



BORNE OF EARTH

STRATEGIES FOR APPROPRIATE CLIMATE & CULTURE DRIVEN

DESIGN

SITE
WATER
MATERIALS
INTERIOR ENVIRONMENT
ENERGY + ATMOSPHERE







"For there is no such thing as independence in nature. The whole of nature is a unified system of interdependent variables, each a cause and a reaction existing only as a concentrated whole."

– Peter Joseph

Photo : Storrs building: UNCC-Charlotte, NC

foreword

BORNE OF EARTH

Fall Semester 2008, Climate Responsive Design Studio

We are participating in a global renaissance that is challenging the values that our social/ economic institutions have long been rooted. Not since the industrial revolution has there been such a compression of human circumstances and explosion of technologic innovation whose coincident promise mandates such a large scale reordering of our collective world view. The discipline of architecture is being influenced by this inertia to address its primary responsibility to human occupation. New terms such as “sustainability”, “green”, “biophilic”, “biomimicry”, “global warming”, “carbon foot printing” and “net zero performance” have become the watch words that are a mantra for a more accountable, humanistic centered ethic through design. The introduction of these terms are fostering an awareness for the professional design community (landscape architects, architects, interior designers and engineers) to embrace integrated, systemic methods in the knowledgeable consideration of their impact upon the mosaic of built form across all scales of design. Yet how should we approach teaching these issues and their influence upon design thinking. This document is the embodiment of a pedagogical studio approach; rooted in the bio-climatic design ethic introduced over sixty years ago by the likes of J. Marston Fitch and the Olgyays (amongst many others) and the belief that greater understanding to meet the global challenge must be introduced as a system of integrated design based inquiry . The over arching premise of the studio has been conceived to produce a design primer that allowed the class to personalize the intentional aspects of design that can be formed from a clear understanding of place. And to provide for themselves a vehicle for their own personalization to gauge the influence of ecological design thinking upon the formal aspects that determine environmentally appropriate settlements, landscapes and infrastructure that supports built formal order. This document is the embodiment of 15, third year design students’ semester long journey to describe the appropriate application of architectural principle. Their work, formatted against contemporary standards, illustrates the formative application of design inquiry tempered by precedents and their analysis and understanding of Global Climate Classification, the Mahoney Tables and the Human Area Relations Files.

Enjoy,

Dale , Professor of Architectural Technology

preface

Those who look for the laws of nature as a support for their new works collaborate with the creator.

-Antonio Gaudi

This is a compilation of the ideas and opinions of fifteen architecture students from the United States interested in designing buildings in hot humid and hot arid climate zones all over the world. Over the past few decades, humanity has developed an irresponsible appetite for arbitrary substitutes of natural aesthetic. This book addresses the profound need for efficient design with a number of basic principles and strategies. Humankind must re-establish its equilibrium in the natural cycle and architecture is one of the vehicles for such a movement. More specifically, climate responsive and culturally responsible architecture are large steps towards absolute efficiency. Though these are broad terms in and of themselves, they can be dissected in to practical processes and arranged in an ephemeral matrix. The matrix relates the five basic architectural needs (site, water, materials, interior environment, energy + atmosphere) to the four environmental elements (solar, wind, water, biological), and determines the method for organizing the information within. Each chapter covers one of the five architectural intentions in a manner that reveals its significance to the whole idea of responding to the climate. The basic principles of each element are explained and supported with examples that emulate climatic fit. Cultural implications will be discussed alongside methods for construction and analysis of design strategies. Though this document is to cover a broad scope enabling architects to build in any climate, an understanding of specific cultural elements improves the building's ability to belong, to preserve the sense of place. This notion is crucial to the success of a piece of architecture, which ought to serve the people who will inhabit it as well as the environment in which it is built. As the ephemeral matrix illustrates the climatic web linking all of the elements into one holistic concept, so do elements of culture explain an anthropological method of a society responding to its particular climate. As one navigates through, the book begins to reveal the cyclical nature of the climatic design process; by isolating each path along the matrix, it is possible to quickly reference any part of that cycle. It is organized in a manner that allows for quick reference into any part of that cycle, but written with the intention of producing a holistic understanding that will remain in the subconscious of architects as they consider each design decision.

SITE

WATER

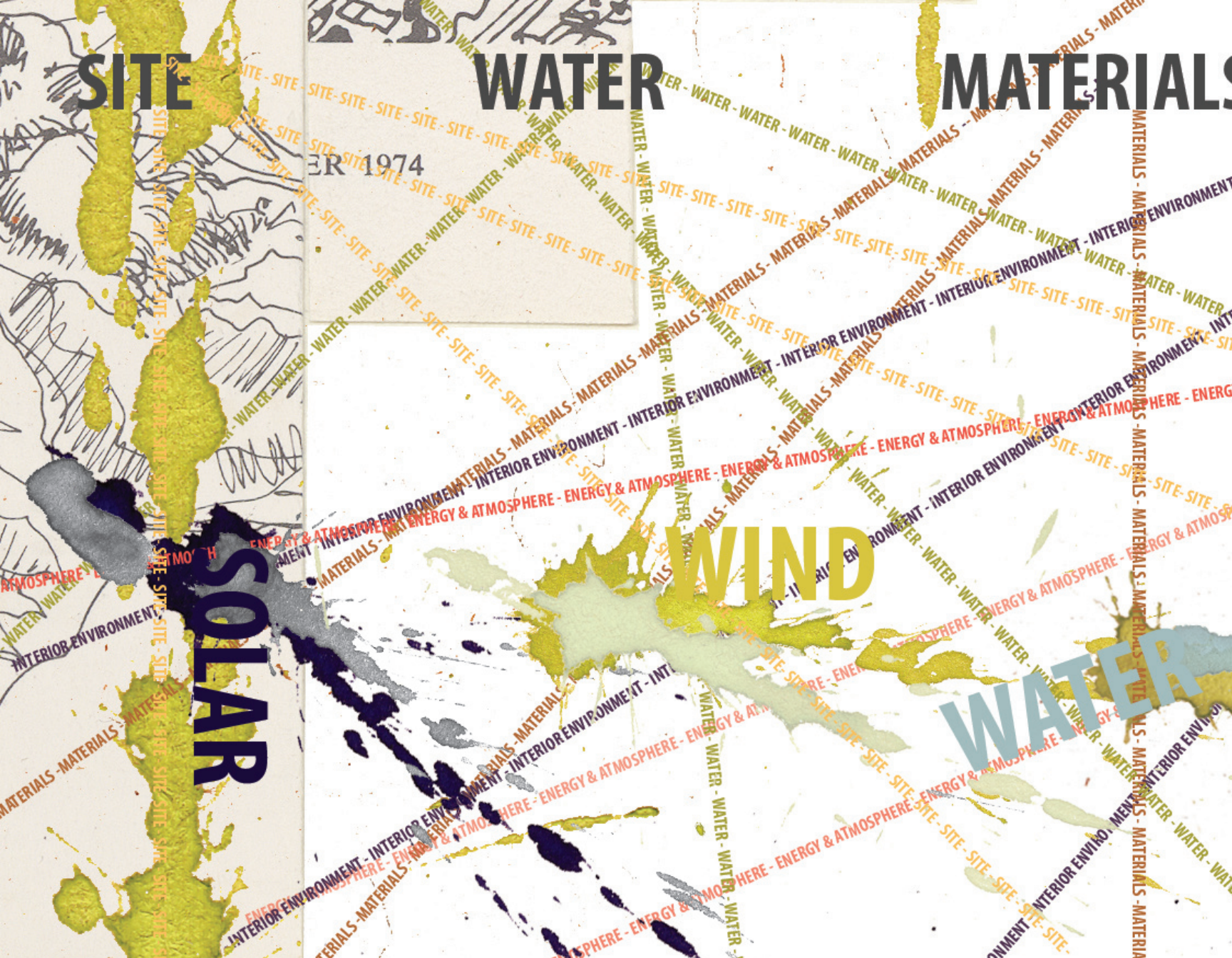
MATERIALS

ER 1974

SOLAR

WIND

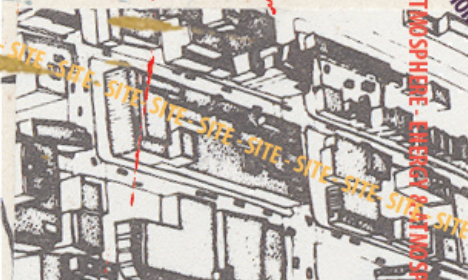
WATER



INTERIOR ENVIROMENT

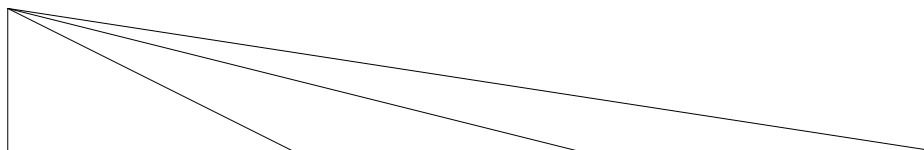
ENERGY & ATMOSPHERE

BIO

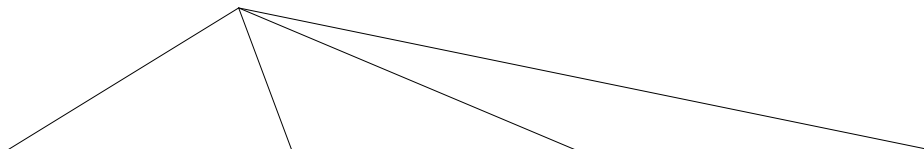




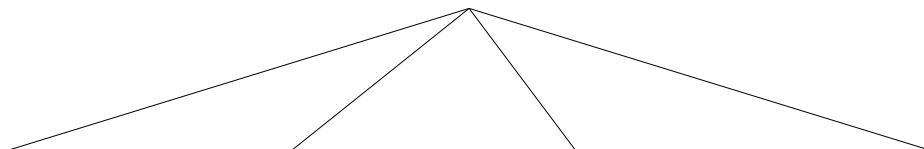
SITE



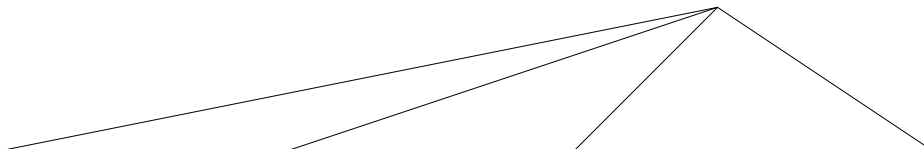
WATER



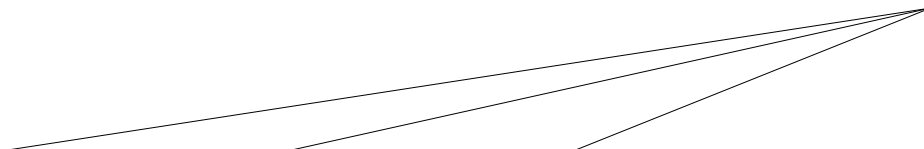
MATERIALS



INTERIOR
ENVIRONMENT



ENERGY +
ATMOSPHERE

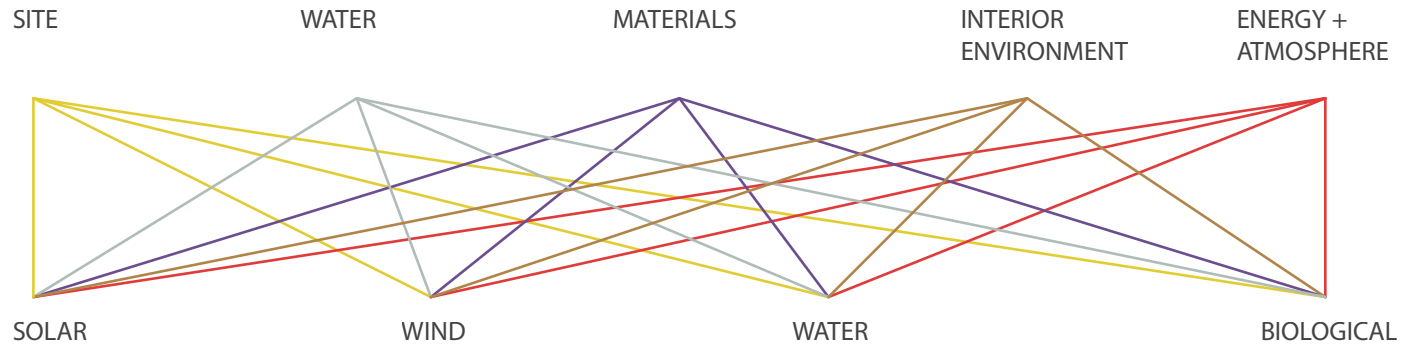


SOLAR

WIND

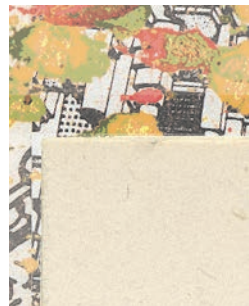
WATER

BIOLOGICAL



THE TABLE OF CONTENTS ORGANIZED AS A MATRIX -

This diagram shows the means for expressing architecture divided in to five categories on the top. They are ordered to parallel the design process, beginning with analysis of the site. Below the matrix, the four elements of site that must be considered in climate responsive design. Biological elements, in this case, include the living environment and anything with which it interacts (besides the sun, wind, or water). The lines represent each section of this book and their directly interconnected relationship with one another. The opposite page has a qualitative representation of the table of contents.



15

SITE

"When beginning the design process, the first element to be considered is site, which consists of three layers. The macro-layer relates the site to the global context..."

45

WATER

"Water. We simply cannot live without it. As a species, we need it for survival. Our daily lives depend on availability of water and the duties it perform in the preparation of food, cleansing ourselves and belongings, the disposal of waste and the nurturing of life..."

67

MATERIALS

"Materials are the means by which architecture is realized, thus fulfilling their role as the concrete representation of design. It forms one of the five layers of design elements that are manipulated to achieve climate responsive architecture..."

95

INTERIOR ENVIRONMENT

"The qualities of the built environment result from a state of equilibrium between inside and out that allows for manipulation of inherent characteristics. Interior quality is different from the other methods for creating a climate responsive architecture..."

125

ENERGY & ATMOSPHERE

"To complete the cycle linking the natural to the built environment, we must finally discuss energy and atmosphere. Energy and Atmosphere are linked in two primary ways..."



SITE

WATER

MATERIALS

ENVIRONMENT

ENERGY





JOURNAL/SEPTEMBER

ER 1974

SITE

“We should always remember that a site is never inert, but is an ongoing set of very active networks that are intertwined in complex relationships.”

– Edward T. White

When beginning the design process, the first element to be considered is site, which consists of three layers. The macro-layer relates the site to its global context. The meso-layer is generally limited to the city, acknowledges prevailing winds, cultural factors, and vegetation. The micro-layer is the most complex as it contains varying degrees of local environmental conditions. When stacked together, the three layers of information form an intricate fabric that expresses a relationship between nature and the built environment. **This concept of separating the levels of site is a method by which to filter the design. It is present throughout this chapter and the entire document. In order to respond to a particular climatic need with the available natural elements, one must first gain a dynamic understanding of each site layer.** This understanding enables the architect to filter out inefficient solutions and focus on spatial, formal, and aesthetic aspects of the architecture. Beginning with the macro-layer, one distinguishes the climate region of the site and alludes to the nature of which design strategies could be implemented. For instance, a building in the equatorial and monsoonal region requires cooling tactics and shelter from the rain, while all heating strategies would be filtered out at the macro level. The macro-layer also contains latitude, longitude, and altitude, which determine the altitude and azimuth of the sun and ultimately determine shading, solar heat gain, and photo voltaic strategies. One uses the meso-layer to sift through ideas for natural ventilation, which depend on the prevailing winds as well as the need for such ventilation as determined by the macro-layer. This layer also contains information on vegetation that is native to the site, which is useful in passive cooling, shading, and ventilation strategies. Most importantly, the meso-layer includes examples of the cultural heritage and vernacular, which aid in determining spatial hierarchy, comfort requirements, and the overall aesthetic. The final layer of site, the micro-layer, is contained to absolutely local conditions including topography, bodies of water, surrounding structures, and human activity. This is the last filter because it is used for fine tuning strategies determined by the first two layers. Site considerations appear in the first chapter of this book so that design strategies that have not been filtered out can be understood more in depth in the chapters which follow.

3 SITE layers





DESIGN strategies

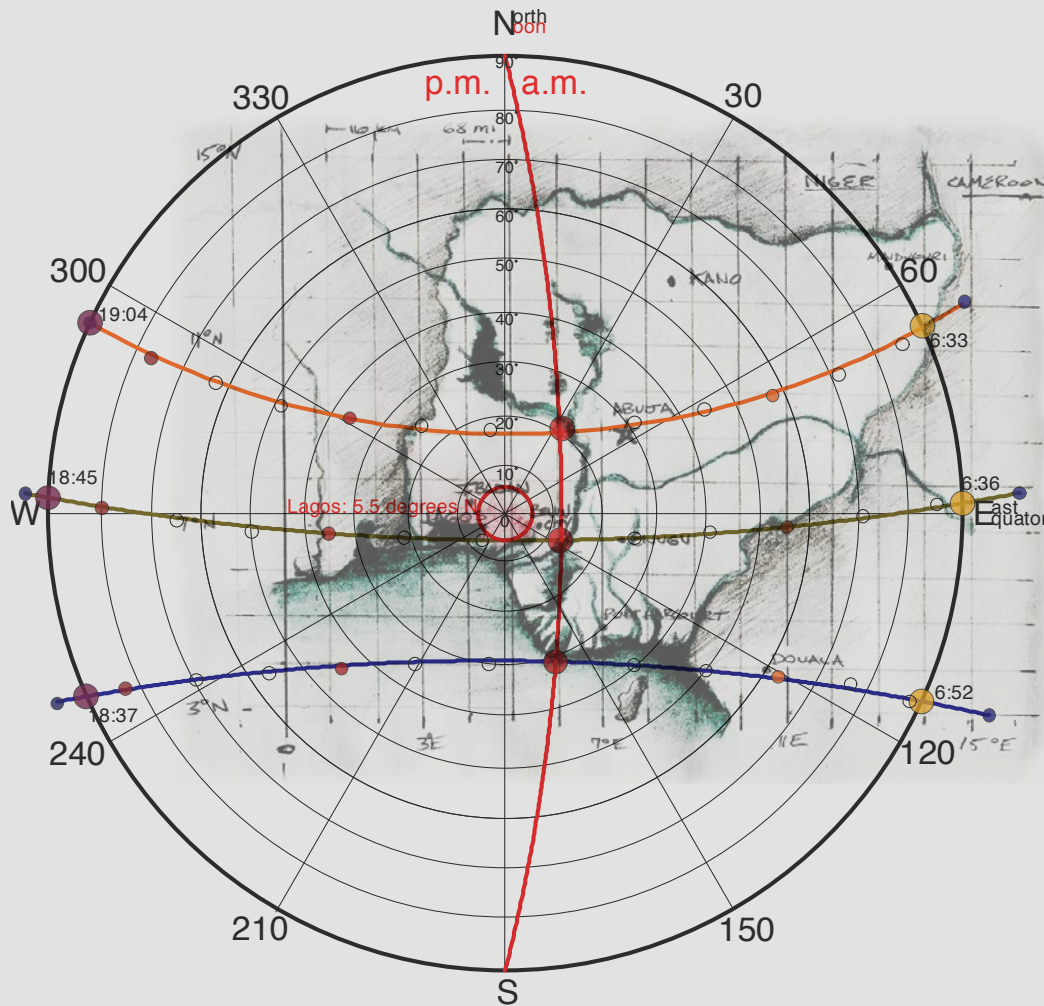
Site Filter: At the top, the broad band of color represents the entire spectrum of design strategies that could be used to accommodate any architectural problem. As the band of color passes through each layer of site analysis, it gets narrower and more precise. The remaining strategies are illustrated at the bottom, and they will determine the form, which will begin to speak back to its surroundings.

site

Solar



The first element of site to be addressed is its exposure to the sun. The majority of solar analysis takes place on the macro-layer, which places the site into its climate region. Solar energy will have different implications depending upon its climatic classification. Sites that are located between the tropics will receive ample direct sunlight throughout the year, and the days will be of more uniform length than sites outside the tropics. A sun path diagram, determined by latitude at the macro-layer, is useful in determining sunrise and sunset times, angles of incidence of direct sunlight, and the location of the sun in relation to the cardinal directions at any given hour of the year. **An understanding of the sun's path about the site is crucial to success in climate responsive design in both active and passive strategies. This understanding is also at the core of daylighting design.** Analysis of the mesosite layer will include an understanding of native methods of sunlight regulation. Cultural preference of temperature and daylight intensity should ultimately affect the design as well. Vegetation native to the site should be studied for its growth patterns in relation to the seasonal changes. Native plants and trees are always an aesthetically, ecologically, and economically sound way to regulate direct radiation. However, in hot arid climates, vegetation can often be limited. Finally, at the micro-layer, the sites proximity to other structures, hills or mountains, water, and vegetation are factored into the solar analysis gathered thus far. The sun's rays will bounce off of light colored surfaces and reflective materials surrounding the site, which will affect the overall lighting situation. Surrounding dark colored opaque objects will absorb radiation before it reaches the site, which, depending on the climate region, can often be a favorable characteristic of site. Urban contexts will generally provide an extensive variety of indirect solar radiation bouncing off of a multitude of surfaces, both natural and man made. Urban sites are also susceptible to heat islands, which refer to a higher temperature caused by artificial surfaces and densely populated energy consumption emitting excess heat. Rural sites, such as the one Glen Mercurt chose for the Marika-Alderton house, are free from such complex microclimatic conditions, but are often completely exposed to the sun's direct rays, especially in hot arid climates. By analyzing the relationship that the site has to the sun in layers, successful daylighting, shading, and heating strategies can be developed to respond to the climate in a manner that places the occupants and the environment in harmony.



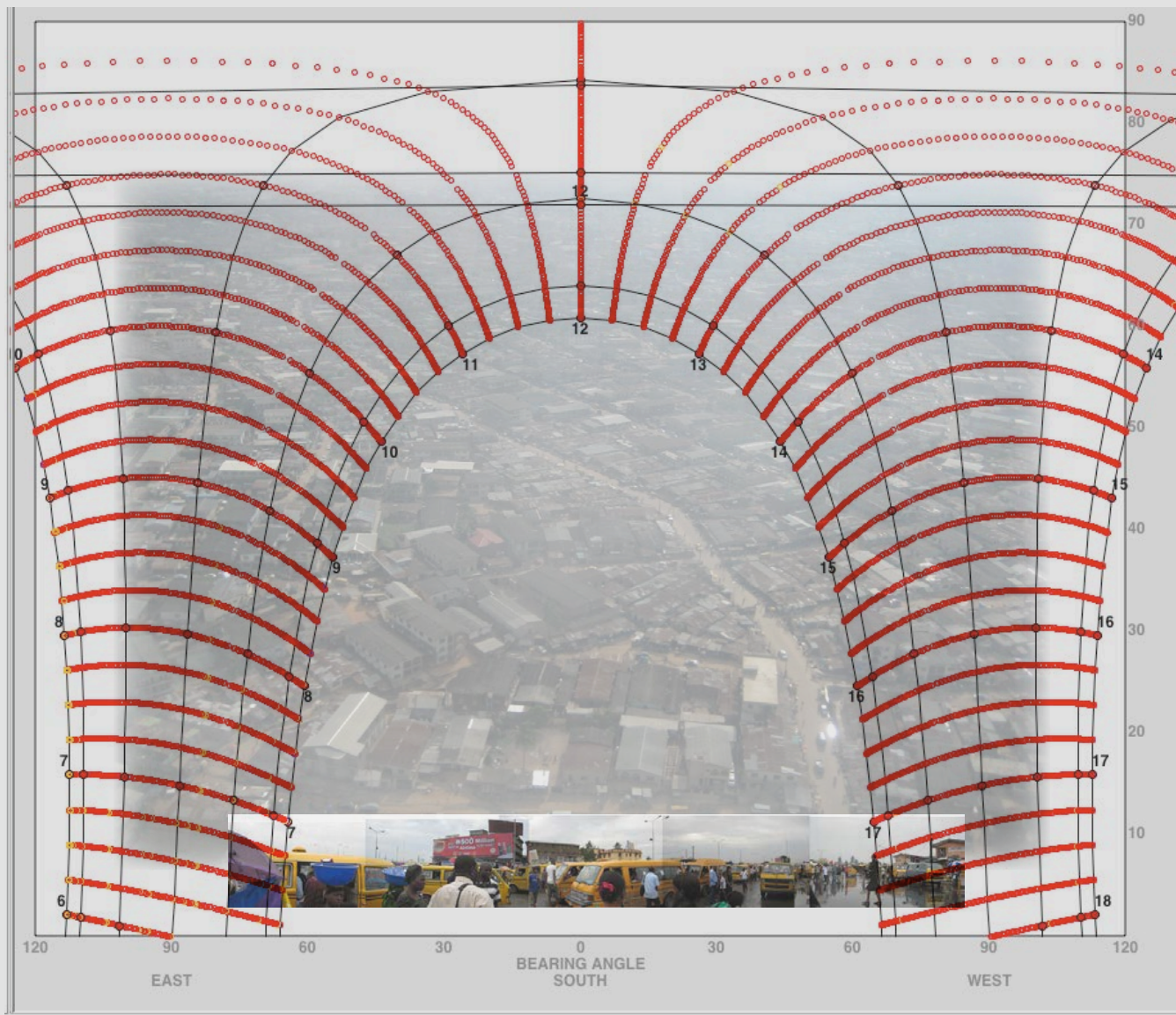
Summer Solstice — 6.21

Equinox	3.21
	9.21

Winter Solstice — 12.21

Macrosite : Sun Path Chart
Lagos, Nigeria : 5.5° North
Hot Humid Climate Region

Opposite Page : Shading Chart showing sun angles applicable to sections and elevations. Chart derived from Climate Consultant 3™.





site

Wind



Another element of climate that needs to be discussed is the air movement across the site. An architect should be knowledgeable of the local wind patterns, how they vary seasonally, and the local site characteristics that affect the air movement. The knowledge of air magnitude and direction is critical to where to position the building, in which direction to orient it, and how to engage with the exterior space. Analysis of the macro-site determines the need for ventilation and cooling, while analyzing the meso-site layer will tell of prevailing wind patterns. Finally, micro-site analysis will include local obstructions blocking the wind and bodies of water that affect the winds temperature.

Four factors of wind that need to be considered and their affect on the site globally and locally:

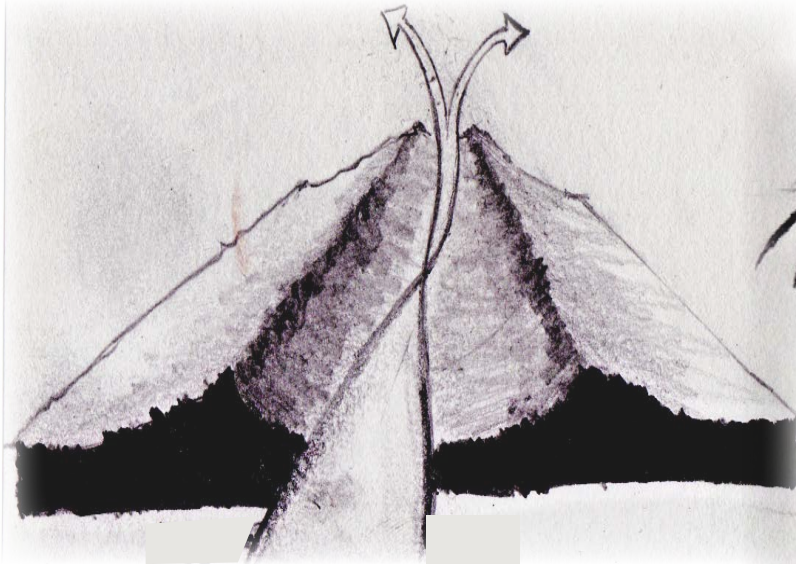
The seasonal global distribution of air pressure.

The earth's rotation about its axis.

The daily variations in the heating and cooling of the land and sea.

The topography of the region and its surroundings.

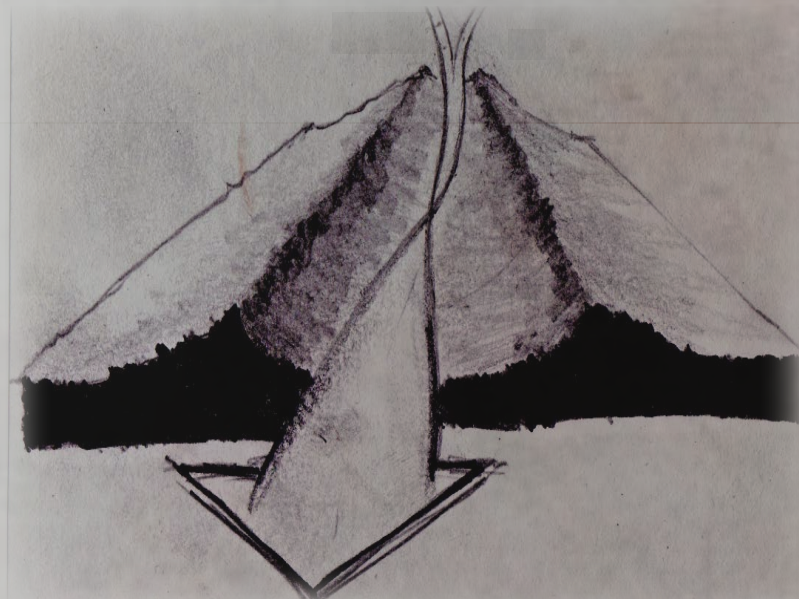
Air Pressure and temperature influence local wind and the direct climate of the site. Air generally moves from high-pressure to low-pressure zones. Also, during the daytime, the warm air rises uphill and at night when the air cool off and becomes denser it moves back downhill. Large bodies of water have a considerable effect on everyday wind patterns in that during the day air blows in from the oceans, and at night blows back out across the water. Characteristics of air movement are similar to those of liquids; wind will take the path with least resistance, moving around objects in any way it can. Streamline objects encourage the air flow around them smoothly while objects that are obtrusive will create turbulence on the side of the object receiving the wind. Architects can use these facts to respond to the climate and optimize their design; various methods for designing for wind are explained further in the chapter.



During the **day**, wind moves up the valley.



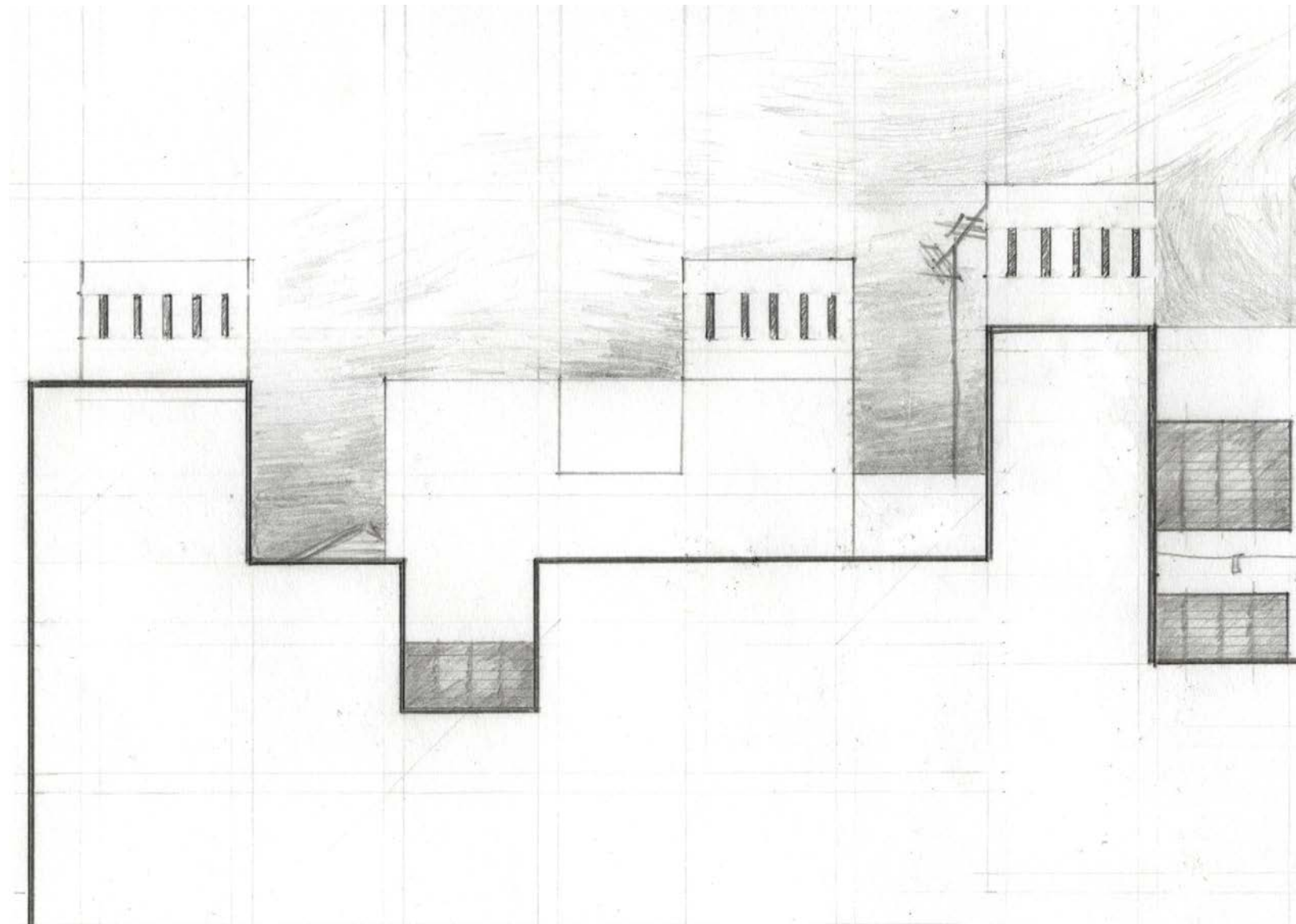
Day also brings cooler wind in from the ocean.



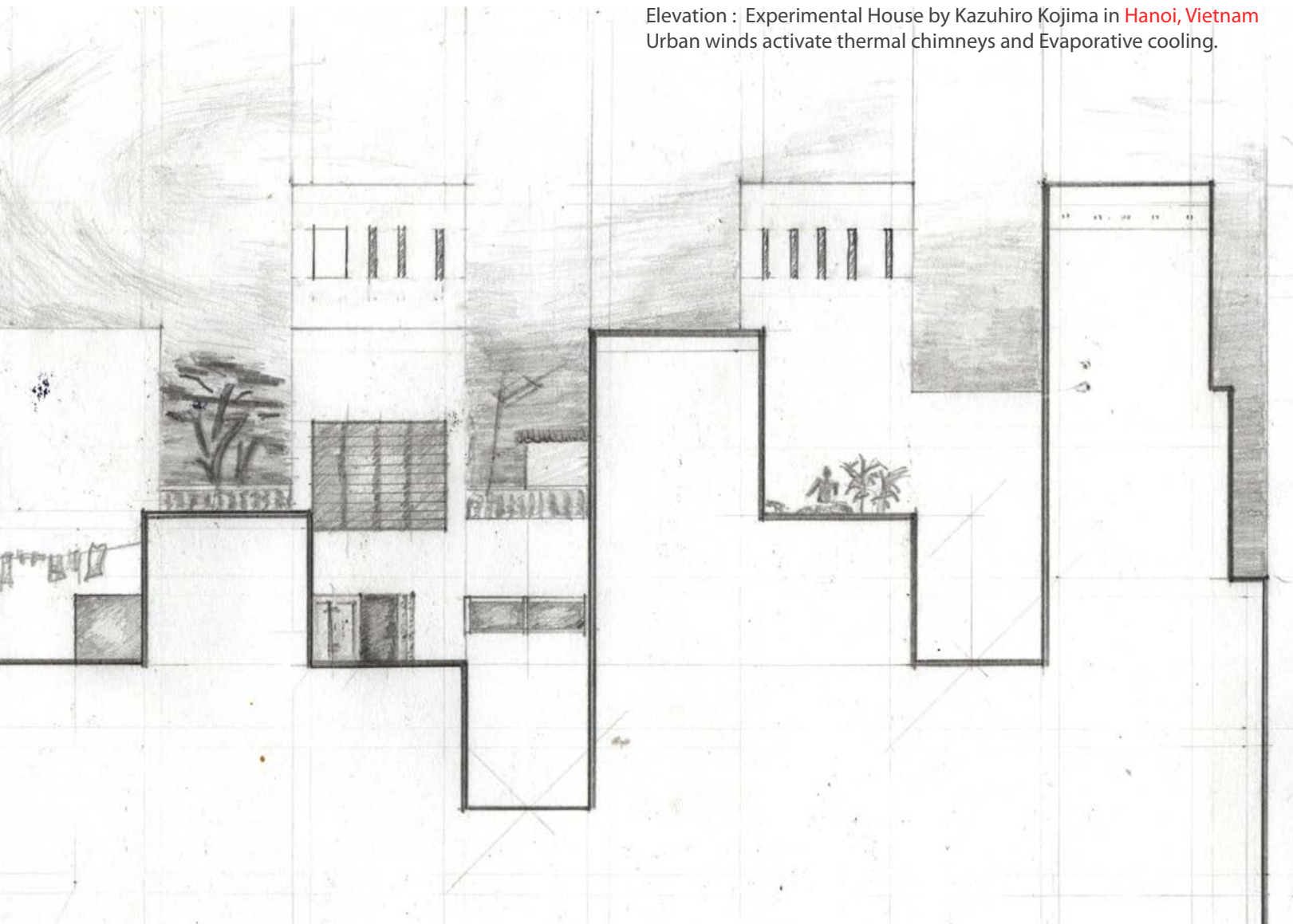
At **night**, wind moves down the valley.



Night wind moves off the land towards water.



Elevation : Experimental House by Kazuhiro Kojima in **Hanoi, Vietnam**
Urban winds activate thermal chimneys and Evaporative cooling.



site

Water



There is a multitude of ways in which water affects the site, and thus, the way an architect should design in response. The first way that needs to be looked at is how surface water affects the site. The planner needs to be able to understand how water operates throughout the site. Solar energy drives the process known as hydrological cycle. A designer must consider all aspects of this cycle, knowing they could affect a building in different ways. The macro-layer looks at the ways proximity to the ocean affects the site. **The considerations of monsoons, hurricanes, tidal waves, and annual rainfall are analyzed from this perspective.** The influence of surface water has to be analyzed because the affects of flood plains and climatic elements that the bodies of water bring about. The site could be on a flood plain, calling for the design to be raised as in the Marika- Alderton house by Glenn Murcutt. The desire to live near a source of water will always be prevalent in humanity and is a fundamental element of all civilizations. In early times, the water provided man with food and a transportation system. Mesosite conditions of water that need to be addressed include nearby bodies of water, such as rivers, lakes and lagoons, which could overflow during torrential rains. Careful consideration of local building methods will reveal flooding tendencies, rain cover needs, and successful technologies for adapting to such conditions. The Handmade School in Bangladesh embodies these considerations in its materiality and flooding considerations. Microsite considerations include sloping hills and urban drainage infrastructure. How does one plug into the existing infrastructure? Better yet, how does one create an independent and efficient system that large scale infrastructure should be modeled after? The question of how to control water and utilize it as much as possible is a important design consideration when looking to use a particular site. Water will inevitably affect every design and will ultimately affect every civilization, so how does humankind intend to integrate it into its thought processes?

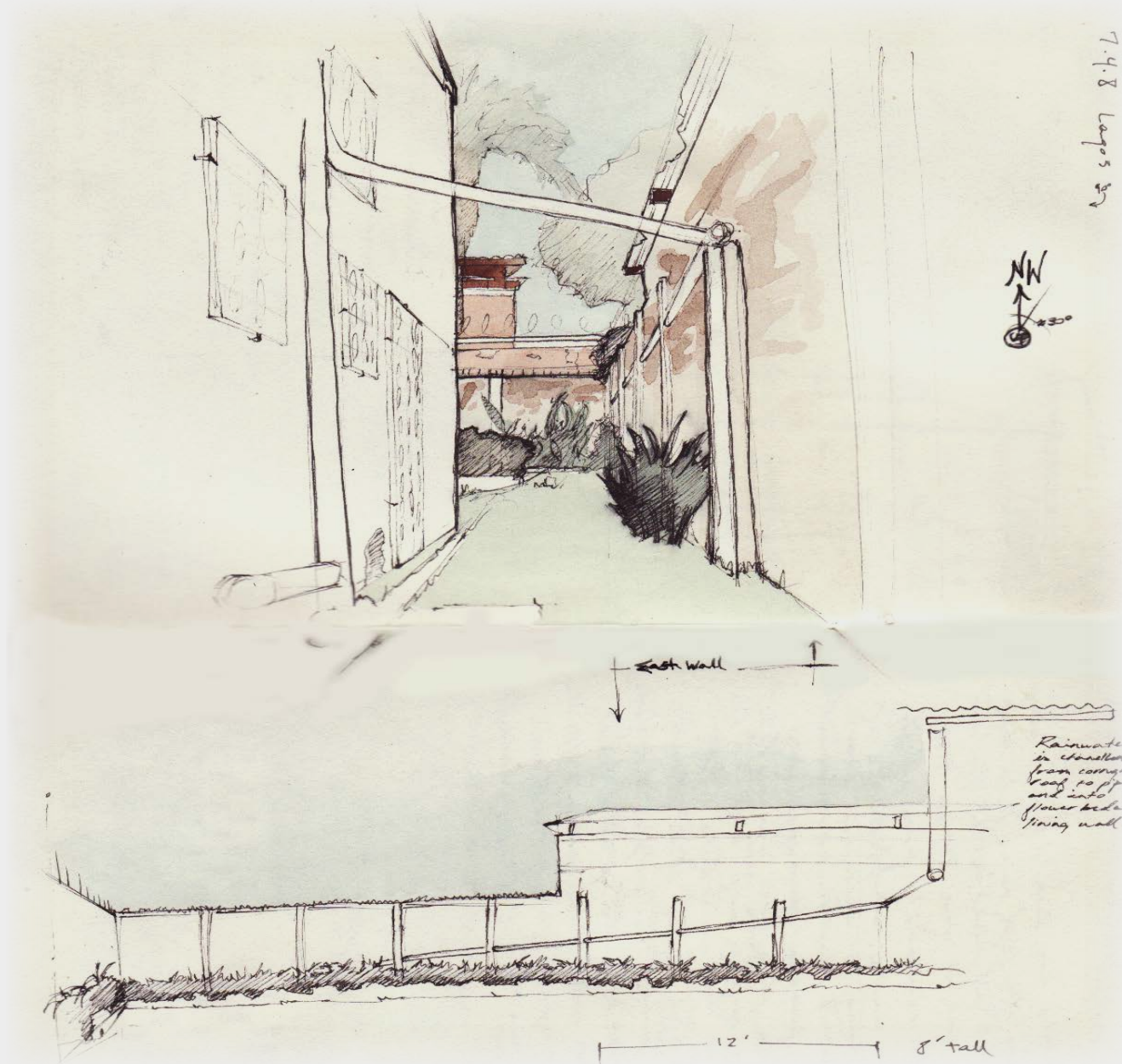


Left : A diagram illustrating wind humidity in Hanoi, Vietnam. Relatively dry air (green) from Asia blows on the site from the northwest for the majority of the year. The saturated (blue) monsoon winds come seasonally for about 2/3 of the year.

Below : A photo of the 3rd Mainland Bridge over Lekki Lagoon from the University of Lagos campus. Coastal winds from the lagoon provide relief from the hot Nigerian sun.

Opposite : Lagos Guest House rainwater system, which irrigates a garden along the adjacent east wall. During the monsoons it rains in southern Nigeria nearly every day and the air is always saturated.





