GEOMANTIC STUDY OF HOMESTEADS IN BANGLADESH FOCUSING ON MAXIMS OF "KHONA"

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DEDICATION

To my adviser

Dr. Qazi Azizul Mowla

For guidance and encouragement

And my parents

Mrs Salma Khanom

Mr.Jahangir Faruque

For moral support and encouragement

ABSTRACT

Geomantic studies are focused on the geo-climatic context and other cosmic settings of a region as applied in the built environment design. Bangladesh is a unique country in terms of its socio-cultural background. Its special geographical and climatic features make it in many ways distinguishable from any other region. The built environment of a region is an integral part of its heritage, which has evolved in harmony with the needs and resources. There are some beliefs all over the world, connected with traditional built form. There were some taboos and beliefs regarding the homesteading in our region as well, for comfort and safety in the built environment. Khona's Maxims deals with such a set of belief. The beliefs and maxims that are directly or indirectly related to built environment designs in Bangladesh is the subject matter of this study. Traditional wisdom in settlement and homesteading is supposed to be sustainable but has never been studied by built environment design professionals particularly in Bangladesh. For sustainable living our built environment need to fit into the natural environment, therefore, this study has been conceived. Bangladesh is at the crossroads of two gigantic civilizations having two built form heritages.ie. Vastu Shastra and Feng Shui and have borrowed from both. Bangladesh is geographically and culturally more akin to Vastu Shastra and the local maxims like "Khona's bachan" can be better explained with it. Towards that end, certain cases were identified for analyzing Khana's maxims.

…If the roots are alive…..it gives rise to new shoots... (Patrick Geddes). The main intention of the study is to rediscovered and redefines the local maxims related to built environment and analyze those with rational norms. The samples were analyzed in terms of parameters set by 'Khona' like-Site layout, Building Design (in terms of orientation, shape and volume, types of forms of buildings, openness and shading, Plinth height, roof, walls, building materials, airflow and openings, ventilation), external spaces, courtyards, landscape, water body etc. It shows that Khona's maxims are a sort of ancient building by-laws for sustainable homesteading in Bangladesh.

Khona's maxims were cross checked vis-à-vis Vastu Shastra, contemporary standards, and findings. The comparative analysis of the maxim's of Khona, Vastu Shastra, Contemporary concepts for sustainable design in the warm-humid climate both in the urban and rural context in Bangladesh provides rationality and validity to this ancient local wisdom of homesteading. Field survey confirms that adherence to Khona's maxims in the built-environment design does bring the built environment to a comfortable and sustainable level. Development of Checklists for application in the contemporary design of built-environment, vis-à-vis building bylaws in Bangladesh is proposed to be the outcome of this study and it can be rightly claimed that this study is the first attempt towards a serious geomantic study on the built environment in Bangladesh, and Khona's maxims does show relevance in the present context.

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Glossary of words

Rural words	Meaning
Bari	homestead
Ghor	House hold
Gram	Village
Para	Neighborhood
Dheki ghor	locally made rise husking rectangular shade
Boithok ghar/khana	Guest room
uthan	open courtyard
pukur ghat	bathing steps
boshoth ghor	main dwelling unit
ranna ghor	Kitchen
Gola ghor	granaries
goyal ghor	cowsheds
do chala/chuchala	Pitched roof
Pak ghar	kitchen
Gosol khana	Bathroom
paikhana	Toilet
Ghor	Room
Khaoar Ghar	Dining room

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Chapter 1: Preamble

Background

Research questions

Objective of the research

Research Methodology

Instrumental Data

Scope of Work

Summary

Chapter 1: Preamble

1.1. Background

Geomancy is a growing science to interpret traditional wisdom drawn from geo-climatic or cosmic forces (Lakshmi, 2000). It is known that there is a close relationship between architecture and its geo-climatic environment (Wang, 2016). Ancient sciences of architecture are basically a combination of rules and rituals being applied by the master builders or the local craftsmen. These rules were applied in almost every traditional culture, which is also evident in their ritual behavior and folklore literature (Fazeli and Goodarzi, 2010). It seems that involving the climatic factors with the prevailing beliefs of each community which defines its culture, may provide the individuality of its traditional built space. There are few dominant beliefs of ancient times that has sustained till to date, like "Vastu Shastra" or "Feng Shui". Chinese Feng-Shui and Indian Vāstu-Shāstra are two of the age-old and well-known architectural traditions of the world (Huang, 2012).The main concepts of this wisdom are to deals with the harmonious relationship between human being and nature. Basically, all the ancient wisdom is based on knowledge and experience related to the built environment that has been accumulated through thousands of years. Bangladesh is an ancient land, a habitat of a struggling people who have been undergoing both physical and metaphysical metamorphosis over the ages (Zamir, 2003). All the external rulers excepting the British could be tempered and later on could be assimilated with the local people and culture (Mowla, 1999). They gradually adopted the local system and norms to create a hybrid one. The roots of traditional architecture and settlements of this region are dug deep into the psyche of the common people (Mowla, 1985 and Haq, 1994). As we can see, Architecture of this country has eked out of the geo-climate of the region, while accumulating the societal norms and traditions of the people (Islam, 2003). The forces of history and tradition of settlements in this country are holding diverse ethnic, imperialistic cultural and religious beliefs. Certain physical and cultural factors not only act as constraints but also as the source of ideas for the formation of the settlement, family structure, art, and architecture in Bengal. Topology, climate politics, and economy are the foremost factors behind it (Mannan, and Barua, 2017).

Like any other part of the world, traditional architecture showed its sustainability with their harmonic relations and balances within the surrounding society and environment and also with their specific character of forms and spatial relationship (Kamrul, 2003).The vernacular built form holds the heritage of the country's long history and traditions. It is found almost everywhere in the world that there are some taboos and beliefs related to traditional built form. That's why the vernacular built environment of this country is strongly related to the traditional wisdom, which still has a strong influence in the contemporary context. Khonar Bachan in Bangladesh is one of such traditional beliefs. Khona who is considered in the literature as a wise lady of olden times,

who authored the famous sayings (on life and living in this region), including on architecture and settlements, which are still popular in the rural society of Bangladesh (Islam and Miah, 2014). The main intention of all her sayings is to ease up and promote sustainability and livability of a settlement. In ancient time architecture was practiced without formal architects. This traditional wisdom acted as building code and guideline of the ancient. As a matter of fact, all the old sayings related to buildings and settlements are a guideline for sustainable built-environment. Therefore, the sayings of "Khona" are taken here as a case to investigate their significance and relevance to the Homesteads and built- environment context. For identifying the maxims suitable for application in the built environment and for its scientific validation the research aims to analyze the environmental performance in terms of solar radiation, daylight analysis of the indoor of homesteads based on built environment parameters and thereby Develop a Checklists for application in the contemporary design of built-environment.

1.2 Research questions:

What is the relevance of Khona's maxims regarding built environment in the contemporary context?

1.3 Objectives of the research:

a. To study the geomantic context in the built environment professions.
b. Compiling and examining the relevant maxims of "Khona" and its influence in the homesteads and settlement of Bangladesh, vis-à-vis scientific norms.
c. Reinterpret the maxims of "Khona" and finding their relevance in the contemporary built- environment context.

1.4 Research Methodology:

i. Relevant literatures will be reviewed to determine the key concepts and develop an understanding to prepare a theoretical background and checklist in order to carry out the field survey and analyze the data (refer to chap. 02).
ii. Collect information to understand the social and psychological needs and the situation of the primary users, on the basis of their past, culture, religious practices and leisure.
iii. Connect with **Living Heritage** to identify and to continue the traditional wisdom. Especially in the case of Geomancy.
iv. Environment Behavior Observation Studies would be mainly used in this study. Human activities are influenced by the built environment and vise -versa. It is known that People's behavior responds towards his context and environment, on the contrary, the environment in which they are living, affects their behavior.

"Environment-Behavior Observation Studies" is a multi-disciplinary field that advocates a greater involvement of users and a more detailed consideration of user aspects of the design process. The term 'environment-behavior Observation studies' communicate to several others like 'environmental psychology', 'human-environment studies', 'human factors', 'behavioral architecture', 'social ecology' or just 'programming'. The applied facets of environment-behavior studies are often called 'user needs' or 'social and behavioral factors'. The most inclusive term, however, is 'environment-behavior studies' (EBS).

It can be said that in the field of architecture, EBS include the systematic inspection of relationships between the built environment and human behavior and their application in the design process. Therefore, inquiry strategy would see the 'environmental cause' and its 'spatial effect'. Other tools would be used to complement EBS study. It was needed for observing the relationship between physical environment and different human behavior/reaction and response. After collecting the data from the site, the findings would be used as guidelines for framing and modifying strategy for planning, design, and construction.

v. Identifying the maxims suitable for application in the built environment design in Bangladesh focusing on "Khona" (refer to chap. 03)**.**

vi. Categorization and compilation of selected wisdom and relevant sayings of "khona".

vii. Observations and field investigation on their practice / relevance in the contemporary context and Reconnaissance survey for sample selection and sample study.

viii. The social response would be assessed through observation and unstructured questioner survey.

ix. Handy tools would be used to evaluate environmental parameters.

x. Critical Analysis and Synthesis vis-à-vis scientific norms, by-laws and research.

xi. Development of Checklists for recommendation to apply in the contemporary design of built-environment as building by laws in Bangladesh.

1.5 Tools Used in Field Survey of Environmental Parameters:

Before final instrumentation for data measurement, a pilot survey was conducted in many different homesteads. For conducting the survey a set of instruments were used. The following portable instruments were used.

1.5.1 Description of tools

I. Digital Thermo-Hygrometer

Used to measure temperature and humidity. Thermo-Hygrometer model PH1000 displays humidity over the range of 10 to 99%rh and temperature over -50 to + 70°C or equivalent °F with a 0.1°C/°F resolution. It also incorporates a 12/24 hour clock. Instrument is housed in a white ABS case which has a foldaway stand and keyhole slot for wall hanging.

Reads temperature and records maximum / minimum temperatures the unit has been exposed since the last time the unit has been reset.

Figure1.1: Temperature and Humidity Digital (Thermo-hygrometer)

II. Instek GLX-301 Light and Illuminance Meters

The GLX-301 digital light meter is a hand-held device ideal for on-site measurement of light quality. In addition to the 270g lightweight , two measurement units, Foot-Candle (fc) for

Imperial system, and lux for metric system, ensure operation is available anywhere. A separate light sensor for optimum position measurement enhances measurement sensitivity.

Figure 1.2: Digital Light Meter

1.5.2 Data gathering strategies:

Temperature Data measurement process

Digital Thermo-Hygrometerwas used to record the average inside room temperature of different hut in the location in different orientation and relative humidity of the surveyed homestead. The data was collected at the same time in different hut of a homestead.

Day light measurement process

Instek GLX-301 Light and Illuminance Meter was used to measure available day light within the different location of living unit spaces at worktop level. Measurements were taken beside window, beside door and at the center portion of the living units.

1.6 Limitations of Study

The main limitation of the study is the availability of resource materials, the maxims that are available are mostly of oral tradition. Some compilations are available, mostly done by literatures' peoples. To the best of our knowledge architects, planners and engineers have never studied those maxims for use in their design.

As this would be the first study in Bangladesh by a design professional, the study will look disjointed. From a huge number of maxims, it is yet another herculean task to screen out only the maxims that are directly or indirectly related to built environment designs. The geomantic study is a relatively recent phenomenon in the world context, as such, there is a real shortage of literature and scientific findings.

Screening out the maxims related to built environment and analyzing those with a rational yardstick is a time-consuming process, therefore secondary source materials are used to ground them scientifically. Due to the time constraints, only limited scale field work is possible, to validate the maxims in the context.

Within this time and resource constraints, this study is expected to be carried out and is the first step towards serious geomantic study in Bangladesh.

1.7 Scope of Work

- The domain of the study is based on literature reviews of different bachans and to find out the current situation in existing built environment.
- The study also asses that all the traditional wisdom played an important role to guide and shape our built environment.
- The present study tries to establish and explain that the practices of Khona's maxims are valid till now and has a rational basis.
- Evaluate Khona's maxims vis-a-vis building bylaws, practices and research.

1.8 Summary of Research Process

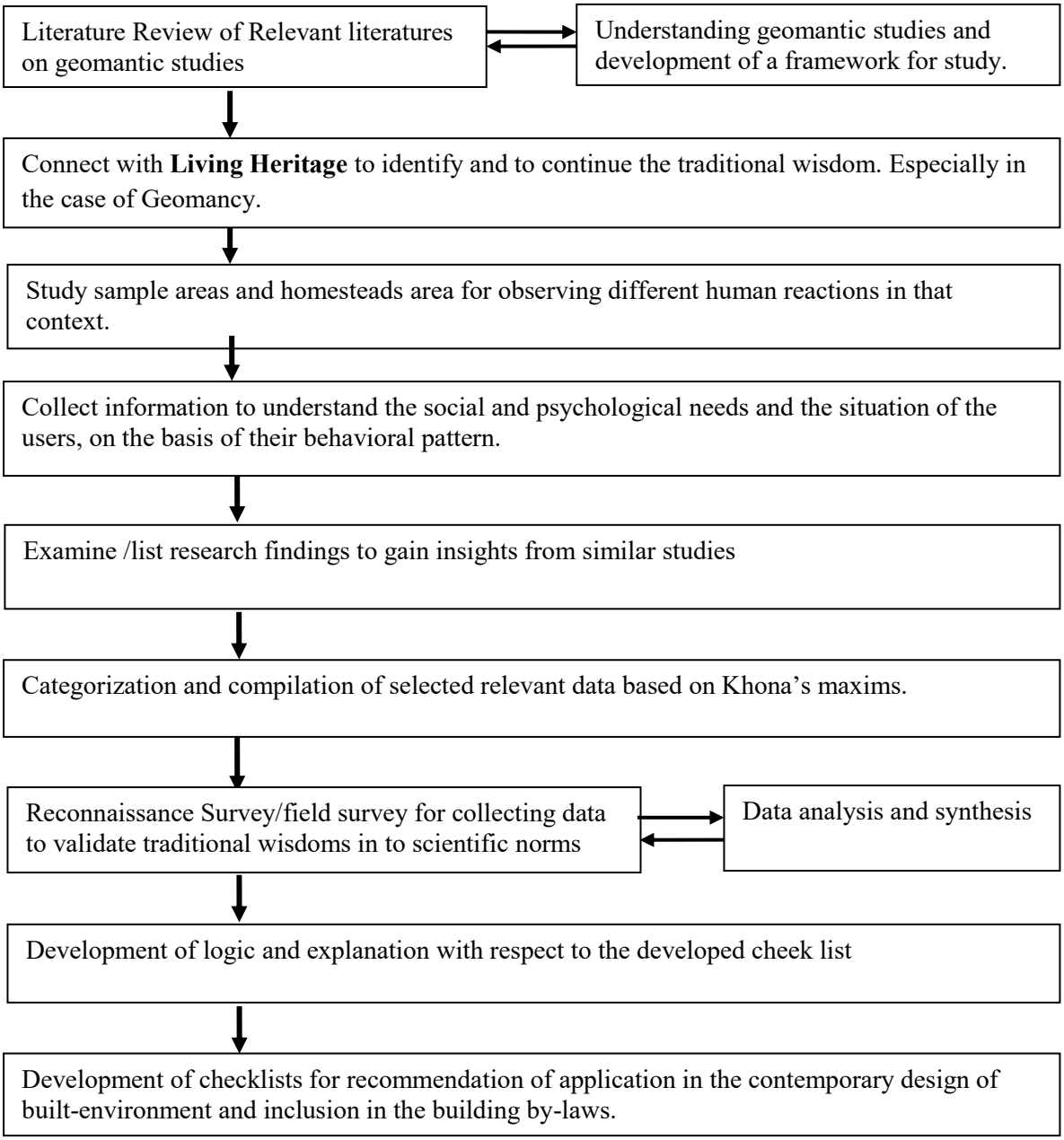


Figure 1.3: Flow diagram of the research process.

The research was started to bridge the gap between the past and present homesteading and also to learn from the wisdom of the past for sustainable living (section 1.1). With the gradual development of the research from the literature review and incorporation of research findings at each stage, on the basis of objectives, methodology, and limitations of the research to make it more definite, distinguished and comprehensive. Figure 1.3 presents a summary of the research process in relation to the objectives, methodologies and concerned chapters.

Chapter 2: Literature Review

Preamble

Definition of Geomancy

Maxim of Khona and her historicity

Categorization and compilation of selected wisdom of “Khona”

Homestead’s Of Bangladesh and Its Determinants

Development of checklist Vis-À-Vis maxim of Khona

Summary of cheek list

Chapter 2: Literature Review

Preamble

The practice of geomancy can be defined as putting humans, their habitats, and their activities into harmony with the surroundings. Throughout history, we identify the traditional rules that are classified as geomancy in every region, noted as the building regulations in the past which originated on the basis of natural constraints and concerned with the sustainable, healthy and safe environment. In fact, the regulation of building construction is not a recent phenomenon. One of the oldest known traditional wisdom of early civilization is the Code of Hammurabi. According to Wikipedia Hammurabi was the founder of the Babylonian Empire over 5,000 years ago. Who reigned from approximately 1792 BC to1750 B.C., is probably best remembered for the Code of Hammurabi. Today, society no longer endorses Hammurabi's ancient laws but in that time his rules assisted in preventing accidents and loss of life and property. Similarly, Vitruvius the famous Roman architect during the 1st century BC, who resolves that the building codes, property boundaries and the relation between neighbors are often of decisive importance in the design of a building. Codes and standards serve many purposes, but their main intention is the overall betterment of the built environment. Their role is particularly important as we work toward the challenges of a safer and more sustainable built environment. In many ways, we consider these rules as bindings. However, these rules and regulations provide a point of measurement to facilitate our lives. In this sense, these traditional wisdom provide the practical foundation for a better living.

2.1 Definition of Geomancy

The Oxford dictionary declares, "Geomancy-is the art of placing or arranging buildings or other sites auspiciously." "Geomancy in its simplest form is a method of divination. The term geo is derived from the ancient Greek goddess of the earth, Gaia; mancy means to divine, divination. According to Tom Graves (1978), author of the landmark book, Needles of Stone, "geomancy literally means 'divining the land, and is concerned with creating an understanding of our relationship with the spaces in which we live, at every scale from a bedroom or an office desk right up to the landscape as a whole" (Hummel, 2004). Geomancy is also a holistic philosophy for understanding the earth and mankind's place upon it. Geomantic philosophy assures us that we are one with the earth and that the energy of the earth is the very force from which we draw our lives (Dannelley, 2001).

Actually, Building codes were the regulatory force in the practice of architecture during ancient times as they are today. However today, building's codes are formulated by changing external constraints of the urban environment, whereas, in the past, balance and harmony with nature to create a sense of mental and physical well-being were the only determinants. This may sound like

an obstruction, but if one delves into the sacred texts and principles that dictated form and defined space in the past, one discovers a fascinating tradition of sacred geometries and metaphysical concepts directed at harmonizing the manifest world with the non-manifest, the physical world of matter and form with the cosmic truth of the Infinite. Call it Geomancy or simply the magic of numbers, there was nevertheless a sound scientific and practical basis to the wisdom and practices of the ancients as is being rediscovered today. In a nutshell, we can define that Geomancy as the "Traditional Wisdoms based on the Geo Climate for the creation of sustainable built environment".

2.1.1 History of geomancy

The word Geomancy was familiar to almost everyone all over the world less than four hundred years ago and professional geomancers were as common in most communities as psychologists from that time to till now. Countless literature handbook of Geomancy were published in the sixteenth and seventeenth centuries. These drew, from an even larger collection of geomancy literature, from the European Middle Ages, in which geomantic divination formed the core of a complete system of Earth wisdom with many practical and spiritual applications.

Veritably, the origins of geomancy are shrouded in mystery, but the historians agree that the first manuscripts describing the practice appear in the advanced Islamic civilization of the Middle East. Nobody is quite sure where the Arabs apprehended it. But it first surfaced in North Africa sometime during the ninth century AD. One plausible theory suggests that it was an adaptation of older African divination systems, many of which use the same basic figures and interpret them in similar ways (Greer, 2009). From there it spread to Europe in the 11th and 12th centuries as part of the reception of many arts and sciences, including the occult arts of astrology, alchemy, and magic by the rapidly civilizing West (Astrological Geomancy, 2006 viewed 4 August 2017). Geomancy had several names in Arabic language but the most famous name in Arabic as ilm al-raml, meaning the science or wisdom of the sand, geomancy became quite popular as a divinatory technique because of its ease of learning and use. The highly developed Arabic traditions of geomancy eventually shifted north into the nations of Europe which lay the foundations for the Renaissance. European scholars studied and applied geomancy, writing many treatises in the process. Geomancy spread eminently in Europe and became an important part of their cultural scene. Like most of the other esoteric traditions that entered Europe from the Arabic world around the same time astrology, alchemy, talismanic magic, and so on. Geomancy soon became part of the stock in trade of the medieval magicians, and in this form was handed down to the renaissance the golden age of western occult traditions. In the hands of the great mages of the fifteenth, sixteenth, and seventeenth centuries, geomancy became an essential part of the renaissance magical synthesis (Greer, 2009). The geomantic figures were not only used to predict the future in divination, the geomantic figures became visible in many different contexts in classic texts of

Renaissance magic, such as "three books of occult philosophy" by Henry Cornelious describes several uses of geomancy in a diverse background of that time.

At the age of renaissance, Geomancy was so widely practiced by people in all walks of life that nobody gave it a second thought. Philosophers of Renaissance occultism, Robert Fludd among them, included in their books carefully reasoned arguments showing that geomancy was a natural art, drawing on the inborn powers of the human soul to glean information from the larger soul of the world. This reasoning was widely accepted all through the Renaissance, and guaranteed geomancy a place in the world. Later on, it took the religious wars and scientific revolutions of the 17th century to shatter the magical culture of renaissance and launch the modern industrial age-an age in which the ancient wisdom traditions of the west, and geomancy among them, were discarded as so merely outworn superstitions. Later on, due to the work of Robert Thomas cross and Edward bulwarlytoon, there was an increment in renewed interest in the occult. Evidence shows that Geomancy made revival once more in the 19th century.

2.1.2 Geomancy around the World

Numerous forms of geomancy were accomplished around the world. In Europe, a lot of such knowledge was lost during the Middle Ages, but the monuments to it remain. Structures such as Stonehenge in England have slowly revealed their secrets over recent years. The network of paths of subtle energy called "ley lines" that coincide with some of the most spiritual places on earth has recently come to the forefront of discussion again (Ludrup, 2012). Another outstanding example is the pyramid of Egypt, now known to be based on certain golden proportions of the dimensions of the base and height and upon the orientating of any one side of the square base of the pyramid to the magnetic north. Mathematically, pyramids are projections of hemispheres and the famous Pyramid of Cheops in Egypt, in its proportions and location is perfectly related to the dimensions of the earth (Poddar, 2003).

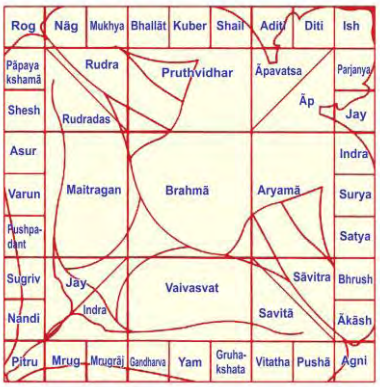
In China, the art of geomancy is called "Feng shui". Nowadays, Feng shui holds the European imagination. Feng shui initially started with the ancient Chinese geomancy masters studying the earth patterns in order to define best places for human dwellings; so, geomancy is at the very root of Fengshui (Tchi, 2017).Feng Shui is a body of ancient Chinese wisdom in knowledge and experience related to the built environment that has been accumulated for more than three thousand years. The principles and practices of Feng Shui aim at creating a harmonized built environment for people to live in, and it represents a traditional Chinese architectural theory for selecting favorable sites as well as a theory for designing cities and buildings (Chen, 2013). Other parts of the world have similar arts. In Africa, it seems that Geomancy means "divination using earth or stones to foretell the future". Another most famous example of geomancy is Vastu Shastra, the most well-known and Feng shui counterpart, is also considered a geomantic art, and so is dowsing (Tchi, 2017).

Vastu Shastra is very similar in many ways to the Feng Shui. Vastu is a derivative of Feng Shui and has completely evolved in India, being practiced regularly. Moreover, many cultures have

geomantic traditions that have been tied to space energies as a method of being custodians and curators of the land or to define harmonious siting. Some of the examples are Australian aboriginal - Rainbow Serpent, sacred sites, songlines, Chinese Feng Shui - Dragon veins, Hindu system of Vastubidya (Vastu Shastra) Vintana in Madagascar, etc.

Australian Aboriginal - Rainbow Serpent

Chinese Feng Shui Dragon veins



Hindu system of Vastuvidya

Figure 2.1: Symbols of Some of the examples are Australian aboriginal - Rainbow Serpent, Chinese Feng shui - Dragon veins, Hindu system of Vastu Vidya (Source: Wikipedia)

2.1.3 The traditional wisdoms and the mysterious energies within and around us

Historically, individuals did not engage in architecture merely to construct a form for defining space. Close inspection allows us the understanding that the conceptualization of forms involves the consideration of understated natural and built impacts of the environment on the body, by all cultures. Subsequently, the most doctrine of conventional architectural guidelines is extracted from the environment, specifically the impact of earth energies. Energy fields existing on the earth which affect humankind on earth are depicted as earth energies. As we know Geomancy deals with the energies of the Earth

The Energy Grids

The considerable amount of powerful energies that exist on earth include Bio-electro-magnetic (BEM) radiations, water energy, energy radiations due to subsoil streams, geomagnetic energy, terrestrial electric fields, gravitational force, artificial radiations due to electrical installations, modern equipment etc.

Bio-electro-magnetic (BEM) radiations

The BEM fields are a form of natural energies which have the property of both electrical and magnetic fields. Previous researchers of two decades have proved that telluric radiations from earth surface have a different width, intensity, and intramural distances. Three fundamental grids have been identified as crucial to man and are associated with very high energies. These grids are called major, principal and normal (Matanhelia,1996).

Telluric BEM grids differ in intensity over the days of the year, as affirmed by research conducted in the Indian subcontinent. however, the cyclic variations have established patterns.

Geomagnetic Energy

"When a magnetic needle is suspended freely, free from any outer influence, it ends rest along the north-south direction of the earth's magnetic field," which proves the existence of magnetic energy field of the earth (Kumar, 2001)."

Earth is a giant magnet and its magnetic energy is known as geomagnetic energy. Basically, the earth is composed of a metallic (iron and nickel) inner core in the same size as the Moon. Both iron and nickel are good conductors of electricity. In this core, due to a high-temperature gradient, strong convection motion is set up, which when superimposed on the daily rotation of the earth, can form an ideal dynamo- an electrical conductor moving in a magnetic field will generate a flowing current and in consequence an associated magnetic field. Over the surface of the earth, the geomagnetic field varies from the vertical field strength of the geomagnetic poles of 0.63 Gauss (63999Nt) TO 0.36 Gauss directed horizontally at the equator. The average field strength is known to be 0.5 Gauss.

The natural earth magnetic field is an important orientation factor for all living beings. It is obvious that every biological process; every cell is oriented to this magnetic field. Some scientists are of the opinion that since we have iron in our blood (as a component of hemoglobin), we are liable to get magnetized. Each iron particle would then act as a small compass needle and react to the unnatural external magnetic fields.

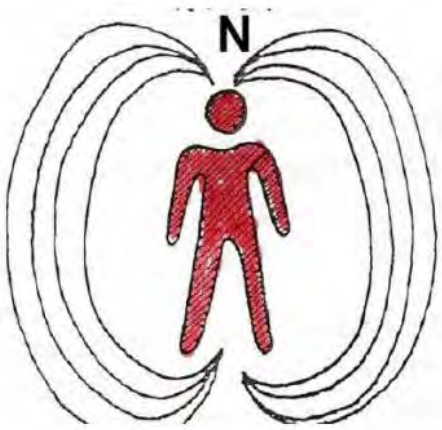


Figure 2.2: Man as a Micro Magnet (Sonal, 2012)

Effect of earth energies and our sense of duty

The actuality is that as we reside on the earth we are bound to get affected by the earth energies. Like every object in this universe, our bodies are also made up of atoms which reverberate continuously in space. This reverberation is bound to cause emissions of an electromagnetic nature, which can be associated with characteristic wavelengths and generally high-frequency levels. The energy level interaction between our bodies and the earth's radiations takes place constantly. Several health problems arise during the geo biological faults. It can be established

that the earth energy affected us and our environment in profuse ways so it would be a gross error to disregard the same while designing buildings. The designing building is, in reality, an investment for a lifetime. Thus it must be built in a way that does not risk health and environment. Surrounding and the positive energies must be taken into consideration. We must consider the orientation of buildings according to their forms, materials used, proportions etc. It is because this design consideration plays a vital role in creating either the right or harmonious environment, or a wrong and negative environment that affects us socially, psychologically, mentally and spiritually. In that case, we can follow our ancestors who had an exact knowledge of the energy field and their effect on our body. We should have to work with the earlier example what our ancestors kept behind us. We must mention an outstanding example the pyramids of Egypt. It is very renowned Golden section found in the great pyramid of Egypt for its golden proportions of the dimensions of the base and height proportions and location is perfectly related to the dimensions of the earth and upon the orientating of any one side of the square base of the pyramid to the magnetic north.

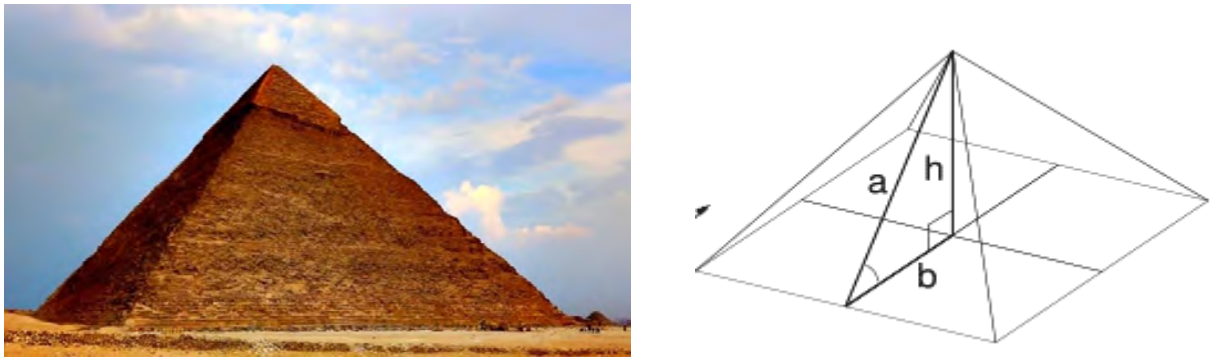


Figure 2.3: Golden section found in the great pyramid of Egypt (Abdul, 2015)

Another the Chartres cathedral, France is a well-known architectural marvel. Legend has it that the cathedral is placed over underground water channels. The altar is placed at the point where water ran under the church to give the necessary permanent vibration support. An interesting but unexplained point here is that the height of the dome (37m) is equal to the depth of the underground water channels.

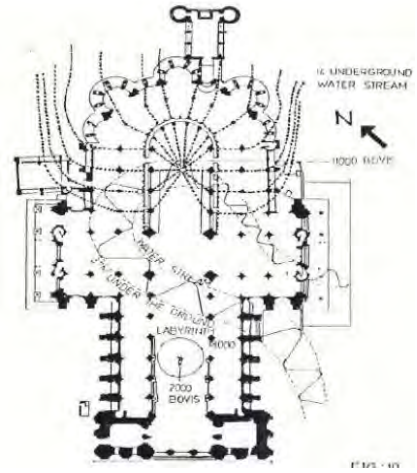


Figure 2.4: Chartres Cathedral, France (Sonal, 2012)

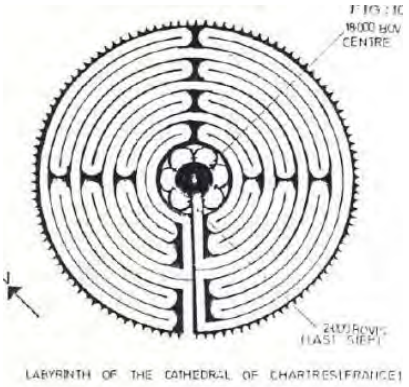


Figure 5: Chartres Cathedral, France

While designing an architect must be apprehensive of these factors. Taking the earth energies as a design Consideration is ultimately left to the architect's carefulness. We should keep in mind that Man- as a sensitive bio indicator- is bound to react to a harmonious built environment, which would also lead to the diminution of social and psychological problems which are faced by our modern society.

The traditional wisdom

Archaic studies of architecture are the consolidation of rules and While designing an architect must be apprehensive of these factors. Taking the earth energies as a design Consideration is ultimately left to the architect's carefulness. We should keep in mind that Man- as a sensitive bioindicator- is bound to react to a harmonious built environment, which would also lead to the diminution of social and psychological problems which are faced by our modern society. While the instructions are adapted from the environment. Among these guidelines, Feng shui and Vastu are the most popular and practiced in present. Both deals with the principles designed to make the most use of the environment and more specifically climate as one of its dominant factors.

2.1.3.1 Feng Shui:

Feng Shui, the Chinese geomancy literally meaning "wind and water", is an ancient traditional Chinese knowledge that aims at creating a harmony among environment, buildings, and people. One definition that has been put forward is: According to John Michell "the art of perceiving the subtle energies that animate nature and the landscape, and the science of reconciling the best interests of the living earth and those of all its inhabitants". It has played a significant role in the design of most traditional buildings in China for thousands of years. It is found to be associated with many beliefs, including Taoism, Confucianism, Buddhism, Shinto, and Vastu Shastra.

As mentioned, In Professor Sang Hae Lee's PhD thesis "Feng shui: Its context and meaning" (1986), he recognized that the principles and practices of Feng shui aimed at creating a coordinated built environment for habitation, and embodies the traditional Chinese architectural theory for selecting appropriate locations and theories for designing cities and buildings.

Factors influencing the Development of FengShui

The origins of Feng-shui can be traced to the Western Zhou dynasty (1100-771B.C.). At that time, a primitive form of geomancy was used to determine locations of houses or graves (Chen, 2013). In fact, Fengshui's development was influenced by China's geographical configuration. There are two main schools of thought and practice in Feng Shui: The Compass School and the Form School. The Form School approach has been well recognized and widely accepted by Feng Shui researchers as it comprises the scientific bases in the analysis of built environment (He, 1990;

Cheng & Kong, 1993). The Form School established a holistic approach that allows integrated components and elements to be considered for the built environment (Mak& Ng, 2008). The five fundamental concepts of Feng Shui in terms of environmental design are summarized as below.

- **Unity between Heaven and Human**

This is the fundamental principle of Feng Shui, it describes the coordination between the universe, earth and human energy. Energy is valued in both the physical and the invisible forms known as "Qi" (natural energy or breath of life) in traditional Chinese Feng Shui culture. Feng Shui designs are projected towards a balanced and harmonious environment that can produce an ample amount of good Qi and filter out the bad Qi (Skinner, 1982). Similarly, the practice of Fengshui is the modification of the flow of qi along the surface of the earth. The whole universe is seen as a living organism. Landscape and all nature were interdependent and part of an irrevocable symbiotic relationship: "Everything depended on everything".

- **The Five Elements Cycles**

Ancient Chinese believed that in the universe, including heaven, earth, and human beings, everything has an attribute according to the five fundamental groups of substances, these being: fire, water, metal, wood and The characteristics of each of these five elements and their mutual relationships are based on observed natural phenomena, and their relationships are identified as productive and destructive cycles as shown below.

