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UNDERSTANDING THE CLIMATE OF PORT HARCOURT FOR ENERGY-EFFICIENT AND SUSTAINABLE BUILDING DESIGN

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ABSTRACT

The objective of this study is to understand the role of the climate of a place in creating environmentally friendly, energy-efficient buildings, designed to effectively manage dwindling natural resources. This entails understanding climate as a prerequisite in building design for a better outlook on how to harness natural energy like the sun and wind and using materials that, in their manufacture, application and disposal, do the least possible damage to nature`s `free resources`; water, ground and air. To do this, a study of the climate of Port Harcourt, Rivers State has been carried out with climatic data sourced from yr.no a research organisation owned and controlled by the joint service of the Norwegian Meteorological Institute and the Norwegian Broadcasting Corporation with weather stations in Port Harcourt and data from World Meteorological Organisation (WMO) to understand weather patterns. This, in turn, gives suggestions for successful natural resource management in building design and the process of integrating with nature. Ecological replacement schemes or ecology integration employing traditional concepts of natural landform integration, natural orientation, and effective methods of harnessing climatic resources such as the sun and winds, as well as a breakdown of the type of building material selection and application, and sustainable construction methods to employ to suit geographical and climatic conditions. All of these topics are covered in this study. By the end of the study, we will have a better understanding of how to effectively incorporate the climate of Port Harcourt into designs and construction in order to achieve sustainability, energy efficiency, and, most importantly, an ecological and healthy living environment free of waste and with minimal environmental pollution.

KEYWORDS
ENERGY EFFICIENCY, BUILDING DESIGN, ECOLOGY INTEGRATION, SUSTAINABLE CONSTRUCTION METHOD, CLIMATE ANALYSIS

INTRODUCTION

Diverse designs and building techniques have evolved over many centuries in various climatic zones across the world, resulting in houses that provide a more or less suitable living environment without the need of complex mechanical technologies. Historically, most construction technicians were familiar with the climate where they worked. They were aware of the ways they could benefit from certain climatic features and overcome those that were less favourable, by opting for appropriate building shapes, location, orientation and the use of appropriate building materials. Designers were freed from climatic and local resource limits thanks to a strong economy and the development of new climate-modifying technology. As a result, architecture increasingly grew disconnected from nature. This mentality has resulted in reckless usage of energy resources, which cannot continue without serious environmental implications. (Gonzalo and Habermann, 2006). This paper identifies options for integrating climatic considerations as an integral part of planning and building design in Port Harcourt, Rivers State. Climatic data is obtained for Port Harcourt and analyzed to formulate design strategies. Climate information for this study has been gotten from (yr.no) a weather service from the Norwegian Meteorological Institute and the Norwegian Broadcasting Corp statistics on the climate of Port Harcourt.

WHAT IS CLIMATE

Climate refers to the general weather conditions of a place after a long time. The keyword there is the weather condition. Weather is the condition of the atmosphere with regard to temperature (how hot or cold the air is), humidity (how wet or dry the air is), the wind, sunlight, rainfall and other elements.

