

Development of a methodological framework to decode the climate response of traditional habitats of Pune Region

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Abstract - Shelters are the fundamental requirements of human beings. Today, with the evolution, this fundamental requirement has transformed to an expensive and merely sustainable built environment. This transformation is adding to the Urban Heat Island effect adding to the long-term effect of climate change in our surroundings. As an architect, it is the responsibility of the fraternity to understand the gravity of the situation and contribute for the noble cause to save our mother Earth. This study is a beginning in this direction, with focusing on the local context of Pune city and its peri-urban areas. This study focuses on the review of the literature on climate responsive habitats of Pune Region. It argues that the study shows climate responsive approach adapted in the contemporary designs to a certain extent, although, there is a need to identify and apply the morphological similarities with a more scientific approach. This study concludes with a framework of methodology from a computational approach. This framework may be used for developing the morphological design guidelines extracted from the analysis of literature.

INTRODUCTION

1.1. BACKGROUND OF THE STUDY:

Pune city is also known as the QUEEN OF DECCAN has recently recorded the change of climate from moderate to hot and dry, which is an issue of concern, this change happened because of the rapid construction of concrete mass in the peri-urban areas. There is an urgent need to study the sustainability factors and come to some conclusions that will help the young architects and designers to build a sustainable design in peri-urban areas.

1.2. AIM:

To develop generic design considerations for the climate responsive design of the habitat/settlement specific to the context of peri-urban areas of Pune city

1.3. OBJECTIVES:

1. To understand the overall process of design of the contemporary buildings of residential typology adapted by the practicing Architects of Pune.
2. To study and analyze the influence of climate responsive design decisions on the residence after execution and while its is functional.
3. To conduct the analysis for the following
 - i. Case Study analysis

- ii. Data collected from architect's interview.
- iii. Data collection from simulation
- iv. Data collected from primary and secondary data collection.

1.4. RESEARCH QUESTION:

1. What should be the design considerations for the climate responsive built environment for the peri-urban areas of Pune?
2. What should be the methods to integrate the design considerations in the process of design?

1.5. HYPOTHESIS:

Design decisions on orientation and simulation study of the solar radiation of the built form are comparatively more important to address the climate response of the habitat in the context of Pune.

1.6. SCOPE & LIMITATIONS:

Scope

1. The scope of this research is to qualitatively analyze the habitat / settlement of pune based on primary and secondary data using methodology of live case study, user interview and simulation analysis.
2. Scope of this study is to derive the design considerations to address the climate of Pune. These design considerations may be integrated in the process of design at the level of conceptualization/ideation.
3. The design decisions derived from the study will support the architectural process of design at the conceptual/ideation stage.
4. Scope of the simulation study is to simulate and analyze the solar radiation on habitats located in the climate region of Pune.

Limitations

This study is limited to the stage of conceptualization/ideation in the process of architectural design and does not consider the aspect of available criteria of rating and assessment.

1.7. SIGNIFICANCE & OUTCOME:

The growth in infrastructure and building is observed to be rapid in the peri-urban areas of Pune city. The identified need is to cater these peri-urban areas with a climate responsive design of built environment. To cater to the growth in the building sector, this study identifies a requirement of design of habitat and/or settlements in the peri-urban areas of Pune. The architects of future generations need support on design considerations for the housing typology ranging between a single-family dwelling to mass housing. The need of this research is identified as "to align with the National Goal of Sustainable Development and to cater to the local climatic conditions, it is necessary to support the decisions for a climate responsive built environment."

1. Analysis of the effect of the design decisions on the built form.
2. Analysis of climate response on the thermal comfort level of the user.
3. Distinguishing the design considerations for climate responsive habitat for the peri-urban areas in Pune.

1.8. METHODOLOGY:

Generic Schema

This research is formulated in the following stages.

1. Interview to understand the design decisions and the process of design.
2. Case study to understand the implications of the design decisions.
3. Simulation study to understand the quantitative data of the implications of the design decisions.
4. Analysis and comparison to identify the generic design considerations specific to the climate of Pune.

The primary data collection is based on,

1. Interview of the Architects practicing in Pune.
2. Live case study of their habitat/settlement design
3. Post occupancy survey of the built environment

The secondary data collection is based on,

1. Literature review of books
2. Literature review of published journal papers
3. Bookcase study of the built environment

A. Evolved Methodology I

1. Primary Data Collection

- a. Live Interview of the architects: Celebrated architects of Pune
 - i. Ar. Poorva Keskar
 - ii. Ar. Girish Doshi
 - iii. Ar. Prashant Deshmukh
2. Online and live case study

- a. Lake House
- b. Khadke House
- c. Residence of Mr. Kanchan
- d. Residence of Mr. Jotawar

3. Secondary Data Collection

- a. Literature Review from Books, Articles and from Research papers
- b. Documentation on Vishrambaug Wada

4. Simulation Analysis

- a. Vishrambaug Wada
 - b. Lake House
 - c. Khadke House
 - d. Residence of Mr. Kanchan
 - e. Residence of Mr. Jotawar
4. Analysis from the interview questionnaire

Objectives of the study are as mentioned below.

- To understand the process of design of the contemporary buildings of residential typology.
- To understand the design decisions for conceptualization.
- To study the influence of the design decisions on the built form.
- To study and analyze the influence of the climate responsive design decisions on the built form.