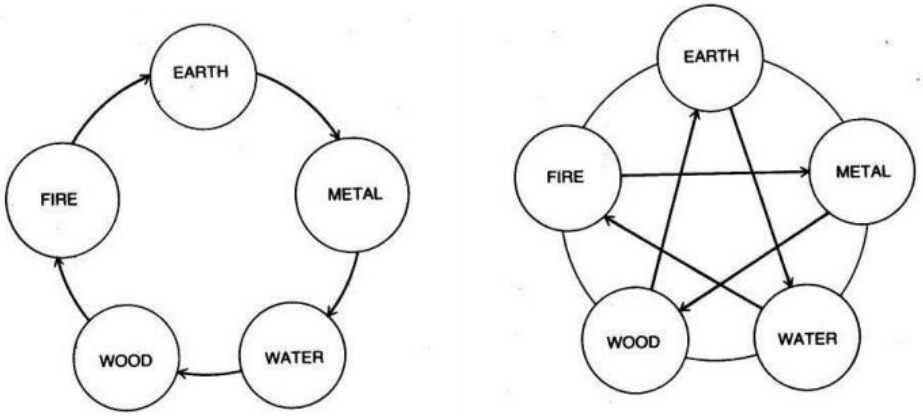


Figure 2.5: Productive and Destructive cycles of the Five Elements (source:Walters, 1989)

- **Yin and Yang Harmony:**

Feng Shui aims to achieve a balance of the opposing characteristics in the world around you, which are known as **yin and yang**. According to the yin and yang theory, everything in the universe consists of two opposing, but interconnected, forces: yin, which is feminine, and yang, which is masculine. Yin qualities are female, soft, passive, nurturing, dark, while the yang

qualities are male, hard, active, aggressive, bright. The theory of yin and yang is one of the ways you can use Feng Shui to balance your interior surroundings. On the human level, Yang symbolizes masculinity and the active, and also represents the realm of the living. Yin and Yang are about balance and harmony within a space designed to create balance in the users' life when engaging in the space (Feuchtwang, 1974).

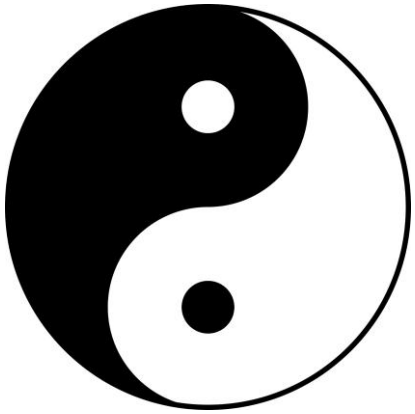


Figure 2.6: Feng Shui yang yin symbol (Source:Sofrina, 2010)

- **The form school approach**

  There are two fundamental schools of thought and practice in Feng Shui: the Compass School and the Form School. The Form School is primarily based on the verification of the physical configuration of mountains and watercourses surrounding sites and buildings. Its theory was built upon an understanding of the landscape: the profiles of the land, the sources of rivers and the terrain. The practice of the Form School first observes the land formation and terrain, and then determines the location and orientation of buildings. The development of the Form School was widely accepted by the upper class of the ancient Chinese society and attracted scholars and intellectuals to join its practice. Contemporarily, Form school approach has been recognized as comprising scientific basis in the analysis of the built environment (He, 1990; Wang, 1992; Cheng and Kong, 1993; Mak and Ng, 2005; Mak and Ng, 2008). The Form School approach considers mountain ridges, surrounding hills, watercourses, locations and orientations as the most important terrestrial and celestial elements for human dwellings because these elements represent both terrestrial and celestial Qi. These elements comprised the basic terms of the form school approach and were known as the "five Feng Shui geographical secrets ",namely ,dragon, sand, water, cave and direction (lip,1979).

(i) Dragon: means the mountain ridges to be traced, and represents the topography.

(ii) Sand: means the enfolding hills and soil condition, and represents the surrounding environment.

(iii) Water: means the flow of water through or by-passing the site.

(iv) Cave: or "Feng Shui Spot" means the niche position, and represents the best location.

(v) Direction: means the facing direction of the site and building, and represents theorientation.

The consolidation of these five Feng Shui geographical factors and the four emblems (the green dragon, white tiger, black tortoise and red bird) symbolizing the four cardinal directions produce a classic Feng Shui model. This model has been interpreted in diagrams of spatial organization of auspicious mountains and watercourses in most of the classic Feng Shui literature (Shang, 1992; Cheng and Kong, 1993; Han, 1995; Yi et al., 1996; He, 1998). A simplified model was established by Mak (2009) to illustrate the relationships between the key factors of the five Feng Shui geographical secrets under consideration and how dragon veins, the four emblems as revealed in the sand, water feature, cave and "Ming Tong" (bright court), and their respective directions were integrated.

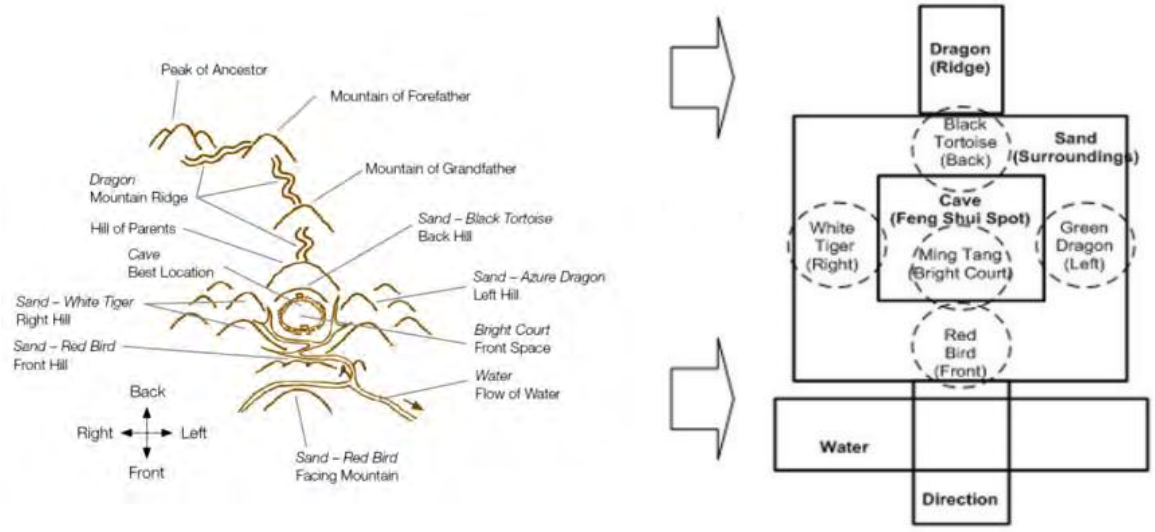


Figure 2.7: Simplified Feng Shui Model (Source: Mak, 2009)

- **Balance between Interior and Exterior Spaces**

When describing the site conditions and the design of dwellings, most of the Feng Shui texts, such as *Yang Zhai Shi Shu* (Ten Books on Dwellings of Living) categorized these aspects into Outer Form and Inner Form. According to Lee (1986), the Outer Form can be identified as the location of the site, conditions that surround the site, topographical conditions of the site and the shape of the site. The Inner Form can be identified as the layout of the building, elevations of the building,

and elements of the building. Feng Shui scholars, Cheng and Kong (1993) explained the application of the Form School approach to the design of dwellings and proposed a further classification into four design modules: surrounding environment, external layout, internal layout and interior arrangement as shown in the following Figure:

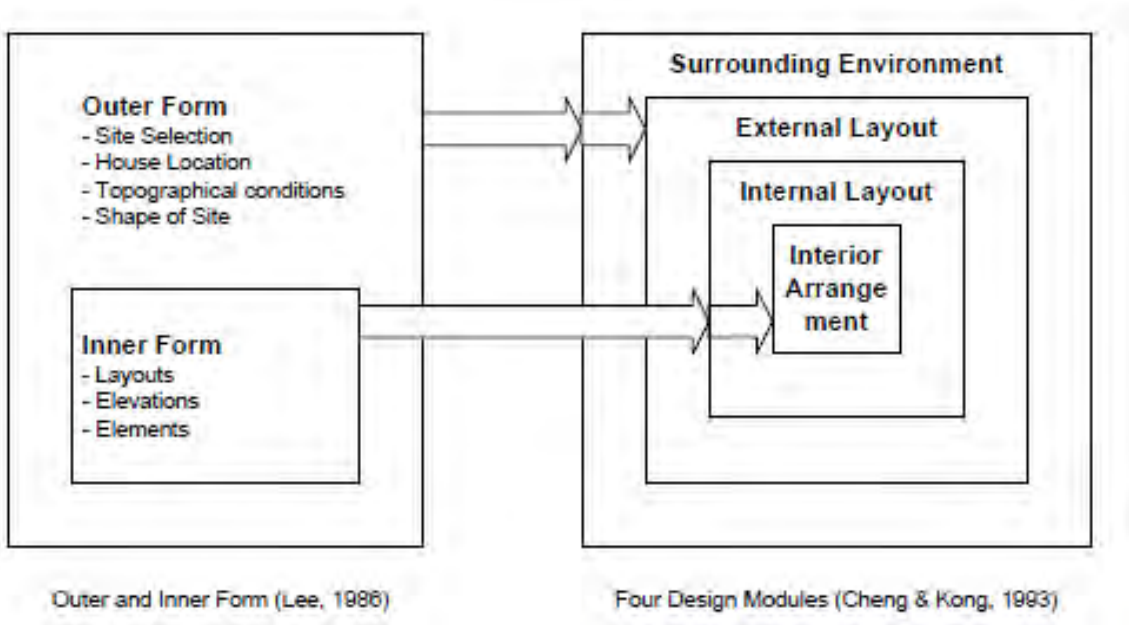


Figure 2.8: Four design modules (Source: Mak 2009)

Surrounding Environment: This aspect speculates the surrounding environment from a geographical point of view. This includes natural elements of topography, geographical features, mountains, watercourses, directions, views and man-made of roads and adjacent buildings.

External Layout: The external layout deals with the external shape and exterior space of a building. This includes the shape of the site, geometry of the building, open space, entrances, driveways, landscaping, and plants.

Internal Layout: The internal layout reflects the spatial management of a building. It considers the locations and functions of rooms, circulation patterns, internal elements of structure, columns and beams, staircases, ceilings, doors and window openings (Rossbach, 1987).

Interior Arrangement: The interior arrangement addresses the internal room arrangement and furniture placement. It considers the size and proportion of rooms and windows and doors. Furniture placement is a major part of the interior arrangement. In practice, the bed in the bedroom, the stove in the kitchen, the desk in the office etc have substantial effects on the use of a building (Rossbach 1987).

Veritably, **Feng shui** is a Chinese system of geomancy believed to use the laws of both Heaven and Earth to help one improve life by receiving positive Qi. It involves the intuitive, aesthetic adjustment of visible and invisible objects or factors, realigning all dimensions of the environment into a balanced, harmonious state.

Feng shui arm of Chinese philosophy emerged thousands of years before and is still popular today. So we can say that the Chinese geomancy "Feng shui" has a historical impact too.

2.1.3.2 Vastu Shastra

Like Feng Shui, the Chinese art of geomancy "Vastu" is one of the most ancient Indian knowledge of architecture is as old as the Vedas, which belong to the period of 1500-1000 BC.,It deals with the principles designed to make the most use of the environment and more specifically climates one of its dominant factors.

The word Vastu means to dwell and Vidya means science and so, quite literally, Vastu Vidya is the sacred science related to designing and building houses. Vastu is rooted in Vedic philosophy and the word Vastu came from the Sanskrit language. The main intention of Vastu is developing environment-friendly relations with the infinite and unknown forces of nature by assigning proper positions to the five elements of nature in the structures of buildings.

The development of Vastu Shastra

The science of Vastu is considered an essential part of Indian architecture. According to modern historian Ferguson, Havell, and Cunningham, this science developed during the period of 6000 and 3000 bc. The mention of Vaastu Shastra can be found in ancient scriptures like the Rigveda, Atharvaveda, Ramayana, Mahabharata, Mayamatam, Manasasaar, etc. From archaic literature, it can be established that Ancient Indian architecture depended on this science for the science of the building of almost all the places and temples. Vastu illustrated that all matter and energy inanimate and inanimate objects in a building, have an interrelationship with each other, connected by electromagnetic forces, and the main intention of Vastu Shastra is to create a balanced and harmonious combination of this electromagnetic wave.

The main five elements of Vastu

Vastu Shastra incorporates the five basic elements making up the world – earth, water, air, fire and space – which have an invisible and constant relationship. These elements sustain us by providing energy. A dynamic balance of matter and energy, in relation to our body, give more flexibility of body and mind, thus making life improved and pleasant (Kumar, 2002).Disharmony between these element results tension, ill health, stress, depression etc.It is possible for one to

improve their conditions by properly designing their buildings with an understanding of the effective use of these basic elements.

EARTH (Bhumi) – Earth is known for its gravitational and magnetic qualities. It is the only element that is connected to all the five human senses which is why it influences us the most. It is associated with the south-east direction.

WATER (Jala) – This is represented by rain, river, ice and gas. It is linked to our sense of taste, touch, sight and hearing. Its direction is north-east.

AIR (Vayu) – The air on earth is a mixture of various gases such as nitrogen, oxygen, helium, and hydrogen, which are essential for humans, so air is fundamental to our survival. Air relates to our sense of sound and touch and is associated with the north-west direction.

FIRE (Agni) – Associated with the sun, fire represents light and heat which accounts for day and night, the seasons, vitality, enthusiasm, passion and strength. The element of fire is related to our sense of sound, touch and sight, and its direction is south-east.

SPACE (Akasha) – Space is infinite with no boundaries. It is linked to our sense of hearing and related to the central position, known as brahmasthan

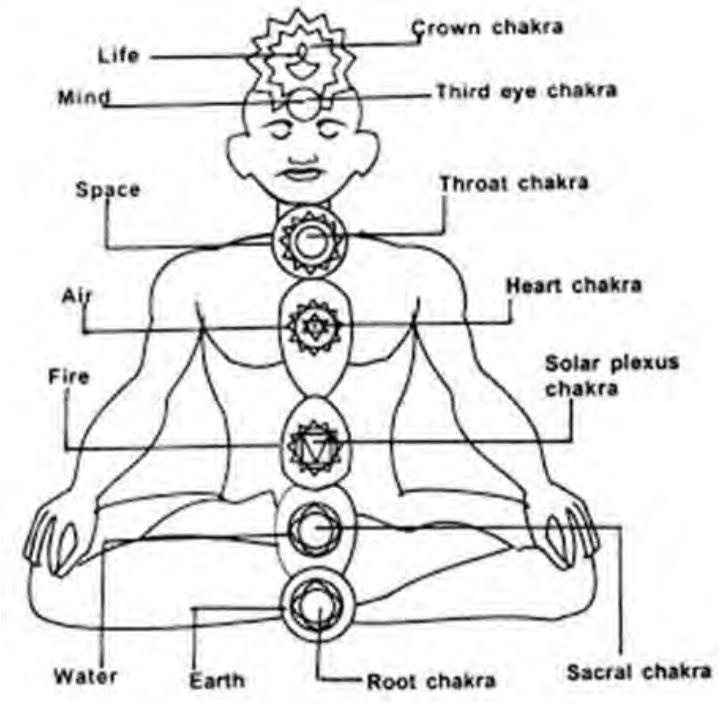


Figure 2.9: This element should be given proper places during the construction of the building(Source: Kumar, 1999).

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Basic principles of Vastu

Vaastu aims to realign the home with cosmic principles. Its approach is holistic. Its principles are ancient, yet it is unconditioned by time, country, climate or geography. Initially, it was

circumspect, but the principles gradually spread by word of mouth (Menen, 2011). Today we have been handed down the science of Vaastu Shastra and the surprising thing is that it's principles are applicable even today, because the Vastu factors namely the elements of Nature, Sun's effects, Earth's magnetic field, cardinal directions and Earth's energy fields have not changed over the centuries and Vaastu Shastra is essentially the science of manipulating the above-mentioned Vastu factors in a building, so that they are in harmony which in turn will make the lives of the inmates happy and peaceful.

There are five fundamental principles on which 'Vaastu Shastra' stands and they are:

i. Site orientation – also called Diknirnaya.
ii. Site planning – also known as Vaastu Purusha Mandala.
iii. Proportions of the building – also known as Maana.
iv. Dimensions of the building– also called Aayadi
v. Aesthetics of the building – also known as Chanda.

Site orientation:

Under Indian beliefs, the cardinal directions hold a paramountcy because the environmental factors that affect man and his buildings, like the Sun, the Earth's magnetic field and the direction of the monsoon winds were always taken with reference to the Cardinal directions. The various associations given to the eight cardinal directions (northeast, east, southeast, south, southwest, west, northwest and north) help elucidate the orientation principles of Vaastu Shastra (Chakrabart,1998).

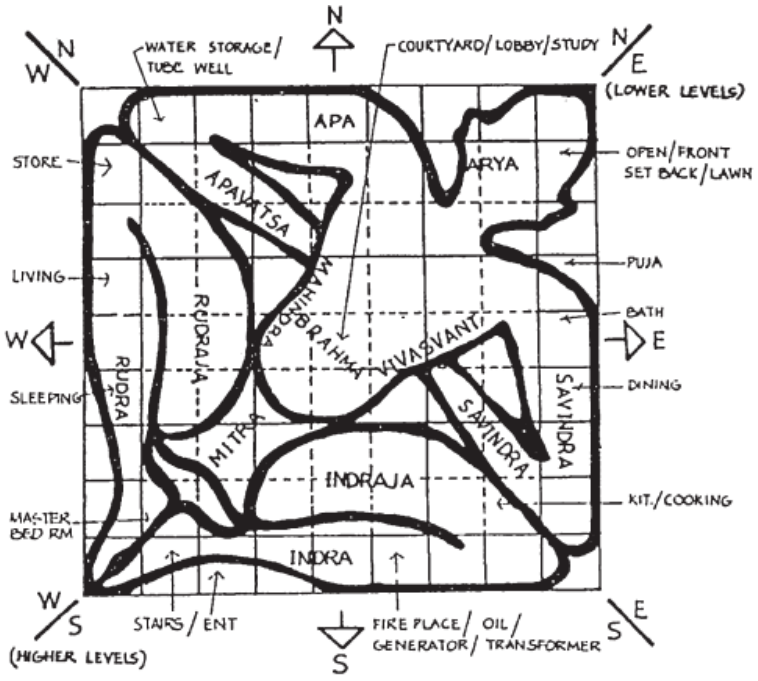


Figure 2.10: Vastu-Purusha-Mandala (Source: Patra, 2009).

Indeed, the doctrine of orientation in Vaastu, emphasis on designing buildings in such a way that all rooms get maximum benefit of the Sunlight by default and irrespective of whether the occupants desire it or not.

Site planning:

In Vaastu Shastra there are various guidelines for choosing the appropriate site. It emphasizes strongly on the examination of the soil, size, shape, taste, color, smell and vegetation features of the land. Enhanced health, wealth and happiness is constructed if a house is designed according to Vastu Purusha Mandala. In scientificallyt*his* is actually based on scientific principles wherein, the Sun, the five basic elements (panchabhutaas), the Earth's magnetic field, Earth's energy fields, and the eight directions are manipulated to create an atmosphere beneficial to man. The Vastu pundits figured out that, when the different rooms were placed according to the Vastu Mandala created by them, good disposition to the Sun, proper ventilation and lighting and privacy would be ensured in the building (Vastu Shastra Principles, 2008). *Vaastu-Purusha-Mandala* is provided for the grid that facilitates the beginning of the design, and in addition to being the 'architect's square pad', where the concepts crystallize, each of its lines and divisions holds within it layers of meaning within which the intricacies of design unfold (Figure 2.12). As purusha mandala rule the square shape become the fundamental form of Indian architecture. The square form can be converted into a triangle, hexagon, octagon or circle of equal area and retain its symbolism. Thus, Vaastu purusha is the form of human in a planned site characterized by the symbols of zodiac signs, constellations and planets, which represent the entire solar system, and make the site, house, palace, village, city etc. a micro-cosmic aspect of the macro-cosmic Purusha or Vaastupurusha (Kramrisch, 1976; Shukla, 1993).

Proportions of the building

The third basic principle of Vaastu architecture is Maana, the proportion of the building. It deals with the perfect ratio of height-to-breadth of a building, to make it look proportionate. The measurements are divided into six categories – measurement of height, breadth, width or circumference, measurement along plumb lines, measurement of thickness and measurement of inter-space. Vaastu Shastra recommends proportionate **ratios** of these 6 measurements in order to create buildings with good proportions.

Dimensions of the building

There are six main components of a building, base (Aadhistaana), column (Paada or Stambha), entablature (Prastaara), ear orwings (Karna), roof (Shikara) and dome (Stupi). The Ayaadi

formulas1 are some of the aspects analysed to assess the qualities ofthe house (Guna). In short, Aaya means measurement of building = length × breadth (Shukla 1993).

Aesthetics of the building

Aesthetics as a branch of philosophy deals with the nature of beauty. In Indian tradition, beauty is considered as *chanda*(moon.). Chanda in Vaastu literally means, a view of the contour of a structure against the sky, i.e. its perspective view. In ancient Indian architecture, the contours of buildings were different for buildings with different functions. Like this way *Vaastu Shastra* has been described as a body of knowledge, which has been sustained, developed and modified by successive generations of architects through many centuries. It means a tradition of knowledge that has, at various times, been ordered and expressed in many ways.

2.1.4 Geomantic Study in Bangladeshi Context

Geomancy a Greek word, geo - earth and mancy – divination, means "earth divination" is the practice of working with the energies of the earth. It's a growing science that describes traditional wisdom based on geo climate of the region in the formation of the built environment.

Bangladesh is a part of the Indian sub-continent. It is located on the north-eastern extremity of the subcontinent. The forces of history and tradition of settlements in Bangladesh is holding diverse ethnic, imperialistic cultural and religious beliefs, the architecture of our country has been transformed and modified in different times with the change of the rulers. The Hindu, Buddhist, Muslims and finally the European colonists made several changes in architecture especially in the urbanized area. We must know that the Topography and climate play an important role in this region. This is the main apprehension of geomancy.

If we look back to history all cultures took into consideration their understanding of the varied subtle effects of the environment, both natural and built, on the body. With this knowledge, termed geomancy, our ancestors created forms that were in harmony with the laws of that greater creation that surrounds us; forms that live not in time but have outgrown time and live in eternity (Poddar, 2003). Their form and function vary from region to region, even from locality as an expression of their sensitive response to the various influencing parameters.

If we look back to the ancient city of Mahasthan, erected 3rd Century B.C. this is the huge settlement ever developed since the Mauryan period. It is the oldest urban-style fortified settlement discovered in Bangladesh to date which had a great impact on the delta land of Bengal. This city had been going through with many civilizations, starting from Mauryan, Shingha, Early Pala, Gupta, Late Pala, Sena and the Sultanate epoch, the ancient landform of Mahasthan is distorted many times with many settlements and situation. The settlement pattern of the city was very much contextual. In a word, it was a climate responsive establishment. The architecture of

this city derived from the traditional value. Mahasthan is noted as a rectangular walled introverted ancient city, however, the city peripheral wall used to have the irregular rectangular in shape. The authenticity of this irregular rectangular planning organization is still greatly evident on the site. Most probably; the construction of the fortified walls considered and followed the natural rampart as the ancient city of Mahasthan is settled on the Paleolithic landform named Varind (Doza, 2016). All the structures of the city especially the Buddhist temple, Buddhist Monastery, stupa constructed by contextual understanding, strictly follow the climatic condition of the region. The Organic city pattern, the green vegetation background, terracotta, Bengali style pitched roofing (dochala, Chouchala), indigenous building material (Figure 2.11), Open spaces, Internal courtyard, identical plinth of the Religious buildings (Figure 2.12), all these features describe the huge influence of the topography and climate of this region in the buildings. That is the main characteristics of geomancy.

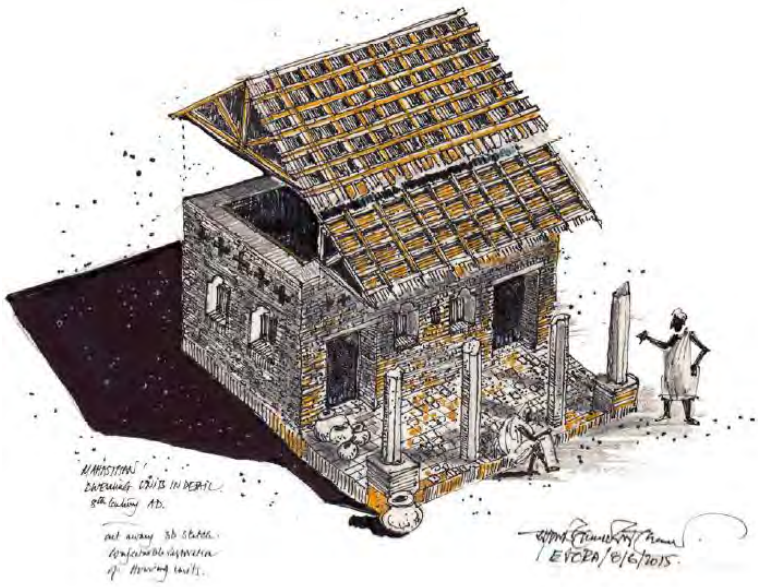


Figure 2.11: house pattern of ancient city Mahastan, The whole system of course of action, roofing with the timber framing, thatches and terracotta tiles.Extended veranda/portico with timber or stone column (Source:Doza,2016)

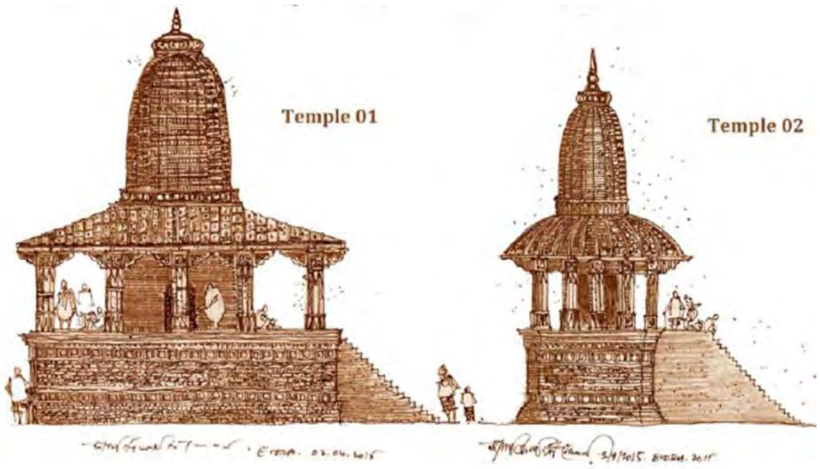


Figure 2.12: Govinda Vita Temple, two separate temple with high plinth (Source:Doza,2016)

So to clearly visualize the forces and energies which shaped the form and content of architecture in Bangladesh, it is necessary to examine buildings from ancient times to the present day. However, this is beyond the purview of this research. Geomantic facts that aim at creating a harmony between heaven, earth and human has influenced most traditional built environmental design in Bangladesh for thousands of years. As Frank Lloyd Wright said, "Folk building growing in response to actual needs, fitted into the environment by people who knew no better than to fit them with native feeling". Indeed, Indigenous architecture in Bangladesh was largely built without any professionals, but it has a clear relationship with collective consciousness, relation with the soil, cultural behavior and values and norms. The locally available natural resources as building materials, easy construction techniques, comparatively simple built form, central courtyard with extensive landscaping everything clearly establishes its regional character. Unlike, being transcribed as a part of the vernacular architecture of Bengal, it is unique in the sense that it might be modernist in principle but deeply rooted in its context. Like all around the world, geomancy was practiced in our context too. In reality, it's like a building code of the ancient time, which guides our architecture till to date and make a balance and harmony with the nature to create a sense of physical and mental well-being.

2.2 Maxim of Khona and Her Historicity

Khona is considered in the literature as a lady of olden times who authored the famous sayings which are still popular in the rural society of Bangladesh (Banglapedia,2014). The exact period of her lifespan is indecisive. Even many doubt as to her very existence. According to Wikipedia the attributed dates of her lifetime range from 800 AD to 1200 AD. However, there are some controversies, about the time of her existence. According to some astrologers, it should be from 400AD-1200AD. There are several statements regarding Khona's birthplace. According to Dr.Dinesd Chandra Sen, Khona lived in the village of Deuli in Barasat in 24 Parganas, West Bengal. Her father is said to have been one Acharya, and she was a resident in King Chakraketu's monastery for a considerable period. Nevertheless, it is only a legend, which may or may not be true. In a book review of "Khonar Bachan Krishi O Krishti" by Dr.Ali Nawaz, Khana was reffered as the daughter of the king of Sinhala (Sri Lanka).She was named Ksana (moment) or Khana because she was born at an auspicious moment.

There are many versions of her legend. The common theme is that the famous mathematician, scholar Varahamihira from Ujjain had a son, and he was horrified by the horoscope he had cast for the newborn. He thought his son would die within a year, and abandoned the child inside a vessel and let it flow with the river. The child was rescued and brought up in a distant land by demons and was named Mihir. Kalhan's Rajtarangini referred to Gauda, the then Bengal, as the kingdom of demons. Mihir later married a brilliant woman (Khona), and they traveled together to

Ujjain to face his father. In the royal court, Mihir's wife defeated Varaha in a debate. She exposed and ridiculed his mistakes in public. Unable to bear the shame, Varaha ordered his son to cut his wife's tongue. The ruins that bear her name (traditionally, the 'Mound of Khona-Mihir') lie about 40 km northeast of Kolkata, at a place called Berachampa near the town of Barasat. These ruins have not yet been excavated and studied well. There have been some excavations in this area in the 1950s, and historians think that the story of the place dates back to as early as the third century BC, judging from the Roman and Mediterranean coins found here. Archaeologists have also found artifacts from ancient times to the Maurya and the Gupta period. This is a theme that resonates in modern Bengali feminism, as in this poem by Mallika Sengupta, Khana's song:

Listen olisten :

Hark this tale of Khana
In Bengal in the Middle ages
Lived a woman Khana, I sing her life
The first Bengali woman poet
Her tongue they severed with a knife

Dr. Ali Nawaz (2011), also stated that the maxim of Khona was extensively influenced by the maxim of Dak (Daker Bachan). During the ancient time, there was some dirge base on Khona and Dak, and they used to engrave in public places. In Tibbaten Language Dak means Knowledge, the tale of Dak means Wise verse. Like Dak, Khona's maxims are also mentioned as the wise verse of olden time. According to Dak, sometimes agro-based maxims are described as the Khona'smaxims. According to pandit Horoprasad Shastri and Dineshchandra Sen "Dakarnab" is the original manuscript of Bangla language. Dr. Mohammad Shohidullah also mentioned about the Tibbeten influences on ancient Bengal (eastern Indian Subcontinent). Though Khona's maxims are very much influenced by Dakarnab. The maxims of Khona are also similar to the Indian scripture. However, she was not mentioned in the pages of Indian Astrology Scripture. Dr. Ali Nawaz (2011), said in his book "khonar bachon krishi o krishti" because she was against the ruling Hindu Brahmins; rather she followed the atheist Charvaka (Hedonist) of that time this is the reason behind her absence in the history. Nevertheless, she was mentioned in the fourteenth century in the book of "ponchoshor" by Bengali astrologer Projapoti as and in the book of Shoshti Das. It is possible that the myth of Khona was circulated in order to give an authority to the accumulated wisdom of the rural society acquired from experiences and passed on from generation to generation in her name. In a book review of "Kingbodonti Khona o Khonar Bachan" by Purabi Basu (2015), Some scholars think that before seventh century there was no book written in the Sanskrit language in whole Bengal. As a result, there is a possibility that the Magadhi language which is similar to the Bengali language has been used in the composition of Khona's Maxims. Khona's Maxims are the invaluable folktale of Bengal. Despite many obstacles, thousands of words have been collected. But Dr. Ali Nawaj stated strongly that there were more

than thousands of Maxims that actually existed. Though most of Khana's maxims are associated with agriculture yet, there are some maxims which are related to Architecture, season, weather, livestock, health and nutrition, food habit, astrology etc.

2.2.1"Maxim of Khona" Traditional wisdom of Bangladesh

Khona's maxims are believed in this region to have been passed down orally over thousands of years. It remains a practical and influential way to unite science and norms within the context of design to create environments for human beings that are in harmony with nature, cosmic forces, and the universe.

2.2.2 Maxim of "Khona" and vernacular architecture of Bangladesh

Architecture is vernacular when it exhibits all of the criteria related to the ''native context' in the sense that it can only be acceptable and recognizable within any particular society applying some particular technology, material, social rules and system (Kausarul,2003).In fact, Vernacular architecture originated when mankind was forced to make use of the natural resources around him, in order to provide him with shelter and comfort which is responsive to the climate and works as a shield from the elements. It is a pure reaction to an individual's or society's building needs and has allowed a man, even before the architect, to construct shelter according to his circumstance. Vernacular Architecture of Bangladesh is not an abrupt phenomenon; it is the outcome of the prevailing topography, extremes of the climate and other natural forces.

Moreover, our traditional buildings were designed mainly to achieve human comfort by using passive climatic control, locally accessible building materials and construction technology which were more responsive to the climatic and geographic conditions.

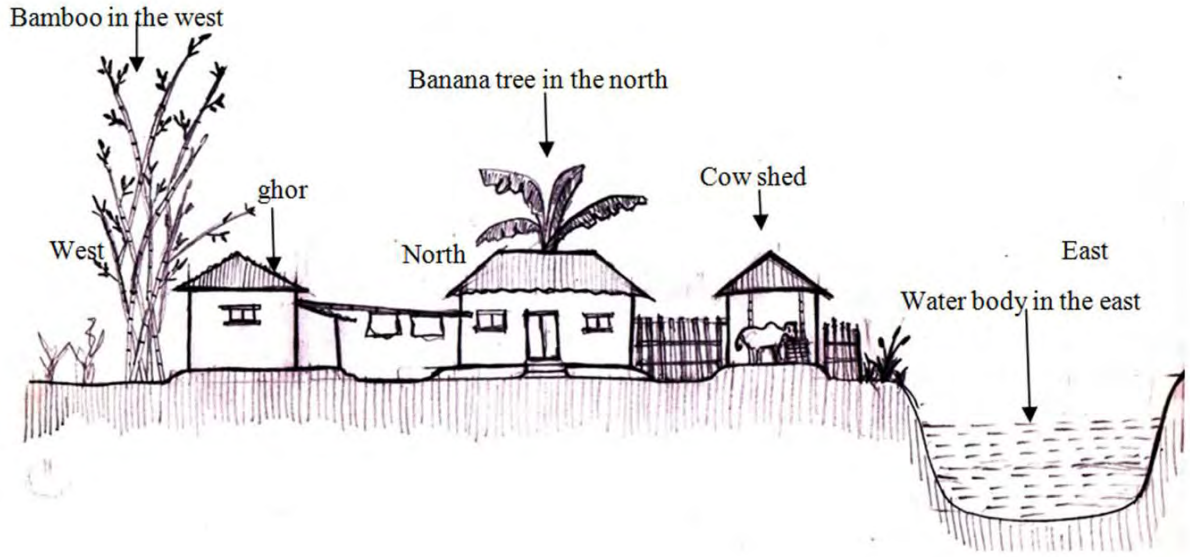


Figure 2.13: Section of a rural homestead. The section shows a complete site planning according to the maxim of Khona

As we know in ancient time, architecture was practiced without architects; they did not have any building code. Hundreds of years of experience, self-learning, and traditional wisdom have led to the development of the contextual based traditional architecture of that time. If we carefully scrutinize we can erect a strong influence of traditional wisdom of our vernacular architecture. In fact, all the traditional wisdom during then worked as a building code of that time.

