

The Contemporary Public Market:  
A Sustainable Design Approach to Low-Cost Operating Public Markets in Oman

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A thesis  
submitted in partial fulfillment of the  
requirements for the degree of

Master of Architecture

University of Washington

2021

Committee:

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Program Authorized to Offer Degree:

Architecture

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**Abstract**

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Attempts to design public markets in Oman failed to capture the social and cultural essence of historical markets in the region. The versatility of use and utilization of site resources in public markets diminished due to focusing primarily on the commercial aspect and the utilization of mechanical systems to provide comfort solutions. This study focuses on the lost elements of public Markets that go beyond commerce. This study introduces a set of principles to evaluate a site's compatibility with a thriving public market. These principles are later utilized to design a semi-open public market designed to deliver a contemporary experience the harmonizes social, cultural, and commercial practices. The public market design focuses on affordability by minimizing operational costs through the utilization of existing site resources and implementing primarily passive sustainable strategies. The design of the market's sustainable systems is derived from weather data files and vernacular construction practices. Strategies implemented in the market focus on utilizing wind flow along with other cooling strategies. The wind system is developed and refined through wind simulation software. Daylighting of the market's interior spaces is refined and developed through the use of climate-based simulation software. The overall design of the market is developed to create a unique internal culture that connects visitors and merchants while integrating into the site's context socially, culturally, and environmentally.

# PREFACE

Nowadays, every person owns their personal smart device, the smartphone, that functions as a medium to communicate with the entire world. A window opened up where a multicultural new generation started to emerge, or at least what was predicted. For years, I started noticing how people behaved differently from before, or rather similarly to one another from multiple parts of the world. Heritage and culture appeared to be melting together and unifying into one. The line that created contrast and variance between nations started fading away.

This does not mean we are heading toward a bland and monotone future, rather it is more vibrant and liberating for many. However, there is a drawback, and a big one to be concerned about. As we advance, we leave behind important aspects in identifying our cultural background. The modern world brought consumerism, a fast-paced advancement in developing convenient products, but in the process, they started overpowering native cultures. Due to its nature, consumerism is set out to sell convenience making it unable to have a symbiotic relationship with local crafts and products. Selling convenience became a successful business model for large corporates, resulting in the emergence of supermarkets, shopping malls, and branded products. Local businesses, despite their excellent and desirable products, could not keep up due to their lack of capitalistic, mass-producing, and marketing powers.

Ever since my earliest trips to public markets in Oman, I started noticing changes undergoing public markets. The line of offered products changed, the social aspect of the market shifted, and cheap products businesses started replacing local crafts. Such adaptation to modern times made me think about the adaptive capabilities of the public market, and why are no new public markets emerging? In this thesis, I will share my journey of finding answers to my questions and hopefully realizing how a contemporary public market needs to be to create a sustainable operation while retaining its identity.

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# CHAPTER 1

## INTRODUCTION



fig 1.01 | Mutrah market corridor

The public market's concept has persisted for centuries globally and in the region of Oman, adapting and changing through time with an efficient and flexible evolving program. With modern infrastructure, comfort, health, and safety standards are elevated requiring public markets to adapt. While many public markets diminished overtime, historical public markets persisted and remained a busy place of commerce, social interaction, and cultural expression. Their historical significance became the backbone maintaining their commercial success. Public markets in Oman are some of the most commercially successful areas in the region, but only in historical public markets.

Attempts made to build new smaller versions of public markets either failed to capture the same atmosphere and success of historical public markets or struggled to maintain activity to become a row of vacant shops, or run by corporate-owned businesses. Failure in replicating the experience of the public market is due to factors related to the misinterpretation or a lack of understanding of the complex system present in public markets. Typical design attempts of modern markets focus primarily on the commercial aspect only. Public markets house a variety of social, cultural, educational, and commercial activities creating an experience unique to each market. In order to design a successful public market, one must understand all previously mentioned aspects of the public, but there has been very little work done in exploring the public market's characteristics and design principles.

In the last decade, the need for designated areas allowing for low investment businesses is desired more than ever, due to the rise in living costs and lack of job opportunities in Muscat. Many individuals nowadays resort to side gigs and businesses to offset their lack of income. Another portion of the population is running their own businesses full time. Craftsmen in the region

are persisting for the passion and connection to the craft despite its low profitability. An apparent issue with starting a new business is the initial investment to rent and run a business, which in most cases is costly and requires a full-year commitment. Public markets provide low-cost spaces and a high customer volume that minimize the risk of loss. However, the lack of public markets in the region increased the number of street vendors, which has been perceived positively by the public. Still, many such businesses struggle due to the lack of organization, health and safety, and low customers, especially at the beginning.

Public markets offer a practical solution to organize small businesses and ensure their success and longevity. Due to the lack of analysis and literature related to public markets, detailed analysis and a set of design principles of public markets are required to better understand the needs of the public market program. Focusing on more than commercial activities will assist in developing a set of design principles to what a contemporary modern market requires, as well as potentially to inform future adaptations of public markets program.

With the emergence of large corporations, supermarkets, and shopping malls, the emergence of new public markets diminished completely. Because of the rapid development of civilized living standards, creating commercial spaces that are only inspired by the layout of existing public markets has

failed. This thesis aims to create a design of a contemporary derivative of historical public markets existing in Oman. Historical research of public markets globally will be conducted to gain an in-depth understanding of the evolution of the public market's design and program. Studying previous attempts will aid in realizing what design implementations were successful and what was replaced over time. Historical understanding will also allow realizing the differences and similarities in market design relative to local cultures.

Analysis of commercial patterns will be used to determine requirements and needs to be accommodated in the public market. by realizing the diverse economic needs, space can be designed to house a wide range of businesses in terms of investments and services. Finally, sustainability is one of the main drivers in the success of public markets. Low dependence on mechanical and on-demand systems ensures low-cost operation and the longevity of the market's operation.

## **Project Rationale**

The need for a new form of the public market can be associated with many factors other than the need for a space that supports small businesses. Open public spaces function as stages of cultural expression and social

interactions. For the general public, they function as spaces that provide relief zones that disconnect them from daily work routines, offering a pallet of new experiences for locals and tourists to enjoy. Public markets should be designed to serve as places that make people belong, generating a sense of place, in contrast to a simple convenient shopping experience. For vendors, public markets should be places that provide pedestals for their humble product and services to gets the crowds without relying on modern advertising. Public markets need to be places where small-scale new business practices are tested, explored, and advanced without worrying about financial risks.

This thesis will primarily focus on the limits and possibility of designing and an energy-efficient public market through the use of construction materials, passive design strategies in the region of Muscat. The development of the sustainable design system will follow a four-step hierarchical system organized in the following order, minimize electricity loads, utilize passive design strategies, use energy-efficient systems, and produce or use power from renewable energy systems. Social behaviors and cultural significance will be used to build the program of the market's design. Cultural and historical design elements, in terms of meaning, aesthetics, or interpretations, will only be utilized if they serve the program and experience of the market. Design aesthetics will be derived from the program

and the proposed experience.

The program of the proposed design will be highly driven by the social needs of the locals and studied precedents locally and globally. This includes historical public markets such as Mutrah Dark Market, Nizwa Fort Market. International case studies will create and form the design principles of the public market program. This includes areas in North America and Europe. Each region's public markets will be analyzed to understand the design methodology and cultural and social significance of the design. Despite each region's unique cultural uniqueness, such a study will help in understanding the extent to which cultures are integrated into the design of a public market. A historical timeline will be created to realize public markets' evolutionary milestones to understand the minimum requirements in creating a program for a public market.

Site selection for a public market plays a big role, as depends largely on existing commercial activities, site accessibility, infrastructure, and the site's geographical characteristics. Through the proposed public market design principles, potential sites will be analyzed to evaluate their potential in creating a successful public market. This will also aid in narrowing down the approach of designing sustainable strategies and systems compatible with the site.

## CHAPTER 2

### THEORETICAL FRAMEWORK



fig 2.01 | Socializing in Nizwa Fort Market

At the beginning of the research process, there was a lack of documentation concerning public markets and their programmatic progression. In most case studies, markets are analyzed and studied from an architectural form and construction point of view. Analysis of such papers delved into the construction and ornate parts of the structure. The program or the type of activities that took place in the market were rarely mentioned. Since this thesis focuses largely on the program and the performative aspect of the public market, architectural and design styles will only be analyzed if they play a role in the program.

Public markets have been around long before the emergence of modern establishments designed to provide for our daily needs. To this day, many public markets remain standing, mostly as large landmark structures. The Grand Bazaar in Istanbul, Rynek Główny in Poland, and most public markets in Oman are prime examples. Other historical markets remain as ruins as the testimony of time, like the Macellum in Libya that was built during the Roman Empire rule. Some markets do not even have any traces left, rather they are immortalized in paintings and history books. To better understand the nature and evolution of the public market design, the history of public markets will be studied and analyzed to create a development timeline.

### Historical & Cultural Background

One of the few detailed and information-rich resources is the British Market Hall by James Schmiechen and Kenneth Carls. The book details the development and changes that public markets have gone through after the middle ages until the end of the twentieth century in the United Kingdom. In the beginning, the concept of a market was very chaotic, unorganized, and most of all, inconvenient. People

perceived it as a hurdle in their daily lives, rather than an enjoyable experience. This was due to the lack of order, program, and the repurposed space to hold a market. The formation of the market was done by placing stalls in open-air public spaces like venues and plazas near landmarks, often near-religious structures, as they indicated areas with large crowds (*fig 2.02*). The areas where markets took place were muddy and wet, where livestock was sold along with other goods, and the congested crowd made crimes such as fraud and theft a typical occurrence (Schmiechen and Carls, 1999). The market became an undesirable place to be in and became associated with the lowest class citizens.