B. Evolved Methodology II

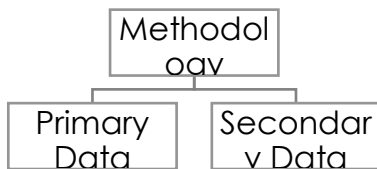


Figure 1:Methodology Chart 1

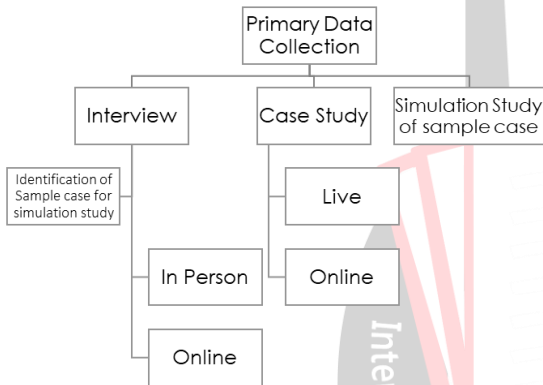


Figure 2:Methodology chart 2

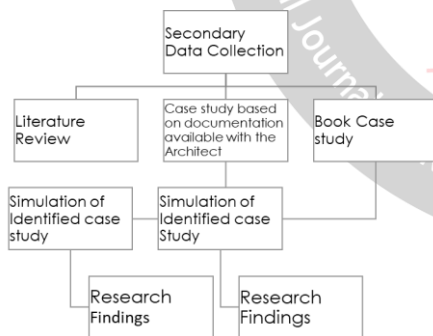


Figure 3:Methodology Chart 3

1. Primary Data Collection

- Live Interview of the architects: Celebrated architects of Pune
 - Ar. Poorva Keskar
 - Ar. Girish Doshi
 - Prashant Deshmukh
- Online and live case study
 - Lake House

- Khadke House
 - Residence for Mr. Kanchan, Urali Kanchan, Pune, India
 - Residence of Mr. Jotawar, Pune, India
- 2. Secondary Data Collection
 - Documentation of Vishrambaug Wada
 - Literature Review from Books, Articles and from Research papers

3. Simulation Analysis

The simulation analysis was conducted for the following habitats located in climatic region of Pune based on the era of their construction.

Table 1:Typology Of buildings

Simulation of the building	Time of construction
Vishrambaug Wada	Peshwe Dynasty
Lake House	2011
Khadke House	2013
Bungalow for Mr. Kanchan, Urali Kanchan	2011
Bungalow for Mr. Jotawar, Sindh Co-operative Housing Society, Pune	2013

The platform used was Rhino 3D and Grasshopper along with its plugin named, Ladybug. The simulation study was further analyzed for solar radiation. Every surface for solar radiation was studied and analyzed using point grid. The solar radiation for a time span of February to October is analyzed. This time span ensures study of solar radiation for the greatest comparable exposure. Study of solar radiation was conducted for time span of 12 noon to 3 noon. This time span ensures study of radiation perpendicular to the roof or walls. Through this study we identified certain indicators as explained in the Research Findings section.

Table 2:Analysis Of Buildings

RESIDENCE	BUILDING ORIENTATION	COURT YARD SIZE	HEIGHT OF SURROUNDING WALLS	ROOF GEOMETRY	TERRACED PLANNING	RATIO (W/H)
LAKE HOUSE	NORTH-SOUTH	-		CURVED	YES	1:1.5
Khadke house	NORTH-SOUTH			FLAT	NO	NA
MR. JOTAWAR		12M x 19.5M	6.7 M	FLAT	NO	1:2.8
VISHRAMBAUG WADA			12.5 M	SLOPING	NO	1: 1.13

Table 3:Analysis Of Buildings

2. REVIEW OF LITERATURE

2.1 CLIMATE RESPONSIVE ARCHITECTURE:

Climate-responsive architecture is a design practice that focuses on creating buildings that function hand in hand with the local climate. The background study shows that climatic response is seen since the ancient era in vernacular architecture. This traditional wisdom is observed to be reflected in the traditional built forms. Further, the scientific studies in this domain provide the architects several tools, techniques, and strategies to support the design decisions. As quoted by Ar. Shashi Bhushan, “Architecture cannot be without a climate response”. It is the primary responsibility of the Architect to design a climate responsive built form. The statistical data shows that, building industry has the greatest impact on natural resources. United Nations Sustainable Development Goals provide guidelines towards the Sustainable Development. With the Initiatives like Renewable Energy, GRIHA and Eco-Niwas Samhita, The Government of India promotes the design of a climate responsive built environment. In this broader area of research, this study focuses on the local context of Pune. Pune is considered to be one of the most livable cities of India. Studies on Pune shows that, from the original moderate zone it shifted to the hot and dry zone of India. Research study on UHI influence of Pune clearly shows that the temperature rose by 2°C in the central parts of the city while in the suburbs it rose by 4 to 10 °C. (Nesarikar- Patki & Raykar-Alange, 2006) which is an alarming situation for the citizens. This is observed to be due to rapid growth of building and infrastructure in the suburbs or peri-urban areas of Pune

II. 2.2. SIGNIFICANCE OF REVIEW:

The growth in infrastructure and building is observed to be rapid in the peri-urban areas of Pune city. The identified need is to cater these peri-urban areas with a climate responsive design of built environment. To cater to the growth in the building sector, this study identifies a requirement of design of habitat and/or settlements in the peri-urban areas of Pune. The architects of future generations need support on design considerations for the housing typology ranging between a single-family dwelling to mass housing. The need of this research is identified as “to align with the National Goal of Sustainable Development and to cater to the local climatic conditions, it is necessary to support the decisions for a climate responsive built environment.”