All over the world, there are some traditional beliefs or maxims related to the traditional built form. "Khonar Bachan" in Bangladesh is one of such traditional beliefs. Most of her maxims are Agriculture, weather, and architecture based. The proverbs of "Khona" that have been used widely, throughout the South Asian region had a huge impact on the traditional built environment of that time. Many of these proverbs include nature and environmental protection. Having such a rich tradition, subaltern is not only the silent managers of their natural resources but are active in protecting biodiversity through their age-old traditional knowledge and practices. They possess intense ecological insights drawn from their culture and their products and maintenance roles. Some proverb is given below which are practiced for hundreds of years for building a subaltern hut:

"South facing is the best; East facing is the next to rest; West facing unwanted they say; north facing has little to pay". Or "light wall and roof is slope; all the family will stay in hope"

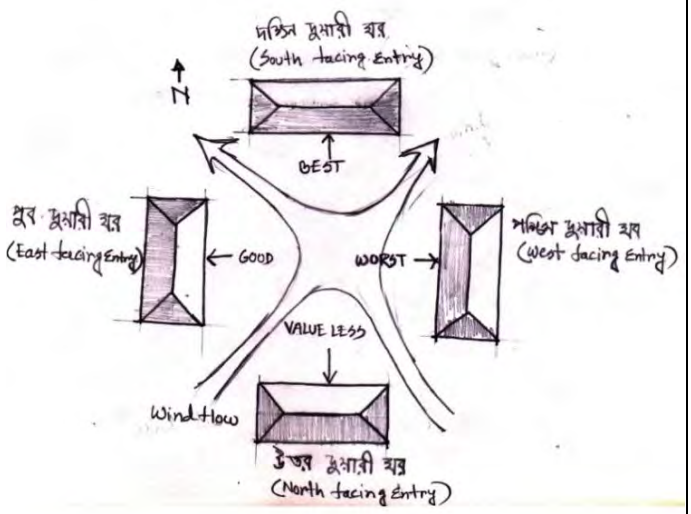
Learning from traditional wisdom of past generations through the lessons of traditional buildings can be a very powerful tool for improving the architecture of the future.

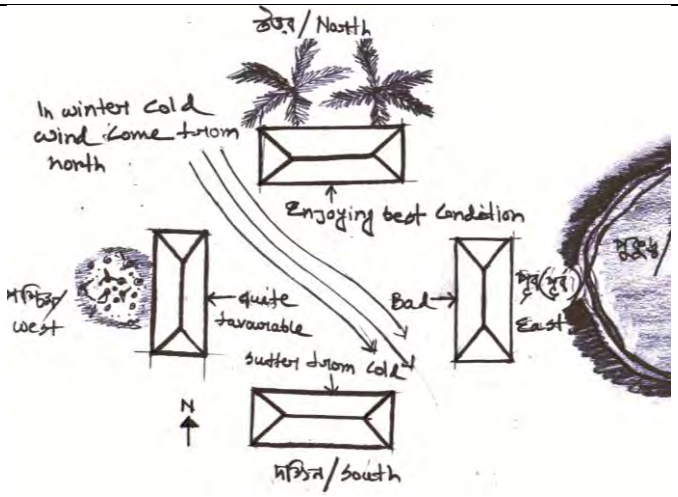
2.3 Categorization and compilation of selected wisdom of "khona" with respect to homestead making.

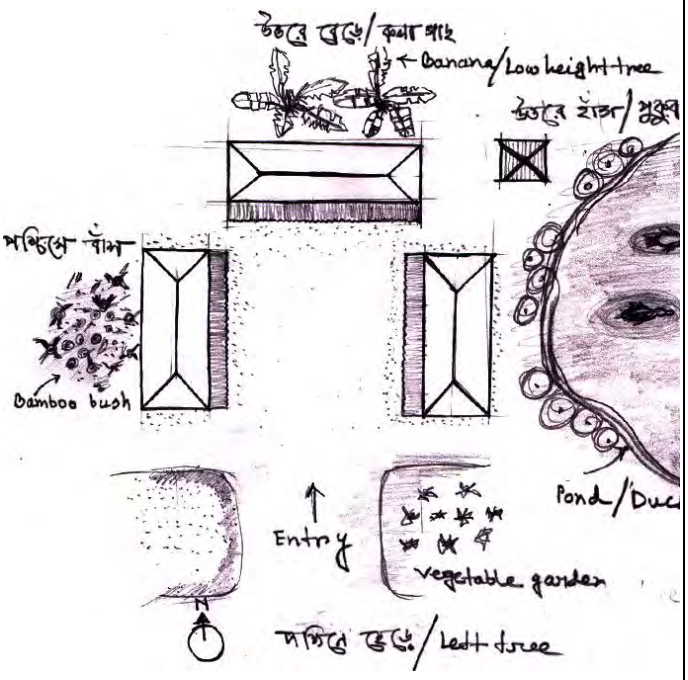
From more than thousand Khona's maxims, those related to homesteads and settlements are selected for this study. With respect to homesteads making, the twenty selected maxims can be divided into following categories:

- Architecture, Planning and Settlements
- Building Material
- Construction Techniques and Treatments
- Landscaping

Table 2.1: The table shows Categorization and compilation of selected wisdom of "Khona"

Category of Khona's maxim	Maxims of Khona with Translation	Explanations of The Maxims in Technical Basis
Architecture Planning and Settlements	1.**দখিন দুয়ারী ঘরের রাজা, পুব দুয়ারী তাহারপ্রজা, পশ্চিম দুয়ারীর মুখেছাই, উত্তর দুয়ারীর খাজনা নাই।।** (Zamir,2003) **Translation:** South facing is the best; East facing is the next to rest; West facing unwanted they say; north facing has little to pay.	**Explanation:** Literally, this maxim describes the entrance system. Here Khona pointed to the south oriented entrance as the best. If we characterize this maxim according to our climatic aspect, in our warm humid region during summer, cool air enters from the south side. Due to this Khona encouraged south facing the entrance. Moreover, she mentioned East oriented room to be much better because the eastern side receives mild heat during the morning, which is highly appreciated during winter. East breeze also encouraged in the summer. She as well revealed that the west oriented entrance is poorer. In our climatic condition, Western exposures receive longer periods of radiation which is also difficult to shade. She acknowledged north oriented entrance as the worst because during winter cold air enters through the northern side which is not comfortable for the dweller.  Figure2.14: The plan shows the Entrance system according to Khona where she encouraged for south-facing entrance to get the maximum benefit of air flow.
	2.উত্তরের ঘরেরা দুধে ভাতে,দক্ষিণের ঘরেরা মরে শীতে,পশ্চিমের ঘরেরা খায় ভাত,পুবের ঘরেরা ফেলে পাত ।।(Zamir,2003) **Translation:** The dwellers of northern rooms having door in south are enjoying the best condition. Again, the dwellers of southern rooms having door in north suffer from cold wind during the winter. Besides, the	**Explanation:** Describing the location of the room based on Environmental condition, it is being elucidated that the health of the residents of a home can depend on the way it is built. This means the dwellers of northern rooms having a door in the south are able to experience the best condition as they can enjoy the southern breeze. Again, the dwellers of southern rooms having a door in north suffer from cold wind during the winter because during winter cold air come from the northern side. Besides, the dwellers of western rooms having a door in the east are quite favorable. Though opening in the east admits the sunlight at a time air temperature is still quite low. Whereas, the dwellers of eastern rooms having a door in the west are unfortunate as light and wind cannot reach them.

	dwellers of western rooms having door in east are quite good but the dwellers of eastern rooms having door in west are unfortunate.	 Figure 2.15: The plan shows the Location of the room according Khona. based on the environmental condition in winter cold air come from northern side reasoning southern rooms having door in north suffer from cold
	3.পূবে হাঁস, পশ্চিমে বাঁশ উত্তরে বেড়ে (কলা), দক্ষিণে ছেড়ে, ঘর করগো পোতা জুড়ে।।(Zamir,2003) **Translation:** Duck in east, bamboo in west, banana in north, left empty in south, build your home taking all the area of the high and spacious platform (Figure 2.14).	**Explanation:** Literally, this maxim depicts a complete site planning. The maxim describes duck in the east, bamboo in the west, banana in the north, and a vacancy in the south, build your home taking all the area of the high and spacious platform. This is the most famous proverb regarding traditional architecture and is found almost indistinguishable with some exceptions in Bikrampur, Pabna, Faridpur and West Bengal (Ahmed & Ahmed; 2015). If we fragment the verse- duck in the east means water body or pond should be kept in the east. In fact, this is the traditional practice of our rural areas that pond should be situated in the east side; because the sun rises in the east, during the day the east side of the dwelling is hotter than another side. That's why evaporation of water from pond associated with south breeze helps to reduce the heat and humidity also after digging the pond. The erected soil is used to raise the plinth level of the house too. We can describe it in an alternate way; duck in the east means Khona preferred east side for farming and poultry. Bamboo in the west means bamboo or big trees must be placed on the west side, as a cluster of bamboo or big trees in the west minimize excessive solar radiation. Banana in the north means low height trees should be planted in the north side because low height trees like profitable tree banana don't interrupt the passing winds of south-north orientation. Finally, the south should be kept empty. Khona describes it as "let the wind flow to penetrate the homestead and define this cardinal as an entry" (Ahmed & Ahmed, 2015). Moreover, the south side of a dwelling should be left free or low height vegetables should be planted for enhancing proper ventilation and to take advantage of the southern breeze. In her last line, she mentioned also to build home taking all the area of the high and spacious platform.

		 Figure 2.16: The plan shows site Planning based on the maxim of Khona in respect to the climatic condition.
	4.পুবে হাঁস, পশ্চিমেবাঁশ উত্তরে বেত,দক্ষিণে ক্ষেত॥(Nawaj,2011) **Translation:** Duck in the east, bamboo in the west, banana in north, field in the south.	**Explanation:** This maxim is similar to maxim 3, where Khona describes duck in the east that means water body in the east. Big trees in the west, banana tree or deciduous in the north and low height vegetable or the south should be left free (fig.2.14 and fig.2.17).
	5. সুখদ দক্ষিণ বায়ু,তাহে বৃদ্ধি পরমায়ু॥ (Nawaj,2011) **Translation:** Happiness of the South wind increases life span.	**Explanation:** In our climatic condition south facing room is the ideal condition for planning. Khona in her several maxims stated that south should be left empty or planted low height in the south for allowing the south breeze.

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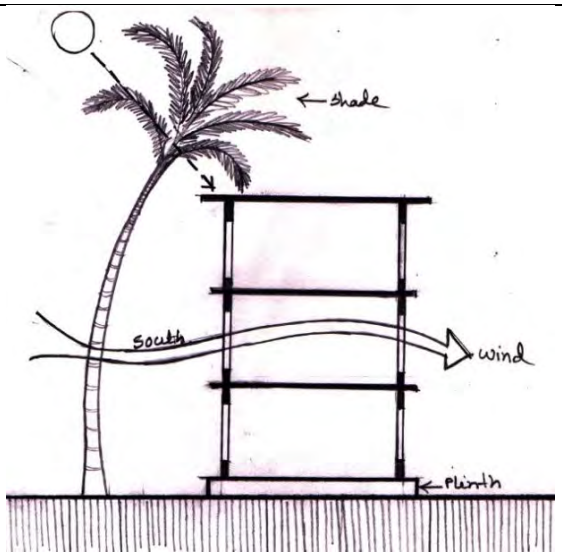
<td> 

Figure 2.17: The section shows that south facing room is the best for enjoying light and air in Bangladesh's climatic conditions.</td>
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<td>6.দক্ষিণে ঢেঁকি উত্তরে বেল, লক্ষী বলে এই বাড়ি গেল॥ (Nawaj,2011)

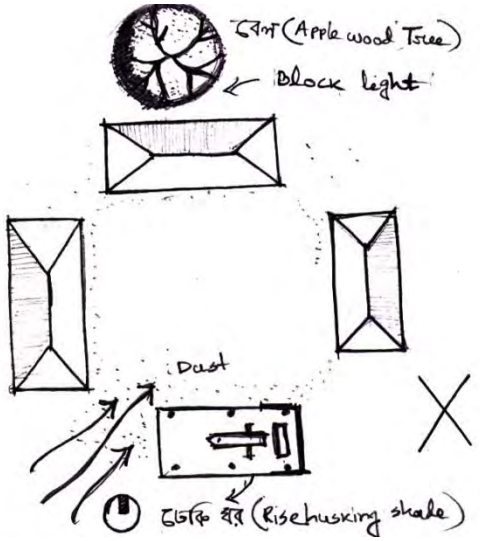
Translation:
Rise husking shade should never plan in southern area and wood apple tree not to place in north. It is ominous for the house.</td>
<td>Explanation:
If we placed Rise husking room into the south, the dust of the rice husking room will enter the house. On the other hand, the height of the wood apple tree or any other big trees too close to the north side of the house interrupts the diffuse light of north, while allowing cold wind flow in winter entering the house that result in low illumination and dampness.
 

Figure 2.18: The plan shows that the Rise husking shade and apple wood tree should be avoided in southern area in response to climatic conditions.</td>
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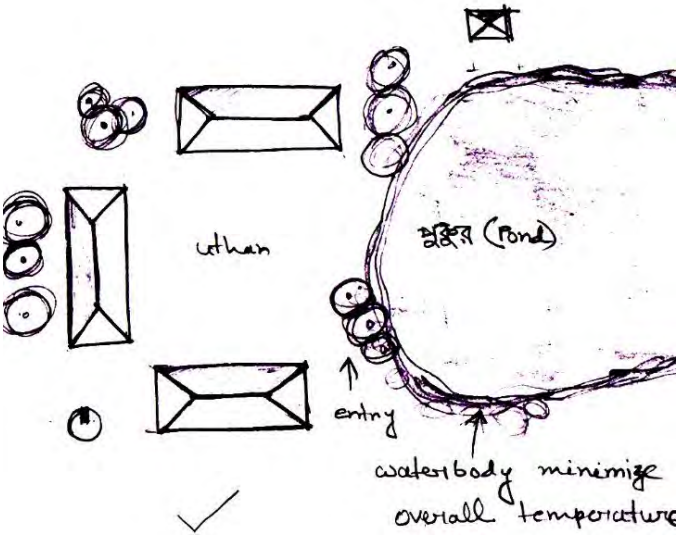
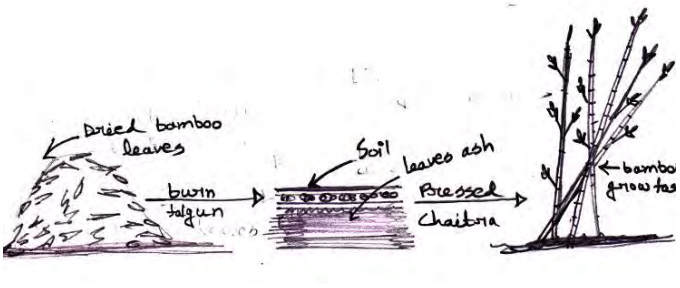
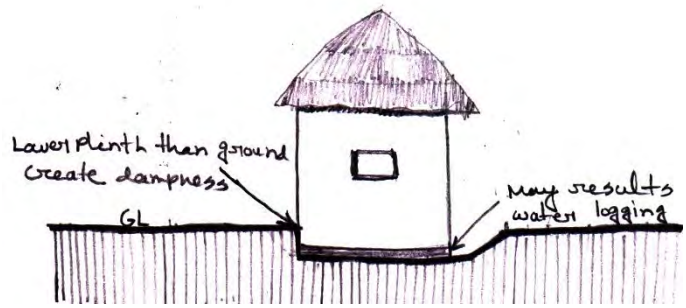
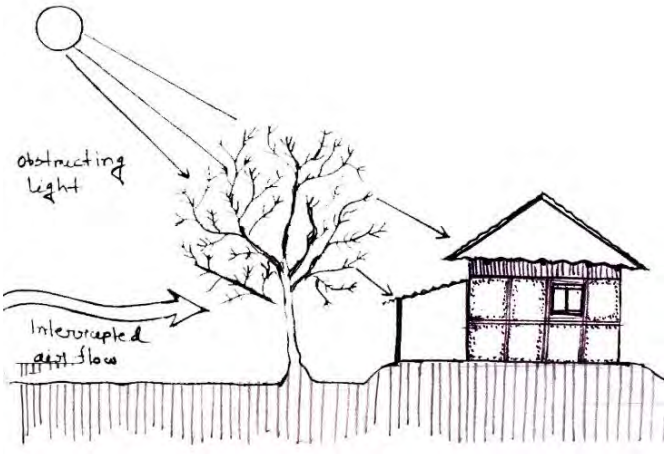
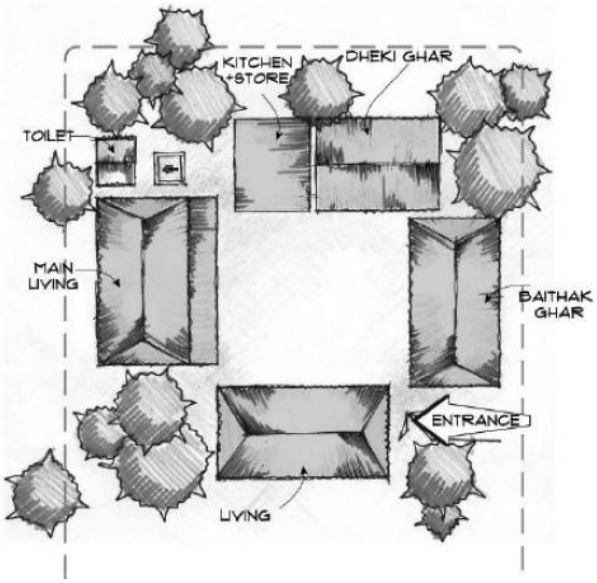
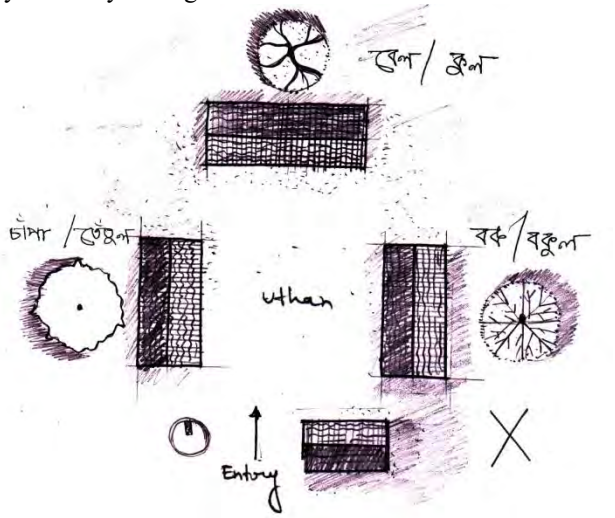
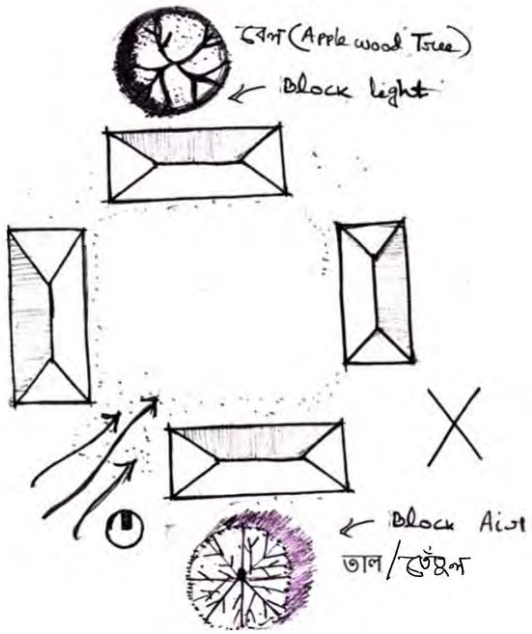
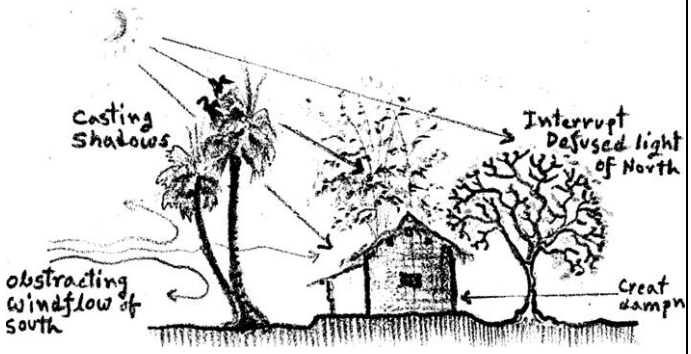
	7.মনে যদি লই কসর, পোখরি পাহাড়ে (পুকুরপাড়ে) তুলিও ঘর॥(Nawaj,2011) **Translation:** One should build house beside the pond.	**Explanation:** Water body beside the house helps to minimize the overall temperature by evaporative cooling. The erected soil from the pond is also used to raise the plinth level of the house too.  Figure 2.19: The plan shows, water body beside the house helps to minimize the overall temperature by evaporative cooling.
Building Material	8.ফাগুনে আগুন চৈতে মাটি, বাঁশ বলে আমি শিঘ্র উঠি II(Nawaj,2011) **Translation:** If burnt down the Falling dried leaves of bamboo bush during the Phalgun month and pressed the ashes into the soil in the month of chaitra, results grow bamboo faster and it helps to raise new branches too.	**Explanation:** Experts agreed that the ashes contain nitrogen and phosphate which work as fertilizer that helps to grow bamboo rapidly.  Figure 2.20: According to Khona after burning the dried leaves, if its ashes are pressed into the soil, it helps to grow bamboo faster.
	9.শুন বাপু চাষার বেটা, বাঁশ ঝাড়ে দিও ধানের চিটা, চিটা দিলে বাঁশের গোড়ে, দুই কুড়া ভুঁই বেড়বে ঝাড়ো॥ (Nawaj,2011) **Translation:** Khona describes that the deformed and barren rice husk helps to grow bamboo faster.	**Explanation:** Deformed and barren rice husk is an excellent fertilizer for bamboo. It helps to grow bamboo faster.

		 Figure 2.21: According to Khona the Deformed and barren rice work as fertilizer which helps to grow bamboo faster.
Construction Techniques and Treatments	10.পিড়ে উঁচু মেঝে খাল ,তার দুঃখ্সর্বকালII(Zamir,2003) **Translation:** If the plinth is lower than the land, it's unhygienic for living.	**Explanation:** The maxim depicts, that the lower plinth results in unhygienic conditions which affect the residents by increasing diseases throughout their lifespan. Furthermore, if we analyze the maxim, in our climatic condition, raised platform facilitates with better ventilation. Continuous circulation of air increases the space livability with appropriate temperature and humidity. Lower plinths are damp and unhealthy.  Figure 2.22**:** Lower plinth than the existing land level results in low ventilation and dampness.
	11.জর ভিটায় তুলে ঘর ,সে আসে তারই জর॥(Basu,2015) **Translation:** Unhygienic space causes illness.	**Explanation:** To construct house in Untidy and clumsy space is not healthy. It causes several diseases in house.  Figure 2.23: According to Khona unhealthy space causes several diseases.

	12.আলো হাওয়া বেঁধোনা,রোগে ভোগে মরোনা। (Basu,2015) **Translation:** Blockage of light and air causes diseases.	**Explanation:** It means to construct obstacles in the way of ventilation, results in insufficient light and air which is not good for our health. At the time of design, we need to be cautious about the appropriate amount of natural lights and ventilation i.e appropriate orientation for light and ventilation.  Figure 2.24: The section shows big trees in front of the house create obstacles on the way to ventilation and, results in insufficient light and air.
Landscaping	13.ঘিরিলে বাড়ি,সাজায়েলে তিরী II(Nawaj,2011) **Translation:** Plantation in the surroundings of house brings happiness and healthiness.	**Explanation:** Planned garden around the house is Delightful, beautiful and healthy. It also protects the house from storms/cyclones.  Figure 2.25: The plan shows that the Plantation in the surroundings of the house brings happiness and healthiness (Source: Rashid, 2013).

	14.বক বকুল চাঁপা, তিন পুঁতোনা বাপা॥(Nawaj,2011) **Translation:** Bok, Bokul, Chapa these kinds of trees should never planted at a time.	**Explanation:** Here "khana" advised to avoid these types of trees near the houses. If we plant these trees near the houses, then the root system may damage the house structure.  Figure 2.26: These kinds of trees should never be plant at a time. According to Khona these kind of trees may damage the house structure due to their root system.
	15. .দক্ষিণেতাল/ তেতুল,উত্তরেবেল; লক্ষীবলেএইবাড়িগেল॥ (Basu,2015) **Translation:** Palmyra or tamarind tree in the south and apple wood tree in the north is ominous for the house.	**Explanation:** If the houses have big trees too close to the north side of the house it interrupt the diffuse light of north, when the cold wind enter the house in winter, inhabitants suffer from diseases.  Figure 2.27**:** Palmyra or tamarind tree in the south and apple wood tree in the north is ominous for the house.
	16.তাল, তেঁতুল ,কুল ;তিনে বাস্তু নির্মূলII(Nawaj,2011) **Translation:** Palmyra, Tamarind, plum trees harmful for building.	**Explanation:** If the houses have big trees too close to them, the wind flow and sun get interrupted. Less light and air create dampness and unhygienic atmosphere in the house (figure: 2.27).

	17.তাল, তেঁতুল ,মাদার তিনে আন্ধার ॥(Nawaj,2011) **Translation:** Palmyra,Tamarind, Lakoocha or monkey jack trees results darkness.	**Explanation:** If the houses have these trees too close to them, these trees are responsible for creating darkness in the house as these are dense foliaged (Figure:2.27).
	18.গৃহ-পাশে খিলেতাল ;শকুন পক্ষি বসিতা 'পরে , নানা ব্যাধিজাতকরেII(Nawaj,2011) **Translation:** The location of Palmyra tree adjacent to the house is not acceptable, Vultures lives in these trees spread diseases.	**Explanation:** Palm tree is a shelter for corpse scavenger birds like vultures. They spread germs of touchy diseases. As a result, the inhabitants get short life.  Figure 2.28**:** The location of Palmyra tree adjacent to the house may damage the house structure. (Source: Ahmed & Ahmed, 2015).
	19.উঠান ভরা লাউ শসা ,ঘরে তার লক্ষ্মীর দশা॥ (Nawaj,2011) **Translation:** If there is gourd, cucumber planted in the courtyard, it's a sign of good omen.	**Explanation:** Planting vegetation inside the courtyard increases the humidity and reduces the speed of wind but it provides better thermal comfort at certain periods of daytime. According to Khona gourd, cucumber these vegetables have a rich source of minerals and vitamins, as well as contain many healing and medicinal properties. That's why Khona mentioned these vegetables auspiciously and should be planted in the homestead to supplement nutrition to households.  Figure 2.29: The section shows vegetables planted in the homestead , ensure supplement nutrition to households.
	20.নিম নিসিন্দা যথা ,মানুষ কি মরে তথা II(Basu,2015) **Translation:** Neem, Chaste tree where planted, inhabitant will be healthy there	**Explanation:** These trees have great medicinal value; moreover, oxygen is produced in large amount by the leaves of the trees. These trees also spread kind of fragrance which will kill the bad smell from the weather.

2.4 Homestead's of Bangladesh and Its Determinants

The tradition of the region and culture-specific architecture is still followed in the habitats in different parts of the world and the traditional house form in Bangladesh offers a fine example of a region and culture-specific architecture. That's why to investigate the geomantic study of Bangladesh; this research is focusing on the homesteads of Bangladesh.

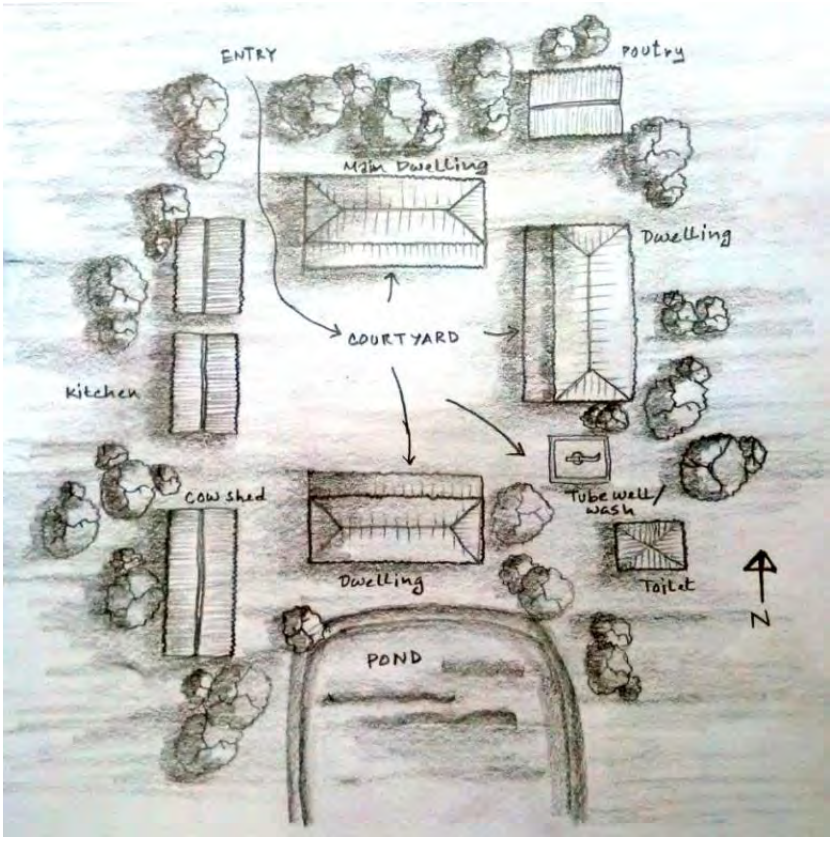


Figure 2.30: The plan shows the organization of a rural Homestead.

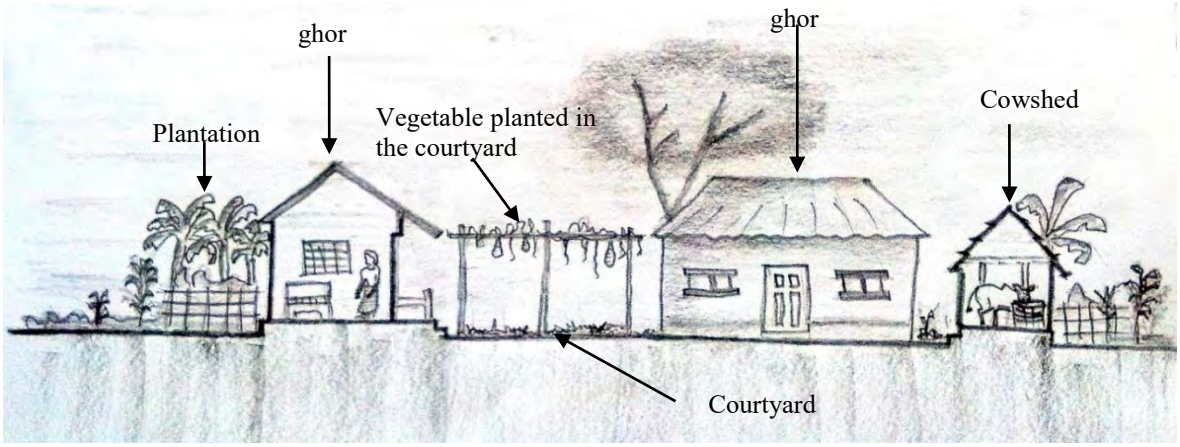


Figure 2.31: The Section of rural homestead shows the function at arrangement of inner house. Planting vegetation inside the courtyard provides better thermal comfort.

2.4.1 General Form of the homesteads

A typical morphological feature of the rural homestead is the arrangement of dwelling units and additional buildings around an open courtyard. It has basically two zones without considering the changes of locations, materials, climates etc and their impact on the house forms (Khan, 1982). All the activities of a house is arranged by following these zones. The zones are specified as,

a. Formal zone (male, outer part of the house)

b. Informal zone (female, inner part of the house)

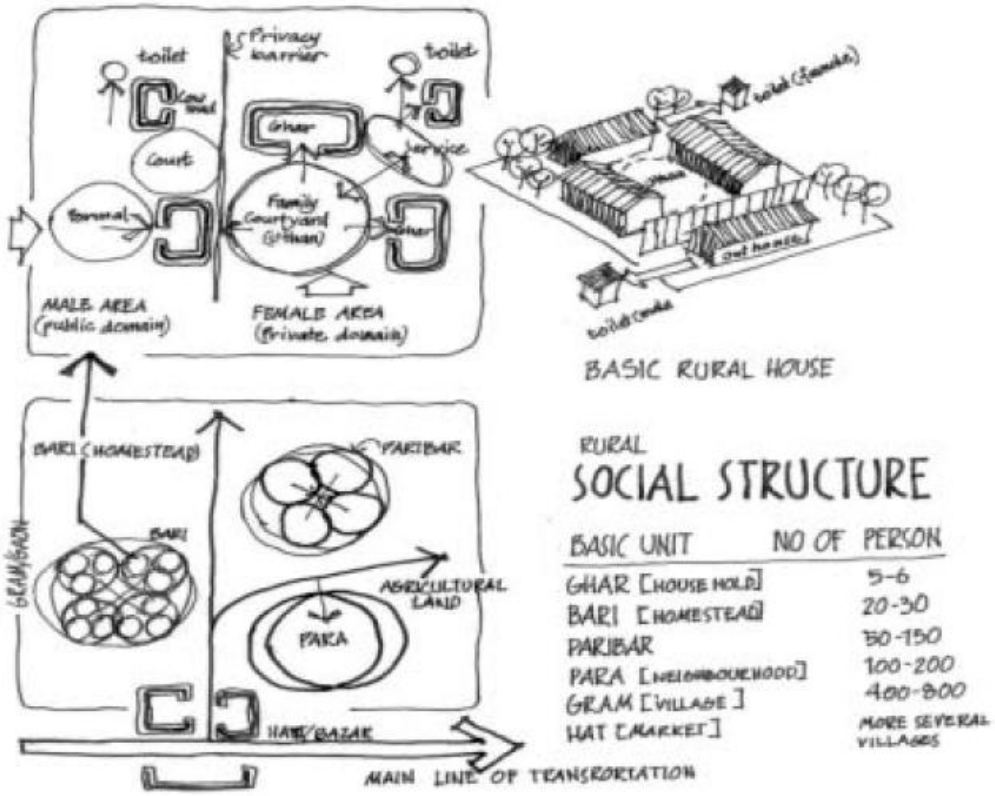


Figure 1.32: Basic arrangement of a Bengali house (Source: Mowla, 1997)

The courtyard has important physical, social and functional characteristics derived from local climatic requirements and living patterns. Generally a homestead possesses at least a living room, a space for kitchen and a space for vegetation. A rural homestead starts with a main living unit associated with other ancillary functions like rooms for granary, cattle, cooking, husking etc around a court. The periphery of a homestead is surrounded either by vegetations or screens by jute sticks and bamboo. These vegetations are used not only for maintaining the property demarcation but also for maintaining the privacy of the houses. Usually a pond is excavated to obtain earth for raising the land above flood level and to store water for house hold use.

2.4.2 Material and Construction

Most houses in rural homestead are built by indigenous, locally available material. Such as timber, bamboo, thatch are the common material. The main room is usually made of a well-built structure and the ancillary structures made of a semi-permanent material.

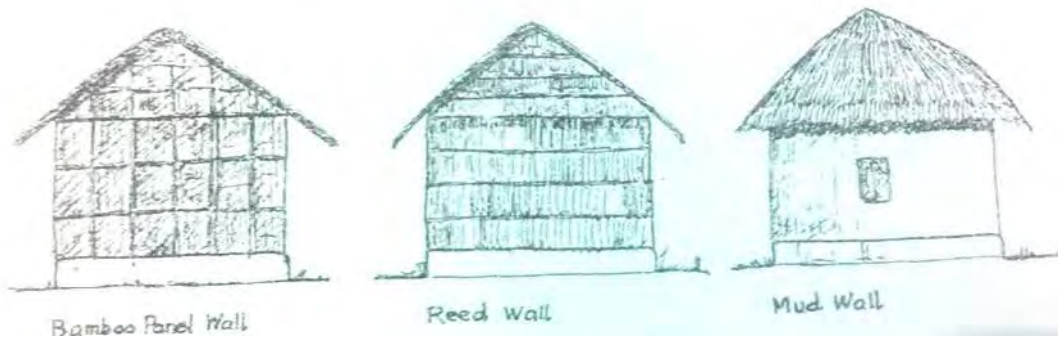
The construction of the rural homestead structure may be discussed with reference to the major elements namely, the plinth, the walls and the roof. The most common materials to be used in construction are:

Plinth: The first step before construction of a house is the construction of a plinth. The plinth is the platform where the structure of the house stands. The most familiar material is earthen material, Brick edge with earth infill, raised wooden plinth with bamboo or timber posts and now a day's cemented floor also is seen. Red soil is preferred for the construction of plinth. They first knead and mix by water to make it softer. sometimes rice –husk or wood dust is mixed with the soil mass and left idle for a few days to allow the water to be absorbed uniformly (HBRI, 1984).And later the soil plaster is applied on the surface of the plinth to make it neat and ready for use.