At the beginning of the eighteenth century, health and safety became a big concern in open markets. The proposed solution was to decentralize the market and have it partitioned into areas scattered around the city. Smaller designated areas were created where certain types of goods can only be sold to avoid mixing of products and the spread of diseases. For example, poultry and fish areas were separated from vegetables and grain. When the new scattered market was put into action a few issues came to light. The main problem was a drop in the numbers of customers visiting the markets lowering the amount of sales. Vendors traveling to the city on a weekly basis were not able to make enough profit. Citizens also complained about the inconvenience of having to walk long distances

to get their variety of goods. After some time, each scattered market offered other products to attract a bigger crowd. At this point, the concept of the scattered market was conceived to be a failure, as it did not solve any of the centralized market problems except expanding the reach of the market into smaller areas (Schmiechen and Carls, 1999). However, the one characteristic that persisted was the daily operation of the market rather than being a weekly event. This in turn greatly reduced the health and safety risks by reducing the number of shoppers in one place at the same time.

The inconvenience of the scattered market was highly criticized by vendors and consumers, urging for the return of the centralized market. By the end of the nineteenth century, the most commonly known type of public market emerged, the Market Hall. The concept utilized the best of the previous versions of the public market, centralized and specialized at the same time. Market halls were developed to host a variety of merchandise in a zoned layout to maintain a healthy environment (*fig 2.03*). The market hall received its own designated area with a defined perimeter and in some cases roofed that (Schmiechen and Carls, 1999). The market remained to be an open-air environment but defined entry gates, paths, and pavilion-like structures that divided the market into zones. Poultry, fish, and livestock sales were placed in designated areas separate from each other and far away from vegetables, grain, and non-animal food products.

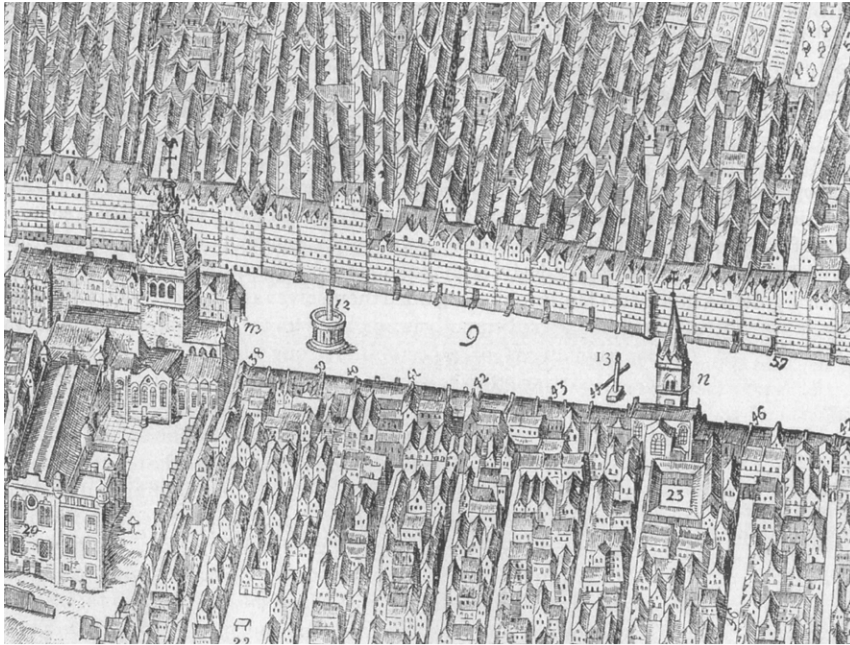


fig 2.02 | Plan of Edinburgh showing a popular site for markets



fig 2.03 | St. John's Market Hall, 1882, interior organization.

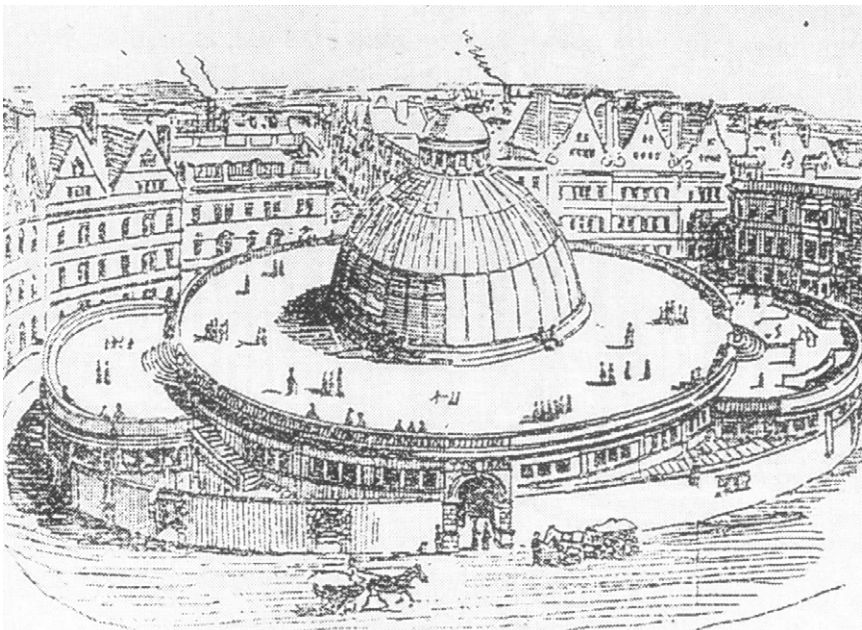
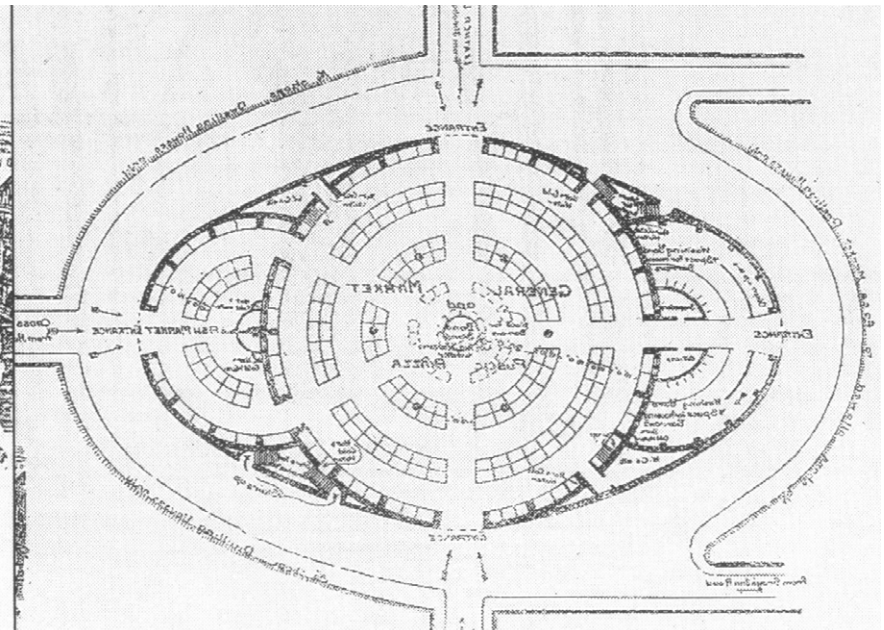


fig 2.04 | Proposal for Leather Lane Market in London, 1893. The presented is part of a new market form study.



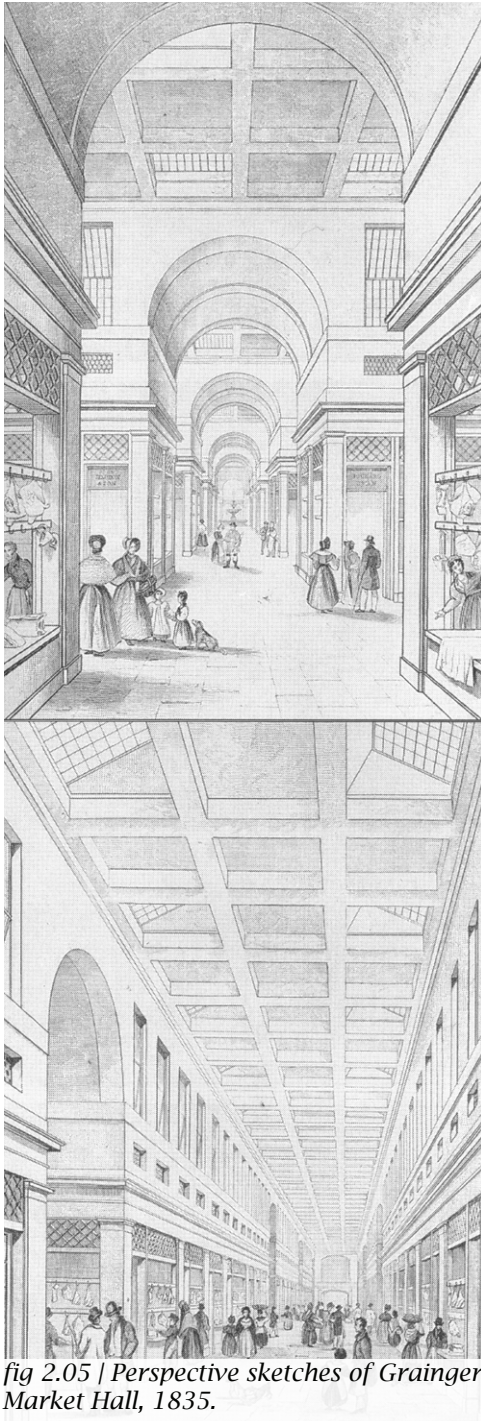


fig 2.05 | Perspective sketches of Grainger Market Hall, 1835.

At this point, the market hall only supplied food products and was still managed by local municipalities.