III. WHAT IS CLIMATE RESPONSIVE ARCHITECTURE?

Climate Responsive architecture is the method of architectural practice and research. It helps in measuring

environmental situations through sensors, in order to enable buildings to adapt their form, shape, color or character. The aim of responsive architecture is to refine and extend the architectural discipline by improving the energy performance of buildings with the help of technologies like sensors, control systems, actuators etc., and also designing buildings that reflect the wonders of technology and culture. The distinction between responsive architecture and other forms of interactive designs is the incorporation of intelligent technology into the core elements of a building's fabric, and its capacity to get aligned with the changing weather conditions.

IV. STEPS TO DESIGNING CLIMATE-RESPONSIVE ARCHITECTURE

1. Perform a Site Analysis
2. Layout the Building on the Site
3. Plan with the Sun in Mind
4. Window Considerations
5. Building for Geographic Area
6. Minimize the Building Footprint
7. Design for Natural Ventilation
8. Conduct Modelling and Analysis
9. Perform Multiple Iterations

V. PUNE'S CLIMATE-

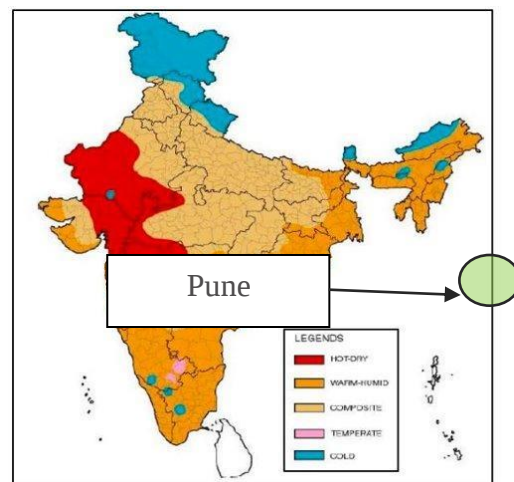


Figure 4: NBC Climate Region Map Of India

Pune has a hot and dry climate (type BSh) bordering with tropical wet and dry (type Aw) with average temperatures ranging between 20 and 28 °C (68 and 82 °F)

A. Characteristics of Hot and Dry climate

- In this type of climate temperature is usually very hot.
- Humidity is very low.
- Hot winds and frequent dust storms.
- Very little rainfall.
- Sandy and rocky ground with very low vegetation cover.
- High solar radiation.
- Clear sky most of the year.

VI. DESIGN STRATEGIES FOR HOT & DRY CLIMATE (O. H. KOENIGSBERGER, T. G. INGERSOLL, 2016)

(1) **Climate** is one of the major factor which impacts the **Architectural design**.

Whenever **Climatic** conditions are considered in the **design** then the building will be ideal to reside.

1. Detailing building fenestration design and **construction** details to promote shading, heat loss and insulation.
2. Larger building dimensions should face north & south.
3. Double walls with insulation in between are a suitable solution
4. The size of the windows on the east and west sides should be minimized in order to reduce heat gain
5. The flat roof is a good reflector and re-radiates heat efficiently, especially if it consists of a solid, white painted material.
6. The courtyard is provided with water and plants; it acts as a cooling source.
7. Internal courtyards provide cross ventilation and natural cooling.
8. Inlets to be provided at lower levels and outlets at a higher level as they serve to vent the hot air.
9. Suitable radiation barriers in the form of canopies, chajjas, and long verandahs should be provided on the west side of the **building**.

VII. 2.3 BOOK REVIEW:

(1. CLIMATE RESPONSIVE ARCHITECTURE : A DESIGN HANDBOOK FOR ENERGY EFFICIENT BUILDINGS KRISHNAN, 2001)

Points to consider while studying a built form.

- Materials and health of built.
- Ozone depletion
- Embodied energy
- Energy consumption and renewable energies
- Sustainable architecture and energy
- Green effect
- Energy consumptions
- Passive solar heating

Points to consider while studying an element.

- Climate implication
- Theoretical understanding
- Building design
- Other possible effects

(Gupta, 2007)

2 Wada of Maharashtra



Figure 5 Vishrambaag Wada

Wades evolved as the important element of the Maharashtra, its form on the principal of modular planning in architecture which can be used by all kinds of classes according to the need. which later evolved according to the climatic conditions and social conditions. the factors that influenced the design of Wada were the construction techniques that were used during the period along the history.

