustainable design guidelines for India.

3.4.2. Water Management

Potable water is a scarce resource in many regions of the world, and it is a critical issue in India. The average rainfall is higher in most of the Indian climate zones than in USA. However, it is necessary to maintain the flow of this rainwater to ground in order to preserve the water table beneath, which is the primary supply of drinking water. A Green building should thus have a well planned storm and waste water management system with means to harvest water within the site. Second, re-use and land recycling of water is important for different activities and should be increased.

3.4.3. Material and Resources

Materials used in the buildings and their resources always remain one of the prime aspects of sustainable design, which combines all the other aspects together. For any climate zone the architect should prefer building materials that are truly ”local” in terms of proximity of their origin; to be more precise, the origin should be within the same climatic and geographic region of the building site. Brick masonry, clay tiles, bamboo, and adobe are the building materials indigenous to the Indo-Gangetic Plain. A major portion of this zone falls under the Warm-Humid climate zone. These materials, combined with concrete structure produce excellent thermal mass and protection from the weather. These materials are also sustainable in terms of availability, production cost, and lifecycle turnover. Hence, while designing in this context it is not wise to import stones and other materials from different part of country as primary building materials. Furthermore, the use of glass and similar materials should be balanced with locally available high insulation materials like brick. This choice again indicates the kind of method and technology that can be used for shading and ventilation systems.

The above discussion for buildings in the warm-humid climate zone in India could be summarized as follows:

1. Air circulation (cross ventilation) is more effective than temperature control to achieve comfort.
2. Minimization of solar heat gain in summer is more critical to comfort than winter heating.
3. Daylighting is preferred for indoor illumination with consideration for glare issues.
4. Water resources are scarce and their use should be controlled.
5. Choice of materials is crucial and depends upon local availability and processing.

3.5. Preferred Traditional passive Design Techniques

For warm-humid climate, several passive design techniques effectively control the indoor environment quality, solar gain, and daylighting. These time-honored techniques, developed through sometimes have various names and forms in India and abroad under similar climatic situations but works on same basic principles. Below are some of the very common examples of such techniques which work very effectively for this climate and can be combined with modern active techniques to achieve better control.

3.5.1. Techniques to Control Natural Ventilation and Air Quality

1. **Operable Louvers and Shutters:** Louvers are one of most effective passive methods to control natural ventilation in buildings. Typically the louvers are manually operable and are sometimes integrated with the window shutters. The advantage is thus one can

change the aperture of opening to control the amount of heat and air inside the building depending upon the weather condition. Traditional louvers are generally made with wood.

Figure 3.6 Operable louvers

Figure 3.7: Shutters with operable louvers

2. **Courtyard:** While elements like louvers are the elementary component of the ventilation system, courtyard planning can be considered as the technique to be applied in major scale. The courtyard, as an open space in the center of the building surrounded by occupied spaces enhances the airflow through the building while working as the outlet for the through air, eventually creating a “stack effect” (Fig. 3.8, 3.9 & 3.10).[4]

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[4] Das, Nibedita, 2006

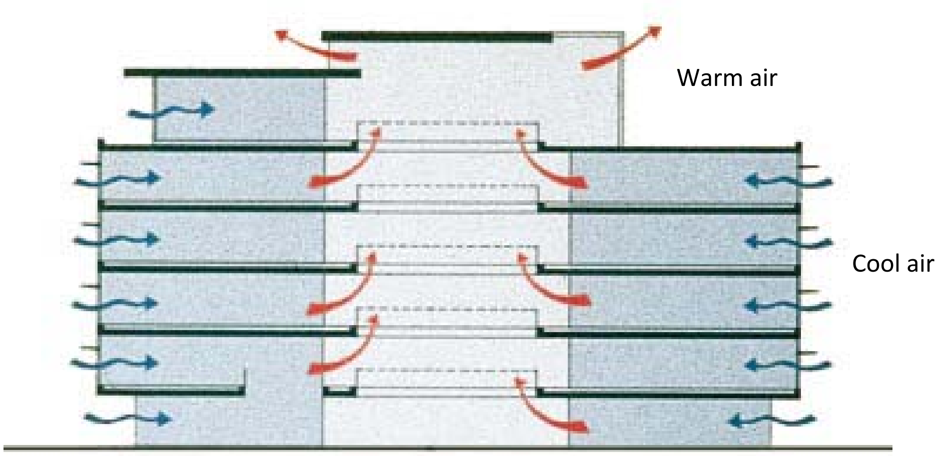

Figure 3.8: Stack effect through courtyard. Image Source: Carbon Trust Practice Guide 291

Figure 3.9 and 3.10: Traditional courtyard and louvered windows, Kolkata. Image Source: Nibedita Das

3.5.2. Techniques to Control Solar Gain and Daylighting

1. **Building skin as thermal mass:** Due to the extreme solar heat gain throughout most of the year in warm-humid India, it is important to create a thermal barrier between the building interior and exterior to minimize solar penetration. The building skin (or more precisely, the wall) thus has to provide ample thermal mass. Traditionally, this has been achieved by producing a thick wall with materials with high volumetric heat capacity like

brick or adobe. In more recent times, concrete also has been proved to be a good choice.

However, the entire façade cannot be covered in such a way, as one needs to have openings with glazing and materials with less thermal protection. To maintain some protection from the sun in these openings, shading devices must be used.

2. **Blinds/Louvers:** internal blinds are very effective in controlling the sunlight during the day. They can be rolled up and down and rotated to achieve various degrees of aperture. Louvers serve the same purpose, as they work on the same principle.

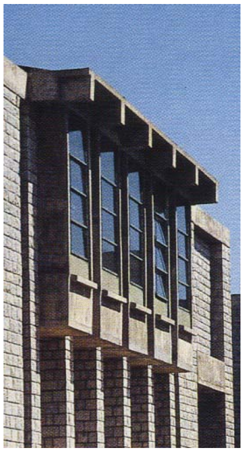

Figure 3.11: Light Shelves, Figure 3.12: Blinds, Figure 3.13: Projection

Image Source: www.wikimedia.org, B. V. Doshi

3. **Projection and Light Shelf:** Projections, also known as brise soleils, cornice or chhajja, are very common in Indian buildings and are generally placed over the window opening to cutoff the direct high angle sun. Sometimes they can act as light shelves also, depending on the design.

4. **Pergolas:** Pergolas are one of the very common features in Indian buildings. They provide semi-covered spaces and provide additional protection to the building façade,

Figure 3.13: Pergola: City Center; Kolkata, Charles Correa. Image Source: www.skyscrapercity.com

5. **Lattice Screen:** Lattice screen, commonly termed as *jali* in India, is a building feature traditionally developed to avoid direct solar rays and heat gain while still allowing air movement for natural ventilation.

Figure 3.14: Lattice screen: Tata Center, Kolkata. Source: www.skyscrapercity.com

3.6. Comparative Case Study of LEED-Certified and Other Green Buildings in India

The current credit structure of the LEED rating system and guidelines in India is not sufficient to emphasize the critical issues discussed above for sustainable building design. The LEED rating system has allowed buildings with unsuitable design elements to claim equal, and in some cases even more sustainable, credits over buildings reflecting context sensitive design solutions. A positive LEED rating thus, becomes a marketing tool for builders to sell poorly designed and inefficient buildings. The purpose of this case study is to inspect real world examples to understand the effect of LEED on design decisions made by comparing LEED-certified and non-LEED certified-buildings in the same context.

3.6.1. Buildings for Case Study

For research purposes, the following buildings have been selected for comparison:

1. **West Bengal Renewable Energy Development Agency (WBREDA), Kolkata, India,** Building type: office; year of completion, 2000; listed in TERI (Tata Energy Research Institute) list of energy efficient Indian buildings.

2. **Technopolis, Kolkata, India**, Building type, office; year of completion, 2006; LEED Rating: Gold. (LEED Core and Shell).

Both the buildings are in operation and share the same climatic, geographic and functional context. The first building is one of the good examples of the energy conservation drive throughout the country before the advent of LEED rating systems. The other one boasts the new growth of the IT sector in Kolkata. Though Technopolis was rated using the LEED core and Shell credit structure, the format remains the same with respect to the research framework, and thus can be considered good for comparison.

Figure 3.16: Technopolis, Kolkata, India

3.6.2. Criteria for Analysis

Designs of both the buildings are analyzed with the project checklist from LEED to compare the building operations based on the following aspects:

Indoor Air Quality and Ventilation: The design of the WBREDA building shows serious concern for natural ventilation throughout the year, responding to the warm and humid nature of Kolkata from March to October. Natural ventilation is the easiest and most economic way to maintain comfort level within the building. The orientation of the building allows the prevailing south-west breeze to flow through the building. The division of work zones also helps to minimize the requirement of mechanically ventilated spaces. To ensure continuous airflow, landscaping features, such as trees and water are scientifically used to enhance airflow speed and penetration. The chimney on the roof between the two types of ventilation zone completes the airflow pattern.

In contrast to the WBREDA building, the design for Technopolis relies mostly on mechanical systems for HVAC control. These controls enable the required amount of fresh air intake and other aspects following the LEED and ASHRAE standards to maintain the indoor air quality. Provision for natural ventilation is almost absent in the design. An online CO_2 monitoring system and fans for air exchange makes the system more efficient, but at a higher installation and running cost.