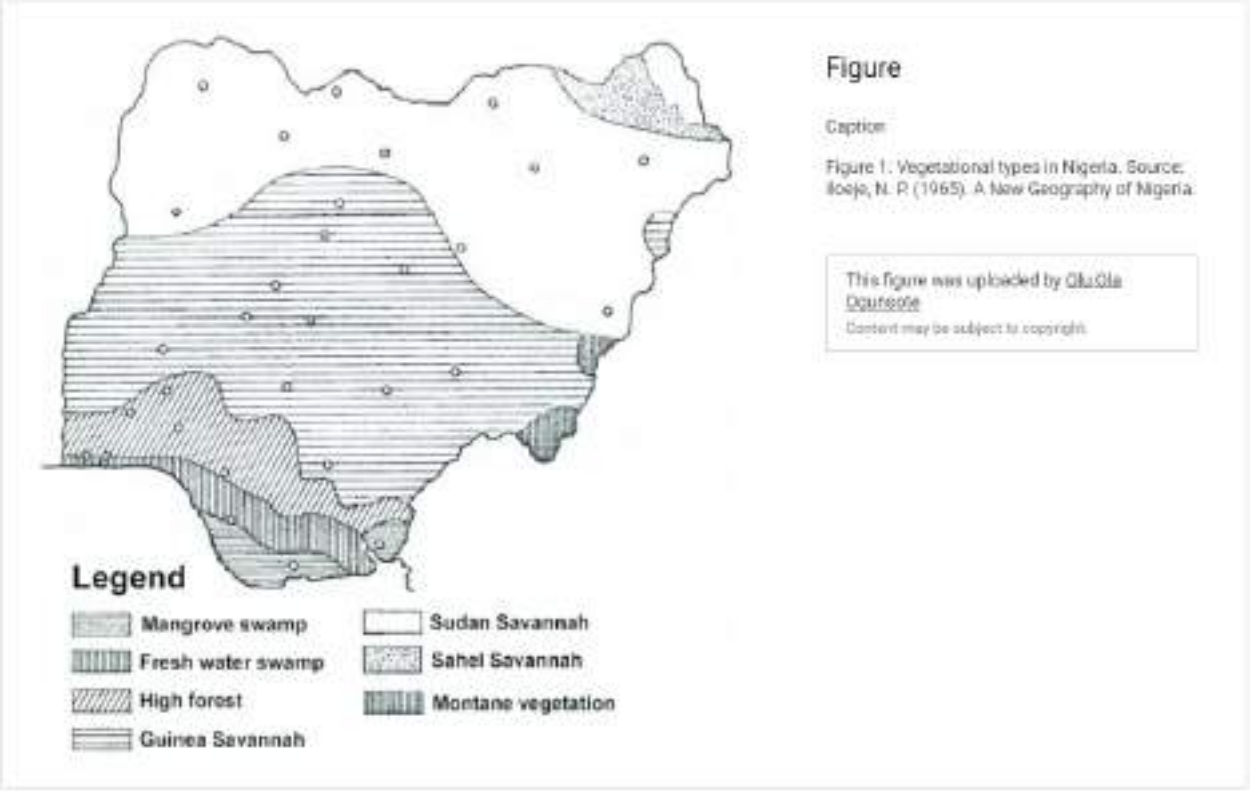
These elements in various ways affect building materials and also determine the comfort of a place. To ascertain this claim, it is critical to analyze the climate type within which the site is located and to collate relevant data that will inform design decisions and material choices.

The different Climates of the world, are usually grouped by temperature. It is important to note that even within the same climate zone; a wide range of distinct climate characteristics can be found. This is normally referred to as micro-climate. Micro-climate is usually viewed in relation to a bigger climatic region. To characterise local climate more precisely than merely using broad typologies, specific data on local air temperature, humidity, and wind patterns are necessary. The required data can be gotten from weather stations located in the region. The data acquired is based on hour after hour monitoring of weather over several decades, although, not all of that information might be relevant for design purposes. How much data is required is based on the scale of the design project and its implications for the environment, and the people.

THE CLIMATE OF PORT HARCOURT

The city of Port Harcourt is located in Rivers State, Nigeria. The image below is a sketched representation of the location of the city of Port Harcourt.

The Nigerian climate using the Köppen Climate Classification System falls in the tropical moist climate in the southern parts of Nigeria and the Dry climate in the Northern parts of Nigeria. Port Harcourt is situated in the Southern parts of Nigeria and falls in the Tropical monsoon climate. The climate is further grouped based on the type of vegetation prevalent in the region. The figure below shows this grouping.