This books describes the evolution and development of the Wada form of dwelling as development of the traditional form of having a courtyard. using the courtyard with habitable space on the periphery as the module, the grandness, scale, style, technique, technology and materials usage is perceived as a lateral phenomenon with attributes that evolved due to climatic, social and cultural aspects, that led to the house of command people

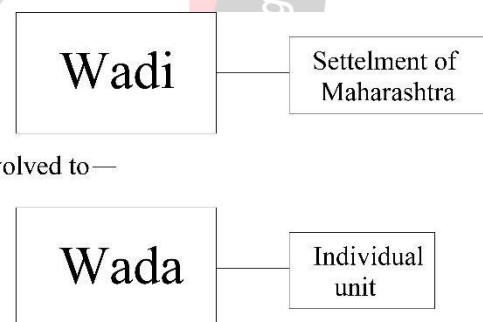


Figure 6:Evaluation Of Wada

Structural grid ----- spaces -----Form

Background:

- The word Sala (house) is stated to have been derived from Sakha (branch), because originally branches were arranged lengthwise, breadthwise, crossed and then thatched to make the first house

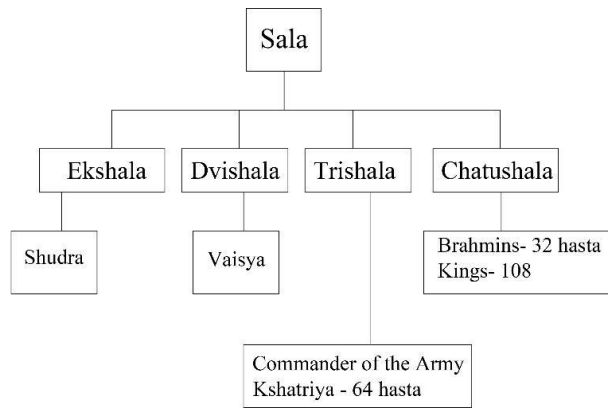


Figure 7: Classification Of Sala

*1 hasta = 1and half foot

- Courtyard plans were based on concept of kakshys and Sala
- Courtyard served as a convenient thermostat, giving protection from extreme weathers, averaging out the diurnal temperature difference
- Courtyard were narrow enough to maintain a shaded area in summer and wide enough to receive the winter sun
- In arid the courtyards were used for collecting and storing scarce rainwater
- The courtyard in the content of cluster of houses was that it was an outdoor usage of space
 - , a form a climatological and social point of view that necessitated the courtyards getting formally integrated into the built form.
- The courtyard became the hub of activity in a more organized way
- The chowks became the central feature of the built form, and was referred to as the womb or the sacred center and became the icon of Cosmo-religious symbolism
- The courtyard thus became the womb, from where emerged, the hub from where all activity radiated and the bindu (center), symbolizing the religious center.

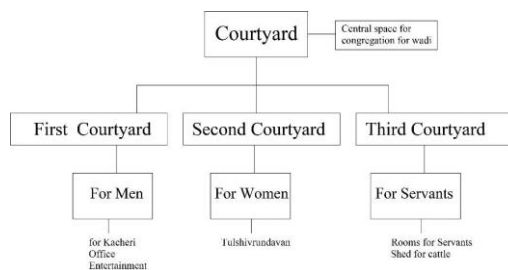


Figure 8: Classification Of Courtyard

- Climatological variations across Maharashtra led to variables in form
- E.g. In garnish, the outer enclose of ram pants and bastion was made of blocks of laterite with the parapet courses in bricks. circular or octagonal bastions flanked the main entrance or at the corners. these ram pets made an impervious wall of the Wada within

(shanivarwada, Purandar Wada) both have octagonal bastions flanking the main entrance.
wades emerged as the form of domestic architectural in response to social and climatic characteristics of times; derived from west Asian and peculiar house type of the tropics, wades had one or many courtyards with rooms overlooking it. Wada have essentially introverted plan. all the spaces and privacy was maintained within the walls.

3 (SUSTAINABLE SPATIAL DEVELOPMENT UNDER THE CONDITIONS OF DRY, 2013)

Macro climate responsive design strategies for hot and dry climate in Abu Dhabi

- Distance between buildings
- Enclosed urban environment.
- - Narrow and irregular streets.
- Building form.
- Self-efficiency in materials.
- Optical and thermos physical properties of the building envelope.

INDIA

Layout of buildings for hot-dry climates

2.1 orientation north-south for the living rooms

2.2 external layout: compact planning

2.3 internal base: rooms concentrated around the yard

2.4 external openings: small, near the ceiling

2.5 external walls, roof: heavy

2.6 external surfaces: reflexive

2.7 internal walls: massive

2.8-yard surfaces: shaded ground

2.9 external communications: shaded

NOTE: A special care to be paid to the protection of sand storms and insects

A. (Critical review of the Climate Change Impact on urban areas by assessment of Heat Island effect. Case of Pune, India, 2017)

- In the core areas of Pune, the temperature is interestingly low, which does not relate Pune area with most of the western cases for Urban Heat Island effect.
- As the outskirts or border areas of the city show elevated temperatures than the core areas of the city, should it be concluded that we have no heat island effect? This is due to the Vernacular City Pattern- which plays an important role in dissipating heat by obstructing and circulating winds.
- Also, the built materials used in the core city are stone and other natural materials, instead of concrete, asphalt. These built materials have thermal properties which absorb and radiate very less heat, thus contributing towards dissipating the heat islands.