With the success of the market hall, new forms to the public market emerged each, represented an exploration of an architectural expression form (*fig 2.04*). The overall expressive style in market hall designs followed a vernacular style closely resembling victorian ornate styles to distance it from industrial or factory aesthetics. This was to detach the activity of being in the market from the daily routine of being at work (Schmiechen and Carls, 1999). This concept was highly welcomed by working-class and higher-class customers as it maintained high levels of standards in organization and order. The disassociation from work architectural expression also reflected a need to express local cultures that were missing from the emergence of factories. The separation aided in marketing vendors' products and marked the market hall as the center of town. The victorian aesthetic application was intended to elevate good behavior, but it also resulted in a drop in crime frequency, increasing safety standards especially for women. Social acceptance amongst people of different classes became part of daily social life. Market halls became known as places of virtue and cultural expression, making non-commercial types of activities, including social gatherings, bard singers, and other performances coexist in the market hall (Schmiechen and Carls, 1999).

Market halls became status symbols of towns throughout the UK. For every new market that emerged, a new form or some improvement took place. The most notable changes were observed in the layout and program of each market. The Agora was one of the earliest archetypes of market hall forms to gain popularity. It derived its form from Roman Agoras but was highly modified and simplified to fit within the urban fabric. The main feature of this type of architecture was its array of stalls on the inside. The form was initially a difficult fit for most cities in the UK which

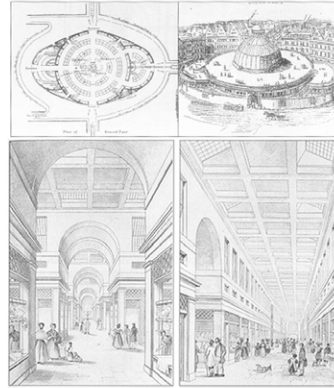
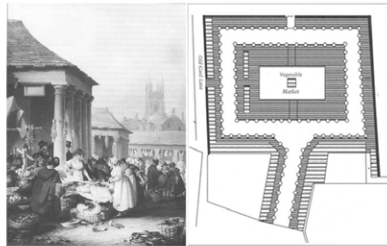
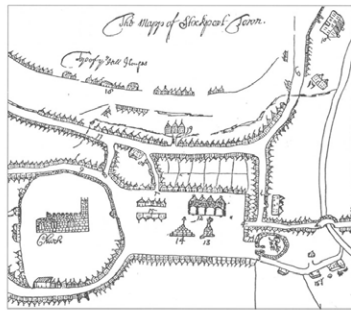
later evolved into the Enclosed Market hall that took a circular form instead of a linear array. Arcade markets emerged later expanding on the linear form and directionality of existing streets or empty parts of cities (Schmiechen and Carls, 1999). The Arcade market design was designed with a layout that supported future expandability by increasing their lengths. This made Arcade markets function as connections between different parts of the city.

In 1820, John Foster proposed what can be defined as the first Flagship Market Hall. In his proposal for St. John's Market in Liverpool, he designed a large structure with decorative interiors instead of only having an ornate entry, a large and wide covered structure with interior spaces for vendors to utilize instead of only stalls (McLoughlin, 2016). Landscape features were proposed to be included in some parts of the open court spaces (Schmiechen and Carls, 1999). With the emergence of the flagship market, the market hall evolved to offer more than food products (*fig 2.05*). Textiles, art, services, and banks took place in the Market Hall. In some other flagship market halls like Aberdeen Hall by Archibald Simpson, a mezzanine level was constructed to expand the space even further. Many market halls incorporated open piazza, landscaping features, and landmarks, such as clock towers or large pavilions to empower the presence of the market hall. This paved the way for the market hall to be the center of commerce of towns and cities. The grand design and

novel form of flagship market halls made them a sightseeing hotspot and a place to express status. The crystal palace was the pinnacle of market hall design combining modern materials and powerful architectural expression.

What made the market hall successful was its focus on the services that empowered the experience of the shopping process. It offered a healthy and safe environment through ventilation to control odors and heat, and better safety natural lighting through a well-designed program and solid construction. But what drove the market's success was its developed experience to accommodate a design that supported the people's social life. Emphasis on a design to promote good behavior was a big driver to push for new market halls (Schmiechen and Carls, 1999). However, with the large focus on the experience and design aesthetics of markets, the convenience of market halls started to diminish.

In the 1890s, the supermarket & department stores took over through what is described to be the retail revolution of the era. Such retail establishments took advantage of newly developed infrastructure to focus on selling through comfort, convenience, and most importantly saving time. With time and social advancements, the typical life of the average worker became busier. Supermarkets offered simplicity by providing every possible consumer product under one roof While only needing to pay less and once for everything (Alexander, 1970). On the contrary, the public market offered similar



## 1680 OPEN SPACE VENDORS

- CENTRALIZED
- OPEN TO STREETS
- **UNHEALTHY**
- ALL IN ONE PLACE
- **REPURPOSED SPACE**
- **NEGATIVE ATMOSPHERE**
- **DISORGANIZED**
- 7 MILES APART
- **WEEKLY EVENT**

## 1760s SCATTERED MARKETS

- **SCATTERED**
- DESIGNED FOR VENDORS
- CONTROLLED
- SPECIALIZED MARKETS
- SMALL OPEN AREAS
- **LESS CUSTOMERS**
- MANAGED
- **INCONVENIENT**

## 1800s THE MARKET HALLS

- FENCED & ROOFED
- ORGANIZED STALLS
- GOVERNED
- ZONED SINGLE MARKET
- ARCHITECTURAL DESIGN
- MULTI-CLASS CUSTOMERS
- VERY BUSY
- MANAGED
- MORE THAN FOOD
- ENCLOSED
- AGORA | LOGGIA
- ARCADE
- FLAGSHIPS

## 1890s THE SUPERMARKET

- **NEW INFRASTRUCTURE**
- ALL IN ONE PLACE
- **VACATED MARKETS**
- **DEMOLISHED MARKETS**
- **HIGHER SAFETY**
- **BETTER RELIABILITY**
- **MODERN PRODUCTS**
- **BRANDING**
- **SINGLE PURCHASE**
- **NEW EXPERIENCE**

## 1920s ADAPTATION

- **WORK CLASS CUSTOMERS**
- USED PRODUCTS
- COMMUNITY & SOCIAL
- NEW BUSINESSES
- SPECIALTY MARKETS
- TOURISTS ATTRACTIONS

fig 2.06 | Public markets in the United Kingdom through time. Each period defines a shift in the design due to different drivers pushing public markets to reiterate and change.

products from various vendors, increasing the competitive atmosphere making decisions difficult, and individual transactions for each vendor took valuable time from customers (Schmiechen and Carls, 1999). The mass production of automobiles also played a role in corporate control of consumer goods. Fast transport meant supermarkets can acquire large produce from farmers who do not need to travel to the market in order to sell their products anymore.

Due to the sudden change in the shopping experience, most market halls lost popularity or were deemed relics of what shopping used to be. Many market halls were either converted to be building with another purpose or abandoned and demolished, hence the lack of market halls in the UK today. However, the few market halls that survived did so because they were deemed to have historical and architectural significance, or were still regularly active with local support. Of the few that persist today, their marketing adapted to the circumstances. Instead of competing against the supermarket, they became specialty markets, by focusing on local products and produce that is difficult to find in a supermarket or a shopping mall (Schmiechen and Carls, 1999). The market hall also persisted to be a destination that offers an experience of more than simple convenience through the promotions of social interaction and being a place of cultural expression.

Markets developed and changed to meet the requirements needed to provide a successful market hall experience. The past experiences and experiments in the form and function of the market are thoroughly tested and compiled through the past designs of market halls. However, The information did not provide how a new market is programmed. Finding

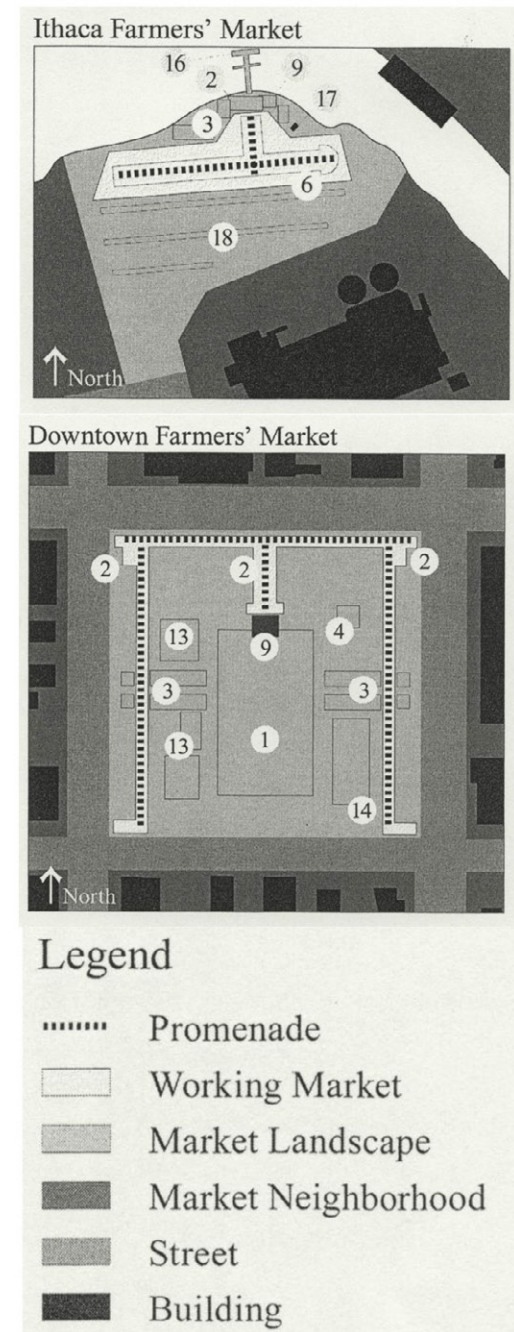


fig 2.07 | Farmers markets in U.S layout and utilization of existing site features.

literature that analyzes modern markets are severely scarce due to the lack of development of such projects. In order to understand how the public market is developed in modern times, case studies of markets that are relatively contemporary and have persisted for decades will be conducted (Schmiechen and Carls, 1999). With every generation of a public market, new forms and program elements were introduced (*fig 2.06*). Nevertheless, of each iteration, some characteristics persisted in the following new generation of markets.