Figure 3.17: WEBREDA Building, Kolkata, India

As stated earlier, the climate in Kolkata is warm for the greater part of the year and almost comfortable for the rest of the year. Mechanical heating, therefore, is the least important factor to be concerned about while designing the HVAC system. For cooling, again, since the temperature is not very high, provision of natural ventilation and shade does half the job. Hence, the WBREDA building should achieve more points than Technopolis for this category as the latter does not show any effort to incorporate design elements to minimize the external solar gain during summer or to passively ventilate the building. The project boast follows the ASHRAE standards for indoor environmental quality which is the standard minimum requirement for any building today and a Green building is rated on the amount of betterment it achieves over that standard. It is relevant to note that even the most efficient and economic mechanical

HVAC system cannot match the energy savings of natural ventilation, as it will always require some energy to run itself.

The LEED rating, however, does not acknowledge the design and operation efficiency of the WBREDA building over the Technopolis building under the current credit structure. As previously discussed, there is no provision to earn more points for natural ventilation than mechanical ventilation for equally good indoor air quality and energy efficient indoor spaces. For both the cases, four points are available under the Indoor Air Quality section and ten points under the Energy and Atmosphere section. The only way to recognize the design features in the WBREDA building in terms of extra points is to provide credits under Innovative design/operations section which again can be given for other innovative design features in Technopolis.

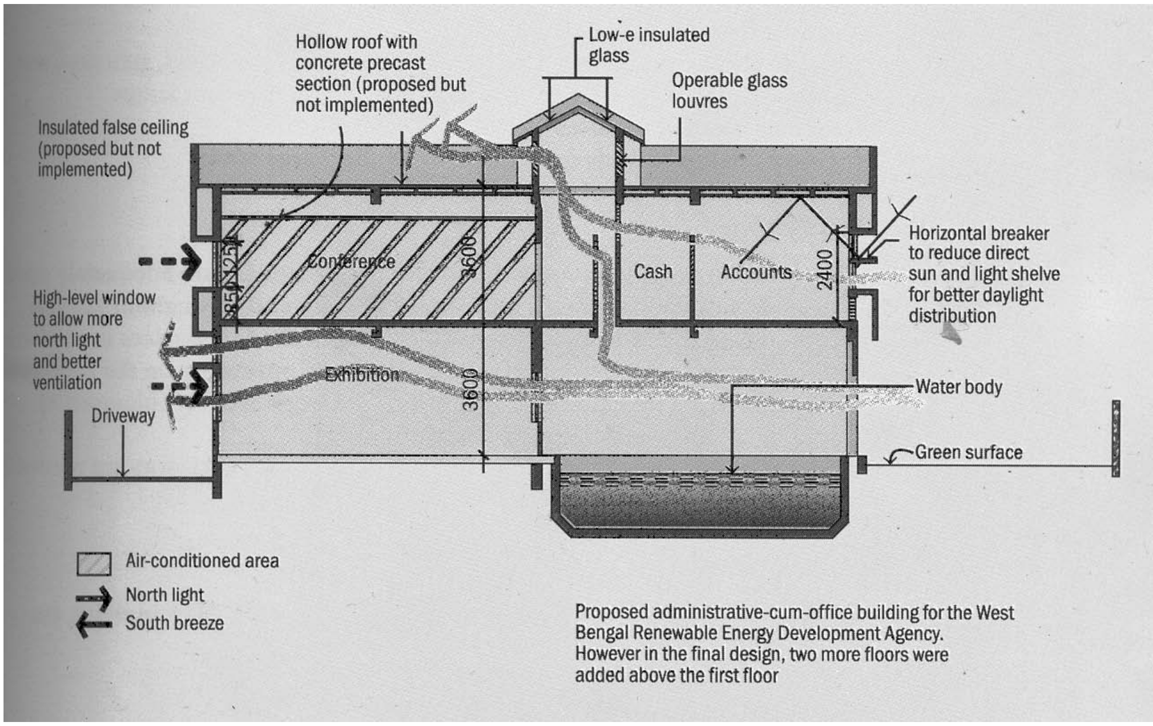

Figure 3.18: WEBREDA Building, Section for initial design scheme, two floors added later

Image Source: Majumdar, Mili, Energy Efficient Buildings in India, 2001

Solar Radiation and Daylighting: For a building in Kolkata where the solar angle is relatively high throughout the year, it is more important to control the amount of solar heat radiation and amount of daylight than to maximize solar exposure. The WBREDA building is oriented North-South to minimize solar heat gain on the east, west and south facades. Daylight is controlled through the placement of openings and solar shading devices, depending upon the directions. Features like light-shelves and a light well allow ample daylight, but control glare at the same time.

Figure 3.19and 3.20: Technopolis, facade detail showing extensive glazing. Image Source: Sridipa Chowdhury

Extensive use of glass and aluminum cladding on most of the facades of Technopolis, which is the current trend in almost every new corporate building in India, complicates the task of controlling solar heat gain and glare. Though the building incorporates glazing with a low U factor and solar heat gain coefficient, it seems to be a secondary solution to compensate for the wrong material selection. Artificial lighting is introduced to light the spaces, which results in higher energy consumption, even with energy efficient lighting systems and online monitoring and controls. However, the situation could be easily made better using louvers, light shelves, or blinds on either side of the glazing common practices in that region, without a significant increase in construction cost.

LEED guidelines stipulate achieving a minimum two percent of daylight factor. In the LEED rating system, one point is given for openings that permit daylight and one point for good views. An additional point is can be granted for exemplary performance, but this point is not required to achieve a rating. Only two to three points out of 69 total possible points for such a major aspect of sustainability in a warm-humid climate zone illustrates the bias against properly rating buildings with better daylighting operations.

The following table summarizes the comparison aspects and the observations for this study with respect to the preferred techniques and their interpretation in LEED credits.

	Ventilation System	Solar Shading	Daylighting
Preferred Approach	Building orientation and openings should respect wind direction, natural cross ventilation with flexibility to alter mode of ventilation	Extensive shading over openings, variation of window aparture based on solar path	Narrow floor plan, daylighting elements either on façade or in terms of skylight or atrium, control over glare
WEBREDA	Combination of natural and mechanical ventilation based on functional zoning, reducing energy demand	Horizontal projections over window openings to reduce direct sun rays, Low-E glazing in skylight, building orientation to reduce heat gain	Projections over window work as lightshelves for daylighting, bigger windows on northern façade
TECHNOPOLIS	Entirely mechanically ventilated, CO_2 monitoring system, fans for complete air exchange	Glass façade with glazing with low U factor and solar heat gain coefficient, minimal shading	Any daylighting element is not installed, artifitial lighting is required during the day, no glare control available
LEED Credits	Indoor Environmental Quality: Credit 1,2,6 and Energy & Atmosphere: Prerequisite 2, Credit 1	Energy & Atmosphere: Prerequisite 2, Credit 1, Credit 2	Energy & Atmosphere: Prerequisite 2, Credit 1, Credit 2 and Indoor Environmental Quality: Credit 8
Observations	LEED does not provide additional credit for employing passive ventilation systems	Points are scored based performance over ASHRAE standards, which does not state prefernce for passive elements	LEED provides 1 point for Daylighting, and is not necessary for certification. The relation to other credits are not clearly mentioned

Table 3.1: Summery of comparison between WEBREDA and Technopolis

From the above discussion it can be concluded that the present structure of the LEED rating system does not respect the traditional and vernacular aspects of sustainable design in India which have been used to respond the contextual issues effectively, and the new LEED certified buildings cannot be always considered as the most appropriate design solutions for their context. Hence, the primary purpose of the sustainable rating systems is not met. Hence, it is a good idea to look into the structure and development of the LEED rating system itself.

Chapter 4

TOWARD A LEED RATING SYSTEM FOR INDIA

The intent of this chapter is to take a deeper look into the LEED rating system in terms of its origin, development and structure in detail. This discussion also provides a general critical analysis for the entire system with identification of potential loopholes that could have triggered the issues with the Indian version. Finally the LEED India rating system is discussed regarding all the amendments made and relations to other Indian design guidelines in an effort to make the system more applicable. The assessment of the present modifications lays the foundation and provides justification for the discussion on major condoned issues in the next chapter.

4.1. Background

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary, consensus-based standard for developing high performance, sustainable buildings[1]. The main concept of LEED has been developed over 7 years of effort by professionals from different fields related to the building industry. Starting with USA, the format has become more popular abroad in recent years in several other countries.

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[1] US Green Building Council, 2009

4.1.1. Purpose

According to the US Green Building Council (USGBC), LEED has a number of purposes to fulfill. The first of them is to define ‘Green Building’ by establishing a common standard of measurement. LEED promotes integrated whole building design approach which can sometimes be the only way to interpret and successfully imply credits under its current structure in a project. Some of the most important purposes that LEED was intended to comply with were creating public awareness for sustainable design and eventually transforming the building market towards more sustainable solutions. Although, with the reference from the earlier case studies, it can be argued that in India, and possibly in other countries including USA also, the idea is getting misinterpreted as marketing tools. To be precise, instead of opting for appropriate sustainable solutions, LEED rating is often looked as the ultimate goal to sell projects better instead of being a good measure for sustainability.