- Also, the rivers Mula – Mutha pass from the core areas of the city, which lower their temperature and increase the green cover even further. We can also see such behavior near lake areas in Pune.
- Thus, Heat Island effect does exist here, but in smaller range of areas; or when we consider a district wide area- the rural underdeveloped areas with a lot of green cover as well. It can be seen from temperature graphs for summer and winter for specific land covers, that the mean temperature is increasing over time. More prominently for built areas than green and water bodies; a proof of Climate Change.

VIII. RESEARCH PAPER

A. (1. Building Orientation as the Primary Design Consideration for Climate Responsive Architecture in Urban Areas Alisha Sinha*, 2020)

Points to consider while studying a built form.

Orientation is a design parameter that plays a major role in climate responsive architecture and helps achieve comfort within the built environment. However, it is difficult to achieve an ideal orientation, the main aim of this paper is to develop alternate strategies to overcome the challenges faced in designing as per preferred orientation and then derive a set of tools that can help decide the orientation of a building on site both under normal and congested site conditions. Thereafter, the inferences from the paper can act as references for choosing an optimum orientation for placement of buildings in warm humid climate. It can act as a significant pedagogical guideline for students of architecture in deciphering solutions for a climate responsive design in a simplified manner. The results can also be utilized for future research in formulating similar tools for other climatic regions.

IX. GOVERNMENT OF INDIA INITIATIVES

A. (Eco Niwas Samhita (India, N.D), 2018)

Giving a fillip to India's energy conservation efforts, Ministry of Power has launched the ECO Niwas Samhita 2018, an Energy Conservation Building Code for Residential Buildings (ECBC-R). The Code was launched on the occasion of National Energy Conservation Day 2018

It aims to benefit the occupants and the environment by promoting energy efficiency in design and construction of homes, apartments and townships. Part-I of the Code has been launched which prescribes minimum standards for building envelope designs with the purpose of designing energy efficient residential buildings.

B. (MNRE (Ministry of New and Renewable Energy) ("Ministry of New and Renewa`ble Energy," n.d.), n.d.)

To develop new and renewable energy technologies, processes, materials, components, sub-systems, products & services at par with international specifications, standards and performance parameters in order to make the country a net foreign exchange earner in the sector and deploy such indigenously developed and/or manufactured products and services in furtherance of the national goal of energy security.

2.6 CLIMATE RESPONSIVE CHECK PARAMETERS (O. H. Koenigsberger, T. G. Ingersoll, 2016)

1. Sunpath

- Sun path refers to the apparent significant seasonal-and-hourly positional changes of the sun (and length of daylight) as the Earth rotates, and orbits around the sun.

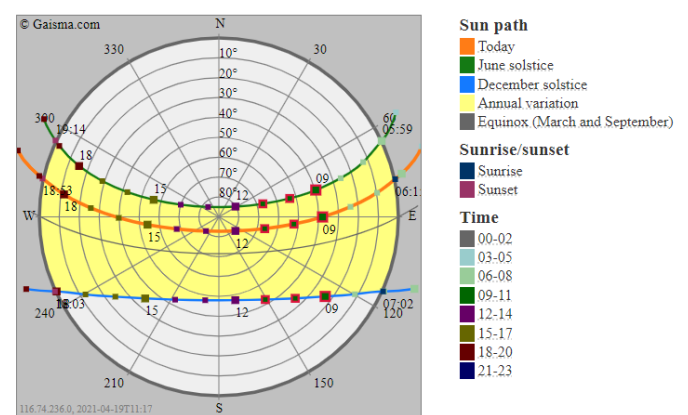


Figure 9 Sun Path Diagram of Pune

2. Winds

- Winds are basically convection currents in the atmosphere, tending to even out the differential heating of various zones.
- The pattern of movements is modified by the earth's rotation.

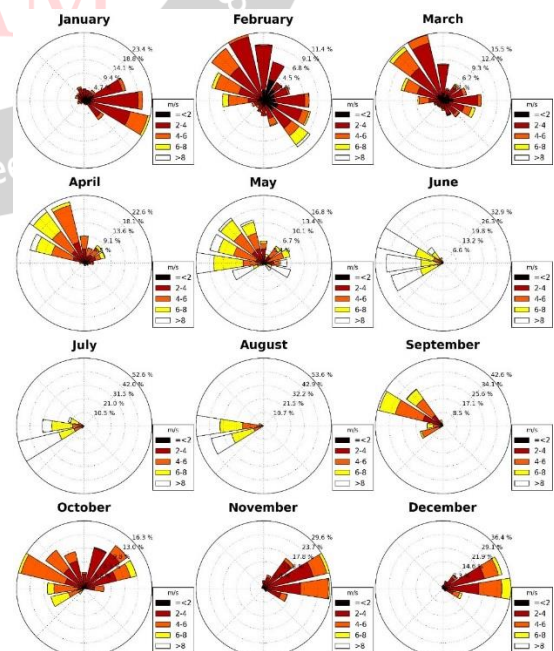


Figure 10 Wind Rose Diagram of Pune

3. Wind speed

- Wind speed, or wind flow velocity, is a fundamental atmospheric rate.
- Wind speed is caused by air moving from high pressure to low pressure, usually due to changes in temperature.
- Wind speed is now commonly measured with an anemometer.