## Stories of Successful Public Markets

Farmers' markets in the US are gaining popularity in most cities through their seasonal organization. Despite their less convenient experience and potentially higher prices compared to supermarkets, they are considered to be a successful weekly event. Their seasonal theme and exclusivity in products are what most people expressed to be their driving success. However, farmers' markets tend to have a more complex systematic organization that expands beyond commercial exchange according to Mark Francis and Lucas Griffith. In their article 'The Meaning and Design of Farmers' Markets as Public Space,' they discussed the complexity that ensures the success of farmers' markets, challenges, and their strong program layout in terms of site characteristics and layout.

Farmers' markets in the US are authorized to operate by local authorities, but their form is adaptive to the existing urban fabric. They tend to be "...disassociated from the planning of official public open space systems." (Francis and Griffith, 2011). In most cases, such as in Seattle, the occurrence of farmers' markets news spread through social media or local knowledge exchange. They never existed in official city plans; in some cases, they are marked in social media maps as an event.

The design of a public market is highly dependent on existing landmarks to be incorporated in its layout design. The typical space that hosts a farmer's market is centralized with high traffic flow, this could be a park, city landmark, busy street, or empty lots. landscape elements, topography, and landmarks provide an empowering aspect to create a highly active social environment and ensure the longevity of such markets (Francis and Griffith, 2011). Each part of the landscape plays part in forming one of the four identified realms of the farmers' market layout (*fig 2.07*).

The promenade is the customer's space with stalls on both sides forming a corridor. This defines the overall shape of the market, which can take multiple forms. The key aspect of the promenade is to define a space that gives a clear view of merchandise while forming a space where the crowd can come in contact with vendors and other customers, encouraging social interaction (*fig 2.08*). The backstage is the



*fig 2.08 | Pike Place Market in the year 1915, brimming with activity and traffic 8 year after its completion and official opening.*

area behind the stalls for vendors to organize and administer their commercial presence. The market landscape is the existing urban fabric in which expands the market's domain to have other non-commercial activity including seating areas, playgrounds, art exhibits, and many others (Francis and Griffith, 2011). Finally, the market neighborhood defines the theme of the space through the community and its culture (Francis and Griffith, 2011).

A case study of what a modern adaptation of a public market can be with a lower budget through organized markets in an even form in farmers' market in the United States. The core concept of the farmers market relates back to the original form of the markets in the 1600s in the UK, although modified and better organized under regulations and safety standards. While such type of markets are not the same as a market hall, it provides a more flexible form to the public market, in terms of layout, design, and adaptation to modern issues. However, since the farmers' market is flexible and not permanent, it is also dependent on weather conditions.

In this case, neither literature provided sufficient analysis on the environmental impact on the operation of a market. Due to the contrast in weather conditions between markets located in the previously studied regions and Oman, climate and weather conditions need to be studied and analyzed to determine and develop strategies to counter the excess amount of heat in the region. Rain in Oman, a rare event

which occurs less frequently to be an issue, in some cases twice a year. A suitable environment, which in the case of Oman is hot and humid, is required to host pop-up market events in Oman.

In some cases, pop-up markets gain large popularity, growing their customer base, to eventually evolve into the fully-fledged market hall with its own designated building, similarly to what happened in Seattle with Pike Place Market (Francis and Griffith, 2011). Such markets are built upon contemporary needs rather than adapting to previous historically built structures. These types of markets are characterized to appear disorganized or chaotic in nature, but they are adequately built, adaptive, and highly popular.

Pike Place Market in Seattle is a significant landmark in the history of public markets of the United States. It represents the desire of having a place for the general public to sell local specialized food and produce. While its history is of great importance, this analysis will focus on what influences the market's success and its evolution. The site in which the market was founded plays a significant role in its present activity. Commercial activities were taking place before the market's opening in 1907 in an area called the Lots. Wholesale warehouses took advantage of the farmer's busy schedule of commuting between the market and their farms by acquiring all of the farmers' produce.

The situation sparked fury amongst consumers and



*fig 2.09 | Camden before the establishment of the market was used as an industrial area and as a shipping station, until 1974.*



*fig 2.10 | Camden Lock market with its iconic entry bridge sign.*

producers due to a lack of availability and price markups. Corruption rumors about farmers getting denied their due share of profits, pushed the public to complain and require a solution. The market's establishment's purpose was to reconnect farmers' and small shops with customers. The concept was successful as it provided a specialized area to provide high-quality local goods and a unique experience that was missing from the city. The market was designed to maximize contact with traffic and pedestrians by having it built along Western Ave and Pike St. Frank Goodwin did not design the entire market or plan every part of it at the beginning, as his intention was to kickstart the market with the core structure, intending that it would grow with time.

In the following years, the market was expanded due to the high demand and popularity. In 1911, the market doubled in size, to later have parts of it defined to be known as the sanitary market, marking the first zoning act of the market's interior. The most recent expansion to the project was completed in 2017 with the market front pavilion. With time, the market kept growing creating a wider façade with entries that can be accessed from any side. One of the most prevalent early characteristics of the market was the lack of ornaments. Due to the differences in cultural interpretations between the United Kingdom and the United States, Frank Goodwin requested to not have any ornaments in the façade of the market. His intention was to not deter the public from the market by expressing an image that could be interpreted as a high-cost market, rather he wanted to attract people looking for good prices. On the contrary, in the United Kingdom, ornament would have been interpreted as a place of culture.

Camden Lock Market in the UK is a type of market that differs from traditional market halls that existed in the pre-supermarket area. Its development follows a similar design and logic as Pike Place Market. Camden Lock was a result of a desire to have a place for good retail that specialized in certain products that were not available in general all under one roof markets (*fig 2.09*). In 1976, the market was established after a pop-up market started emerging in Regent's Canal warehouse area since the year 1974. The market gained popularity quickly which made the government's plans for the areas switch.

The initial intention was to replace warehouses with a railroad station, but due to the high commercial activity, Camden Lock Market was built instead. The market was expanded throughout the years as demand grew. In 1991 the recognizable three-story market was constructed solidifying its presence, followed by a large indoor market hall in 2006 (*fig 2.10*). The market does not incorporate ornate design or pursues older architectural styles, but it shares a similarity in the powerful and recognizable entrance.

With the previous two case studies, the appearance of new markets in the twentieth century always linked to a modern at the time construction style, utilizing neon lights and colorful materials. The shift in construction style used for such a market linked to the present culture at the time to communicate a message for its people. In such a case, assuming that the site of a public market is highly dependent on local activities and contemporary design style is true. This links to the nature of the activity that occurs in



*fig 2.11 | Santa Catrina Market old roof pre-renovation.*



*fig 2.12 | Santa Catrina Market post renovation blending a contemporary touch with the old market structure.*

the public market also. For a market to succeed, a customer base and commercial activities need to be present. Traveling long distances and setting up shop is not financially feasible for a low-budget business. In comparison, supermarkets and shopping malls fall under single corporate management with the financial capability of developing retail spaces in areas where only potential customers need to exist.

Older markets, maintain significance through preservations, renovations or improvements. The previous methods are a more likely occurrence than developing new markets in a highly dense area, due to existing customers and lack of construction sites. Successful modern renovations take a contemporary modern look that break away from typical construction through the incorporation of colorful graphics and expressive elements.

Santa Catrina Market, also locally known as Mercat de Santa Caterina, is an older market, established in 1848 as a replacement to an older market nearby that was converted to an archeological site. It was designed to use the same program and layout as the market halls in the United Kingdom, with a fenced area and a grand entrance. The interior layout of the original market matches the latest documented in the United Kingdom market halls before the retail revolution (*fig 2.11*). The reconstruction process of the market began when the old market started hindering its performance. The old walls and lack of maintenance deterred the public from visiting. In

2005 the market's remodeling was commissioned to Enric Miralles and Benedetta Tagliabue, two architects living in Barcelona. Their approach was to preserve part of the old market's circulation and program, as it was deemed successful. Their focus was on refreshing the look of the market by introducing a colorful element that can attract people from far away yet feel welcoming and cheerful (*fig 2.12*). The designer duo proposed a wavy and colorful roof built from ceramic tiles. The wavy form and colorful design of the roof peaked locals' and visitors' interest to become a recognizable landmark.

Ghent Market Hall is an addition to an already existing market in the city of Ghent in Belgium. The location, activities, and surrounding urban fabric of the city match how early public markets appeared in the 1600s. The proximity to Saint Nicholas' Church, Het Belfort van Gent clock tower, open plaza, and surrounding buildings created a focal point for the pop-up market to happen, which is an organized event that occurs a handful of times every month. What makes this market different is the low dependence on the products offered by vendors. Delicacies, arts, crafts are sold in this market rather than daily needs. The market is treated as a holiday event where locals can visit the market and experience it as a local traditional activity. The Market Hall pavilion was constructed to empower the market activity by providing a place to create variety and diversity when the



*fig 2.13 | Rotterdam Market Hall visualization of the retail spaces and glass barriers at the entry points.*



fig 2.14 | Muttrah new fish market, designed by Snøhetta.



fig 2.15 | Muttrah new fish market low activity, months after its opening. Sellers preserve their fish in ice to avoid having their catch spoil.

market takes place. The newly constructed hall functioned as a landmark that attracted visitors to the area despite its lack of program.