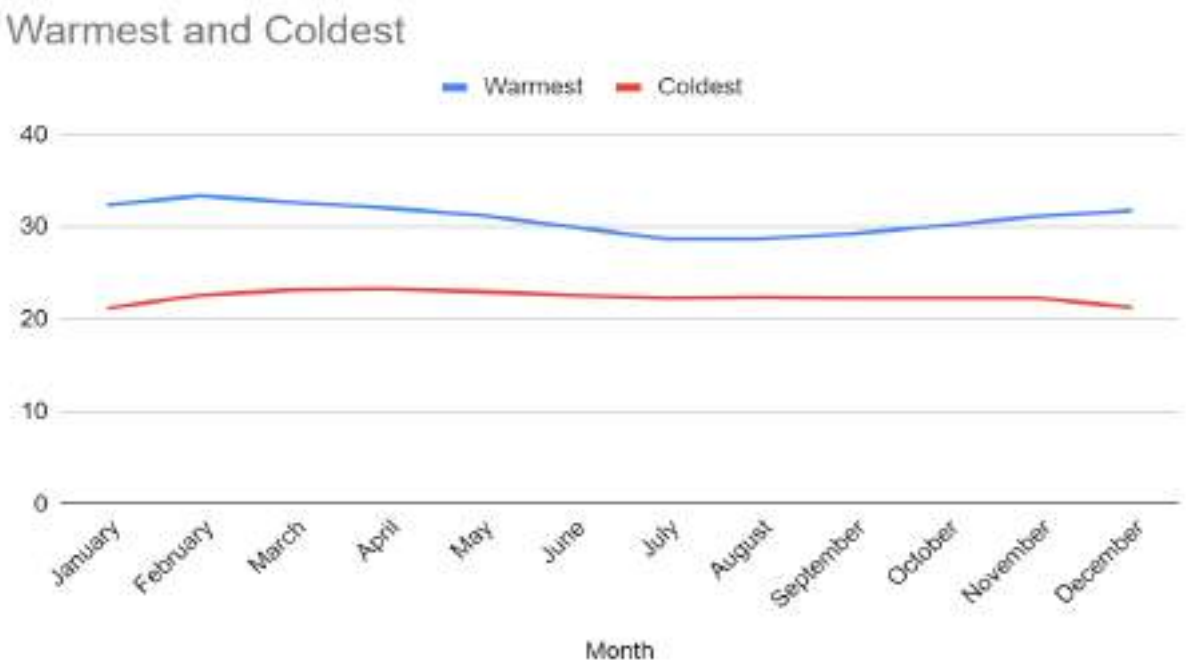
The table below shows the average maximum temperature daily and minimum temperature daily in a month within the period of 1961 - 1990 (Data sourced from WMO as provided by yr.no). It also shows the number of days with precipitation within a month. Precipitation is said to have occurred in a day (24h) when the amount of rainfall surpasses 1mm on that day.

AVERAGE TEMPERATURE AND PRECIPITATION PER MONTH

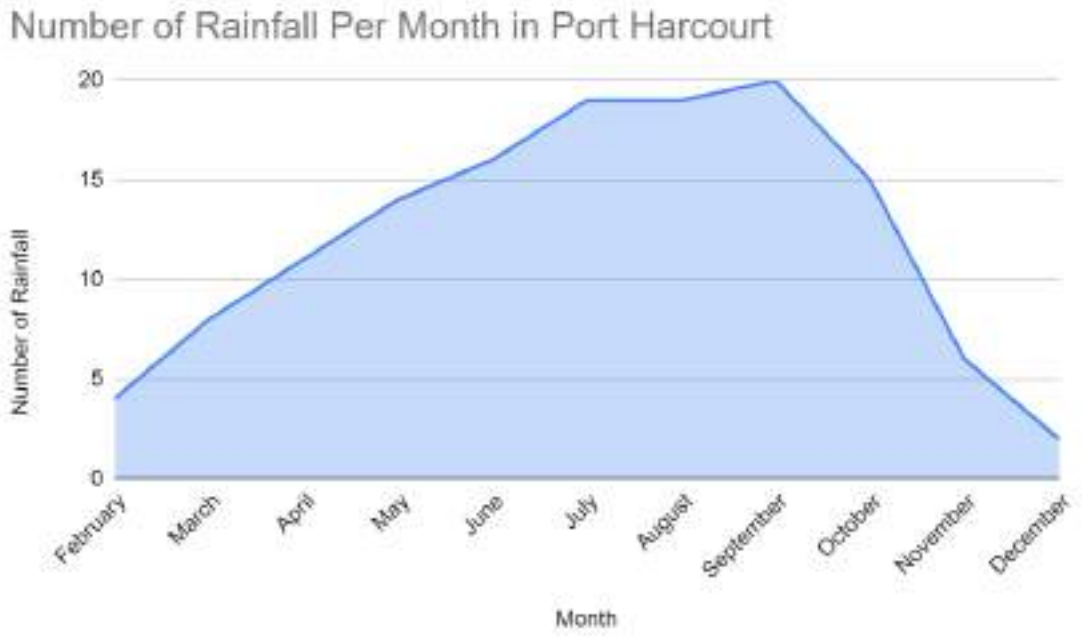
	Temperature		**Precipitation**
Month	**Warmest**	**Coldest**	**Normal**
January	32.4	21.2	2
February	33.4	22.6	4
March	32.7	23.2	8
April	32.1	23.3	11
May	31.3	23.0	14
June	30.0	22.6	16
July	28.7	22.3	19
August	28.7	22.4	19
September	29.3	22.3	20