Lagos, Nigeria : This view from the third Mainland Bridge illustrates how overpopulation can often catalyze a dynamic integration similar to the one between this fishing village and Lekki Lagoon.





site

Biological

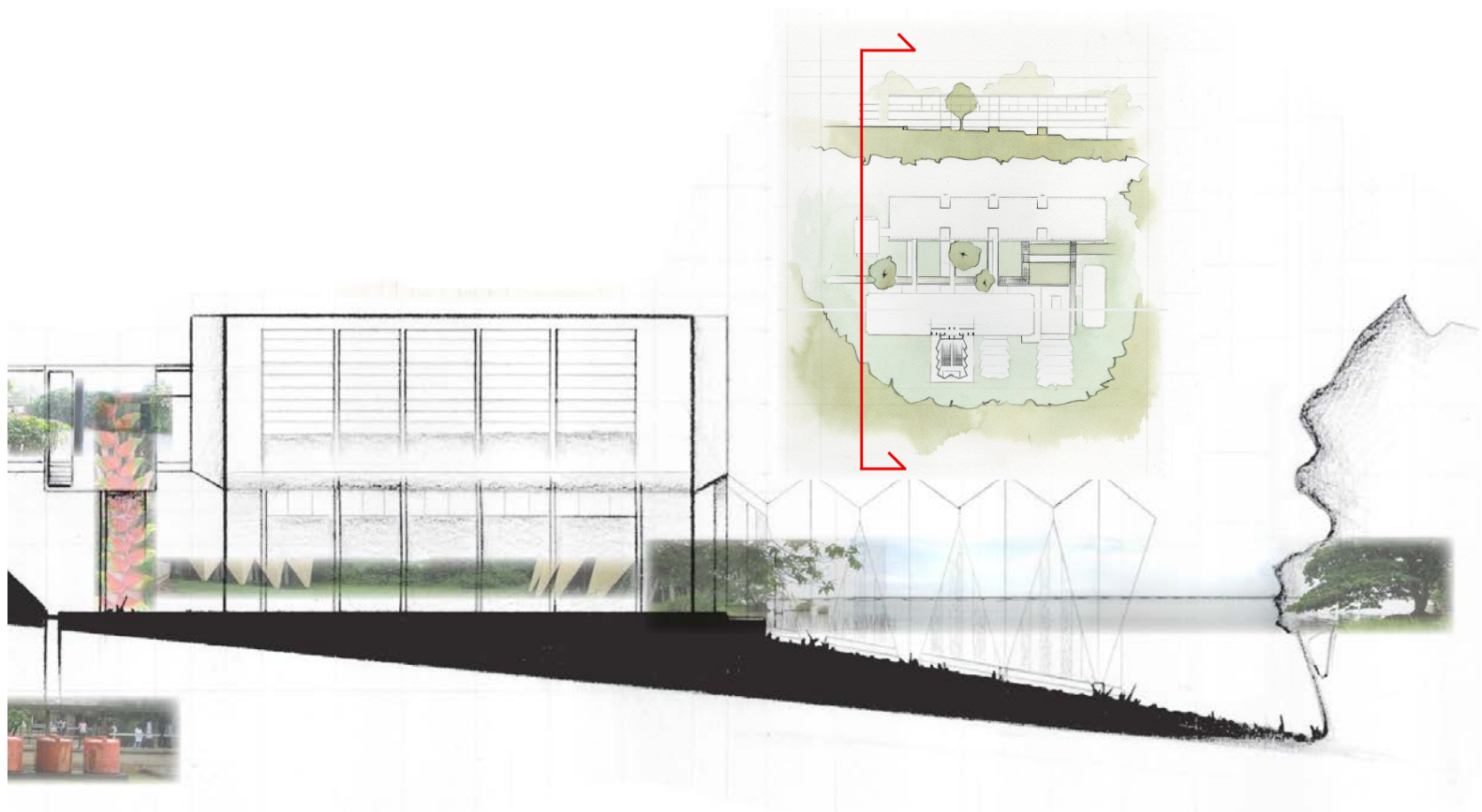


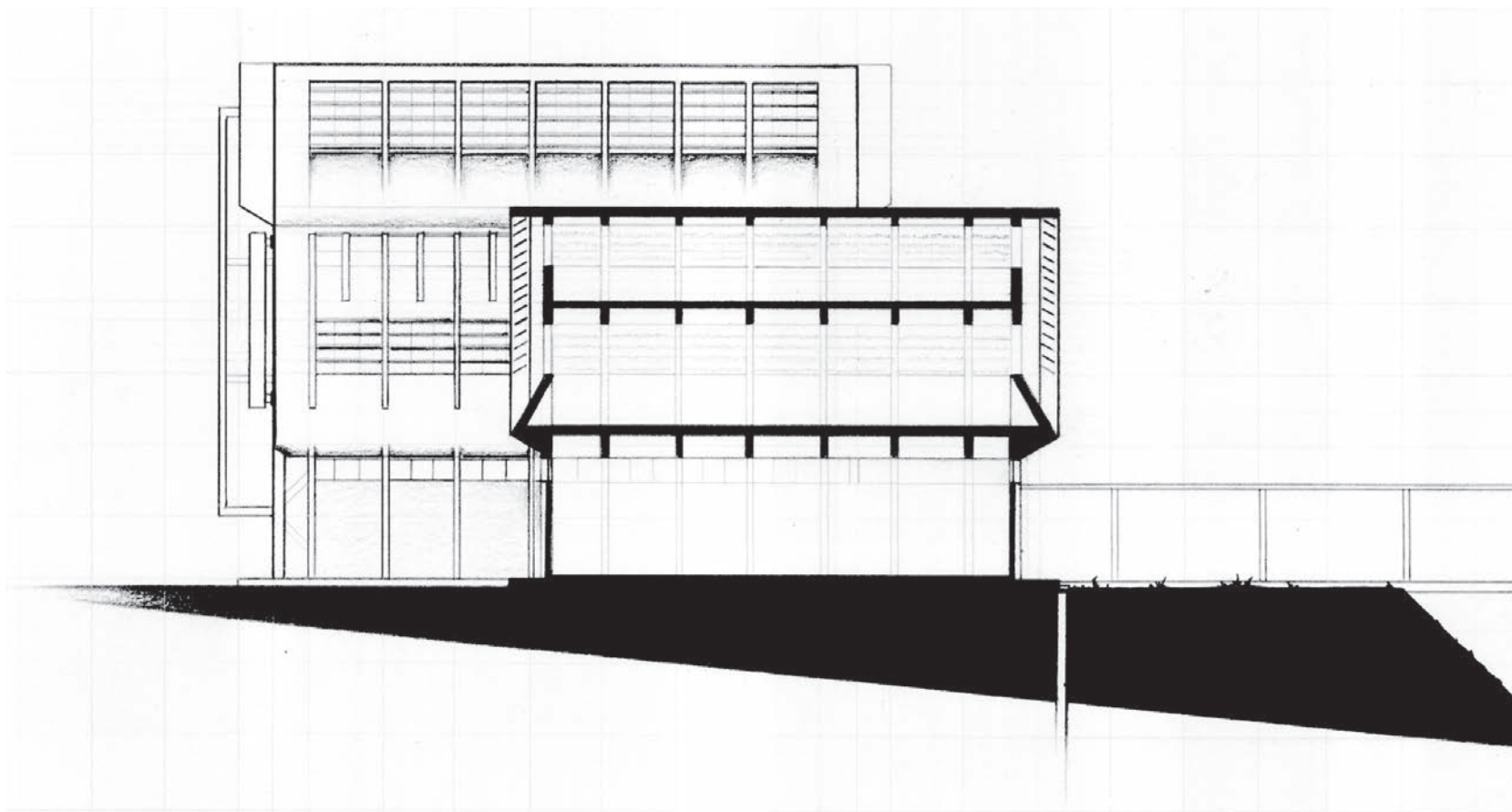
In every layer of site consideration there is a biological element which alters the effects of the previously mentioned elements. Biological elements of the site include, but are not limited to, flora, fauna, soil, and culture. While most exist at the microsite layer, the cultural element is ever-present throughout the entire filtering process. The macrosite layer containing the general climatic information is responded to by native cultures in their customs, garments, and architecture. Some cultural and religious traditions have predetermined building orientations and forms that override any climatic strategies. For example, traditional Chinese structures were always oriented toward the east. Many religious buildings are also constricted by tradition; Islamic mosques are axially aligned toward Mecca and Christian cathedrals are generally aligned to face eastward. Analyzing traditional garments can also allude to successful passive heating and cooling strategies; the thin layers of desert inhabitants speak to a manner in which the building skin must act. Much of the biological activity affecting design takes place at the meso-layer. Dissecting the culture of a particular city in which the site lies will reveal a vast array of cultural factors to be considered. Buildings in Lagos, Nigeria are susceptible to an under developed maintenance culture, a polluted atmosphere, a vast array of insect species, as well as an exponentially increasing population. Though it is hot and humid, the dynamic range of biological activity in Lagos demands a particular degree of attention for architecture to succeed there. **It is this biological element of every site which establishes its sense of place, which makes it unique from all other sites across the globe. When combined with the microsite conditions, the sense of place ultimately determines the form, materials, and aesthetic of successful design.** The biological factors occurring at the microsite layer include topography, soil content and consistency, altitude, and proximal human activity. A number of first-hand site visits are necessary to observe the biological effects at the micro-layer. The work of Maxwell Fry emulates this concept, as he is a British born and educated architect who built mostly in West Africa's hot humid and hot arid climates. Fry's architecture still influences both local and foreign designers in the region, and his publications mark time in the evolution of climate responsive architecture.

Photo : Ibadan, Nigeria

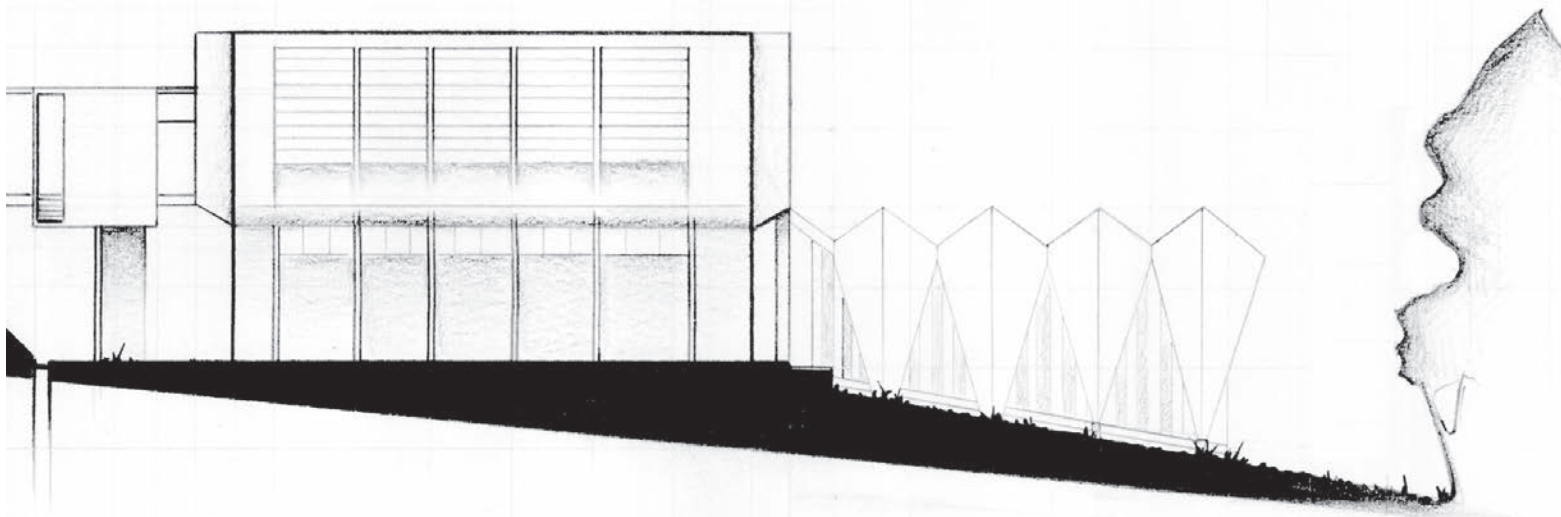
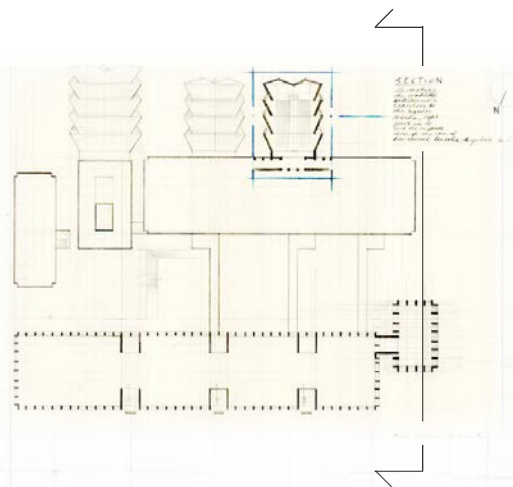
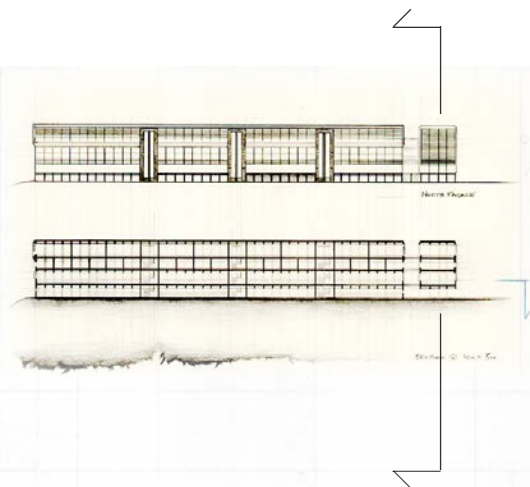


University of Lagos Science Block in **Lagos, Nigeria** by John Godwin + Gillian Hopwood. The reciprocating nature of biological responses to and from architecture.

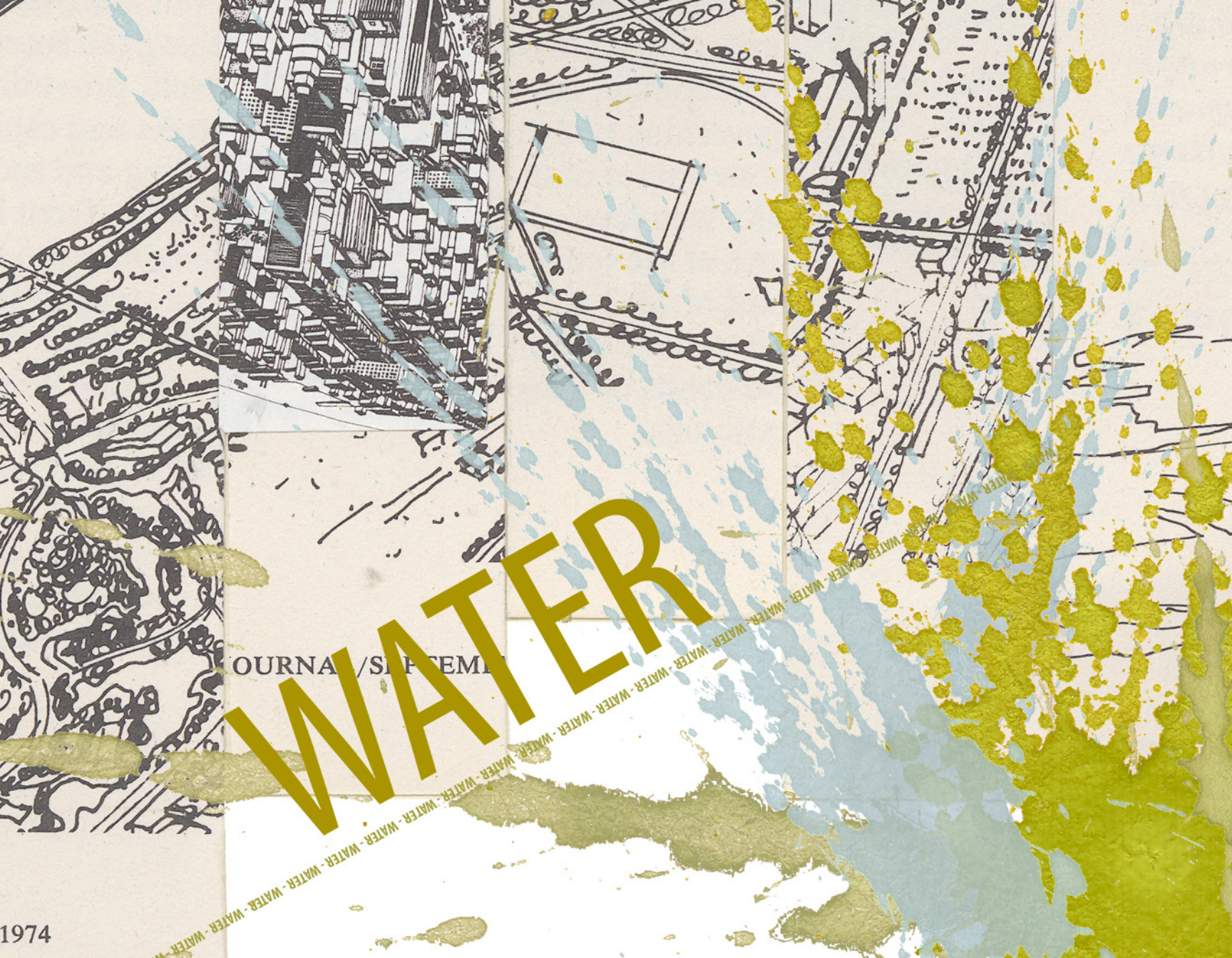




University of Lagos Science Block
John Godwin + Gillian Hopwood
Lagos, Nigeria 1969







JOURNAL / SYSTEM

WATER

“Man must go back to nature for information”

-Thomas Paine

Water. We simply cannot live without it. As a species, we need it for survival. Our daily lives depend on availability of water and the duties it perform in the preparation of food, cleansing ourselves and belongings, the disposal of waste and the nurturing of life. It is understood that water is vital for man, animal, and vegetation, this culture or any other. What is not always understood is that water is a limited resource. **This chapter addresses water in climatic responsive design through means of an aesthetic, conceptual, and philosophical approach while promoting conservation strategies.**

The technological aspects of these strategies will be introduced, though the bulk of information will be left out, allowing for the countless sources available that concentrate on specific technologies to provide any needed additional information. Simply, a building can have all the cutting edge technologies available, but if it is unattractive or does not agree with the environment, than it will not be accepted. Consider this: while the availability of water in most hot-humid climates is not a primary concern, that is not the case in many regions of hot-arid climates. Each person intending to use any suggested strategy must determine their own loss-gain analysis. This book may promote evaporative cooling as means for indoor atmospheric quality, but if implemented in a low-precipitation, hot-arid climate, the water usage necessary to operate evaporative coolers may not justify the saved cost. The inclusion of such passive systems is for the client to decide; our task is to educate. Water flows through the entire scope of climate responsive design, which makes it somewhat of an anomaly on the matrix. Just as water serves multiple functions in daily life, it is integrated into many of the strategies present in this text. This understanding, along with nature of water in certain climates, calls for an alteration of program. While still allowing for the matrix to act as a guide, it is prudent to discuss rainwater collection and conservation practices in hot-arid climates. Similarly, an issue of groundwater run-off in hot-humid regions deserves attention. Both of these topics are crucial to the discussion of water, as they determine the need and availability. Conservation and collection fall under the anomaly within the ephemeral matrix, which occurs when the line from water as an architectural means links to water as a natural element.

water

Solar

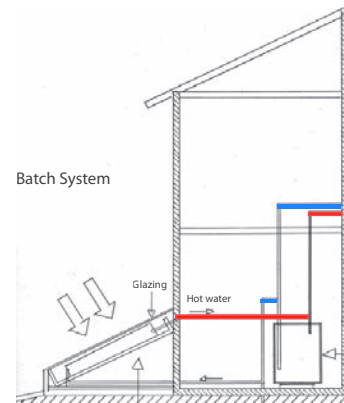
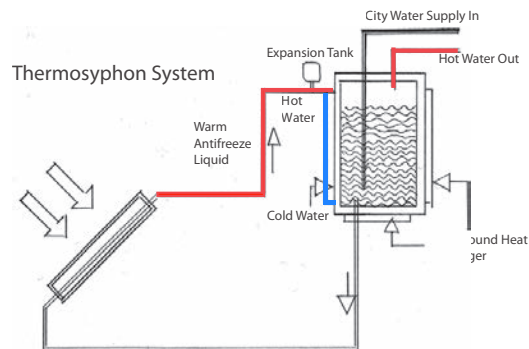
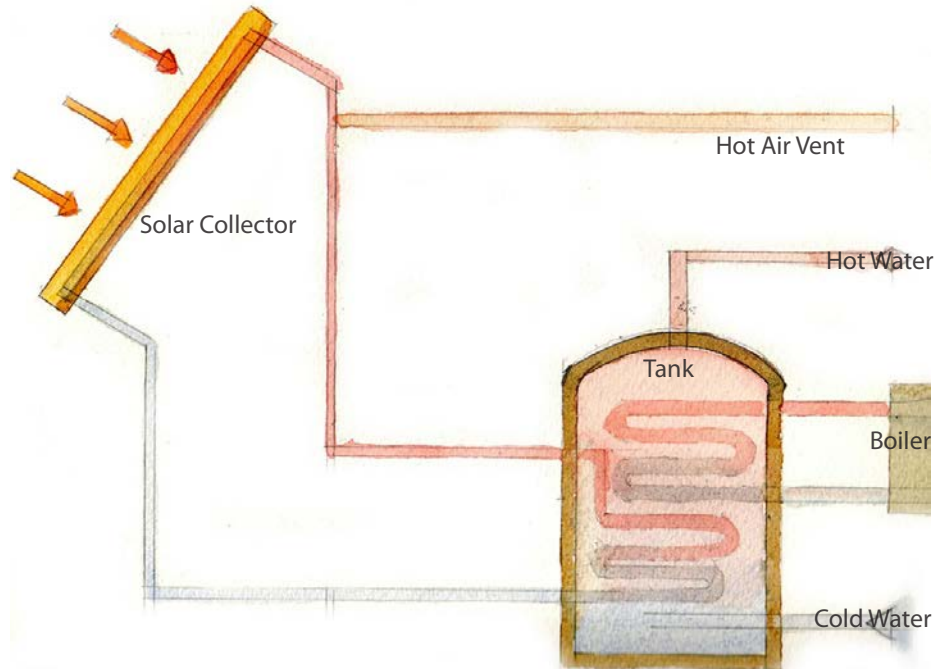


In both hot-arid and hot-humid climates, the sun's energy can provide many services. Among these is heating of water. Conventional water heaters account for 10%-15% of annual energy costs for a typical home. This cost can be reduced by implementing the clean and renewable source freely provided to us. There are both active and passive ways to harness the sun's energy for heating water. Active systems use pumps and additional applications to control and circulate the water through solar collectors. Passive systems allow convection or water pressure to circulate water. While passive systems may not be as efficient as conventional or active systems, they are simple and affordable. There are two primary passive solar heating water systems; batch and thermosyphon. A batch system involves metal tanks with heat-absorbing paint placed in insulated containers with a glass or plastic surface. The sun's rays hit the containers heating the water inside, which then is pumped to the storage tanks. The constraints of this system are that water, unless highly insulated, will lose heat throughout the night and that hot water use is optimal only in late afternoon and evenings suggesting that this system may not be appropriate for some hot-arid regions where temperature change for one day is drastic. A thermosyphon system uses a flat plate collector that is lower than the storage tank. If any solar energy system is used to heat water, there will still be a need for additional components. **Solar energy can provide up to 85% of a domestic hot water need**, a very welcome percentage, but it can't carry the load all the way. Allowing boilers to run off the same storage tank can provide the additional energy needs. This is a highly efficient and safe system that allows a client to conserve on energy costs because the boiler is only operating at a fraction of the typical energy requirement. Using solar energy to heat water works well in both hot-arid and hot-humid climates but it is not limited to these regions. All over the world, solar water heating is gaining popularity as the **users of solar water heating save 30%-50% on the energy bill**. It must be noted that in higher latitudes, the cost of this system is higher. The cooler air stresses the need for extra components, adding cost and complexity. Another positive aspect of solar water heaters is the reduction of global dependence on oil. It is estimated that a **conventional 50-gallon electric heater uses 11 barrels of oil a year. Therefore, using solar energy is not only climate responsive, but also environmentally responsible.**

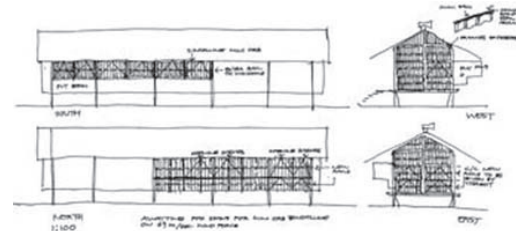
Photo : Falmouth, Jamaica

Solar Water Heating

To the right, a diagram illustrates the process for heating water through solar collectors. Cold water from the tank is pumped to the solar collector where it is heated and pumped back to the storage tank. A boiler is included as a back-up system. Below is the thermosyphon system, where the storage tank is located above solar collectors. The bottom right diagram depicts the batch system for heating water.



Marika - Alderton House



The Marika-Alderton House, designed by Glenn Murcutt, was commissioned for an aboriginal artist in the Northern Territory, Australia. The site, existing in a hot-humid/tropical climate, presents a design that limits over-heating by increasing the amount of ventilated air to counteract the stale humidity. The house is constructed on stilts to allow for cool air flow underneath the structure, help stem cyclonic effects of flooding, and simultaneously diminish the impact the structure has on the site. Implemented into this design is the a solar collector to heating water. Located on the roof, the orientation of the structure allows the solar collector to achieve maximum exposure towards the sun.



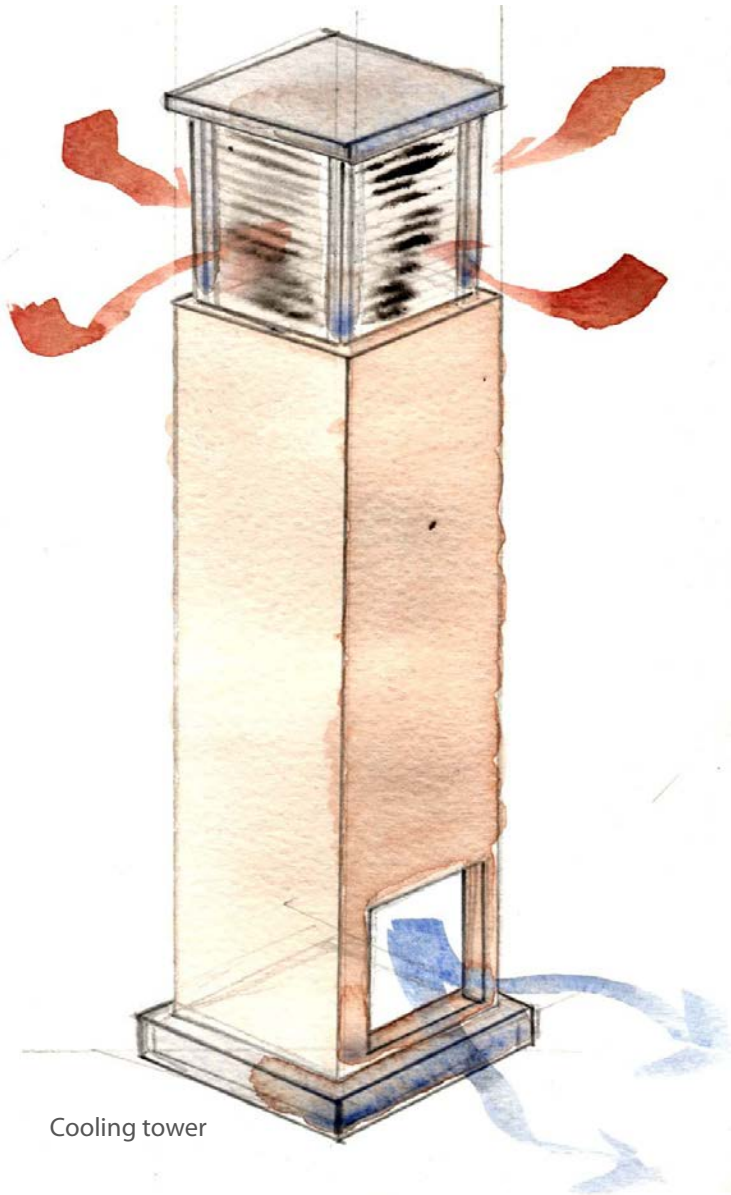
water

Wind

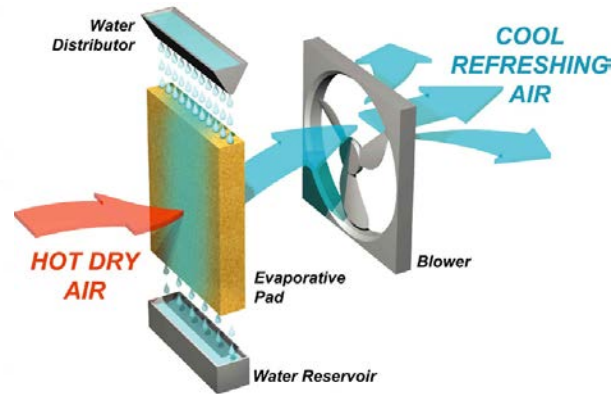


Understanding the orientation of prevailing winds on a particular site can offer critical information pertaining to architectural design. **Regarding climate responsive design, the prevailing winds of a given site can provide opportunity for a passive means of cooling of space through cross-ventilation and evaporative cooling.** Cross-ventilation relies on the ratio of input openings to output area. It is ideal for input apertures to be in line with prevailing winds for maximum cooling. The inclusion of a source of water in line with cross-ventilation allows for evaporation to assist in cooling a space. Evaporative cooling is a process where evaporation puts more moisture into the air, thus cooling a breeze as it travels over a body of water. It is the process of trading sensible heat for latent heat. The evaporation rate of heat transfer depends the amount of humidity in the air and the temperature; this is why a person will perspire more in a hot-humid climate than they will in a hot-arid climate. Perspiration is the body's way of cooling itself and there is a lesson to learn from our own adaptive nature. In order for evaporative cooling to function properly, there needs to be an incorporation of ponds or water tables on site if there is not any already. To make this process work requires a conscious consideration of massing walls, glazing, and operable fixtures. **Evaporative cooling uses less energy than conventional means of cooling, and is generally a cheaper alternative.** The problem with evaporative cooling in a hot-arid climate is that bodies of water are typically scarce and prevailing winds are not given the opportunity to cool. This is the same concern for evaporative cooling towers in hot-arid climates as they need a water source to function. However, if the proper amount of water is provided, cooling towers can be an efficient and architecturally cool way to respond to a climate. Evaporative cooling by means of cross-ventilation is best used in hot-humid climates that are equatorial, where there is minimal temperature change seasonally and bodies of water can cool prevailing winds. Evaporative cooling towers in hot-humid climates have generally produced welcomed results and work best in open space plans which allow the air to circulate freely.

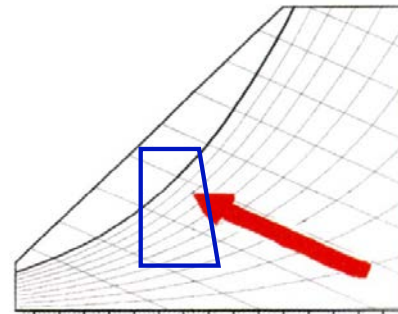
Evaporative Cooling



Cooling tower



Cooler pads generally made of a wood by-product placed inside a containment net. The wood absorbs water, cooling the passing air.



Evaporative cooling as a psychrometric process

S t r e t t o H o u s e

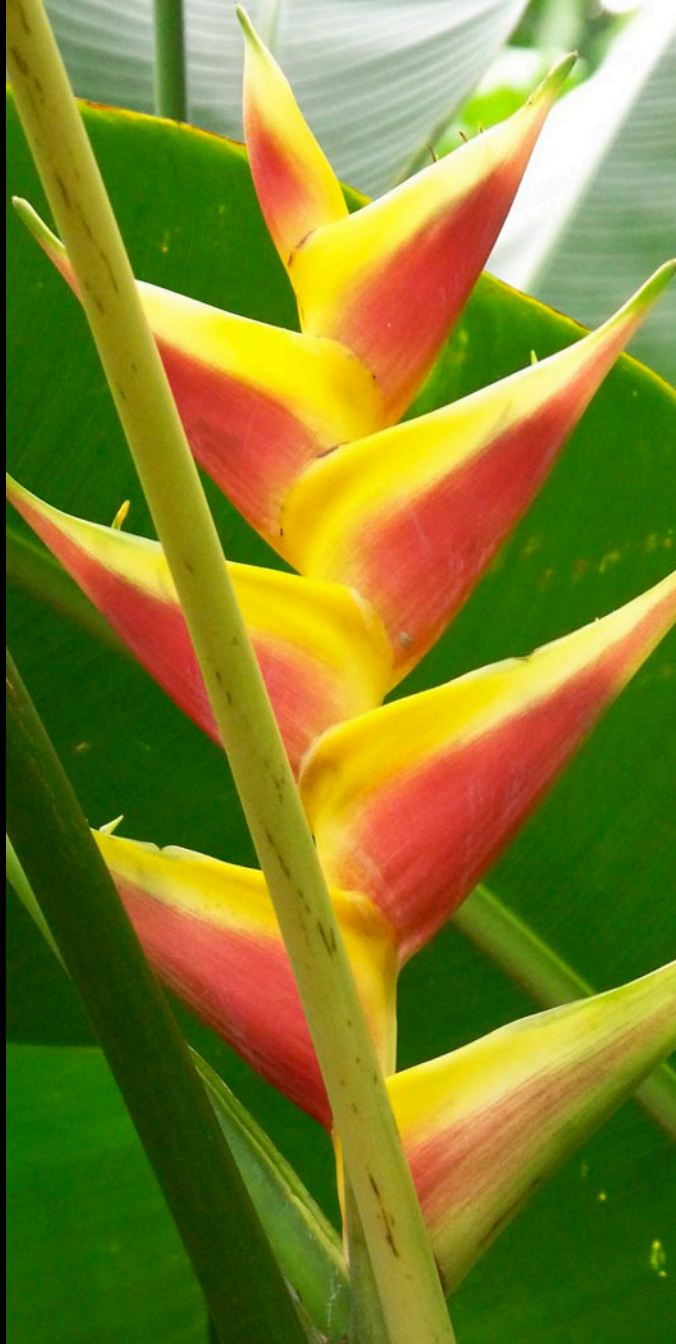


The Stretto House, designed by Steven Holl for the hot-arid region of Texas, is situated on a site that sits adjacent to three ponds with dams. It was the architects intention to embody the project with the same spatial series as the dams leading to a result of, "spatial dams," which allows cooled air, collected by breezes skimming over the bodies of water, to flow between the configured bays cooling the space.



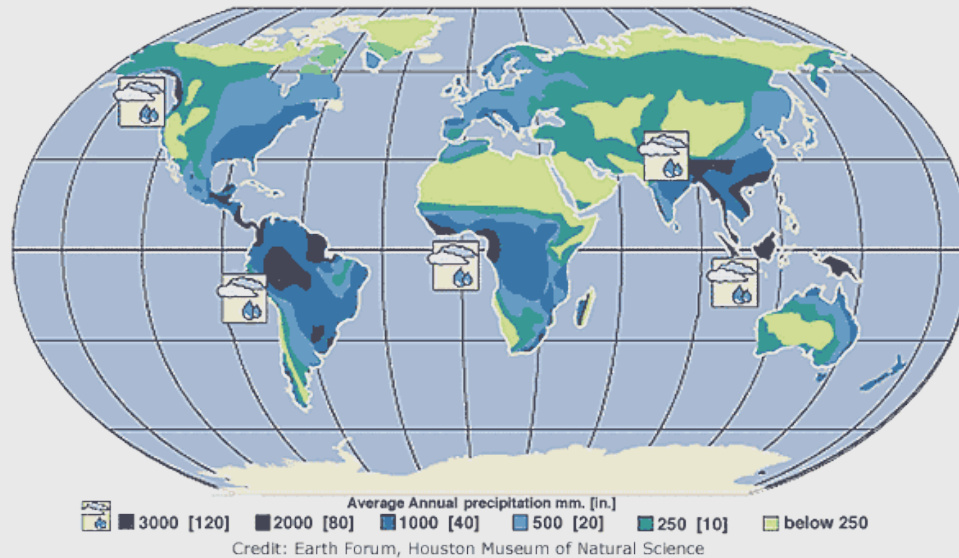
water

Water



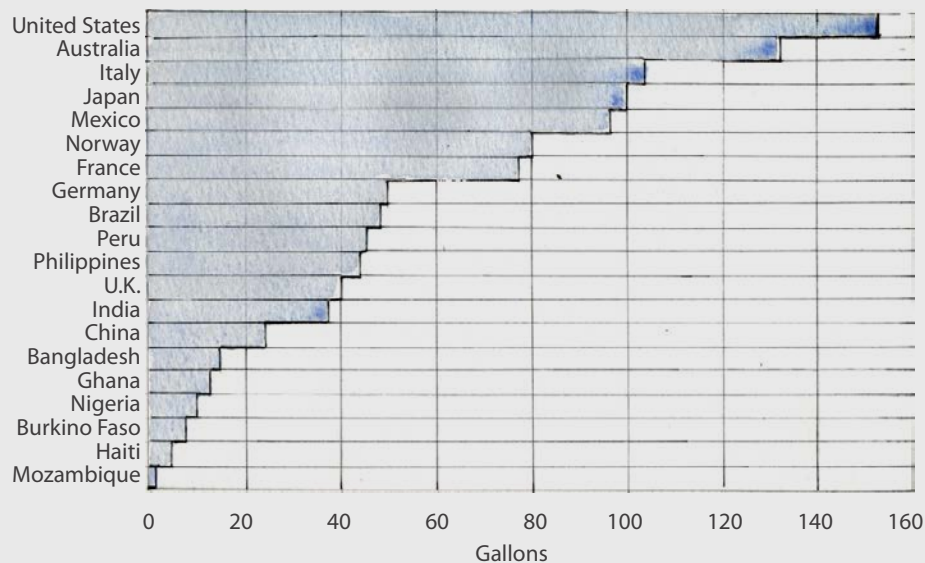
Where possible, conservation of any resource within a building should be common practice, as is the case with water. The collection of rainwater is a relatively simple process and the benefits include cost and resource efficiency. However, it must be understood that in certain regions, specifically hot-arid regions, annual precipitation amounts will not sustain all of the average buildings domestic water needs. In these environments, grey-water reclamation (wastewater collected from sinks, showers, clothes and dish washers, and bathtubs), is very beneficial. Grey-water can be treated and reused for landscaping needs diminishing the need for additional water. Collecting water for domestic use can be described in a six-step process: catchment, conveyance, purification, storage, distribution, and grey-water reclamation. **Catchment practices are the best insurance for areas where there are extended periods of drought.** Rainwater catchment typically occurs on the roof and is conveyed to storage cisterns or barrels. Water may travel through a bio-filter before reaching a cistern to remove unwanted debris and/or an active filtering purification system can pump untreated water from one cistern to another after purification. In climates where rainwater is collected for year-round use, larger cisterns will be needed; unfortunately these can sometimes be unattractive and distract from the aesthetic. One solution might be burying the cisterns underground or in a crawl space. Distribution methods can depend on technologies present. If solar panels are used then water can be pumped using the solar energy. The high specific heat of water makes it a good insulator and this is the fundamental idea behind roof ponds. Since water will remain at a lower temperature than the air, water contained on the roof will help keep the interior environment cool by filtering solar radiation. An alternate strategy, which works on the same principles, is the practice of roof sprays. This system uses sprinklers on the roof that emit water at specific times of day to offset direct solar radiation through evaporation. If using either of these systems, one must acknowledge the amount of water needed to achieve optimum cooling, additional structural needs and components for carrying and transferring water loads, and securing against water infiltration.

Precipitation



When addressing the element of water for climate responsive design, a logical and necessary step is to determine the amount of precipitation that a given site will receive throughout the year. It is also important to determine at what time of the year a specific region will receive most of its precipitation. By understanding the quality of the source of precipitation, one can begin to analyze the necessary design criteria needed for various functions of a structures performance. For instance, if the collection of rainwater is part of the design strategy in a hot-humid climate, the amount of annual precipitation can guide the designer to determining the size tank needed to store water for the year. If the design is for a hot-arid climate, a lack of precipitation may discourage the use of evaporative cooling. Knowing when, where, and how much it is going to rain at a given site is valuable knowledge for any design.

Average Water Usage Per Person Per Day

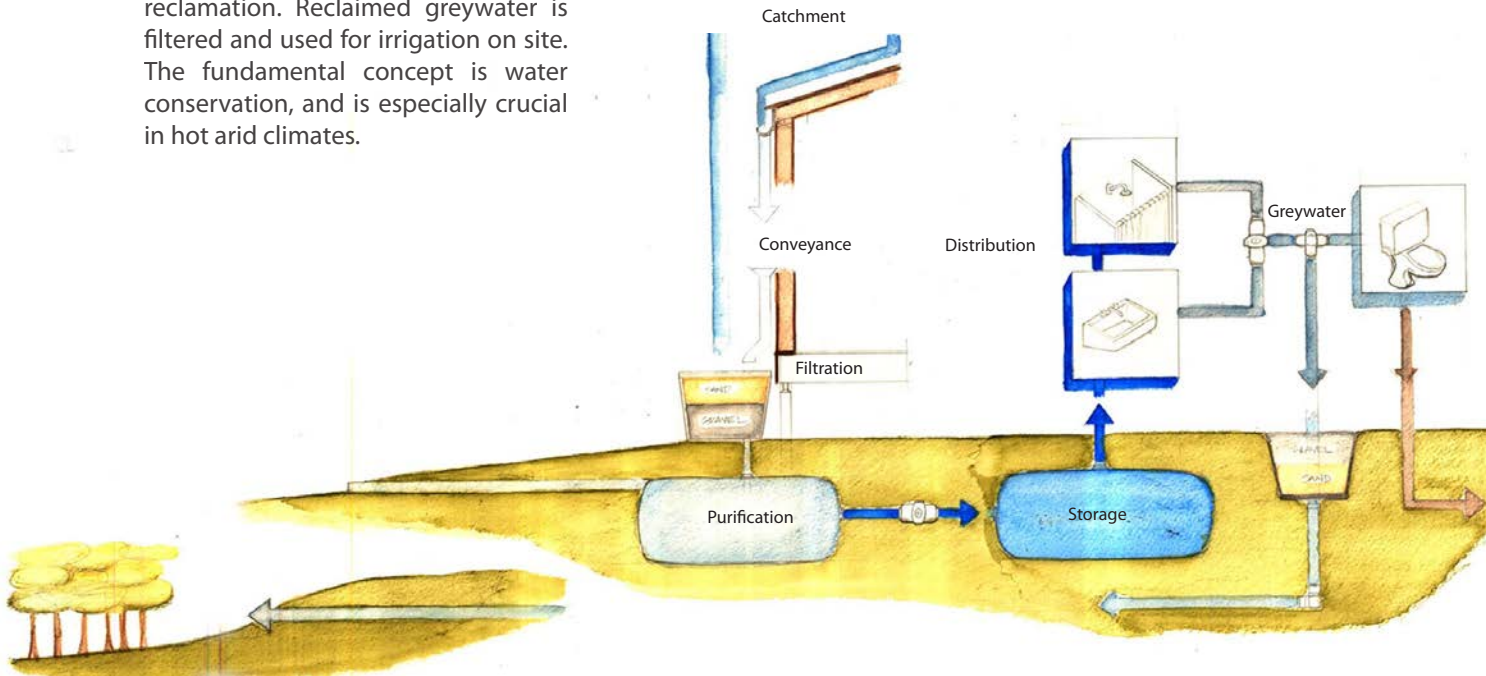


United Nations Development Program - Human Development Report 2006

Water usage for the average person in the United States, much like other natural resources, is consumed faster than in any other place in the world. Australia, where climates are similar to those found in the United States, is the second largest consumer of water. This data suggests that these two areas are prime for the encouragement of water conservation. Other areas of the world, such as China in far east Asia or Nigeria in western, equatorial Africa survive on a fractional amount of water usage compared to the U.S. or Australia. Though conditions could undoubtedly improve in China or Nigeria with the implementation of clean and efficient water harvesting, the general idea is that there are areas of the world with not enough water and other areas that use way too much. This text addresses the issue of collecting water where water is needed and saving of water where there is opportunity to do so.

R a i n w a t e r C o l l e c t i o n

This diagram illustrates the process for rainwater catchment. Starting with catchment, rainwater goes through a process of conveyance, filtration, purification, storage, distribution, and reclamation. Reclaimed greywater is filtered and used for irrigation on site. The fundamental concept is water conservation, and is especially crucial in hot arid climates.