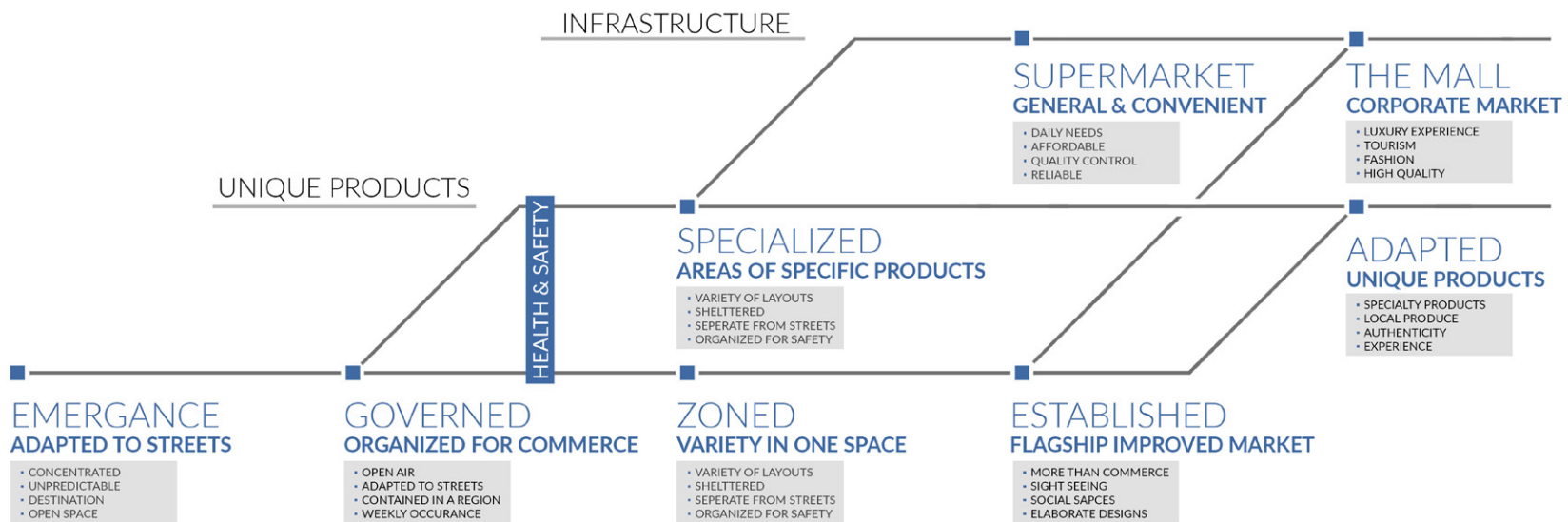
New constructions of flagship market halls is a rare occurrence due to the lack of development interest for such projects with a relatively low-profit margin. In most cases, new construction of a market hall take place in a site where market halls existed or function as an expansion of an existing market. Shopping malls or supermarkets appearing in new locations has been the norm. However, in order to understand how a modern public market program is developed, a market that was built from the ground up will be studied and analyzed, despite not being located in a site where no previous market took place.

Rotterdam Market Hall, referred to as the Markthal is designed with similar principles to newly renovated or constructed market hall structures, colorfully contemporary, and an unusual form that stands out from its surroundings. However, the Rotterdam market takes a more grand approach to the function of a public market, especially in its size, and program. The building is designed to be a hybrid of a market hall, an apartment complex and, an office building with car parks enough for more than 1200 vehicles. Designed by MVRDV, the market hall was completed in 2014 costing 178 million Euros (*fig 2.13*). The Markethal is a rarity amongst public markets in terms of management, since it is owned by a group of developers. The building's maximum height measures at 40 meters high, equivalent to a 10-story building that arch over the ground level to shelter the public market. The unusual shape of the building attracted visitors and activities to become a tourist destination. However, the cost of the building was criticized for what services it provided, referring to it as financially unviable. However,

the Markthal was not designed to only serve as a market, it was built as a place of rest, socialize, and break away from daily routines, while offering other rentable spaces. The Markthal is a statement that speaks to how a market hall's existence is not primarily commercial or capitalistic, it serves the social presence of the city by connecting people together.

On the opposite side, introducing a new market by a developer can fail if the program and businesses designed for are irrelevant to the area. In the city of Mutrah, a new fish market was built to face the port. The intention behind the market was to link its activity to the scenery (*fig 2.14*). The project was designed and developed by Snohetta, a renowned Danish architecture firm. At a glance, the project felt like it should be

a success, but the market's activity diminished quickly. In a few months, the number of customers and sellers visiting the market was too low to sustain a profitable business (*fig 2.15*). The failure of the market is due to the the aesthetics of the design and programming of the market. The design of the market appeared monotone and international, making it feel corporate and uninviting despite the unusual form. The selection of the site and program was also unsuccessful due to the lack of vendors in the area. Fishing in the port of Mutrah is not permitted since it functions as a stop for cruises and tourists. The overall intended experience of the design felt scripted and artificial, leading to its rejection by the locals.



*fig 2.16 | Constructed timeline of how shopping experiences evolved overtime and major influences that allowed for such changes, including health and safety concern and the introduction of infrastructure.*

## Climate Conscious Design

Public markets differ from other shopping establishments in their climate control and layout design that tends to have the majority of their accessible spaces in an open air, rather than being enclosed and fully conditioned. This makes public markets operational costs consume less energy. Such a design approach is the result of design iteration throughout history and before the emergence of infrastructure and utilization of on-demand systems. Public markets, especially in Oman, adapted modern infrastructure to have on-demand cooling and lighting to elevate and improve the comfort level of visitors. This in turn overpowered the passive vernacular systems incorporated into the design of the public market.

To study and utilize passive systems, literature with projects utilizing vernacular sustainable systems will be studied. However, due to the lack of such studies with relatively modern construction and data, the literature that will be utilized is of a residential unit. Saleh Al-Saadi and Awni Shaaban analyzed a Zero Energy residential unit in Oman located in Sultan Qaboos University's campus (*fig 2.17*). The building was part of a research application to study and analyze the potential of having a building that is built to minimize electrical consumption from the grid. Throughout the study, each design strategy and system are analyzed to get an understanding of how effective each strategy is in reducing the building's energy loads. Analyzed systems are

divided into, landscape and microclimates, design and form, envelope and façade, shading and fenestration, ventilation and air conditioning, lighting, and solar array system (Al-Saadi, and Shaaban, 2019).

The design of the building utilizes a four-step hierarchy system, minimize building's loads, utilize passive design strategies, use energy-efficient systems, and finally supply power through renewable energy sources (Al-Saadi, and Shaaban, 2019). According to ASHRAE Standard 169-2013, the climate in the location of the house is categorized as a 0B Zone, referring to an extreme heat and dry climate (ASHRAE, 2013). While this zone contrasts with the other areas with a humid climate, 0A, most strategies utilized in the Zero Energy Building house can be used in humid areas, apart from humidification cooling systems.

The layout of the house is designed to utilize airflow by passing it through the building through air scoops, cross ventilation systems, and the geometry of the building. This system works in tandem with a water fountain that functions as a humidification system to elevate the comfort level of the occupants at a higher temperature. The humidification system utilizes geothermal temperature differences to dissipate heat in the ground and provide cooler water vapor. Wind reaching the house is diffused and redirected to reach inlet windows. The thermal comfort level is further enhanced by using ventilation, exhaust, and ceiling fans in case the

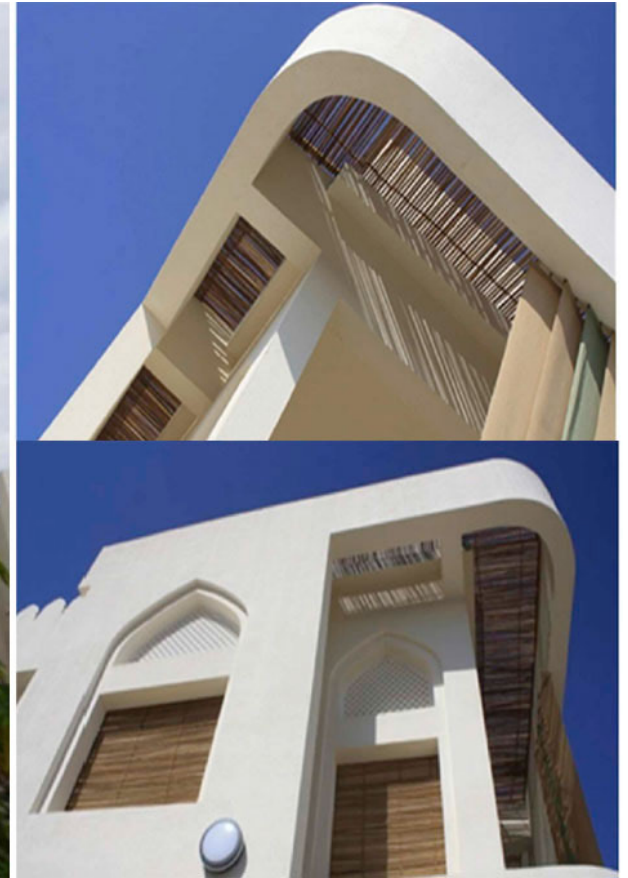


fig 2.17 | The Zero Energy Building Located in Sultan Qaboos University. Shading strategies are implemented on the exterior of the building to reduce heat gain and direct sunlight to the interior.

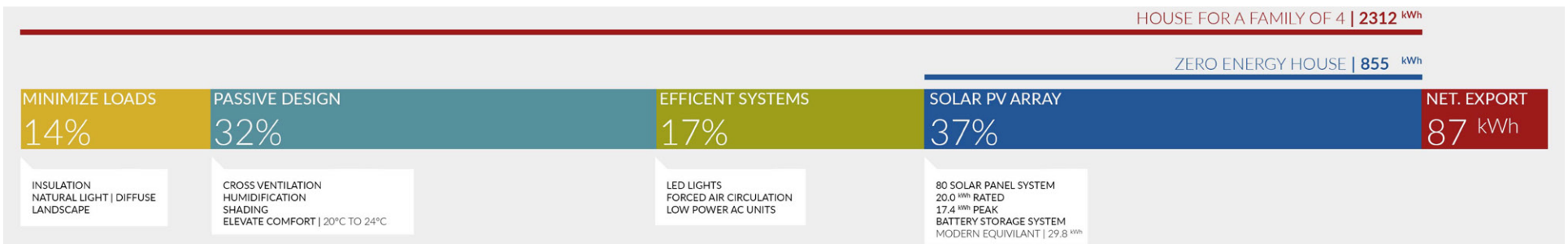


fig 2.18 | Strategies implemented in the Zero Energy Building reduce loads and electrical consumption compared to a typically constructed building in the region.