October	30.2	22.3	15
November	31.2	22.3	6
December	31.8	21.3	2

GRAPH REPRESENTING THE AVERAGE MONTHLY TEMPERATURE IN PORT HARCOURT



GRAPH REPRESENTING THE AVERAGE NUMBER OF RAINFALL MONTHLY IN PORT HARCOURT FROM 1961-1990



In general, Port Harcourt experiences a very high amount of rainfall throughout the year with short periods of dryness. The difference in temperature between the highs and lows daily is also not much at approximately 4^0C.

THE ROLE OF CLIMATE IN DESIGN

As earlier discussed, Port Harcourt experiences a high level of rainfall and mild temperature change ranging between 4^0C - 7^0C. This level of rainfall and humidity, over time, results in water seepage through walls, rusting of iron-based building parts, and rotting of timber. To achieve comfort and durability, the climate of a place has to be put into consideration.
The climate of the place will influence

- Design strategies
- Material Selection
- Design technologies that can be used

DESIGN STRATEGIES

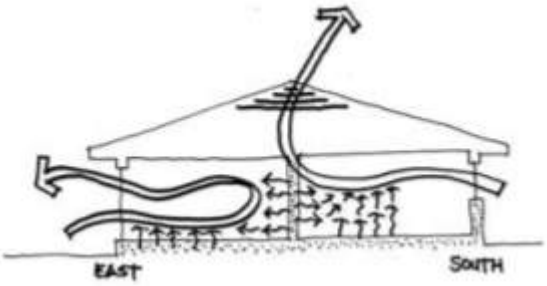
In designing buildings for human occupancy and occupancy by any living thing for that matter. The comfort of the human is very important. We, therefore, need to understand the threshold of human comfort - which is very slim and quite complex to evaluate. There are various environmental and physiological factors that affect the comfort condition of an individual. The effect of climate is evaluated considering the physiological condition of a normal individual. Various climatic parameters are combined to form the thermal index to express their effect on man. In this study, the Bioclimatic chart (Olgyay, 1962) and Building Bioclimatic chart (Givoni, 1976) are used to evaluate comfort conditions and formulate design strategies to respond to them. Bioclimatic approaches to architecture are efforts to produce comfortable conditions in buildings by studying microclimatic factors and resultant design methods such as natural ventilation, lighting, and passive heating and cooling.

Olgyay's (1962) Bioclimatic chart is extremely helpful for assessing the comfort level.
The chart determines if a specific temperature–humidity relationship is within the comfort zone and gives solutions for achieving pleasant circumstances. It makes recommendations on things like the requirement for radiation in cold weather and wind flow or humidification with wind flow in hot weather. The Bioclimatic chart, on the other hand, is limited in its applicability because the study of physiological needs is dependent on the external environment. Later, Givoni (1976) utilised the Psychrometric chart to define the comfort zone, extending the likely area of external circumstances under which specific passive control approaches may assure interior comfort.

BUILDING STRUCTURE

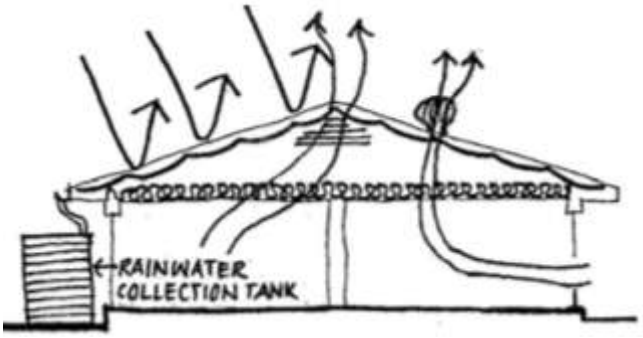
Port Harcourt requires cooling almost all year round. The thermal conditions require utilization of wind effects, as well as, protection from them, during the dry dusty season. Hence, a dual role is required in the structure. Thermal mass helps to store daytime heat during the day and release it at night to balance room temperatures. For this, there must be enough mass in the building to absorb

the heat gains, and the mass must be distributed over enough surface area so that it can absorb the heat quickly and keep the interior air temperature comfortably low. The opening must be large enough to allow cool outside air to flow past the mass to remove the heat accumulated during the day and carry it outside the building.