Walla Womba Guest House

1+2 Architecture designed this house to respond to a hot-humid climate setting. Water collected on the curved roof is conveyed through the gutters to a sand and gravel pit, which removes excess debris. Water seeps to the bottom of the pit and stored in a cistern before being pumped, by solar power, through a purification filter and sent to a second cistern, which stores water until use.



water

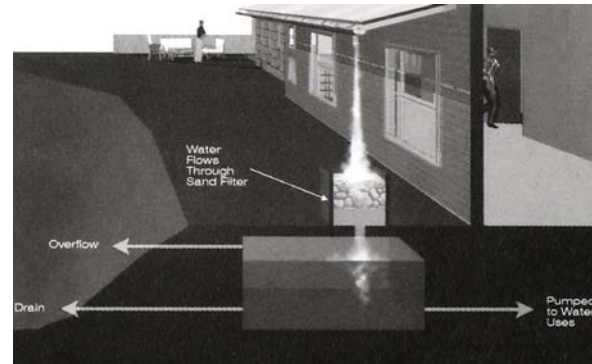
Biological



While water is a precious resource, it can also be a powerful force. Both hot-arid and hot-humid climates are susceptible to flooding; ranging from entirely monsoonal seasons to unexpected deluges. When these storms come, it can provide a vast amount of water that can be stored for extended use, but can also lead to problems with run-off and flooding. Groundwater run-off can have a dynamic effect on site. The amount of rainfall along with the nature of the soil will determine how water interacts with the site conditions; the steeper the grade or harder the soil, water run-off increases and seepage decreases. The opposite is true of flat, soft surfaces. Understanding the character of water run-off on a particular site can influence the distribution of vegetation for landscape design. Flooding will always be a concern for any structure. It is important to determine, if living in a lowland valley, the likelihood of flooding on site and what can be done to prevent possible damage. The Bruny Island Guest House solves this issue by raising the house on steel and concrete pilings. This method not only protects against flooding but also allows the structure to exist lightly on the land, limiting the impact it has on the site. The same is true for the Cocoon house designed by Paul Rudolph and Ralph Twitchell. The difference for this project is that it is built on an ocean channel inlet that is susceptible to sea surges. This house needed to be raised off the existing sea level datum if it were to successfully inhabit the site. In the area of landscape and water use, there are a few things to consider: in a hot-arid climate, planting vegetation that can survive on minimal water supply is optimal. If one plans to use collected water for irrigation of landscape, having a lush green lawn in a hot-arid environment is not feasible. However, if additional water for irrigating small gardens on site is needed, as used in the Lagos Guest House in Nigeria, a simple solution that can be implemented in nearly every climate zone is the use of rain barrels that are fed water from the gutter system. The untreated water can be removed of debris by a simple sand and gravel bio-filter, and though the water is not potable, it is fine for landscaping needs.

B i o f i l t r a t i o n

Biofiltration is a technique using natural and organic materials to filter out collected debris in water. Biofilters can also be used as ground surfaces which capture unwanted elements of run-off.

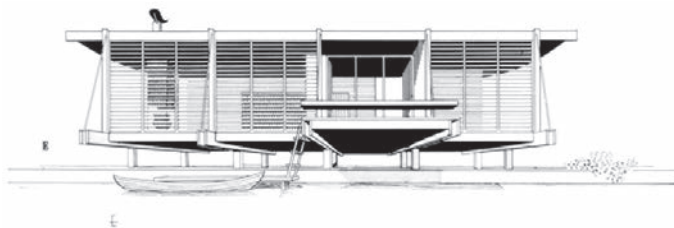


B i o s w a l e s

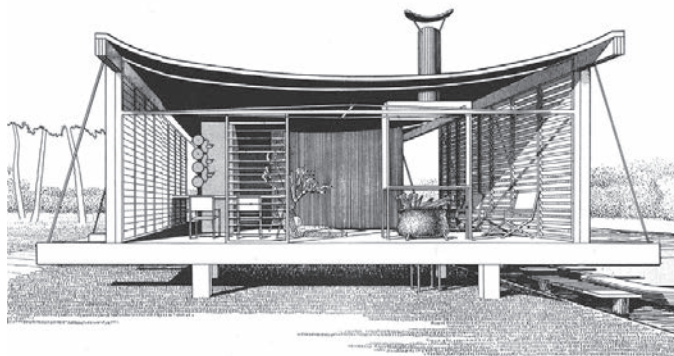
The issue of storm water run-off can be treated by use of bioswales. Bioswales function as micro-treatment systems that capture and hold water for a short period of time. After storm water is treated it can be handled in a couple different ways. The water can infiltrate the soil, flow to a bio-retention area or pond, sent to storm sewers or receiving waters.

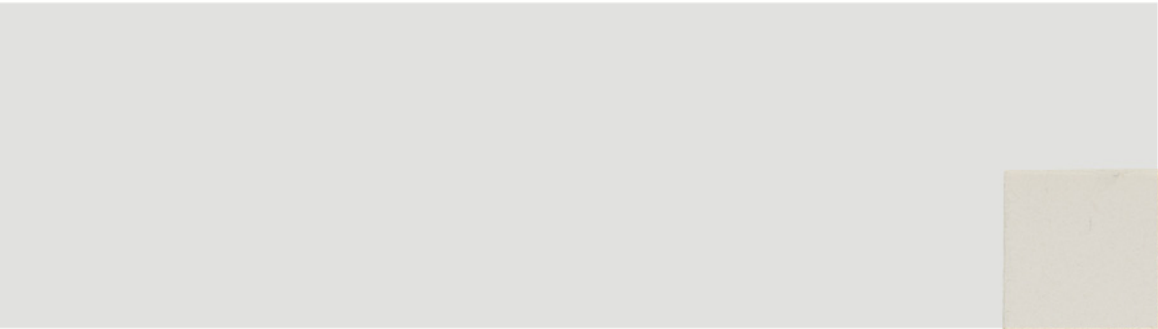


C o c o o n H o u s e



Paul Rudolph and Ralph Twitchell's Healy Guest House, also referred to as the Cocoon House, is located at the edge of a river estuary adjacent to the ocean. The raked concrete slab floor promotes ventilation as it cantilevers over the water's edge. Rudolph states that he wanted to "use the least material and make it as light as possible."

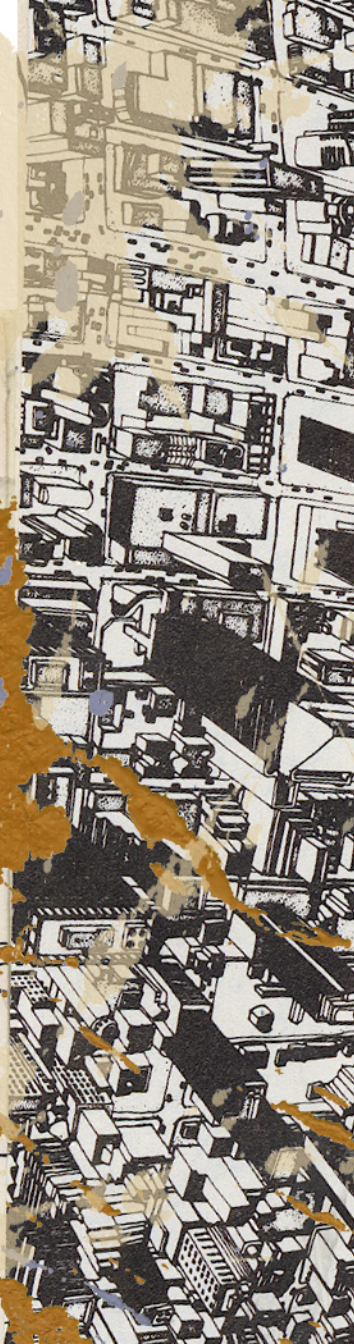




JOURNAL SEPTEMBER

1974

MATERIALS



“The materials of wealth are in the earth, in the seas, and in their natural and unaided productions.”

-Daniel Webster

Materials are the means by which architecture is realized, thus fulfilling their role as the concrete representation of design.

They form one of the five layers of design elements that are manipulated to achieve climate responsive architecture.

In order to understand the significance of materials to design, one must analyze their purpose in relation to ideology, strategy, and protection. With respect to ideology, materials play a vital role in articulating the intent behind the design and expressing the architect's ideas. It is utilized to strategically achieve the overall goal of the structure, for example, to design a building that needs no electricity. It distinguishes the interior and exterior boundaries of a structure, containing the space inside while repelling unwanted elements outside. As the physical layer that determines what penetrates the structure and what does not, materials essentially reject unwanted elements while trapping those that are wanted. When selecting the proper material for a design, one must look at the solar, wind, water, and biological conditions of the site. Rays from the sun are manipulated to provide light in the structure, but not heat. Wind is controlled to move air through a building while filtering out anything that travels along with it. Water does not permeate completely through material, but instead is trapped for cooling efforts or later usage. Cultural and social aspects include utilizing local materials and cutting down in importation; this decreases wasted energy and ultimately cost. Using local materials to speak to the vernacular is a design tool that helps incorporate the building into the community. Three projects will be referred to in this section to provide examples of how to use material to achieve climate responsive design: Ann Haringer's Hand Made School located in Bangladesh, Paul Rudolph's Healey Guest House in Florida, and the Casa Kike in Costa Rica designed by Gianni Botsford Architects. Casa Kike is located within one mile of the Caribbean Sea in a hot-humid, tropical climate. Local materials, such as corrugated metal and Cacha wood, are utilized in a native manner to achieve proper ventilation. The Hand Made School is composed of several materials found within or close to the site that use moisture and wind to cool the interior. The Healey Guest House uses traditional Native American building methods to provide natural cooling in the hot-humid environment.

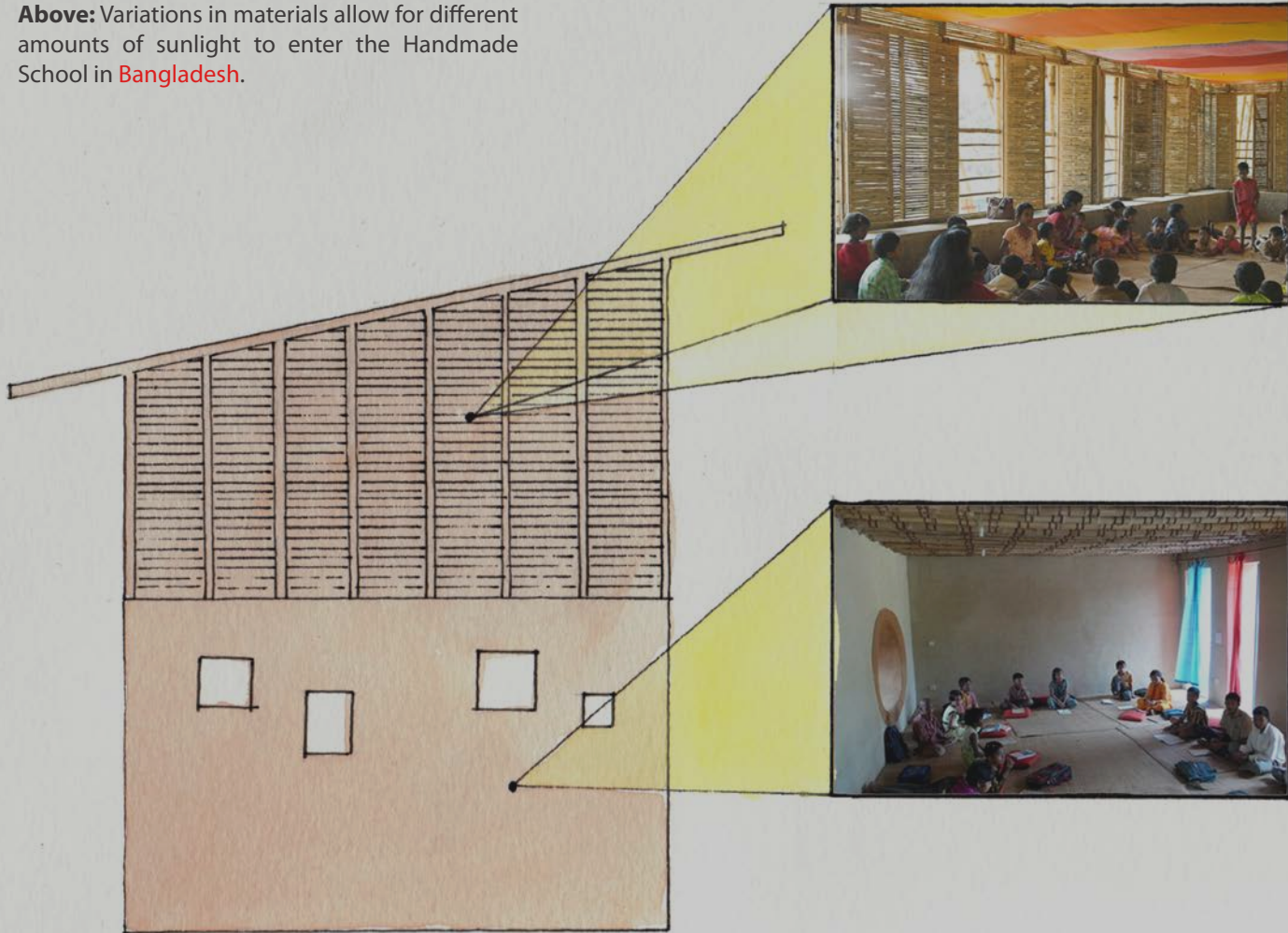
materials

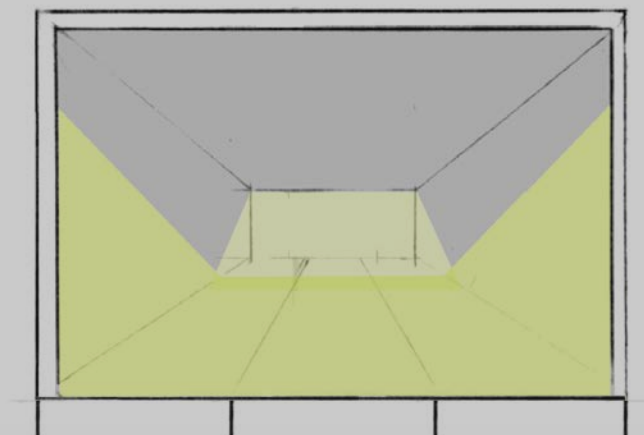
Solar



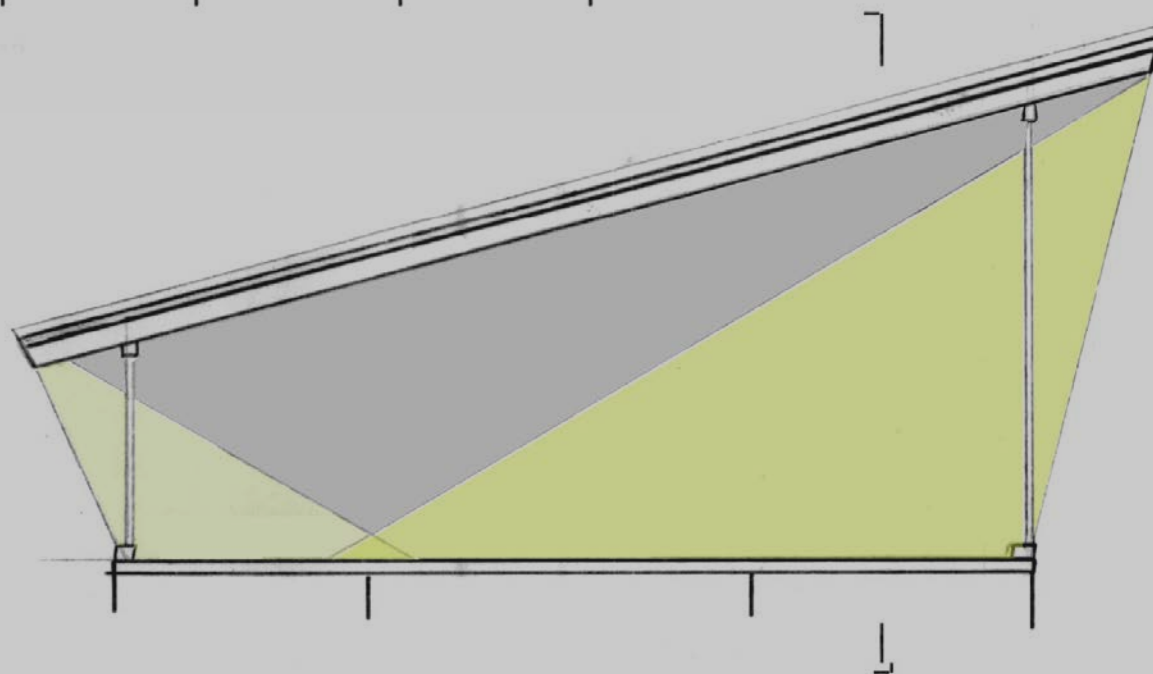
When considering how materials are to be used in any given design scenario, solar factors should be taken into account in order to determine the spatial, aesthetic, and thermal qualities of a structure. Several facets of solar phenomena that should be considered in material selection include sun shading, heat gain, thermal protection, day lighting, solar radiation, energy production, and solar orientation. Each of these factors plays a part in how the designer develops the character and visual qualities of a structure. For example, when designing in a climate zone with a low amount of sky cover and a high amount of direct sunlight, opaque or translucent materials with low thermal transmission would be appropriate in order to reduce heat gain and maximize the amount of shade and passive cooling provided by the structure. The Science Block at the University of Lagos, Nigeria utilizes these strategies by enveloping the facade with vertical and horizontal shading devices and using wood and concrete to minimize heat transfer. Contrarily, when approached with designing in a climate zone that does not provide a large amount of natural heat gain, solar radiation, or direct sunlight, it is more appropriate to build using materials that maximize passive heating strategies and allow sunlight to penetrate the building envelope for interior lighting and heating. Glenn Mercurt designed the Magney House with a thick concrete floor that acts as a thermal mass to absorb heat during the winter months. During the day, the concrete absorbs the winter sun and releases it slowly into the house at night as the exterior temperature drops. As you can see, materials are critical in determining how uncontrollable external factors, such as solar qualities, affect the character of the space provided by the structure. Furthermore, materials are the key to design strategies that deal with solar factors, and these materials regulate how the natural characteristics of a particular climate zone are transferred into the interior environment of a structure. Overall, when considering solar design strategies in various climate zones, do not underestimate the layer of articulation and amount of control that materials can provide for your design.

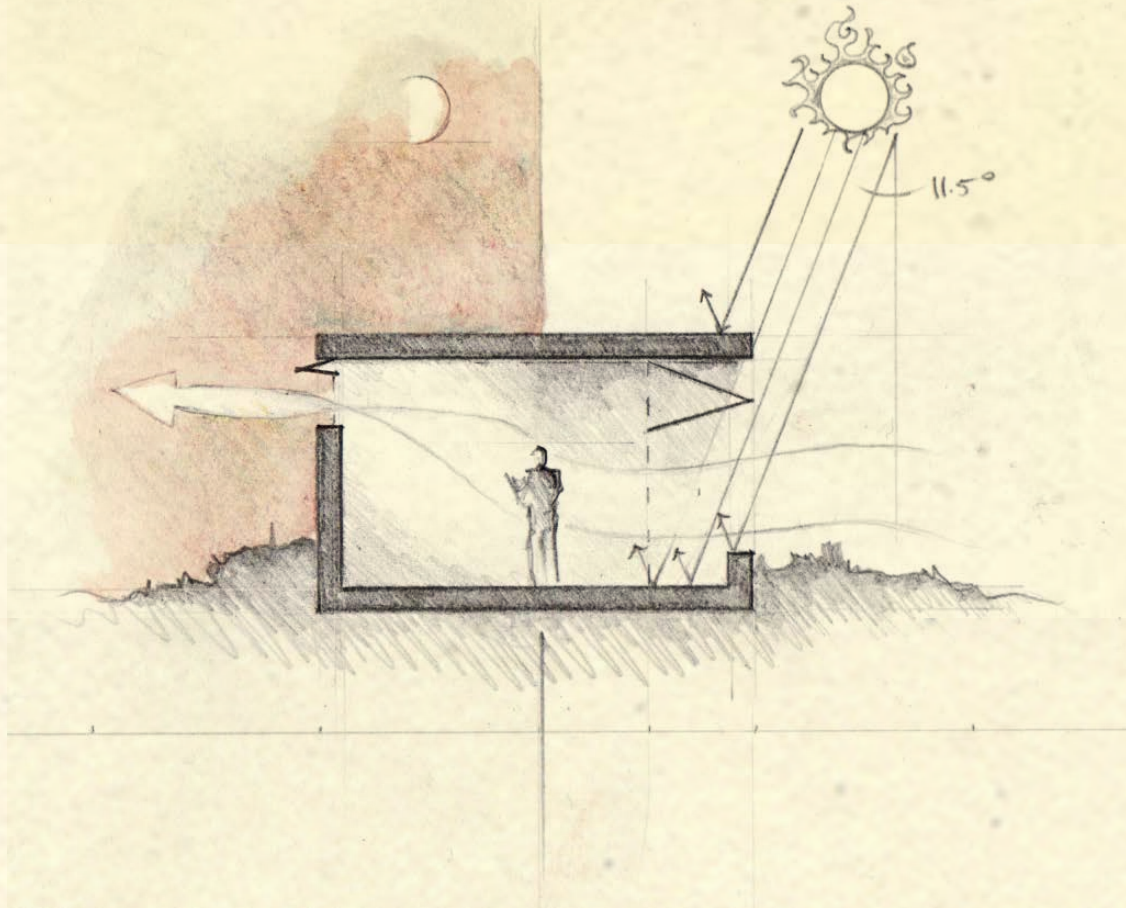
Above: Variations in materials allow for different amounts of sunlight to enter the Handmade School in **Bangladesh**.



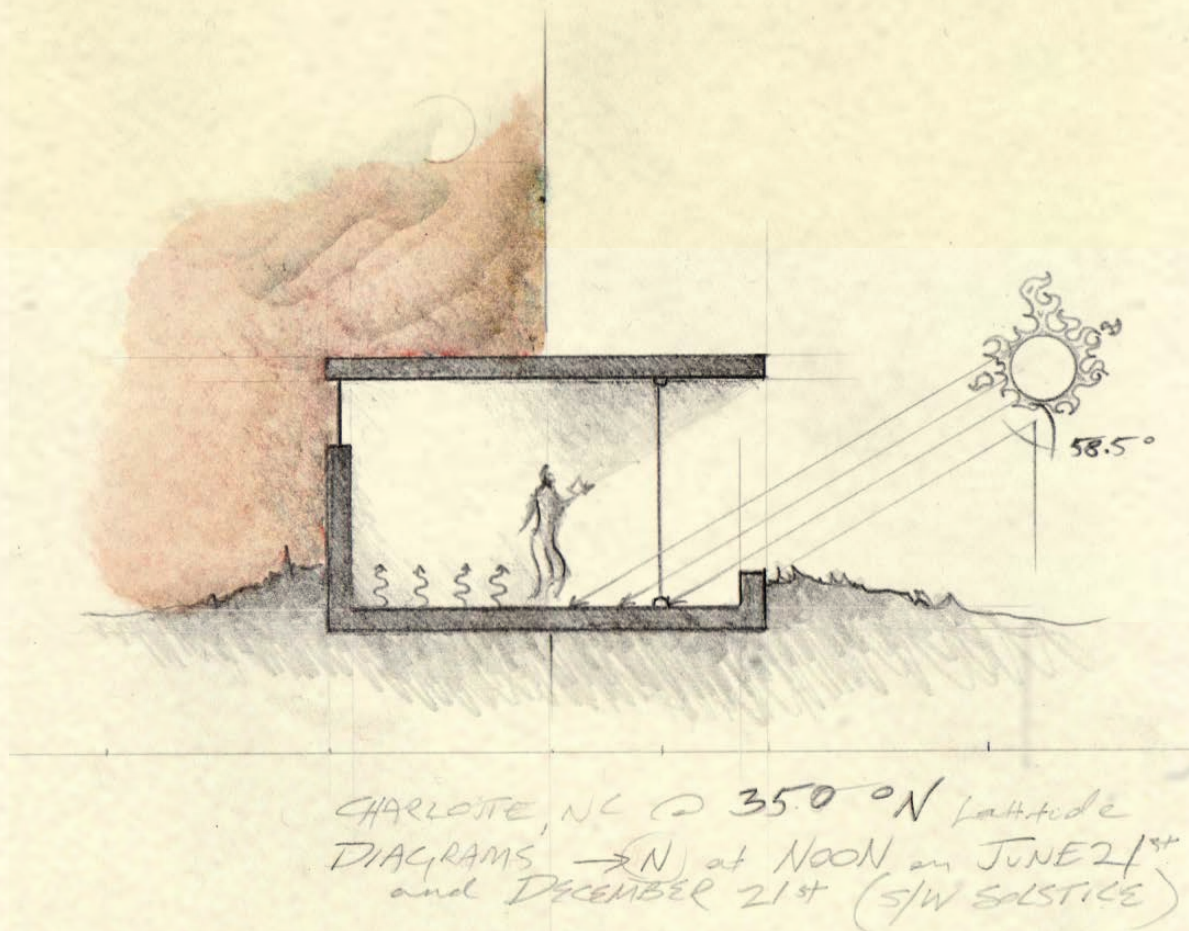


The east/ west orientation of the Casa Kike takes advantage of the Costa Rican Sunlight early in the morning and later in the evening while protecting the interior from the harsh midday sun. The opaque outer shell, consisting of wood and corrugated metal (shown in the lower section), protects the interior from direct rays and heat.



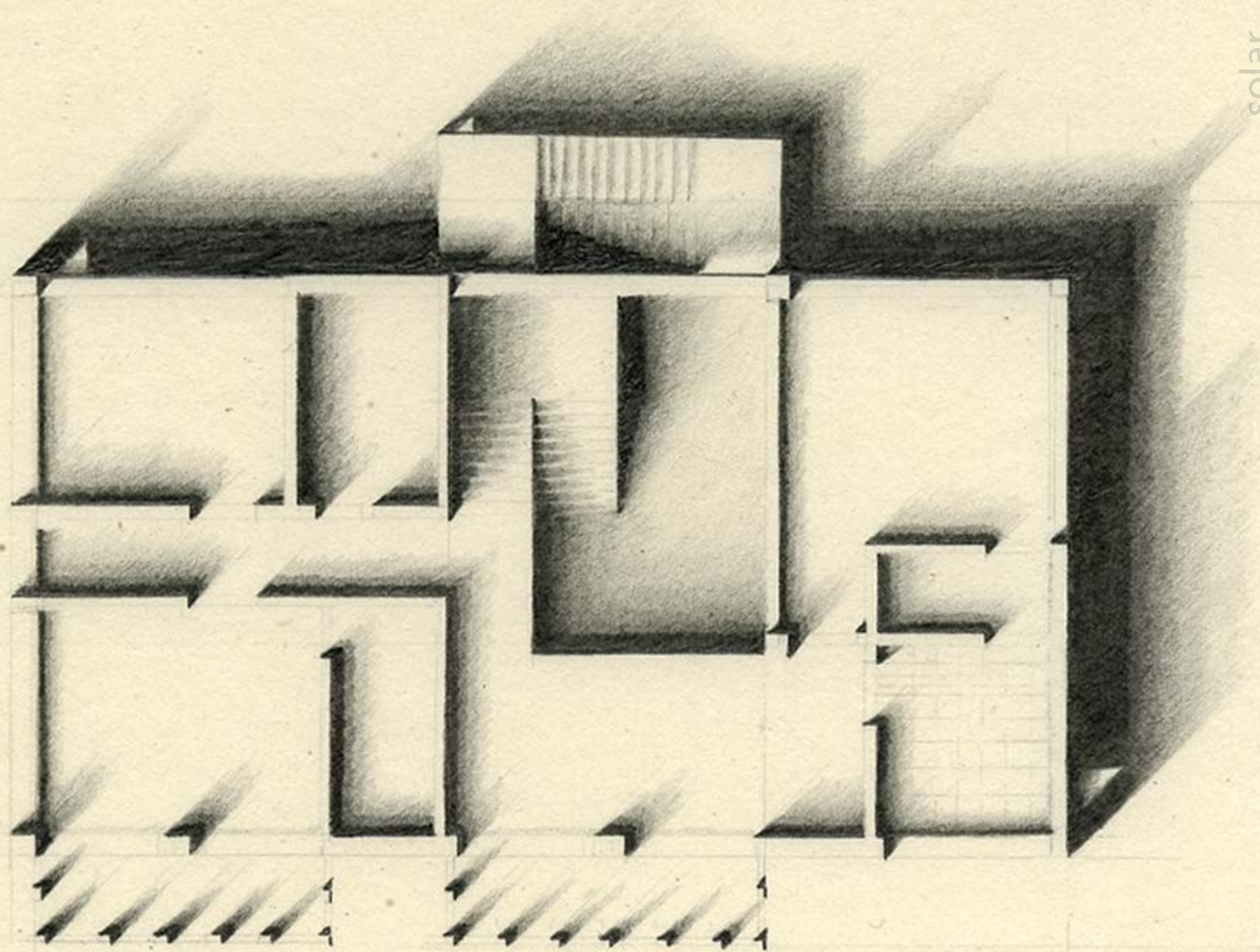


Summer sun is deflected by overhangs and ventilation is induced through openings during the summer in Charlotte, NC.



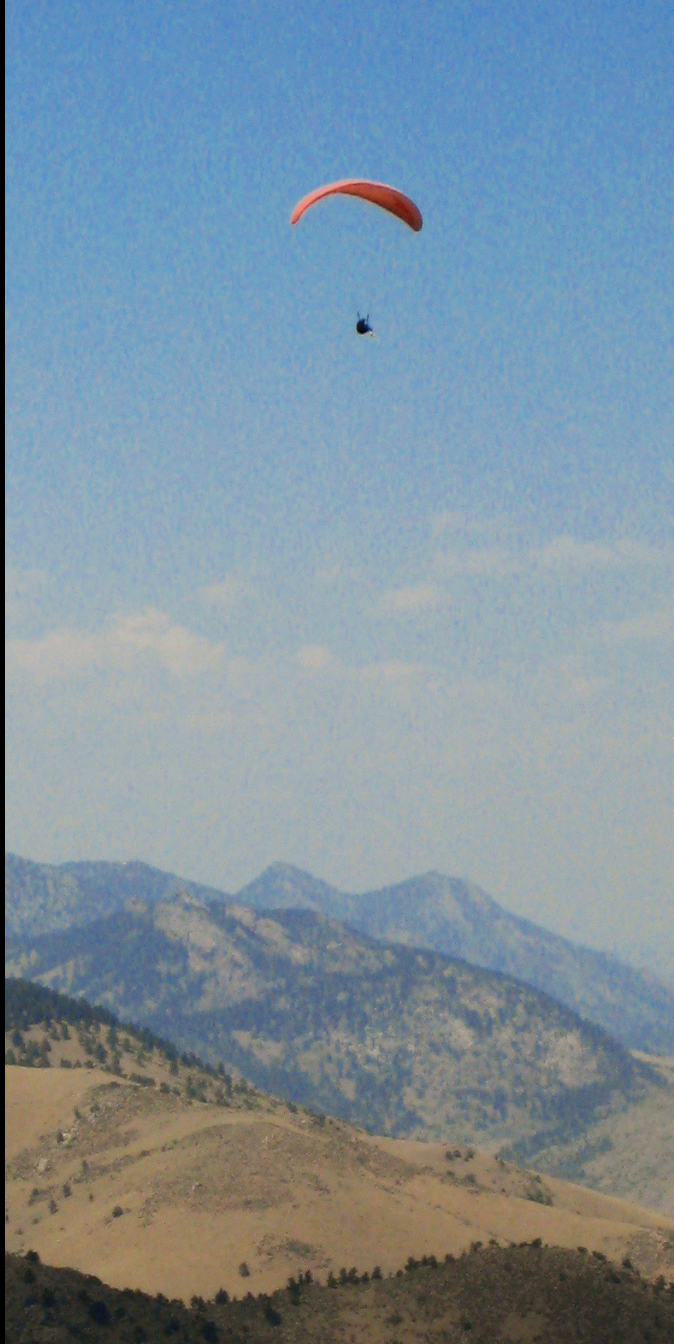
During **winter** months, radiation from the sun is absorbed by a thick concrete slab, which acts as a thermal mass releasing the heat during the cold nights.

Apartamento residencial
Multi-family High Rise
Costa Verde, Lima - Peru

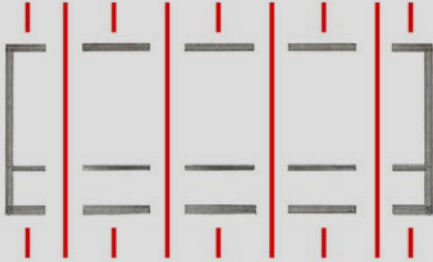


materials

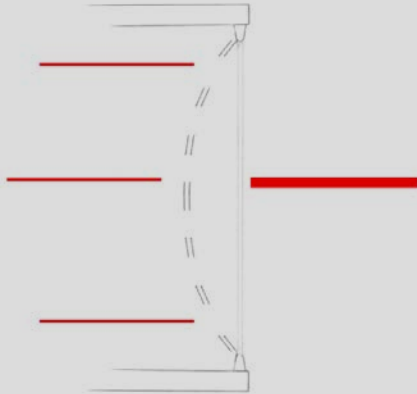
Wind



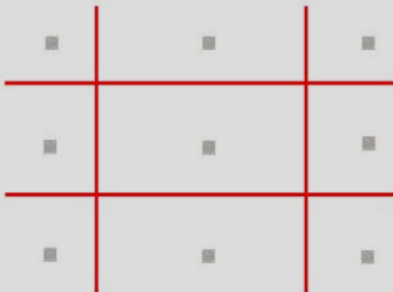
When discussing materials with respect to wind, the main issues that must be addressed concern ventilation. If situated in a hot-arid or hot-humid climate, it is important that the building has the ability to breathe on its own. Once the structure is strategically oriented on the site and apertures are established (windows, doors, etc.), choosing the proper material is next to promote ventilation. Materials of different permeability and density are used to accomplish various tasks. There are three levels of permeable material that accomplish the same goal in different manners. An impenetrable material is used to guide wind through a building in order to circulate the air. For example, the Casa Kike utilizes a hard opaque shell around three surfaces of the structure to direct wind and air flow through the home in a linear manner. The intentions behind the design are to take advantage of the natural wind patterns and to avoid the presence of any meandering or stagnant air by using a simple, enclosed volume. A more permeable material, such as screen or cloth, is used to diffuse wind into the interior of a structure. This system is used in areas where temperatures are cooler during the night or during certain seasons, but hot and humid throughout most of the year. The Healy Guest House, designed by Paul Rudolph, implements a canvas roof and tent-like structure to create a semi-opaque spatial environment. Though air does flow freely through the roof layer, warm air is able to gradually escape while the cooler air stays in the lower region of space. Screens around the vertical surfaces are also used to filter out debris, insects, etc. out of the building. A third system that is used to provide natural ventilation within a building is one of columns with a shade-producing canopy or roof. In the case of the Man Made School in Bangladesh, bamboo columns are utilized in the upper classroom layer to open the space while providing protection from the sun's rays. By opening the room to the environment, occupants will experience natural ventilation while staying cool in the shade. Material selection to enhance ventilation is guided by the climate and the intentions of the building. All materials are categorized under the one or more of the three types mentioned in this section. By using this method of classification, the architect or designer is able to clearly decide what system would work best in the design.



Strategic alignment of fenestration is necessary in order to achieve proper **cross-ventilation** when using solid materials.



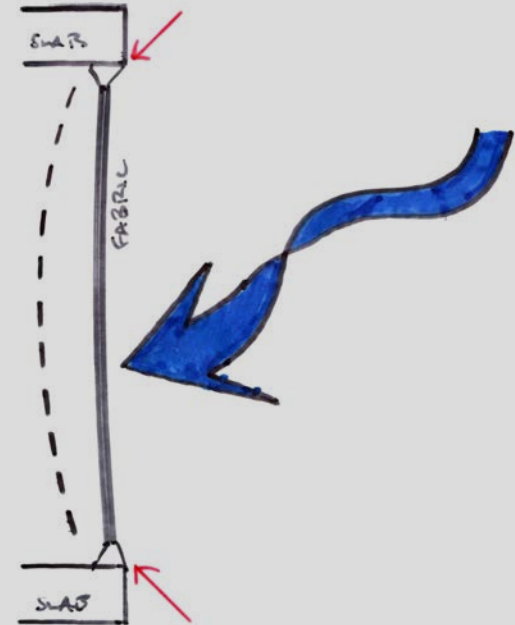
A semi-permeable material allows for **air** circulation during the day and diffuses cool **air** to the interior at night.



A permeable system to provide **ventilation** is depicted in the diagram to the left. The use of columns and lack of infill completely exposes the interior to the elements outside. This strategy is useful in hot-arid climates. Shade provided by the roof canopy cools the covered area while eliminating any thermal mass that would be provided by enclosing walls.

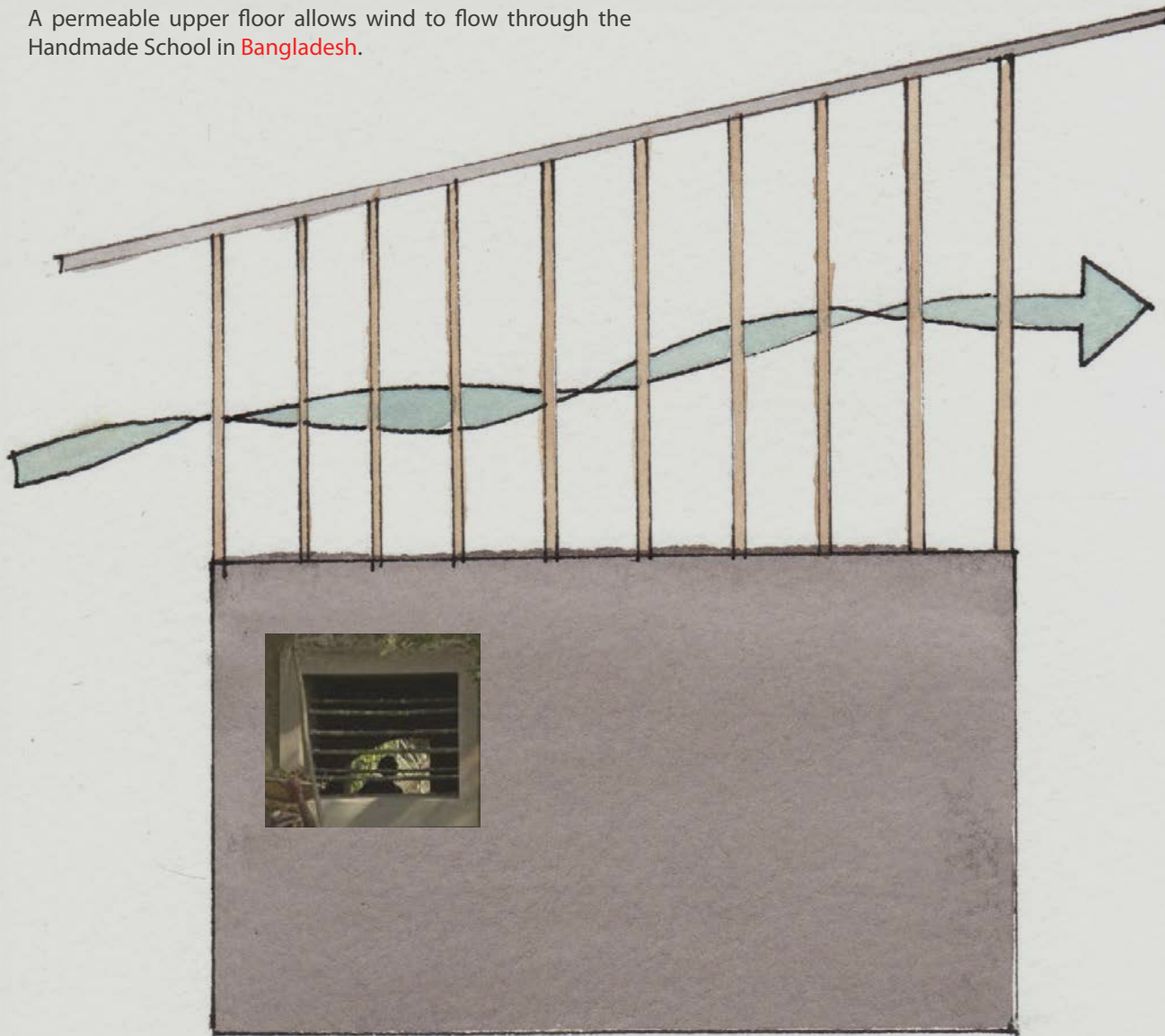


Casa Kike in Costa Rica manipulates its **windows** to act as thin louvers on the east and west facing facades. The essence of these louvers can be either permeable or impermeable.



The Healy Guest House in Tampa, Florida uses a canvas envelope, a semipermeable membrane that catches wind stress, to protect the interior from direct sunlight and heat gain.

A permeable upper floor allows wind to flow through the Handmade School in [Bangladesh](#).





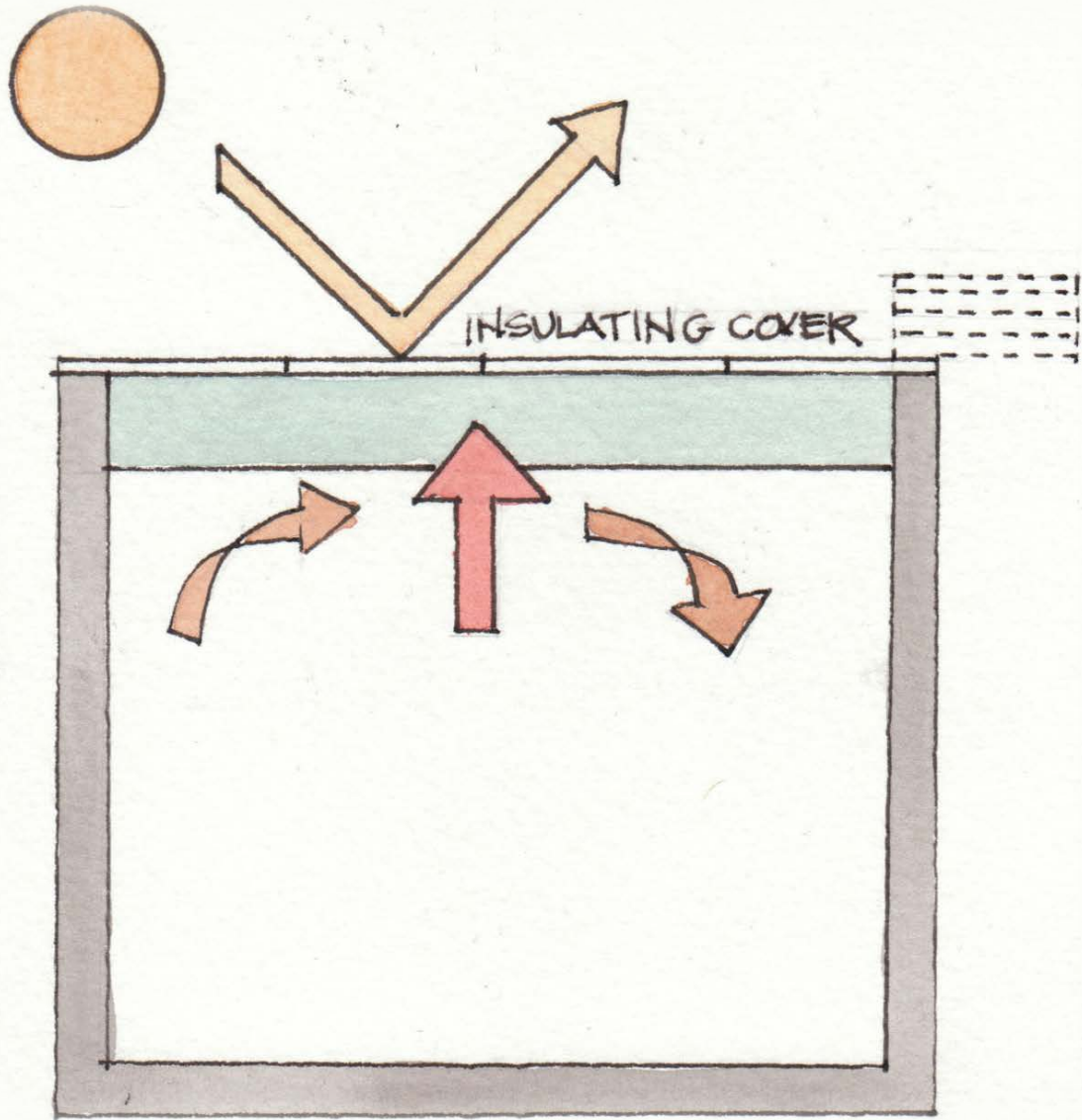
materials

Water

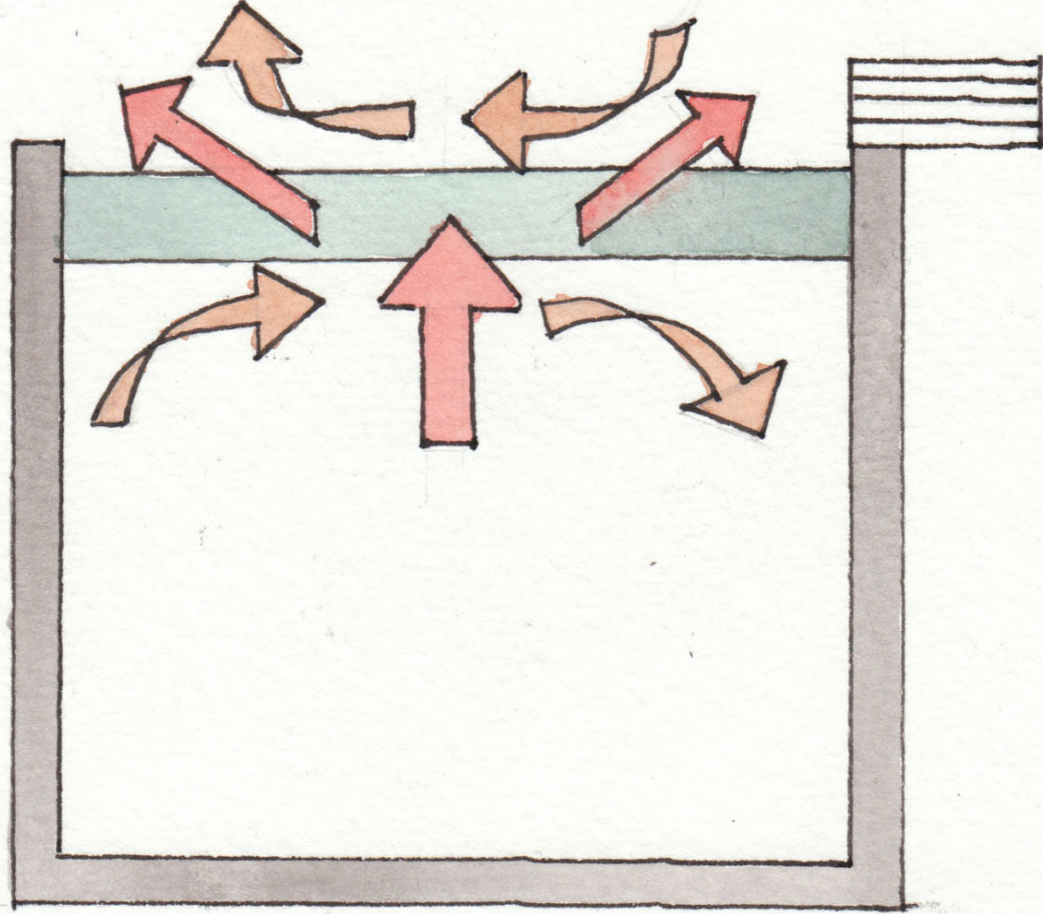


Material choice for a project can either change, enhance, or negate climatic effects. Appropriate material selection for the structural membrane is crucial to protect the from excessive moisture in humid climates; whereas, In an arid climate, water collection is desired. The water collected could be recycled for reuse by the building or stored to use for cooling purposes. When considering the issue of water in a given climate, in either a humid or arid climate, materials are selected for their impermeability. Roof ponds are a very effective means of passively cooling a building. A roof pond employs a flat roof with six to twelve inches of water that is commonly stored in plastic containers covered by glazing. Roof ponds are especially effective in hot, desert environments. An insulated cover is removed at night to expose the water to cool night air. The water will then absorb the heat from below during the day. At night, the heat radiates out into the space. (The concept is illustrated on the following pages). The Handmade School was designed to work with the wet conditions of the tropical-monsoon climate in Radrapur, Bangladesh. The heavy, earthen walls of the ground floor take advantage of the high groundwater level, relying on the walls to retain the cool temperature transferred from the damp ground. The school was constructed using traditional building materials and methods, drawn from the surrounding community. Given the area's tendency for monsoons, local residents were concerned because their own earthen-walled homes had been destroyed by recent flooding. Several material modifications were added to the design to protect the building while maintaining the local vernacular: a corrugated metal roof with a large overhang was added to shed water away from the building and protect the earthen walls from erosion, bamboo joints were connected by a steel pin and nylon lashing rather than jute alone for durability, and a damp-proof course and brick foundation were supplemented to protect the structure.