Figure 2.33: section showing the house with plinth (Source: Rashid, 2013)

Enclosing Materials: There are two basic types of wall commonly seen in rural houses, like- the mud wall and the bamboo mat or reed walls. Apart from these, some more organic materials are found, like straw, grass, jute stick, and CI sheets with timber and bamboo framing. Initially, construction of a mud wall is started by digging foundation trenches, about .75 m wide and 1m deep all over the plan of the house. Afterward, the entire width of the trenches is filled and gradually narrowed upwards. Prepared mud is placed in layers of about 0.25m depth rammed well and left for a week. Next layer follows the aforesaid procedure. On contrary, for bamboo and reed walls no foundation is needed. In this case, the plinth is built first and then combined. Here

bamboo poles or timber logs are used as a structural material. These poles are dug into the plinth and up to a depth of 0.75m. This allows the vertical posts to be jammed substantially then they constitute the horizontal cross members at the top tide to the vertical members with ropes and GI wires. Finally, the frame receives the wall panels which are fixed firmly to the frame by GI wires.



2.35: Types of Wall Construction (Muktadir And Hasan, 1985)

Roofing Material: The roof is the eminently crucial and expensive part of the homesteads. The roof has a rectangular base frame coinciding with rectangular outline of the plan of the house. Thatched rice or wheat or maize straw, long grass with bamboo framing, CI sheets with bamboo or timber framing is used as roofing material. The indigenous materials and methods of construction and designs of rural homestead clearly establish its regional character. The review and analysis so far proved our rural homestead is precisely influenced by our geo climate, which is the main principle of geomancy and as described by Khona.

2.5 Development of checklist as per Khona

"Maxims of Khona" is a particular way of thinking and engaging in the practice of architecture in Bangladesh. It is clear that many of the principles found within the maxims resonant with those of many well known traditional practices in the region are below the table showing the checklist as per the maxims of Khona.

Table 2.2: Checklist according to the guidelines of Khona.

Sl.	Category of Khona's maxim	Parameter	Guidelines according Khona
01.	Architecture, Planning and settings	Orientation	North-south orientation is preferred.
		Entry	From South side is proffered but east is also allowed.
		Site settings	The water body in the east side, bamboo trees in the west side to avoid the sun of the west, small height trees planted in

			the north not to obstruct the passing of winds of south-north orientation and south should be empty to enjoy the south breeze. Shaded water body on the south or east to allow cool breeze into the house and thick trees on the north-west to protect the homestead from nor-wester.
.		Openings position	Based on environmental condition Khona mentioned, the dwellers of northern rooms having door in south are enjoying the best condition and the dwellers of southern rooms having door in north suffer from cold wind during the winter. Also preferred East and west are more solid than north-south.
		Courtyard	Courtyard preferred for more Air circulation and also for equal flow in all direction as well as an outdoor family socialization space.
02.	Building Material	Indigenous material	Mostly bamboo, mud, thatches (locally available material).
03.	Construction Techniques and Treatments	Plinth	The height of the plinth should be maximum above flood level to allow better ventilation and prevent flooding.
		Land height	High ground level preferred in order to safeguard from the natural hazard. Like-flood, effects of temporary water logging.
		Roof	Pitched roof preferred because the roof slopes helps the rain water to fall quickly and reduce the risk of leaking roof. It also shades the opening under it.
		Natural lights	Mentioned about Windows, central courtyard which act as a source of natural light in the working area.
		Ventilations	Importance on having proper ventilation in a house. The house is recommended to be open, airy and to get ample of sunlight.
		Construction technique	Local techniques suitable for local material and labors were preferred.
04.	Landscaping	Plantation	Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness of mind as the nutrition supplier.
		Distance of big trees	Advised to avoid Palmyra, tamarind, plum, bokul kinds of tree too near the houses because big trees too close to house interrupted the wind flow and sun

			light.
		Medicinal herbs	Neem, Chaste these kinds of medicinal herbs are mentioned as helpful tree, contributing to the health of the inhabitants.
		North setting	Small height trees, like banana which also locally available tree advised to plant in the north as the north wind is not desirable.
		South setting	Open or low height vegetation is preferred for welcoming the summer wind.
		East setting	Water body in the east to allow cool breeze.
		West setting	Bamboo tree is advised to plan in the west to shield the west sun.

2.6 Summary of Checklist

The subsequent chapter critically analyzes and synthesis the maxims of Khona vis-à-vis various aspects of scientific norms. The analysis and synthesis follows the checklist given below:

i. Architecture, Planning and settings
   - Orientation
   - Entry
   - Site setting
   - Openings position
   - Courtyard

ii. Building Material
   - Indigenous material

iii. Construction Techniques and Treatments
   - Plinth
   - Land height
   - Roof
   - Natural lights
   - Ventilations

iv. Landscaping
   - Plantation
   - Distance of big trees
   - Medicinal herbs
   - North setting
   - South setting
   - East setting
   - West setting

Chapter 3: Critical Analysis and Synthesis of Maxims of Khona Vis-À-Vis Scientific norms

Data Collection on Typical Setting Satisfying “Khona”

Case studies

Collected Instrumental Data

Setting Condition

Identifying the Maxims Suitable for Application in the Built Environment Design

Chapter 3 Critical Analysis and Synthesis of Maxims of Khona Vis-À-Vis Scientific norms

3.1 Data Collection on Typical Set up Satisfying "Khona"

3.1.1 Field investigation

A filed investigation is carried out to validate the assessment rationally.

3.1.2 Introduction

To make an assessment more evidence-based and conclusive it is essential to gather a large number of data from the built environment. However, it is not possible to collect exact environmental data directly from the field at a time. It is also impossible to get data from areas as per our requirements from the meteorological offices. The main target of the study is to relate the geo-climatic context of a region and the maxims of Khona as a case study. Since Khona's utterance was fully formed in a rural context, the remote rural environment has been chosen for Case Studies.

3.1.3 Objective of the field survey

A survey was conducted to provide a knowledge base for the study and to collect information about related climatic issues of traditional houses. A physical survey is made on the basis of the local area plan and visual observation; in all survey sites, it was to identify notable physical characteristics that have the potentiality to influence the environment. Temperature, humidity, day light is measured in different spaces and is collected. The research is targeted for rational validation of the identifying maxims which is suitable for application in the built environment. Form performance relationships were observed in terms of climatic elements.

3.1.4 Description of the survey areas

It has already been mentioned that Khona's verses were compiled in ancient times of rural background that's why remote rural settings were selected to conduct the survey. A pilot survey was conducted and a few remote rural sites were selected, named Shalgram, Mohipur,Moglishpur that more or less satisfies the conditions described by Khona. The study area is located 10 km away from Mohadevpur Upazila of Naogaon in the Division of Rajshahi. Most of the homesteads are old and have sustained within the rural environment for a long time. These houses experienced several stages of development(s) through generations and possess the traditions and culture.

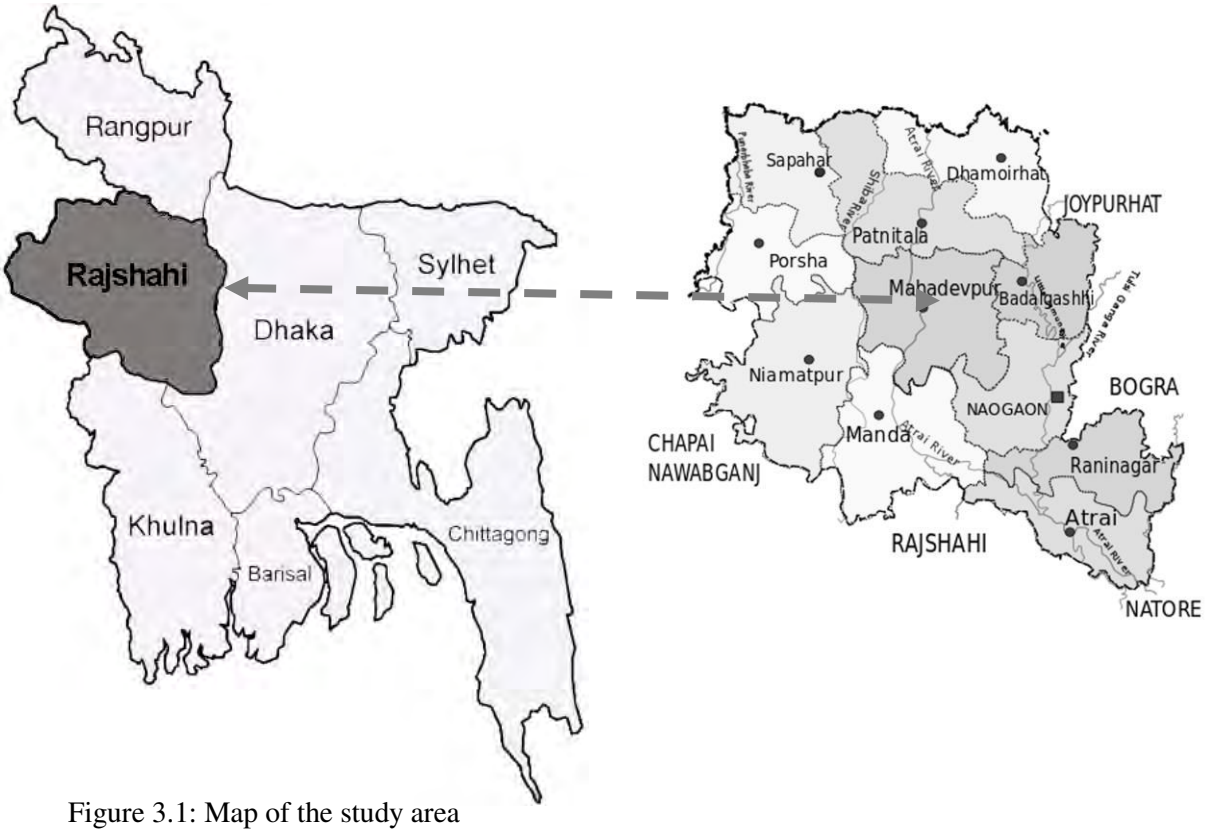


Figure 3.1: Map of the study area

It was expected that the selected cases would provide necessary information to study the house forms and its responsive patterns. The study is mainly based on observations, user's perception and some instrumental reading to verify user's response.

3.2 Case Studies

3.2.1 Case study 01 (Refer to Annexure, Case study 01)

House type: Rural Homestead

Village: Mohipur, Mohadev pur

Zilla: Nagaon

Type of Construction: Mud

Figure3.2: Layout of homestead 01

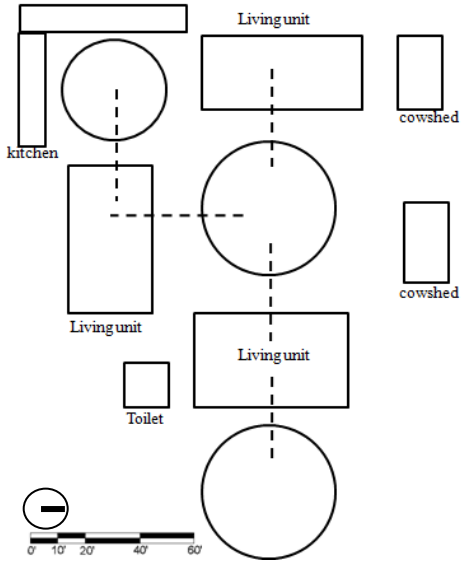


Figure 3.3: Space organization of homestead 01

Table 3.1: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan,et.al.2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind Few rooms are seen in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.

		should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Though semi-open verandahs, Windows are seen as a source of natural light, the ratio of window and wall is deficient there.
05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space (Bramhasthan)should be set aside or left free (Suriyanarayanan,et.al.2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Not only inner,the outer courtyard is also seen. Courtyard here helps to ensure higher thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning,	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	The main entrance to the east ensures large openings for ventilation.

		which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.		
08	Building material	Indigenous material preferred.Mostly bamboo, mud, thatch. **Technical reasons:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	Only new bricks, wood, and materials should be used when building a new house (Olivera, 2013). **Technical reasons:** According to Vastu Shastra Materials that have been stored for a long time should not be used. The materials are easily available and relatively low longevity and also locally available.	Locally available material, like-mud and bamboo are used as construction material. Ensures good ventilation and shade.
09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays, big trees should be planted**.**	Various types of trees are planted. Like -wood apple, Plum, bamboo bush this high trees are seen at the western part. Excessive plantation works as a thermal barrier and also protects the house from storms/cyclones.
	Medicinal herbs	Neem, Chaste this kinds of medicinal herbs are mentioned. **Technical reason:** Easily available and have great medicinal value.	Good trees that can be planted in a house compound are useful trees like coconut, neem, betel, sandalwood, lemon, pineapple, bilva, almond, jackfruit, pomegranate, mango, amla, and katha (nanda, 2018). **Technical reason:** Most of the trees have great medicinal, economic value.	Nim tree is seen.Alsoand coconut, Mango, Jackfruit, guava tree, are seen inside the court. All the trees have great medicinal and economical value. plants inside the courtyard provides better thermal comfort at certain periods of daytime.

			That's why Vastu Shastra mentioned these trees as auspicious	
10.	Water body	Khona mentioned about presence of water body on the east in her maxim. **Technical reasons:** A water body takes up a large amount of heat in evaporation and causes significant cooling of air that flows into the house.	Water bodies create energies in house and attract peace and prosperity in the house (AstroSaathi, 2017). **Technical reasons:** Shaded water body minimizes the overall temperature by evaporation.	Pond surrounded by trees is seen near the south side. Excessive plantation and water body makes the south breeze cooler.
11.	Orientation and Laying of room	SL.No.one (01) discusses the issue.		
	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet, et.al. 2016) **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all unit but open elongated plan shapes with single rows of few rooms in the south direction enhance cross ventilation.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.
	Toilets and Bath rooms	Didn't find any observation of Khona according Toilets and Bath rooms.However, these one traditionally placed in North-West. **Technical reasons:** As we know West side is hotter. Bath room in West helps to block the radiation to other parts of	The optimal location for Toilets should be the North-West or West of building. The other choice for the position of the Bathroom is the South-East. Sun rays from the east will make benefits (Suriyanarayanan,et.al.2016). **Technical reasons:** The Bathroom has to be in the North-West or West. The	Original toilet located on the west side.

		the house, keeping them relatively cool.	infra-red rays of the Sun get projected on the West direction and so the West side is hotter, especially in the evenings. Hence the bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	

Note: Shading and Ventilation has been encouraged both by Khona ,Vastu Shastra and the scientific reasoning support this for a warm humid condition like ours. Case study also adheres to this concept.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.2-Temperature and relative humidity data in the Case study 01

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
11/11/2017 11 am	East	**30.8**	64	Data recorded in the morning. The maximum temperature is seen in the east i.e. 30.8°C, average relative humidity level was 64%. Temperature on the East is a little bit higher than the south and west. The sun rises from the east and the sun's rays first reach the east corner of the homestead. That's why the room temperature on the east side is higher than other living units. The changing sun direction affected the room temperature.
	South	29.9	65	
	West	29.6	64	

Day light Analysis

Figure 3.4: Window positions shown in layout 01

Table 3.3: Homestead 01 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No. of room		Amount of light at the work top (Lux)		
			Beside window	Middle row	Beside door
11/11/2017 12.30 pm	ER1		90.2	30	105
	ER2	W1	128	26	28.1
		W2	139.7		
	ER3		40	13.7	100
	ER4		98	21	142
	SR1		46	25.7	95
	SR2	W1	85	18	27
		W2	97		
		W3	50		
	WR1	W1	77	16.3	20.5
		W2	100		
	WR2	W1	75	14	19
		W2	71		

Observation from the collected day light data:

It is observed from the above chart that the illumination range of east side room is relatively better than the others. Opening from the side results in higher illumination range than other units. Excessive plantation in the west surface results in lower lighting than needed. During daytime, the sun passes through east to west tilted towards the south. This is the reason, why during the daytime south-east portion gets maximum solar exposure. However, the south side units do not

have any courtyard oriented window and also surrounded by other settlement that's why this portion is also deprived of sufficient light. As has been discussed in 1.6 (Refer to Annexure-1,Case study -1), the average illumination of the homestead is not sufficient due to the thick mud wall and small window. Low light leads to the dependence on artificial lighting.

Overall observation on case study 01

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. West facing rooms are less comfortable due to obvious reasons and the kitchen is less comfortable due to obvious reasons and the kitchen on the south-west corner obstructs cool breeze from the south.

3.2.2 Case Study 02(Refer to Annexure, Case study 02)

House type: Rural Homestead

Village: Mohipur,Mohadev pur

Zilla: Nagaon

Type of Construction: Mud

Figure 3.5: Layout of homestead 02

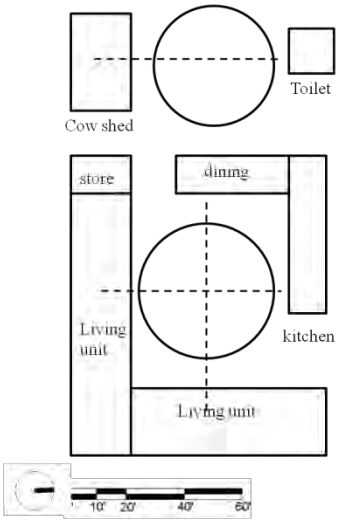


Figure 3.6: Space organization of homestead 02

Table 3.4: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south(Suriyanarayanan,et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind. Mostly rooms are seen in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010).	Elevated Plinth is spotted. Elevated plinth avoids the effect of the flood.

			Technical reasons: Higher plinth acts as a safeguard from the effects of the flood.	
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Though Windows are seen as a source of natural light, the ratio of window and wall is deficient there.
05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space (Bramhasthan)should be set aside or left free(S. Suriyanarayanan,et.al.2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Not only inner outer courtyard is also seen. Courtyard here helps to achieve high thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	The main entrance to the west which gets the maximum sun exposure. According to Khona, the west oriented entrance is poorer.

08	Building material	Indigenous material preferred.Mostly bamboo, mud, thatch. **Technical reasons:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	Only new bricks, wood, and materials should be used when building a new house (Olivera, 2013). **Technical reasons:** According to Vastu Shastra Materials that have been stored for a long time should not be used. The materials are easily available and relatively low longevity and also locally available.	Locally available material, like-mud and bamboo are used as construction material. Ensures good ventilation and shade.
09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.**	Various types of trees are planted. Like -wood apple, Plum, bamboo bush this high trees are seen at the western part. Excessive plantation works as a thermal barrier and also protects the house from storms/cyclones.
10.	Water body	Khona mentioned about presence of water body on the east in her maxim. **Technical reasons:** A water body takes up a large amount of heat in evaporation and causes significant cooling of air that flows into the house.	Water bodies create energies in house and attract peace and prosperity in the house (AstroSaathi, 2017). **Technical reasons:** Shaded water body minimizes the overall temperature by evaporation.	A Pond is seen near the east side which is used to meet the regular needs of cleansing, bathing etc. Evaporation of water from pond helps to reduce the heat and humidity of the homestead.
11.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		
	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet, et.al. 2016) **Technical reasons:**	Though not all unit but open elongated plan shapes with single rows of few rooms in the south direction enhance

		least solar exposure and also receives highest prevailing wind.	Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	cross ventilation.
	Dining room	Didn't find any observation of Khona according to dining Room.	The Dining room positioning depends on the distance to the Kitchen, wash basin etc., Dining room has to be located in the West. The direction while eating can be east (or) west (indianetzone, 2010). **Technical reasons:** Because Eating, facing south will create restlessness since the body will be affected by repelling forces.	Dining at the west is very near to kitchen the temperature of the dining is high.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.
	Toilets and Bath rooms	Didn't find any observation of Khona according Toilets and Bath rooms. However these one traditionally placed in North-West. **Technical reasons:** West side is hotter. Bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	The optimal location for Toilets should be the North-West or West of building. The other choice for the position of the Bathroom is the South-East. Sun rays from the east will make benefits (Suriyanarayanan, et.al. 2016). **Technical reasons:** The Bathroom has to be in the North-West or West. The infra-red rays of the Sun get projected on the West direction and so the West side is hotter, especially in the evenings. Hence the bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	Original bathroom located on the North-west side.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.5-Temperature and relative humidity data in the homestead 02

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
12/11/2017 11.45 am	East	**31.3**	46	The data was taken at the first hour of the day when the sun passes through the east. The temperature of east and south is very near, i.e. only 0.2 °C is higher. West is 29.3 °C, relatively low among them. The excessive plantation on the west is another reason behind the lower temperature of this unit. Here building orientation and plantation both are responsible for temperature variation.
	South	31.1	47	
	West	29.3	48	

Day light Analysis

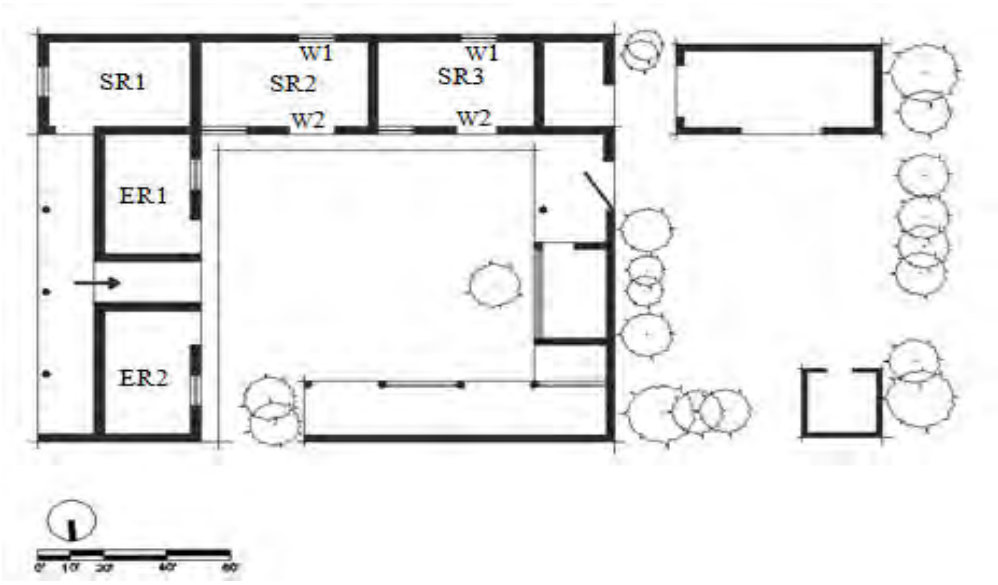


Figure 3.7: Window positions seen in layout 02

Table 3. 6: Homestead 02 daylight conditions in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room		Amount of light at the work top (Lux)		
			Beside window	Middle row	Beside door
12/11/2017 12.00 pm	ER1		98	21	105
	ER2		88	25.3	101
	SR2	WI	105	59	145
		W2	139		
	SR3	W1	98	65	148
		W2	141.4		

Observation from the collected day light data:

The above chart shows that the illumination ranges of south side units are relatively better than the east. The east surface of the eastern part units are closed and prevent the east light.

Overall observation on case study 02

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. The excessive plantation on the west is the reason behind the lower temperature of this unit. Dining is less comfortable due to its position near to the kitchen which generates high temperature.

3.2.3 Case Study 03 (Refer to Annexure, Case study 03)

House type: Rural Homestead

Village: Moglishpur,Mohadev pur

Zilla: Nagaon

Type of Construction: Mud, Brick

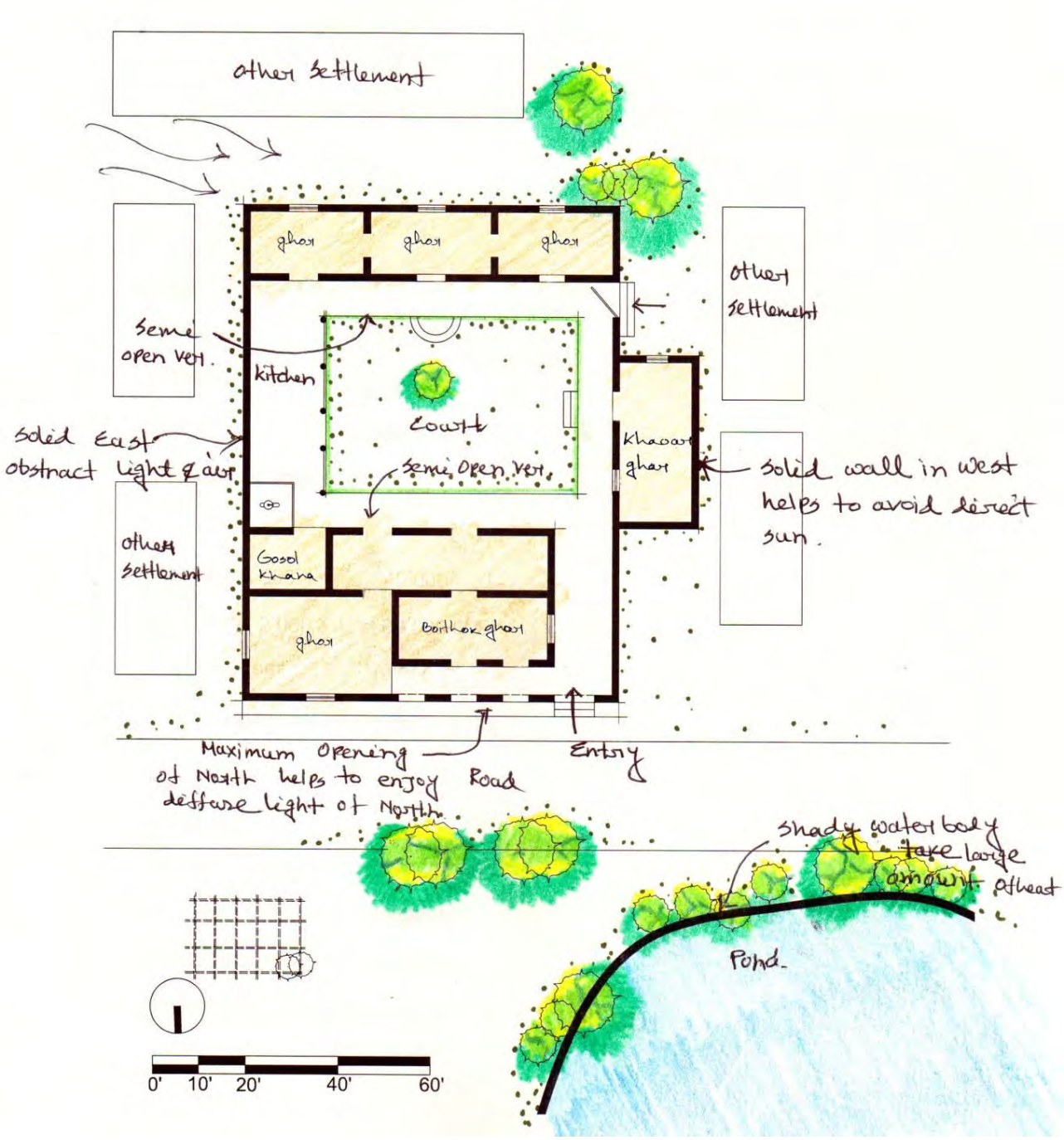


Figure 3.8: Layout of homestead 03

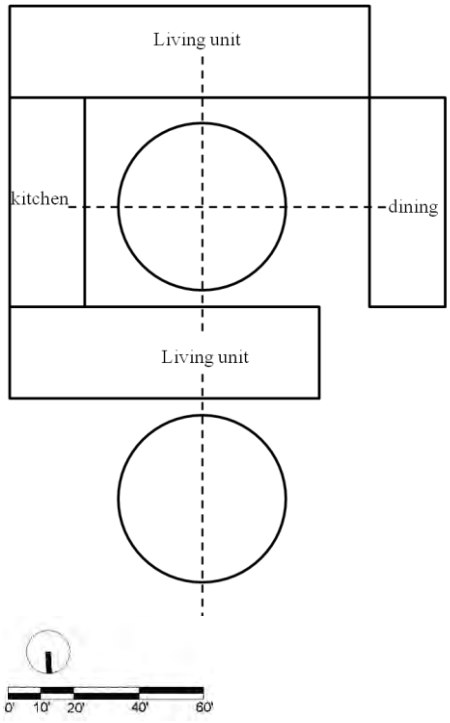


Figure 3.9: Space organization of homestead 03

Table 3.7: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south(Suriyanarayanan, et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	Living units located in north-south orientation get maximum air, and minimum sun exposure.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.

03.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space (Bramhasthan)should be set aside or left free (Suriyanarayanan,et.al. 2016). **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Not only inner outer courtyard is also seen. Courtyard here helps to achieve high thermal comfort.
04.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth avoids the effect of the flood.
05.	openings /ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Though semi open verandahs, Windows are seen s a source of natural light but the ratio of window and wall is deficient there.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to	The main entrance to the north. Though it's receiving cold air during winter but also get diffuse light throughout the year.

		Technical reasons: According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	allow useful sunlight to enter constantly, throughout the day	
08.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays, big trees should be planted**.**	Various types of trees are seen .Like - mango tree in front of the homestead. There are also some vegetables are planted at the external open spaces. Like bean, Gourd trees are planted. A guava tree is seen at the middle of the central court. Excessive plantation works as a thermal barrier and also protects the house from storms/cyclones
09.	Water body	Khona mentioned about presence of water body on the east in her maxim. **Technical reasons:** A water body takes up a large amount of heat in evaporation and causes significant cooling of air that flows into the house.	Water bodies create energies in house and attract peace and prosperity in the house (AstroSaathi, 2017). **Technical reasons:** Shaded water body minimizes the overall temperature by evaporation.	A pond is seen near the north-west side. Excessive plantations surrounding the Waterbody take up a large amount of heat of the west and make the space cooler.
10.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		

	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet, et.al. 2016). **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all unit but open elongated plan shapes with single rows of few rooms in the south direction enhance cross ventilation.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.
	Dining room	Didn't find any observation of Khona according dining Room.	Dining room has to be located in the West. The direction while eating can be east (or) west (indianetzone, 2010). **Technical reasons:** Because Eating, facing south will create restlessness since the body will be affected by repelling forces.	Dining at the west.
	Kitchen	Didn't find any observation of Khona according dining Room.	The ideal position for a kitchen is the Southeastern corner of a house **Technical reasons:** The sun's rays (cosmic rays) first reaches east corner of the earth and the ultra violet rays in it kills the germs collected in the	Kitchen placed at the east which is the beneficial location. Because It Helps to get benefit from early morning solar gain throughout the year and it will be cooler in the late afternoon when evening meal preparation takes place.

			kitchen overnight, keeps the food free from contamination and avoid small insects to grow inside the kitchen, hence kitchen is located South-East corner (Suriyanarayanan,et.al. 2016).	

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.8-Temperature and relative humidity data at homestead 03

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
12/11/2017 10.00 am	North	Room 01 26.1	78	Admittedly north side mostly does not receive direct sunlight; it can be quite bright and well illuminated with indirect sunlight. The minimum difference of the temperature between north and south is recorded only 2 °C. The water body on the north-west side and an excessive plantation surrounded it minimize the overall temperature of the north side made the northern wind cooler.
		Room 02 26.6	77	
	South	Room 03 27.1	69	
		Room 04 **27.2**	69	
	West	**27.0**	75	

Day light Analysis

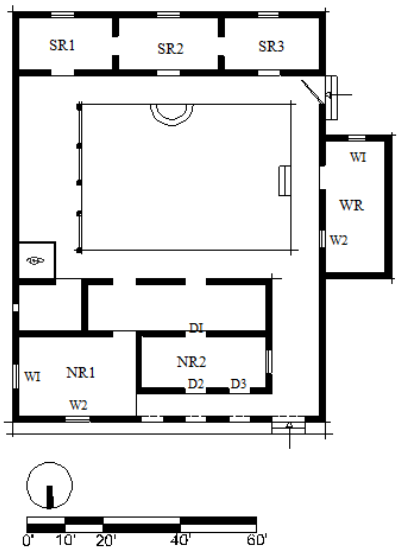


Figure 3.10: Room positions shown in layout 03

Table 3.9: Homestead 03 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date/Time	No of room		Amount of light at the work top (Lux)			
			Beside window	Middle row	Beside door	
12/11/2017 10.30 am	SR2		19	4.0	59	
	SR3		15.4	07.1	46	
	NR1	WI	143	59	26.7	
		W2	139			
	NR2		98	75	D1	36.9
					D2	**128**
					D3	110
	WR1	W1	103	110	250	
		W2	82.9			

Observation from the collected Day light data:

From the chart, it can be observed that the illumination range of West side unit and north is relatively better than the south. The adjacent open space of north and courtyard oriented opening of the west unit results in higher illumination.On the other hand, the south has other settlements on both sides and also minimum and small openings. That results in low illumination on the south side living units.

Overall observation on case study 03

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. Pond near the north-west side and surrounding plantations take up a large amount of heat of the west and make the space cooler. From the physical observations, it is found that the users of northern rooms are enjoying the most comfortable condition. The kitchen is less comfortable due to obvious reasons and the kitchen on the east corner obstruct the light from the east.

3.2.4Case Study 04 (Refer to Annexure, Case study 04)

House type: Rural Homestead

Village: Mohipur Mohadev pur

Zilla: Nagaon

Type of Construction: CI sheet

Figure 3.11: layout of Homestead 04

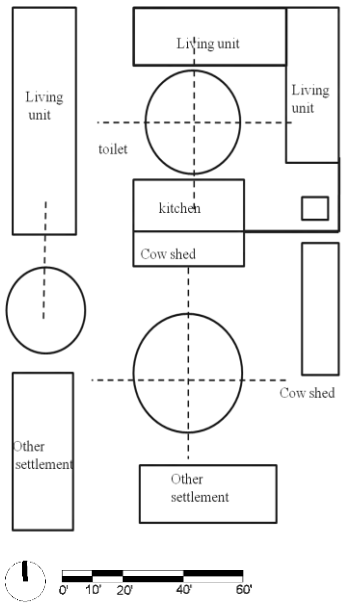


Figure 3.12: Space organization of Homestead 04

Table 3.10: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan,et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind Few rooms are seen in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	Main entrance from the south. Enjoying Summer cool air from the south.
04.	open space	Mentioned about open space like courtyard for proper air circulation.	Encouraged for The central space (Bramhasthan)should be set aside or left	Not only inner, the outer courtyard is also seen.