4.1.2. Structure and Certification

The USGBC has defined a number of variants of the credit systems to address individual aspects of different kinds of buildings and construction which include LEED for New Construction, Core and Shell, Homes, Commercial Interiors, Retail, Schools, healthcare, existing Buildings and Neighborhood development. All these variants, however, are based on the main credit system with modification in credit points or prerequisites. The Indian Green Building Council (IGBC) currently has two LEED systems applicable: LEED for New Construction (NC) and Core and Shell. Since, LEED NC is applicable mostly to new commercial projects and large scale residential projects (four story and above), the focus of this research is on this particular system.

The main structure of LEED rating system, which is the same for LEED NC, is divided into six categories as listed below:

1. Sustainable Sites
2. Water Efficiency
3. Energy and Atmosphere
4. Materials and Resources
5. Indoor Environmental Quality
6. Innovation and Design Process

Under these categories credits are listed which are assigned with points that can be achieved by fulfilling the requirements of respective credits in a project. The total number of points achieved, irrespective of category, is thus counted as the final measure of degree of sustainability for projects. Depending on the count different, levels of certification are provided as follows:

- Platinum: 52 – 69 points
- Gold: 39 – 51 points
- Silver: 33 – 38 points
- Certified: 26 – 32 points

The number of points available is determined by the degree of fulfillment of the requirements. For some of the credits, additional points can be achieved by either going beyond the mandatory requirements or adding completely new design solution or technology which is counted under the Innovation and Design category. While most of the categories have prerequisites which are mandatory measures to be eligible under those categories, numbers of individual points to be achieved are decided by the designer, contractor and owner, depending on the target level of certification. Since there is no such stringent restriction on which credits are to be achieved and to what degree, it is possible to have a tendency to go for credits which are relatively easier to accomplish than others. Considering the commercial mentality of a large section of the building industry, where the final profit dictates the design alternatives, other crucial credits might be avoided.

Documentation for each of the credits has to be submitted to the USGBC (IGBC for the Indian version) for evaluation which is a two stage process. A number of credits can be submitted during the design stage which upon submission can be evaluated as either anticipated or denied while the rest can be submitted later during construction. The design phase evaluation is conducive to the design team to make or modify design decisions to achieve particular credits.

From the designers’ point of view the complexity of the credit structure, the scoring system, and their relation to numerous other design standards makes the guideline unsuitable as reference. Unless active help from an expert such as a LEED AP or an engineer is available, it is sometimes almost impossible for designers to take all the responsibility to satisfy all the requirements and indulge in better design techniques.

4.2. LEED as International Green Building Rating System

Starting with different states within USA, USGBC and LEED has expanded as a global Green Building rating system around the worlds. With more than 100 countries having projects registered for LEED certification, LEED has gained international recognition and is considered one of the most widely accepted rating systems while compared to other rating systems such as BREEAM (Buildings Research Establishment's Environmental Assessment Method) in UK, GreenStar in Australia, DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) in Germany, or CASBEE (Comprehensive Assessment System for Built Environment Efficiency) in Japan.

In 2002, the World Green Building Council (WorldGBC[2]) was formed with the USGBC as one of the founder members, toward a mission to accelerate the transformation of the built environment towards sustainability. With more than 15 established green building councils around the world today, WorldGBC can be considered as the largest forum and leader in green building design and development. LEED rating system is one of the major accepted rating systems accepted by WorldGBC and its member GBCs in different continents which includes India.

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[2] World Green Building Council, 2009

4.3. LEED INDIA NC Rating System

As mentioned earlier, this research is focused on the LEED NC (for new construction) version 1.0 INDIA rating system which is majorly adopted from the LEED NC version 2.2 USA. This version was launched in India in January 2007 and is currently applicable to all new commercial and large scale residential projects.

4.3.1. Credit Amendments

With the objective towards making the LEED rating system to be more applicable to the Indian context, IGBC had proposed a number of amendments in terms of credits and points allocated. The summery of these proposals coming from professionals within the Indian building industry were published in the IGBC web site. The final published version has incorporated some of those proposals while a few were included with modification or not included at all.

It is surprising to note that under the 'Energy and Atmosphere' and 'Indoor Environmental quality' category very few amendments are found which do not at all address the aspects discussed as key factors for sustainable design to the Indian context. While one can easily notice the well thought amendments in other categories, it raises more questions as to what is the reason behind this anomaly. The following table summarizes the proposed modifications in LEED India NC version 1.0 and the final amendments incorporated.

Certain amendments reflect the practical aspects of sustainable design in India. Removal of points for bicycle storage and changing room is one of these decisions which respond to the common practice of using mass transit systems instead of cycles and different workplace culture in India. Potable water resources are scarce in various parts of India, thus it makes a lot of sense to add reduction of use of potable water as a prerequisite. Proposal for two wheeler parking provision directly reflects to the Indian scenario where more people own two wheelers instead of cars. This is though still not incorporated in the final version. Similarly, under Sustainable Site category, the credit for Development Density and Community Activity was proposed to be removed as it was a direct contradiction to the national initiative for urbanization beyond the overly populated cities. The reason behind retaining it can be speculated as a consideration toward long term goals for sustainable development. Similar reasons can be cited for the credit for Green Power under Energy and Atmosphere category, with an expectation of future Green Power supply grid in India. Carpets are not a common feature for Indian buildings and thus the respective credit remained inapplicable. The LEED US version 3.0 however has modified the credit from carpets to flooring system.

4.3.2. Relation to Indian Guidelines

While the LEED India version follows the international codes like ASHRAE standards such as 90.1.2004, 55.2004, 62.1.2004 etc., it respects a few existing Indian guidelines also, in an effort to merge with the contextual aspects of design. These guidelines include the National Building Codes (mostly regarding ventilation and indoor air quality standards) and the Energy Conservation Building Code (ECBC) 2006 for energy related standards. It is thus essential to look into those standards also under the current research scenario and asses their impact on design while referred by LEED.

Overall, the LEED India version does not show any major modifications to address the Indian building context, and leaves a number of issues open for debate that are discussed in the next chapter.

Chapter 5

LEED INDIA FOR NEW CONSTRUCTION:

FINDINGS AND MODIFICATIONS

The problems with LEED India NC version 1.0 have more than one facet. While some of the major issues lie within the credit structure itself, which fails to recognize the priority of one aspect over another through its point system, the complex distribution of points for a single design aspect over different categories makes it less comprehensive as a design guide. Comparisons with other Green design guidelines establish the problems even more clearly.

5.1. Condoned Aspects of Design

With respect to the credit and point system of the current version of LEED India NC, it is evident that these amendments to the US LEED system are not sufficient to promote the design criteria that must be prioritized for Green design in the Indian context. Aspects of these criteria are distributed over several categories and credits.

5.1.1. Air Quality and Temperature

The current versions of LEED India guidelines refer to other national and international standards to define the air ventilation criteria. For mechanically ventilated spaces, the standard is ASHRAE Standard 62.1-2004. However, for naturally ventilated spaces in non-domestic buildings, one has to refer the Carbon Trust "Good Practice

Guide 237" (1998) and the flow diagram available in the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 10: 2005, Natural ventilation in non-domestic buildings (Fig. 5.1).