DAY COOLING



NIGHT COOLING

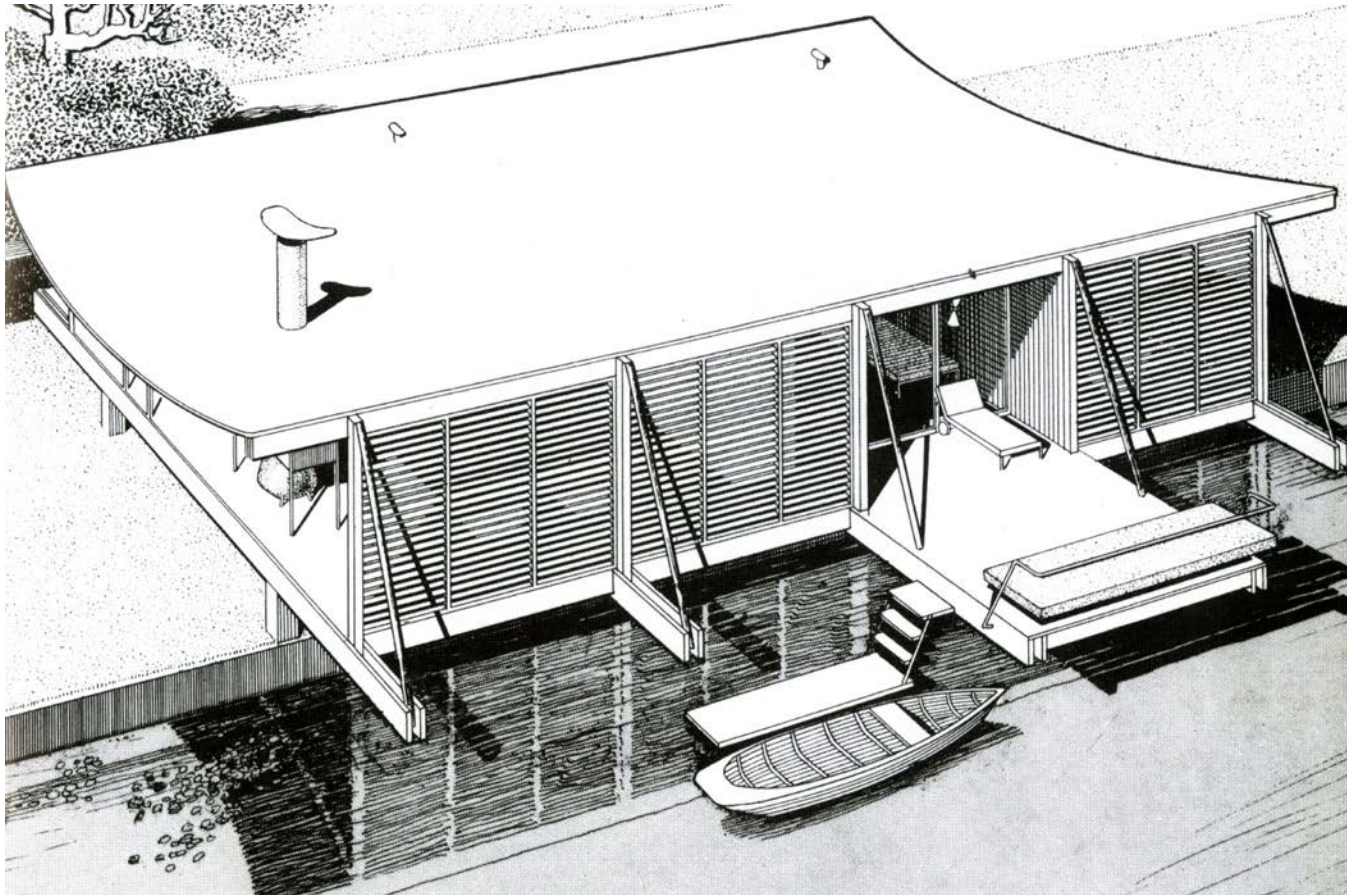


materials

Biological



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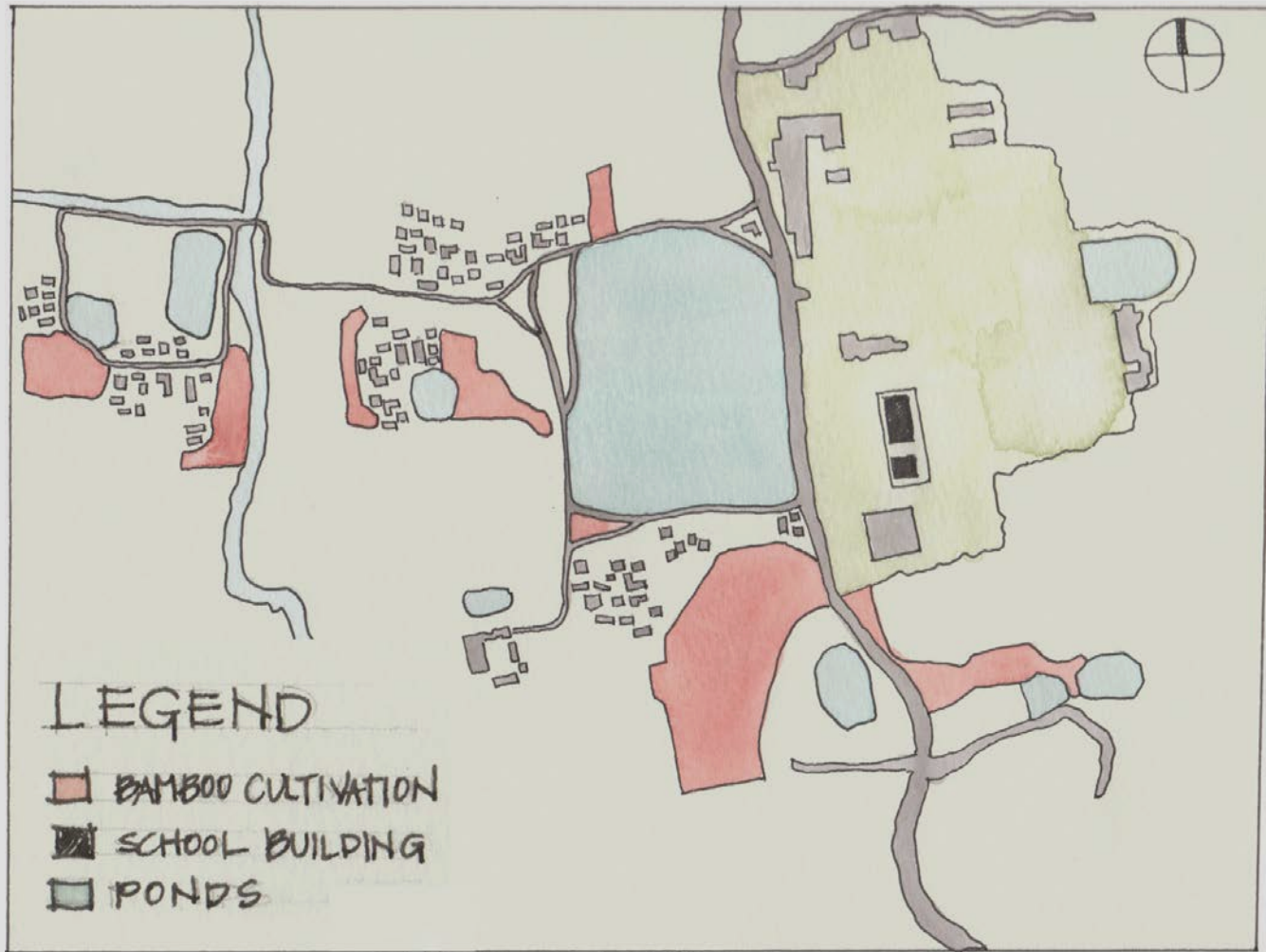
Paul Rudolph uses materials to create a uniquely rhythmic relationship between indoor and outdoor spatial experiences in the Healy Guest House.



Costa Rican residence, elevated above ground with metal roofing for water protection. Constructed using local Cacha wood, a very hard wood that is resistant to water damage.



The Casa Kike uses similar building strategies including an elevated floor plane, metal roofing, open interior space, operable windows, and is also constructed with Cacha wood.



The Handbuilt School was built using strictly local materials. This meso-site plan shows where the various locations the bamboo for the building was cultivated. Bamboo is a rapidly-renewable material abundant in [Bangladesh](#) so it has a very low environmental impact.



Traditional **Bangladeshi** jute hut, using local bamboo and a thatched roof.

JOURNAL/SEPTEMBER

ER 1974





INTERIOR ENVIRONMENT





The qualities of the built environment result from a state of equilibrium between inside and out that allows for manipulation of inherent characteristics. Interior quality is different from the other methods for creating a climate responsive architecture. It is not a tool used to manage the flow of energy or elemental flows. It is a result that is caused by all of the other techniques used, but it cannot be left as an unconsidered by-product. Each tool that is used to manipulate the natural environment affects the quality and characteristic of our lives. These impacts on the interior quality must be anticipated. We must ask ourselves not only how these systems connect us to our environment physically, but also psychologically and culturally. Through this we can determine how these systems begin to represent themselves in built form. On a broader scale the disregard of this connection has created the pull and tug between technology and tradition that is globalization. In looking across cultural boundaries, domestic and international, we must consider not only efficiency and economics, but also the impacts of architecture on culture and its potential dissolution of regional identity. This chapter will focus on how interior qualities are impacted at the building scale. It must be remembered that people are influenced by conditions that reach far beyond the building envelope and these conditions must be considered.

Photo : Colvard Building at UNC Charlotte

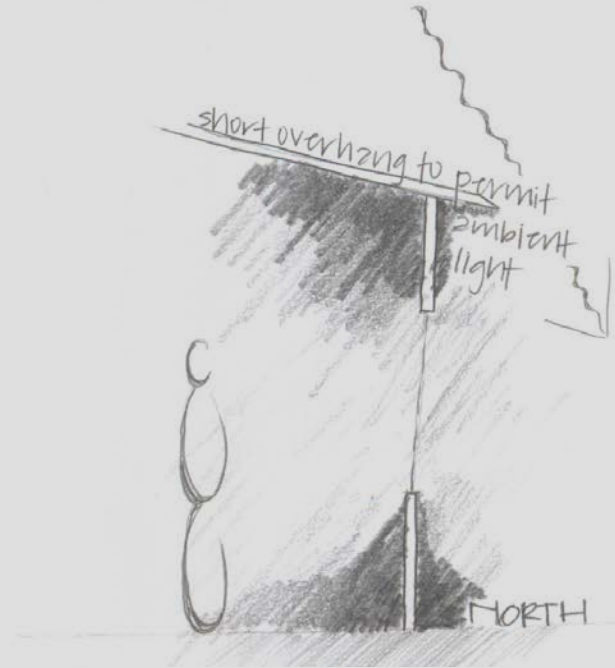
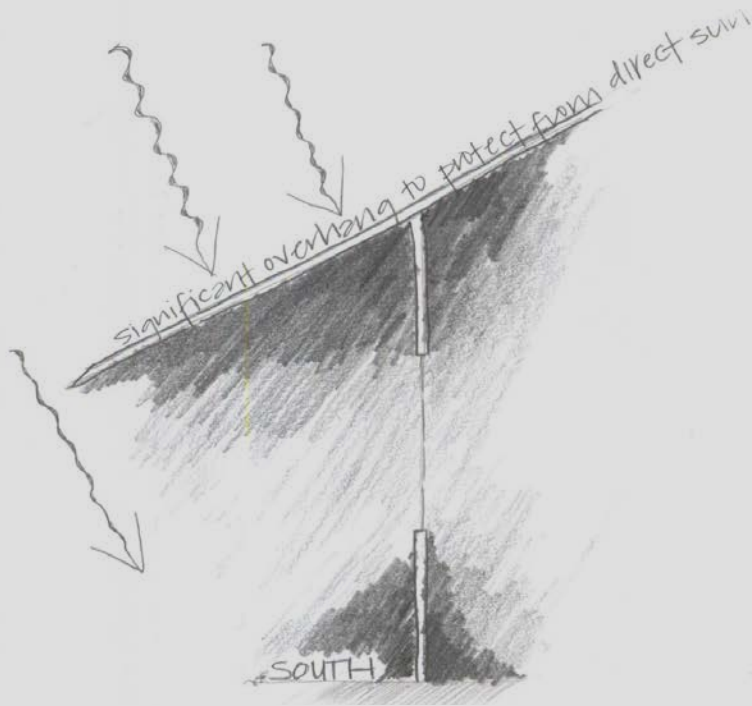
interior environment

Solar



The relationship of solar energy to interior qualities is based on the unique transformation of energy that is radically impacted by natural processes. Variations in this transfer of light to thermal energy creates radically different experiential qualities. Architecture has evolved in response to the conditions of light and heat created by this transfer. From its earliest beginnings architecture has been inspired by naturally occurring environments. The Indian civilization at Mesa Verde found refuge in cliffs which were shaded during the summer and in direct sun during the winter. Orientation, geometry, and site selection can be manipulated to create these environments when they are not naturally existing. Understanding how this transfer affects inhabitants is the key to effectively responding to the potential of solar energy. The human eye has evolved to handle the natural ranges of light. Optimal day lighting addresses the needs of the eyes for contrast, color quality, and the amount of light necessary for tasks. Architecture must also address the thermal needs of its inhabitants. Solar heat gain is effected by surface reflectance, insulation, material heat capacity, thermal lag, shading, and radiation levels. In order to use these technologies appropriately it is important to consider climatic conditions such as diurnal temperature swings, heating and cooling degree days, sky coverage, solar angle of incidence, and day length. In hot arid climates where diurnal temperature swings may be large, direct solar gain may be necessary for quick warm up in the morning. High thermal mass with a twelve hour temperature lag can absorb heat during the hot periods of the day allowing for nighttime release of heat. Hot humid climates generally have much narrower temperature ranges with nighttime temperatures above comfortable range. In this environment it is advantageous to avoid as much solar radiation absorption as possible. This is generally done by shading and envelope dimensions that reduce the amount of surface area in direct light. Cultural associations with light impact the way that architecture must respond to climate. The daily tasks that are performed need conditions suitable at the right time. Tasks completed in the morning may need to be located on the east facade for adequate lighting. Spiritual and emotional associations with color must be addressed. An example of cultural associations with the color black. Indo-European cultures tend to view black as depressing, evil, and a symbol of mourning; antonym of purity. African cultures tend to view black as being full of color, rich with emotion and life.

Photo : IIT Chicago, Illinois



Sun Exposure:

A significant overhang can protect from the sun's rays during hot summers and allow for an additional space to become comfortably occupied along the south facade. A short overhang along the north facade will allow ambient light.

Solar Gain Strategies:

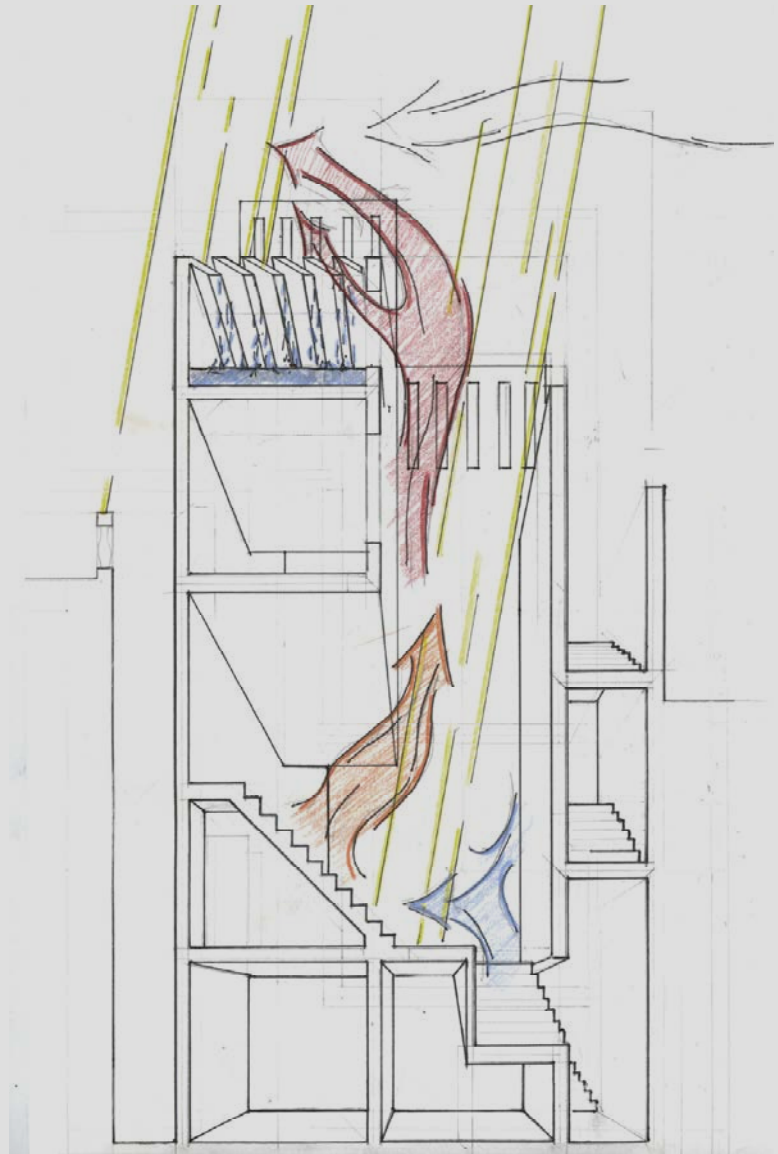
As sunlight warms the building during the day, excess heat is removed through the induced convection. Air moves across warm surfaces and rises from the building. Vertical shading devices reduce heat gain in enclosed areas.

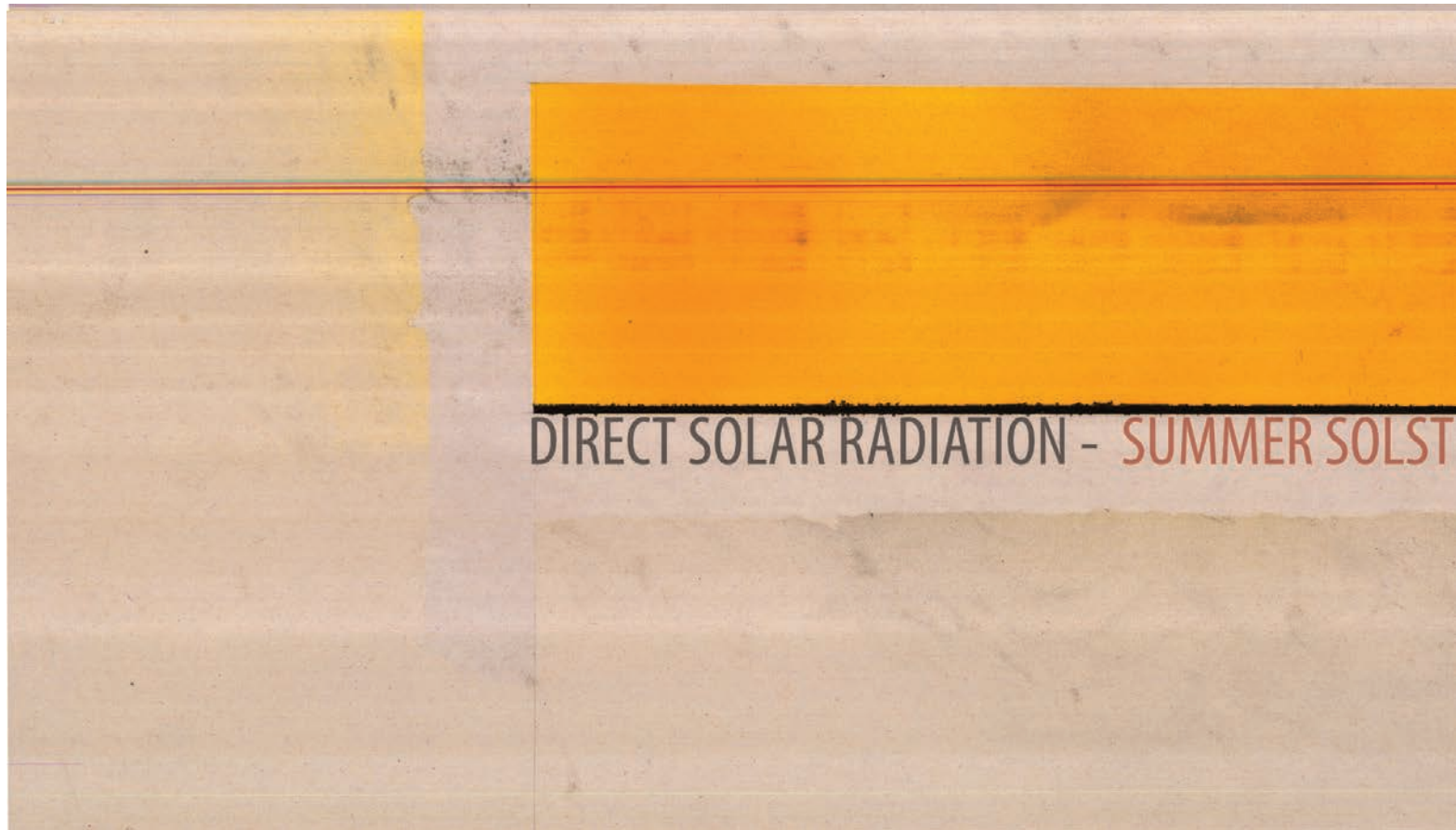
Stack Effect:

Overhead air currents can be used to help induce this stack effect by creating low pressure at exhaust vents and high pressure at intake vents. Sun light penetrates deeply into the building allowing light to reach the lower levels of the building.

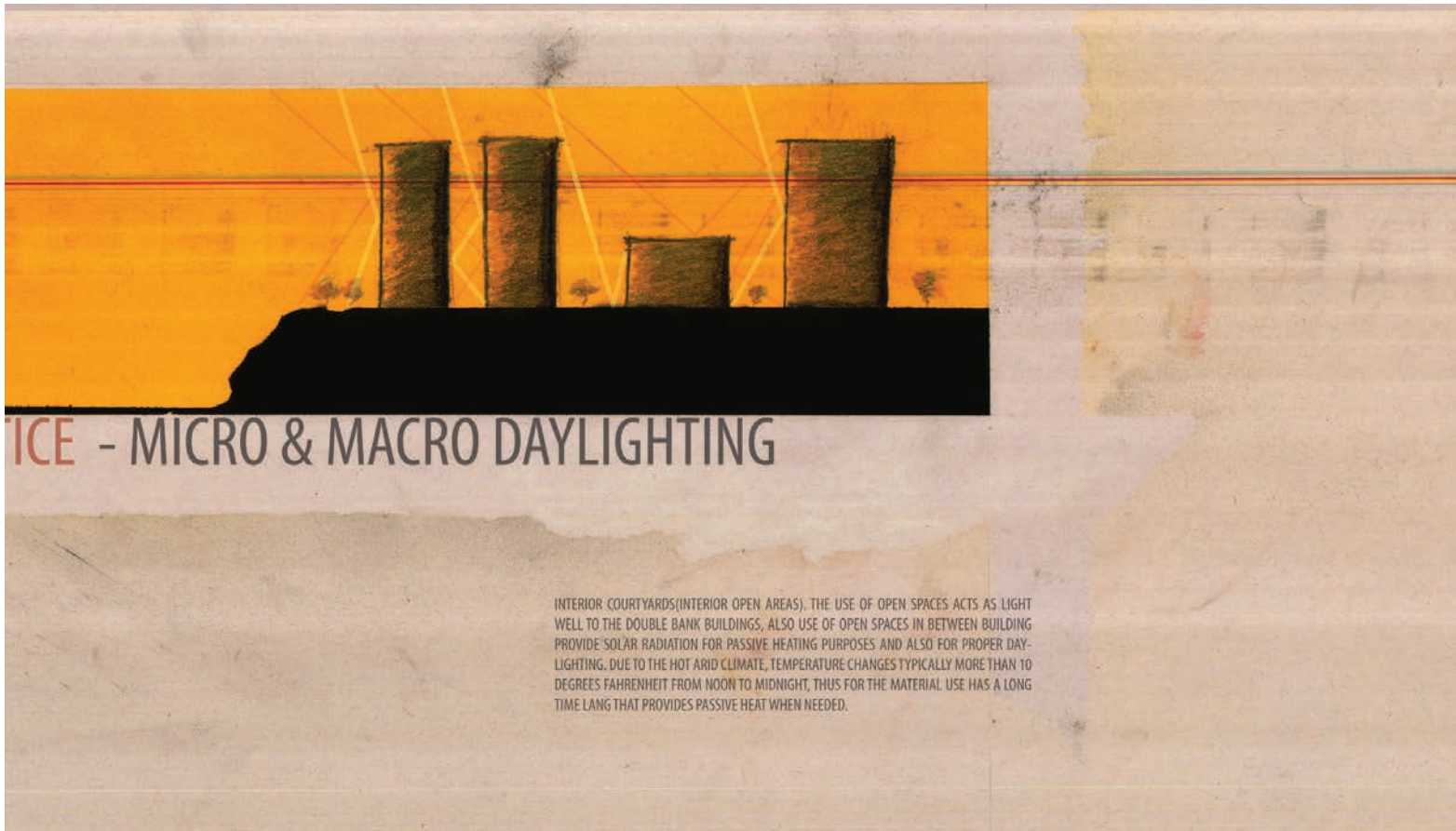
Daylighting:

In planning daylighting strategies, it is important to consider sun altitudes and seasonal conditions. Daylighting in this narrow space only works due the high altitude of the sun year round.





Direct solar radiation diagram: *Costa Verde* - Lima, Peru.



ICE - MICRO & MACRO DAYLIGHTING

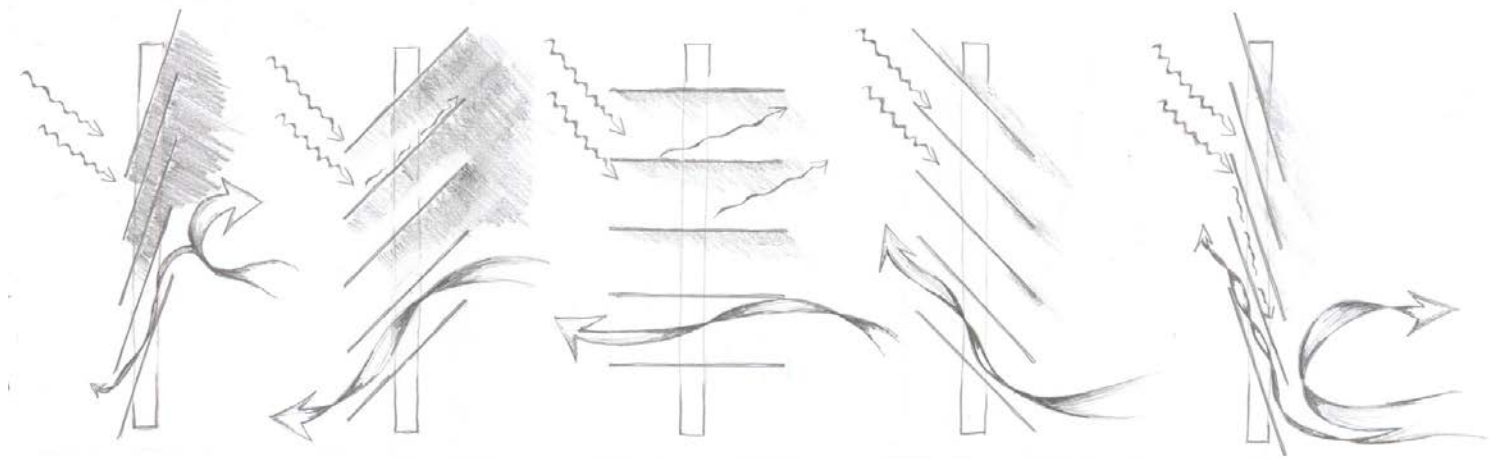
INTERIOR COURTYARDS(INTERIOR OPEN AREAS), THE USE OF OPEN SPACES ACTS AS LIGHT WELL TO THE DOUBLE BANK BUILDINGS, ALSO USE OF OPEN SPACES IN BETWEEN BUILDING PROVIDE SOLAR RADIATION FOR PASSIVE HEATING PURPOSES AND ALSO FOR PROPER DAYLIGHTING. DUE TO THE HOT ARID CLIMATE, TEMPERATURE CHANGES TYPICALLY MORE THAN 10 DEGREES FAHRENHEIT FROM NOON TO MIDNIGHT, THUS FOR THE MATERIAL USE HAS A LONG TIME LAG THAT PROVIDES PASSIVE HEAT WHEN NEEDED.

interior environment

Wind

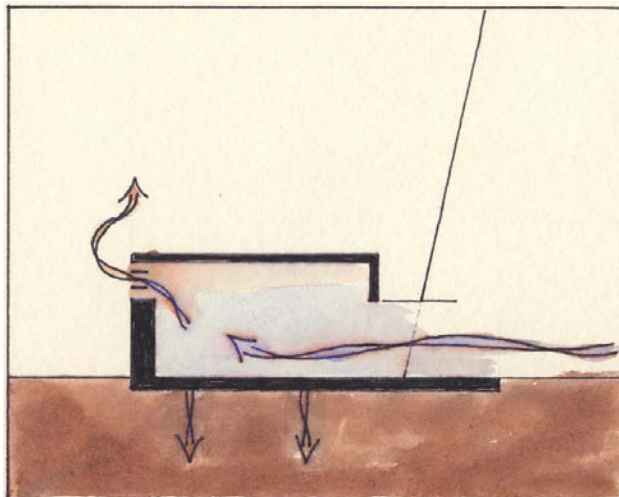


It is a force that is invisible to the naked eye, but whose effects can be seen and felt everywhere around us. It ranges in behavior from a light whisper to a screaming rage. It is wind. An architect's ability to utilize wind is key in creating interior quality through climatic responsive design. By studying wind patterns in a particular climate, and more specifically a particular site, a structure can be formed for maximum utilization. Proper ventilation in a space can greatly decrease the need for mechanical systems and provide a more comfortable environment for its inhabitants. Wind has an inherent behavior and through the use of different types of apertures, materials, shading devices, and orientation, this behavior can be altered to fit the inhabitants' needs. Common knowledge dictates that if a stream of wind is blowing on an obstruction, there is shelter to be found on the opposite side. The same basic principle is true to this day. The main differences to be found in natural ventilation are in wind patterns from place to place, the comfort threshold as it relates to a particular culture and the specific characteristics of a building site. In the case of the Magney House by Glen Murcutt in Australia, the clients were accustomed to camping on the site and had an appreciation for the breeze that came off the ocean. The large, wide-open and fairly flat topography of the land allowed passive ventilation to be used to its fullest extent in Murcutt's design process. The lack of obstruction on the site made it possible to employ cross-ventilation, one of the techniques for natural ventilation. This can be in contrast to an urban site, like Hanoi, where its surrounding borders call for ventilation through vertical movement. The vertical nature of an urban space uses the second technique of stacked or buoyant ventilation, which takes advantage of the nature of warm air to rise through a space and exit at the top. There are many other nuances that branch off of and combine cross-ventilation with stacked ventilation; it is through these abstractions that climate responsive design can evolve and ultimately be free from the omnipresent grid.

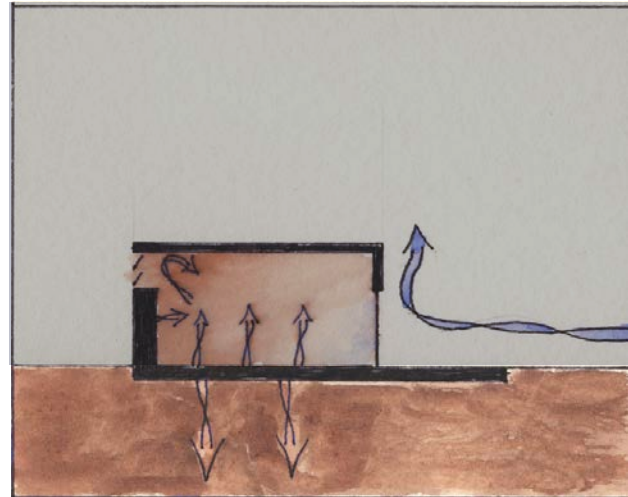


winter

summer



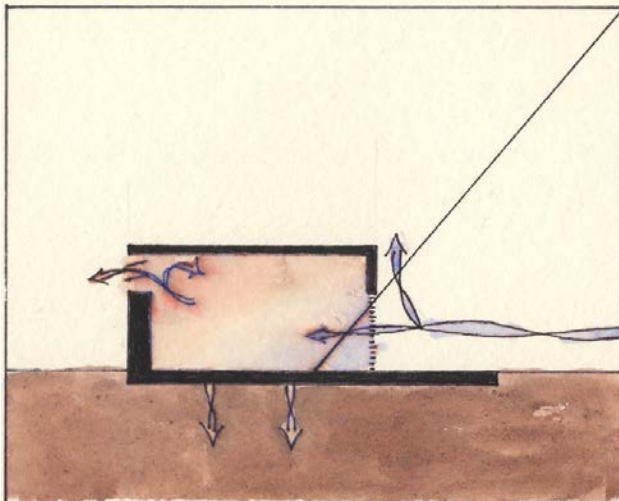
day



Left :

Through the use of louvers, doors, and windows, natural winds can be controlled to cool the interior spaces during a hot season.

winter

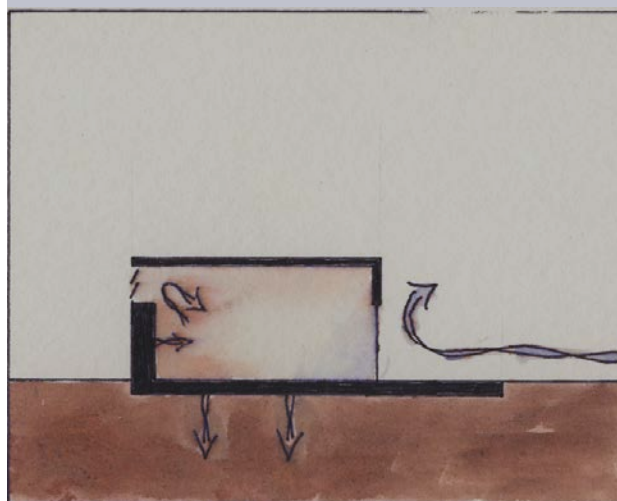


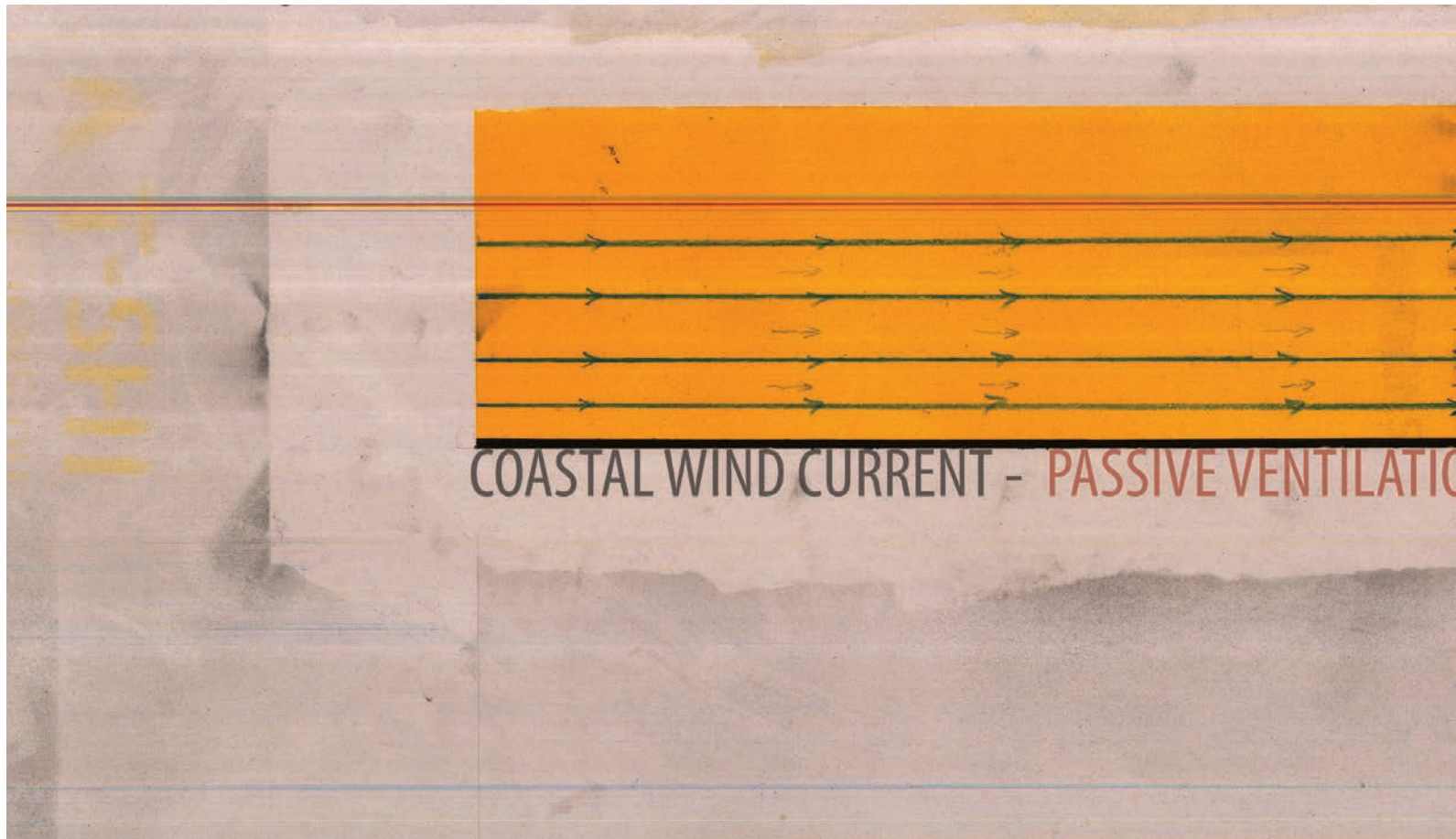
night

Bottom of Spread:

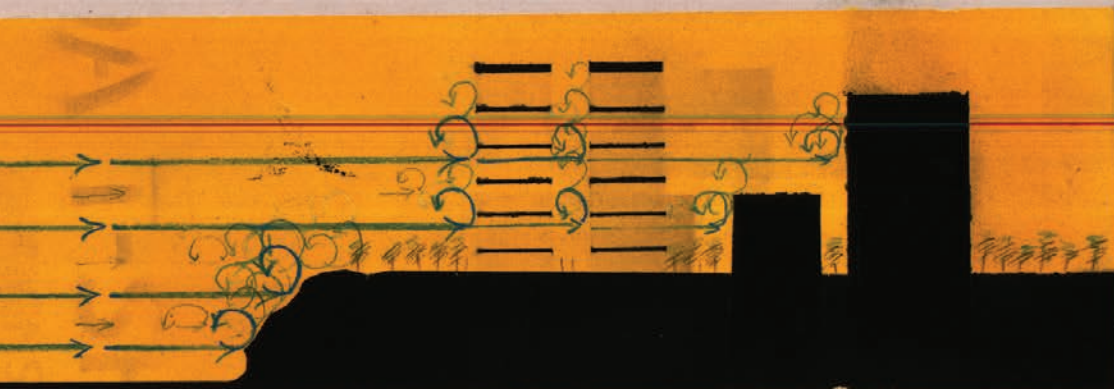
Interior quality is maintained while the diurnal temperature fluctuates, in both seasons. Louvres and an overhang regulate wind and light.

summer





Costal wind diagram: *Costa Verde* - Lima, Peru.