ROOF DESIGN

Horizontal solar radiation is very high in Port Harcourt and longer hours of sunshine impart maximum heat flux from the roof. A double roof with an outer layer of lightweight, highly reflective surface, insulated from the inside, helps to keep the heat from entering the building envelope. Ventilation between the two layers will dissipate the heat trapped in the gable space. A sloped roof is beneficial to collect rainwater and also provides shade for windows and protection from the rain.



SHADING DEVICES

Shading devices are required on the openings to protect them from extreme solar radiation. Vertical and horizontal shading devices can be used for the purpose. Deciduous trees can also be good for shading, allowing sunlight at a comfortable degree to the living areas but blocking out extreme sunlight. In Port Harcourt, during the dry season, prevailing North-East Trade wind comes from the North-East so, the north façade can be effectively shaded by plantations.

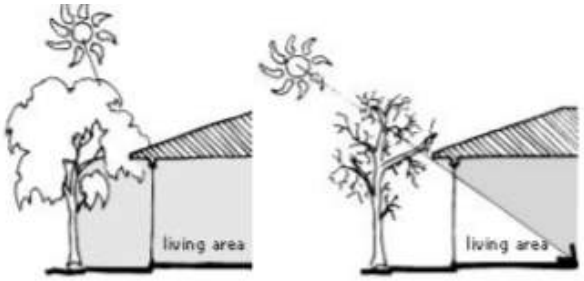


Fig.21. Shading arrangement by a tree

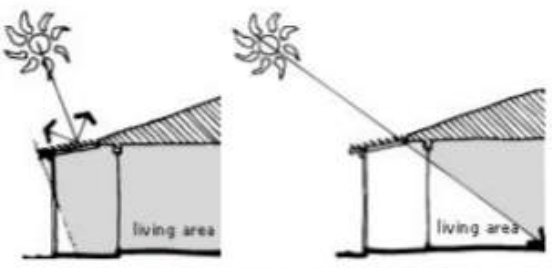


Fig.22. Shading arrangement by trellis

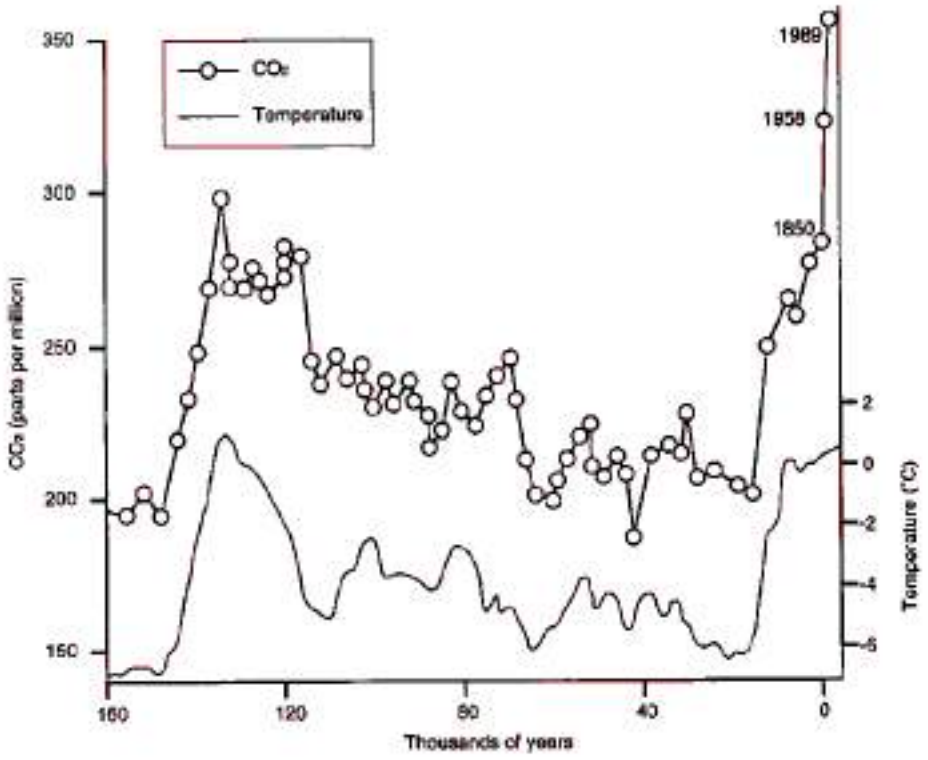
MATERIAL SELECTION

The choices of materials to be used should be once that repel heat and generally remain cool during hot conditions. They should also be able to withstand the high levels of rainfall in the area. It should be all these while staying safe and environmentally friendly. This way, we can achieve energy efficiency

BUILDING MATERIALS, CLIMATE AND THE ENVIRONMENT

Certain kinds of materials, and design practices used in building design affect the environment leading to climate change and global warming. Such design practices are not sustainable nor environmentally safe. These practices have become very common among building designers and architects. It is paramount that such practices be avoided.

Some might argue that climate change is just a natural course of the environment over time. The graph below proves otherwise. It shows the amount of carbon emission over a long period of time and the registered temperature change.



It could be argued that there are other causes of climate change such as population growth. But chief among them is carbon emission of which the current design process has contributed a great deal towards increased emissions.

The design approach needs to think more energy-efficient, consuming less fuel and therefore resulting in reduced carbon emission. That way, our environment and climatic conditions is preserved and kept comfortable.

SUSTAINABLE DESIGN

The goal of sustainable design is to "totally remove negative environmental effect via skilled, sensitive design." Sustainable design manifestations use renewable materials, have a low environmental effect, and link people to the natural environment.

“Human beings don't have a pollution problem; they have a design problem. If humans were to devise products, tools, furniture, homes, factories, and cities more intelligently from the start, they wouldn't even need to think in terms of waste, contamination, or scarcity. Good design would allow for abundance, endless reuse, and pleasure.” - The Upcycle by authors Michael Braungart and William McDonough, 2013.