4. Body comfort

- Air movement affects body cooling.
- It does not decrease the air temperature but causes a sensation of cooling due to heat loss by convection and due to increased evaporation from the body

5. Humidity

- Humidity is the amount of water vapor in the air.
- Water vapor is the gaseous state of water and is invisible
- Humidity indicates the likelihood of precipitation, dew, or fog.
- There are three main measurements of humidity: absolute, relative and Specific

6. Bioclimatic chart

- A bioclimatic chart is a preliminary analysis tool used during the early planning stages of a building project.
- In the process known as bioclimatic architecture, an architect uses the bioclimatic chart to design buildings that include the most efficient passive cooling and heating strategies based on the climate and location of a building site, according to the Centre for Renewable Energy Sources and Saving.

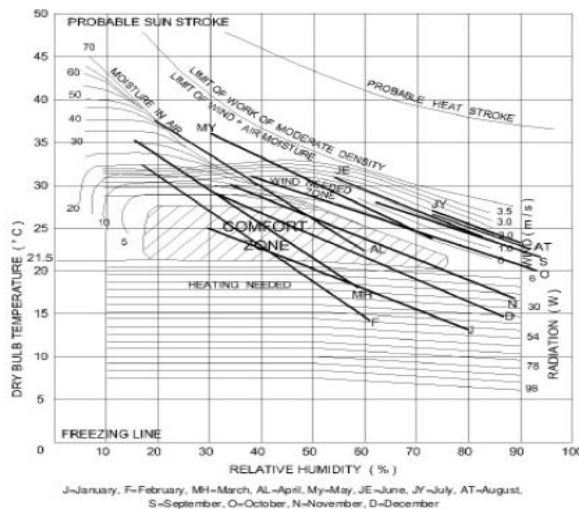


Figure 11 :Bioclimatic Chart Of Pune

7. Psychrometric chart

- A psychrometric chart is a graph of the thermodynamic parameters of moist air at a constant pressure, often equated to an elevation relative to sea level.
- The ASHRAE -style psychrometric chart, shown here, was pioneered by Willis Carrier in 1904. It depicts these parameters and is thus a graphical equation of state.

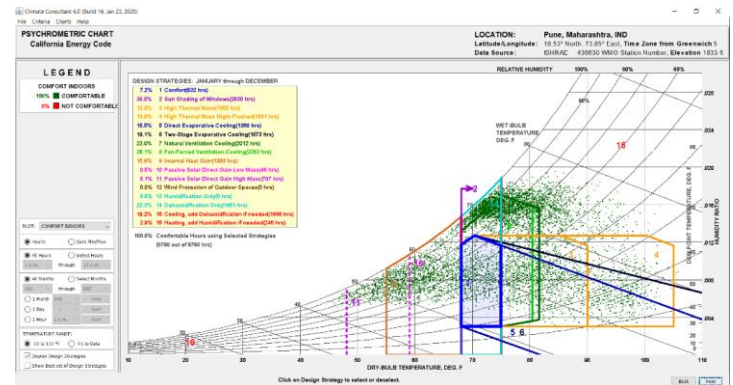


Figure 12 Psychrometric Chart

C. 8. Tools Available

- Climate Consultant
- LMNt Climate Visualizer

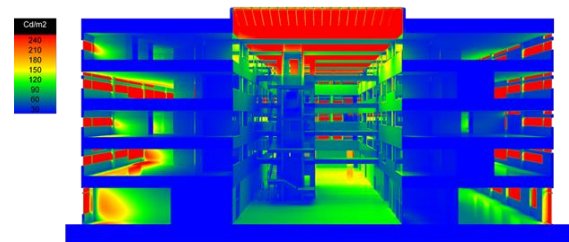
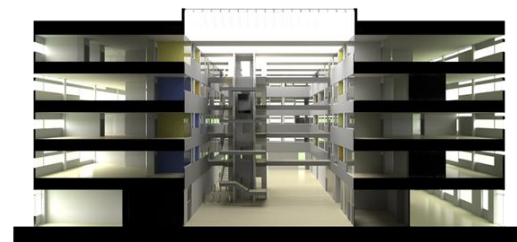


Figure 13 Sample Image for LMNt climate visualize

- Ladybug + Honeybee (open-source plugins for Grasshopper)