ATION - OPEN PLAN/OPEN CIRCULATION ZONES

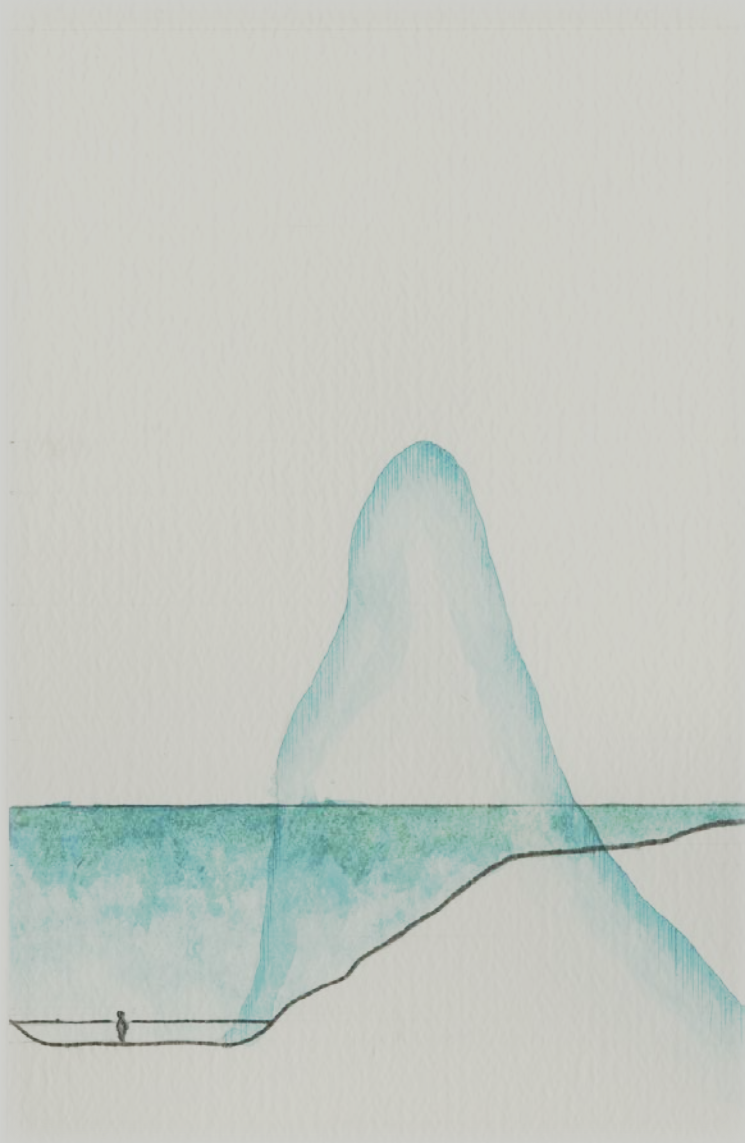
OPEN PLAN BUILDINGS ALLOW FOR AN OPTIMIZED AIR FLOW. WESTERN & EASTERN MOVABLE GLAZING ALLOWS FOR AIR MOVEMENT THROUGHOUT THE BUILDING. SINGLE BANK ZONES MAXIMIZED VENTILATION. IN CASE OF DOUBLE BANKING THE BUILDINGS ADD AN OPEN EXTERIOR SPACE, IN BETWEEN BANKS. THIS IS TO ALLOW PROPER VENTILATION IN BOTH ZONES. THE OPEN EXTERIOR SPACES, IS USUALLY USED AS A HORIZONTAL AND VERTICAL CIRCULATION POINT.

interior environment

Water



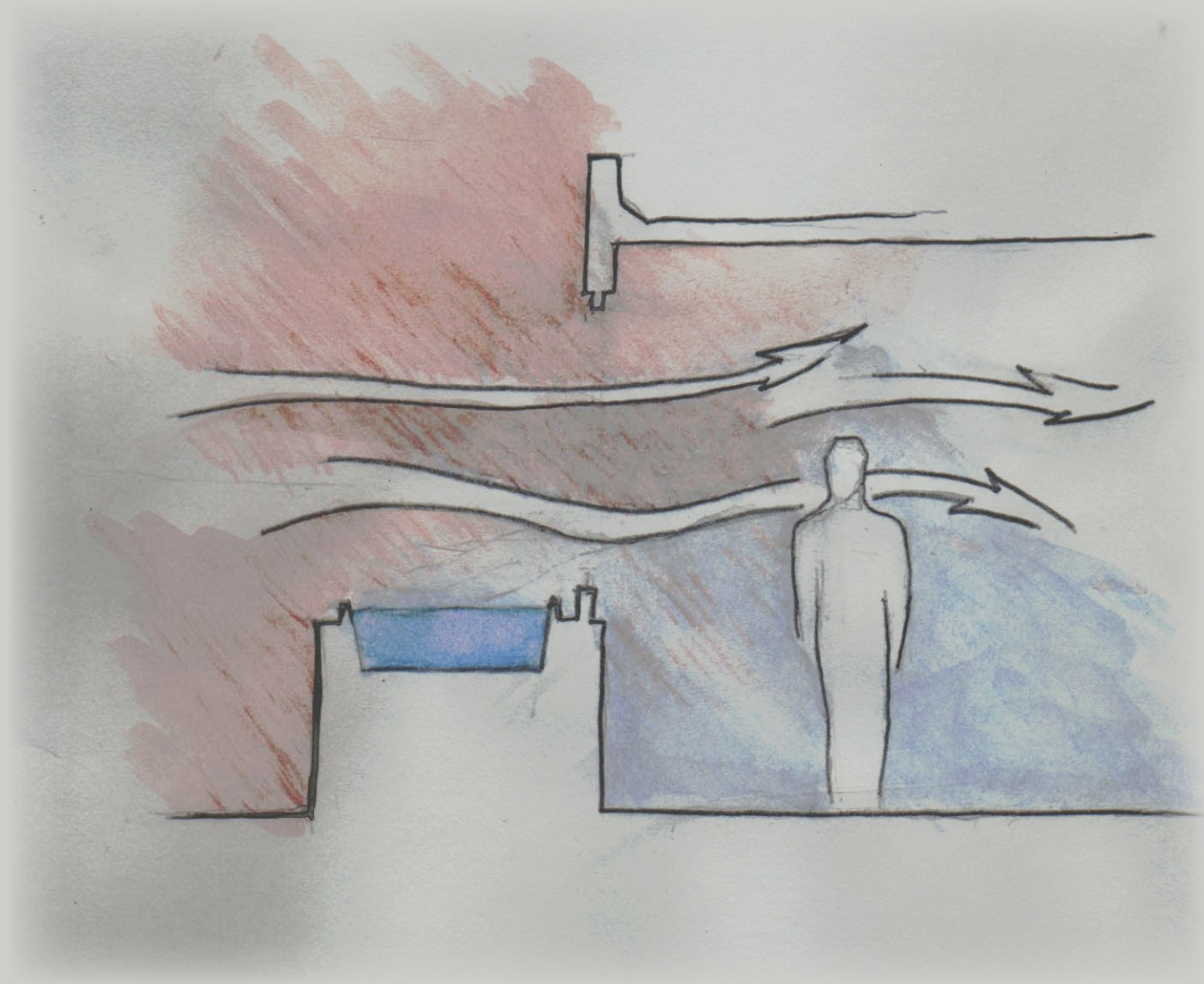
Water is an essential element in every climate. Design solutions can be used to maximize the collection of water in a hot-arid climate, which lacks precipitation, or dissipate excess water in a hot-humid climates experiencing seasonal flooding. The scarcity of water, its destructive capabilities and regional associations affect the way that different people understand the same conditions. There are many issues that have relevance to the initial design stage. Architects ought to be conscious about the impacts water can have on the success of an environmentally responsible envelope. The proper containment of water is essential to the integrity of a structure. If the envelope allows precipitation to penetrate, it will compromise the structural stability and diminish the efficacy of controlling the thermal comfort of the interior environment. It is also beneficial to contain runoff water from buildings in a city context in order to reduce pollution. There are other reasons to work to capture rainwater; one being the deployment to an evaporative cooling pool another being the ability to bring the collected water inside for treatment and use in facilities. The quality of a building's interior environment is greatly affected by the presence of water. An indoor fountain can serve as a soothing audible compliment to entry ways, while a fountain that reuses rainwater adds the ephemeral notion of a connection with nature. Arup designed its Druk White Lotus School in Ladakh to instill this connection with all of earth's elements. The school is in a cool mountainous climate region and rain is a precious gift that is collected and used by the students and faculty there. In a climate like Hanoi, Vietnam designers face a dry season for most of the year, but for four months the monsoons come and flood the region with the life giving element that also creates a nearly saturated hot atmosphere. Kazuhiro Kojima designed his Experimental House complex with thermal chimneys and evaporative cooling capabilities to ensure a comfortable environment for the occupants.

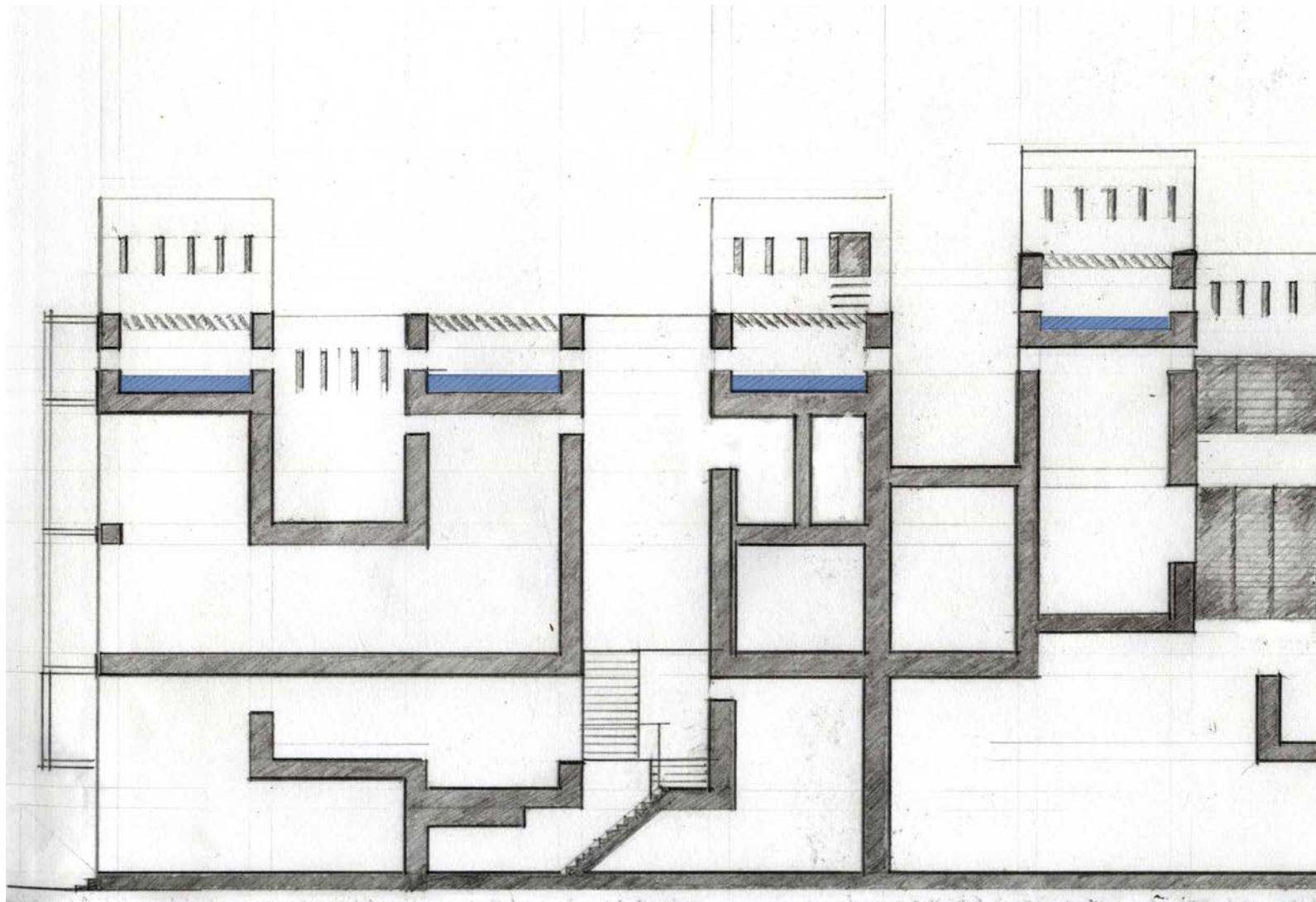
**left, Rainfall:**

Monsoonal regions of the world like Northern Vietnam can receive torrential rainfall of more than 8" in a month during the rainy season and no rain at all during the dry seasons. Cycles of flooding and drought has influenced architectural convention and public associations with water as both a bringer and a taker of life.

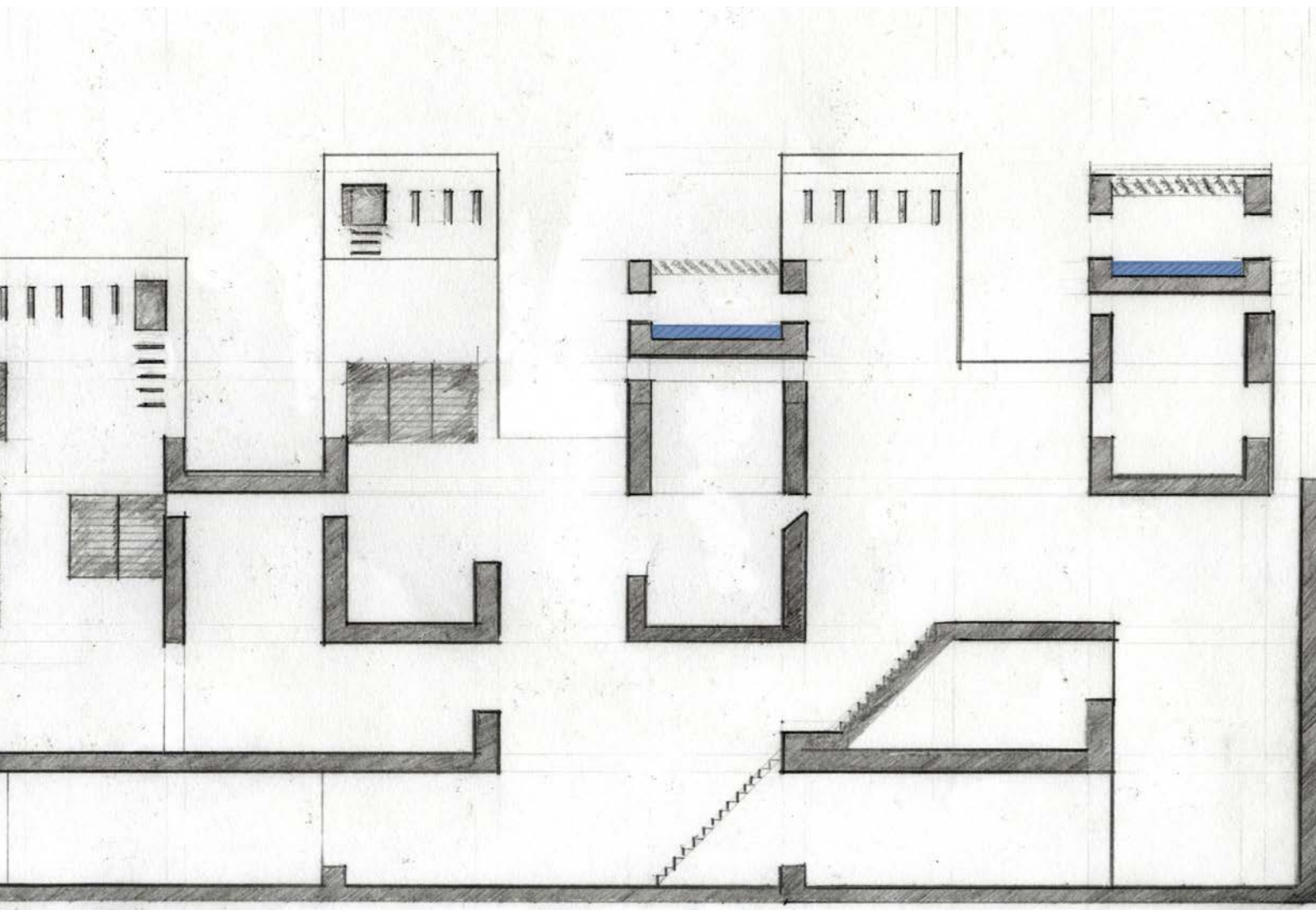
opposite, Evaporative Cooling:

A building's orientation can help take advantage of natural wind patterns and aid a natural convective current. In this instance, a long pool helps cool an interior space in an urban context by taking advantage of masonry wall and a large opening into the space cooled.





Section : Experimental House by Kazuhiro Kojima in **Hanoi, Vietnam** Evaporative cooling and thermal chimneys are integrated to provide interior comfort in the hot humid climate.



interior environment

Biological

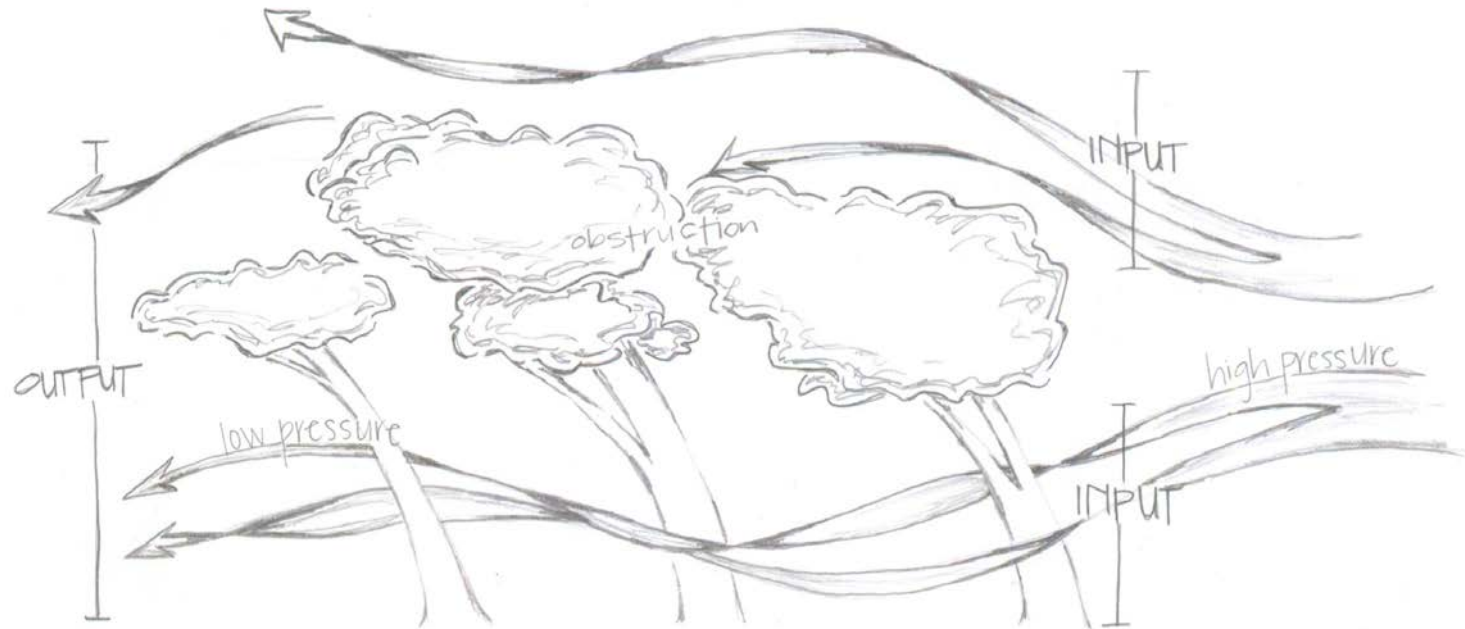




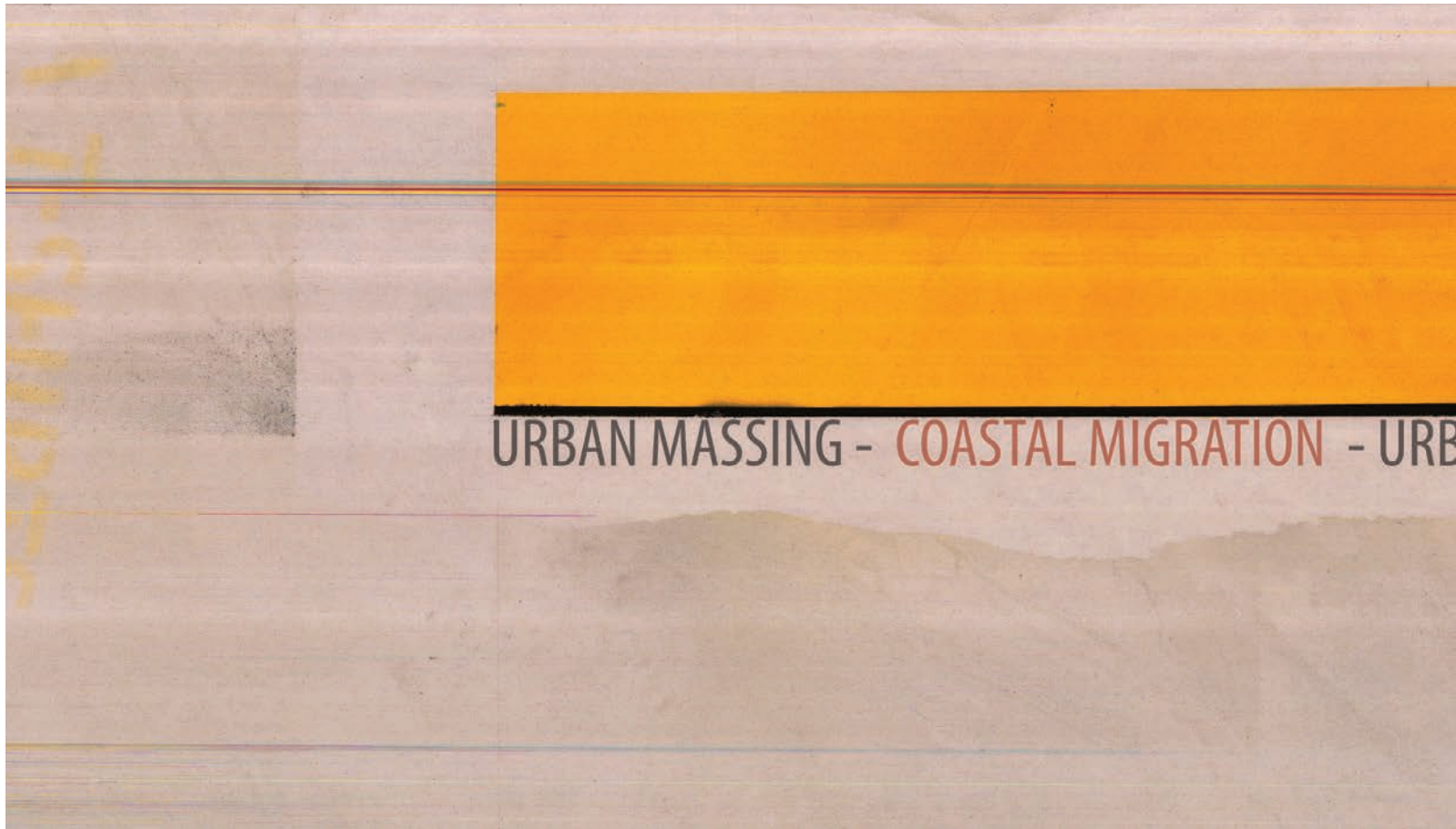
Biological systems and their components are facts of our natural world and integral in our lives. Just as one regulates external environmental elements with layers of clothing, our buildings should interact with the biological environment in the same manner. Biological elements are an immense resource when considering how to vary passive interior design elements such as light, air quality and thermal comfort. Climate responsive design is the mitigation of the different biological conditions so that they are best utilized in service of passively energizing our built environment. For illustration: the Costa Verde district in Lima Peru. Here the architecture migrated to the coastline to take advantage of the biological attributes of the site. The stable, rocky soil provides the strength to use heavier materials, which traditionally have a longer thermal lag. The coastal site allows for passive ventilation and east-west orientation optimizes southerly indirect solar gain. Some basic schematics: building orientation that allows for an appropriate amount of solar gain; orientation of fenestration to facilitate interior day lighting, passive ventilation and solar gains; use of vegetation for seasonal shading and to enrich the quality of light; and any other principle that takes advantage of natural energies. Basic principles have been adapted and integrated cross-culturally over time. Only recently have some cultures deviated from (and had to return to) the tendency to capitalize on natural resources to enhance interior quality. From the ground up most of the earth's systems can be realized experientially. The soil gives reflective qualities concurrent with specific ground cover for example, grass or plants, not to mention the possibilities for a combination of biosystems to achieve a composting area. It also provides a significant source of cooling, but sometimes an unfortunate possibility of aromatic properties. An extension of the soil that reaches into the atmosphere catching elements of wind, water, and sun; trees. Trees provide a multitude of functions biologically and in conjunction with the built and interior environments, so much so that trees are most often the element that transcends the interior/ exterior barrier.



The layout of spaces and the movement within a building can be modeled after organic forms and relationships, such as those found in the ratio of branches, the rigid spatial organization of a honeycomb or the seemingly random veins of a leaf. By incorporating biological elements from the exterior into the interior, a more conducive relationship can be achieved between the natural and the built environment.



The surrounding environment acts as a first layer of skin around the building. The membrane of trees and other foliage can be a barrier or a means of mitigation from the wind and sunlight. Depending on the placement of plants around the building, a more aesthetically pleasing substitute for blinds or shading devices can be found. Trees can also impede or create different views; depending on the need for privacy they can become a visual barrier from the outside while having a pleasant effect on the interior.



Urban massing diagram: *Costa Verde* - Lima, Peru.

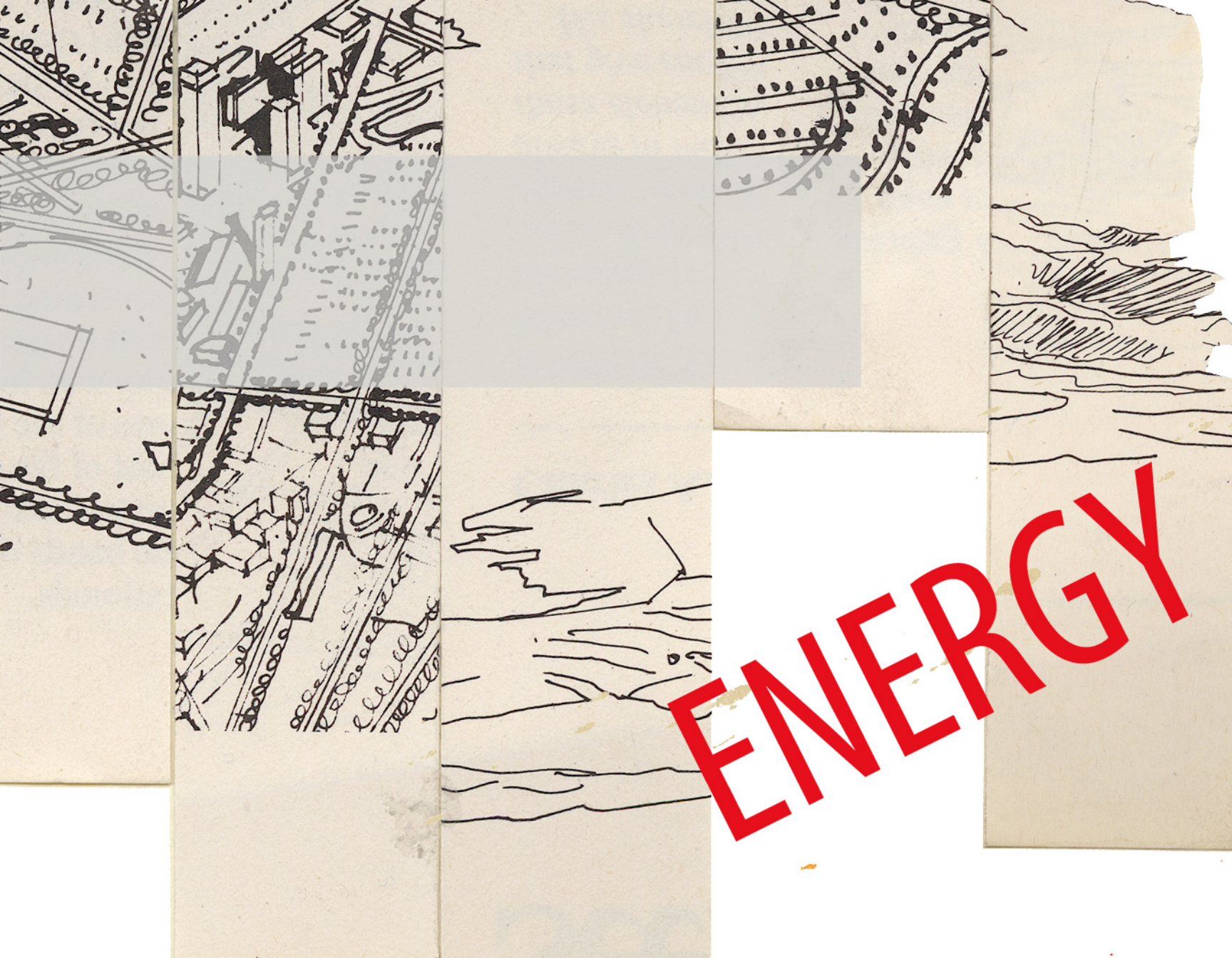


URBAN RHYTHMIC PATTERNS/SPACING

THERMAL COMFORT AND EXTERIOR VIEW ARE THE MAIN REASON FOR ARCHITECTURAL MIGRATION TOWARDS THE COASTAL AREA. BUILDINGS ARE CHARACTERIZED BECAUSE OF THE USE OF WHITE HEAVYWEIGHT HORIZONTAL SOLID ROOFS. THE MATERIALS USE IS REINFORCE CONCRETE 10 CM THICK. BUILDINGS ARE FINISHED IN LIGHT COLORS TO MAXIMIZED THERMAL GAIN (SECONDARY) AND TO HELP INDIRECT LIGHTING.



SOUTH FACING ELEVATION: COSTA VERDE - LIMA PERU. WATERCOLOR
RENDERING. CULTURAL/CLIMATE DRIVEN ARCHITECTURE.



ENERGY

ATMOSPHERE

ATMOSPHERE

ENERGY & ATMOSPHERE

“What’s the use of a house if you haven’t got a tolerable planet to put it on?”

-Henry David Thoreau

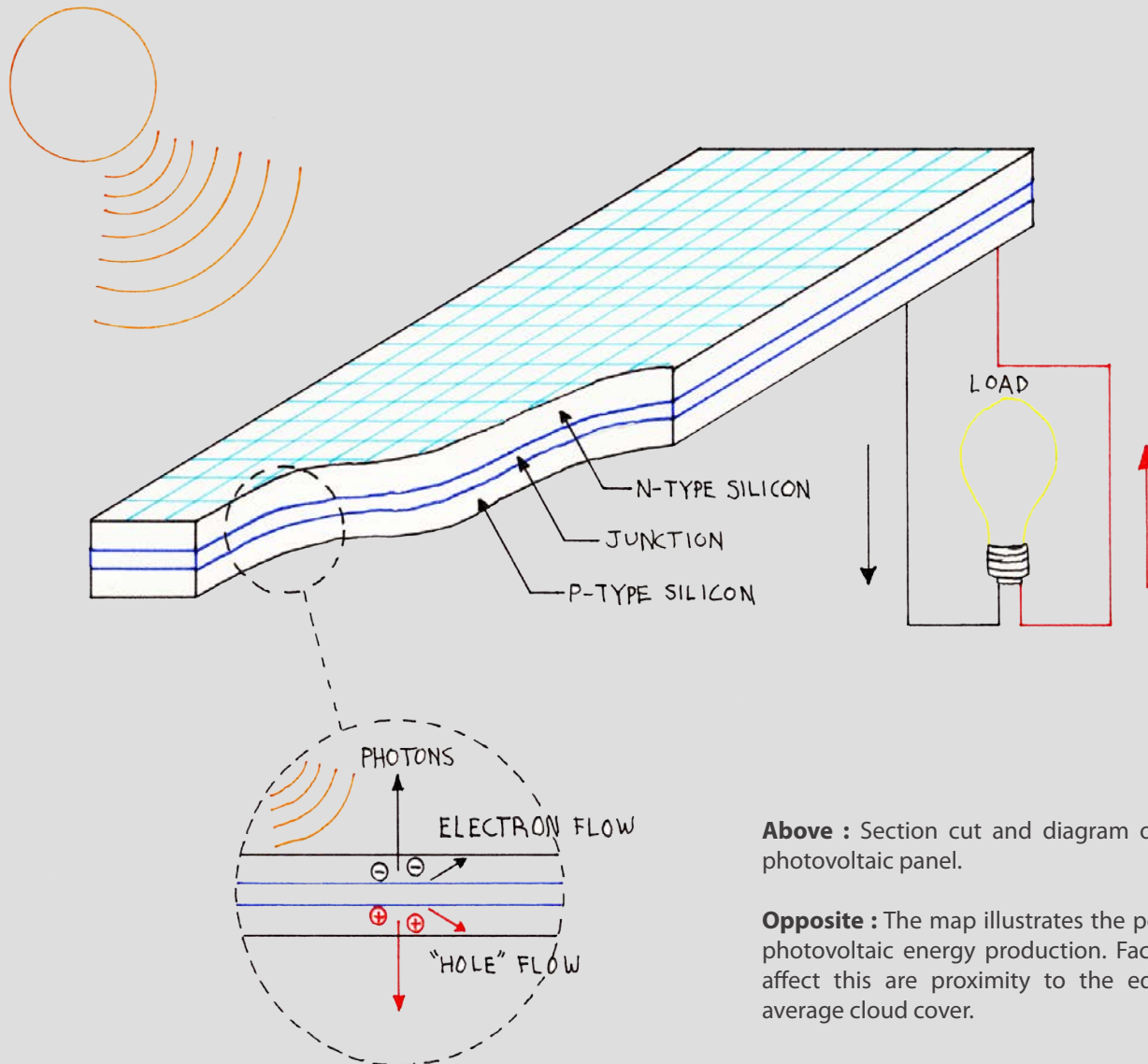
To complete the cycle linking the natural to the built environment, we must finally discuss energy and atmosphere. Energy and Atmosphere are linked in two primary ways. First, fossil-fuel energy contributes directly to air pollution and climate change. Second, solar radiation, atmospheric winds, hydroelectric dams, and geothermal plants are infinitely abundant sources of renewable energy. **Energy and Atmosphere are naturally coupled together since optimizing the use of natural energy resources, understanding the effects of energy technologies, and increasing the efficiency with which energy is used can mitigate atmospheric problems in the best manner possible.** Energy consumption remains the single most important issue not only because of its environmental impacts, but also because of the probability of significantly higher future energy costs due to the scarcity of resources. Since buildings consume nearly half of the total energy used worldwide, optimizing energy efficiency at the design stage can significantly reduce energy demand while producing great benefits to the environment. Renewable energy is derived from natural processes that are replenished constantly. Included in the definition is electricity and heat generated from solar, wind, water, and biomass energy. The potential contribution of renewable energies is crucial to site specific architecture. Technology can also help integrate a structure with its surroundings by making the most of the natural resources available. Rapidly evolving computer software helps to expose unanticipated conflicts and provides dynamic means for developing solutions. Energy self-sufficiency and minimized reliance on fossil fuels should be promoted by incorporating on-site renewable energy sources such as solar, wind, water, geothermal, and biomass. By using both local wisdom and modern tools to guide them, today's sustainable designers create structures that provide a sense of place, are in tune with their environment, and enrich their natural setting. We must promote the design, construction, and operation of sustainable, high-functioning facilities that will minimize overall environmental impacts, preserve occupant safety, and optimize whole building efficiency on a life-cycle basis. Climate responsive design considers the long-term effects of the building, its users and its environment, and the preservation of our finite natural resources for future generations

solar

Energy + Atmosphere

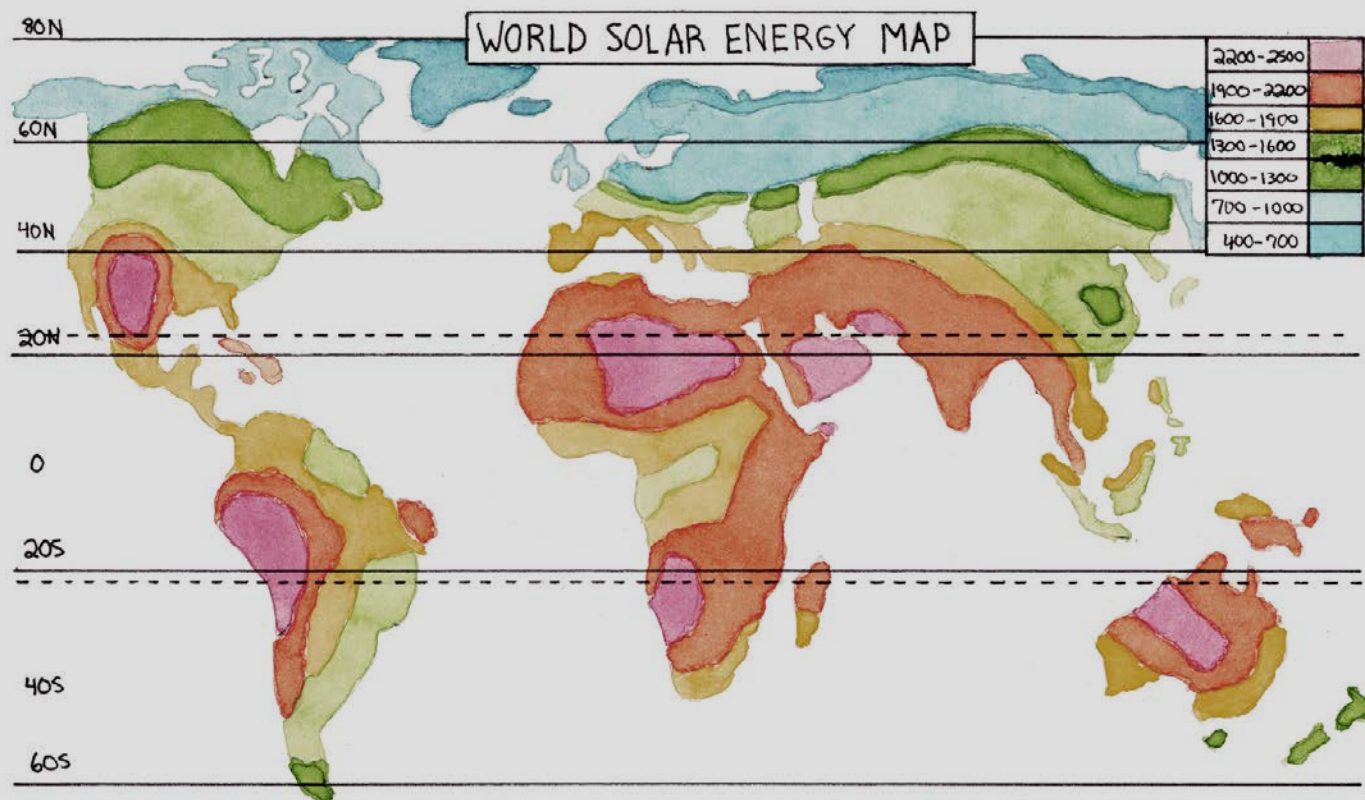


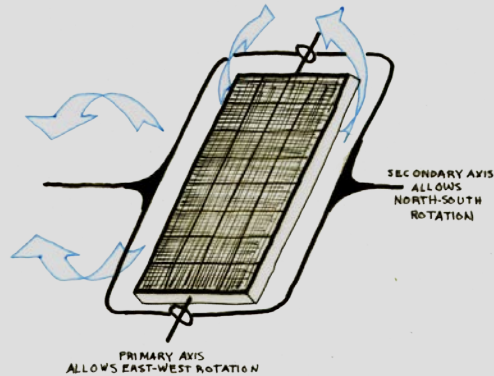
Solar power refers to the conversion of the radiant energy from the sun into electricity or heat. A solar power system is an array of photovoltaic cells wired in a series designed to meet a predetermined electricity demand. Photovoltaic (PV) systems can be either located in the building design or on the ground near the building. Building integrated photovoltaics (BIPV) are integrated into the roof and/or façade of a building. Surface-to-volume ratio largely determines the surface area available for either roof or façade installation. A high ratio of surface to volume indicates opportunities for incorporation of PV's into a façade, while lower ratios point to roof PV's. The efficiency of a PV system in a given location will depend on several factors. The building's orientation and the angles of its surfaces dictate the potential of a system. The climate of the site is significant to the success of PV's. Pollutants in an environment can hinder the potential of success of solar electricity. Also it is not available at night and is less available in cloudy weather conditions, therefore, a storage or complementary power system is required. The location of the PV's will have an impact on the appearance of the building and possibly landscaping. Solar power is a healthier source of energy because it requires no fuel, has no moving parts, produces no emissions, generates no waste, reduces our dependency on coal and oil, and it's manufacturing has minimal impact on land use and ecology. As global demand for energy grows, and the supplies of the fossil fuels used to generate much of it shrivel, the cost of energy is increasing worldwide. The conservation of fossil fuels is a simple, but very important benefit that results from the use of photovoltaic (PV) solar power. With the expansion of our global economy and rapid growth in highly populated countries, the demand for energy is escalating at an exponential rate. The use of PV solar systems decreases the amount of local air pollution. There are major environmental impacts attributed to electricity generation from non-renewable fuels. Emissions of atmospheric pollutants (particulates, Sulfur Dioxide (SO_x), Nitrogen Oxide (NO_x), Carbon Dioxide (CO₂), and others) have a serious impact on public health, our water and crops, whereas Photovoltaic systems produce electric power with no CO₂ emissions.



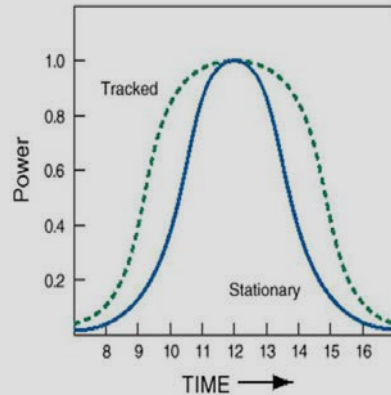
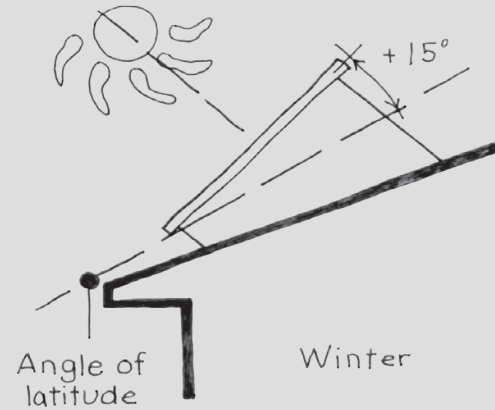
Above : Section cut and diagram of a typical photovoltaic panel.

Opposite : The map illustrates the potential for photovoltaic energy production. Factors which affect this are proximity to the equator and average cloud cover.

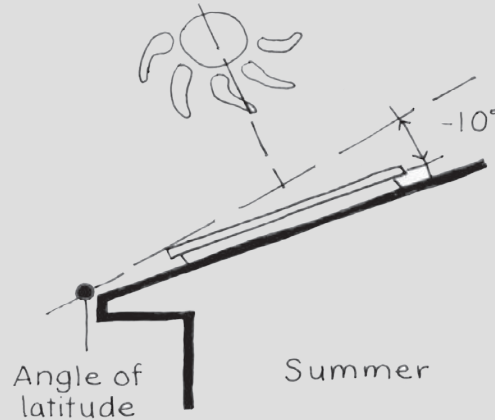




Above: Rotational diagram showing the increased efficiency when rotated on east/west and north/south axis.



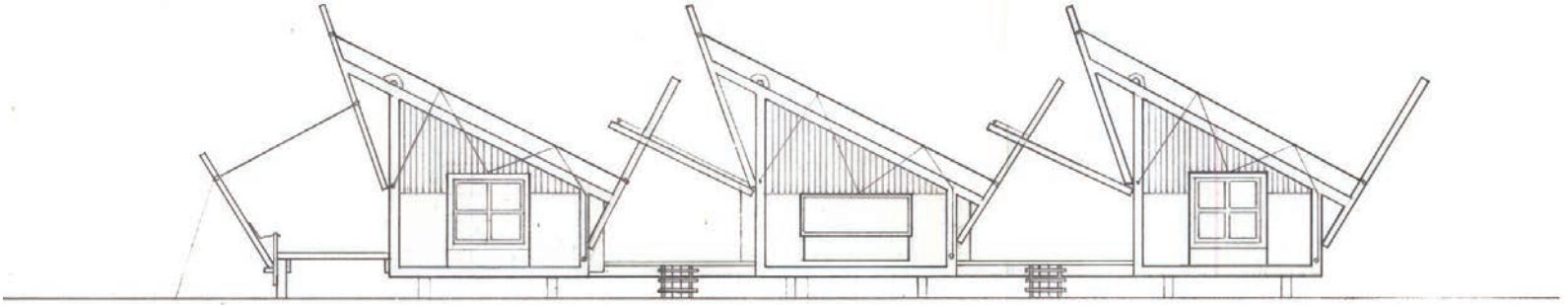
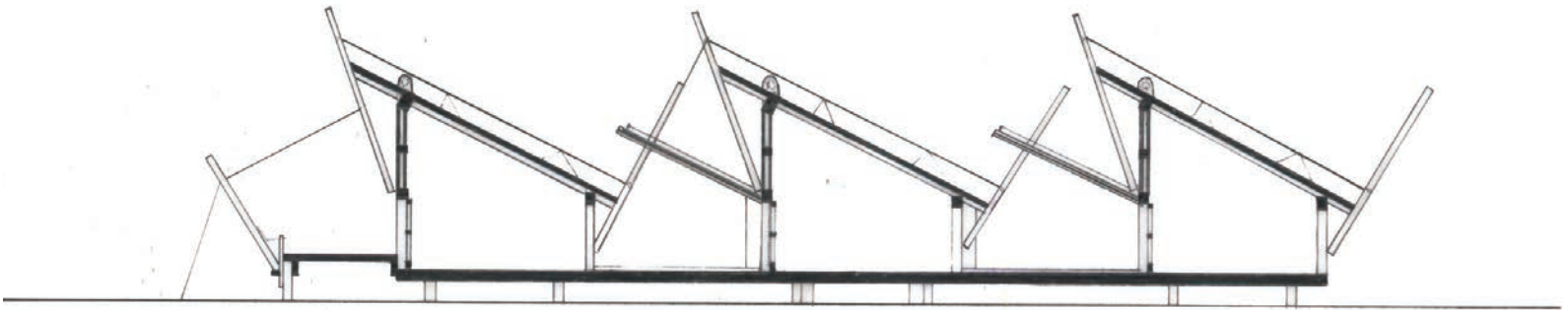
Above: chart comparing the efficiency of fixed and rotational tracking photovoltaics.