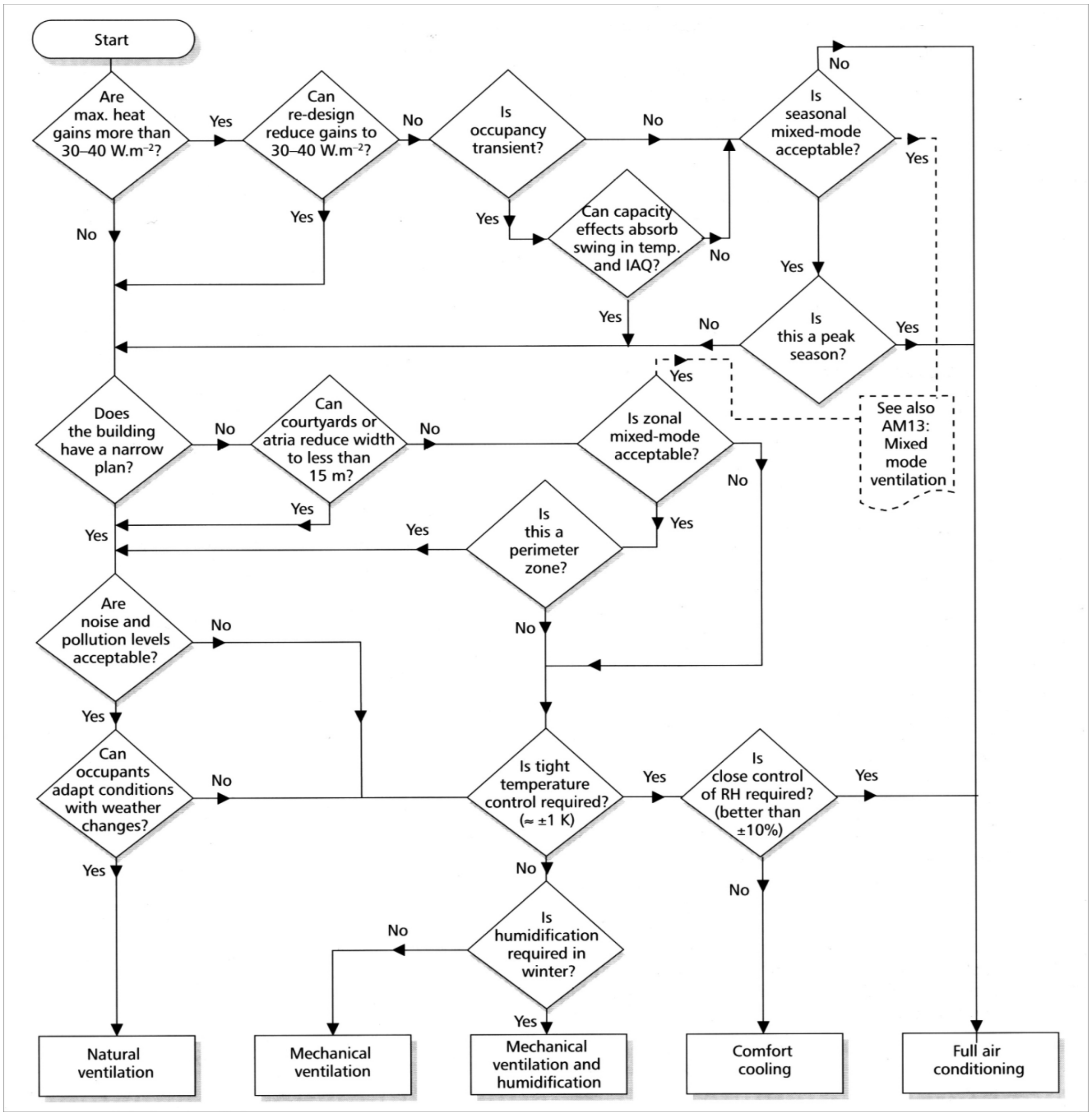

Figure 5.1: Selecting a strategy. Image Source: CIBSE Applications Manual 10:2005, Natural ventilation in non-domestic buildings

In the Energy and Atmosphere section, reference is made to Energy Conservation Building Code (ECBC) 2006, which was present before the advent of LEED in India. This guideline again refers to the National Building Code of India 2005 for natural ventilation requirements. Hence, the issues are as follows:

It is very difficult to consult all the other standards while designing and following LEED guidelines for different requirements. For example, the Carbon Trust flow diagram for ventilation provides ample information on how to decide on the mode of ventilation for a particular project. Yet it is highly likely for the design team to overlook the process without a thorough understanding of details of the credit system. Also, without very good interaction between the architect and the engineer from the very beginning of the design stage, it is practically impossible to incorporate a natural or mixed mode ventilation system in an effective manner.

LEED guidelines provide equal credit points for both mechanically and naturally ventilated spaces and fail to recognize that in the Indian context, it is wiser to prioritize natural ventilation systems, which respect the local climate and economy, over mechanical ones. Builders, who are not the most environmentally conscious people in India, dominate the architectural industry. Hence, with the current rating system, they have every reason to opt for mechanical ventilation over natural ventilation because it is a relatively easier route to earning the same number of LEED credits.

The only modifications made in this section are on the use of low-energy emitting materials that respond to the material aspects. Hence, it can be said LEED does not show concern on how the air quality is maintained within a building and if that responds to the climatic conditions.

5.1.2. Solar Radiation

Heat Gain: In the Energy and Atmosphere section of the LEEDS guidelines, HVAC is perceived as a single system which does not prioritize cooling over heating for a warm climate—where solar heat gain provides most of the heating in winter and needs to be minimized in summer. The guidelines follow the ASHRAE standard and raise many questions. Although there are credit points for using solar radiation as a renewable energy resource, the number of credits (1-3) does not seen to be encouraging enough to pursue the additional design measures.

Daylighting: The entire idea of daylighting is split under different credit points within the Indoor Environmental Quality section as follows:

A. Controllability of systems: 1-2 points: This section gives some idea of how potential design strategies, such as operable windows, which could address the daylighting requirements. However, the word daylighting is not mentioned here even this works as a “synergy” if manual control is available to the windows shutters or louvers, for example, which are definitely part of the daylighting strategy.

B. Daylight and Views: 1-2 points: Here the term is formally defined, and gives a sufficiently clear idea of the requirements. One can find design strategies to enhance daylighting suggested here and earn an additional point through the Innovation and Design category, which is commendable. These facts notwithstanding, it is clear that this critical aspect of sustainable design pertaining to the climatic factors has not been given enough importance within the rating system, as it is assigned only a few credits compared to the other aspects. Hence, the desirability of daylighting over artificial lighting during the daylight hours is not well established.

5.1.3. Choice of Materials

The Material and Resources section is quite elaborate and addresses local factors by providing credits for the use of regional materials and rapidly renewable materials. LEED defines the intent for the credit under Regional Materials as to "increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation."[1] However, setting the radius of 800 Kilometers[2] as the limit for finding local materials does not make good sense in India, where the climate and topography can change drastically within this distance; making the whole objective useless. This raises the question as to which aspect of the use of local material should be most emphasized: the cost of transportation, local availability, or extraction/production. It can definitely be argued that in the Indian context, these factors vary in importance depending on local geographical and climatic contexts.

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[1] LEED for New Construction Version 2.2, Reference Guide, 2008

[2] LEED India NC Version 1.0, 2008

5.2. Comparison with TERI GRIHA Guideline

GRIHA (Green Rating for Integrated Habitat Assessment) is the new national Green building rating system for India developed by the Tata Energy Research Institute (TERI) launched in 2008. The intent for this rating system was to incorporate the contextual factors unique to India which might be not well addressed by other international rating systems.[3] With this intent and similar applicability in terms of projects, GRIHA can be directly compared with the LEED India NC rating system.

5.2.1. Focus for Comparison

The primary objective for this comparison is to assess how the credit structure of the GRIHA rating system differs from that of the LEED India NC and if that addresses the design aspects that are inadequately addressed in the LEED system. It is also important to make a comparative assessment of the two systems as Green design guidelines in terms of the simplicity and clarity of their design goals as these relate to sustainability.

5.2.2. Comparison of Credits

The GRIHA credit structure is fairly simple and straightforward in comparison to LEED. The rating system has 34 criteria (similar to LEED credits) divided broadly under three phases: Site Selection, Building Planning and Construction, and Building Operations and Maintenance. Building Operations and Maintenance is subdivided under categories such as Energy, Waste Management, etc. Each criterion carries one point, with one star for each of the five levels towards the certification. The maximum of 5

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[3] www.grihaindia.org, 2009

stars corresponds to 91 to 100 points in the LEED rating system. An additional 4 points are available under criterion 34: Innovation.

Some of these criteria are mandatory for a certification, which is similar to the prerequisite system for LEED (Table 5.1). Some of these mandatory criteria require a context-specific approach that considers the climatic and other local factors. Criterion 13, in particular, is a mandatory criterion which talks about optimized building planning to reduce conventional energy use for mechanical air conditioning and illumination. The explanation for this criterion goes one step further by suggesting design directions like arranging service areas, toilets, and staircases as naturally ventilated buffer areas around core functional zones to reduce mechanical conditioning loads. Solar analysis using energy models for shading and daylighting are also suggested. The 12 points allocated clearly signifies the importance of this criterion in the scoring system. Criterion 14 provides quantitative values for ventilation modes under different climate zones and the mandatory building codes, working as the required supplement for the previous criterion. Again the six points allocated here ensures a massive reduction in energy consumption which will be hard to achieve with artificial HVAC as the only choice. The partially mandatory Criterion 18 endorses use of renewable energy which can be effectively achieved with passive techniques. This can be considered as a good example of how a Green rating system can become more than a compilation of required points but a suggestive design guideline to enhance context specific design process with clarified design objectives. LEED, despite having explanatory texts for the credits and suggested design techniques, has failed to prioritize the importance of minimizing mechanical ventilation for reducing energy loads.

TERI GRIHA ascribes importance to the building operations and maintenance as well as the initial design. This is commendable as it allows the design team to compare the effect of the system as designed and as performed, and is thus conducive to better design decisions in the future.

From the above discussion it becomes evident that when the choice between passive and active techniques becomes a question for the architect, TERI GRIHA exhibits a clear inclination toward considering the passive as the first choice for the design decision. LEED India, however, with all the explanatory suggestions describing advantages of passive methods fails to emphasize the same in its credit structure. For India, this small factor looms large at the time for decision making which is largely driven by the profit oriented market. Hence, it is a major issue that LEED has to address immediately to prevent misinterpretation of Green design principles.