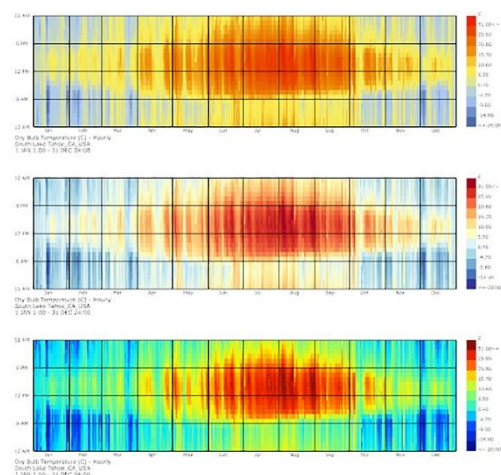


Figure 14 Sample Image for Ladybug + Honeybee software

- Energy Plus weather data

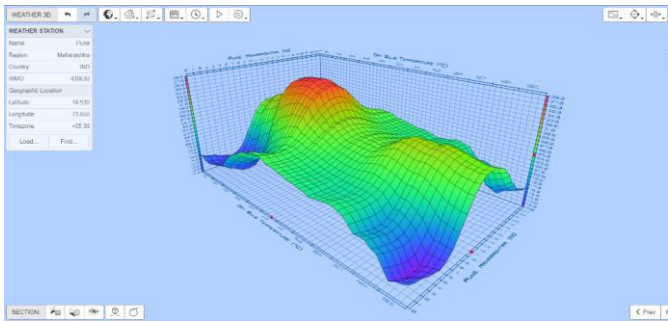


Figure 15 Energy Plus weather data for Pune

- Additional sources of weather data

1. CLIMATE CONSULTANT SOFTWARE (“Energy Design Tool,” n.d.)

Free, easy-to-use, graphic-based computer program that displays climate data in DIFFERENT of ways useful to architects, builders, contractors, and homeowners, including temperatures, humidity, wind velocity, sky cover, and solar radiation in both 2-D and 3-D graphics for every hour of the year in either Metric or Imperial units. Climate Consultant also plots sun dials and sun shading charts overlaid with the hours when solar heating is needed or when shading is required. The psychrometric chart analysis shows the most appropriate passive design strategies in each climate, while the new wind wheel integrates wind velocity and direction data with concurrent temperatures and humidifies and can be animated hourly, daily, or monthly. Because energy codes require slightly different types of buildings in each climate zones, it is important for people who are designing, constructing, or maintaining these buildings to understand the unique attributes of their climate and how it impacts their building’s energy consumption.

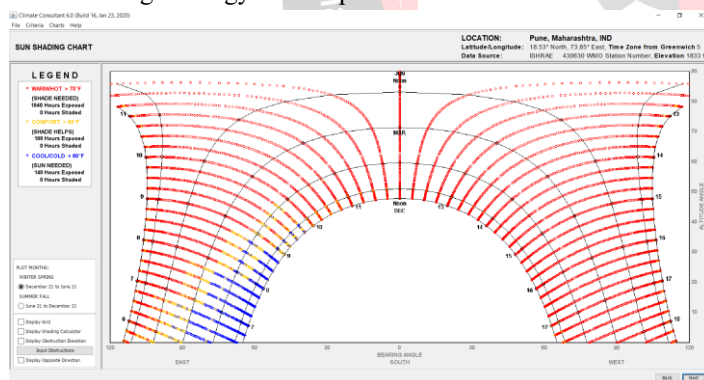
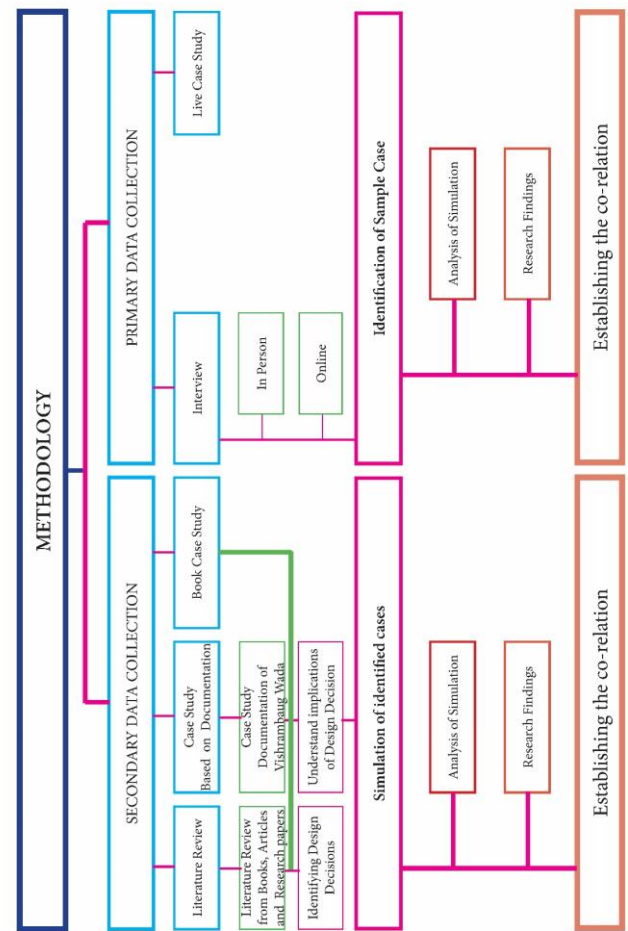


Figure 16 Sun Shading Chart for Pune

X. METHODOLOGY



XI. DATA COLLECTION & ANALYSIS

A. 4.1 Secondary Data & Analysis:

This research study uses the mentioned software platform for simulation study

Grasshopper, plugin to Rhino 3D: (Rutten, n.d.)

Ladybug allows you to import and analyze standard weather data in Grasshopper; draw diagrams like Sun-path, wind-rose, radiation-rose, etc.; customize the diagrams in several ways; run radiation analysis, shadow studies, and view analysis.

Honeybee connects Grasshopper3D to validated simulation engines such as Energy Plus/Open Studio and Radiance for building energy, comfort, daylighting and lighting simulation.

Dragonfly enables the creation and manipulation of large-scale Energy Plus and Radiance models by capitalizing on an abstracted 2D representation of building geometry, where all rooms are assumed to be extrusions of floor plates.