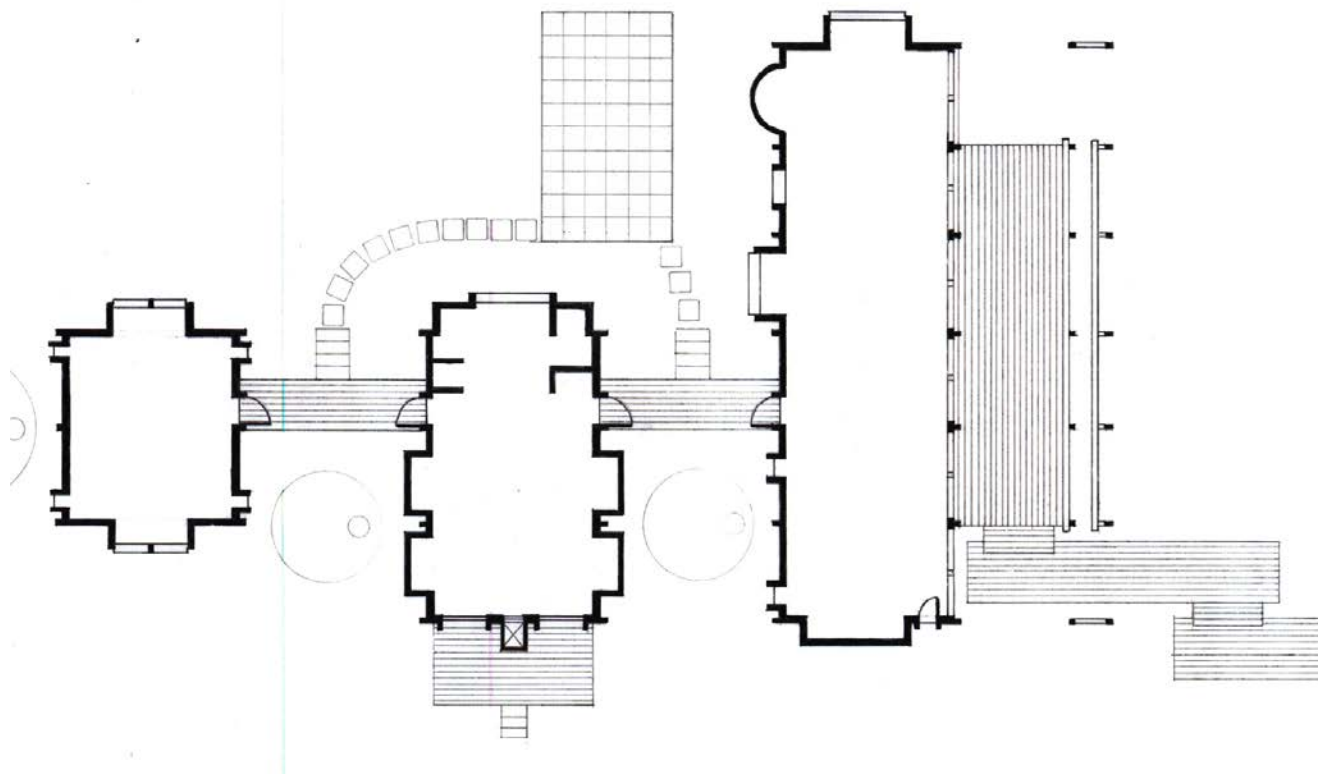


Above: Tilt angles for photovoltaics during winter and summer seasons. Winter angle becomes more vertical (latitude plus 15 degrees). In the summer the tilt should be reduced (latitude minus 10 degrees).

ORIENTATION

[illegible]





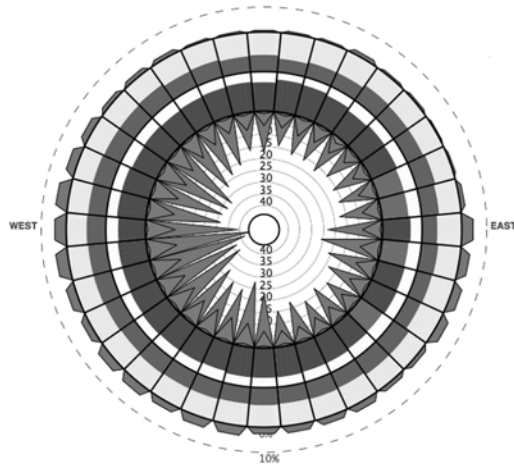
Lake Weyba House
Queensland, Australia
Gabriel Poole

energy + atmosphere

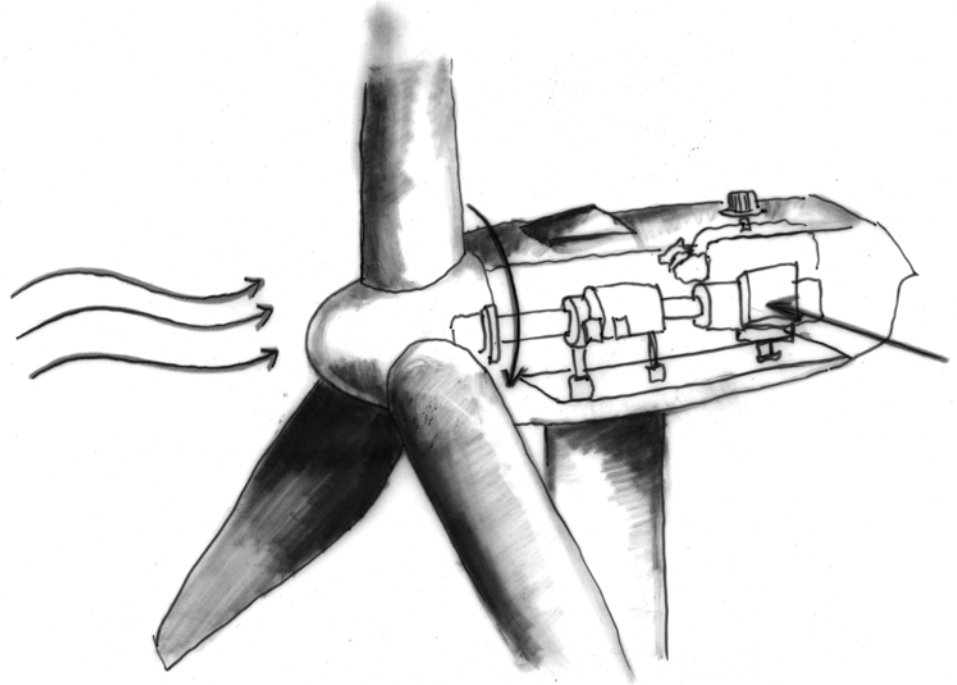
Wind



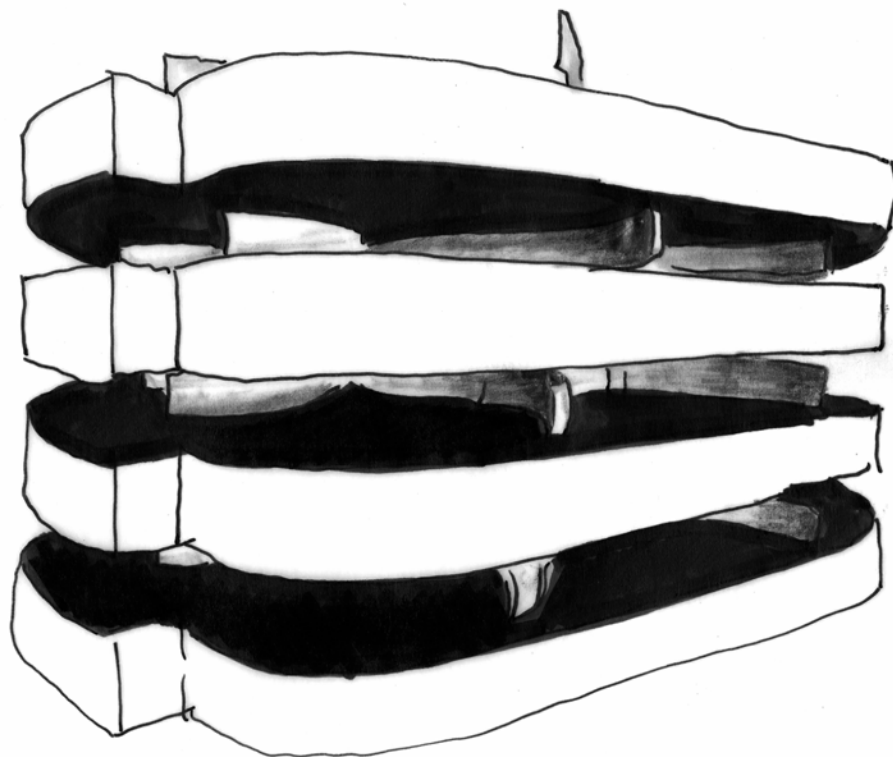
Wind energy relies on the renewable power of the wind, which cannot be completely consumed. Winds are caused through the heating of the atmosphere by the sun, the rotation of the earth, and the earth's surface irregularities. We have been harnessing the wind's energy for hundreds of years. From old Holland to farms in the United States, windmills have been used for pumping water or grinding grain. Today, the windmill's modern counterpart, the wind turbine, can use the power of the wind to generate electricity. These turbines are generally mounted on towers to capture the most energy, however, the Dutch Pavilion, built by MVRDV for the 2000 World's Fair, has turbines mounted on towers to the roof. At 100 feet or more above ground, they can take advantage of the stronger and more consistent winds. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft rotates the generator, producing electricity. Wind energy is one of the least expensive and fastest-growing energy source in the world. An example of architecture which capitalizes on this is David Fisher's Dynamic Tower project in Dubai, which utilizes turbines at 79 of its eighty total stories to generate electricity for the entire building, making it a completely sustainable skyscraper. The major challenge to using wind as a source of power is that the wind is intermittent and it does not always blow when electricity is needed. Electricity generated by turbines is generally stored in batteries, since not all winds can be harnessed to meet the timing of electricity demands. High-quality wind sites are often located in remote locations, far from cities where the electricity is needed. Although wind power plants have relatively little impact on the environment compared to other conventional power plants, there is some concern over the noise production and aesthetic impacts. Most of these problems have been resolved or greatly reduced through technological development or by properly siting wind plants.



Wind Chart / Relative Humidity gauge
Hanover, Germany
52.6 N latitude

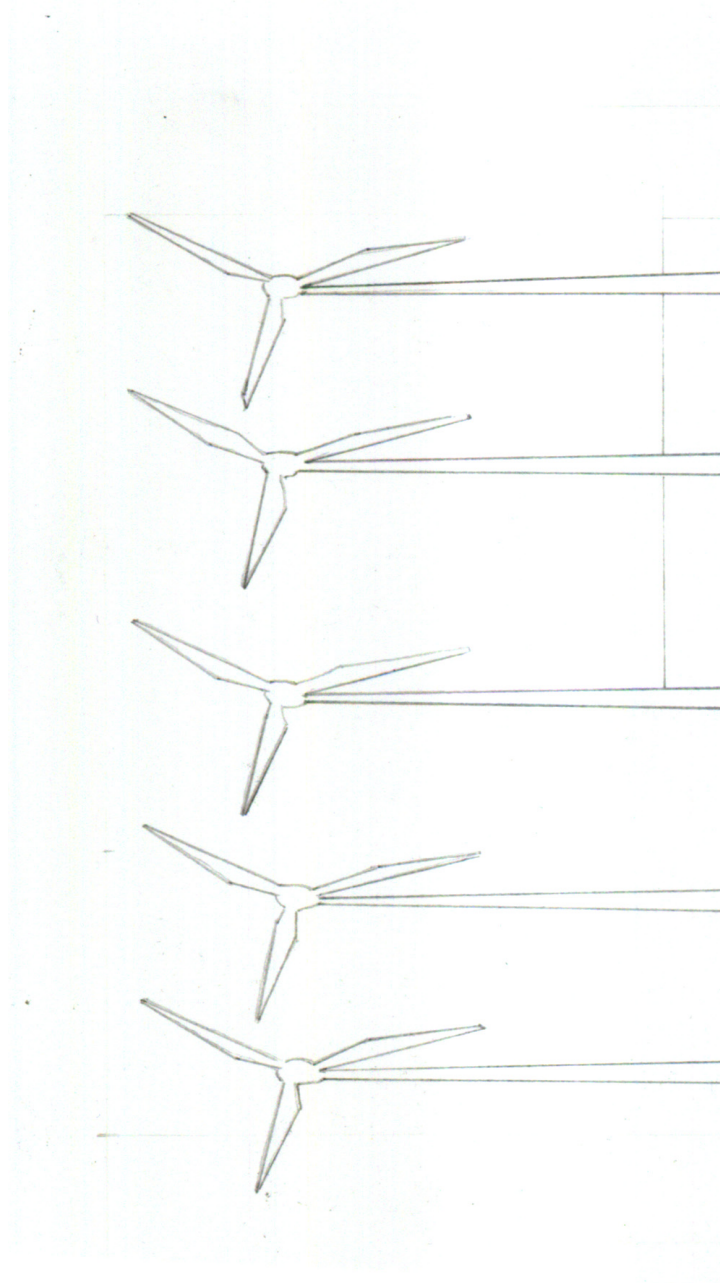


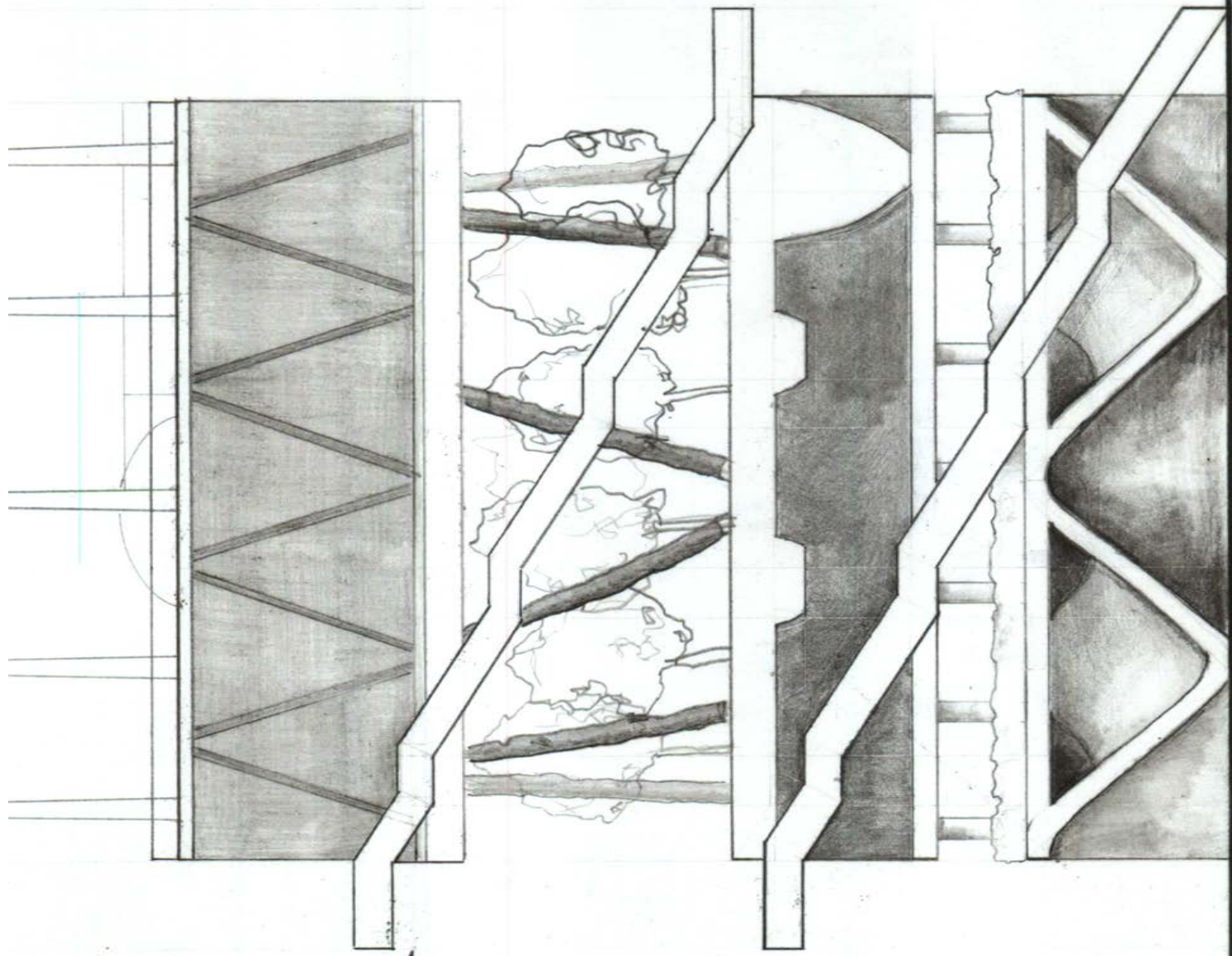
Wind pushes on the contours of the blade causing the rotor blades to rotate, which transfers down a shaft into an electromagnetic generator.



Large scale wind turbines separating each of the individually rotating floors provide the necessary energy for David Fisher's sky-scraping powerhouse. This building technology harnesses powers of wind that are typically troublesome to high reaching projects and puts them to work. Individual floor rotation makes this tower a dynamic design.

Wind turbines placed on the top of the Dutch Pavilion increase their effectivity substantially, avoiding turbulence and capitalizing on the more consistent winds in order to **maximize energy** production.





energy + atmosphere

water



Water energy is using water to power machinery or make electricity. When flowing water is captured and turned into energy, it is called hydroelectric power or hydropower. There are several types of hydroelectric facilities; they are all powered by the kinetic energy of flowing water as it moves downstream. Turbines and generators convert the energy into electricity, which is then fed into the electrical grid to be used in homes, businesses, and by industry. Water constantly moves through a vast global cycle, evaporating from lakes and oceans, forming clouds, precipitating as rain or snow, and then flowing back down to the ocean. The energy of this water cycle, which is driven by the sun, can be tapped to produce energy or for mechanical tasks like grinding grain. Water is not reduced or used up in the process, because the water cycle is an endless, constantly recharging system. It is generally available as needed because the flow of water through the turbines to produce electricity can be controlled on demand. Home-scale hydroelectric power systems offer an opportunity for humans to forge a sustainable partnership with sun, rain and running water. Sometimes dubbed “microhydro,” this approach uses low-impact mechanical systems to harness moving water that generates clean and reliable electric power. Unlike the intermittent power from wind or solar systems, hydroelectric power can flow night and day from streams, as long as they do not experience drought conditions. Large and small-scale hydropower plants can be impacted by drought. When water is not available, the hydropower plants can’t produce power. Additional benefits from large-scale hydropower plants may include water supply, flood control, and recreational uses. The downside of hydropower plants is that fish populations can be impacted by the inability to migrate upstream past impoundment dams to spawning grounds or if they cannot migrate downstream to the ocean. Hydropower can also impact water quality and flow by causing low dissolved oxygen levels in the water, a problem that is harmful to riverbank habitats and is addressed using various aeration techniques, which oxygenate the water. Maintaining minimum flows of water downstream of a hydropower installation is also critical for the survival of riverbank habitats.



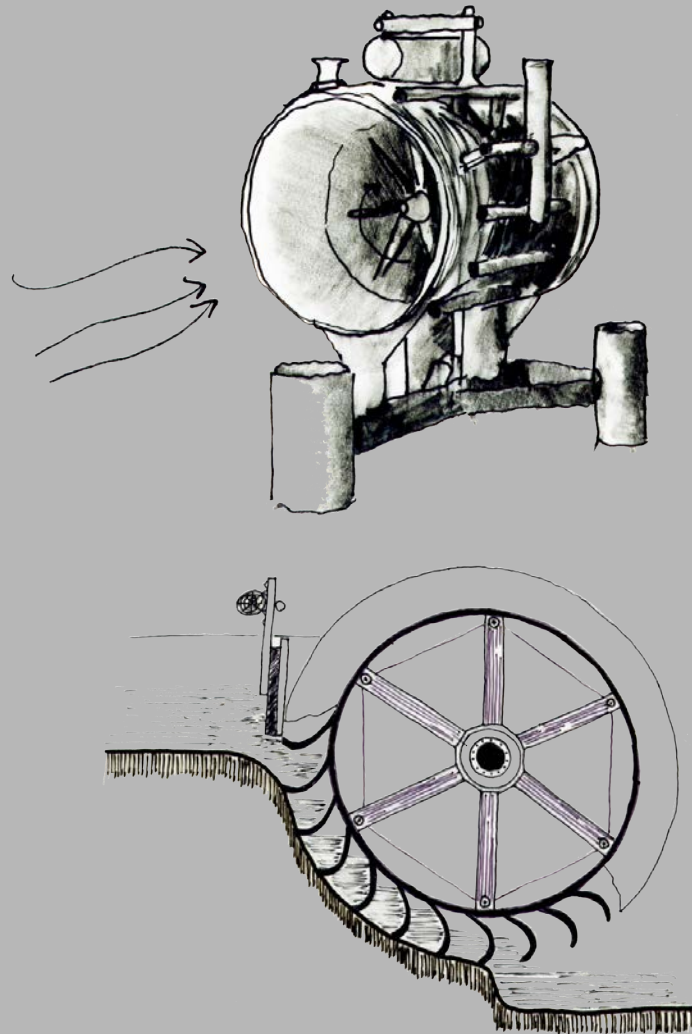
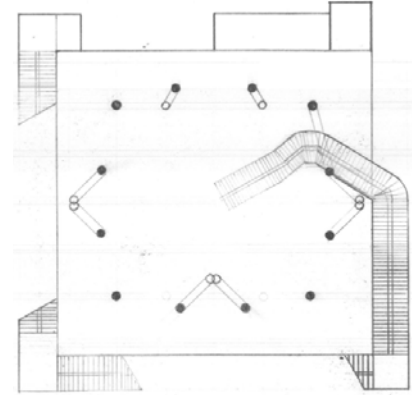
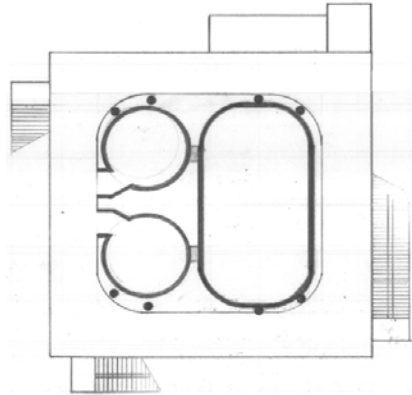
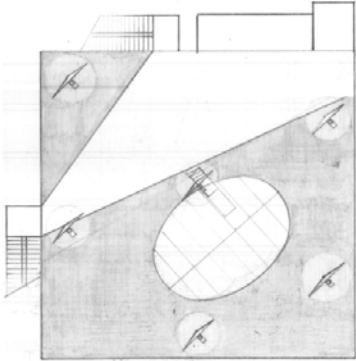
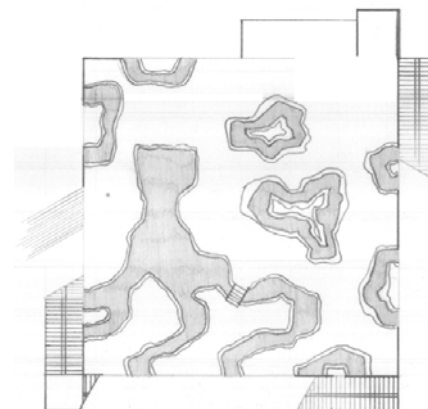
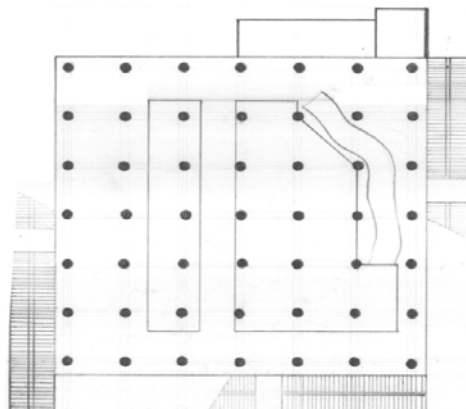
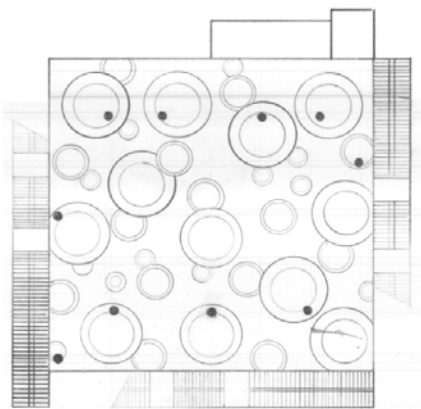


Photo : Table Rock Lake Dam, Branson, Missouri



Plans of the **Dutch Pavilion** for the World Expo 2000 reveal the layering of various terrains. Water is filtered through the building in the form of liquid and vapor. It is caught in the basin on the top floor then sent to water tanks on the fifth floor where it is stored for distribution.

Water flows out of the tanks via pipes and impluvia to the forest below. It flows into the soil and then vaporizes, producing fog. The water that doesn't evaporate is then filtered down past the dune level to the agriculture floor, where the water is used for plant growth.



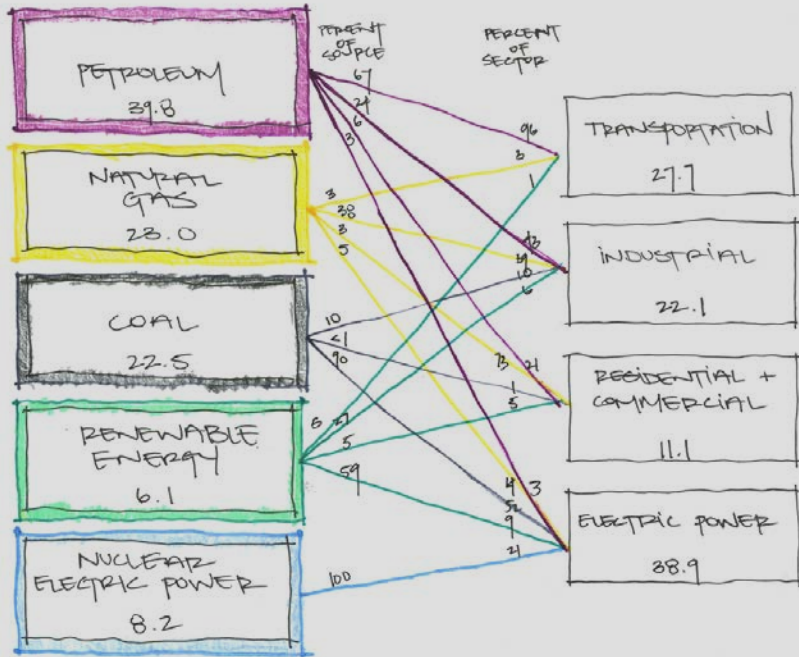
The basement contains rest rooms in which the water is used to flush toilets. Any remaining water from this cycle is flushed from the building to aid the plant production.

energy + atmosphere

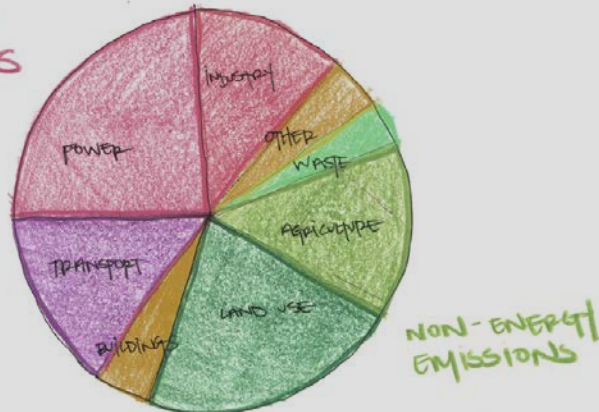
Biological



Biological factors of Energy + Atmosphere are **directly related** to human consumption and production of energy. This relationship exists because energy can be neither consumed nor produced, but merely transformed into its various forms. If this transformation is efficient, then all the biological elements of a place will thrive in harmony. However, modern society perpetuates the inefficient transformation of absurd amounts of petroleum, natural gas, coal, and nuclear energy into electric power. The by-products of these transformations are carbon dioxide and heat, which are distributed into the atmosphere. In energy transformation, by-products are evidence of inefficiency, and inefficiency disrupts the balance between biological elements of site. How can humankind's insatiable hunger for energy be mitigated and the balance restored? The answer is renewable energy. Renewable energy sources can be completely efficient and exist in part, in every climate region. Solar, hydro, and wind sources were discussed in the previous pages, this will discuss some of the others. Green roofs and gardens reduce heating a cooling loads, reduce storm water runoff, filter pollutants, and interact with wildlife rather than block it out. Biomass energy has also had an increasing share in meeting energy needs worldwide. It is viewed as an inexhaustible source of energy capable of serving as a transportable energy source after the exhaustion of the reserves of crude oil, coal, and natural gas. Geothermal energy harnesses heat from several miles below Earth's surface to produce steam. The steam is produced in wells over a mile deep when water collides with the very hot subterranean temperatures. This steam is then used as the force that will drive turbines to create usable energy. Geothermal energy has incredible potential, but most of that potential only exists around fault lines. With appropriate infrastructure, the entire world could be provided with copious electricity by geothermal power plants alone. As society advances, the development of energy sources will expand and become much more refined in terms of their applications. If a post-carbon economy is our goal, then advances in efficient energy transformation are necessary.



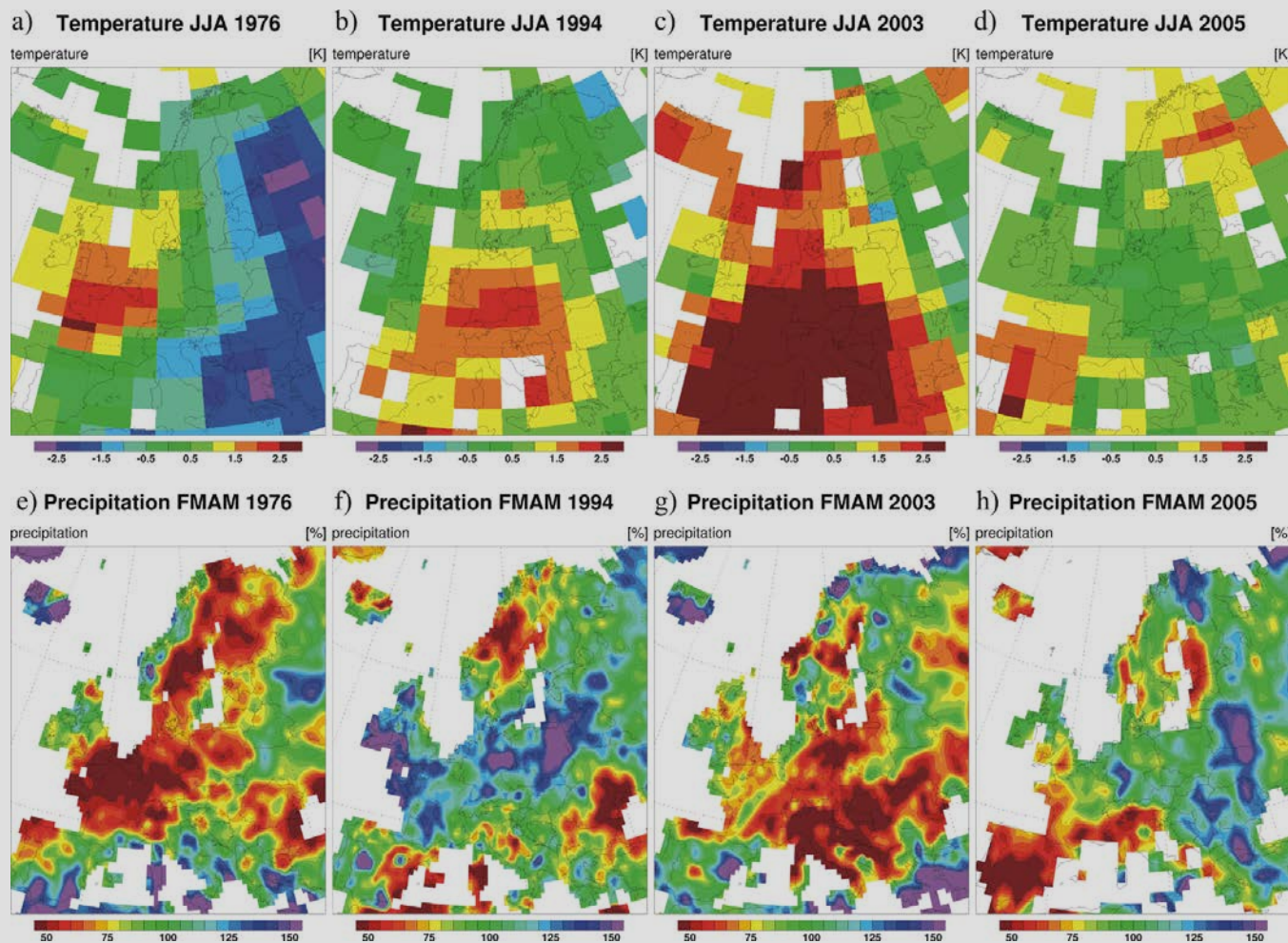
ENERGY EMISSIONS



Left: Primary sources of energy and their breakdown in terms of various sectors.

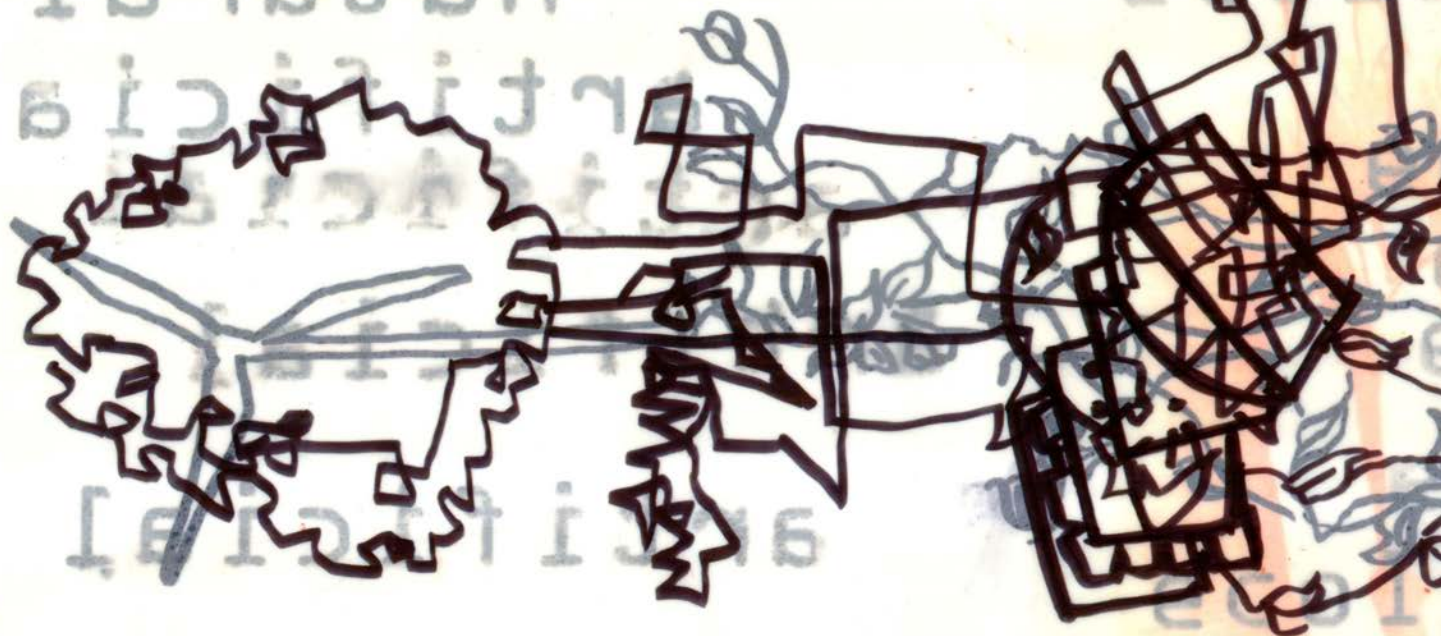
Bottom Left: Both energy and non-energy emissions relative to energy sectors.

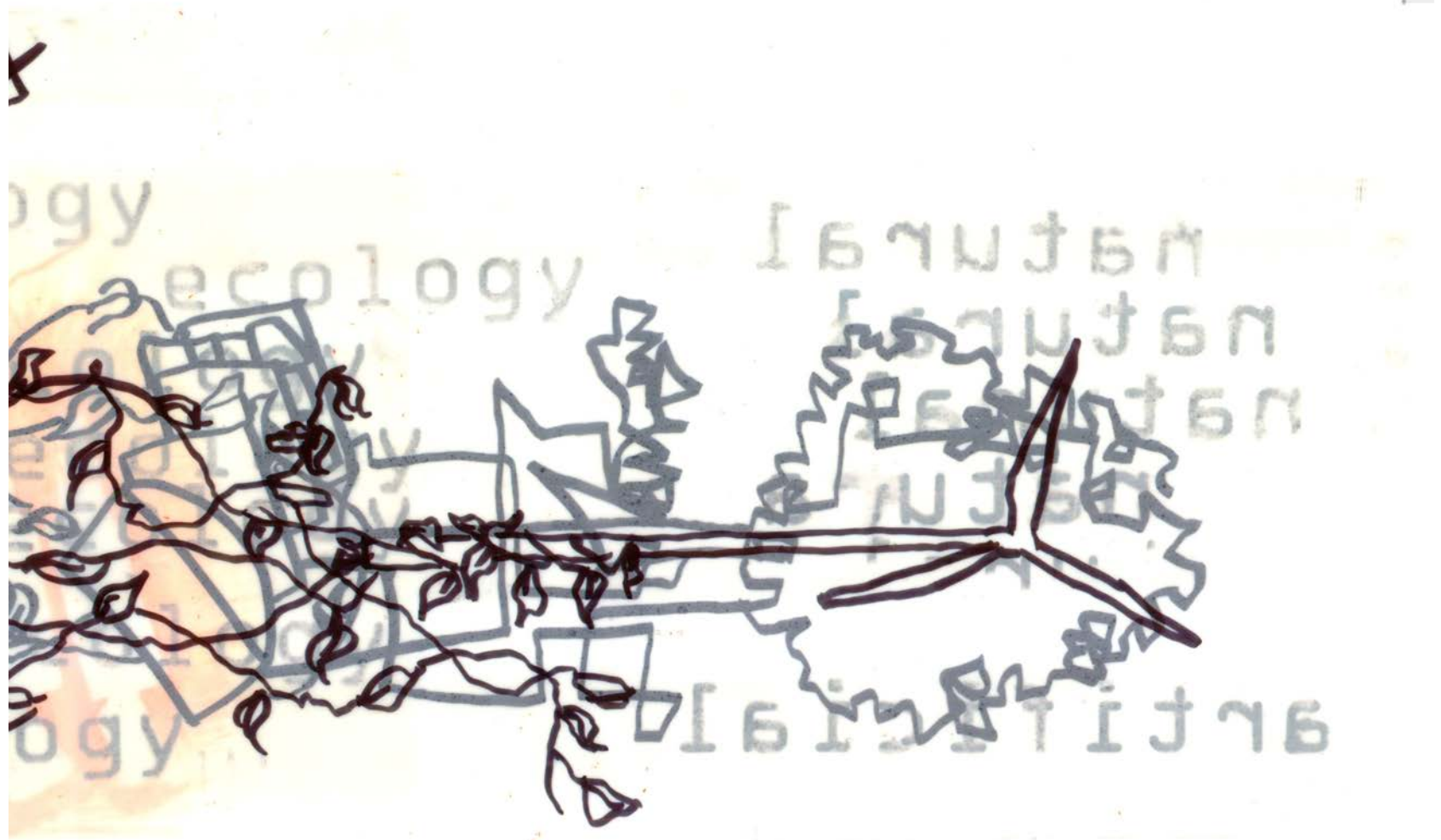
Above: The "forest" on the fourth floor of the Dutch Pavilion for the Expo 2000. This forest capitalizes on the building's water catchment and circulation, further implementing renewable energies that promote a pleasant space.



Temperature and precipitation fluctuations for the past three decades. The atmosphere's depletion, caused by harmful emissions, directly influences temperature and precipitation, in turn changing the climates we inhabit.

חננו
ישראל

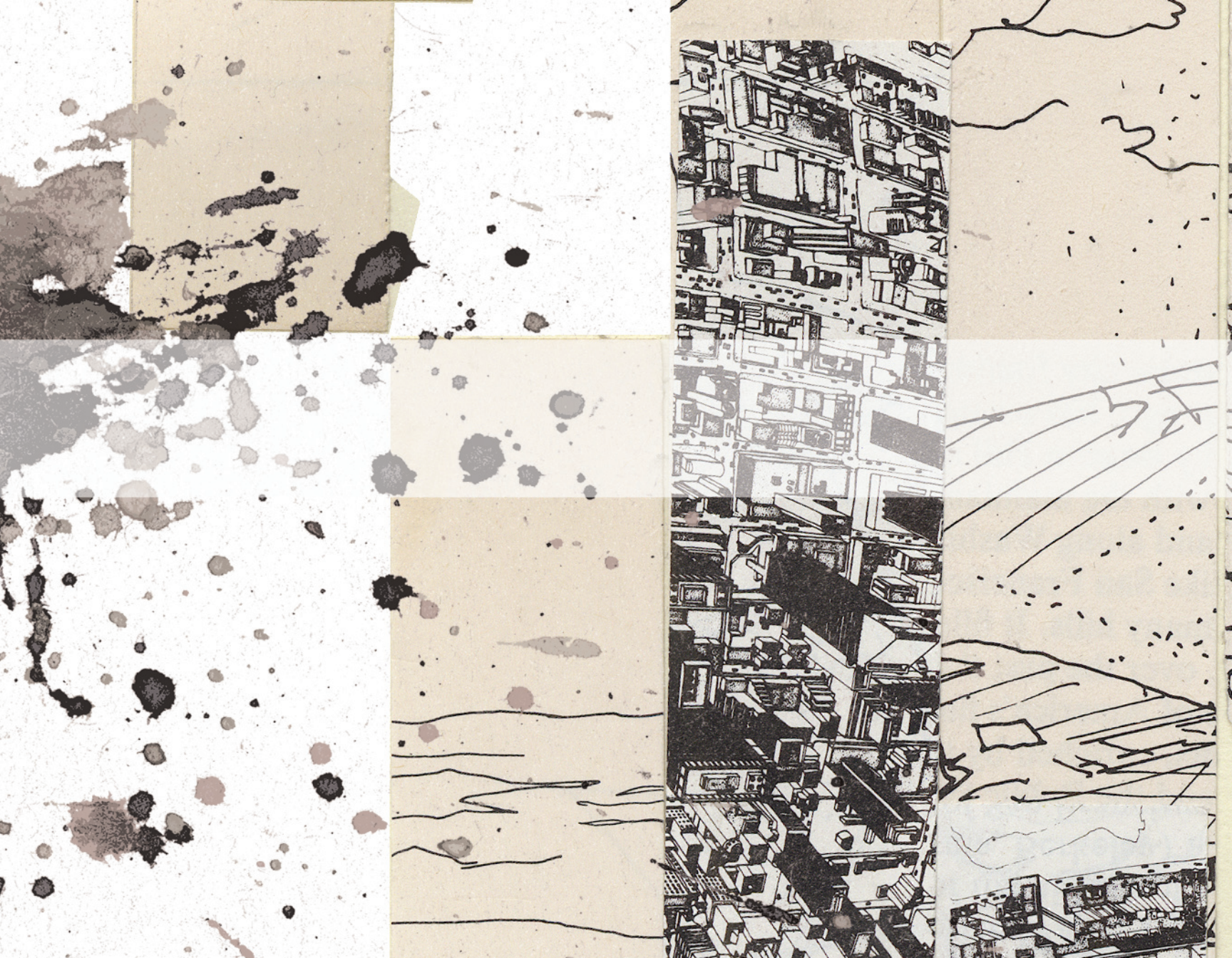






OUR

APPENDICES



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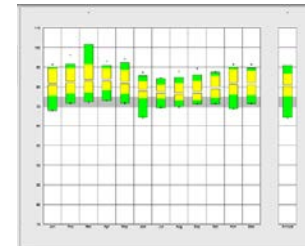
The diagrams and photos that are not referenced were produced by the students.