*fig 2.19 | Mutrah Market corridors, left, and Sultan Qaboos Grand Masjid, Right. The ceiling design, decorative elements and use of materials in the masjid follows a similar design style to Mutrah Market.*

amount of wind reaching the interior is not sufficient (Al-Saadi, and Shaaban, 2019). The hierarchical development of air circulation systems allows for a user-customizable operation. This creates a set of low power-consuming solutions to create comfortable spaces and expands the comfort temperature zone.

Typically, the ideal comfort zone for a hot area like Muscat is between 24° C to 27° C. by circulating air, the comfort level can be elevated to be at a higher level as per ASHRAE 55 (ASHRAE, 2004). In the case of a humid area where the selected site is located, the comfort zone requires lower temperatures, estimated to be 4° C lower than normal conditions with 30% humidity (AMS, 2012). This matches with specified comfort zones for tropical areas, such as Singapore and Taiwan, where comfort zones hover between 25° C and 26° C. (Majid, et al, 2014). Other than the humidity, comfort zones shift in different seasons is a topic that was not discussed in terms of comfort

zones. apart from listing the time from November to March as times to require no thermal control apart from air circulation.

The study's comprehensive analysis provided a clear understanding of what strategies can be utilized to create an efficient indoor environment. While some parts of public markets are indoor spaces, most of the market's activities and circulation pathways are in exterior, non-conditioned spaces. The hierarchical ventilation system that utilizes fans and on-demand electronic equipment will not be applicable for exterior space. Depending on air circulation will utilize winds and breezes, with landscape incorporation to influence the flow of air. To design such a system, climate analyses are required which will be discussed in later chapters.

High levels of heat are encountered by shading to reduce heat gain in spaces. Shading and aperture systems were influenced by vernacular architectural practices. The two most prominent strategies focused on reducing direct solar gain are the utilization of mashrabiya and overhangs made from palm tree branches. Walls had increased depth and multiple layers of materials to provide an insulating mass (Al-Saadi, and Shaaban, 2019). Wider walls also functions as a lighting control solution by blocking direct sunlight from entering spaces in hot months. With the high levels of radiations, diffused light is desirable to create an evenly lit space rather than have overexposed areas (Al-Saadi, and Shaaban, 2019).

Controlling sunlight to develop comfortable

microclimates indoors is an effective method to reduce heat levels. For an outdoor space, similar strategies can be utilized but they cannot rely on other supplementary systems to elevate the comfort level even further. Since the Zero Energy Building house's main focus is on housing and residents' comfort relative to power consumption, further studies and research is required to address passive design strategies that can be used to create comfortable outdoor spaces. Furthermore, most of the data addressed by the previous study provided analytics and standard design goals for indoor spaces, exterior spaces may not require strict thermal control management for a successful experience (Majid, et al, 2014). The comfort zone for an outdoor space is more flexible and wider, allowing for creative and unusual design strategies that cater to the experience alongside comfort. To better understand the possibilities and potential design solutions, studying the historical public markets of Oman can provide an insight into how vernacular architecture offered solutions to such environmental challenges (*fig 2.18*).

Markets in Oman drive the design of government-owned buildings due to their cultural significance. In Nizwa, the use of 'guss', a plaster-like material, and limestone can be seen in large mosques, Nizwa's Sultan Qaboos Mosque. In the case Mutrah's Market, two of the most notable buildings to be inspired by such design are Sultan Qaboos Grand Mosque built-in 2000, and Oman's Opera House completed in 2011 (*fig 2.19*). The interior of Mutrah Market uses decorative



*fig 2.20 | Nizwa Fort Market was designed to have a finish and look similar to historical structures by using Gypsum mud to finish the exterior of the market.*

wooden elements that can be observed in both buildings. Sultan Qaboos Grand Mosque's ceiling of the 'liwan' corridors, perimeter structure of the masjid, was designed to form a rectangular grid ceiling that houses suspended chandeliers in each. Design inspirations were only used to serve aesthetic purposes.

Mutrah's market commercial activity, design, and construction differ greatly from Nizwa's Fort Market. The market corridors and pathways are completely shaded with a wooden canopy structure blocking most of the light, hence its nickname the Darkness Market. The market takes the form of a tunnel stretching from the port area to the back mountains. Throughout the market's stretch, branching nodes are located along its path, some lead to other branching nodes and loop around, while other lead to one of two main entries or one of many branching exits. The use of guss is minimized as it can be damaged with the humid atmosphere. Instead, the construction is mostly dependent on Wood, stone, and reinforced concrete after recent renovation works (*fig 2.20*). Perhaps the most interesting aspect of the market is its interior, consisting of decorative ceilings that utilize traditional and historical patterns painted and carved in the support palm tree beams. The path of the market also utilizes a different material resistant to humidity. The streets are paved with granite rocks and limestone. The overall form of the market functions as an air tunnel, bringing cool air from the sea and distributing it through the branching paths. Combined with the shaded interior, the Darkness Market atmosphere is comfortable

most of the year, except for peak summer days.

Nizwa fort market is located at the center of a valley in a hot and dry region. Compared to the Darkness Market, the Fort Market is constructed in a Liwan configuration where a large market forms the boundary wall. At the center is an open court that can be accessed from the perimeter shaded pathway that connects to the rows of markets. The design intention of such configuration is to block vertical summer sun from entering shops and heating the space while allowing low winter sun to light the corridors and shops. The use of landscaping is more prevalent in the middle court to create shaded areas for events for social groups (Hassan & Lee, 2014). Compared to the Darkness Market, the Fort Market is smaller, but it feels more spacious and less congested.

Designing a public market in the present requires an approach that connects with people. Depending on cultural influence and historical public market designs will not yield a successful contemporary market experience. The public market is an adaptive type of architecture, in a way similar to fashion design, always changing to stay relevant. Designing a public market needs to be in tune with the times to peak locals' and visitors' interest by focusing on the experience and leaving an ever-lasting impression. The public market is not a place that sells convenience, rather it is a place to step out of the daily ordinary in order to experience something different, whether it is to try food, socialize, or even linger.



*fig 2.21 | Decorative mashrabiya implemented in Mutrah fish market offer a cultural presence and define the identity of the space as well as function to reduce heat gain and direct sunlight.*

## CHAPTER 3

### METHODOLOGY



fig 3.01 | Frankincense merchant in Mutrah Market

At the beginning of this research, the focus was on or reviving the tradition of the public market to provide a source of income for small businesses by introducing a dedicated place of commerce for the public. Throughout this research, I realized that the adaptive nature of the public market is still active, but not only in form as I believed them to be. The purpose of the public market is the main driver in shifting the program and form of how public markets are changing. What used to be a place of commerce is no longer applicable due to the emergence of a more convenient experience.

Competing with supermarkets and shopping malls is not the answer to reviving the public market, since the supermarket concept has been perfected to serve large populations consistently. Therefore, the public market needs to deliver what supermarkets and shopping malls do not, a way to design for inconsistency. As unappealing as it may sound, ‘Designed Inconsistency’ refers to the ever-evolving experience that is constantly shifting. For example, when visiting a supermarket, a person is familiar with where all his needs are located. With time, visiting the supermarket becomes a routine task. A public market needs are to deliver an experience that works for every person at every visit. Creating such an experience is possible because of the program of the public market that incorporates art, social spaces, landscapes, rich varieties of products, and food of many types.

The goal of this thesis is to create a set of principles that can be utilized to develop a successful program for public markets. These sets of principles start with site compatibility evaluation to host a public market by connecting existing activities and features. Next is the program of the market that defines the types of activities to take place and how to divide and zone the program. Finally, the structural elements and services that need to be incorporated into

the program of the public market. These sets of principles will be developed based on the literature findings and case studies of old and new public markets.

The sustainable approach to the design of the market will be studied for the selected site of the project, as it can vary from an area to another, therefore the sustainable design strategies will not be part of the principles set. The incorporation of sustainable design strategies will follow a similar hierarchical system, starting with passive systems, minimizing loads, using efficient systems, and finally generating energy from a sustainable power source. The primary goal of the design is not to create a net-zero system, rather, it will be to design a high-performing affordable space for local vendors. Such a goal will be achieved through the utilization of vernacular design and construction methods.

Culture and heritage are attractors to locals and tourists visiting historical public markets in Oman, due to the experience and value they represent. For the design of public markets, culture is an essential aspect in developing the program, as it ties to the type of activities, behavior that take place, and the overall design aesthetics. This study will analyze the cultural impact on the program of the market only. Aesthetics and historical architectural styles will not be incorporated. Local design styles will only be considered if they assist in the development of the market's program or if they offer benefits in sustainable design strategies.

# The Three Sets of Principles to Establishing a Public Market

## 1. Site Compatibility: Is the site suitable to establish a public market?

Due to the complexity of social interaction that occurs between vendor and consumer, building a public market in an area that does not relate to a market’s activity is difficult. This is especially true when cultural factors are taken into consideration. In the area of Muscat, public markets are connected to the history and culture of the nations and they fit the population’s lifestyle. Introducing a new type of activity in any area can yield unpredictable results. The site compatibility principle is designed to evaluate a site’s existing characteristics through a rating system in the form of a checklist (fig 3.02). The list is divided into two parts, the first consisting of social and commercial aspects, while the second is geared toward understanding a site from an urbanistic point of view.

This evaluation method is designed to provide a score that measures the potential of success to establish a market. Parts of the evaluation checklist are of more importance than other parts, such parts include existing commercial presence and area type. To test this principle, each of the previously studied markets will be evaluated to determine the success of the evaluation checklist. The test will also help in understanding what parts of the evaluation are more relevant. The resulting score after the evaluation will also be used to create a scoring system in which a decision can be made on the rate of success for a site to be utilized as a public market.