List of criteria	Points	Remarks
Criteria 1: Site Selection	1	Partly mandatory
Criteria 2: Preserve and protect landscape during construction /compensatory depository forestation.	5	Partly mandatory
Criteria 3: Soil conservation (post construction)	4	
Criteria 4: Design to include existing site features	2	Mandatory
Criteria 5: Reduce hard paving on site	2	Partly mandatory
Criteria 6: Enhance outdoor lighting system efficiency	3	
Criteria 7: Plan utilities efficiently and optimize on site circulation efficiency	3	
Criteria 8: Provide, at least, minimum level of sanitation/safety facilities for construction workers	2	Mandatory
Criteria 9: Reduce air pollution during construction	2	Mandatory
Criteria 10: Reduce landscape water requirement	3	
Criteria 11: Reduce building water use	2	
Criteria 12: Efficient water use during construction	1	
Criteria 13: Optimize building design to reduce conventional energy demand	6	**Mandatory**
Criteria 14: Optimize energy performance of building within specified comfort	12	
Criteria 15: Utilization of fly ash in building structure	6	
Criteria 16: Reduce volume, weight and time of construction by adopting efficient technology (e.g. pre-cast systems, ready-mix concrete, etc.)	4	
Criteria 17: Use low-energy material in interiors	4	
Criteria 18: Renewable energy utilization	5	Partly mandatory
Criteria 19: Renewable energy based hot-water system	3	
Criteria 20: Waste water treatment	2	
Criteria 21: Water recycle and reuse (including rainwater)	5	
Criteria 22: Reduction in waste during construction	2	
Criteria 23: Efficient waste segregation	2	
Criteria 24: Storage and disposal of waste	2	
Criteria 25: Resource recovery from waste	2	
Criteria 26: Use of low - VOC paints/ adhesives/ sealants.	4	
Criteria 27: Minimize ozone depleting substances	3	Mandatory
Criteria 28: Ensure water quality	2	Mandatory
Criteria 29: Acceptable outdoor and indoor noise levels	2	
Criteria 30: Tobacco and smoke control	1	
Criteria 31: Universal Accessibility	1	
Criteria 32: Energy audit and validation		Mandatory
Criteria 33: Operations and maintenance protocol for electrical and mechanical equipment	2	Mandatory
Total score	100	
Criteria 34: Innovation (Beyond 100)	4	
Total score	**104**	

Table 5.1: Evaluation procedure of criterion of GRIHA. Source: www.grihaindia.org

5.3. Comparison with LEED 2009

The preceding discussion of the LEED guidelines has been based on LEED Version 2.2, which is the basis of the current LEED India guidelines. On April 27, 2009, USGBC released a new version of the rating system as LEED Version 3.0, or 2009. This version includes a number of major and minor modifications in terms of credit structure, point allocation, and regional issues. The new LEED rating system has 100 base scores with 6 possible Innovation and Design and 4 Regional Priority credits. This version is clearly an attempt to make LEED more context-specific, providing more attention to regional factors. The effects of the changes in Version 3.0 on the current research are discussed below.

5.3.1. Credit Weighting System

The credit structure and the point distribution system of LEED have gone through significant alteration in LEED Version 3.0. Before LEED Version 3.0, the point distribution system for the credits in the rating system did not have a consistent and logical background. For example, the few points allotted to credits like daylighting and natural ventilation options did not encourage the design process to use these options in the Indian context, where they are major factors in sustainability. The new version makes a serious attempt to rectify the problem with the new credit weighting system. The term “weightings” refers to the process of redistributing the available points in LEED so that a given credit’s point value more accurately reflects its potential to either mitigate the negative or promote the positive environmental impacts of a building. With this new method, there is a greater degree of variation in points available for credits, depending on their importance to achieve the major goals of sustainability. For example, the Development Density and Community Connectivity Credit under Sustainable Sites category is worth 5 points, rather than 1, in Version 3.0. In the Energy and Atmosphere category, the maximum points available for optimizing energy performance have been increased from 10 to 19. This validates the importance of reducing the energy demand for HVAC systems. Surprisingly, it is still hard to find any recommendation for a mixed-mode ventilation system which combines natural and mechanical ventilation systems to maximize efficiency while minimizing the use of conventional fuel. There is no change in the point distribution for credits in the Indoor Environmental Quality category, either, ignoring the importance of thermal comfort and daylighting again (Table 5.2).

LEED Credit & Point system Comparison		point removed	credit added	point/value changed
	Credits	**Points**		
		LEED NC v 2.2 USA	**LEED NC v 1.0 INDIA**	**LEED NC v3.0 USA**
		Total 69	**Total 69**	**Total 100**
Sustainable Sites	Construction Activity Pollution Prevention	Prerequisite	Prerequisite	Prerequisite
	Site Selection	1	1	1
	Development Density & Community Connectivity	1 **ID 1**	1 **ID 1**	5
	Brownfield Redevelopment	1	1	1
	Alternative Transportation: Public Transportation Access	1 **ID 1**	1 **ID 1**	6
	Alternative Transportation: Bicycle Storage & Changing Rooms	1 **ID 1**	0 removed	1
	Alternative Transportation: Low Emitting & Fuel Efficient Vehicles	1 **ID 1**	1 **ID 1**	3
	Alternative Transportation: Parking Capacity	1 **ID 1**	1 **ID 1**	2
	Site Development: Protect or Restore Habitat	1	1	1
	Site Development: Maximize Open Space	1	1	1
	Storm water Design: Quantity Control	1	1	1
	Storm water Design: Quality Control	1	1	1
	Heat Island Effect: Non-Roof	1	1	1
	Heat Island Effect: Roof	1 **ID 1**	1 **ID 1**	1
	Light Pollution Reduction	1	1	1
Water Efficiency	**Water Use Reduction 20%**			Prerequisite added
	Water Efficient Landscaping: Reduction	1 for 50%	1 for 50%	2
	Water Efficient Landscaping: No Potable Water Use or No Irrigation	1 for 100%	1 for 100%	2
	Innovative Wastewater Technologies	1 **ID 1**	1 **ID 1**	2
	Water Use Reduction: Reduction	1 for 20%	1 for 20%	2
	Water Use Reduction: Reduction	1 for 30% **ID 40%**	1 for 30%	2
Energy & Atmosphere	Minimum Energy Performance	Prerequisite	Prerequisite	Prerequisite
	Fundamental Refrigerant Management	Prerequisite	Prerequisite	Prerequisite
	Fundamental Refrigerant Management	Prerequisite	Prerequisite	Prerequisite
	Optimize Energy Performance	1 to 10 **ID 1**	2 to 10 **ID 1**	1 to 19
	On-Site Renewable Energy	1 to 3 2.5-7.5% **ID 17.5%**	1 to 3 2.5-7.5% **ID 17.5%**	3 to 7
	Enhanced Commissioning	1	1	2
	Enhanced Refrigerant Management	1	1	2
	Measurement & Verification	1	1	3
	Green Power	1 **ID 1**	1 **ID 1**	2
Materials & Resources	Storage & Collection of Recyclables	Prerequisite	Prerequisite	Prerequisite
	Building Reuse: Maintain of Existing Walls, Floors & Roof	1 for 75%	1 for 75%	1 to 3 for 55%, 75%, 95%
	Building Reuse - Maintain of Existing Walls, Floors & Roof	1 for 95%	1 for 95%	
	Building Reuse: Maintain of Interior Non-Structural Elements	1 for 50%	1 for 50%	1
	Construction Waste Management: Divert From Disposal	1 for 50%	1 for 100%+50% internal	1
	Construction Waste Management: Divert From Disposal	1 for 75%	1 for 75%	1
	Materials Reuse:	1 for 5%	1 for 5%	1
	Materials Reuse:	1 for 10% **ID 15%**	1 for 10% **ID 15%**	1
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 10%	1 for 5%	1
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 20% **ID 30%**	1 for 10%	1
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 10%	1 for 20% manufacture	1
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 20% **ID 40%**	1 for 50% extract	1
	Rapidly Renewable Materials	1 for 2.5% **ID 5%**	1 for 6.5%	1
	Certified Wood	1for 50% **ID 95%**	1for 50% **ID 95%**	1
Indoor Environmental Quality	Minimum IAQ Performance	Prerequisite	Prerequisite	Prerequisite
	Environmental Tobacco Smoke (ETS) Control	Prerequisite	Prerequisite	Prerequisite
	Outdoor Air Delivery Monitoring	1	1	1
	Increased Ventilation	1	1	1
	Construction IAQ Management Plan: During Construction	1	1	1
	Construction IAQ Management Plan: Before Occupancy	1	1	1
	Low-Emitting Materials: Adhesives & Sealants	1	1	1
	Low-Emitting Materials: Paints & Coatings	1	1	1
	Low-Emitting Materials: Carpet Systems	1	1	1
	Low-Emitting Materials: Composite Wood & Agrifiber Products	1	1	1
	Indoor Chemical & Pollutant Source Control	1	1	1
	Controllability of Systems: Lighting	1	1	1
	Controllability of Systems: Thermal Comfort	1	1	1
	Thermal Comfort: Design	1	1	1
	Thermal Comfort: Verification	1	1	1
	Daylight & Views: Daylight	1 for 75% **ID 95%**	1 for 75% **ID 95%**	1
	Daylight & Views: Views	1 for 90% **ID 1**	1 for 90% **ID 1**	1
Innovation & Des. Pr.	Innovation in Design	1	1	1to 5, ID (1 to 5) and Exemplary (1 to 3)
	Innovation in Design	1	1	
	Innovation in Design	1	1	
	Innovation in Design	1	1	
	LEED Accredited Professional	1	1	1
Regional Priority	Regional Priority			1 to 4 added

Table 5.2: Modifications in LEED INDIA NC V 1.0 and LEED USA NC V 3.0 in comparison to LEED USA NC V 2.2

5.3.2. Regional Credits

With Version 3.0, LEED has taken a significant step toward acknowledging regional factors in sustainable design with the introduction of Regional credits. These credits address specific design criteria for different defined regions within the USA. These points will be available as Innovation and Design credits, acknowledging additional design accomplishments based on regional priority. This opens up the door for new possibilities for LEED as a better guideline acknowledging contextual factors.