The images that introduce each concept were taken by the students who made this book. They are the images of our experience which speak to our senses when understanding concepts of climate and place. Like a windy boat ride on a Caribbean estuary or rays of the sun piercing the clouds in the mountains of North Carolina, we chose these images based on the experience to heighten the readers' sense of each element. They set the mood.

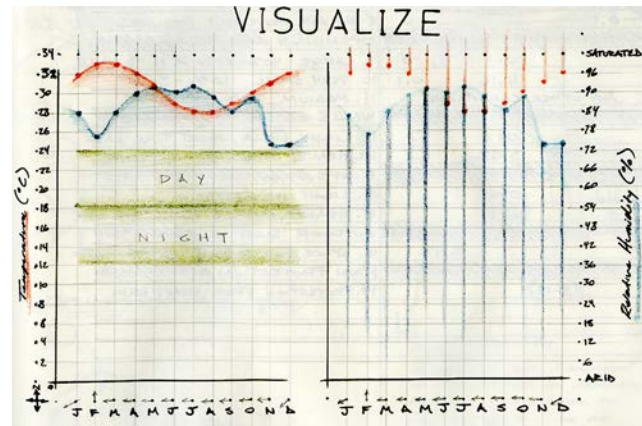
-Antonio Nevada Martinez, editor

<http://www.climateconsultant3.com>

Temperature Range

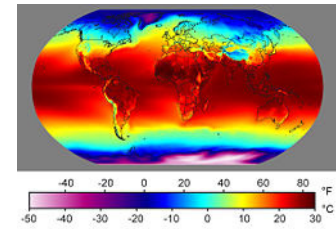


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4	MONTHLY MEAN MAX																31	30	30	30	31	32	32	32	32	32	32	30	30	30	30	32	37		
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8	TABLE 2																HUMIDITY, RAIN, WIND																		
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11	AVERAGE																68	69.5	69	69	69.5	62	62	62	62	62	62	62	62	60	60	60	60	60	
12	RAINFALL MM																239	402	455	397	278	198	149	117	150	150	94	205	205	205	205	205	205	205	TOTAL
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14																	SECONDARY		SE	SW	SE	SW	NE	NE	NE	SW	SW	SE	SE	SE	SE	SE	SE	SE	
15	TABLE 3																DIAGNOSIS OF CLIMATIC STRESS																		
16	TEMPERATURE DEGREES C																1	2	3	4	5	6	7	8	9	10	11	12	HIGHEST	AMT					
17	MONTHLY MEAN MAX																31	30	30	30	31	32	32	32	32	32	32	30	30	30	30	32	37		
18	DAY COMFORT																27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	
19	WIND																23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23		
20	MONTHLY MEAN MIN																21	21	21	21	21	21	21	22	22	22	22	22	22	22	22	22	22		
21	WIND COMFORT																23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	23	
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31	WIND																17	17	17	1															



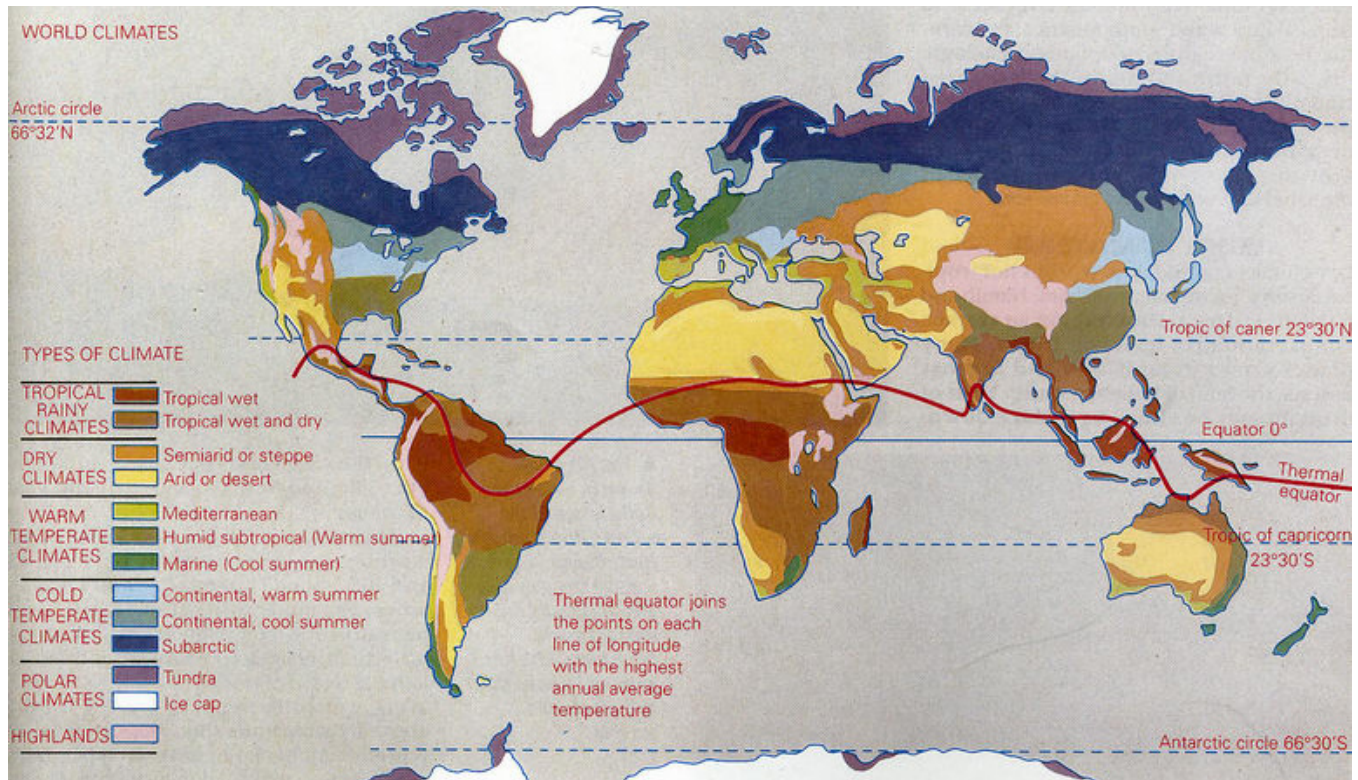
Climate Region Classification (Macrosite Analysis)

<http://www.geocities.com/profemery/pavement.html>



Annual Mean Temperature

Thornthwaite Map of Global Climate Regions (1948) :



ANTONIO MARTINEZ 6

HOLLAND HECK 3

MICHAEL SUPINO 12

MEGAN STOKES 11

ROBYN SCHAFFER 9

ASHLEY SG KEANE 5

MICHAEL VINO 14

ADRIANE REED 8



OMAR VILLA CEVALOS 13

LAURI ZANINE 15

JESSE CAMPBELL 1

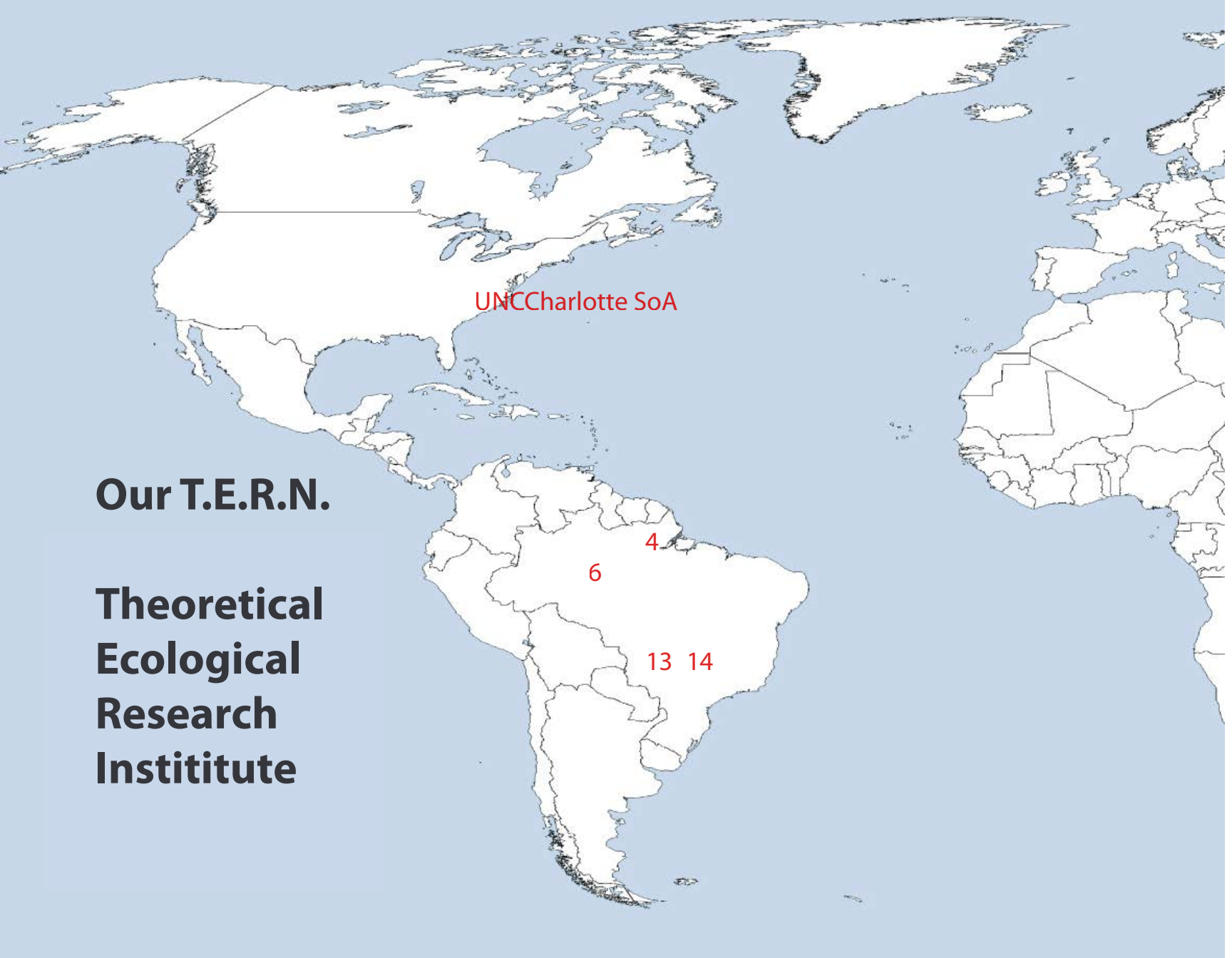
NIKI DESINIMI 2

MARK PELZ 7

RYAN SMITH 10

PROF. DALE BRENTUP

4 BRANDT HEWITT



UNCCharlotte SoA

Our T.E.R.N.

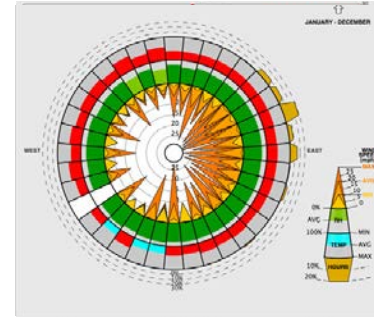
**Theoretical
Ecological
Research
Institute**



Projects

1. Jesse Campbell : Papua New Guinea
2. Niki DeSimini : Kerala, India
3. Holland Heck : Democratic Republic of Congo
4. Brandt Hewitt : Macapa, Brazil
5. Ashley SG Keane : Tozeur, Tanzania
6. Antonio Nevada Martinez : Manaus, Brazil
7. Mark Pelz : Maun, Botswana
8. Adriane Reed : Yemen
9. Robyn Schaffer : Alice Springs, Australia
10. Ryan Smith : Pursat, Cambodia
11. Michael Supino : Kerala, India
12. Megan Stokes : Nukus, Uzbekistan
13. Omar Villa Cevallos : Caraja, Brazil
14. Michael Vino : Mira Estrela, Brazil
15. Lauri Zanine : Jaipur, India

The Project given was a Climatic Responsive Research center in tropical rainforest climate. The location of my building was a remote part of Papua New Guinea. The Independent State of Papua New Guinea is islands located just above Australia in the pacific ocean. It is claimed to be one of the most diverse countries on earth with over 800 languages spoken representing 12% of the worlds. The country has also not been explored much in the past geographically and culturally. Transportation is very hard because of the terrain and mostly just use planes to get around. The land is also quite diverse in that it has large mountains running through the middle of the island and in the lowlands rainforest. The country is devived into 20 different provinces and the research center is located in the Minle Bay region. The country is located near the ring of fire meaning there are a few active volcanoes and earthquakes are also common. Has been slow to develop because of sub-par government, rugged terrain, and the problems with the native tribes. 96% of the inhabitants are of a Christian church, broken up in the most of the different types.

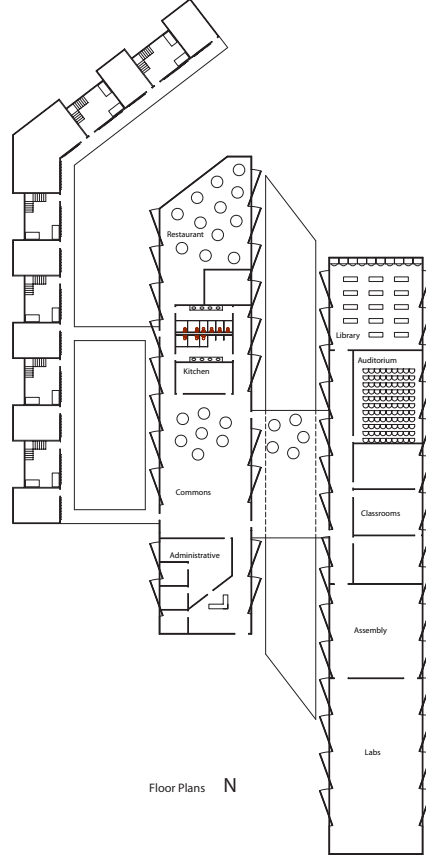


Jesse Campbell



CLIMATIC RESEARCH CENTER PAPUA NEW GUINEA

Floor Plan JESE CAMPBELL

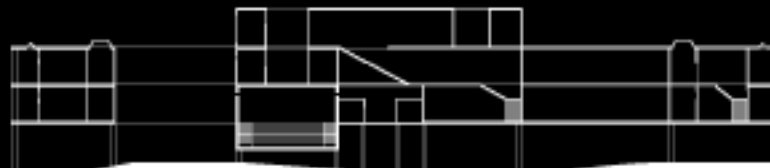
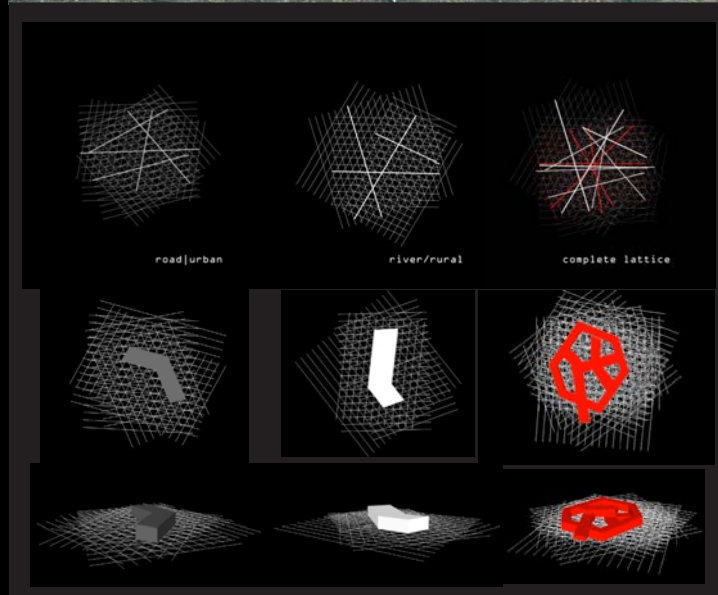


muvattupuzha.kerala.india
self-sufficient taluk center
niki de simini

The natural environment shapes and influences the built environment. In this project, The Kerala Self-Sufficient Taluk Research Center, the architecture came directly from its surroundings physically and metaphorically. In order to develop the form of the structure, a relationship between the river and road was derived by the strategic use of grids. These grids were inspired by the actual river and road system of the site. The lines produced a set of rules that were supported by careful studies of wind, solar, and water patterns. Located close to the southern tip of India in a monsoonal climate region, each of these were taken into extreme consideration when designing. The idea of creating layers of material in order to achieve multiple goals, such as shading, rain protection, etc., proved to be the most effective way to accomplish a comfortable environment. The transition from open air, to a columnar border, to complete protection became the scheme for this building.

The process of creating climate responsive architecture does not simply end at the study of natural forces and events. The cultural influences must be reflected in the structure built. Traditional techniques, such as the inclusion of verandas, were not neglected. The material choice of concrete has been used for years and proves to be one of the most effective means to build, deeming it appropriate for this structure. Courtyards, a traditional Indian element, are evident throughout the complex.

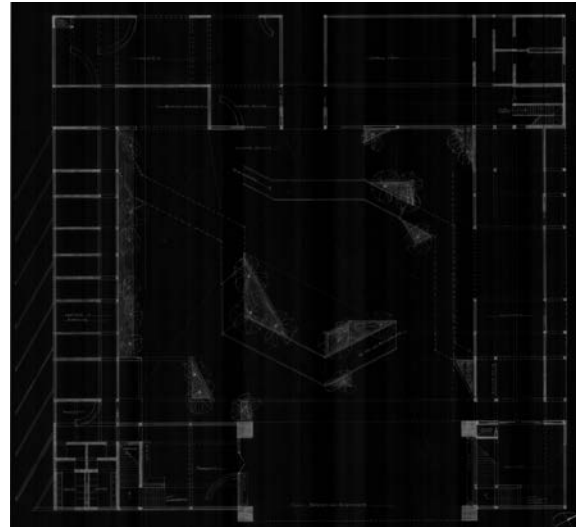
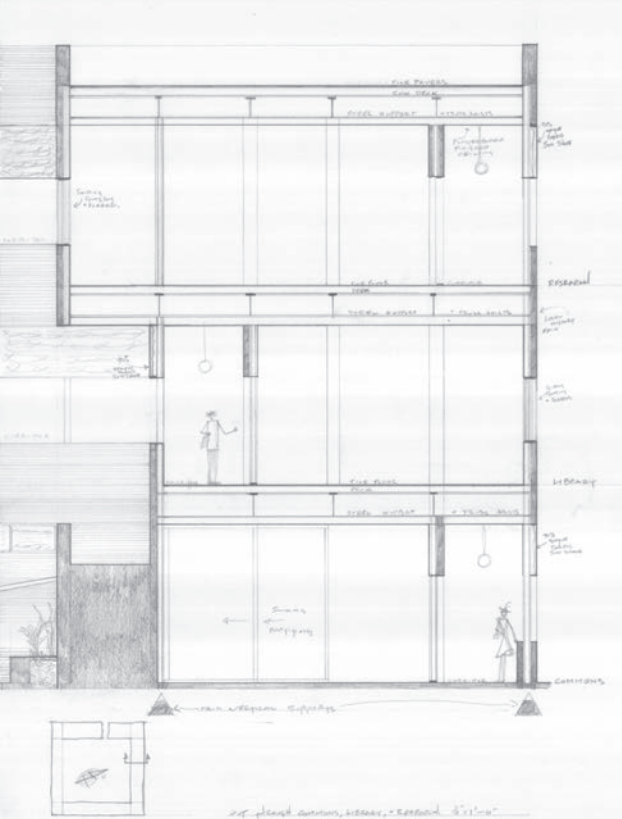
Climate responsive architecture is not produced by loosely studying the environment, but instead, it is about understanding how it feels in that space once these elements of water, solar, wind, and culture are taken into consideration.



Designing for a Bwh Arid Climate in Tozeur, Tunisia

Center for Environmental Studies

Ashley SG Keane



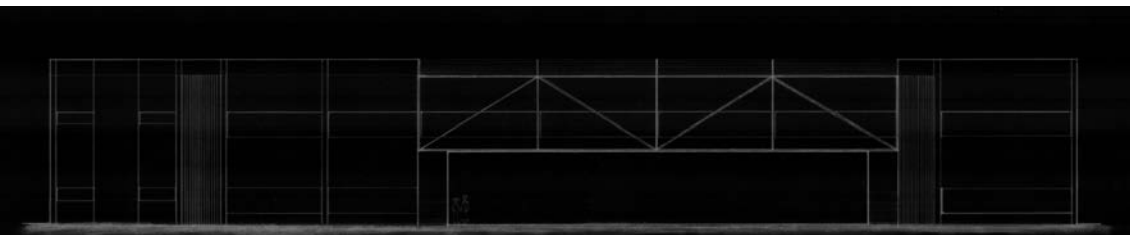
Above Left: Section Cut through the commons, library, and research labs.

Above Right: Plan of courtyard garden with programmatic elements (clockwise from top left: cafeteria, great hall, commons, entrance, admin, and offices). A pair of ramps lead visitors to the auditorium and library above. Bicycle racks are also located in the shade.

Below Left: The front facade would feature the craft of local masons. A truss holding classrooms above the main pedestrian entrance invites people in from the street. Wide circulation stairs are behind the vertical louvres on each side of the facade.

Below Right: The back facade faces the service street behind the complex.

Sun shades throughout are crafted by local weavers.





Above Left: Plan of first floor with programmatic elements (clockwise from top left: auditorium, residences, library, classrooms, and covered gathering space).



Above Right: The top floor plan with programmatic elements (clockwise from top left: auditorium balcony, residences, and research space). All of the roofs are tiled and occupiable.



Above: A section cut through the entrance and a classroom in the truss above.

The center is organized around a central courtyard that is open to pedestrians so that everyone is welcome. The plans are also organized by single loaded exterior corridors.

Tozeur has a long tradition of resisting outside influences. For this proposal, a three dimensional grid is set up to be filled in by local masons. Local weavers also can showcase their craft by making many decorative sunshades. The central garden features indigenous plants and date palms. In this way, the construction and maintenance would belong to the the local people.

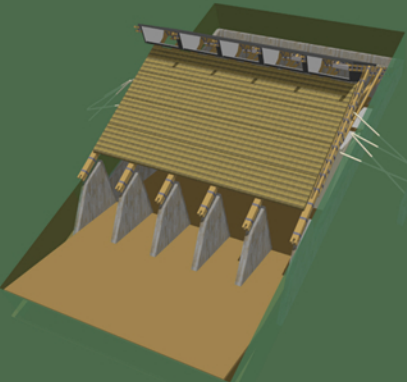
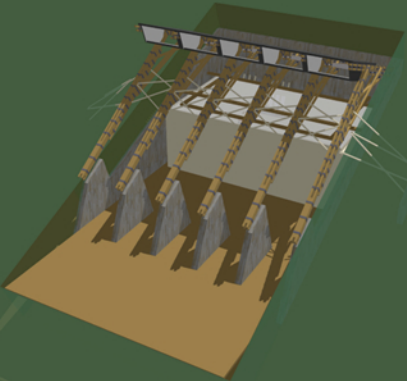
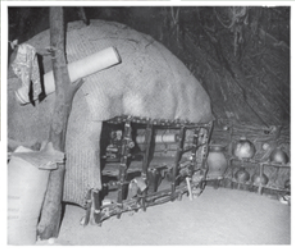


neighborhood next door.



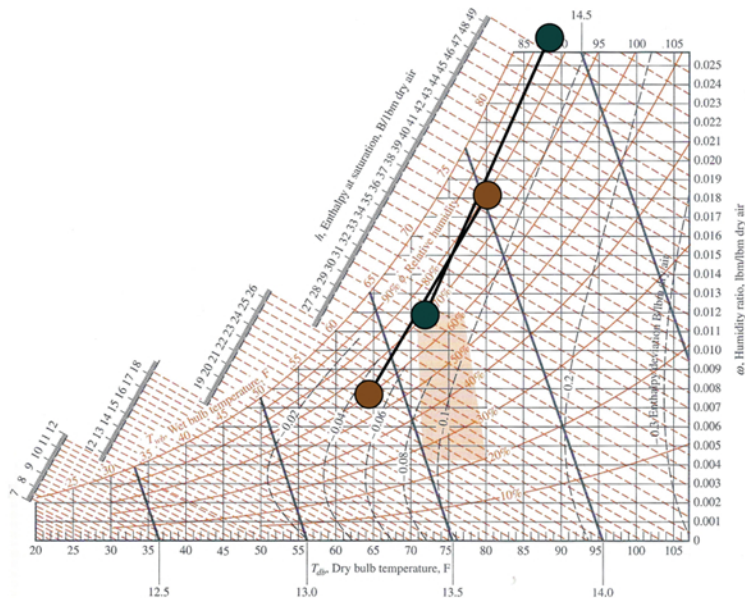
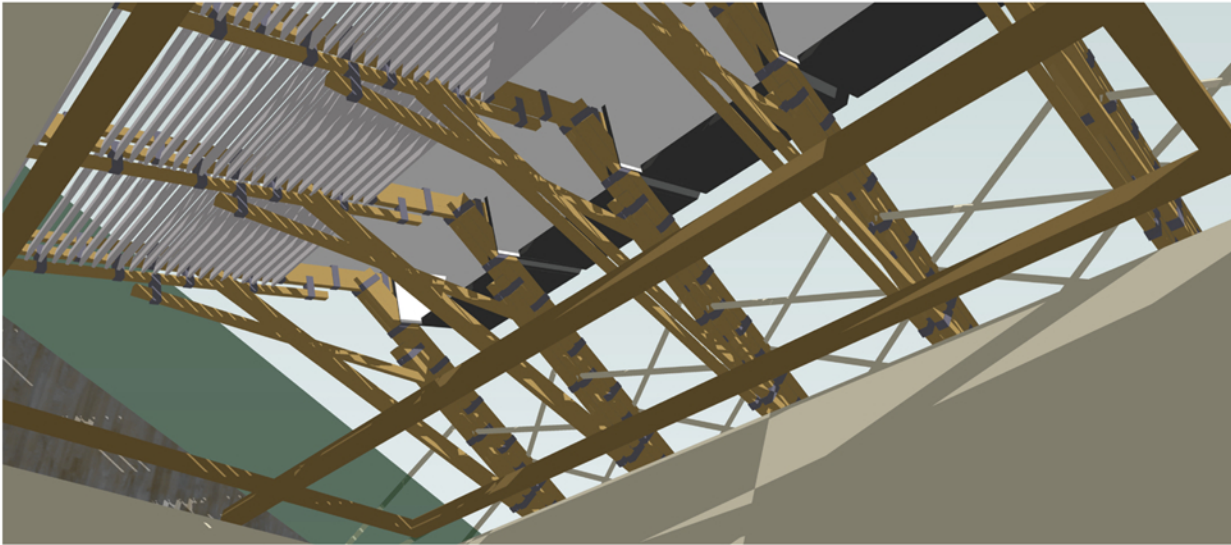
This exercise in the Democratic Republic of the Congo developed in to a system of building that would be an adaptation of traditional typology. The Congo has undergone dramatic westernization in the past one hundred years. The cultural legacy that has developed over thousands of years is being abandoned for foreign building strategies and lifestyles. The key to making this facility an adaptation was to use traditional strategies as a basis for development.

The Congo is an equatorial monsoonal climate at five degrees south in central Africa. The monsoonal season last two thirds of the year while the sun is directly overhead. The regional receives little if any rainfall during the three-month dry season. The psychometric chart on the opposite page shows the typical diurnal temperature changes during the wet and dry seasons.



The pair of images to the left show the building system during different seasons. During the wet season the rafters are covered by a regional thatching system of woven millet straw. The result is a good water barrier that insulates against the high temperature experiences at this time.

During the cooler season the thatch is removed for greater ventilation. This coincides with a three-month drought and the annual need for replacement. Inside secondary inclosures creates interior spaces. These spaces can be cooled by absorptive chilling and evacuated tube solar collectors. In traditional homes a smaller room is found within the home as shown.



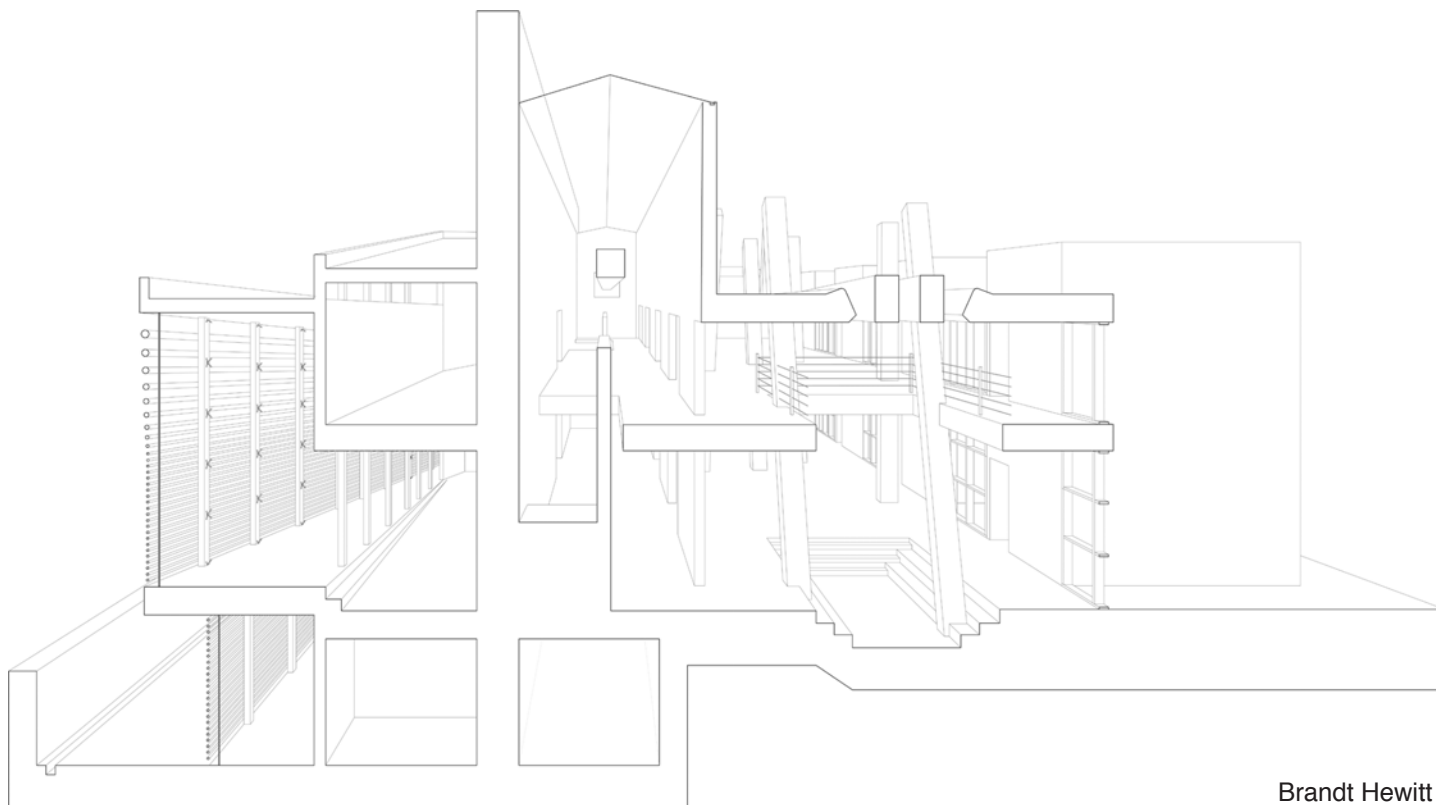
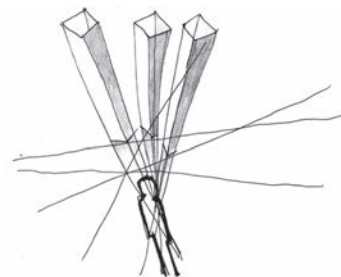
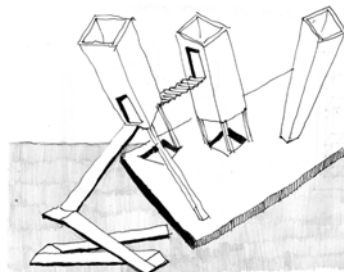
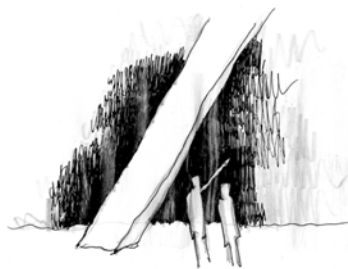
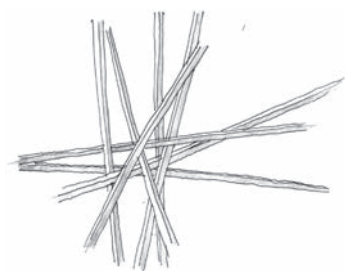
The image above shows the exterior envelope from below during the dry season. Light is diffused louvers with heat up in direct light. The heat generated helps to a convective current of air and is exhausted through a solar vent further up and to the right. Cool air is brought close to the ground and passes by thermal mass.

Traditional support member were made from small-uncut braches bound together. Large timbers were too remote and heavy to be carried by hand. Today, the demand for building materials is too great to be meet locally if large timbers are used. By resawing and fastening it in to large members the smaller and faster growing trees of the region can be more efficiently used. This method is inspired by traditional strategies and allows for greater dimensional stability.

The National Academy of Sciences: Macapa

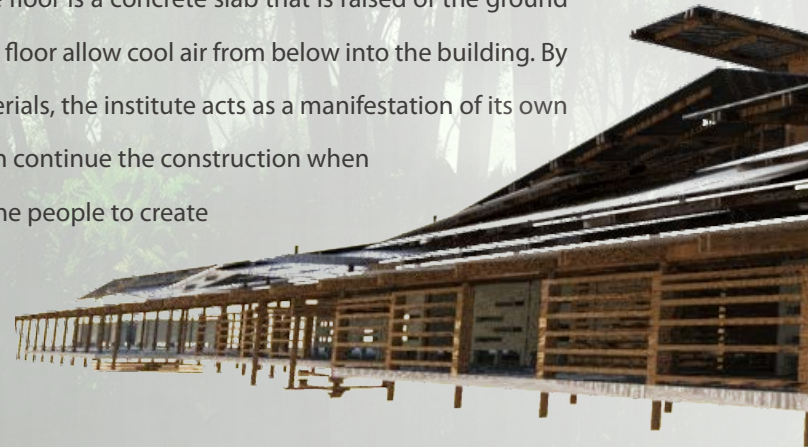
The National Academy of Sciences: Macapa is sited on Avenue Equatorial in Macapa, Amapa. Macapa lies exactly on the equator in the estuary of the Amazon River and Atlantic Ocean. Twice a year, between the months of February and March when the water level in the Amazon is at its lowest, a tidal bore known as the Pororoca occurs. This natural phenomenon happens when the Sun and Moon are aligned with the Earth, creating a large gravitational pull on the water on Earth's surface. The Atlantic rushes into the Amazon, sending four meter high swells down the river that destroy all in their path. The notion of the Pororoca as a destructive and erosive force becomes the framework that dictates many of the formal and compositional decisions. The building functions as an observatory and institute for measuring the effects of global warming on a global scale by looking directly to the habitat of the thriving estuary and studying the effects of the wave over a span of several years. This study strives to relate the effects of global warming on the local scale to more global trends.

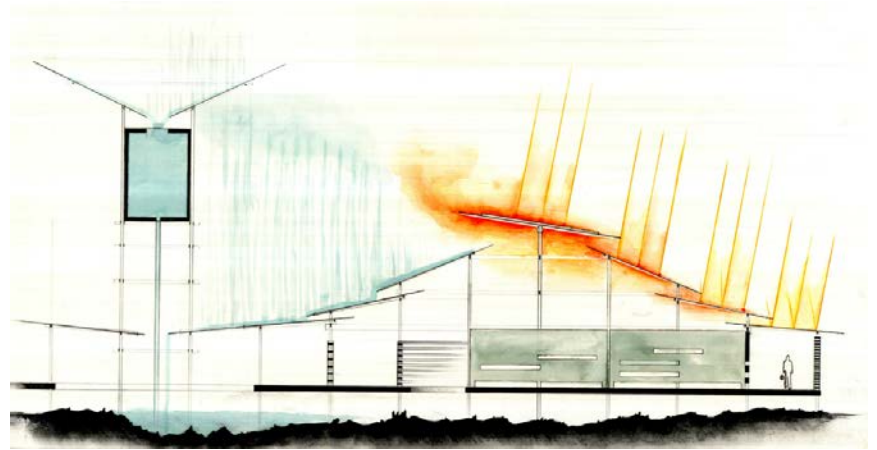
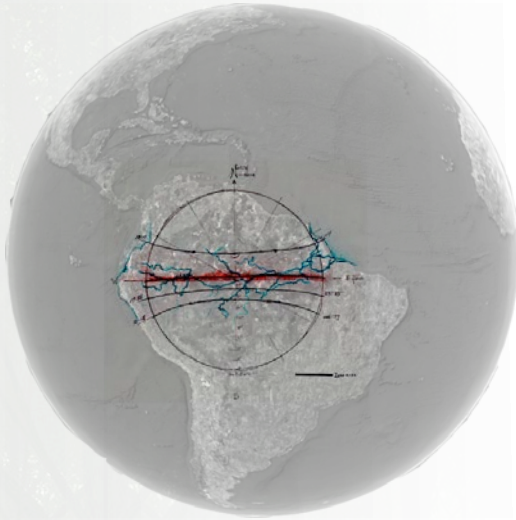




Brandt Hewitt

The Ecological Institute of the Amazon was formed to strengthen the relationship between mankind and Earth. While the Amazon Rainforest and the Amazon River support the most complex examples of natural harmony between all other species, mankind has begun to disrupt that harmony. The project to house the institute established a method of construction that will manifest the built environment in a way that is congruent to the natural environment and promotes the education of said harmony. Set on a previously and illegally cleared site 5km south of Manaus, Brazil, the project will be exposed to ample direct sunlight and 2 meters of rain per year. In response, the rainforest forms a canopy to absorb sunlight and redirect rain. The building's roof system is comprised of layered sheets of corrugated metal, which are colored and gauged to optimize stack ventilation. A more reflective galvanized aluminum is used the lowest and outermost layer, while dark steel and photovoltaic panels make up the uppermost, middle layer. This top roof layer also has the largest surface area, and a pulley system which enables it to be manually adjusted to achieve the optimum angle for absorption on any given day. This interaction with the building and its environment through the inhabitants is crucial to the institute's ideology. The rainforest canopy is held up by a complex system of branches known as the understory, which directs the circulation of the wind and forest inhabitants. In the building, this layer is made up of salvaged timber and joined without any fasteners. Concrete walls cast in the earth modulate the interior spaces and The floor is a concrete slab that is raised of the ground to allow for air to circulate underneath, while punched openings in the floor allow cool air from below into the building. By only using efficient methods of construction and absolutely local materials, the institute acts as a manifestation of its own ideals. This modular solution can be utilized by its inhabitants, who can continue the construction when expansion is needed. The project itself is not an end, but a means for the people to create their place. It is an organic modular derived from the layers of the Amazon Rainforest.





The Ecological Institute of the Amazon Manaus, Brazil

3 degrees north, 60 degrees west

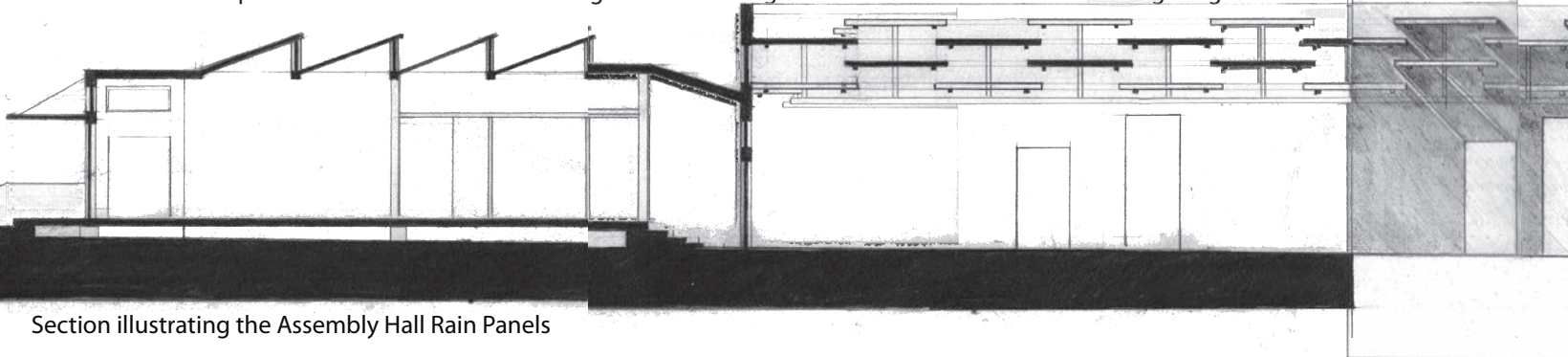


M a u n , B o t s w a n a

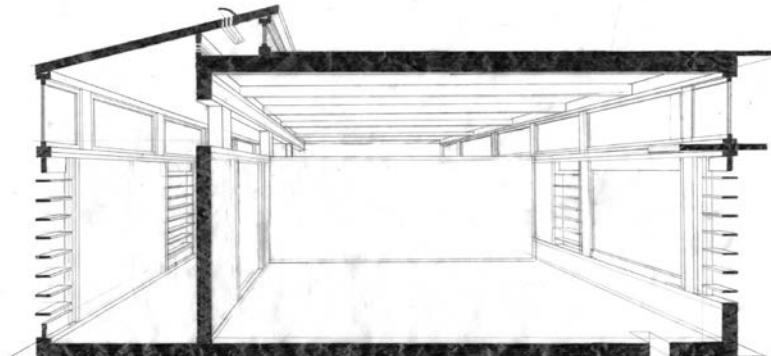
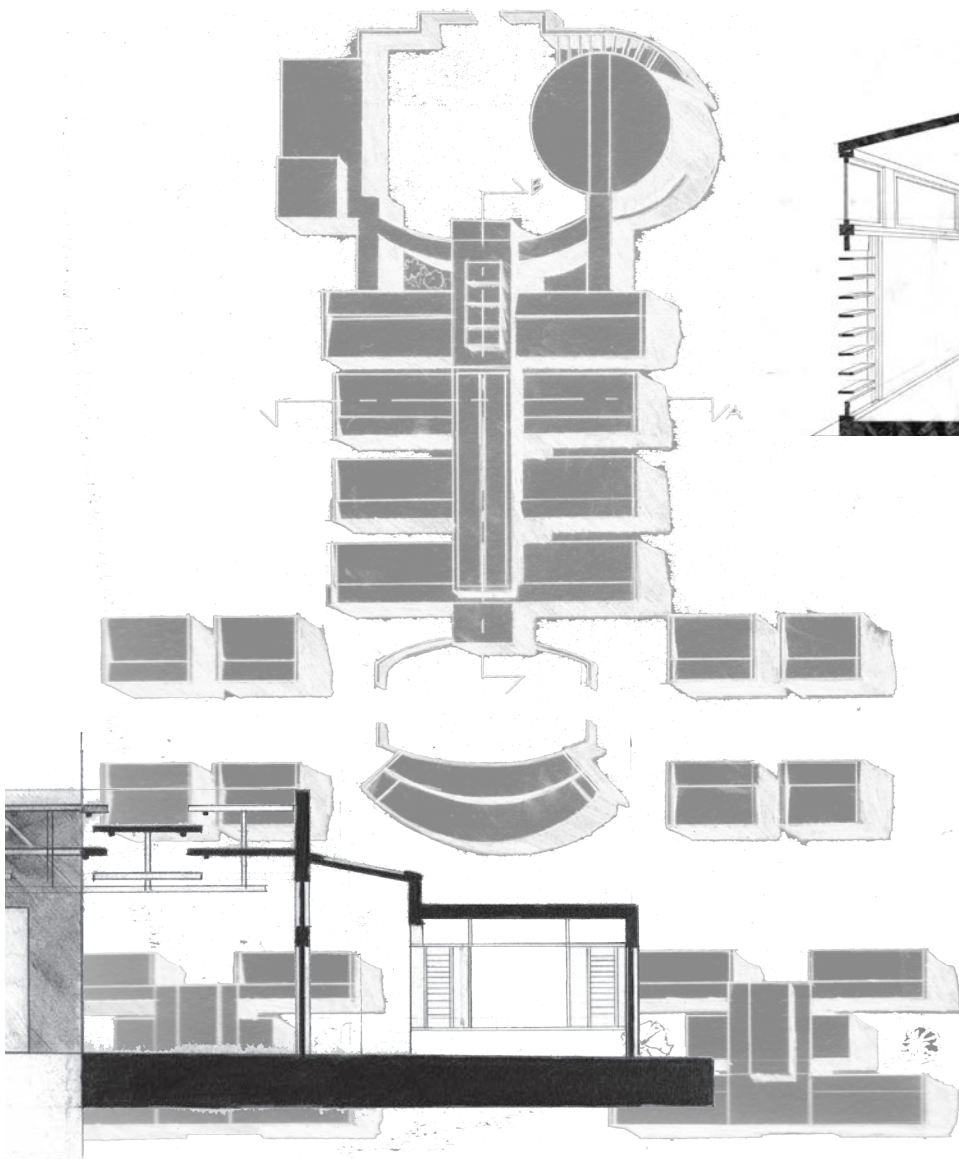
Semi-arid steppe

The site in sub-saharan southern Africa is where the Okavango Delta, the world's largest inland delta, meets the large and arid Kalahari Desert. The climate created out of these two converging geographies is one that experiences both a wet and dry season with vast diurnal range for temperature both daily and seasonally. This is an area where nights and mornings can be very cold and the days heat up quickly and intensely. The Rainfall recieved reaches +18 inches annually and prevailing winds due N to NE have a mean monthly range of 3 - 5 meters per second.