Butterfly connects Grasshopper to the Open FOAM engine, which can be used to run advanced computational fluid dynamic (CFD) simulations.

4.2 Primary Data & Analysis:

Information was collected by conducting Interviews and also simulation of bungalows in span of 5 years were done this is how primary data was collected. this also guided us to move forward with our research work. we interviewed 5 architects in Pune who have specifically worked on the climatic responsive design of a bungalow.

According to many of the architects we interviewed the main outcome was there are many ways to handle a site with a climate responsive design but the can be narrowed down according to the context and location of the site.

Analysis:

generically speaking the design process of every architect starts with the context and site analysis, later according to specific portions elements like courtyards, and wind towers are added, after a specific stage functionality of the form is checked in accordance to the end user also the comfort factor is keenly focused on along with the planning considerations climatic considerations are also kept in mind. architects have suggested to use these strategies while designing.

1) designing in levels is suggested

2) proper orientation according to the site is suggested. We have specifically considered these points during the simulation study which was observed to be implemented in their projects.

XII. DISCUSSIONS

It is understood from the interviews that, Architects designing for the Pune and its Peri-Urban areas should focus on the qualitative aspects of the local climate, social health, and aesthetics along with the functional qualities of the habitat. It is possible to achieve these standards in case of a residential bungalow, although, the mass housing should focus on these aspects as well. All the five designers practicing in Pune have endorsed the possibility of achieving the design quality even in the mass housing projects through their own projects. They explained the demonstrated process of design to achieve the same in the mass housing projects. They have emphasized on the following aspects to be considered for a climate of Pune.

- i. Optimize the built form for its orientation specific to the site and site surroundings.
- ii. Ensure daylight and natural ventilation to the optimum level.
- iii. Use of sustainable materials for construction.
- iv. Use of courtyards for a climate response and social health of the habitants.

To analyze further, solar radiation analysis was simulated for the identified sample cases. The analysis period of solar radiation was considered to be between February 15th to October 15th. The time for solar radiation analysis was considered to be for 12 noon to 3 PM to ensure maximum

radiation falling on the built form. The analysis results were compared for its qualitative analysis with the design process and design decisions explained by the Architects. Through the simulation study it is established that the implementation of design decisions yields the desired results when all the above-mentioned aspects have been followed. Further through this study the correlation of width of the courtyard to height of the surrounding walls is established as explained in the Conclusions section.

XIII. CONCLUSION

Qualitative analysis of the solar radiation simulation study shows that, for a climate of Pune, following should be the fundamental considerations to be included as design decisions at the ideation level.

1. The built form should be optimized for its orientation in relation with the site.
2. The longer walls should orient in the N-S axis.
3. The built form should include the courtyard as an essential element of design.
4. The courtyard should be surrounded by walls in a ratio (for height of the surrounding walls to the width of the courtyard) ranging from 1: 1.5 to 1: 3.6.
5. The roof optimization, creating levels in horizontal plane ensures comparatively low radiation

In this Research we came to know about the transition of the design of a habitat located in Pune. This study found several aspects that are still been followed.

I. The timeline study was as under

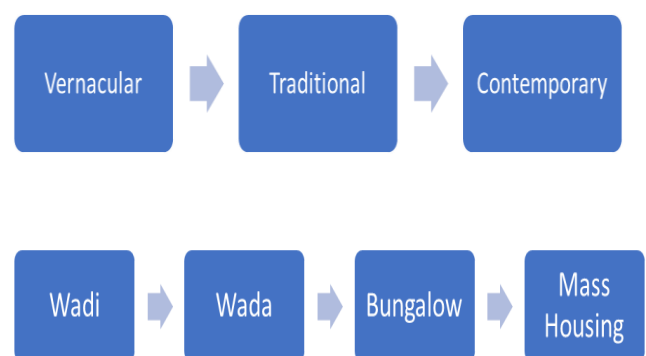


Figure 17 Timeline Study Of Buildings

II. We Propose that the designers of Pune should apply the learnings from the Traditional wisdom.

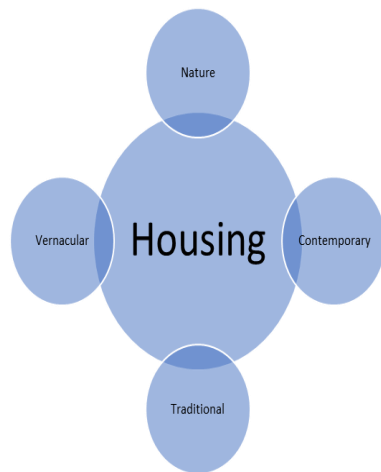


Figure 18 Traditional Wisdom

- I. The literature review was broadly based on 2 objectives
 - a. Overall of process of design followed by architects practicing in Pune
 - b. Component of Process that addresses to the climate of Pune
- II. The secondary data collected through
 - a. Documentation of vernacular and Traditional habitats
 - b. Documentation of contemporary bungalow and mass housing project
- III. Primary data collection
 - a. Interview of the designers of the identified sample cases for Wada and contemporary houses
- IV. Research Findings
 - a. Process of design
 - b. How is the response to climate in the process of design?
 - c. How is the response in a wadi, in a Wada and in a contemporary house?
- V. This study proposes the following parameters for a further analysis

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