Sustainable building design refers to design processes that are sustainable and environmentally friendly. Sustainable in the sense that the process can be maintained for a very long period of time.

In sustainable building design, the methods of construction, building materials, finishes used, and the general manner in which the building is used is designed to be efficient and generally have a very low carbon footprint. Other renewable and more efficient energy sources are considered, such as solar energy.

In sustainable design, buildings and structures are designed to properly utilise energy, conserving power rather than wasting it.

SUSTAINABLE DESIGN PRINCIPLES

Some common principles in sustainable design are as follows:

- Low-impact materials: choose non-toxic, sustainably produced or recycled materials that require little energy to process
- Energy efficiency: Designs that are energy-efficient can function very well and be a comfortable living space without the use of mechanical or electrical means.
- A diversity of materials in multicomponent products should be minimized to enable easy disassembly and value retention.
- Sustainable design standards and project design guidelines are also becoming more widely available and are being actively developed by a diverse range of private organisations and individuals.There is also a large body of new methods emerging from

the rapid development of what has become known as 'sustainability science' promoted by a wide variety of educational and governmental institutions.

- Biomimicry: "Design structures should be on biological lines ... enabling the constant reuse of materials in continuous closed cycles.
- Renewable resource: materials should come from nearby (local or bioregional), sustainably managed renewable sources that can be composted when their usefulness has been exhausted.

Before sustainable design can be fully implemented, a complete understanding of the science of buildings is required. This is required to help us understand areas where we can implement some sustainable design principles and the various sustainable design methods at our disposal for use.

CONCLUSION

Climate obviously has an impact on building design and planning. Energy-efficient and sustainable design practices should be able to integrate natural energies (i.e. solar radiation and wind) as parts of their design features. Consideration of the climate of a place should start as early as the design stage, allocation of spaces, orientation of buildings and in day to day operation of the building, helps to maximize the use of natural energy to achieve comfortable conditions. This study reveals specific planning and building design ideas for Port Harcourt which can make use of natural energies to achieve comfortable living conditions in a building. Heating during nighttime can be met by incorporating solar energy and the use of thermal mass while cooling can be achieved with the use of cool breezes. The wind direction at different times across seasons helps designers/ urban planners to orient building and openings to catch the cooling breezes.

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