The design intention was to develop a building system that would respond to the climate with regards to environmental and cultural consideration, staying within the means of the local eco-culture and enviroconomy. This is a theoretical building concept based on modular construction intended to serve as a prototype for campus-based research facilities in similar climates around the globe. The structure is a simple system involving a concrete plinth, timber-framing, structurally-insulated-panels, and a corrugated roof and is conceived as a quick construction process. The climate response systems of the design involves an operable building envelope that would permit the inhabitant to control air flow and lighting for certain nodes. Both cross-ventilation and stacked-ventilation are methods used for circulating air and they are promoted by manual louvres which are a staple of the design. Light shelves that manually slide between exterior and interior space control levels of direct heat-gain while having influence over direct and indirect lighting.



Section illustrating the Assembly Hall Rain Panels



Perspective Section of the office structure



Rendering of Assembl Hall

Climate Research and Education Center: Alice Springs, Australia

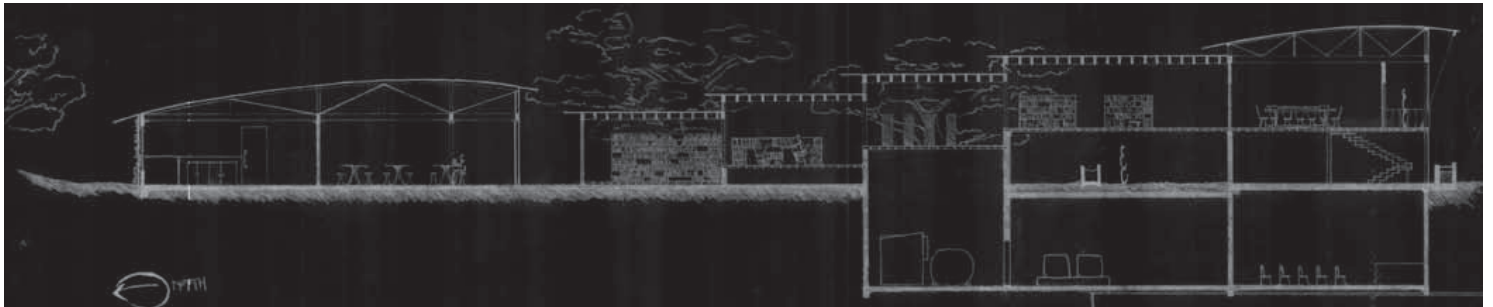
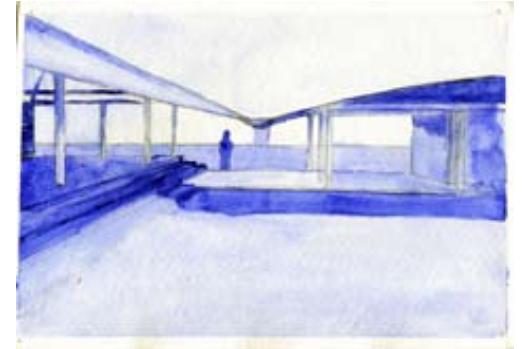
This interpretive center was intended to be a response in built form to the climate and culture of Alice Springs, Australia. Research about the Place revealed a fairly developed area, unlike many of my classmates' sites, so my biggest challenge was to respond to an established vernacular and to the peculiar climate. The most interesting thing about Alice Springs is its rain patterns: no more than ten inches per year and all during a monsoonal period of a couple of days. During this period the major river, the Todd, floods its banks and most of the city. The festivities surrounding the flooding of the Todd are a large cultural event and the significance of this mighty [dry] river was something I wanted to reference in my design. That is where the idea for the narrow water cisterns came from and they worked not only as a means by which to separate program, but also as a source for evaporative cooling on the southern façade of the education center.

The other significant element of climate I had to design for was how hot and dry it is which meant two things: shade! and ventilation. The tricky part about designing in the southern hemisphere is remembering that the sun's axis leans towards the north; whereas in the northern hemisphere southern sun is considered undesirable, the northern facades must be shaded in Alice Springs. I felt that it was important to stick to a thin, lightweight structure that encouraged permeability and a feeling of lightness. While I did not quite figure out all the specific materials for the complex, I wanted to use light materials that could not only respond to the climate, but also to the culture. Alice Springs does not contain a lot of natural resources, except some stone products, so all the materials need to be easily shipped in. Some of these materials include corrugated steel (for the roofs), concrete (for the foundations and trombe walls: it is easy to pour in place once on site), and steel mesh panels (for shading devices and the green screen on the northern façade of the research area).

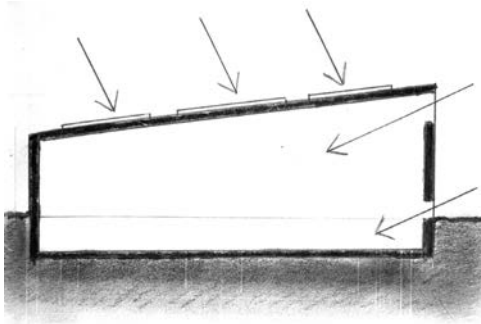
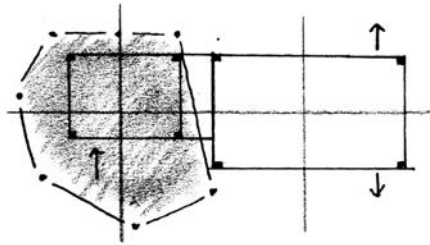
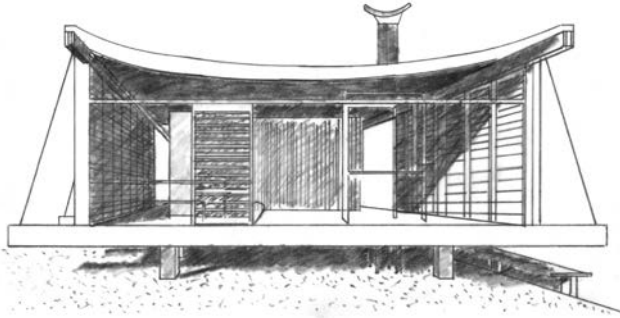
As far as the compositional configuration of the center, I began with three separate forms, all basically rectilinear, and over time melded them together to form a more suitable courtyard space between the research and educational areas. It took a long time to resolve the way in which the residential spaces would be linked to the main complex, but I decided on a pathway, guided by narrow cisterns, that linked the main courtyard with the residential courtyard. The two spaces are visually linked as well, while being in one you can always see the other from certain angles, allowing free movement with a screen of privacy.

All the northern facing facades were shaded by means of a green screen, an extended, bowing roof line, or a concrete trombe wall that collected heat during the day and was allowed to ventilate at night. I oriented the residential block east to west to maximize southern exposure in the living areas: the kitchen and living room/entryway and used the same tactic with the rest of the complex: placing high-use areas towards the southern facades.

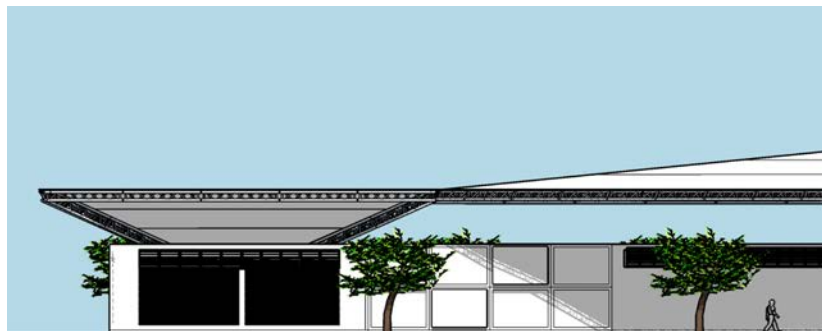
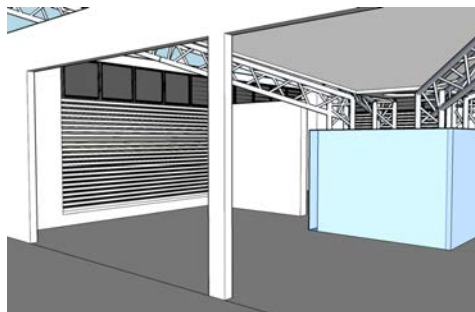
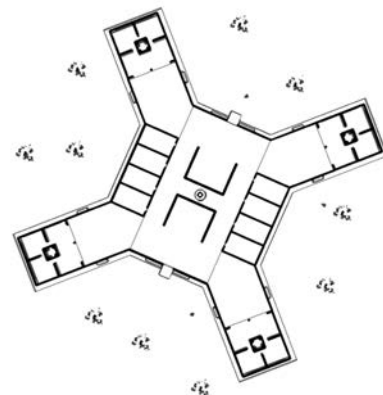
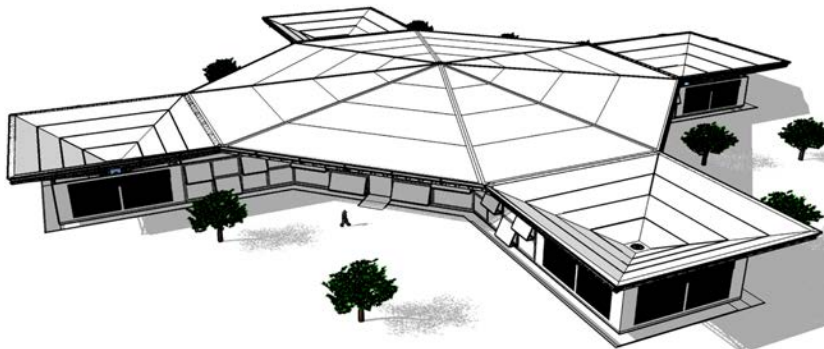
Overall I wanted this center to be a place of learning about the climate and culture that Alice Springs has to offer through means of well-designed spaces and enjoyable exteriors and I think I took great strides towards achieving it.



robyn schaffer.



IN THE PURSAT PROVINCE OF CAMBODIA, CLEAN WATER IS A PRECIOUS NECESSITY. CLASSIFIED AS MONSOONAL, PURSAT IS SUBJECT TO A RAINY SEASON LASTING ALMOST FOUR MONTHS OF EACH YEAR. HOWEVER, THE PEOPLE OF PURSAT HAVE LITTLE TO NO ACCESS TO ANY FORM OF CLEAN DRINKING WATER FOR MOST OF THE YEAR. MY DESIGN PROPOSAL IS DRIVEN BY THE OPPORTUNITY TO UTILIZE RAINWATER THROUGH THE USE OF A ROOF STRUCTURE DESIGNED TO COLLECT RAINWATER FOR FURTHER STUDY ON WATER PURIFICATION TECHNOLOGY. THROUGH THE USE OF A LARGE, SELF-SUPPORTED ROOF STRUCTURE, WATER IS COLLECTED BY FOUR MODULES ON THE PERIMETER OF THE CENTRAL MASS OF THE ROOF STRUCTURE. THE WATER IS TRANSFERRED FROM THE ROOF, THROUGH THE BUILDING, AND DOWN INTO A COLLECTION POOL THAT SITS DIRECTLY UNDER THE STRUCTURE. BENEATH THE COLLECTION ROOF, A SUSPENDED FLOOR SLAB HANGS FROM THE ROOF SUPERSTRUCTURE, AND SEEMINGLY FLOATS ON THE WATER POOL BELOW. THROUGH THE USE OF LOUVERED PANELS AND AN OPEN AIR STRATEGIES, THE INHABITABLE SPACE IS SUBJECT TO CROSS VENTILATION. "CLERESTORY" SPACE BETWEEN THE INTERIOR WALLS AND THE OVERHEAD ROOF STRUCTURE PROVIDE THE BUILDING WITH DAYLIGHT. THIS DESIGN SHOWS HOW DESIGN STRATEGIES CAN BE USED TO UTILIZE A NATURAL RESOURCE FOR STUDY, TECHNOLOGY, OR ENVIRONMENTAL DISTRIBUTION.





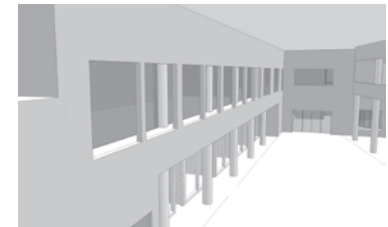
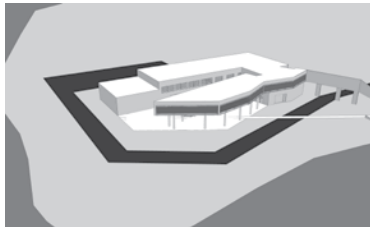
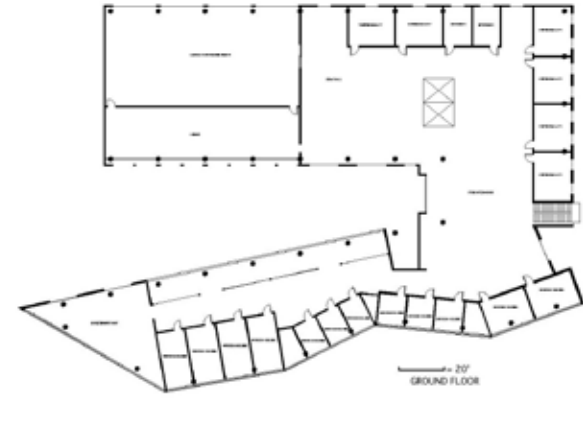
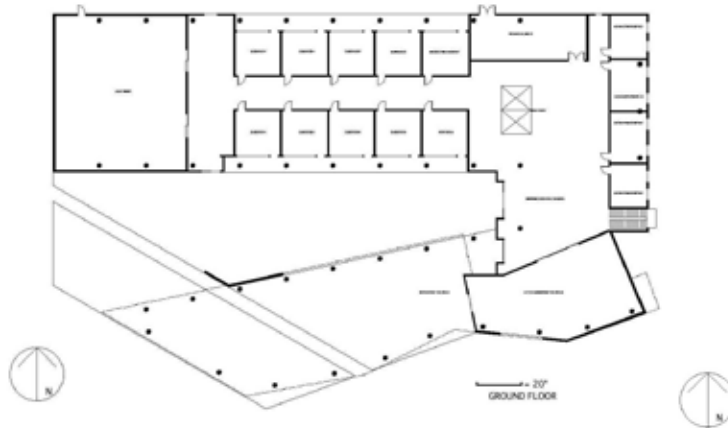
Center for Global Environmental Studies

Nukus, Uzbekistan

Uzbekistan's climate is strongly influenced by its location in the northern band between the subtropical and temperate zones. High solar radiation, coupled with the unique features of its surface and air circulation patterns form a continental-type climate. This climate is characterized by seasonal and day-to-night fluctuations in temperature, long, hot, and dry summers, humid springs, and irregular winters. Highly arid, continental, tropical air forms in the summer months, intensely heating the deserts. On the whole, precipitation is minimal (within the range of 3-8 in a year), yet very unstable. Uzbekistan's territory is penetrated by diverse air masses. Transformed Atlantic and Arctic air masses penetrate the vast plains from the North and Northwest. Penetration by tropical air masses and warm southern cyclones can occur across Central Asia, particularly during the cold half of the year, provoking intensive warming and abrupt changes in the weather and an average of ten sandstorms a year.

Formerly located on the Aral Sea Nukus, is the fastest growing city in Uzbekistan due to the deteriorating environmental conditions in the surrounding countryside. The surrounding area is being turned into a wasteland by wind-borne salt and pesticides. Water is a very limited resource and the local supplies are highly polluted due to the misuse of the supply. Even though it is the fastest growing city it has been deemed the true "middle of nowhere".

While researching the site it became obvious that a defensive approach was to be engaged in order to respond to the climate. The design intent was a pragmatic building with a sculptural flair that responded to its environment. A single complex would allow for movement between areas without having to confront the exterior elements unless desired. The North wing, for the most part, is a rectangular block where as the south wing is more dynamic. Part of it sits on pilotis, creating a shaded plaza on the south. Both volumes frame a paved courtyard. The varied facades take their cues from the sun. The housing was located in the South wing since it would receive the most direct sunlight and would be the least populated during the daylight hours. A trombe was used on this facade to utilize the sun for heating purposes in the evening hours. In the North wing glazing walls were recessed at least three feet from the facade in order to shade the interior from direct sunlight.



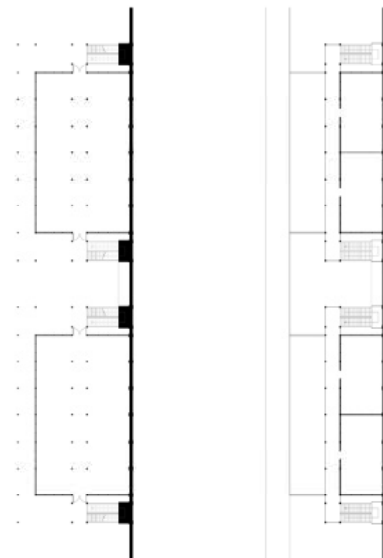
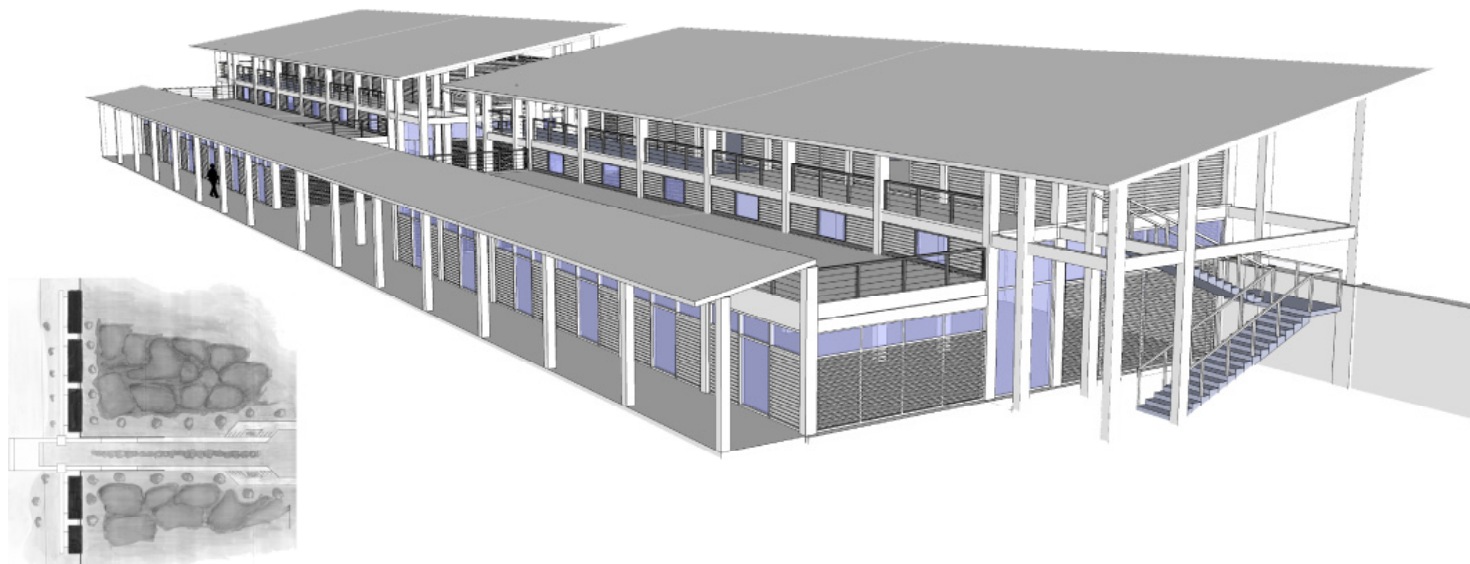
Kerala Research and Educational Center

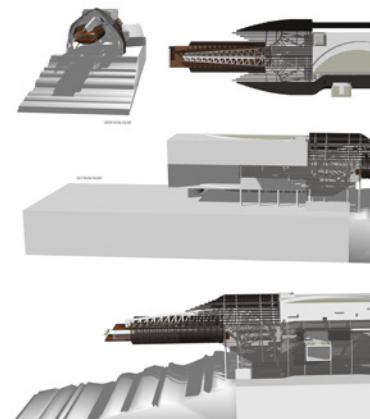
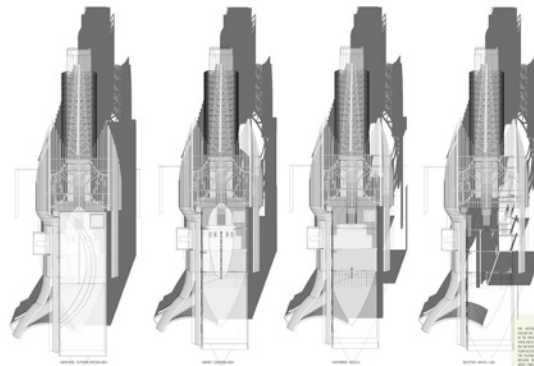
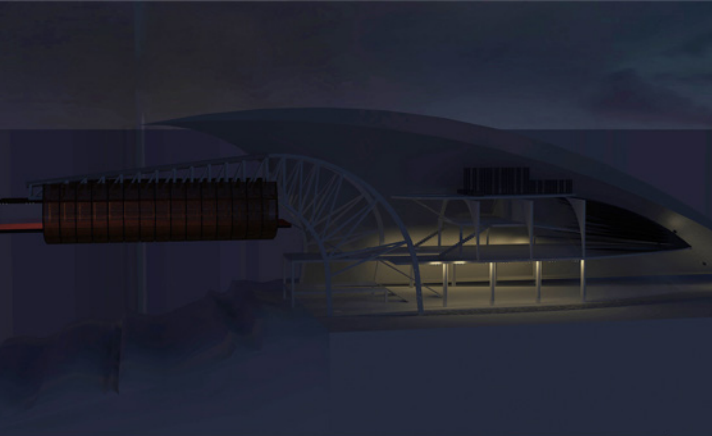
Ashtamudi Lake Kerala, India

The Kerala Research and Educational facility is located on the southwest tip of India in the state of Kerala. It borders, Ashtamudi lake, one of the main lakes in the district. The facility responds to climatic and cultural characteristics of the area. The construction methods are derived from local masonry and timber construction. Specific climatic adaptation in local building styles, like broad overhangs or verandahs, have been implemented in the design. The main axis of the facility ends with a symbolic gesture of the connection to the water and the importance of water to the people and culture.

The facility also serves as an example of how a building can function with and respond to a specific climatic region. The monsoonal equatorial area is a hot humid climate that has extensive rainfall from June until September. The average monthly temperatures vary slightly and provide a fairly constant approach to sustainable design in this area. As the psychrometric chart shows, the greatest opportunities to reduce the need for conventional air conditioning are shading, evaporative cooling, and ventilation. The building responds to the issue of shading by hiding beneath a double corrugated, highly insulated and ventilated, metal roof. This roof provides a barrier that will help to reflect a larger percentage of solar radiation back into the atmosphere. It will provide the first line of defense against overheating, which is the biggest problem in that area. To increase the buildings cooling potential, it has been oriented axial and placed so that it is protected from the driving rain of the monsoonal period but can accept natural ventilation from the land sea affect that dominates the breezes during the rest of the year. The next level of protection involves a green roof above the first level in efforts to gather water, that is essential in the dryer months of the year, and create an opportunity to use direct evaporative cooling to further reduce the interior temperatures in the lower level. The key to the building is a shell that consists of operable louvers that can let the seasonal breezes and light in or keep them out. The louvers add a level of manual operation that can adjust to variations through days or seasons.

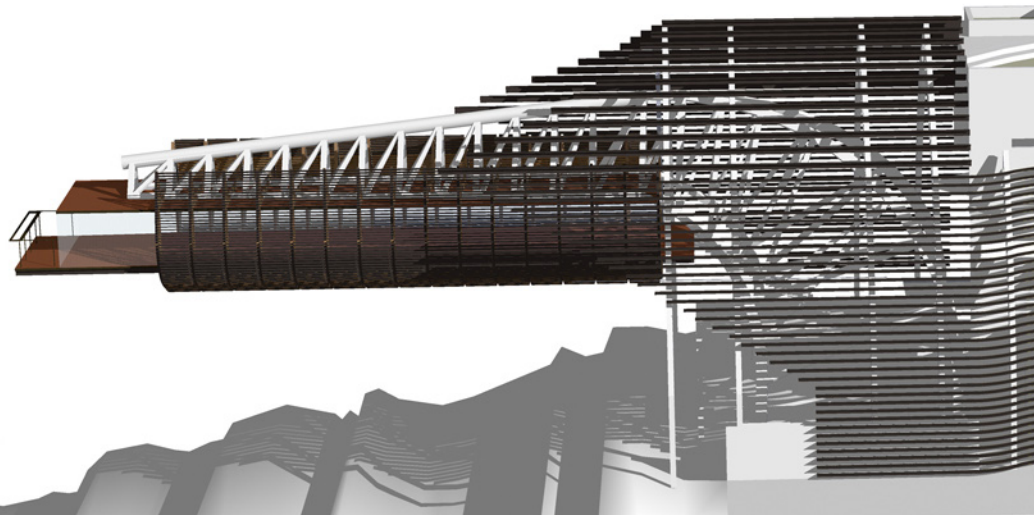
The combination of all elements creates a building that is dynamic and can be adapted to seasonal or daily variations in the climate of Kerala. The use of traditional construction methods and religious symbolism help to make the design relate and connect to the local culture and community.





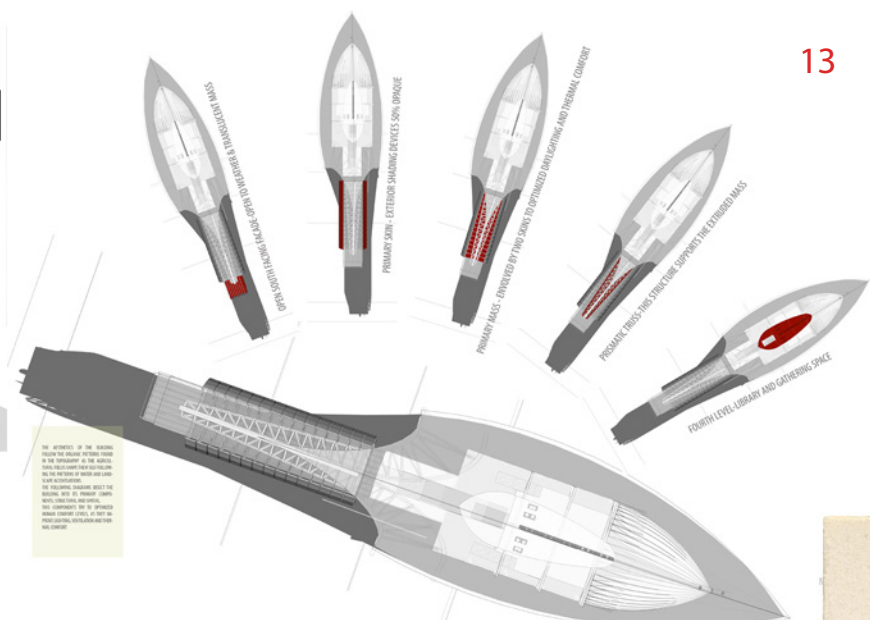
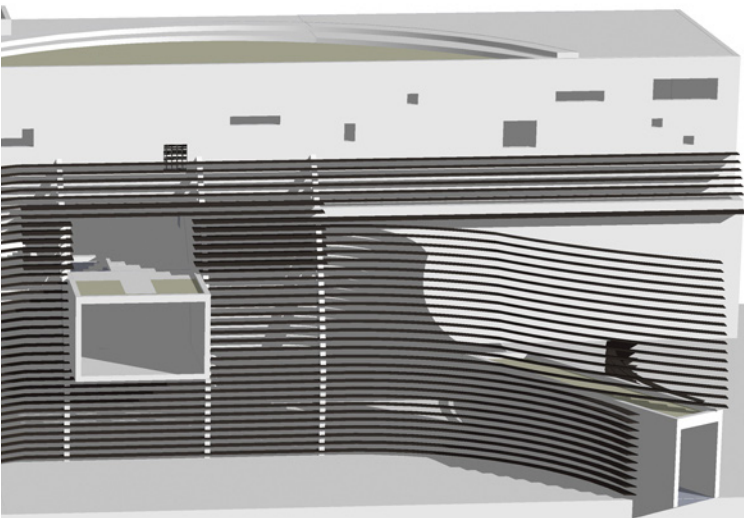
RESEARCH FACILITY - CARAJA BRAZIL ARCH STUDIO FALL 2008 - CLIMATE AND CULTURAL RESPONSIBLE ARCHITECTURE
HOT HUMID CLIMATE - KARAOCTAL RESEARCH FACILITY, LOCATED SUBURBAN OF CARAJA BRAZIL

RESEARCH FACILITY - CARAJA BRAZIL ARCH STUDIO FALL 2008
HOT HUMID CLIMATE - KARAOCTAL RESEARCH FACILITY, LOCATED SUBURBAN OF CARAJA BRAZIL

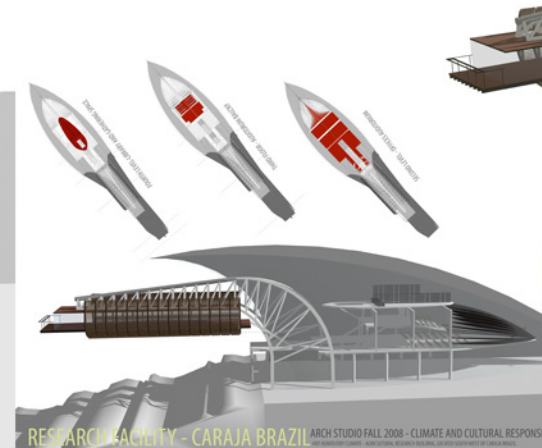


FACILITY - CARAJA BRAZIL

ARC
HOT HUMI



RESEARCH FACILITY - CARAJA BRAZIL ARCH STUDIO FALL 2008 - CLIMATE AND CULTURAL RESPONSIBLE ARCHITECTURE
HOT HUMID TROPICAL CLIMATE - AGRICULTURAL RESEARCH BUILDING, LOCATED SOUTHWEST OF CARAJA BRAZIL.





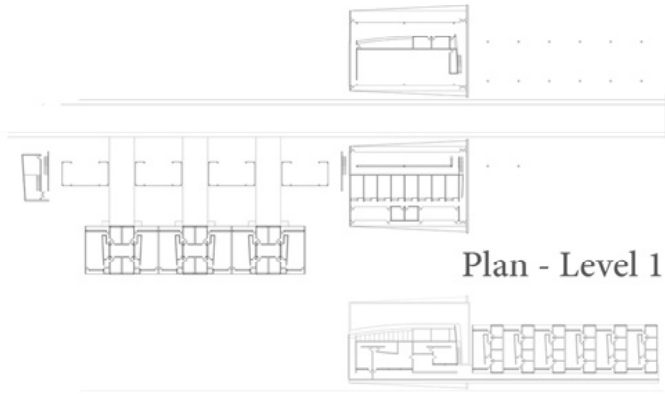
Educational Center for Global Environmental Research

Mira Estrella, Brazil

Preface

This studio emphasizes the importance of an intelligent design. There is an interaction between the architecture and its position upon a site, the methods + culture it will interact with, and the climate it will ultimately have to pay respect to and address the interior comfort. This project is a research facility that will have to address a climate with two extreme seasons. One being a hot - dry season + the other being a cold - wet season. The site is located in Mira Estrella, Brazil, which is a small agriculturally dependant town located southwest of Brazil's capital. Even though this community has a small population of 2,600 inhabitants, it has an urban quality to it. The intent to address this urban quality was formulated through the organization of its program within two facilities. One being an educational facility that houses classrooms, labs, a library, and an auditorium. The second facility is parallel to the first and bridges the street. It houses dorms and the chancellor's courtards. Both facilities are linked at the street level with public space. This space mirrors itself aesthetically and is intended to bridge the street. The public space provides a great hall, two dining facilities, two lobbies, offices, and conference rooms. My intent was to not only pay respect to the environment in which it resides in, but to incorporate the community within its performance. I decided to take advantage of the dominantly agriculturally based economy to provide locally produced products for the research center. This enticed an open air market to be incorporated within the programs. These markets are shaded by the classrooms above and activate the street level. A small cafe is still incorporated within each facility but the market will take place of a primary eating facility. This market will allow local farmers and ranchers to provide a more sustainable approach for providing food to the facility. The interior comfort will be controlled independently within each space. The facility is located along a main avenue and takes advantage of a north facing position. Movable louvers, vents, and hangovers provide shading from direct light and natural ventilation to cool a space. The positioning of roof top gardens are placed above the classrooms, a cafe, faculty lounge, and the conference room to extract heat from the spaces used primarily during the day. They also allow the activation of the community to address this space. This facility is a concrete structure and it allows the concrete to act as a thermal mass to heat the spaces at night when temperatures mainly fall to mid 60's. The classrooms and dorms are rapped to allow the heat to become dispersed throughout the entire space evenly.

Michael Vino



Plan - Level 1

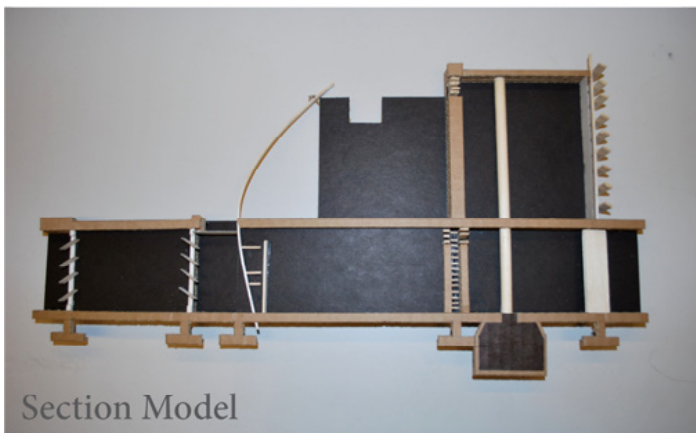


Plan - Level 2

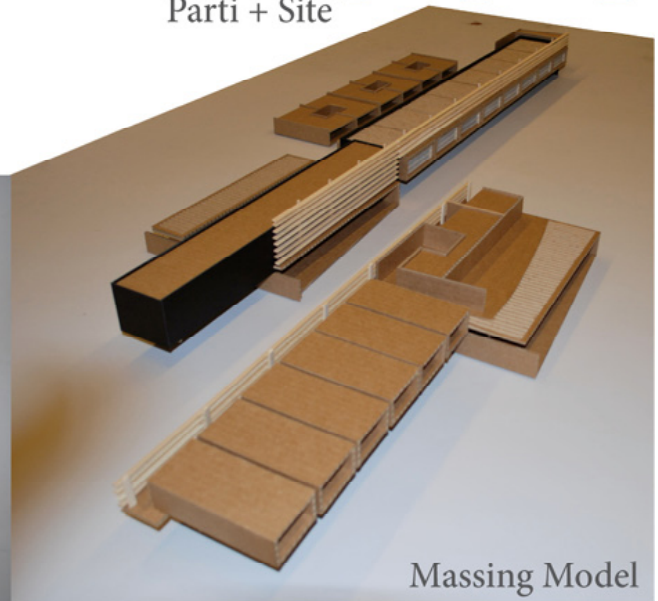


Open Market

Parti + Site



Section Model



Massing Model

PROJECT: PERSPECTIVE

SITE: ~JAIPUR, RAJASTHAN, INDIA

LOCAL ISSUES: POPULATION DENSITY, CASTE BASED PREJUDICES, AIR & H2O POLLUTION, FOOD PRODUCTION & H2O CONSUMPTION

OBJECTIVE: CREATE A DATUM LINE ON X AND Y PLANES

CREATE TENSION OVER DATUM LINES USING HUMAN CIRCULATION, OCCUPANCY, MATERIALS AND STRUCTURE

ADDRESS CLIMATE RESPONSIBILITY THROUGH ENVELOPE/ SKIN

APPROACH SOCIAL ISSUES WITH OCCUPANCY AND CIRCULATION

STRUCTURAL CONSIDERATIONS: BASE ISOLATORS AT COLUMN BASES, 6' MODULE, 12' & 24' O.C. COLUMN SPACING

MATERIALS: PRIMARY- TRANSBUOYANT CONCRETE

SECONDARY- TRI*CHORD STEEL

SKIN- SPHELAR, SOLARWALL & 'PHOTOVOL GLASS'

DUALITIES

"BLUE" BUILDING

"BROWN" BUILDING

PLAINS

RURAL

DIVERGING

PRODUCTION

SKY

TENSION

TRANSPARENCY

MOUNTAINS

URBAN

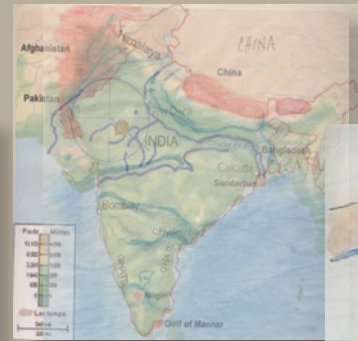
CONVERGING

CONSUMPTION

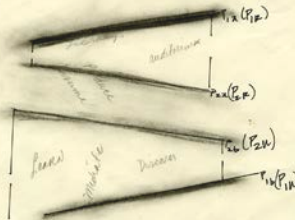
GROUND

COMPRESSION

OPACITY



PUT ON GRID
3D for 4.33



2 - RUGBY 4 - VEGAN

P2 is - dissolve; P2 is - Fresh Green

CONVERGING + DIVERGING; PARALLEL LINES; $TAN = \frac{SIN}{COS} = \frac{Rise}{Run}$



LAURI ZANINE FALL 2008



JAIPUR MOUNTAINS



MASSING



LAURI ZANINE FALL 2008

Students

Jesse Campbell
Antonio Martinez
Mark Pelz
Niki DeSimini
Adriane Reed
Ryan Smith
Holland Heck
Ashley SG Keane
Robyn Schaffer
Omar Villa Cevallos
Michael Vino
Lauri Zanine
Brandt Hewitt
Megan Stokes
Michael Supino

Instructors

First Year

Jeff Balmer
Jeremy Fisher
Jason Slatinsky
Greg Snyder
Michael Swisher
Peter Wong

Second Year

Deborah Arbes
Nick Ault
Jeff Balmer
Josie Holden-Bulla
Emily Makas
John Nelson
Herb Sprott

Third Year

Dale Brentrup

SITE

WATER

MATERIALS

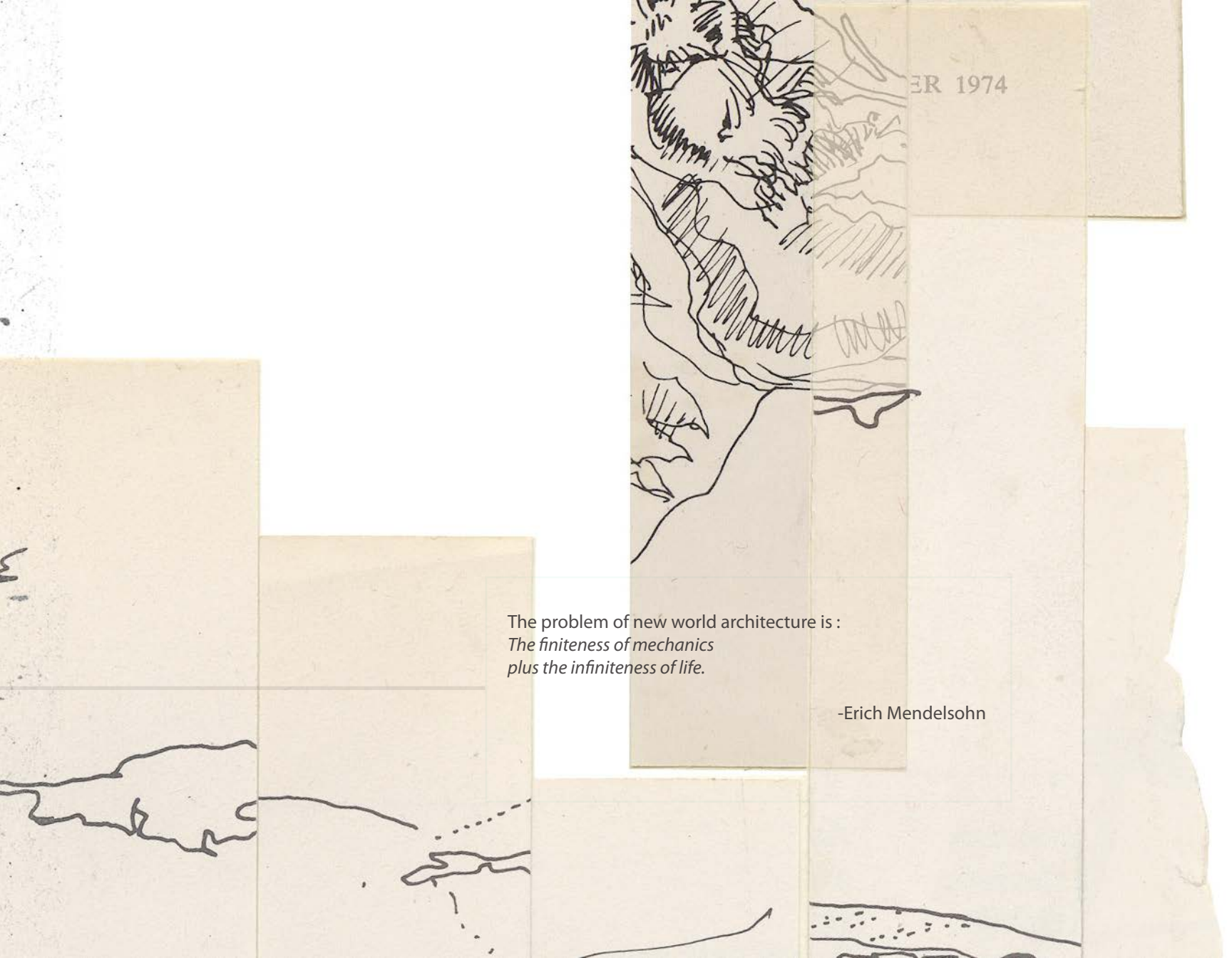
INTERIOR QUALITY

ENERGY + ATMOSPHERE

Editors

Antonio Martinez
Omar Villa Cevallos

Climate + Culture Response Studio
School of Architecture
College of Arts + Architecture
University of North Carolina Charlotte

The image is a collage of several strips of aged, yellowish-brown paper. Overlaid on these strips are black ink sketches. A prominent sketch in the upper right shows a profile of a person's head with curly hair, looking down. Below this, there are more sketches of a face and a landscape with hills. In the lower left, there are sketches of a landscape with a wavy line representing a body of water or a path. The text is printed on a semi-transparent rectangular box in the center of the collage.

ER 1974

The problem of new world architecture is :
*The finiteness of mechanics
plus the infiniteness of life.*

-Erich Mendelsohn

BORNE OF EARTH