In summary, with respect to the current research question, LEED Version 3.0 acknowledges certain serious concerns for sustainable design and incorporates major modifications to address those issues through credit alteration and weightings. On the other hand, it still avoids the issue of recognizing a context-specific passive design approach.

5.4. Findings and Suggestions

Based on the literature review and the critical analysis presented here, certain specific facts can be short-listed as a summary of these research findings revolving around the research questions. These findings help us to understand the root of the problems analyzed and establish facts which provide the foundations for the suggestions made for LEED as an international Green design guideline and rating system considering the Indian version as an example.

5.4.1. Findings

Following are the issues found with LEED as a Green building rating system and design guideline. It is obvious that some of these findings are specific to the design context for India and thus the LEED India version of the rating system. However, these issues indicate that the conditions that LEED must address before it can be truly considered an international benchmark for sustainable design.

1. **External References Raising Complexity:** Though considered as a new and separate platform for rating Green buildings and certifying sustainable design process, LEED relies heavily on pre-established design standards and guidelines in terms of definitions and required design parameters. Some of these standards, such as ASHRAE standards, are internationally accepted, and some are more regional and local standards. The LEED credit system often requires that several external guidelines be consulted for a single design decision. From the designer's point of view, it can be very difficult to keep track of these references, which sometimes refer to each other. For example, the ECBC and National Building Code referred in LEED India for ventilation and energy calculations refer to ASHRAE guidelines. The choice of ventilation system refers the designer to the CIBSE manual for ventilation, but in such a way that it is easy to miss the referral. The difficulty of working with multiple guidelines can discourage the design team from for the task of creating passive context-friendly design, and encourage the use of readymade solutions that earn the same credits toward certification.
2. **Disparity in Credit Weightings:** LEED as a evaluation system for Green buildings can be considered fairly flexible in terms of accomplishment of major sustainable goals for

the designers and contractors, compared to the stringent character of other similar Green building rating systems like BREAM or Energy Star. As previously discussed, until the release of the Version 3.0 in 2009, the point distribution for individual credits was not weighted logically, resulting in unfair weightings between major and minor credits. The downside for this weighting disparity is that the building industry, which is heavily influenced by the client's desire for immediate profit rather than long-term goals, is encouraged to bypass some of the crucial credits and replace with minor ones relatively easier to achieve and still manage to bag a good certification. With this, the certification loses its impact on sustainable design and becomes a mere marketing tool for builders. It can be understood that the primary goal for LEED was to get the building industry involved in sustainable design practice in the early stage, which is probably the foremost reason to allow building projects achieve the easier goals with good scores as encouragement. Following its successful start within USA, when LEED claims to be one of the best international benchmark for sustainable design, it is strongly recommended that the credits be weighted differently for different geographic areas in order to ensure the primary objectives. The newer version tends in the right direction with this, but it needs to push the envelope further in every category.

3. **Lack of Clarity for interrelated credits:** From the point of view of designers, it is sometimes difficult to understand how a particular design decision affects the credits placed under different categories. For example, using a particular building envelope for allowing more daylight can help one to get more points in the daylight section, but at the same time, the heat gain increase can make it more difficult to get credits under the

Energy and Atmosphere category. On the other hand, a particular choice of technique can be beneficial for a context (for example, louvers in warm-humid climate, see chapter 3, page 48) which can make a building achieve different credits simultaneously. This complex connection between the credits is termed “synergy” when the credits are complementary to each other and “tradeoff” when they contradict each other. It is essential for the design team to have a thorough knowledge of this factor as it can severely affect a design decision which looks good initially but has adverse effects on other aspects of the design. Considering the complexity of the design process, it becomes impractical to cultivate various design options with this respect. However, the credit structure and the explanations available in the reference guide demands extensive research on this aspect to effectively choose the right technique and applicable credits to that choice. LEED also provides Innovation and Design credits which sometimes work as extension of existing credits. These credits could be provided using newer technology or design innovation with even better performance and environment. Again, since these credits are optional and require additional effort to effectively employ with proper understanding and documentation, they often remained untouched.

4. **Neutral Attitude for Passive Design Techniques:** The importance of passive design techniques for sustainable design in today’s world of depleting energy resources is undoubtedly confirmed. It is very simple to understand that even the most advanced mechanical building component cannot match passive techniques in terms of energy savings as the mechanical system will always require some energy to operate compared

to passive techniques which run without active energy generation. It is true that in adverse conditions, passive techniques cannot provide as good results as mechanical ones. However, adopting a better design principle which employs passive techniques in integration to mechanical systems can reduce the energy demand significantly. The present format of LEED does not actively support the inclusion of passive techniques and its advantage over systems entirely managed with constant energy consumption. Also, integrating passive techniques in a project is always more cumbersome than a readymade mechanically controlled, overdesigned system. Since LEED hardly provides any extra credits for the added effort, inappropriate and less efficient solutions are often embraced as the convenient option.

5. **Pre-assumption for Integrated Design Process:** With respect to the above findings and the understanding of the vision for LEED in future, it is evident that to encompass the design goals for sustainability while referring to LEED as the guideline, the design process has to be integrated from the very beginning. The idea of LEED Accredited Professional (LEED AP) supports this idea in which one person in the design team specializes in the LEED rating system and works as a coordinator between architects, engineers, and contractors throughout the process. Though this idea of the design process is probably the future of sustainable design, the present reality of most of the design industry, especially in countries like India, creates conflicts. First, Integrated Design Process is still a developing idea for most of the design firms, and the conventional method, which prohibits close interaction between architects, engineers and contractors at all stages of design, is still the standard. Again, appointing a LEED

Accredited Professional is not a necessary credit to achieve LEED certification today which makes the situation even worse.

5.4.2. Suggestions for LEED India Credit System

Based on the findings mentioned above, certain amendments and additions can be suggested in order to improve the proposed new version for a LEED India (for New construction) rating system. These modifications will also relate to the entire LEED system in terms of credit weightings revisions and interpretations. These proposals are limited within the credit structure. The primary modifications are proposed in the point distribution system under the previously defined scope of research. Since the rating system for LEED has already been developed to a large extent, particularly after the advent of Version 3.0, the proposals follow a path to make the modifications by remaining within the current format. A change of numbers of points allocated could be the immediate solution; however, it does not allow LEED to be flexible enough to fit into contextual variations. On the other hand, LEED already has provided scope to use Innovation and Design points as a method to encompass aspects beyond the current format. Hence, it seems more logical to emphasize the use of weighted credits which can be varied from one context to another. Below is the example for suggestions for modifications of the specified section of the credit structure for a proposed version of LEED India for new construction.

	Credit	Points			
		LEED NC v 2.2 USA	LEED NC v 1.0 INDIA	LEED NC v3.0 USA	Changes for LEED NC v2.0 India
		Total 69	Total 69	Total 100	
Energy & Atmosphere	Minimum Energy Performance	Prerequisite	Prerequisite	Prerequisite	
	Fundamental Refrigerant Management	Prerequisite	Prerequisite	Prerequisite	
	Fundamental Refrigerant Management	Prerequisite	Prerequisite	Prerequisite	
	Optimize Energy Performance	1 to 10 **ID 1**	2 to 10 **ID 1**	1 to 19	
	On-Site Renewable Energy	1 to 3 2.5-7.5% **ID 17.5%**	1 to 3 2.5-7.5% **ID 17.5%**	3 to 7	
	Enhanced Commissioning	1	1	2	
	Enhanced Refrigerant Management	1	1	2	
	Measurement & Verification	1	1	3	
	Green Power	1 **ID 1**	1 **ID 1**	2	
Materials & Resources	Storage & Collection of Recyclables	Prerequisite	Prerequisite	Prerequisite	
	Building Reuse: Maintain of Existing Walls, Floors & Roof	1 for 75%	1 for 75%	1 to 3 for 55%, 75%, 95%	
	Building Reuse - Maintain of Existing Walls, Floors & Roof	1 for 95%	1 for 95%		
	Building Reuse: Maintain of Interior Non-Structural Elements	1 for 50%	1 for 50%	1	
	Construction Waste Management: Divert From Disposal	1 for 50%	1 for 100%+50% internal	1	
	Construction Waste Management: Divert From Disposal	1 for 75%	1 for 75%	1	
	Materials Reuse:	1 for 5%	1 for 5%	1	
	Materials Reuse:	1 for 10% **ID 15%**	1 for 10% **ID 15%**	1	
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 10%	1 for 5%	1	
	Recycled Content:(post-consumer + 1/2 pre-consumer)	1 for 20% **ID 30%**	1 for 10%	1	
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 10%	1 for 20% manufactured	1	**Add ID 1 for using materials within climate zone to utillize local resources**
	Regional Materials: Extracted, Processed & Manufactured Regionally	1 for 20% **ID 40%**	1 for 50% extract	1	
	Rapidly Renewable Materials	1 for 2.5% **ID 5%**	1 for 6.5%	1	
	Certified Wood	1for 50% **ID 95%**	1for 50% **ID 95%**	1	
Indoor Environmental Quality	Minimum IAQ Performance	Prerequisite	Prerequisite	Prerequisite	
	Environmental Tobacco Smoke (ETS) Control	Prerequisite	Prerequisite	Prerequisite	
	Selection of HVAC system as prerequisite				**Add Prerequisite to ensure review of CIBSE flow chart for natural ventilation**
	Outdoor Air Delivery Monitoring	1	1	1	
	Increased Ventilation	1 for 30% increase	1 for 30% increase	1 for 30% increase	**Add ID 1 for using natural or mixed ventilation for applicable situations to discourage mechanical ventilation system**
	Construction IAQ Management Plan: During Construction	1	1	1	
	Construction IAQ Management Plan: Before Occupancy	1	1	1	
	Low-Emitting Materials: Adhesives & Sealants	1	1	1	
	Low-Emitting Materials: Paints & Coatings	1	1	1	
	Low-Emitting Materials: Carpet Systems	1	1	1	
	Low-Emitting Materials: Composite Wood & Agrifiber Products	1	1	1	
	Indoor Chemical & Pollutant Source Control	1	1	1	
	Controllability of Systems: Lighting	1	1	1	
	Controllability of Systems: Thermal Comfort	1	1	1	
	Thermal Comfort: Design	1	1	1	
	Thermal Comfort: Verification	1	1	1	
	Daylight & Views: Daylight	1 for 75% **ID 95%**	1 for 75% **ID 95%**	1 for 75% + ID 1	**Add 2 Additonal points for 75%**
	Daylight & Views: Views	1 for 90% **ID 1**	1 for 90% **ID 1**	1	
Innovation & Design	Innovation in Design	1	1	1to 5, ID (1 to 5) and Exemplary (1 to 3)	
	Innovation in Design	1	1		
	Innovation in Design	1	1		**Additional point to encourage IPD as part of the informative design process**
	Innovation in Design	1	1		
	LEED Accredited Professional	1	1	1	
Regional Priority	Regional Priority			1 to 4 added	**Provide additional points for individual preferences based on each of 5 major climatic zones in India.**