		Technical reasons: Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	free(Suriyanarayanan,et.al. 2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Courtyard here helps to ensure higher thermal comfort.
05.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
08.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light,south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees planted in the South-West, but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.** Trees that can be planted in a house compound are useful trees like Mango, Guava,banana,coconut,neem,betel, sandalwood, lemon, pineapple, bilva, almond, jackfruit, pomegranate, mango, tulsi,amla, and katha.Most of the trees have great medicinal,economical value that's why in vaastu they mensioned these trees as auspicious	Mango, guava, coconut trees are seen. There is also vegetable (gourd) is planted beside the main entry. All the tress has economic value and healthy, works as a thermal barrier and also protects the house from storms/cyclones.
09.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		

	Bedroom	South facing room is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet,et.al. 2016) **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all unit but open elongated plan shapes room in the south direction enhances cross ventilation.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.
	Toilets and Bath rooms	Didn't find any observation of Khona according Toilets and Bath rooms. However these one traditionally placed in North-West. **Technical reasons:** West side is hotter. Bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	The optimal location for Toilets should be the North-West or West of building. The other choice for the position of the Bathroom is the South-East. Sun rays from the east will make benefits (Suriyanarayanan, et.al. 2016). **Technical reasons:** The Bathroom has to be in the North-West or West. The infra-red rays of the Sun get projected on the West direction and so the West side is hotter, especially in the evenings. Hence the bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	Bath area located on the South-East side that gets the maximum benefit from sun rays.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table3.11 -Temperature and relative humidity data at homestead 04

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
14/11/2017 02.00 pm	North	27.6	71	The maximum temperature in the west 29.0 °C which is 2.4°C higher than the other side. As we know, the north never gets the direct sun and also the data was collected at 2pm.when the sun was moving from the east towards the west. That is the reason behind the higher temperature of the west unit. Building orientation affected the temperature of the homestead.

Day light Analysis

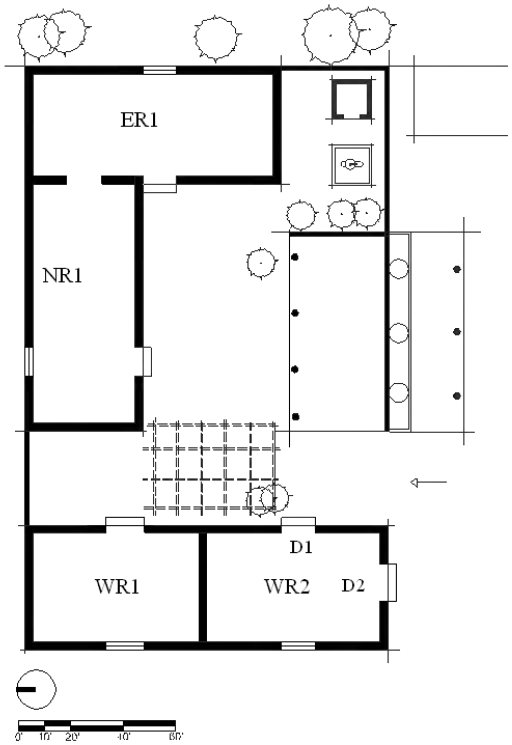


Figure 3.13: Room positions shown in layout 04

Table 3.12: Homestead 04 daylight conditions in different orientation in same time of the day (Source: Field Survey)

Date/Time	No of room	Amount of light at the work top (Lux)			
		Beside window	Middle row	Beside door	
14/11/2017 2.15pm	ER1	98	4.0	120	
	NR1	89	09.4	107	
	WR1	173	94	78	
	WR2	275	100	D1	88
				D2	153

Observation from the collected day light data:

From the above chart, it can be seen that the illumination range of Westside is relatively higher than the east and north unit. Longer room but minimum window results in insufficient light in north unit.

Overall observation on case study 04

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. Westside rooms are less comfortable due to obvious reasons and the kitchen is also less comfortable due to obvious reasons, the kitchen on the south obstructs cool breeze from the south.

3.2.5 Case Study 05 (Refer to Annexure, Case study 05)

House type: Rural Homestead
Village: Mohipur,Mohadev pur
Zilla:Nagaon
Type of Construction: CI Sheet

Figure 3.14: layout of homestead 05

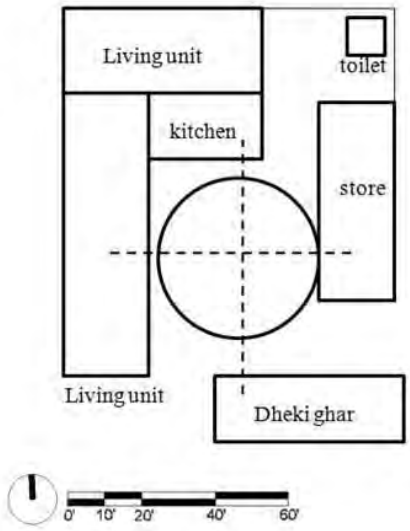


Figure 3.15: Space organization of homestead 05

Table 3.13: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan,et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	A room is seen in this orientation. But kitchen adjacent to the room blocking the natural light and results in high temperature.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Though Windows are seen s a source of natural light but the ratio of window and wall is deficient there.

05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space(Bramhasthan)should be set aside or left free (Suriyanarayanan,et.al. 2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Not only inner,the outer courtyard is also seen. Courtyard here helps to ensure higher thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	The main entrance to the south ensures maximum ventilation.
08.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted.	Plum tree, Mango, coconut, banana, and drumstick trees are seen. This tress has a great economic value and good for health.

		should be planted nor to obstruct to enjoy the south breeze.		
09.	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters. (Ranjeet,et.al.2016) **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all units but few rooms are located in the south direction and, get the maximum benefit of ventilation.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.14-Temperature and relative humidity data in the homestead 05

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
15/11/2017 01.00 pm	North	26.0	80	The measurement was taken at 1 p.m. in the month of November. While taking the data it was raining, as a result, the overall temperature is relatively low with high humidity. The temperature was very near 26.3°C-.26.5°C difference.
	East	26.3	79	
	West	26.5	81	

Day light Analysis

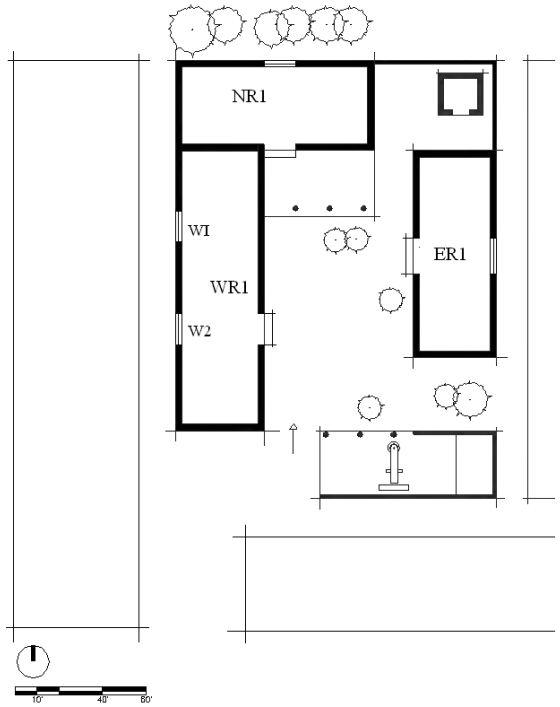


Figure 3.16: Window positions shown in layout 05

Table 3.15: Homestead 05 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room		Amount of light at the work top (Lux)		
			Beside window	Middle row	Beside door
15/11/2017 1.15pm	NR1		40.8	1.2	31
	WR1	W1	38	4.0	55
		W2	41		

Observation from the collected day light data:

From the above chart it can be observed that the illuminationcondition of the homestead is very low. It was raining when the data was being collected. The cloudy sky resulted low light. North always gets the diffuse light and also kitchen in front of north, that doesn't allow sufficient amount of light to enter into the room. Other settlement of west side also prevents adequate illumination from entering inside the room.

Overall observation on case study 05

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally facing uncomfortable condition. West facing room is less comfortable due to obvious reasons and the south facing room is less comfortable due to its adjacent position to the kitchen which results high temperature.

3.2.6 Case Study 06 (Refer to Annexure, Case study 06)

House type: Rural Homestead
Village: Shalgram, Mohadev pur
Zilla: Nagaon
Type of Construction: CI Sheet

Figure 3.17: Layout of homestead 06

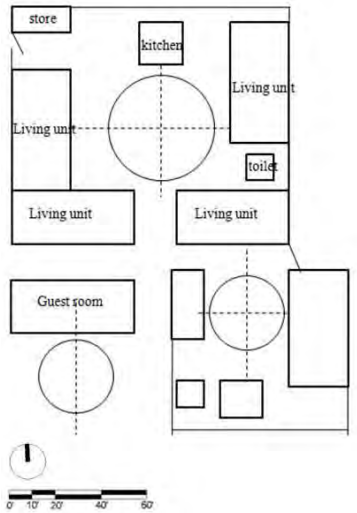


Figure 3.18: Space organization of homestead 06

Table 3.16: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan,et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind. Few rooms are located in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Though Windows are seen s a source of natural light but the ratio of window and wall is deficient there.

05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space(Bramhasthan)should be set aside or left free (Suriyanarayanan,et.al. 2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	The inner Courtyard is seen. Courtyard here helps to ensure higher thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	Main entrance to the east ensures large openings of east for ventilation.
08.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		
	Bedroom	South facing room is preferred and cross ventilation is preferred.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet,et.al.2016)	A room is placed in this direction. South facing room gets minimum solar exposure and also receives highest prevailing wind.

		Technical reasons: South facing room is better for least solar exposure and also receives highest prevailing wind.	**Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithokghar seen near the main entrance. That ensures the privacy of the dwellers.
09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.**	Guava tree is seen inside the court and coconut tree is also seen periphery of the back side and front side. Big Coconut trees placed in the west help to avoid the direct sun.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.17-Temperature and relative humidity data in the homestead 06

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
15/11/2017 2.00 pm	North	25.1	80	Rainy weather resulted in high humidity 80% and relatively comfortable temperature 25.5 °C. But according to the user, the north side temperature is higher because the kitchen is adjacent to the north side room. The arrangement of function also affected the temperature.
	South	25.0	79	
	West	25.3	82	
		Guest house 25.5	82	

Day light Analysis

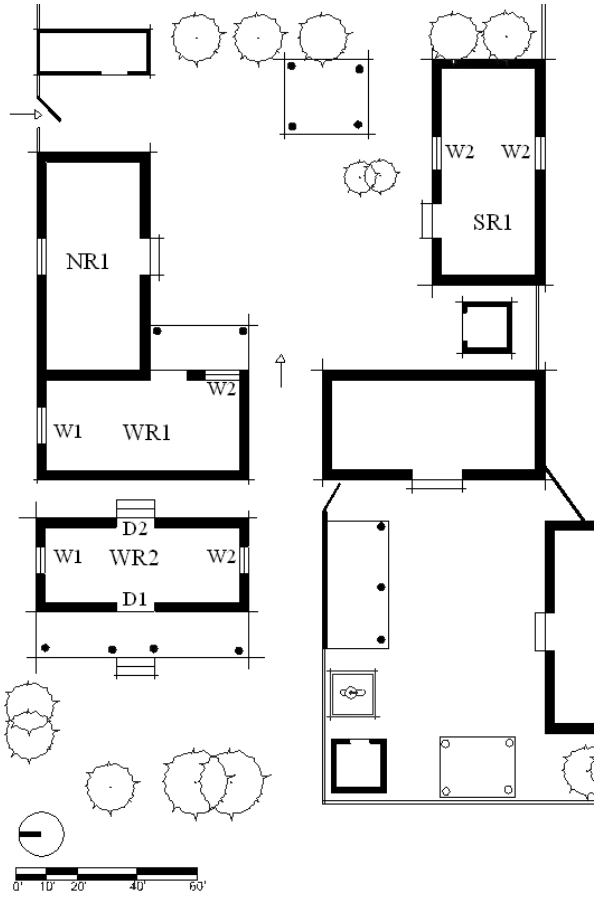


Figure 3.19: Window positions shown in layout 06

Table 3.18: Homestead 06 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room		Amount of light at the work top (Lux)			
			Beside window	Middle row	Beside door	
15/11/2017 2.15pm	NR1		15.8	02.4	45	
	SR1	W1	25	09.4	44	
		W2	38			
	WR1	W1	21	03.7	38.3	
		W2	38			
	WR2	W1	23	5.7	D1	47
		W2	28		D2	38

Observation from the collected data:

Data taken on a rainy day resulted in low illumination. From the above chart, we see the illumination range to be very Low in all unit. The dark sky and surrounding settlement results in low illumination.

Overall observation on case study 06

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. West facing rooms and the kitchen are less comfortable due to obvious reasons.

3.2.7 Case Study 07 (Refer to Annexure, Case study 07)

House type: Rural Homestead
Village: Shalgram,Mohadev pur
Zilla:Nagaon
Type of Construction: Mud

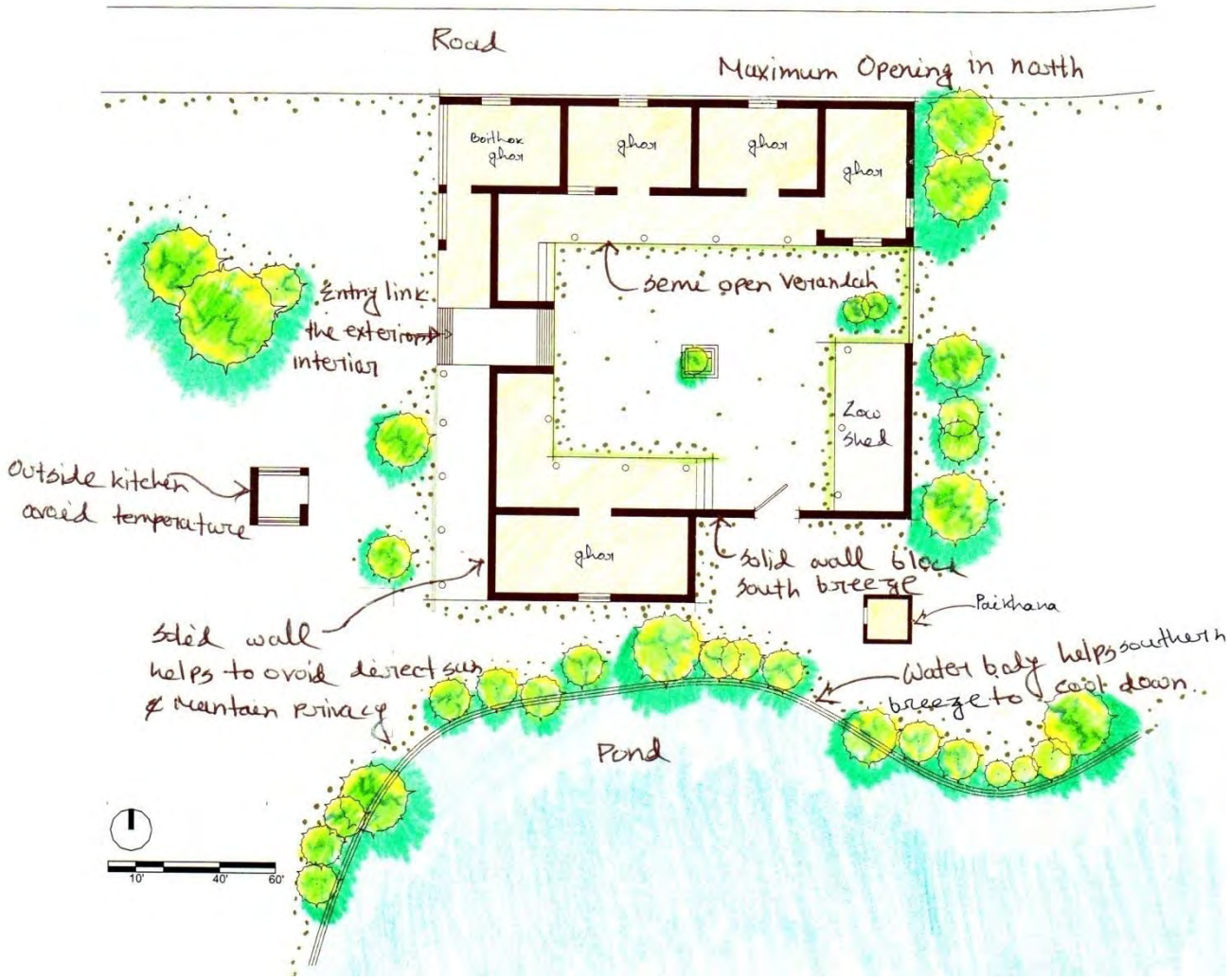


Figure 3.20: Layout of homestead 07

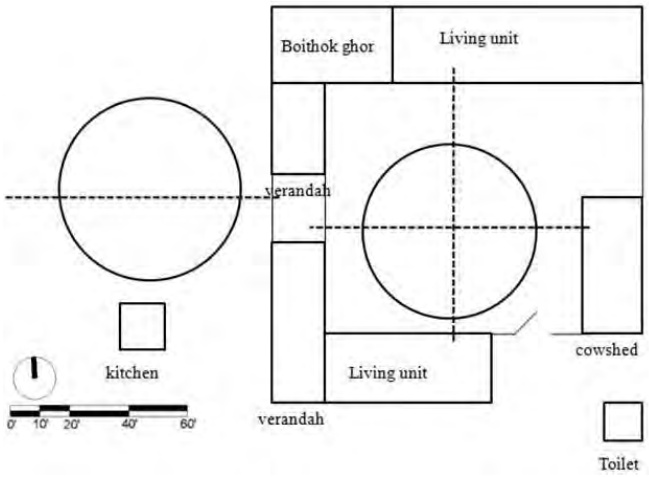


Figure 3.21: Space organization of homestead 07

Table 3.19: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan,et.al.2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind. Maximum rooms are seen in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm	Though semi-open verandahs, Windows are seen as a source of natural light, the ratio of window and wall is deficient there.

		building and results in unhygienic space.	humid climate.	
05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space(Bramhasthan)should be set aside or left free. (Suriyanarayanan,et.al.2016). **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	Not only inner,the outer courtyard is also seen. Courtyard here helps to ensure higher thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	The main entrance to the west that results in received longer periods of radiation.
08	Building material	Indigenous material preferred.Mostly bamboo, mud, thatch. **Technical reasons:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	Only new bricks, wood, and materials should be used when building a new house (Olivera, 2013). **Technical reasons:** According to Vastu Shastra Materials that have been stored for a long time should not be used. The materials are easily available and relatively low longevity and also locally available.	Locally available material, like-mud and bamboo are used as construction material. Ensures good ventilation and shade.

09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.**	Trees are seen outside and inside of the homestead. The pond is also surrounded by lots of trees like Cauliflower Tree, bamboo. Excessive plantation Maintain the thermal balance of the homestead.
10.	Water body	Khona mentioned about presence of water body on the east in her maxim. **Technical reasons:** A water body takes up a large amount of heat in evaporation and causes significant cooling of air that flows into the house.	Water bodies create energies in house and attract peace and prosperity in the house (AstroSaathi, 2017). **Technical reasons:** Shaded water body minimizes the overall temperature by evaporation.	Pond surrounded by trees is seen near the south side. Excessive plantation and water body makes the south breeze cooler.
11.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		
	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet,et.al.2016) **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all unit but few rooms are located in south direction receives highest prevailing wind.

	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence . (Suriyanarayanan,et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.20 -Temperature and relative humidity data in the homestead 07

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
16/11/2017 11.00 pm	North	Room 01 27.1	75	The small opening, semi-open verandah, building material minimizes the average temperature of the homestead. Here the temperature of the east side is 27 °C, which is higher than the other units. As we know the sun rises in the east and moves towards west tilted from the south. In that case, the temperature of east and south should be higher than the north. But because of the excessive plantation, breeze and water body of the south minimizes the temperature of the south unit that is 1.5 °C lower than the other unit. So, we must say landscaping or shading played an important role while designing.
		Room 02 27.1	75	
		Boithok ghar 27.1	75	
	East	27.5	75	
	South	26.0	79	

Day light Analysis

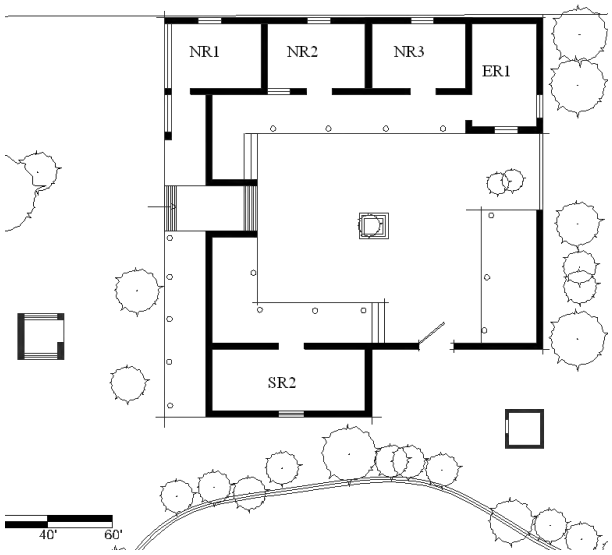


Figure 3.22: Window position seen in layout 07

Table 3.21: Homestead 07 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room		Amount of light at the work top (Lux)		
			Beside window	Middle row	Beside door
16/11/2017 11.20am	SR1		35.9	13.4	2.0
	NR1		118	68	57
	NR2		97.8	69.1	17
	NR3		85.9	63.8	14
	ER1	W1	95	21	59
		W2	78.6		

Observation from the collected Day light data:

The thick mud wall in most of the homestead and small opening results in lower ventilation but from the above chart, we found that the lighting condition of the north unit is better than the other. The adjacent road beside the north unit invites more lights than the others. Excessive trees planted in the south and east unit obstructs the direct light to come and results in low illumination.

Overall observation on case study 07

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that generally the South side room is enjoying the best condition, due to the Pond surrounded by trees is seen near the south makes the south breeze cooler.

3.2.8 Case Study 08 (Refer to Annexure, Case study 01)

House type: Rural Homestead

Village: Mohipur,Mohadev pur

Zilla:Nagaon

Type of Construction: CI Sheets

Figure 3.24: Space organization of homestead 08

Figure 3.23: Layout of homestead 08

Table 3.22: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south. (Suriyanarayanan, et.al. 2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	In north-south orientation, we can get the maximum prevailing wind. Most rooms are located in this orientation.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth prevents the effect of the flood.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural	Though Windows are seen s a source of natural light but the ratio of window and wall is deficient there.

		and results in unhygienic space.	ventilation is mandatory in the warm humid climate.	
05.	open space	Mentioned about open space like courtyard for proper air circulation. **Technical reasons:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	Encouraged for The central space(Bramhasthan)should be set aside or left free.(Suriyanarayanan,et.al. 2016) **Technical reasons:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air.	An inner courtyard and space in front of the homestead is seen. Courtyard here helps to achieve high thermal comfort.
06.	Roof	Pitched roof preferred. **Technical reasons:** Pitched roof slopes help the rain water to fall and reduce the risk of leaking roof. Besides it is more stable against high wind.	The roof of the house should slope towards the northeast (Olivera, 2013). **Technical reasons:** Driving rain is from south to south-east direction.	Pitched roof (chouchala) is more stable against rain and wind and to provide shade.
07.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	Main entrance to the east .east ensures large openings for ventilation.
08.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays	Big trees are seen on the west side and relatively small height trees seen at the north side results in maintaining the thermal balance. Guava, Mango trees auspicious according to Vastu is seen. Both of

		in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	big trees should be planted**.**	them are full of nutrients and health.
09.	Orientation and Laying of room	SL. No. one (01) discusses the issue.		
	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet,et.al.2016) **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Though not all unit but few rooms in the south direction enhance cross ventilation.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al.2016) **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Boithok ghar seen near the main entrance. That ensures the privacy of the dwellers.
	Toilets and Bath rooms	Didn't find any observation of Khona according Toilets and Bath rooms.However these one traditionally placed in North-West. **Technical reasons:** As we know West side is hotter. Bath room in West helps to block the	The optimal location for Toilets should be the North-West or West of building. The other choice for the position of the Bathroom is the South-East. Sun rays from the east will make benefits (Suriyanarayanan,et.al. 2016).	Original toilet located on the west side.

		radiation to other parts of the house, keeping them relatively cool.	**Technical reasons:** The Bathroom has to be in the North-West or West. The infra-red rays of the Sun get projected on the West direction and so the West side is hotter, especially in the evenings. Hence the bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.23-Temperature and relative humidity data in the homestead 08

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
17/11/2017 10 am	East	Boithok ghar **28.4**	65	The temperature of the east (28.4 °C) and south (only difference .3°C) is relatively same and higher than the west side. Excessive plantation or shading minimizes the temperature of the west side.

Day light Analysis (Homestead 08)

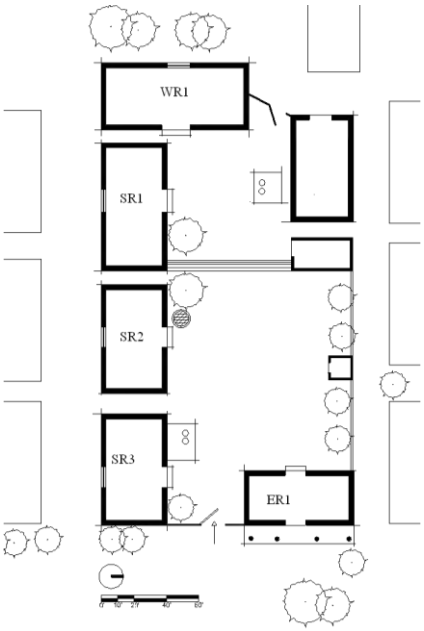


Figure 3.24: Window position seen in layout 08

Table 3.24: Homestead 08 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room	Amount of light at the work top (Lux)		
		Beside window	Middle row	Beside door
17/11/2017 10.20am	ER1	112	97.2	105
	WR1	67	21	57
	SR1	99.4	43	85
	SR2	85.9	50	97
	SR3	97.8	47	80

Observation from the collected data:

Because the data was taken at the first half of the day when the sun was moving from east to west with a tilt towards the south, east and south get more light and also open space on both sides of the east unit helps more light.

Overall observation on case study 08

In nutshell, the homestead layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. West facing rooms are less comfortable due to obvious reasons but plantation or shading minimizes the temperature of the west side. Plantation inside the courtyard increases the humidity and reduces the speed of wind but it provides better thermal comfort at certain periods of daytime

3.2.9 Case Study 09 (Refer to Annexure, Case study 09)

House type: Urban House (Apartment -01)
Location: Shyamoli,West Agargaon
Zilla:Dhaka
Type of Construction: Brick, RCC

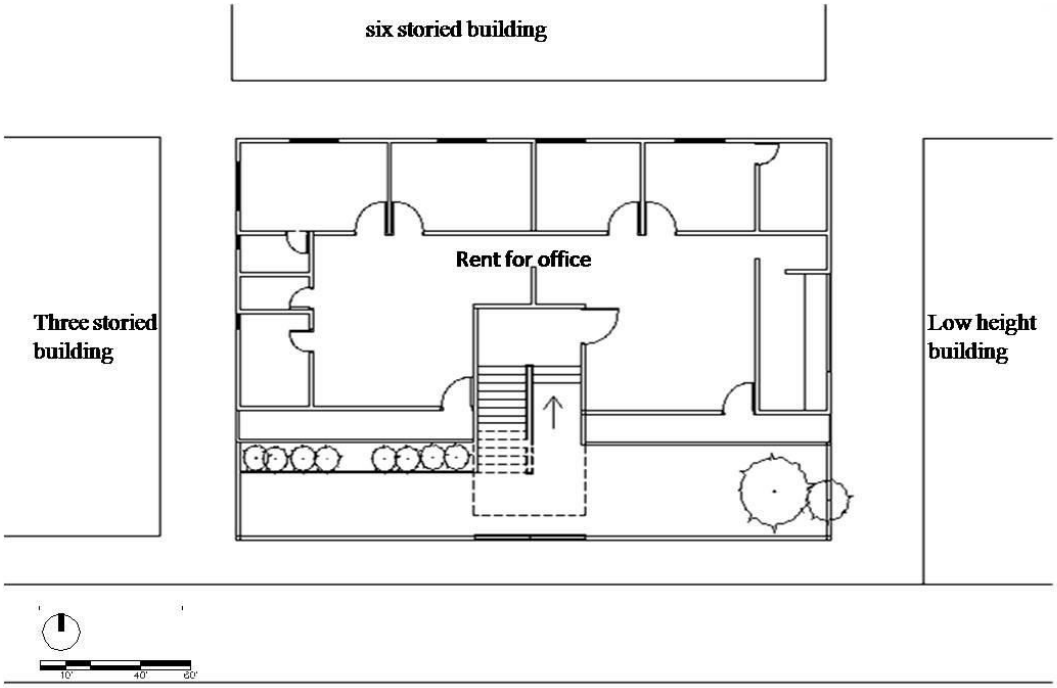


Figure 3.26: Ground plan of Apartment

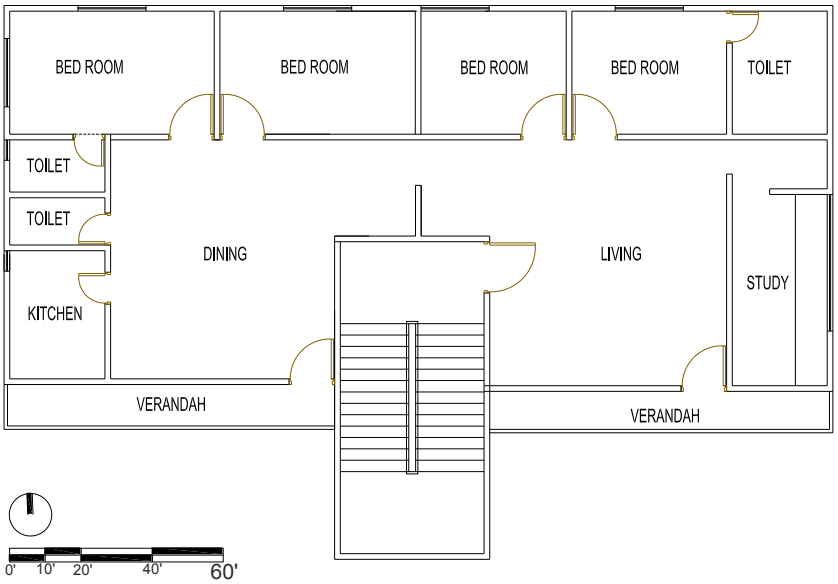


Figure 3.27: 1st Floor Plan of the apartment

Table 3.25: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south(Suriyanarayanan,Muthu,Venkatasubramanian,2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	All the bed rooms are in North-south oriented. That is very positive attempt for our warm humid region.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth avoids the effect of the flood and ensures good ventilation.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	Semi-open veran-dahs, Windows are seen as a source of natural light. The ratio of wall and opening is well maintained.
05.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite comfortable. West oriented entrance is poorer.	The main door should always be in the north, north-east, east, or west, as they are considered auspicious (Sharma,2018)	Main entrance to the east .East side entrance is better for enjoying maximum ventilation.

		Technical reasons: According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	**Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	
08	Building material	Indigenous material preferred.Mostly bamboo, mud, thatch. **Technical reasons:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	Only new bricks, wood, and materials should be used when building a new house (Olivera, 2013). **Technical reasons:** According to Vastu Shastra Materials that have been stored for a long time should not be used. The materials are easily available and relatively low longevity and also locally available.	Brick is the main construction material. That is the most common and available indigenous building material.
09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.**	jackfruit, carambola trees planted in the west. Few flower trees are seen also.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan,et.al. 2016). **Technical reasons:** Because of the privacy of the residence, living room is preferred to be located near the main entrance.	Living room seen near the main entrance. That ensures the privacy of the occupants.

	Toilets and Bath rooms	Didn't find any observation of Khona according Toilets and Bath rooms. However these one traditionally placed in North-West. **Technical reasons:** West side is hotter. Bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	The optimal location for Toilets should be the North-West or West of building. The other choice for the position of the Bathroom is the South-East. Sun rays from the east will make benefits (Suriyanarayanan, et.al. 2016). **Technical reasons:** The Bathroom has to be in the North-West or West. The infra-red rays of the Sun get projected on the West direction and so the West side is hotter, especially in the evenings. Hence the bath room in West helps to block the radiation to other parts of the house, keeping them relatively cool.	Few toilets located on the mentioned side.
	Dining room	Didn't find any observation of Khona according dining Room.	Dining room has to be located in the West. The direction while eating can be east (or) west (indianetzone, 2010). **Technical reasons:** Because Eating, facing south will create restlessness since the body will be affected by repelling forces.	Dining at the west. The semi-open verandah in front of the dining doesn't allow direct sunlight. But it helps to receive adequate light and air.

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.26-Temperature and relative humidity data in the homestead 09

Date/Time	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
20/11/2017 10 am	East	Bed rooms(beside kitchen) **28.0**	74	In our climatic condition during the morning the temperature of the east side is 28 °C. That is maximum. However, there is a six-story apartment on the east side obstructing the wind flow. North side temperature is high because of the placement of the kitchen in the north. Adjacent room and the dining with the kitchen also results in higher temperature. Although kitchen and dining also get the west exposure, the semi-open verandah didn't allow the direct sun to

				enter. It helps to reduce overall temperature. The surroundings, arrangement of function affects the overall temperature here.

Day light Analysis

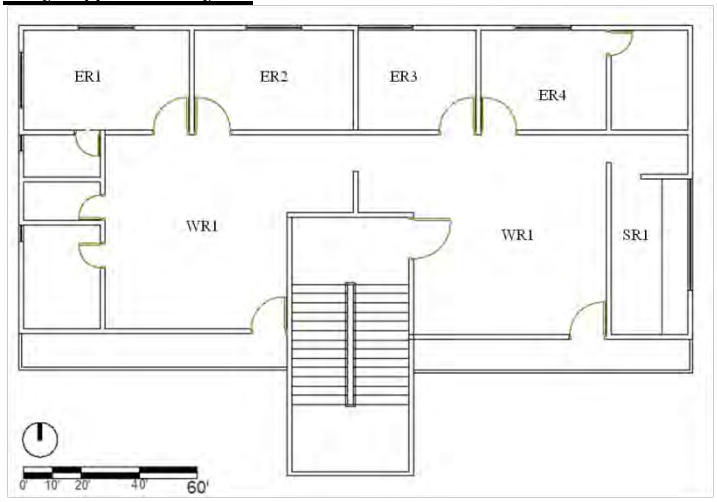


Figure 3.28: layout of case study 09

Table 3.27: Homestead 09 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date	No of room		Amount of light at the work top (Lux)		
			Beside window	Middle row	Beside door
20/11/2017 11.30 am	SR1		1047	500	302
	WR1		118	68	57
	WR2		58.9	44	11.7
	ER1	W1	546	75	15.9
		W2	119		
	ER2		85.9	12.9	5.9
	ER3		38.7	09.7	5.5

Observation from the collected data:

From the above chart the noticeable illumination was found on the south side of the study area. The low height structure of the south doesn't interrupt the ventilation. Large window also helps to allow ample natural light. The data was taken in the first half of the day when the sun was moving from east to west tilting south; however the six-storied building in the eastside hampers light

entering the bedrooms. Another noticeable illumination was found the north east room. The unfilled space of this corner helps to enjoy maximum light.

Overall observation on case study 09

In nutshell, the Urban House (Apartment -01) layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. All the bedrooms are in North-south oriented that results in comfortable condition. West facing rooms are less comfortable due to obvious reasons and the kitchen is also less comfortable due to obvious reasons. Adjacent room to kitchen and the dining room besides the kitchen also results in discomfort due to higher temperature.