## 2. Program and Zoning: what activities will take place in the market?

Of the three principles, the zoning and program principle is the most complex with two separate categories that define different yet connected parts of the public market. This



fig 3.02 | First Principle, site selection. Each category evaluates an existing characteristic of the site to see if it is fit for a public market development.

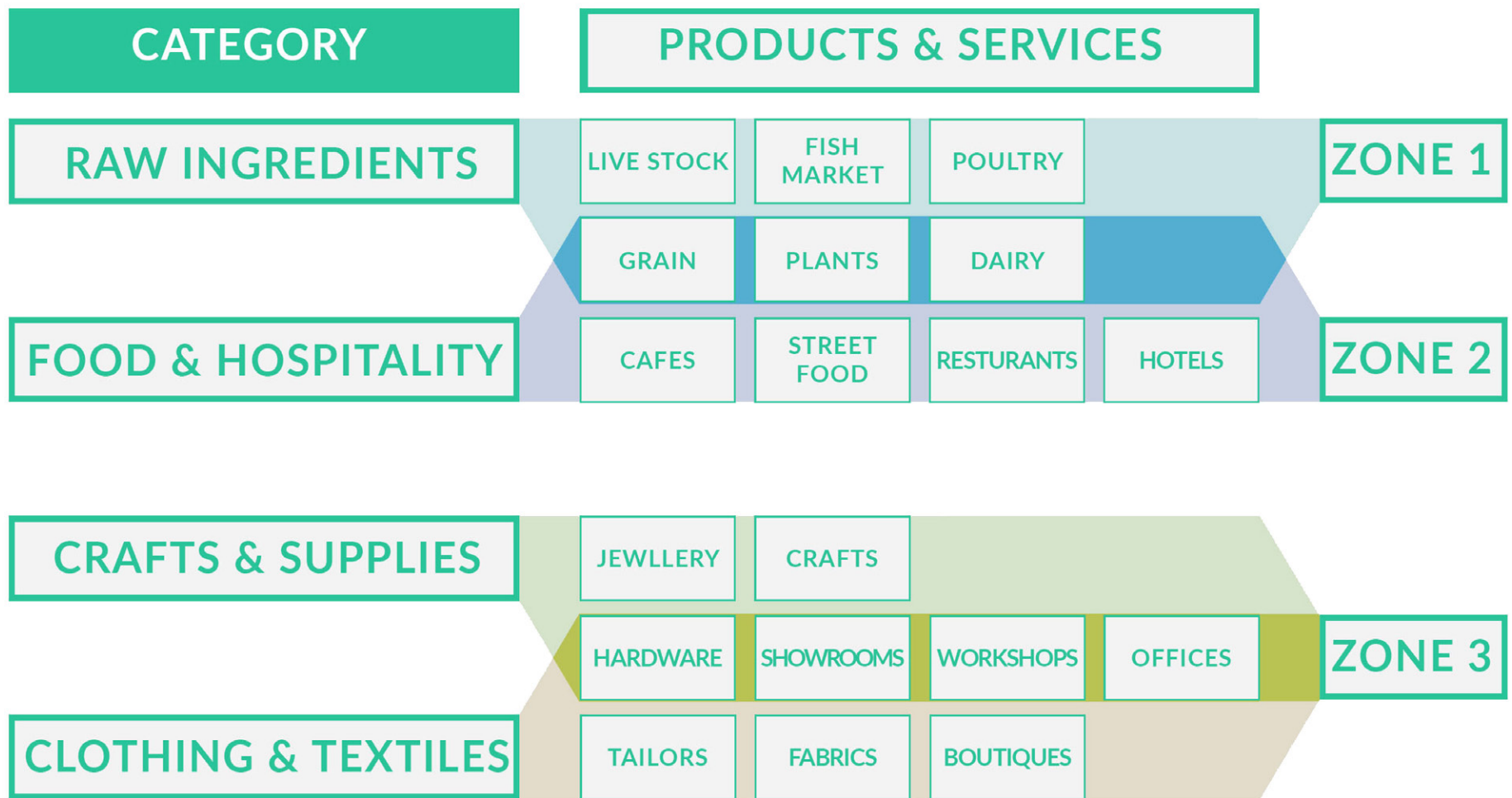


fig 3.03 | Second principle, Commercial Layout. Each activity that would be included need to be placed in a specific zone.

principle defines the economic characteristics of the market's activity, considering the merchants' side of the market. The first is about the variety of products sold in the market which can subdivide the market layout up to three zones (*fig 3.03*). The subdivisions are a result of health or safety concerns and users' comfort. this can be linked to byproducts of selling certain types of merchandise that can produce foul odors or a grouping of relative types of activities that require a crowded environment to operate and vice versa (Alexander and Christopher, 2010). While some types of products are restricted to a single zone, such as fish and poultry, other types can be placed in more than one zone.

The size of each zone is relative to the number of businesses offering similar services. The second part of the principle determines the type of space and services to be utilized for a business. Electricity, conditioned spaces, and storefronts are not a requirement of certain types of businesses, such as food trucks or pop-up markets. By understanding the presence and quantity of certain types of products, certain parts of the program can be utilized to host more relevant businesses (Bradley, 2010). Defining the type of businesses in the market requires local knowledge and observations of people's behavior on site. Introducing types of businesses irrelative to the site can make the market not function to its full potential or even fail, similarly to the case of Mutrah Fish Market.

### **3. Experience Development: What needs to be part of the public market?**

Creating an experience for a public market is beneficial to both vendors and customers. These principal lists considerations to be incorporated in the final public market design. The listed considerations are an accumulation of the previous iteration of market design improvements. The list is based on added amenities and implementations of design elements as the public market progresses through time. The list is divided into two categories, essential program element, and additive elements to enhance the presence of the market. Some of the listed program essentials are not typically present in a public market space, but they are necessary for modern needs, including amenities, restrooms, and management offices. The second is a list of additions that elevate the experience of being in a market. The additional program elements list is what needs to be considered to create a unique experience and empower the presence of the public market (*fig 3.04*).

Developing a unique identity to the market marks its presence with a strong impact to make it a destination. Non-commercial activities taking place in the market are part of defining characteristics of the market experience. These types of activities take place in outdoor areas in landscaped areas providing spaces for activities that can range from cultural events to family trips to enjoy the market experience.

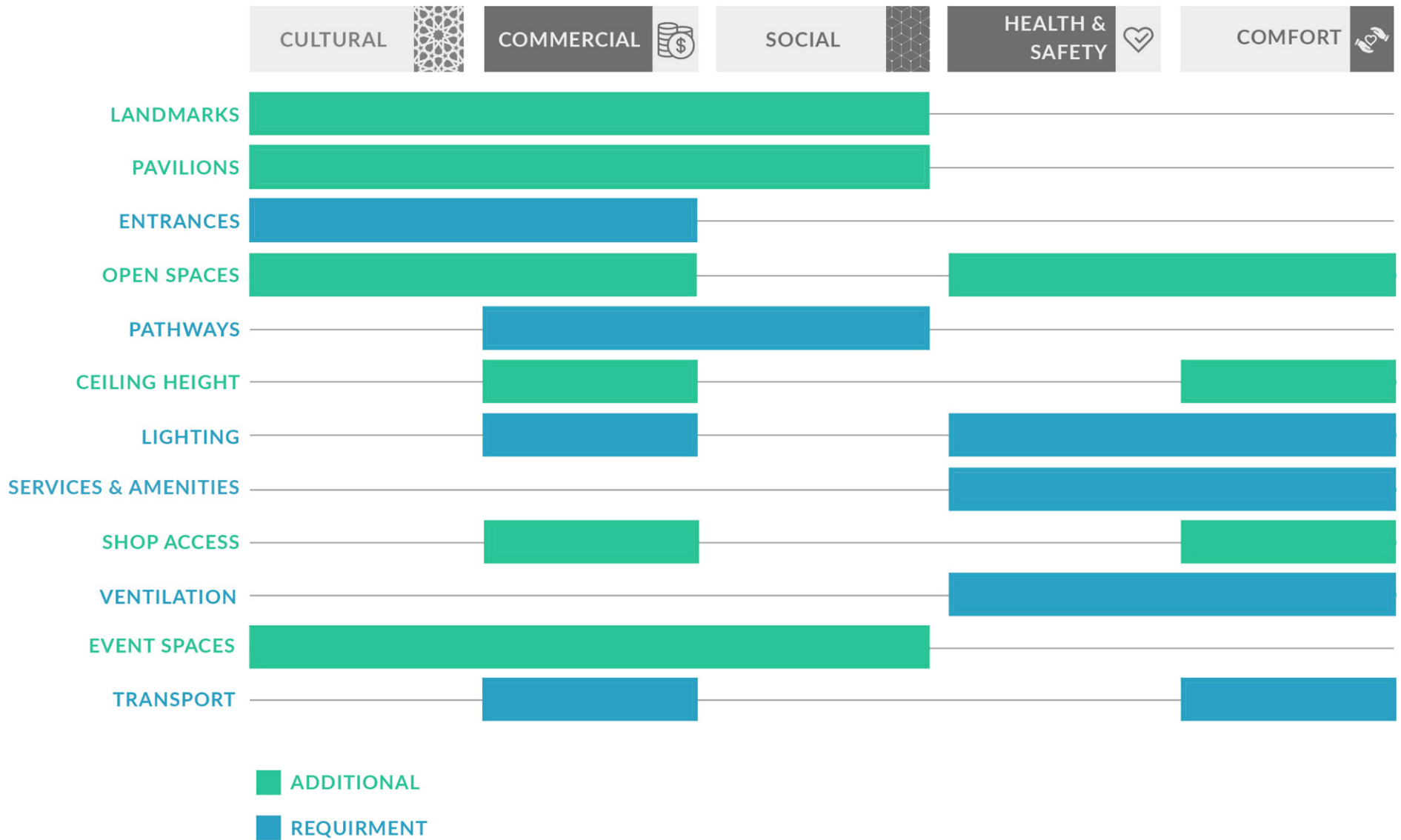
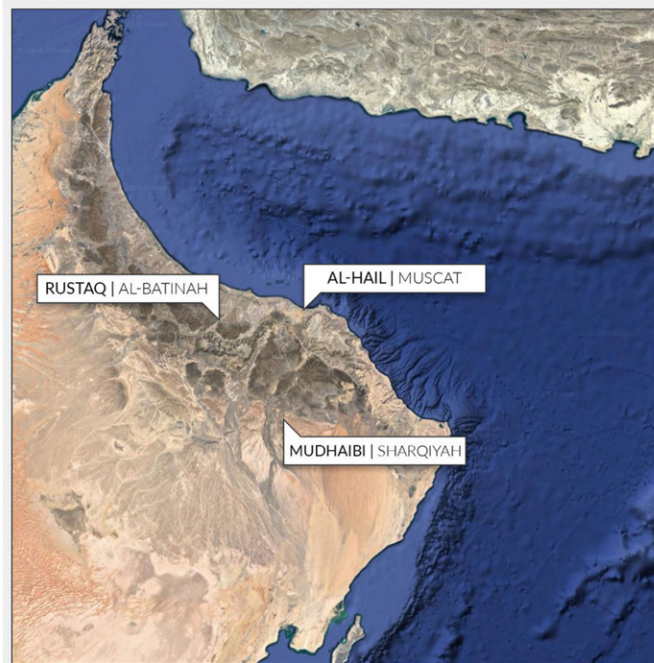