Table 5.3: Proposed credit modifications for LEED India NC version 2.0

Including a LEED Accredited Professional is an optional factor to get LEED certification and only one point is available for this initiative through Innovation and Design Credits. As mentioned before, this is not enough to ensure in depth interpretation of the LEED credits and interaction with members of design team. Since it is crucial to establish this understanding throughout the project, and thus to ensure proper exploration of appropriate design solutions it is also suggested if possible, to make this aspect a prerequisite for all projects seeking LEED certification. It might seem difficult from the practical point of view, but looking at the number of LEED APs getting certified every year, it should not be a major setback towards LEED certification.

The suggested modifications to the credits and points allocated for the new version of LEED India NC can be summarized as:

- Under Material and Resources, 1 additional ID point is provided for use of regional materials originated and/or manufactured within a single climate zone.
- Review of CIBSE manual for natural ventilation is added as a prerequisite under Indoor Environment Quality. Additional ID point for using natural or mixed mode ventilation under appropriate conditions.
- Under Indoor Environment Quality, 2 additional points are available for daylighting of 75% of spaces.
- Under Innovation and design, 1 additional point is available for getting a LEED AP in the design team.

- Regional Credits will allow additional points for prioritizing credits based on the aspects of five climatic zones in India.

While the suggestions are for the credit structure and scoring system, correct explanations of these credit points must be provided in the Reference guide that is primarily followed during the design process. For example, the guide should clearly specify the importance of passive techniques while designing the ventilation or solar protection system and should mention the available additional credits for this initiative. Examples of preferred systems should be cited under the Potential Technologies and Strategies section for each of those credits.

These suggestions respect the structure of LEED rating system, which thus do not intend to change the entire system in order to incorporate solutions for the identified issues. Thus, it is very obvious that they will have limitations and boundaries defined by the system and can be observed as the beginning of further steps in future.

Chapter 6

CONCLUSIONS

This study began with a discussion on the changing approach toward architectural practice in India over the past few decades. The history of architecture in the country demonstrates a continuous development of environment-conscious and context-specific architecture. It also showcases a strong inclination toward passive techniques to accomplish the goal for comfortable living conditions while conserving natural resources. Still, majority of the buildings designed in the country today lack the connection to this traditional knowledge base. An urge for modern design and techniques are reflected in these highly sophisticated buildings, which draw inspiration from developed countries that have very different backgrounds. This approach to architecture and development that is more akin to imitation than adaptation and results in buildings alien to the surroundings. The idea of Green buildings and their definitions for India is misleading and creates a wrong notion about sustainable design. Certification from LEED has worked as a stimulant to magnify this false notion. This encourages the profit oriented building industry to choose a readymade, globalized path to design without regard to traditionally developed design approach.

It is evident that there is a big debate on the effect of adoption of modern active technology against traditional passive techniques for Green building design. It is not easy to decide between these two and the decision depends on various factors including context, economy, technical resources, and finally the choice of the architect. However, looking back at the very primary objectives of sustainability, it can be argued that there is a preference for passive design approach indigenous to the context before shifting to the active and more generalized solutions. LEED was developed for the building industry in USA, which in comparison to the Indian counterpart is more advanced and robust in terms of industrialized construction. The climatic, geographical, and cultural aspects put these two countries almost in diametrically opposite situations. Hence, even if LEED was desirable for Green design practice in USA, the attempt to adopt the same in India has led the sustainable development to a wrong direction. It is also true that there is a dire need for a Green building standard and guideline, especially for India, to push the building design process away from a mere imitation of other buildings and look back into the approach that was developed and tested over ages inside the country. LEED, as an internationally accepted system, needs to take this additional responsibility and it can be only achieved with the confirmation that the rating system respects sustainable design aspects of India. This research can be considered as a step towards the immediate major modifications that must be incorporated in the LEED India credit structure.

6.1. Impact of Suggestions

Based on research findings, the suggestions made for LEED India NC credit structure are primarily intended to enable LEED to emerge as an appropriate Green building rating system and design guideline for the Indian context. As for the immediate impact, these changes will act as a compilation of definitive guidelines for the new version for LEED India NC, with the Indian Green Building Council committee members as the target audience. It is expected that with these modifications incorporated, the new LEED India NC will initiate a change in the present outlook towards Green Building in India. The new guideline now will undergo a shift from being completely neutral about design strategies and convey to the building industry that the design process must embrace context specific strategies before the projects are certified as Green.

On a larger scale, with mandatory requirements for every building to be certified as Green building in future, the entire building industry must start to address these issues from individual to community level. With better recognition of the passive indigenous techniques, the construction process is expected to develop and offer better alternatives. India as a rapidly developing country is promoting extensive urban development. Hence, it is at a very crucial stage where the building industry must choose the appropriate approach to design and sustainability to shape the entire future of the sustainable initiative for the country. If LEED can contribute this desired role to show the right direction and prevent inappropriate choices for the design process, Green design in India, in its true sense, will be re-established.

6.2. Constraints of Suggestions

The modifications proposed in this research are based on a previously developed system of Green building rating and thus have a few constraints which must be considered.

First, the modifications follow the existing structure of LEED, which prohibits any radical change to the integrity of the system. Addition or removal of credits may alter the balance between different aspects of design. Hence, the priorities for certain design aspects are expressed in terms of pre-requisites, additional points, and regional credits - the only sections where LEED allows some flexibility.

Second, this research is carried with the warm-humid climate zone as the focus and does not encompass the attributes of other climate zones which have different design parameters. It is practically impossible for a single guideline to encompass all relevant attributes. This study concentrates on major issues common to the majority of climate zones in India.

Finally, it is the responsibility of the design team which comprises of architects and engineers to decide on a particular system. A design guideline can only suggest possibilities, but not the ultimate solutions as every individual project is unique. In addition, considering the mentality of the client, one cannot assure that only these modifications in LEED will ensure appropriate designs.

6.3. Future Directions

LEED is a tool that has facilitated the spread and acceptance of sustainable design as a serious concern globally. It has been instrumental in defining the individualized approach to green design by providing a visible framework for the building industry. Like other standard~~s~~ and guideline~~s~~, it is bound to evolve and develop based on past experiences. The introduction of LEED Version 3.0 has already dealt with some of the major issues with the system discussed in this research, such as credit weighting system and regional credits. This is a positive sign and demonstrates that LEED has started to acknowledge the importance of context-specific architecture. However, there have still not been many changes to the other sections that are responsible for dictating the choice of techniques used for solar radiation, daylighting, and ventilation, especially for the Indian context. Introduction of other new Green building rating systems such as TERI GRIHA validates the urgent situation regarding the present trend toward sustainable architecture in India. It is a matter of concern that as GRIHA responds to some of the key aspects of Green design in India if the industry should choose GRIHA over LEED in the near future. However, certain arguments can be made against this choice, too. First, although GRIHA demonstrates a very simple and specific system responding to major design aspects in India, the structure of LEED comes from a much more well organized and established thought process and incorporates several other aspects that are absent in GRIHA system. It should be also kept in mind, that GRIHA itself draws reference from the LEED as a parent system. Hence, it makes more sense to incorporate these aspects from GRIHA into a better LEED structure for

India. Second, LEED as an internationally recognized rating system has more validation and acceptance worldwide. This also makes it a more powerful and attractive tool than GRIHA for the building industry to adopt Green design and gain recognition. This also ensures financial viability for the market which makes LEED a more practical solution. However, GRIHA can continuously question the approaches taken by LEED, which can eventually help LEED to learn from its mistakes. Another new version of LEED is already being considered and could be introduced by the year 2011. This reason opens door for further research on the future of LEED and sustainable architecture in India.