3.2.10 Case Study 10 (Refer to Annexure, Case study 01)

House type: Urban House (Apartment -02)

Location: South Paikpara, Kollyanpur

Zilla:Dhaka

Type of Construction: Brick, RCC

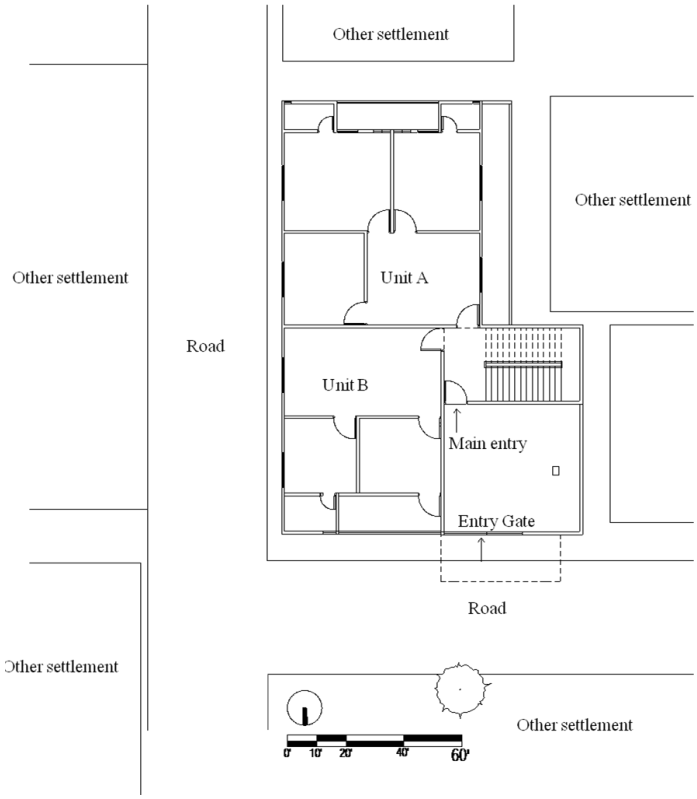


Figure 3.29: Ground floor plan

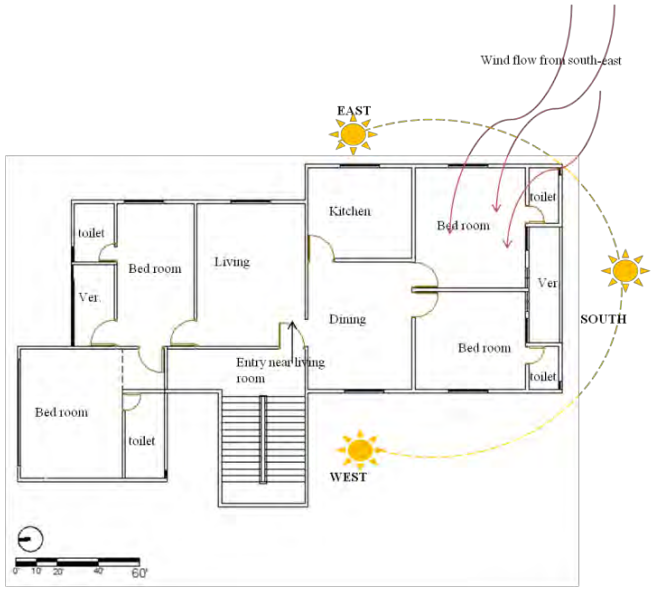


Figure 3.30: 1st floor plan with sun path diagram

Table 3.28: The table shows the relevance of Khona and Vastu Shastra with the traditional architecture of Bangladesh vis-a-vis technical reasoning.

Sl.	Parameter	Khona's Guidelines and technical reason	Vaastu shastra Guidelines and technical reason	Author's Observation on the site
01.	Orientation	North-south orientation is preferred. **Technical reasons:** In our warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of the building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	The north south wall of the building must be orientated to coincide exactly to the cardinal direction of north south (Suriyanarayanan, et.al.2016). **Technical reasons:** Prefer north-south orientation to get minimum solar exposure and maximum prevailing wind.	All the bed rooms are in North-south oriented. That is very positive attempt for our warm humid region.
02.	Shape of the site	Didn't found any undeviating observation of Khona according to the shape of the site. However, the maxims were compiled in a rural background. Where most of the building layout is in a regular shape.	Square and rectangular plots are the best (Gupta, 2016). **Technical reasons:** The Regular shape helps in avoiding wastage and creates a good design & brings harmony	The Rectangular shape of the house followed the configuration of the site. Open elongated plan shape enhances the ventilation system.
03.	Plinth	Given emphasize on plinth height. **Technical reasons:** The height of the plinth should be maximum. Because lower plinth height results in unhygienic space. Plinth height ensures good ventilation and prevents the flood.	Rules related to the plinth (upana and Adhisthana) are also to be essentially followed. The height of the plinth should be determined based on the height of the whole structure, which height is ascertained from the width of the building (indianetzone, 2010). **Technical reasons:** Higher plinth acts as a safeguard from the effects of the flood.	Elevated Plinth is spotted. Elevated plinth avoids the effect of the flood and ensures good ventilation.
04.	Openings/ ventilators	Importance on having proper ventilation in a house. The house should be open, airy and get ample amount of sunlight. **Technical reasons:** If the ventilation is not adequate it creates dampness on the building and results in unhygienic space.	According to Vastu ventilators are used to provide proper ventilation and airflow in the house with the natural process (Pujala, 2011). **Technical reasons:** To create comfortable built environment natural ventilation is mandatory in the warm humid climate.	The Semi open verandahs, Windows are seen s a source of natural light .The ratio of wall and opening is well maintained.
05.	Entrance	According to Khona south oriented entrance is the best, east oriented entrance is quite	The main door should always be in the north, north-east, east, or west, as	Main entrance to the south. Ensures large

		comfortable. West oriented entrance is poorer. **Technical reasons:** According to our climatic aspect in summer cool air comes from the south side. We may say in that case south oriented entrance is better. The eastern side receives substantial heat during the morning, which highly appreciated in the winter time. East breeze also encouraged in the summer. And the west side received longer periods of radiation. This Khona mentioned west as inappropriate.	they are considered auspicious (Sharma,2018) **Technical reasons:** It's preferable to orient in the North and East to allow useful sunlight to enter constantly, throughout the day	openings of south for ventilation.
08	Building material	Indigenous material preferred.Mostly bamboo, mud, thatch. **Technical reasons:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	Only new bricks, wood, and materials should be used when building a new house (Olivera, 2013). **Technical reasons:** According to Vastu Shastra Materials that have been stored for a long time should not be used. The materials are easily available and relatively low longevity and also locally available.	Brick is the main construction material. That is the most common and available indigenous building material.
09.	Landscaping	Khona gave emphasis on landscaping. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Technical reason:** According to her Big trees in the west side to avoid the sun of the west, small height trees or deciduous trees planted in the north not to obstruct the passing of winds and light, south should be empty or very low height vegetables should be planted nor to obstruct to enjoy the south breeze.	Tall trees like Coconut and lemon can be planted in the South-West, West sides but should not be too close to a building as they block the sunlight completely (Nanda, 2018). **Technical reasons:** To avoid the direct sun rays big trees should be planted**.**	Minimum plantation is seen. Only a jackfruit tree in front of the apartment is seen.
	Living Room	Didn't find any observation of Khona according living room. (Here Khona meant Bed room by Ghar). Preferred orientation is South and East.	The Living Room is to be located near the entry to the residence (Suriyanarayanan, et.al. 2016).	Living room seen near the main entrance. That ensures the privacy of the occupants.

			Technical reasons: Because of the privacy of the residence, living room is preferred to be located near the main entrance.	
	Bedroom	South facing room is preferred and cross ventilation is preferred. **Technical reasons:** South facing room is better for least solar exposure and also receives highest prevailing wind.	Main bedroom should be constructed on South-West corner for peace full sleep. It is a place where positive energy enters (Ranjeet,et.al.2016). **Technical reasons:** Bio energy is released in the south west corner. As science says North East corner is famished with lots of positive energies, the opposite of North East is South West corner. So the positive energies flow from NE to SW corner where the bedroom should be located & with this energy people will be getting privileged.	Bed rooms located in south direction.
	Dining room	Didn't find any observation of Khona according dining Room.	The Dining room positioning depends on the distance to the Kitchen, wash basin etc., Dining room has to be located in the West. The direction while eating can be east (or) west (indianetzone, 2010). **Technical reasons:** Because Eating, facing south will create restlessness since the body will be affected by repelling forces.	Dining at the west.
	Kitchen	Didn't find any observation of Khona according dining Room.	The ideal position for a kitchen is the Southeastern corner of a house **Technical reasons:** The sun's rays (cosmic rays) first reaches east corner of the earth and the ultra violet rays in it kills the germs collected in the kitchen overnight, keeps the food free from contamination and avoid	Kitchen placed at the east.

			small insects to grow inside the kitchen, hence kitchen is located South-East corner(Suriyanarayanan, Et.al.2016).	

Comfort level Analysis

To get the thermal performance, temperature and relative humidity data was collected during the survey (Refer to chapter 01, Section 1.5).

Table 3.29 -Temperature and relative humidity data in the homestead 10

Date	Room location	Temperature °C	Relative Humidity %	Observation from the Collected Data
21/11/2017 1pm	East	living 27.4	58	The temperatures of all rooms are relatively same 27.4 °C. The west temperature is little a bit higher (.3 °C) because the kitchen is adjacent to the dining area i.e. the orientation and function arrangement influence the overall temperature pattern of a residence.
	South	Bed Room 01 27.4	59	
		Bed room 02 27.4	58	
	West	Dining 27.7	55	
	North -east	Bed room 01 27.4	57	
	North -west	Bed room 02 27.5	59.1	

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Day light Analysis

Figure 3.31: Layout of case study 10

Table 3.30: Homestead 10 daylight condition in different orientation in same time of the day (Source: Field Survey)

Date /Time	No of room	Amount of light at the work top (Lux)		
		Beside window	Middle row	Beside door
21/11/2017 1.30 pm	SR1	26	14.1	05.1
	SR2	16.5	03.1	05.3
	WR1	13.9	02.1	12.3
	ER2	84.5	23.8	12.3
	NER1	95	14.1	5.0
	NWR2	599	136.9	47.2

Observation from the collected data:

The northwest room enjoys maximum illumination for the full height window. The adjacent road in front of the north room allows the light and view. The west and south side blocked by other structure results in less illumination. Short of a satisfactory amount of light, mostly in the west leads to dependence on artificial lighting.

Overall observation on case study 10

In nutshell, the Urban House (Apartment -02) layout seems to be complying with the Khona's as well as Vastu Shastra's guidelines. From the physical observations, it is found that the users are generally comfortable. West facing rooms are less comfortable due to obvious reasons and the kitchen is also less comfortable due to obvious reasons. Adjacent rooms to the kitchen results in discomfort due to high temperature. The west and south side blocked by other structure obstructs adequate light and cool breeze from the south.

3.3 Collected Instrumental Data:

Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. The air temperature is mostly high between 21° and 32°C with little variation between day and night, high relative humidity in the range of almost 100% to 60%, high annual rainfall in the range of 2000-5000 mm with driving rain index of 3-7m2/sec, low air velocity in the range of 3-5 m/sec and high sky glare. These conditions, as also seen in the case studies, recommended large shade and large openings for ventilation in the habitable structures. It is seen that the vernacular buildings are the structures that use the bioclimatic concepts and locally available building material to a large extent for their sustainability.

Most of the vernacular buildings are climate responsive; that results in a sustainable built environment. Therefore, in the present context of increasing comfort requirement and energy efficiency regulation and guidelines, it is an urgent necessity to look back to old vernacular homesteads for an answer and improve upon those generic responses for comfort and sustainability.

Thermal and illumination data as seen in the case studies show the effect of different design features of the homesteads. Based on the analysis of collected data and standards few proposals are made for a sustainable built environment.

Table 3.31: General findings of the selected homesteads

Building type	homestead
Climatic zone	Warm and humid
Building material	Mud, bamboo, wood, thatch, CI sheets.
Ventilation type	Naturally ventilated
Temperature range	25-31°C
Layout and orientation	Open layout
Relative humidity (%)	55-81

During the survey it is found that there are some variables in building design that needs to be considered for achieving homesteads comfort and sustainability.

Orientation of Building:

As per Khona's Maxims, the building orientation plays an important role in its thermal performance. According to Koenigsberger (1975), the building will need to be opened up to the breeze and oriented to catch whatever air movement is there. He preferred open north-south

elongated plan shapes to allow cross-ventilation in Bangladeshi context. In the case studies, it is found that the temperature varies within the living units due to the building orientation. The orientation of the homestead also affects the illumination level indoors. The north-south oriented room gets the maximum light throughout the year. But in our rural homestead all the rooms are not north-south oriented In the case study (Refer to Table 3.9, 3.15) the north-south orientation room enjoy the maximum light and ventilation and least solar radiation.

Shading devices:

The use of shading devices is highly recommended, and their thermal benefits are recognized by several researchers (Olgyay and Olgyay, 1957; Croiset, 1976; Givoni, 1981) as well as by Khona. External shading devices are a passive design strategy to control solar heat gain in buildings and influences energy performance. It can reduce solar heat gain more effectively than interior devices, and its efficiency depends on the provided shading (Olgyay and Olgyay, 1957).The shading devices provide a greater coverage, obstructing most of the sky and not just the location of the sun. He also mentioned some shading tools. Like: open verandahs, galleries, elongated roof, broad overhanging eaves etc. The broad leaves shade the walls and openings; provide protection from driving rain and sky glare and permit the openings to open all the time. The shading tools have a positive impact on the thermal performance of buildings especially in warm-humid climates, selecting good shading tools increases the comfortable hours by 26% for unventilated buildings and 4.7% in ventilated conditions in warm-humid climate (Tamimi, Fadzil, 2011).Shading tools also help to avoid the direct sun in the case studies we found the units which have shading tools, its temperature, and illumination level is lower than the others (Refer to Table: 3.26; Table-3.27).Khona also recommended shading by more natural means.

Air flow and Openings:

The opening must be suitably placed in relation to the prevailing breezes to permit natural air flow. Through the internal spaces of body level, i.e. in the living zone up to 2 m /Second of wind is recommended and advised to avoid fixed glass panel and encouraged large and fully openable window (Koienigsberger, et.al.1973).As is known, the openings are not limited to 25% of the length of the wall (Ballast, 2013), that's why gave higher attention on openings for warm-humid region i.e. minimum 30%. During the case study, it is observed that the small window opening affected the ventilation in the homesteads. The small opening of the window causes low illumination level (Refer to Table-3.9) as well. However, traditional homesteads have must ample openings on the walls and large overhang roof for shading.

Landscaping:

Khana and Koenigsberger (1975) also have given importance to the plantation at proper places to direct breeze. According to them, the plantation had a huge effect on earth. They denoted warm humid region as favorable for the growth of vegetation. According to them the plant cover of the ground reduces reflected radiation and lessens the heating up of the ground surface. The excessive plantations of the homesteads result in minimum temperature (Refer to Table: 3.8).In some cases, the excessive plantation at closer distance also results in low illumination level (Refer to Table-3.3).

Building Material and technique:

One of the most important goals is to build shelters with "lightweight and low heat-storing materials". So there won't be much heat radiated towards the inside (Koch-Nielsen, 2002). This kind of material holds little heat and cool adequately during the night. He also preferred the elevated position of plinth to provide better security and better air movement as well as safety from flooding. He mentioned the thatched roof as an excellent thermal insulator. During the survey, it is found that maximum homesteads are made of mud. The mud, a low-cost indigenous material has a very high capacity to store heat energy – commonly referred to as 'thermal mass'. Inside remains cooler than outside during day-time. The mud stores the heat gained during day-time and dissipates it gradually after 8 PM at night, after getting heated from 7 AM to 5 PM in summer (with peak heat gain during 10.30 AM in the morning to 3.30 PM in late afternoon). Inside Temperature is less than the outside temperature from 8 AM in the morning to 7 PM, during the night hours the inside temperature is almost equal to outside temperature (Madhumathi, et.al.2014).The porous material results minimum temperature (Refer to Table-3.8, and Table 3.20).However, with lower temperature, RH increases requiring proper ventilation and body level. This is precisely seen in the case studies as per the description of Khona.

3.4 Setting Condition

This section is based on the data collected during the study made on the comparative analysis of the two-different context of rural homesteads and the urban context. All the data of both contexts shows the relevance of the Maxims of Khona and Vastu Shastra and its effect on the local built environment. As per the case studies, it is found that the most significant common factor and the core intention of the entire homesteading are to design a climate responsive sustainable built environment, where shading and ventilation is the crux of the matter. Khana's maxims deal with that.While observing the entire homestead, the simple, rectangular free structure, ventilation system, landscaping, construction technique all the characters that combined our local knowledge with an understanding of sustainable materials and energy flow system is to encourage healthy interaction with the natural environment.

In the cases of urban case studies, the reverse scenario is found from the rural homestead. There are a lot of limitations present in the urban settings like the land shortage, site settings, building material, different functions etc. This constrains result in a different texture of built environment. However, the cases with rural characteristics in the urban context seem to provide better comfort conditions.

The example of the homesteads and houses and their compatibility analysis with the maxims of Khona and Vastu Shastra shows the extent and the possibilities to implement the potentialities of the traditional wisdom in our contemporary context for building sustainable and comfortable environment.

Through the case studies of the urban and rural setting analysis, some common factors have been determined. These characteristics reflect Khonar bachon and are a fundamental prerequisite for a sustainable environment. This can be taken into consideration and acknowledged as guidelines when designing the built-environment in Bangladesh.

3.5 Identifying the Maxims Suitable for Application in the Contemporary Built Environment Design.

3.5.1Contemporary standards
3.5.2 Relevance with comfort conditions
3.5.3 Relevance with building by law
3.5.4 Application in the contemporary context

3.5.1Contemporary standards

It is often forgotten that our architectural traditions are rich in content, given that they have originated from the exact harmony between the necessities of existing, the environment, material resources and ideas on the use of space. Using these standards, contemporary architecture could take a lesson where cultural continuity and adaptability take leading place but also provide guidelines for climate-adapted and sustainable architecture. Today exceeding numbers of contemporary buildings utilize natural components and synthesizes with the natural surroundings. In that sense, the purpose of contemporary style and the "Maxims of Khona" is substantially similar. Contemporary architecture can be characterized by few key standards.

Table 3.32: The table compares the maxims of Khona and the Contemporary standards in practice.

Sl.	Parameter	Guidelines according khona	Contemporary standards
01.	planning	Spread out plan	To provide sufficient air circulation, buildings should be scattered (SKAT, 1993). BNBC gives importance to set back (Refer to Clause 1.8.1).
02.	Natural, sustainable components	Mentioned for natural indigenous material.	Encourage for eco friendly building material. Recycling building materials is one of the techniques for materials being employed to reduce the environmental impact of buildings (Yılmaz, 2006).
03.	Integration with nature.	Khona encouraged for openings in the house for good light and ventilation for healthy living.	Rooms have multiple outdoor views, or multiple access points, encouraging light and ventilations, an appreciation of healthy living (Karin Beuerlein ,2018).
04.	Roof	Pitched roof is preferred because the roof slopes helps the rain water to fall quickly and reduce the risk of leaking roof.	One area of contemporary architecture that can draw much attention is the roof. In today's world, flat overhanging roofs is a common way to add eye-catching design elements, while providing additional shady regions adjacent to the structure and still protect the overall structure from sun and rain (Bauholz, Jun 11, 2011).
05.	Natural lights	Khona Mentioned about Windows, and central courtyard which act as a source of natural light.	Another goal is to have adequate natural light in the interior spaces of the building (Bose, 2012) .Because Courtyard in hot humid climate is open extended form to allow the air movement to achieve the thermal comfort (Abed,2012).BNBC gives importance to natural lights (Refer to Clause 1.19).
06.	Ventilations	Khona gives Importance on having proper ventilation in a house. The house should be open, airy and get ample sunlight.	Encouraged Natural ventilation for low energy alternative to produce thermally acceptable and improved air quality in the spaces within the buildings(Ogwezi,et.al,Viwed 7th March 2018). BNBC gives importance to natural lights (Refer to Clause 1.19.1).

08.	Plantation	Khona Encouraged plantation because Plantation on the surroundings of house brings happiness and healthiness in mind.	Add trees to the top of their buildings to facilitate natural cooling and also to create a building that is more harmonious with the natural surroundings (Henri Bauholz, 2018).Building by laws Call for at least 25% open space for greening.

3.5.2 Relevance with comfort conditions

Space organization plays a crucial role in ensuring a comfortable built environment. A built environment must be designed in such a way that establishes maximum comfort to support living and its sustainability. Climate responsive designs are required to assure certain comfort conditions. Unfavorable climatic conditions and the resulting stress on body and mind causes discomfort, loss of efficiency may eventually lead to a breakdown of health (Koenigsberger, 1975). Majority of vernacular buildings are constructed, suited to the particular geo-climatic condition and socio-cultural setup rather than based on the technological solution. Preceding investigation shows that the vernacular buildings are predominantly inspired by the local traditional wisdom. The main intentions of these maxims are to make a balance between dwellings, dwellers and its physical environment, which is often neglected in modern times. Though there is no scientific basis in Khona's maxims, but still we can learn lessons from the approach of the maxims and acknowledge the interdependence of human beings, buildings and physical environment. According to Givoni (1969) among all amenities in life, appropriate thermal environment plays a very significant role in meaningful, pleasing and efficient day to day comfortable living. Maintenance of thermal equilibrium between the human body and its environment is one of the primary requirements for health, well-being and comfort (Givoni, 1969) and this is precisely what Khona's maxim's advocate. As we know criteria of total comfort depend upon each of the human senses. Givoni and Khona focused on human thermal comfort, which they pointed as the dominant problem in a tropical climate. The thermal comfort conditions of a built environment can be measured by some design parameters, such as:

- Form and orientation
- Surroundings
- Natural ventilation
- Day light
- Landscaping
- Material

Form and orientation

The form and orientation with respect to sun and breeze is a major part to maintain the comfort level of the built environment. In the case studies, it is found that the form and orientation of a building affect the airflow around and inside the building. Actually, if there is a conflict between the wind and the solar consideration the cross ventilation should be the primary factor to be considered in warm humid climate (Givoni, 1994) to wash away humidity. When we consider the orientation of a building, the main focus should be on the orientation of the openings. In a warm humid region, a building should be spread out with large open spaces for unrestricted air movement as well as large shaded openings in the buildings. Traditional Bangladeshi architecture is an ideal example of such consideration. Traditional architects and Khona's maxims take care of these facts.

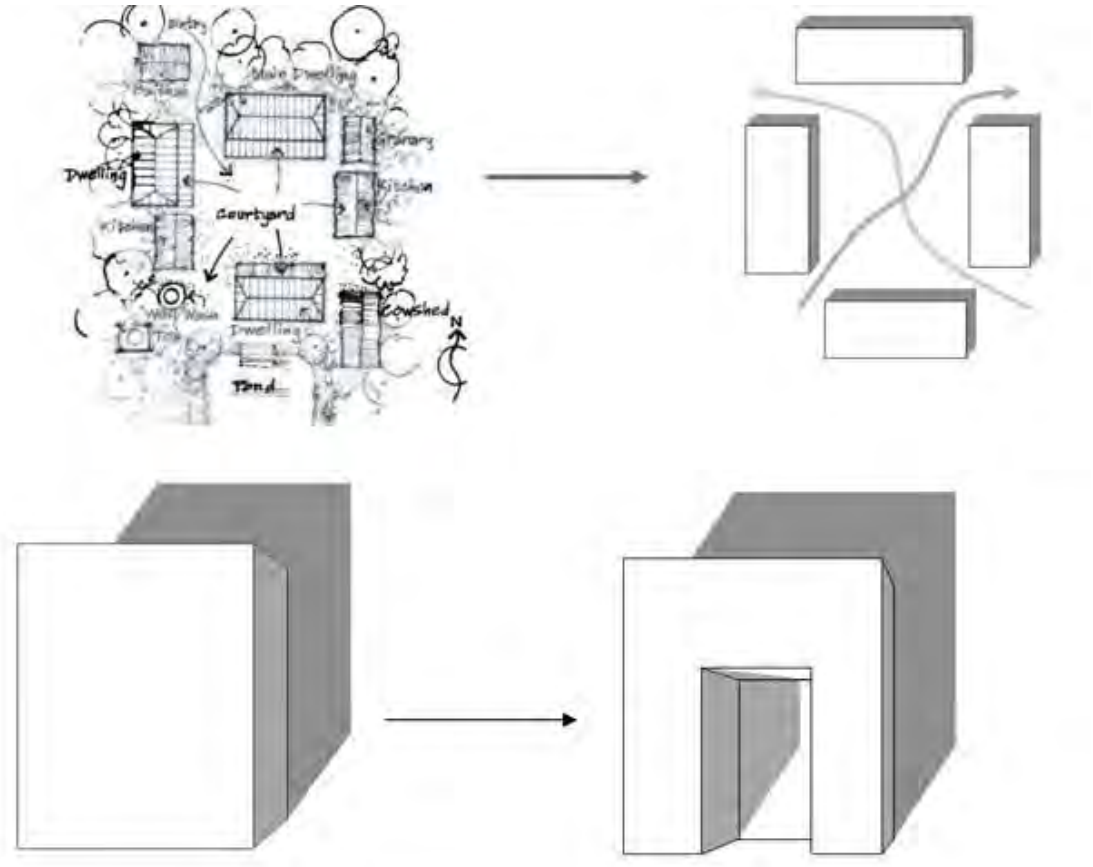


Figure 3.32: Plan derived from basic rural homestead layout to urban building as per Khona'a Maxim

According to Khona, the building should be oriented in north-south direction because North and south orientation provides the highest amount of wind flow and shade.

Settlement Planning:

Settlement should be planned to ensure the thermal comfort and ensure maximum airflow besides other factors like: Transportation means and ways, water access, water supply, available materials

and technical means, infrastructure, social structure and defense considerations etc (SKAT, 1993). Water body and Plantation can be used to reduce the radiation on the site. Regarding site planning Khona's maxim is clear and specific i.e.

Large shady trees are in the west to protect from the direct sunray, low height trees in north prevent the blockade of the breeze and light, and south is left open to get the advantage of the south breeze. It also advises building houses in a high land to avoid the natural hazard. This recommended layout provides a comfortable setting (Refer to table 2.1).

Figure 3.33: Rural Settings as per the maxim of Khona (source: Ahmed & Ahmed, 2015)

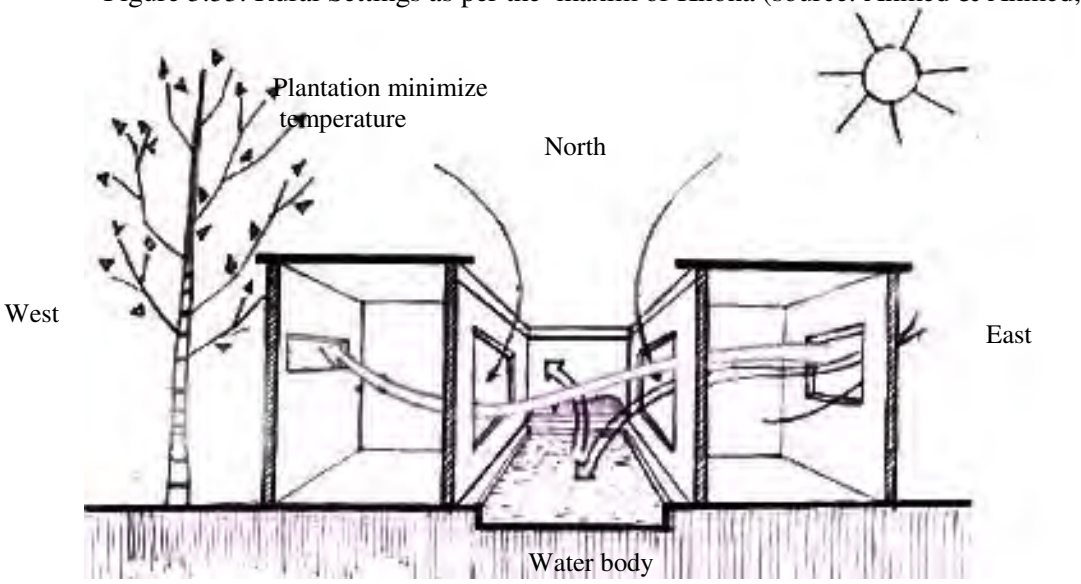


Figure 3.34: Maxim applied in the urban settings

Natural Ventilation:

Natural cross ventilation is one of the elements to designing for comfort in the built environment. Natural ventilation uses the natural forces of wind and buoyancy to introduce fresh air and distribute it effectively in the buildings for the benefit of the occupants (Tong Yang, et.al. 2015).Proper natural ventilation in a dwelling ensures adequate air flow, improve thermal comfort and reduce the increasing energy demand for cooling. In the case studies, it is found that the

courtyards, openings as a source of natural ventilation. Khona gives importance to natural ventilation (Refer to Table 2.1).

According Khona, creating an obstacle in the way of ventilation results in insufficient light and air. Adequate natural ventilation draws cool air, maximizes the flow of air and minimizes the solar radiation on the homesteads. Courtyard and proper ventilation system improves thermal comfort and reduces the increasing energy demand for cooling of a building.

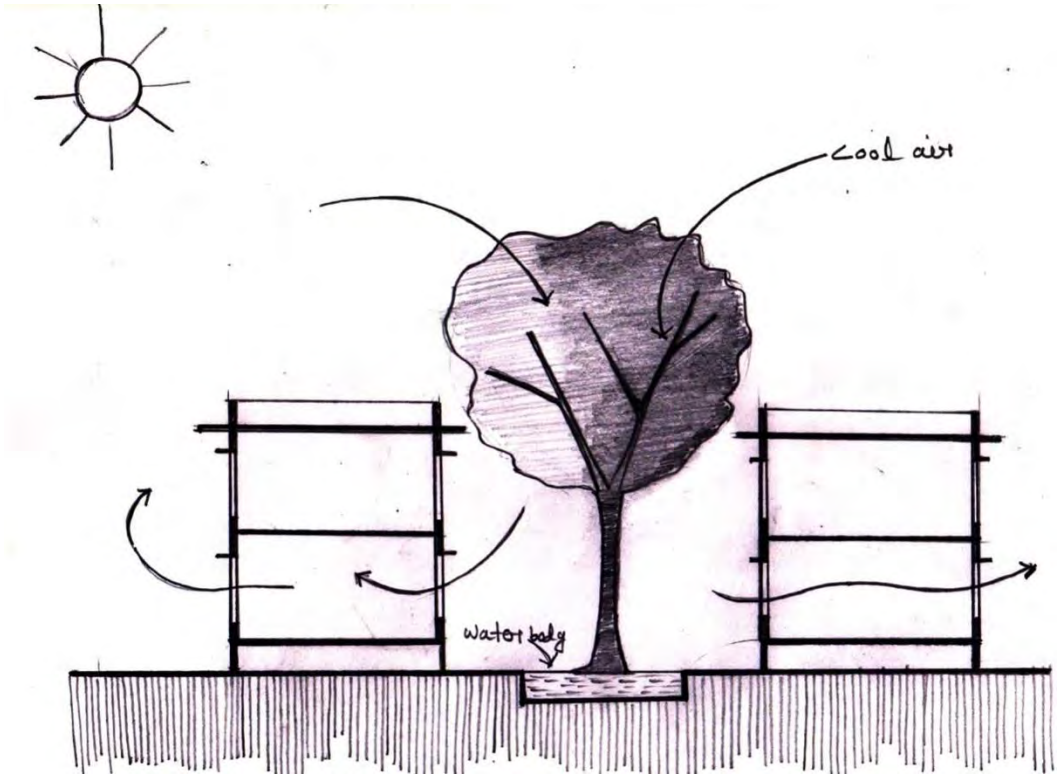


Figure 3.35: Courtyard and proper ventilation system improves thermal comfort in a compact setting

Daylight:

Natural light or daylight is a dynamic and ephemeral tool for expressing the quality of space (Siobhan Rockcastle, 2011).The main intention of daylight is to make the view and create a comfortable space for the user. Adequate daylight can provide a more pleasant and comfortable visual environment. That's why Khona emphasizes on her maxims about the daylight. She forbids to plant large trees too close to the proximity of the house because these trees block the sun which results in insufficient light and creates dampness.

Landscaping:

Designs using vegetation in the urban environment are of functional, aesthetic as well as the climatic importance for its radiation absorbent surface and it's evaporative and shade-giving properties. The vegetation in and around buildings and cities also has definite effects on air movement (SKAT, 1993).Most of the maxims of Khona encouraged for landscaping e.i.

a. Plantation in the surroundings of the house brings happiness and healthiness in your mind (Refer to table 2.1).

b. Vegetables have a rich source of minerals and vitamins, and also contain many healing and medicinal properties. Khona mentioned vegetables auspiciously and should be planted in the homestead to supplement nutrition to households (Refer to table 2.1).

c. Neem, Chaste these trees have great medicinal value as well as produce oxygen in large amount. Proper plantation reduces the direct Sun and can manipulate the airflow patterns. The shades created by trees, shrubs and other plants decrease the air temperatures in the space adjoining the buildings and provide evaporative cooling. The Plantation is a significant factor in changing the microclimate of a built environment (Refer to table 2.1).

Material:

The building materials are of major significance for protection against heat and cold. Great care must be taken in the choice of the building materials. In a warm humid climatic region, high temperature accompanied by very high humidity requires the use of a variety of material that take a longer time to heat up or heat reflecting material can also be utilized. There are materials available locally which are not only cost-effective but also less energy intensive. The maxims of Khona suggest the use of indigenous material and local construction techniques. Observation of vernacular architecture shows that, it is much influenced by the maxims of Khona. Though the maxims are from archaic times still it is widely applicable in present context. Rudofsky (1964), in his architecture without architects, points out that "untutored builders fit their work in the environment and topography. They don't try to conquer nature." If we look at the roots, each rural builder adapts to environmental circumstances rather than confronting them (NagarajuKaja, 2012).This is the only way to design a sustainable built environment.

3.5.3 Relevance with building by law

A building law is a code written by local authorities for planning and design. The main purpose of these laws is to provide comfortable and sustainable built environment. It can be traced through the recorded history of over 4000 years. In the early ages, the traditional wisdom played a significant role to design a safe and healthy built environment that was in effect the oral building by law. In that sense, the maxims of Khona or the laws of Khona have a remarkable impact on our built environment for sustainability. An impact of Khona's maxim can also be found in the recent building codes and are also in conformity with Khona's maxims.

Table 3.33: The table shows the relevance of maxims of Khona with the Bangladesh National Building Code, 2015.

Sl.	Parameter	Guidelines according Khona	Guidelines according BNBC,2006
01.	Open Space	Based on our environmental condition Khona encouraged for open space for uninterrupted wind flow.	Volume 1, point 1.8.1 discussed open space within a plot. Where BNBC encouraged open space. Minimum open space/set back requirements for the sides, rear and frontages of a plot are as per the provisions of this code. Point 1.8.2 stated that at least 50 percent of the minimum open space in a plot shall remain unpaved with or without vegetation to allow water penetration. 1.8.3 Clause states that the total open area in a plot on which a building is constructed, shall not be less than 50% of a pilot area.
02.	Entry	Khona gave emphasis on the orientation of the entry.	1.14.12 discusses about the entrance of the building.
03.	Site settings	The Water body in the east side, bamboo trees in the west side to avoid the sun of the west, small trees planted in the north not to obstruct the passing of winds of south-north orientation and south should be vacant to allow the south breeze.	Clause 1.8.11.1 discusses site surroundings, landscaping, walkways, water body which is to be permitted in the open space. Clause 4.3 emphasizes on-site sustainability.
04.	Courtyard	Courtyard preferred for more Air circulation and also for uniform air flow in all direction.	Clause 1.8.10 describes an area having appropriate dimensions as per provision of the code for open to the skyspace in the formation level and surrounded by buildings or walls or combination thereof to be designed as a courtyard. Enclosed open to sky spaces is recommended to provide ventilation and daylight to the adjacent space.
05.	Indigenous material	Mostly bamboo, mud, thatch	Several building materials are discussed in VOL-1 ,chapter 2.Clause 2.1.1 says that any such material may be approved provided it is shown to be satisfactory for the purpose intended for and at least the equivalent of that required in this part in quality, strength, effectiveness, fire resistivity, durability, safety, maintenance, and compatibility.