With the recent rise in the rate of economic development in countries like China, India and UAE, there has been a dramatic shift in living standards for a major portion of urban population that idealizes the concepts from developed countries. This changed mindset has been instrumental in emulating certain globalized concepts, which has affected the styles in architecture also. In India, except few architectural practices and research facilities, the major trend toward modern architecture is highly influenced by these global concepts for design and sustainability. This indicates that there is a tendency to accept everything standardized blindfolded. Because a Green design guideline can be considered as one of the few visible definitions for sustainable architecture, the authors of the guideline must ensure that correct interpretations are made to educate the architects, engineers, and the common people. Again, in any building design process, architects, engineers, and the clients make the final decisions for a building project. A building design has to address a number of problems simultaneously, sustainability being one of them. Thus, one should not look at it as a discreet criterion for design and rather consider it as an integral part of a complex system where every criterion overlaps the other. Often, Green design in Indian consumer society is considered as a new term which adds on to the current design practice. Thus, the design process does not reflect the desired approach towards environment-friendly architecture and sustainable features are applied as an add-on over the final design. For example, a building must consider orientation, floor width, and aperture of openings to achieve optimum results for controlling heat gain through solar radiation and daylight levels throughout the year. Therefore, a building designed without making these considerations at an early stage ends up using more energy for HVAC and lighting system. In the first case, however, the possibilities of over-designed systems are greatly reduced and guarantee more efficiency than the system developed on an ill-designed building form. The LEED guideline, under this context is intended to inform the design team about the pros and cons of different choices and their relation to other aspects of the design. Though it cannot ensure the appropriate choice, as the possibilities of design options to a particular problem cannot be restricted. But it can recommend the preferred general approach towards Green design for a particular context. Hence, this thesis can be considered an attempt to provide an in-depth analysis of the reasons behind the superfluous shift in sustainable design concepts in India and begins the quest for a better alternative.

BIBLIOGRAPHY

ASHRAE. *Standard 55-2004: Thermal Comfort Conditions for Human Occupancy.* Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2007.

ASHRAE. *Standard 62.1-2007: Ventilation for Acceptable Indoor Quality.* Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 2007.

ASHRAE. *Standard 90.1-2007: Energy Standard for Buildings Except Low Rise Residential Buildings.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2007.

Bay, Joo-Hwa and Boon-Lay Ong. *Tropical Sustainable Architecture: Social and Environmental Dimensions.* Oxford: Elsevier Ltd., 2006.

Bhatt, Vikram and Peter Scriver. *After the Masters*. Ahmedabad: Mapin Publishing Pvt. Ltd., 1992.

Bureau of Indian Standards. "Part 8, 5.4.3, 5.7.1.1." In the National Building Code of India. 2005.

Bureau of Energy Efficiency. *Energy Conservation Building Code*. http://www.hareda.gov.in/ECBC.PDF (accessed April 21, 2008).

Carbon Trust. *Natural ventilation in non-domestic buildings – CIBSE Applications Manual AM10*. London: CIBSE, 2005.

Carbon Trust. “Natural ventilation in non-domestic buildings – A Guide for Designers; Developers and Owners.” *Carbon Trust Practice Guide 237*. London: Carbon Trust, 1999.

Carbon Trust. “Natural ventilation in non-domestic buildings – A Designer’sGuide to the options for ventilation and cooling.” *Carbon Trust Practice Guide 291*. London: Carbon Trust, 1999.

Confederation of India Industry. "LEED India, Summery of Suggestions." http://www.worldgbc.org/docs/LEED-INDIA%20SUGGESTIONS.pdf (accessed April 22, 2008).

Confederation of Indian Industry. "Green Building Movement in India – Catalysts and Course." www.igbc.in. http://www.igbc.in/igbc/publication.jsp (accessed April 22, 2008).

Correa, Charles. "The Blessings of the Sky" In *Charles Correa*, by Charles Correa and Kenneth Frampton, 17-32. London, Thames & Hudson, c1996.

Das, Nibedita. "Courtyards Houses of Kolkata: Bioclimatic, Typological and Socio-Cultural Study." 2006. Master’s Thesis, K-State research Exchange. krex.k-state.edu/dspace/bitstream/2097/146/1/NibeditaDas2006A.pdf (accessed March 11, 2007).

Emmanuel, M. Rohinton. "Thermal comfort in the urban tropics." Chapter 3 in *An Urban Approach to Climate Sensitive Design-Strategies for the tropics,* 63-95. Abingdon: Spon Press, 2005.

Frampton Kenneth. “Towards A Critical Regionalism” in *The anti-aesthetic: essays on postmodern culture*, edited by Hal Foster, New York, New Press, c2002.

Hindrichs, Dirk U., and Klaus Daniels. *Plusminus 20/40 latitude - Sustainable building design in tropical and subtropical regions*. Stuttgart/London: Axel Menges, 2007.

Indian Green Building Council. "LEED India NC Version 1.0." http://www.igbc.in/igbc/LEEDAbridVer.pdf (accessed April 21, 2008).

LEED India-Summary of changes. http://greenbusinesscentre.com/leedindiarating1.asp (accessed December 15, 2008).

Majumdar, Mili. *Energy-efficient buildings in India*. New Delhi: Tata Energy Research Institute, c2001.

Majumdar, Mili. “Eco design sustainable buildings for a new India” *Electrical India*, Vol. 48, No. 6, pp. (June 2008) 111-116. http://www.teriin.org/upfiles/pub/articles/art380_20080721105236.pdf (accessed November 01, 2009).

Mathur, Deepika. "Examining the technological approach to environmentally sustainable architecture in India" World Architecture community. http://www.worldarchitecture.org/links/?waurl=http://www.inter-disciplinary.net/ptb/ejgc/ejgc5/mathur%20paper.pdf&aclsno=1198 (accessed 2007)

Merhotra, Rahul. "Architectural Responses in Tropical India." In *Tropical architecture : critical regionalism in the age of globalization* , by Alexander Tzonis, 193-213. New York: Wiley-Academy, 2001.

Miner, Colin. “LEED Seeks to Beef up Its Credentials.” The New York Times, November 25, 2009, Energy and Environment section. http://greeninc.blogs.nytimes.com/2009/09/04/leed-seeks-to-beef-up-its-credentials/ (accessed October 20, 2009)

Nanda, Puja. “The culture of building to craft: A regional contemporary aesthetic – Material Resources, Technological Innovation and the Form Making Process”. http://www.idemployee.id.tue.nl/g.w.m.rauterberg/conferences/CD_doNotOpen/ADC/final_paper/648.pdf (accessed November 9, 2009).

Navarro, Mireya. “Some Buildings Not Living Up to Green Label.” The New York Times, August 30, 2009, Environment section. http://www.nytimes.com/2009/08/31/science/earth/31leed.html?scp=4&sq=leed&st=cse (accessed November 9, 2009).

Reddy, B. V. Venkatarama. "Sustainable building technologies" *Current Science* vol. 87, no. 7, (October 2004) 899-907.

Rewal, Raj. *Humane Habitat at Low Cost: CIDCO Belapur New Mumbai.* New Delhi: Tulika, 2000.

Robson, David, *Beyond Bawa.* London: Thames & Hudson, 2007.

Sharma, Anupama, K K Dhote, and R Tiwari. “Climatic Responsive Energy Efficient Passive Techniques in Buildings." *IE (I) Journal* AR 84 (April 2003).

Srinivas, S. "Green Buildings in India: Lessons Learnt." http://www.igbc.in/igbc/publication.jsp (accessed April 21, 2008).

Sutaria Ruchita and Aalok Deshmukh. “Whose Sustainability Is It Anyway?”, Paper presented at 23rd conference on Passive and Low Energy Architecture, Geneva, Switzerland. September, 2006.

Steele, James. *Rethinking Modernism for The Developing World: The Complete Architecture of Balkrishna Doshi*. New York: Whitney Library of Design, 1998.

Tata Energy Research Institute. “GRIHA Rating System”. www.grihaindia.org (accessed November 15, 2009).

Technopolis. http://www.technopolis.in/swf/technopolis.swf (accessed June 11, 2008).

Thapar, Bindia, Suparna Bhalla, and Surat Kumar Manto. *Introduction to Indian Architecture*. Singapore: Periplus Editions, 2004.

Vyas, D. "Traditional Indian Architecture-Future Solar Buildings." Paper presented at International Conference “Passive and Low Energy Cooling for the Built Environment”, Santorini, Greece, May 2005. www.inive.org/members_area/medias/pdf/Inive%5Cpalenc%5C2005%5CVyas.pdf (accessed March 23, 2008).

US Green building Council. *LEED for New Construction version 2.2 Reference Guide*. Washington, DC, 2007.

US Green Building Council. “LEED 2009 for New Construction and Major Renovations Rating System”. http://www.usgbc.org/ShowFile.aspx?DocumentID=5546 (accessed October 15, 2009).

US Green Building Council. “LEED 2009: Technical advancements to the LEED rating system” www.usgbc.org. 2009. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1971 (accessed October 15, 2009).

Williams, Kath. "LEED Green Building Rating System." http://greenbusinesscentre.com/articles.asp. (accessed April 21, 2008).

World Green Building Council. http://www.worldgbc.org. (accessed November 15,2009).