06.	Plinth	The height of the plinth should be adequate to ensure hygienic space.	This parameter has been discussed several times in BNBC, 2006. In B.4.3 the minimum height of the plinth IS recommended to be 300 mm from the surrounding GL (adjacent road center).
	Land height/Level	High ground-level preferred in order to safeguard it from the natural hazard. Like effects of temporary waterlogging.	Clause 1.5.3.2 discussed the formation level of the plot. The level of the plot is recommended not to be lower than the adjacent road levels.
	Thermal insulation	Khona encouraged proper ventilation and plantation as the main element of thermal insulation.	Clause 1.23 state that the thermal comfort in a building shall be achieved through adequate ventilation and thermal insulation of walls and roofs.
	Natural lights	Mentioned about Windows, Courtyards, which act as a channel of natural light.	Clause 1.19 discusses lighting it discusses that at least all the rooms shall be exposed to an exterior or an interior open space of a balcony and verandah exposed to an open space for getting proper natural lights.
	Ventilations	Importance on having proper ventilation in a house is emphasized. The house should be open, airy and get ample of sunlight.	Clause 1.19.1 stated that all rooms and interior spaces designated for human occupancy shall be provided with means of natural or artificial lighting and natural or mechanical ventilation as per provisions of BNBC. It also gave emphasis on at least one side of all the rooms to be exposed to an exterior or an interior open to sky space of a balcony and verandah exposed to an open space.
07.	Landscaping	Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. large trees create shade and also provide thermal comfort.	Clause 1.15 discusses landscaping. Plantation of trees and shrubs within the open spaces of a plot aims at enhancing the environmental quality of the building by complying with the requirements of this section. Clause 1.15.2 states that the Trees and shrubs shall be planted judiciously to meet the requirements of shade and sunshine, to control noise and dust, to provide privacy and to improve visual quality, without jeopardizing natural ventilation and lighting of a building.

08.	Distance of big trees	Advised to avoid taal,tetul ,plum,bokul kinds of tree near the houses because big trees too close to house interrupted the wind flow and sun light, besides damaging the house.	Clause 1.15.3 stated that the Species of trees shall be so chosen and planted that their roots do not endanger the building foundation and their branches do not interfere with the building superstructure. This shall be achieved by maintaining sufficient distance between the trees and the buildings.
09.	Shading	Khona recommended bamboo bush in the west side for shading because Bamboo bush create shadow and protects from direct sunrays but allows air flow.	Clause 4.4.3.2Vertical shading device is discussed to be provided on the west, depth of which shall be calculated, by multiplying the gaps between the vertical fins.
10.	Building material	Mentioned about Indigenous material i.e. bamboo, mud, thatch	Vol 01 part 05 of BNBC discussed not only indigenous material and others compatible building materials.

3.5.4 Application in the contemporary context

Contemporary architecture describes those styles that are being implemented today and includes an assimilation of materials with their natural surroundings. Interior and exterior spaces are designed to incorporate the environment that they are in and make the design a natural extension of nature. Preceding study on the contemporary context reveals that majority of the vernacular architectural element had been forgotten and even neglected. If contemporary architecture adapts vernacular element, it can create a cultural continuity, besides creating a climate responsive and sustainable built environment, contemporary built-environment depends on the mechanically controlled environment, to achieve comfort condition but increases the use of energy consumption, where as traditional built-environment makes use of passive means of climate control for comfort. The intention of the Khona's maxims is to blend architecture with the traditional beliefs and produce a climate responsive built environment. Here we try to find out the relevance and use of "Maxims of Khona" with a book Manual of Tropical Climate by Koienigsberger, Ingersoll, Mayhew, Szokolay, 1973, a guideline for warm humid climate design and authenticates its application in the contemporary context.

Table 3.34: The table shows Relevance with the "Maxims of Khona" with Koenigsberger's manual of tropical climate.

Sl.	Parameter	Guidelines according Khona	Guidelines For Warm Humid Climate Design
01.	Site layout	The main goal of Khona is to take the proper advantage of the site and planning the settings according to	The general site layout is of great importance for minimizing the energy

			climatic consideration.	loads and for enabling passive design strategies. There is a growing awareness to use building performance simulation tools during the design process (Attia, 2011).
02.	Building design	Orientation of buildings	North south orientation is preferred.	According to Gevoni, 1969 particularly in the warm humid region the indoor climate is to a greater extent dependent on ventilation and therefore orientation is more important with respect to winds than in relation to the patterns of solar irradiation. North-south orientation is preferable for sun exclusion. The building will have to be opened up to the breeze and oriented to catch whatever air movement available there. Consideration of Orientation for wind is more advisable.
		Shape and volume	Maxim portrayed the ancient notion of elongated plan shapes which are the most common nature in building design.	Open elongated plan shapes to allow proper cross ventilation.
		Type and form of buildings	All maxims are based on rural context. Where the open flexible plan is observed. The form should be spread out.	For allowing the free movement of air buildings has to be spread out.
		Openness and shading	Khona also emphasized on openness for adequate air that results healthy environment and also concerns about shading to avoid direct sun.	Openness is the dominant factor while designing. Book Pointed out about the door and maximum window openings, accessible verandah, galleries for openness and shading.
		Plinth height	Discussed about plinth level of the dwelling for free air flow and hygienic space.	Given importance to elevate the building on stilts, for avoiding the stagnant or slow moving air at the ground surface and capturing air movement of a higher velocity (Koienigsberger, et.al. 1973).
		External space	External space is the common feature in rural context. That helps to maintain	Maximum shading and maximum ventilation also

			privacy and increase air flow. Khona mentioned about large shading trees for maximizing of shading outdoor spaces.	apply to the design of the outdoor space. Tall shading trees at ground level vegetation are important elements of outdoor space organization. External open space allows free air movement, provide privacy and also generate activity.
		Roof	Pitched roof preferred because the roof slopes helps the rain water to fall and reduce the risk of leaking roof.	Koenigsberger, Mentions about overhanging roof providing shading to both openings and wall surfaces. He also gives emphasis on designing roof. According to him a well designed roof can prevent the indoor temperature increasing above the outdoor air temperature and keep the ceiling temperature around the same level as other surfaces. This could be achieved by a reflected upper surface, a double roof construction and having a good resistive insulation.
		Wall	Khona prefer indigenous material which results minimal heat storage capacity. These should not obstruct the airflow and should reflect radiation. Also mention about plantation to shade the external walls.	The book says that the walls exposed to solar radiation, to have good insulation to prevent the elevation of inner surface temperature above the air temperature. The book also mentions that in case of shaded wall insulation is not obligatory.
		Courtyard	Courtyard preferred for more Air circulation and also for uniform flow in all direction	Denoted courtyard as a excellent thermal regulator (Dunham, 1960). A courtyard draws heat from the surrounding areas, re-emitting it to the open sky during the night.
		Air flow and openings	Both are important as state by Khona for healthy environment. She prohibited to plant big trees very close	Opening must be suitably placed in relation to the prevailing breezes to

			to house that block the opening and air flow.	permit natural air flow. Through the internal spaces of body level, i.e. in the living zone up to 2 m advised to avoid fixed glass panel and encouraged for large and fully openable window. As we know openings are not limited to 25% of the length of the wall (Ballast, 2013).that why he given the higher attention on openings for our warm humid region.
		Ventilation	According to Khona ventilation is very necessary for hygienic space.	Provide importance on proper ventilation for minimizing the room temperature and humidity for keeping place comfortable. Paid attention on the ventilation of the roof space. The roof space can cause a ceiling temperature to drop 2°C, without any constructional change (Drysdale, 1952).
03	Landscaping	vegetation	Most of Khonas maxims are rendering on plantation. Encouraged for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. She also mentioned about some trees which has great economical medicinal value and also good for health. She advised to use proper plantation and use it as a thermal barrier. Evapotranspiration cools down the air.	Koenigsberger also has given importance to plantation. According to him plantation had a huge effect on earth. Warm humid region encourage growth of vegetation. According to him the plant cover of the ground decreases reflected radiation, and reduces the heat of the ground surface.
		Water body	Khona mentioned about water body to minimize relative temperature, and evaporative cooling.	Water bodies cool the air by evaporation and provide visual and psychological relief.

Above discussion validates the Maxim of Khona with reference to the guideline from the book 'Manual of Tropical Climate Design' .The main intension of both is to design a climate responsive built environment. The traditional wisdom seems relevant to the contemporary context.

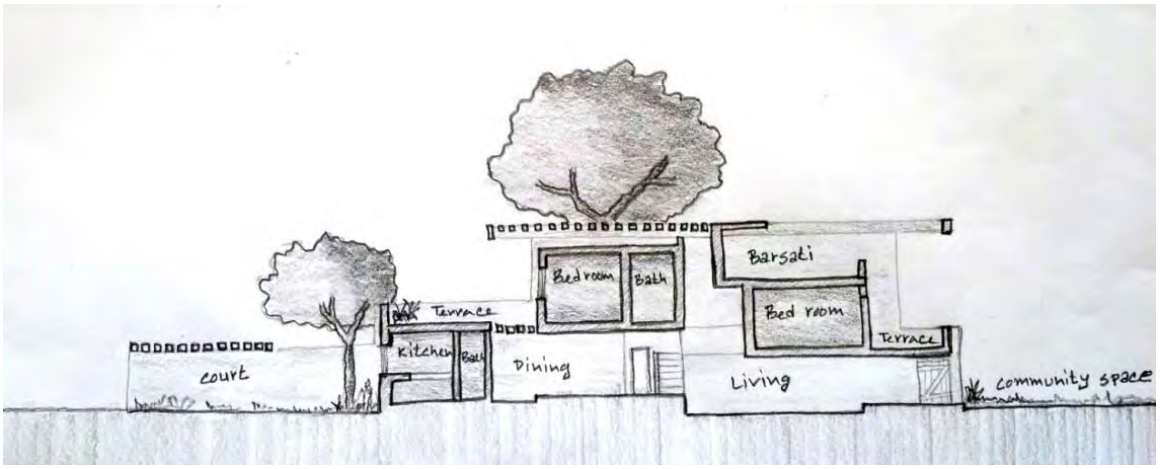


Figure 3.36: An ideal built environment applying the guideline of Khona and the guideline of the book "Manual of Tropical Housing Climate Design."

3.6 Summary

Khona's maxims are evaluated on various counts and yardsticks i.e. i) Physical observation in terms of general technical notions and user's perception, ii) Assessing the comfort conditions with measuring tools, iii) Comparing Khona's maxims, Vastu Shastra and site observations iv)Assessing Khona's guidelines with contemporary standards and finally, v)Validating Khona's maxims with BNBC guidelines. By all yardsticks and checklist, it is found that Khona's maxims are quite rational and are relevant even today.

Chapter 4 Conclusion

Formulation of Checklists for Built-environment design from the maxim's of Khona

Discussion

Recommendation

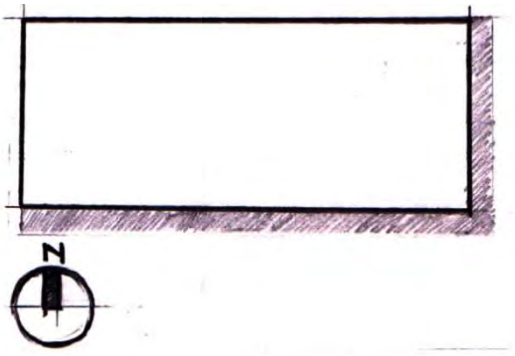
Bibliography

Chapter 4 Conclusion

4.1 Formulation of Checklists for Built-environment from the Maxim's of Khona

It is seen that the sustainable built environment design principles rely on the references to traditional knowledge, and there are numerous examples around the world that validate this understanding. Present case studies also confirm the point. This case study reaffirms that the traditional wisdom of Khona can indeed be used for sustainable built-environment design in Bangladesh, for which architects are seriously searching for. After analysis of the indoor and outdoor spaces of homesteads, based on built environment parameters advocated by the Maxims of Khona, checklist is proposed for application in the contemporary design of built-environment that can be incorporated in the building by laws.

Table 4.1: Below the table checklist for application in the contemporary design.

SL.	Parameter	Guideline According Khona	Final checklist for application in built environment
01.	**Orientation**	North-south orientation is preferred. **Rationality:** In warm humid climate east-west axis is difficult to shade and receive longer periods of direct radiation. That's why longer walls of building should face North & South so that the building gets minimum solar exposure and also receives maximum prevailing wind.	▪ The longer wall of the building must be orientated to the cardinal direction of north south. Southern side should have adequate set back. **Explanation:** In the warm humid climate like in Bangladesh east-west axis is difficult to shade and receive longer periods of direct solar radiation. This is why longer walls of building facing North -South receives minimum solar exposure. Moreover, comfortable south and south-east breeze is directly received to cool the indoors. South side should be left clear and room for living should be south facing.In warm humid region like Bangladesh during summer cool breeze enters from the south or south-east side. For this reason, the south side should be kept free and the rooms be south oriented to enjoy the southern breeze.  Figure 4.1: shows Building oriented in north south direction to minimize solar radiation and increase ventilation. South to have adequate set back.

<table>
<tr>
<td>02.</td>
<td>Built form</td>
<td>Didn't find any undeviating observation of Khona on built form. However, descriptions imply the living units should be spread out for good ventilation.</td>
<td>

The form of the building should be spread out, or an open floor plan is appreciated for adequate light and ventilation.

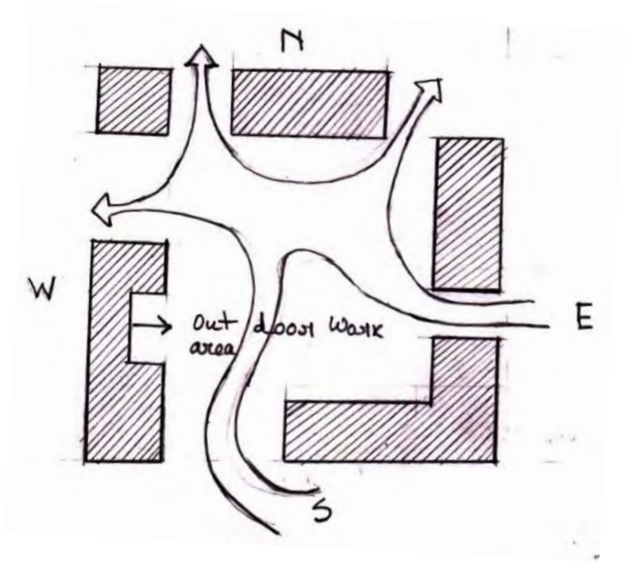
Explanation:
Building should be spread out with large openings and open spaces for uninterrupted air flow to wash out high relative humidity. Alsoto provide sufficient air circulation, buildings should be scattered and have ample open space in the south and east.


Figure 4.2: Building spacing enhance airflow
</td>
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<td>03.</td>
<td>Ventilation and Shading</td>
<td>The house should be open, airy and get ample amount of ventilation and sunlight. Pitched roof preferred for shading.

Rationality:
If the ventilation is not adequate it creates dampness on the building and results in unhygienic space and chouchala is seen more stable against rain and wind and to provide shade.</td>
<td>

Provide maximum free air movement and natural light by large openings and ample shading.
The floor is preferably elevated well above the ground to prevent flooding and allow for better ventilation. Houses are best built on stilts or at least on raised platforms in this region.
Roof should have large overhangs.

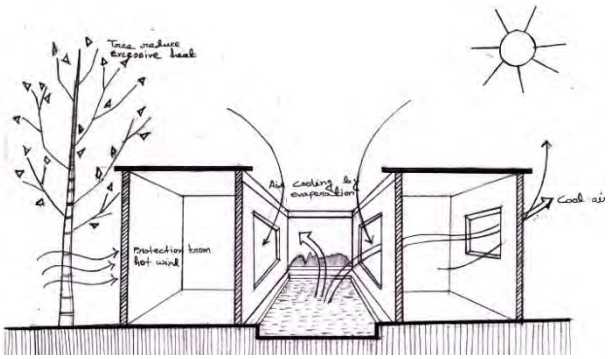

Figure 4.3: Large opening helps to free air movement
</td>
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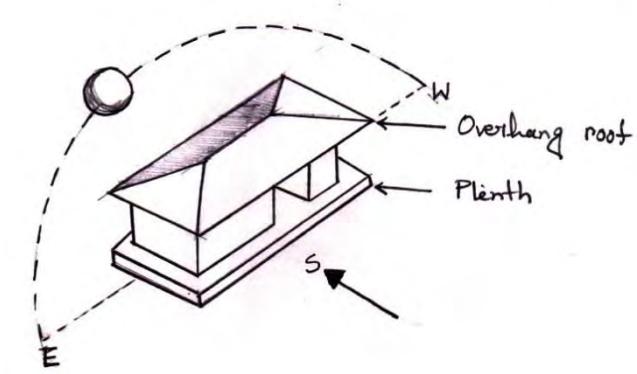
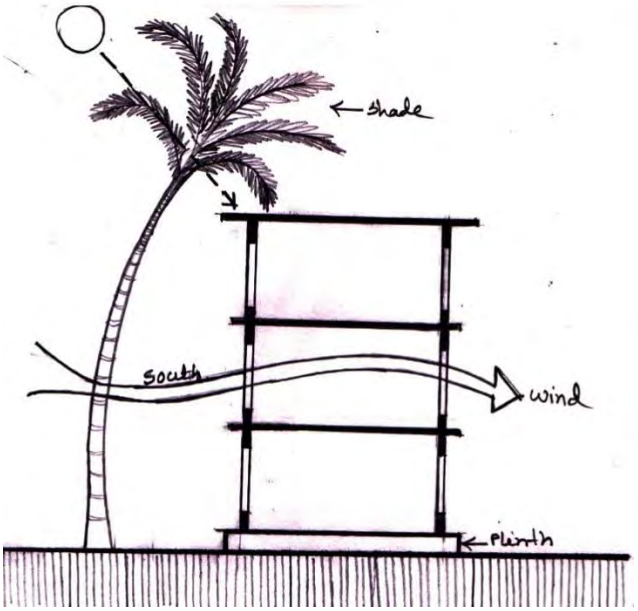
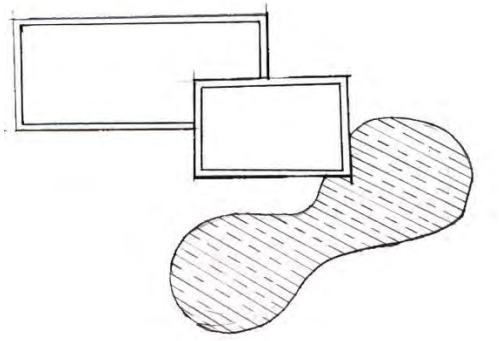
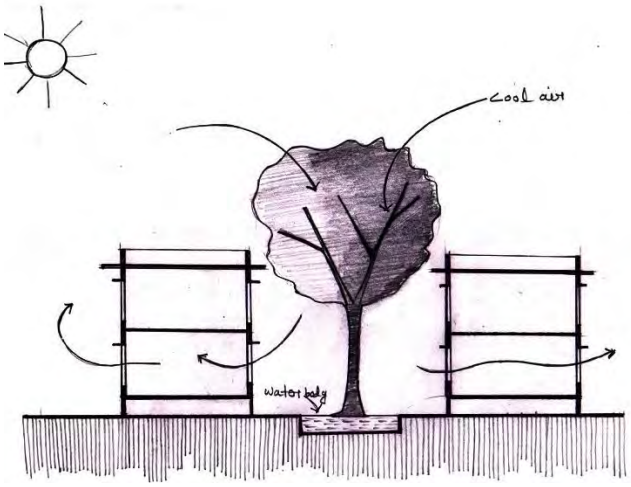
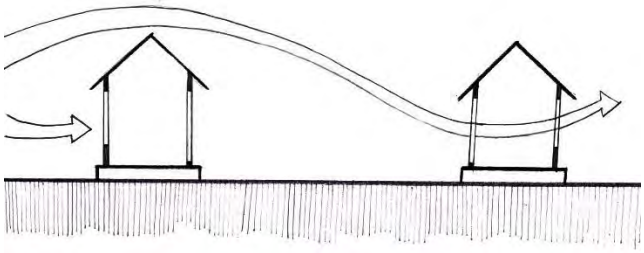
			Explanation: Roof elongated along the east-west axis provide the best shading of the critical east and west walls**.** In warm humid areas openings are important elements for the regulation of the indoor climate. The high humidity and warm temperatures of our climate requires maximum ventilation, which can be ensured by large openings in the walls (at least 30%) and large overhangs roofs to shade the walls from the sun and rain. This is applicable not only for the design of the elevations, but also for the floor plan.  Figure 4.4: Elongated roof provide the best shading from sun and rain
03.	**Plantation**	Khona recomends for plantation because Plantation in the surroundings of house brings happiness and healthiness in mind. **Rationality:** According to her Big trees in the west side is to avoid the sun of the west, small height trees or deciduous trees planted in the north is not to obstruct the passing of winds and light, south should be empty or very low height vegetation should be planted not to obstruct and to enjoy the south breeze.	▪ Large shady trees with deep roots that do not damage foundation and basement should be planted near the west side external walls. **Explanation:** Western exposures receive longer durations of solar radiation and are quite difficult to shade. This can be prevented with large shady trees or large overhang on the western side of the building. ▪ Large Deciduous and medicinal trees should be planted for landscaping in the west and at a distance in the south and south-east. **Explanation:** Deciduous trees are perfect to provide shade in summer and sun in winter. Before reaching the buildings surfaces, if air passes through the trees it will minimize the air temperature. Medicinal trees are good for health as well as, have economic value.

			▪ Deciduous trees should be planted on the northern side of the building at a moderate distance. The evergreen trees are recommended on the north and North West to act as wing breaker for norwesters and winter cool breeze. **Explanation:** North side of the building gets maximum diffused light during day time. Closely planted large trees can interrupt the northern distribution of light. Deciduous tree or adequate spacing from another structure helps to allow proper lighting. Thick Plantation at reasonable distance in north side also prevents cold air during winter.  Figure 4.5: Section shows large overhang, shady large tree prevents solar radiation but allows breeze into the building
04.	**Water body**	Khona recommends water body on the east . **Rationality:** A water body takes up a large amount of heat in evaporation and causes significant cooling of air that flows into the house.	▪ Use water feature like shaded pond /water pool on the south helps the southern breeze to cool down before entering indoors. **Explanation:** A water body takes up a large amount of heat in evaporation and if it is shaded it is cooler and causes significant cooling of breeze.

			 Figure 4.6: Plan shows water body takes up a large amount of heat
05.	**Building Material**	Indigenous material preferred. Mostly bamboo, mud, thatch. **Rationality:** Indigenous building materials are climate responsive, easily available and cost effective therefore Sustainable. Porosity ensuring better ventilation.	▪ Local resources and materials have to be taken into account while designing. Like-mud, brick, bamboo, thatch, timber, brick etc. **Explanation:** Indigenous building materials are climate responsive, easily available and cost effective. Innovative use of local building materials improves sustainability and comfort conditions.  Figure 4.7: House made by local material (A traditional bamboo house)
06.	**Open Space**	Mentioned about open space like courtyard for proper air circulation. **Rationality:** Courtyards maximize Air circulation and also draw equal flow in all direction. Also helps outdoor household activities.	▪ Courtyards, central spaces or semi-open spaces should be used. **Explanation:** Internal courtyard provides cross ventilation, allows proper day light and helps to draw cool air from the internal shaded area. Besides, being used as the socializing space.

			 Figure 4.8.a: Cooling system of a small courtyard house  Figure 4.8.b:Cooling system of a longer courtyard homestead

4.2 Discussion

4.2.1 Rationality and outcome

If the roots are alive.....it gives rise to new shoots... (Patrick Geddes)

The rapid development that is indisputable in the world has led many people to fail to notice the contribution of the traditional wisdom in the built environment. At present, the architecture of Bangladesh is significantly and undeniably affected by the western ideological trends and thoughts and its transplantation in a different context. It should be admitted that the most significant factor for the development and improvement in the architecture and its originality, is be based on traditional wisdom and revisit the history.

The main intention of the geomantic study is to situate the traditional wisdom on geomantic forces of a region as applied in the built environment design. In fact, the core aspiration of all the traditional wisdom is to produce a natural environment responsive and sustainably built environment. Khona has a huge involvement in incorporating architecture with the traditional beliefs and contributed to sustainable built environment design.

Although sustainability seems to be a new concept in today's context, in reality, it is not. After analyzing our rural homestead with respect to the maxims of Khona, it is evident that sustainable architectural design principles depend on advertence to traditional architecture, and there are many examples not only in our context but also in different parts of the world to which we can refer. It is advisable to revisit the past in order to understand and learn about sustainable features of traditional architecture. This work had aimed to demonstrate that the traditional wisdom can contribute to improving sustainability in the built environment. The study evaluates the ancient traditional wisdom in the contemporary context. In order to gain scientific validation, field works were carried out and the homestead architecture of the region was examined on site. The features of the examples have been acknowledged and discussed in the light of contemporary sustainable architectural standards. This work holistically evaluates Khona's maxims, in the light of current knowledge, and finds a rational justification for subsequent recommendation and promotion of its application in the future.

The case studies were evaluated according to the framework established by 'Khona' regarding site layout, external area, courtyards, building design (in terms of orientation, shape and volume, types of forms of buildings, openness and shading, Plinth height, roof, walls, building materials, airflow and openings, ventilation), external spaces, courtyards, landscape, water body. Hence, observations conclude that Khona's maxims are more like archaic guidelines for building viable habitats.

Vastu Shastra, contemporary Standards, and BNBC were all reviewed in with respect to Khona's maxims. The correlated observation of Khona, Vastu Shastra, and building codes allows us to understand the ideas for a viable design that is appropriate for the warm-humid climate of Bangladesh, both in urban and rural conditions. These concepts are also validated through scientific explanations given by researchers regarding homesteading. Direct observations made through field analysis assure that the built environment can be made comfortable and viable through the cohesion of Khona's maxims in the designing and be adhering to the contemporary building codes. Development of checklists for the utilization in the design of built-environment, with regards to the Bangladesh building by-laws, is recommended from this observation, as it can be aptly asserted that this study is one of the very first endeavors towards a genuine geomantic study on the built environment in Bangladesh.

4.2.2 Development of check list from the analysis of Khona's maxims

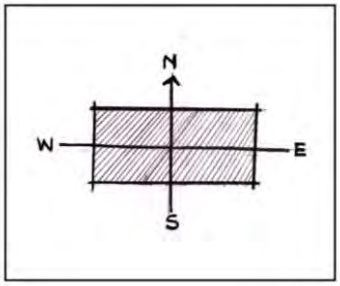


Figure 4.9: Orientation: Figure ground plan Shows North –South orientation

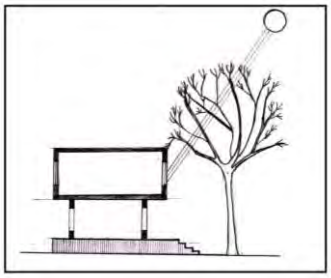


Figure 4.10: Plantation and shedding Section Shows deciduous trees provide access to winter sun but protect against summer sun

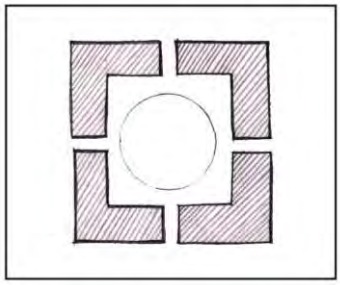


Figure 4.11: Open Space: Figure ground plan Shows Central space/ Courtyard act as a source of light

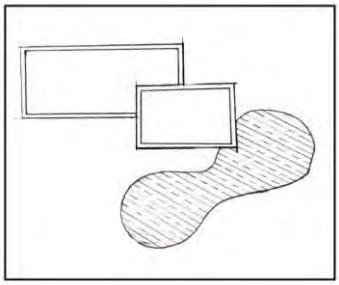


Figure 4.12 : Water Body: Plan shows Water body enhances evaporative cooling.

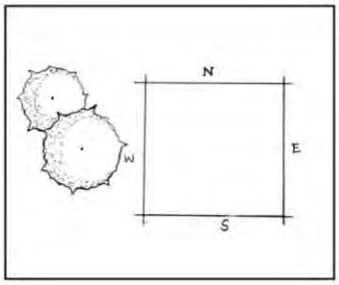


Figure 4.13: Plantation and shedding: plan shows Tall tree in the west.

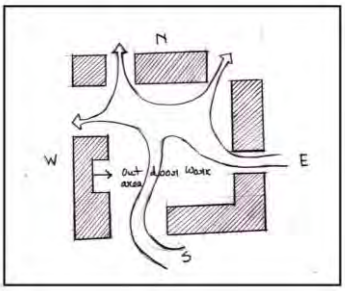


Figure 4.14: Open space and Lay out: plan shows Space between enhance airflow.

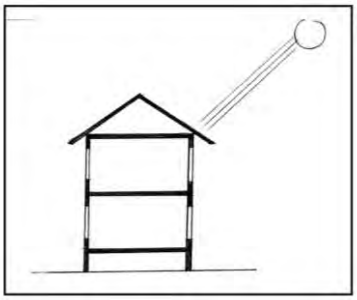


Figure 4.15: Overhang and Shedding: Section Shows Elongated roof prevent direct sun.

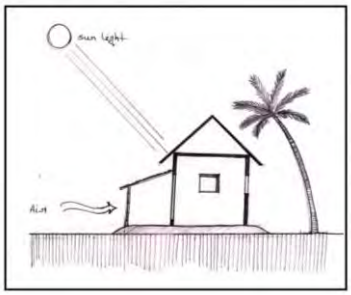


Figure 4.16 :Light and air: Figure ground section shows South should be free to allow light and air (ventilation).

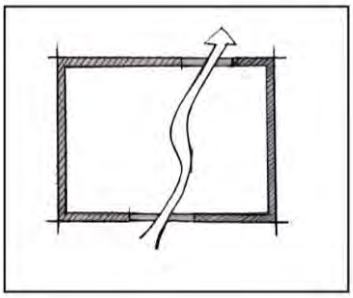


Figure 4.17: Ventilation: Plan shows Cross ventilation is indispensable.

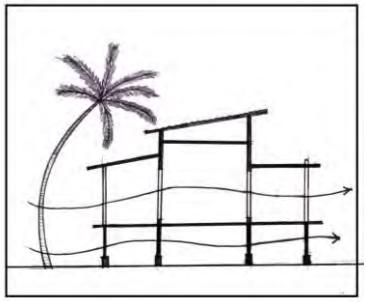


Figure 4.18: Plinth: Section shows Maximum opening and plinth height enhance air flow and prevent flooding

4.3 Recommendation

The "Maxim of Khona" illustrates the effects of the natural and built environment on the human systems through geomancy. This study concentrates on the reinvigoration of the traditional maxims, analysis of these with scientific norms which are connected to the homesteads and built-environment context and develops a checklists for applying it to the contemporary built environment design. From this research, the following, as well as some general recommendations, could be considered:

- For reaching sustainability and sustainable built environment development, we may incorporate our traditional knowledge in the design process.
- Utilizing traditional geo-climatic response in the contemporary context and reduce energy consumption.
- Probable solution is to incorporate the checklists to the current building code.
- Strictly follow the checklists to reach a comfortable built environment design.
- Serious geomantic study focusing on cosmic forces may be undertaken.

Bibliography

Ahmed, I., (2012). The Courtyard in Rural Homesteads of Bangladesh Vernacular Architecture., Vol. 43, pp. 47-57.

Ahmed, Sayed., &Ahmed, Farid., (2015). The maximus of Khona: A contextual study of Sustainability over vernacular architecture practice of Bangladesh, Journal of modern science and technology,Vol. 3, No.1, pp. 1-19.

Attia, S.,(2011) De Herde, A. Design decision tools for zero energy buildings,Conference on Passive and Low Energy Architecture, Louvain-la-Neuve, Belgium, pp. 77– 82.

Ahmed, K. S., (1995)Comfort in urban spaces: defining the boundaries of outdoor thermal comfort for the tropical urban environments, Architectural Association School of Architecture, London.

Abdul,Ruhulla.,(2015)The Golden Ratio,Financial University under the Government of the Russian Federation.

Abed, H., (2012) Effect of Building Form on the Thermal Performance of Residential Complexes in the Mediterranean Climate of the Gaza Strip., Master Dissertation.

Ahmed, M.H.B., &Rashid,Rumana., (2012)Thermal comfort of Bangladesh traditional house in a high density environment with the worst surrounding condition in Dhaka city-A case study at a Bangladesh Traditional House , Gulshan ,Dhaka

Astrological Geomancy.,(2006)viewed 4th august,2017, (www.renaissanceastrology.com/astrologicalgeomancy.html)

BNBC (2015) Bangladesh National Building Code Final Draft, Housing and Building Research Institute, Vol-1,Part 2,Part 3,PART 5, pp-2-19;3-105;5-6.

Bose, Dr.Shivashish .,(2012)Climate and Urban Design Responsive Modern Architecture in Existing Setting ., Bonfring International Journal of Industrial Engineering and Management Science, ISSN 2277-5056, Vol. 2, pp-63.

Ballast, D. K., (2013) Interior construction & detailing for designers &architects, fifth Avenue, Belmont: professional publication, Nc.(PPI).

Basu,Purabi.,(2015) KingbodontiKhona O KhonarBachan.,Onno Prokash,ISBN:978 984 502 232 3, pp-11-37.

Chen ,XueJie ,.(2013) Modern Environmental Design of Feng-shui Culture Ecological Analysis,Trans Tech Publications, Switzerland,Applied Mechanics and Materials,ISSN: 1662-7482, Vols. 361-363, pp -01, doi:10.4028 /

Chakrabart,Vibhuti.,(1998) Indian Architectural Theory and Practice. Contemporary Uses of VastuVidya.,Curzon Press., ISBN 0-7007-1113-9.,pp-101-102

Construction of Central Space and Plinth ,Vastu Shastra ,(2010) indianetzone ,Viewed 7th March, 2018.(http://www.indianetzone.com/48/construction_central_space_plinth.htm)

Contemporary Architecture, Art History & Styles of Art ,(2017),Art.com Wiki.,viwed 13th March,2018 .,(http://blog.art.com/artwiki/~/contemporary-architecture/)

Dannelley,Richard.,(2001) Sedona Vortex 2000, Light Technology, chapter 1.

Dunhum,D.,(1960) The Courtyard House As A Temperature Regulator, TheNew Scientist, pp-663-6.

Drysdale,JW.,(1952)Summertime Temperatures In Building, Comwelth, exp. bldg,Sydney.

Doza,Bin.Sajid.,(2013) Riverine Fortress city of `MAHASTHAN´ in Deltaic Bengal,PHD Research paper, University of ÉVORA, Portugal,pp-273-200.

Esra'a Sh. Abbaas, M. C.,(2017)Progress on thermal performance of courtyard buildings in hot humid areas: A review International Journal of Engineering and Applied Sciences (IJEAS), Volume-4, Issue-7.

Fazeli, H., and Goodarzi,A., (2010) The Principles of Vastu As A Traditional Architectural Belief System From an Environmental Perspective, Department of Architecture, University of Malaya Malaysia, Eco-Architecture III, WIT press, pp-99-100.

Graves,Tom.,(1978) Niddle of Stone,Turnstone Books,ISBN: 0855000902.

Greer, M.J.,(2009)The Art and Practice of Geomancy: Divination, Magic, and Earth Wisdom of the Rennainance,Weiser books,pp-10,23.

Ganguly, Ar.R.T., (2015)Role of vernacular architecture of India in green building design-A case study of Pauni, International journal on recent and innovation trends in computing and communication,Vol. 3, ISSN-2321-8169, 130-135.

Gray, John N., (2006) Domestic Mandala: architecture of lifeworlds in Nepals.l. : Ashgate Publishing, Ltd.

Gupta,Reeta.,(2016)Comparison of Vastu Shastra with Modern Building Science, International Journal of Research and Scientific Innovation (IJRSI), ISSN 2321, Volume III, pp-118.

Givoni,B.,(1976) Man ,Climate and Architecture, Applied Science Publication, London.

Huang, En-Yu., (2012) Comparing The Do's & Taboos In Chinese Feng-shui And Indian Vāstu-shāstra Architectural Traditions, Leiden University dissertation,pp-1

Haq, Saiful., (1994) Architecture within The Folk Tradition: A Representation from Bangladesh.,TDRS VOL.V NO.11,pp- 61

Hummel,Crishtian.,(2004) Space Clearing Kit., One Source Publications.,ISBN:0-97-54793-0-X.,pp-24

Heinberg,Jerry.,(2009) Passive Cooling Of Louisiana Buildings, Louisiana Department of Natural Resources/Technology Assessment Division, pp-3.

Hasan., Saiful. Tariq., &Afroz, Jinia., (2012) Study on rural built forms in Narayanganj, Bangladesh in The Context of Using Building Materials for Thermal Comfort: Stamford journal of environment and human habitat, July 2012.(Vol. 1).

Islam,Kausarul.M.K.A.,(2003)Patterns And Changes Of Vernacular Architecture Of Bangladesh, M.Arch.Thesis,Royal Institute Of Technology, pp-1.

Islam, Sirajul. and Miah,Sajahan.,(Sept 10,2014) Khana, Banglapedia, Asiatic Society of Bangladesh, Viewed 27 November 2016, (en.banglapedia.org/)

Jelle, B. P., (2011) Traditional State-of-the-art and Future Thermal Building Insulation Materials and Solutions – Properties, Requirements and Possibilities Energy and Buildings, 43(10): 2549 - 2563.

Kramer, K., (2006)Applying the Lessons of Indian Vernacular Architecture:The Bungalow as Example of Adaptive Climatic Response., PLEA2006 - The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland., Martin Centre, University of Cambridge, Cambridge, United Kingdom.

Kumar, Ashwini.,(2001) Vaastu: The Art And Science Of Living.,Sterling Publishers Pvt. Ltd., pp-27

Kumar,Vijaya.,(2002)All you wanted to know about Vasushastra.,New Dawn,New Delhi,pp-12

Koranteng,C., Afram, S.O.,& E. Ayeke. (2015) A review on seven principles of architecture. International Journal of Engineering Research and Development, E-1SSN: 2278-067X, p-ISSN:2278-800X, Vol. 11, Issue:11.

Koenigsberger, O. H., Ingersoll, T. G., Mayhew, A., and Szokolay, S. V., (1975) Manual of Tropical Housing and Building.,Orient Longman Limited, India.,pp-213-220.

Khan,Md.Sayem., & Rashid,Ruman., (2009). The sustainable architectural principle of traditional bamboo houses in Bangladesh.

Kumar,Vijaya.,(1999)All You Wanted To Know About Vastushastra.,Sterling Publishers Limited,ISBN 812072199 3,pp-16

Ludrup, Jampa.,(2012) Feng Shui: Seeing Is Believing, Wisdom Publications,pp-02

Lakshmi, Sita, K. S., (2000) Man, Matter and Magic Squares, Architecture Plus Design17.4 :107.

Lee, Sang-Hae., (1986) Feng Shui: Its Context and Meaning, PhD Thesis, Cornell University.

Mowla,Q.A., (1985) Sun and the Built form,M.Arch Dissertation,IIT Roorkee,India.

Mowla,Q.A., (1997) Settlement Texture: Study of A Mahalla at Dhaka, Journal of Urban Design,Vol. 2,Issue 03,UK,pp-259-275

Mowla,Q.A., (1999) Investigative Strategy for Passive Vernacular Design in the Temperate Climate, Khulna University Studies,pp-57-62

Mannan,Vaskor,Ashik., and Barua,Shudipta.,A necdote Of Bengal Vernacular Spaces., AIUB,viewed 29july 2017., (https://www.irbnet.de/daten/iconda/CIB_DC22856.pdf)

Matanhelia, Manisha.,(1996) Geo Bio Energies In Relation To Human Body And The Built Environment , Institute Of Environmental Design, Vallabh Vidyanagar

Menen, Rajendar.,(2011)Benefits of Vaastu& Peng Shui.,V&NPublisher.,New Delhi., ISBN 978-93-813845-3-4., pp-10

M,Umbach., and B,Huppauf., (2005) Vernacular Modernism: Heimat, Globalization, and the Built Environment., Stanford University Press.

Mak, M.Y., (2009) Feng Shui: A Chinese approach to integrated design.

Motealleh, Parinaz., Zolfaghari,Maryam. &Parsae,Mojtaba. (2016) Investigating climate responsive solutions in vernacular architecture of Bushehr city, HBRC Journal.

Nawaj,Ali.Dr.,(2011)KhonarBachan Krishi O Krishti.,Afsar Brothers.,ISBN-984-8005-94-3,pp-42-45,230-231,296-301.

Nanda,Chida.,(2018)Gardenvastu-02,Chidananda Blog

Olivera , Gabriel .,(2013)Vastu Shastra - Ancient Vedic Rules for construction., Ibiza Design Magazine

Olivier, Paul.,(1997)Encyclopedia of Vernacular Architecture of the World,s.l. :Cambridge University Press.

Olgyay, V.,(1963) Design with Climate, Princeton University Press, New Jersey.

Olgyay,A and Olgyay, V.,(1976) Solar Control and Shading Devices,Princeton University Press,N.J.

Patra ,Thakur. Reena.,(2009)Vaastu Shastra: Towards Sustainable Development, Article in Sustainable Development, Wiley InterScience, DOI: 10.1002/sd.388, pp-248.

Poddar, Probvat., (2003) The Mysterious Energies Within And Around Us, YOGALife Autumn, pp-55.

Pujala,Ranjeet.,(2017)Vastu Shastra and Cosmic Energy: Feel the Power of Natural Elements, education pulishing, pp-104

Ranjeet, P., Rao,D.V.S. Narshima., and Khan, Ullah.akram.,(2016) Vastu In Construction In Civil Engineering Point Of View, eISSN: 2319-1163, Volume: 05, pp-103

Rashid, M. U., (2013) The Role of Cultural Heritages on the Physical, Journal on Today's Ideas –Tomorrow's Technologies , Vol. 1, No. 2,pp. 99–112.

Subramanian, C. V., Kamalesvari,S.,(2016) Daylight and Sustainable Architecture for Warm Humid Climate, International Research Journal of Engineering and Technology (IRJET), Volume: 03, Issue: 12, pp-1381-1387.

Sofrina,Erica.,(2010) Yin and Yang: The Key to a Balanced Home,Care2 Healthy Living, viewed 26th March,2018,(https://www.care2.com/greenliving/yin-and-yang-the-key-to-a-balanced-home.html)

Sonal,Ar. Shubhi.,(2012)Channelizing Earth Energies towards a Healthy Built Environment., International Conference on Advances in Architecture and Civil Engineering, pp-864,867.

Starkweather,Llan.,(2006) All-That-Is Waving in Resonance with the Vibes,Wizard at lulu.com,ISBN-978-1-4116-8259-7,PP-22-23.

Suriyanarayanan,S.Muthu.D .,and Venkatasubramanian,C.,(20 16) Application Of Vasthu Sastra In Modern Architecture, International Journal of Civil Engineering and Technology (IJCIET), IAEME Publication, ISSN Print: 0976-6308, Volume 7, pp. 690,691,694.

Sharma, Goswami, Purnima.,(2018) Vastu Shastra tips for the main door/entrance, Housing News, Viewed Viewed 7 March,2018. (https://housing.com/news/vastu-shastra- tips-main-door/)

Saleh,A.Momen.,(1979) Design Of Sun Shading Device., Symposium on Solar Energy, University Of Sydney, Australlia.

Sharma,M.R.(1978) Orientation of Buildings,B.D.74.

Sarkar, A. K., (2015) Indian Vernacular Planning, Civil Engineering and Urban Planning: An International Journal (CIVEJ), Vol.2, No.1.

Singh, M.K. Mahapatra, S., & Teller, J., (2014) Development of Thermal Comfort Models For Various Climatic Zones of North-East India, CEPT University, Ahmedabad, Sustainable Cities and Society,30th International Plea Conference., 14, 133-145.

Shahjahan, Amreen., (2010)Indigenous Rural Housing And Its Indoor Thermal Performances Beside The Padma River Bank Areas, Journal of research in Architecture and planning, Vol.9.

Tchi,Rodhika.,(2017) Feng Shui Basics, Viewed 6 August2017,(https://www.thespruce.com).

Vastu Shastra Principles |Vastu Purusha Mandala | An Architect Explains,(October 22, 2008).

Vaastu Tips For Locating Water Bodies In House (2017),Viwed-7th march 2018, (http://www.astrosaathi.com/)

Vyas,D.,(2005) Traditional Indian architecture - The Future Solar Buildings, International Conference "Passive and Low Energy Cooling for the Built Environment, pp-699.

Wang, F., (2016) Geo-Architecture and Landscape in China's Geographic and Historic Context,DOI 10.1007/978-981-10-0483-4_4. 107 .

Walters, D. (1989) Chinese Geomancy. Longmead, Element Books.

Yılmaz,M.,(2006) Sustainable Design In Architecture, Eco Design Implementation Workshop,PP-1448.

Zamir,Muhammad.,(2003)Anthology Of Bengali Proverbs And Bachans, Bangle Academy,Foreward,pp-v.

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1. Case Study 01

1.1 Form and Setting

The homestead is situated about 10 km from MohadevpurUpazila; post Shujail hat, Zilla Naogaon.Its layout is the reflection of a typical rural house form (Shown in figure 10); the original hut remains same. The family started the construction of single living unit but later the homestead was divided among the remaining three sons of the owner. The homestead structure is rectangular in plan and all the main living units are arranged around the central courtyard. The Clear isolation of formal and informal zones, indirect approach to the inner court, and segregated arrangement of service functions are seen. Two internal courtyards are seen. The users of another courtyard are part of the extended family. The courtyard allows defining the introverted layout of the homestead. And it's intimately linked to the household activities. Here mud is used as building material. The plinth is two feet high from the ground level in order to safeguard it from the effects of the flood. The homestead was surrounded by various types of trees.

Figure 1.1: front view

1.2 Landscaping

There are mainly two internal courtyards seen. One is original and another one is its extension. The extended courtyard is visually screened from the original one. The inner courtyard works as a household service area. One courtyard is older and another one is an extension of the previous court to meet the demand of space with the increase of family members. Many trees are seen not only on the periphery of the homestead but also in the middle of the courtyard. Coconut tree, mango tree, Jackfruit tree, guava tree, neem trees are found inside the courtyard and also wood

apple tree, Plumtree, bamboo outside of the dwelling. Excessive plantation minimizes the overall temperature of the building. A pond is seen near the south side which is used to meet the regular needs of cleansing, bathing etc.

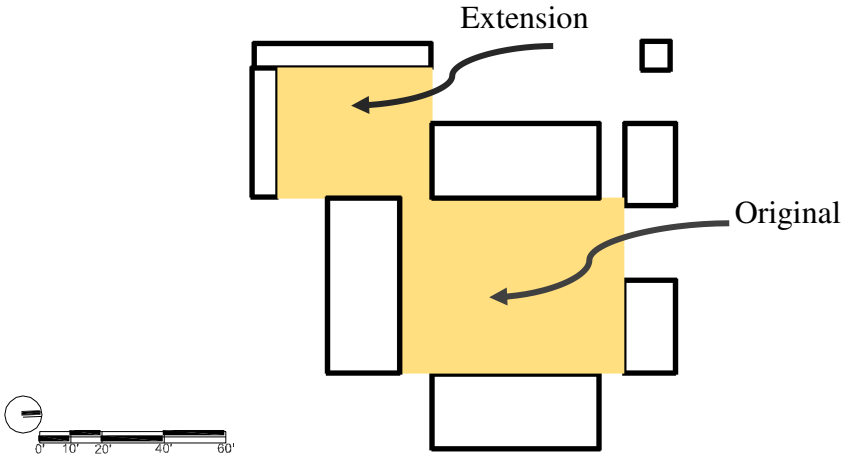

Figure 1.2: Two Internal courtyard

Figure 1.3: Link between two courts

Figure 1.4: View from the main courtyard

1.3 External spaces

The outer courtyard or external space is seen in front of the homestead. External open space provides privacy by distance and also allows free air movement through space between the homesteads. The outer courtyard is adjacent to the boithok ghar (guest house).

1.4 Relation between Homestead units

The layout may be compared to that of a typical rural homestead. It resembles the original one built by his grandfather. There are three main living units surrounding the main courtyard. The cowshed is adjacent to the yard at the north side of the main courtyard and kitchen is a separate structure with its own space. There are two toilets seen. The old toilet seen is in the backyard on the western side and another new is placed on the east side. Only the living unit of the eastern part is two stories but its upper floor is no longer used by the dwellers. A Common Kitchen is seen on

the south-west side.The boithok ghar (guest house) is near to the main entrance at the eastern part which is adjacent to the outer court for the privacy of the dwellers.

1.5 Roof and Wall

Elongated roof made of a corrugated iron sheet with bamboo structure creates a shadow. The roof slope helps the rain water to fall and reduce the risk of a leaking roof. Thick mud wall (75 meters) is seen. The thick walls are working as the thermal barriers in hot and cold seasons.

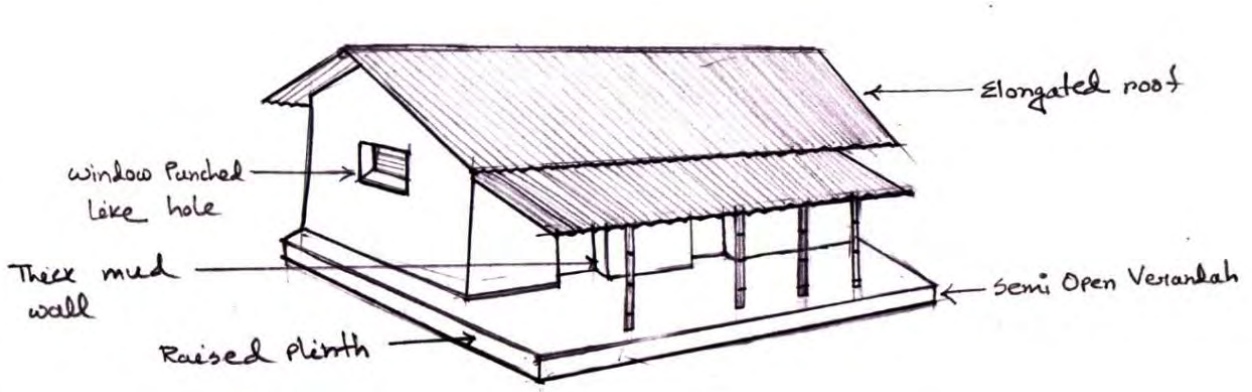

Figure 1.5: Elongated roof provide shadow

2.2.6 Light and View

The central courtyard and semi-open Verandahs are used as a source of natural light. Doors and windows are just punched like holes. Windows openings are kept small. Small window and thick mud wall don't allow direct light inside the room. Cross ventilation is seen.

2. Case Study 02

2.2 Form and Setting

Figure 2.1: Front View

The homestead is situated in the 10 km away from Mohadevpur Upazilla; post Shujail hat. The Rectangular plan of the homestead followed the configuration of the site. It's a west facing homestead. There are an adjacent road and a pond at the front. Two internal courtyards are seen. All the functions are arranged around the central courtyard. The backyard is mainly used for rearing cattle. The central courtyard allows defining the introverted layout of the homestead which is intimately linked to the household activities. The house was built with mud wall and C.I. sheets roofing on brick plinths. Many trees are seen at the front and back side.

2.2 Landscaping

There are primarily two internal courtyards seen. The inner courtyard works as a household service area, and the backyard is used as a cattle husbandry. There is a cowshed behind the main courtyard. Various ranges of trees are seen, such as mango tree in the front, teak, bamboo are seen at the backside of the homestead. There is also a guava tree seen at the middle of the central court. An excessive tree on the west side helps to reduce the temperature. A Pond is seen near the east side which is used to meet the regular needs of cleansing, bathing etc. Evaporation of water from pond helps to reduce the heat and humidity of the homestead.

Figure 2.2: View from the court

Figure 2.3: Pond in the east

2.3 External spaces

External space is seen in front of the dwelling. External space helps to provide privacy by distance. However, this is now being used as a road. The main entry is positioned from the east, which is very near to the adjacent road (As shown figure 2.1).

2.4 Relation between Homestead units

In terms of the arrangement of forms the house reflects a typical rural homestead (As Shown Figure: 2.23). Two main living units adjoining to the central courtyard at the South East Direction. As we know in a rural homestead all the living unit arranged is isolated around a court but here rooms are coming nearer to each other and living units look similar to an L shape. West facing entry of the homestead is seen. There is a shop next to the main entry. Two isolated service units kitchen and dining saw in the north and west direction. Because the rooms are arranged side by side to each other and it looks like L shape. The dining room is totally constructed with C.I. sheets. The inner court is mainly used as the circulation space. There is another entry seen which connects to the backyard. The cowshed is adjacent to the backyard. Toilet is completely separate from the inner part of the dwelling which is placed in the backyard of the homestead. A store is also seen at the back of the living unit. For the privacy of the dwellers, the living room is near to the main entry. All the openings are oriented to the central court which helps to allow lights and air into the rooms.

2.5 Roof and Wall

C.I. sheets with bamboo structure are used as materials for roofs. The roof slope helps the rain water to fall and reduce the risk of the leaking roof. The cowsheds and dining are built with C.I. sheets and the kitchen is constructed of bamboo with mud plaster in some portions. The wall of the living units is made of mud and the plinth constructed with brick and cement finish. The thick mud walls of the living units work as thermal barriers in hot and cold seasons. To get the thermal performance, temperature and relative humidity data were collected into the site.

2.6 Light and View

All the openings are oriented towards the central court that's why daylight easily enters all the living units. Proper ventilation is seen in every unit which helps to draw cool air in and push stale or stagnant, hot air out of the dwelling. The air movement of north side rooms is better than the east side room because the rooms at the east side were closed from the external side All doors and windows in the north-south orientation helps to get the maximum light and air.

Figure 2.4: Openings are oriented towards the inner court.

3. Case Study 03

3.1 Form and setting

Figure 3.1: Front View

The homestead is located about 8 km from Mohadevpur upazila; post Joanpur. The Rectangular plan of the homestead followed the configuration of the site. There are an adjacent road and a pond at the front of the homestead. A central courtyard is seen. All the functions are arranged around the central courtyard. There is also an external open space in front of the house. Both side and back of the dwelling have other settlements. The house was built with mud wall with C.I. sheets roofing on brick plinths.

3.2 Landscaping

The central courtyard allows defining an introverted layout of the homestead which is closely connected to the household activities. Like most other houses, not so many trees are seen. But there is a big mango tree in front of the homestead. There are also some vegetables planted in the external open spaces. Like bean, Gourd trees are planted. A guava tree is seen in the middle of the central court. A Pond is seen near the north side which is used to meet the regular needs of cleansing, bathing etc. Shaded water body takes up a large amount of heat of the north.

3.3. External spaces

An adjacent road with an external space is seen in front of the homestead. The adjacent road is used by the local people. The main entry positioned from the North. A pond is seen near the north side (Figure: 3.8).

3.4 Relation between Homestead units

There are basically two living units, seen at the north and south side. The longer end of the living units is in the north-south direction. All the units are connected by liner shaded verandah, which helps to save movement to the kitchen, toilet, and the room during the rainy season. Two isolated service units Kitchen and dining are seen at the east and west direction. A tube well is adjacent to the kitchen. A toilet is seen beside the tube well. The boithok ghar is near the main entrance to the southern part which has another entry from the external area for the privacy of the dwellers. There is a secondary entry seen from the west corner.

3.5 Roof and Wall

C.I. sheets with wood structure are used as materials for roofs. The roof slope helps the rain water to fall. The wall of the living units is made of mud and the plinth constructed with brick and cement finish. The walls are painted with various colors for decorative purpose. The thick mud walls are working as the thermal barriers in hot and cold seasons.

3.6 Light and View

Apart from the front the rest of the house is surrounded by settlement, that's why the light in the rooms is less accessible. The central courtyard and verandah periphery of the court works as a source of light. Small window and thick mud wall also don't allow so much light inside. Maximum opening in the north and open space in the front helps to allow maximum illumination in the north. Solid west helps to avoid the direct radiation of west.

4. Case Study 04

4.1 Form and setting

The homestead is situated, about 10 km from Mohadevpur upazilla; post Shujail hat. A typical rural house form with an arrangement of segregated service functions. Its rectangular plan has been developed with respect to the site. The indirect approach to the inner court maintains the privacy of the dwelling. All the other services are linked with the inner court. The front yard mainly used for rearing cattle. The front yard is shared by other homestead units. There is an adjacent road on the eastern side. Instead of north side among the rest of the side of the homestead didn't have any other settlement.

4.2 Landscaping

The inner courtyard works as a household service area. Boithok ghor(living room) is linked with the outer court at the western part of the homestead. Like most other cases, not so many trees are seen. A mango tree is seen in front of the kitchen. There is also a Gourd tree planted near the entry. Guava, coconut tree is planted on the east side.

Figure 4.1: View from the court

4.3 External spaces

There is an adjacent road with a common external space seen in front of the dwelling. The road is used by the local people. Boithok ghar is linked with the external court. The cowshed is also

placed there. The external space mainly used for grain processing and a cattle husbandry. The main entry positioned from the south.

4.4 Relation between Homestead units

There are basically three living units surrounded by the central court. Living unit of north and east side connected like L shape. Two separate service units, a semi-open Kitchen, and toilet are seen at the south direction. A tube well is adjacent to the toilet area. This space also used for bathing, cleansing too. In west direction, there is a bedroom and boithok ghar(living room) is seen. The boithok ghar has both entries from the external and internal court. Here the inner court acts as only circulation area.

4.5 Roof and Wall

C.I. sheets and bamboo is used as structural materials for roofs. The roof slope helps the rain water to fall. The wall of the living units is made by C.I. sheets and the plinth constructed with mud. To get the thermal performance of the homestead we took the temperature and relative humidity data from the site.

4.6 Light and View

Apart from the north the rest of the house is surrounded by the settlement. The minimum opening in the north-east units causes low illumination. Though the central courtyard works as a source of light the courtyard opening is missing. Comparatively the air flow pattern of the boithok ghar is better than the other unit.

5. Case Study 05

5.1 Form and setting

The homestead is situated in 10 km away from Mohadevpur upazilla; post Shujail hat. A rural homestead with a rectangular house form which has been developed with respect to the site. The entry is arranged at the corner of the court to ensure more privacy. Here the inner court acts as the main circulation area where services are linked with it. The three sides of the homestead are surrounded by the other settlement. Apart from the north the rest of the house is surrounded by the settlement. The minimum opening in the north-east units causes low illumination. Though the central courtyard works as a source of light the courtyard opening is missing. Comparatively the air flow pattern of the boithok ghar is better than the other unit.

5.2 Landscaping

The inner courtyard works as a household service area. Plum tree, drumstick and mango trees are seen inside the inner court. Banana, coconut trees are seen behind the homestead. Planting inside the courtyard increases the humidity and reduces the speed of wind but it provides better thermal comfort at certain periods of daytime.

Figure 5.1: View from the court

5.3 External spaces

As instead of the back side, all the three sides of the house are surrounded by other settlements, there is no external space seen in front of the homestead. The main entry positioned from the south.

5.4 Relation between Homestead units

There are basically two living units, which are connected like L shape at the North West corner. The longer end of the unit is at east-west direction. An Abandoned room is seen on the east side, but that is used as a storeroom. A dekhi ghar(locally made rise husking rectangular shade) is placed at the south near the main entry. A semi-open Kitchen is seen in the northern direction adjacent to the living unit. The isolated service toilet is also seen at the northeast corner.

Figure 5.2: Dheki ghar (locally made rise husking rectangular shade)

5.5 Roof and Wall

C.I. sheets with bamboo structure are used as materials for roofs. The roof slope helps the rain water to fall and reduce the risk of leaking roof. The walls are made by CI sheets too and the plinth constructed with mud. The dheki ghar is constructed with bamboo stick. And Fences around the compound are constructed with jute sticks for the privacy of the inner house.

5.6 Light and View

Though the central courtyard works as a source of light the homestead is surrounded by the other settlement. Also, windows are not courtyard oriented that's why all the rooms are deprived of ample amount of sunlight.

6. Case Study 06

6.1 Form and setting

The homestead is about 9 km from Mohadevpur upazilla; post joyanpur. There are 130 families living here. Its layout is the reflection of a typical rural homestead (Refer to figure 2.33); the family started the construction of single living unit but later the homestead was divided among the remaining three sons of the owner. The structure is rectangular in plan and it's all the main living units are arranged around the central courtyard. Here CI Sheet is used as building material. Dwell entry is seen. The main entry from the west side and other entry from the north side. Fences around the compound are constructed with bamboo sticks for the privacy of the inner house. Instead of front other side of the homestead is surrounded by settlements.

6.2 Landscaping

The courtyard allows defining an introverted layout of the homestead. All the built units are accessible only from the courtyard, which is intimately linked to the household activities. Guava tree is seen inside the court and coconut tree is also seen periphery of the back side and front side.

Figure 6.1: View from the court

6.3 External spaces

External space is seen in front of the guest room. The main entry positioned from the west.

6.4 Relation between Homestead units

There are basically two bedrooms, which are connected like L shape at the North West corner. An adjacent small verandah is seen at the left side of the west part. And right side living unit has its own separate entry and separate court. Isolated service unit Kitchen is seen at the east and toilet is

seen at the south direction. A store is seen on the east side too. If we carefully analyze the plan we can see the longer portion of north and south side room is in north side direction and the courtyard is getting benefit from the prevailing southern breeze. There is a guest house in front of the homestead which has a separate entry from the external court. The guest house is now used for temporary storage. Tree planted between the gaps helps to allow lights into the bedroom and wind to flow.

6.5 Roof and Wall

The roof is the most important part of the rural homestead. The roof is made of a corrugated iron sheet. And its structure is made of bamboo; the members are tied together with G.I .wires forming square grids. The roof slopes at an angle, usually on each of the four sides to facilitate the flow of rainwater and reduce the risk of leaking. Walls are also made by CI sheets.

6.6 Light and View

All the doors of the living unit are open towards the central courtyard. All the windows are open towards the north-south direction which helps to get benefit from the prevailing southern breeze. The central courtyard works as a source of light. Because three sides of the homestead are surrounded by other settlement that's why it doesn't get so much radiance from the outside.

7. Case Study 07

7.1 Form and setting

Figure 7.1: view from the main entry

The homestead is located about 9 km from Mohadevpur upa zilla; post Joyanpur.There are 130 families living here. The homestead structure is rectangular in plan and its rooms are arranged around the central courtyard. The courtyard allows defining an introverted layout of the homestead. And it's intimately linked to the household activities. Here mud is used as building material. The homestead is located next to the main road. From the outer court, there is a huge pond seen next to the main entrance. The homestead was surrounded by various types of trees.

7.2 Landscaping

This introverted layout of the homestead was emphasized more by planting trees extensively on the periphery of the homestead along the outer wall of the building. We can say the excessive plantation helps reduce overall heat gain of the building. Since the residents of the house are of Hindu religion there is a small altar with a holy tulsi tree seen in the middle of the central courtyard.

Figure 7.2: Pond in the south

Figure 7.3: Courtyard from the entry

There is a huge pond surrounded by lots of trees like Cauliflower Tree, mango tree, bamboo tree are seen on the southern side of the house. The pond allows rearing ducks, fish, and bathing –a regular cleansing ritual of every day. There is an open courtyard in front of the homestead. An outdoor kitchen is seen in open courtyard. This space basically used for processing the grain.

7.3 External spaces

There is an external space in front of the house entrance. The external space mainly used for grain processing and a cattle husbandry.

Figure 7.4: Open courtyard in the front

7.3 Relation between Homestead units

There are basically two living units surrounded the central courtyard at the northeast and south side. Another side is a cowshed adjacent to the courtyard. Verandahs across the periphery around the living units act as semi-open space which provides cool outdoor space. Kitchen and toilet both are separate from the main dwelling and placed outside of the homestead. There is boithok ghor is on the North West side which is now used as a temporary store. It has a separate entry from the external court. The cowshed is placed on the east side of the courtyard. The longer side of the living unit along the courtyard and facing south is getting benefit from the prevailing southern breeze. There are gaps seen between the living units. Trees planted between the gaps help allow lights into the bedroom and helps the wind to flow.

7.4 Roof and Wall

The roof is the most important part of the homestead. The roof is made of the corrugated iron sheet. And its structure is made of bamboo; the members are tied together with G.I .wires forming square grids. The roof slopes at an angle, usually on each of the four sides to facilitate the flow of rainwater and reduce the risk of a leaking roof. Basically, Walls of the homestead are made of mud. The structure consists of a bamboo panel. And mud is used as plaster on both sides of the panel. Thick mud wall prevents natural light from coming. Small window, thick mud wall,

building material keeps the temperature low. To get the thermal performance of the homestead temperature and relative humidity data was collected from the site.

Figure 7.5 Window punched like hole

Figure 7.6: Kitchen window

7.5 Light and View

The central courtyard and semi-open Verandahs are used as a source of natural light. Doors and windows are just punched like holes. Windows openings are kept small. That's why it doesn't allow so much light inside the room. Mostly windows are open towards the north-south direction.

8. Case Study 08

8.1 Form and setting

The homestead is situated about 10 km from Mohadevpur upa zilla; post Shujail hat. Its layout is the reflection of a typical rural house form (Refer to figure 2.33).The family started the construction of single living unit but later the homestead was divided among the remaining two sons of the owner. The homestead structure is rectangular in plan and it's all the main living units are arranged around the central courtyard. The Clear isolation of formal and informal zones, indirect approach to the inner court, and segregated arrangement of service functions are seen. The extension of the courtyard is seen. The users of another courtyard are the part of the extended family. The courtyard allows defining an introverted layout of the homestead. Here CI sheet is used as building material. The outer space is connected by the secondary road. Dual entry is seen at the east and west corner. Both entries arranged at the corner of the court to ensure more privacy

8.2 Landscaping

The courtyard is extended in a linear way to meet the demand of space as a result of the increase in family members. The extended courtyard is 8 inches high from the original one.And it's intimately linked to the household activities. There are bamboo trees seen on the periphery of the west side. A row of mango and guava trees are seen in the south and east side of the homestead. Excessive plantation minimizes the overall temperature of the building. Water well is seen adjacent to the south side living unit.

Figure 8.1: View from the court

Figure 8.2: Adjacent water well

8.3 External spaces

An outer space is seen in front of the homestead. The outer courtyard is adjacent to the boithok ghar (guest house).

8.4 Relation between Homestead units

The living units at the south and west side surround the main courtyard. The cowshed is adjacent to the yard on the north side. A store is next to the cowshed. The boithok ghar is adjacent to the main entrance at the east side. It has a separate entry from the outer court for the privacy of the dwellers. A common toilet is seen on the north side. Two separate open kitchens are seen at the south and north side. The longer side of the living units along the courtyard are north-south oriented are getting benefit from the prevailing southern breeze.

8.5 Roof and Wall

The roof is made of a corrugated iron sheet with bamboo structure. The roof slope helps the rain water to fall and reduce the risk of the leaking roof. The wall is also made by CI sheets.

8.6 Light and View

Central courtyards are used as a source of natural light. All the windows are open towards the north-south direction which helps to get advantage from the southern breeze. Because two sides of the homestead are surrounded by other settlement and windows open towards that side that's why it doesn't get adequate illumination from the outside. Excessive plantation in the west casting shadows which doesn't allow so much daylight inside the room.

9. Case Study 09

9.1 Form and setting

Figure 9.1: Front view

The urban residential building is located in Dhaka Zilla.A two-storied building where ground floor is rented as an office and the upper floor is being used by the owner of the house. The Rectangular plan of the apartment followed the configuration of the site. It's a west facing house. There is an adjacent road in front of the house. Rest of the side is surrounded by other settlement. Brick is used as a core building material.

9.2 Landscaping

There is about ten feet free space in front of the house. Very few trees, like jackfruit, carambola trees, and some low heights flowers trees are seen .these trees create shadow and interrupt the direct radiation from the sun. The small open space in front of the plot is providing the scope of lighting and ventilation.

9.3 Relation between the functions

The compact arrangement of built forms was to utilize the spaces as efficiently as possible. The building is east-west oriented. All bedrooms are placed in the east direction. Dining and living placed on the west side. A clear isolation of public and semipublic zone is seen. The kitchen is on the north-west side.

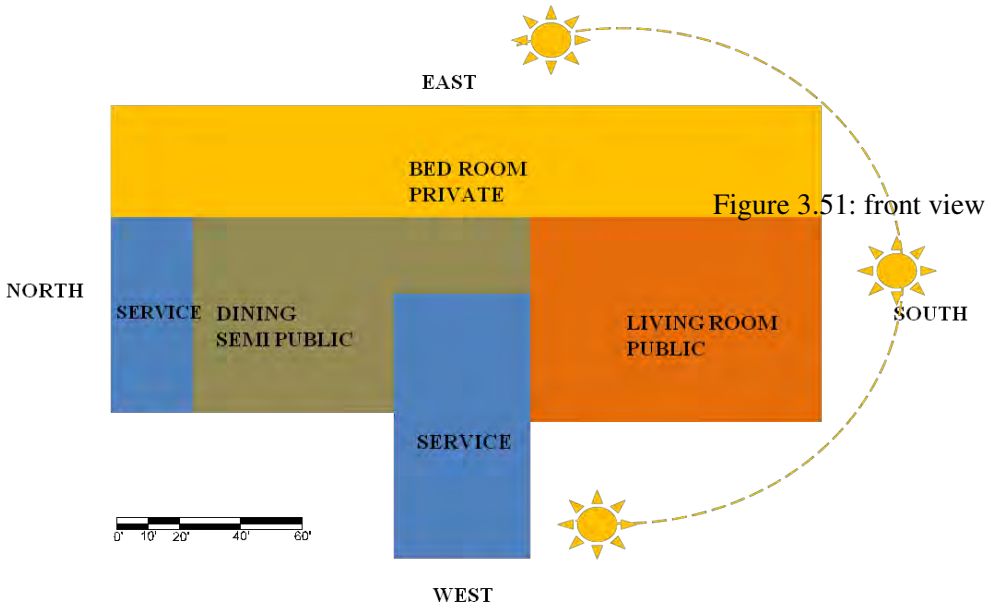

Figure 3.51: front view

Figure 9.2: Zoning Of The floor Plan

9.4 Roof and Wall

The flat roof is seen. That made by concrete. The core building material is brick.

9.5 Light and View

All the openings are oriented towards the external space that helps to get adequate illumination. All the bedrooms are on the east side. As we know the sun rises in the east. In the morning the east side is hotter than the other side. But the temperature of the east side during the morning is fairly tolerable. So, the room temperature of the private zone is better than the public zone. Verandah towards the west side helps to avoid the direct sunlight. The other settlement of south side is low height structure that does not interrupt the light and air of the south side. However, the five-storied building at the east results from minimum ventilation of the back side of the building. The three-storied building in the north also interrupts the diffuser of light from the north but the situation of the north is comparatively better than the east.

10. Case Study 10

10.1 Form and setting

Figure 10.01: front view

The urban residential building Is located in Dhaka zilla.A two-storied building where the ground floor is rented and the upper floor is being used by the owner of the house. The Rectangular plan of the apartment followed the configuration of the site. It's a south facing the house. There is an adjacent road in front of the house. Rest of the side is surrounded by other settlement

10.2 Landscaping

Very few plantations seen. There is a huge jackfruit tree in front of the dwelling. The small open space in front of the plot is providing the scope of lighting and ventilation.

10.3 Relation between the functions

Compact arrangement of built forms was to utilize the spaces as efficiently as possible. There is a total of four bed rooms seen. All bedrooms are placed in the north-south direction. Dining placed at the west and kitchen living placed at the east side. The living is next to the main entry. A clear isolation of public and semipublic zone is seen.

10.4 Roof and Wall

Concrete Roof is seen. The core building material is brick.

10.5 Light and View

All the openings are oriented towards the external space that helps to get adequate illumination. Verandah towards the north and south side helps to avoid the direct sunlight. The other settlement of the west and south is interrupt the adequate light and air to come. The adjacent road at the north east side helps to allow maximum light. The maximum window opening of north-west side allows maximum illumination.