fig 3.04 | Third principle, Experience Development. This principle implies necessary amenities needed for visitors' utilization. Additional amenities provide an enhanced market experience.



3.05 | Potential public markets development sites in Oman and their potential advantages.

## Site Selection

Site selection for public markets is difficult due to the dependence on existing commercial activities. Another way of understanding this concept is that the public market site is not selected, rather it emerges by the commercial activities of the locals of area. The natural process in which a site becomes suitable for a market is dependent on the social behaviors of people and the demand for such a place. Constructing a market is only a way to organize and advertise the activities that already take place. At the beginning of the study, three potential sites were selected to be a candidate for public market development (*fig 3.02*). Each of the three sites will be evaluated along with the case study projects using the first of the three principles, Site Compatibility. The score of each case study and site will be compiled to define a pattern from the results. Of each of the three potential sites, the highest-scoring site will be used for the public market design development.

## Climate Analysis

Oman's geographic form is longitudinal, granting it a diverse geological and climate characteristic. Muscat is located at 23.5 degrees north close to the tropic of cancer resulting in a hot climate. Al-Hail region is on the western coast of Muscat facing the Gulf of Oman. According to ASHRAE Standard 169-2013, Al-Hail is designated as zone 0A, extremely hot and humid. Designing for such outdoor non-conditioned dominated space will depend mostly on passive cooling strategies through shading and site natural resources, such as wind.

Analyzing climate conditions will be done through a series of psychrometric charts to visualize proposed design solutions. The psychrometric chart method also provides an illustration showing the relation between humidity and temperature. Doing so can assist in selecting a design strategy to solve either humidity or temperature levels or both. By using Climate Consultant's psychrometric chart tool, each day's weather reading will be grafted either inside or outside the comfort zone. The goal is to propose solutions that would expand the comfort area (Buloshi & Ramadan, 2015). Psychrometric charts typically depict indoor comfort levels. With an exterior space, the comfort level can be expanded to cover a larger area at the start. Nighttime temperature drops also need to be considered, as the market's activities take place after sunset. Visualizing a temperature graph for after sunset time will also be necessary to provide thermal control strategies that do not involve sunlight.

Due to the site's close proximity to the sea, cool winds are expected to be reaching the project's space regularly. For warm months, utilizing wind as a sustainable cooling method necessary. To understand the characteristics of wind around the site, a wind rose diagram will be visualized for each seasonal period. Winds with an average temperature of 32° C or lower will be considered cool winds in this region. Visualized wind data will only span expected activity times, from 7:00 am to 10:00 pm. Local knowledge for wind characteristics

in the area will be studied along with the collected weather data in order to relate to any potential vernacular design strategies regarding wind utilization. Northeastern winds are predominant in the site during the specified time zone with an average temperature lower than 35° C. Western hot winds blow through the site at an average of 6% of hours during summertime, which needs to be blocked or diffused by using landscaping or structural elements (Ahmed & Choudri, 2012).

The high level of heat in Muscat is due to the high levels of radiation and lack of sky cover throughout the year. Taking advantage of such abundant resources can be done with photovoltaic panels, specifically heat-resistant N-Type panels that can operate in hot conditions without requiring a cooling system. Utilizing photovoltaic panels to produce maximum energy depends on their orientation. The goal is to provide an even distribution of received radiations throughout the year. Since Muscat is located at 23.5° North, the panels orientations should be between 8° South and 56° North. Climate Consultant will be used as a simulation tool to produce a graph showing the total amount of total radiation received by a flat surface between 20.5°, and 26.5°. For each of the simulated angles, the produced graph will display a range of radiation for each month. The most efficient orientation is the graph with the relatively most consistent amount of radiation.

## **Program**

Developing a program for a public market will depend on the second, Program and Zoning, and third principle, Experience Development. The first of the two principles will provide an understanding of the economic level or range of shop requirements to be considered. Acquiring data to evaluate the site requires a site survey and the type of shops that take place. The boundaries of the survey area are not restricted to the business in proximity to the site. Instead, visitors to the site should be used to define the reach of the market space. This is due to the ease of transportation offered by automobiles and car ownership, which is common for every household in Oman. By defining the economic range, the program can be divided into two main categories, low investment, and high investment types of businesses. Of the two, the majority of the market should be catered for low investment business. This includes food trucks, pop-up markets, and small rentable shops.

Places for such business can be placed in streets, plazas, and market rows. Designing for low investment type business should reduce risk and upfront costs of opening shops leading to potential permanency of such businesses. High-investment businesses require more services and demands to operate. Tenant improvements and storefronts are basic requirements for such business. The number of high investments businesses in the market should be moderated and controlled. While they function as an attraction to the market, their excessive

presence can overwhelm smaller businesses, and deter the public from visiting due to a possible high-cost reputation.

The Experience Development principle will dictate the type of requirements and services to be present in the market. Essentials will be incorporated into the program along with the zoning layout. This includes the design of the streets, amenities, lighting, and sustainable strategies. Additional program elements will be selected to build the experience of the design. adding design elements to the program should be done with the purpose to create the market experience. The site does not need to be fully utilized or planned. As with typical market growth, expandability occurs if a high demand is present. The Initially proposed program of the market will be designed to utilize part of the site. Program and layout will be done in a modular system allowing for future expansions.

## CHAPTER 4

### FINDINGS



fig 4.01 | Traditional silver craftsman in Sinaw Market

## Expectations of the market culture and functions

A public market program requires commercial and marketing approaches that differ from profit-oriented establishments like malls and supermarkets. Despite the name “public market,” complex social and economic interconnections exist alongside commercial activities in a system where one does not dominate over the other. A commercially focused market will revert to the original issue of how new interpretations of public markets lack identity and relevance to the community. Likewise, a socially-focused market cannot be financially sustained and will require external funding (Morales, 2009). By designing for both, the market becomes a place of cultural relevance for celebrations and social events, with local businesses providing a rich experience for visitors and merchants alike.

The public market experience needs to adapt to the area’s social and cultural practices. Designing for such a goal is achievable by understanding the social system of the region and the demand for products and services. Programming the market requires local knowledge of the area to understand existing commercial practices and needs. Research and Observation of existing commercial activities present within the site’s proximity define attractions and business practices that also serve as the market’s specialty and attraction. The presence of other businesses are required to provide a richer experience (Erwine, 2017).

Designing for a wide range of spaces for a specific type of business, food, in this case, needs to cover a wide range of needs to create choices for rentable spaces with a wide range of prices. Having diverse options attracts large volumes of vendors, which in turn attracts more customers allowing businesses of all sizes to take advantage of each other. A large business

can benefit small businesses through their advertising and bringing in new customers to the market. Smaller businesses support the market with a healthy and consistent flow of customers through their affordable options and rich variety of choices. Such a strategy also applies to other retail shops where one large business attracts customers while smaller shops provide inexpensive products. The benefits are not exclusive to businesses offering similar services, but they can also benefit any shop or vendor in the market where retail indirectly support food vendors and vice versa.

Public markets need to incorporate a memorable experience with their own unique identity. Building such identity is a slow process that depends on space users', customers and merchants alike (Erwine, 2017). The market should be where visitors go through a social experience while navigating and interacting with vendors and retailers. Achieving such a goal depends on spaces with various spatial qualities that encourage movement and explorations.

Unlike supermarkets and shopping malls, the market relies on its community rather than substantial capital, requiring it to rely on people using the space. The social system of the public market will eventually benefit merchants indirectly by attracting people who do not necessarily need to shop (Morales, 2009). Public markets should not compete with supermarkets, rather offer a unique experience instead of selling convenience. Navigation and movement throughout

the market need to be playful, exploratory, & quirky to create a sense of character. The public market succeeds when it becomes a destination where people want to be rather than need to be.

The design of the market needs to support merchants through logistics design & health standards to manage and maintain their businesses. The concept of spaces connected to shops and merchants for logistics is part of a modern iteration prevalent in the United States Farmers' Markets. Designated logistics areas are often referred to by the organizers of farmers' markets as the backstage. Such space is reserved for vendors to park their vehicles and set up any extra equipment to operate their stalls. The other purpose of the space is to make vendors' stalls more presentable by managing waste, working on preparations, or utilizing the space as storage.

With large markets, such space needs to be more sophisticated to handle more diverse businesses and merchants' requirements. Shopping malls utilize a similar method that includes back corridors connecting to freight elevators and services designated for employees' use only. The result is a space where employees can move freely and manage the logistics of running businesses. Implementing such a system to a semi-enclosed public market creates a presentable image to the public while providing a veil that allows merchants to manage their stock and shops in

comfort and ease.

The public market has to connect its surroundings by integrating them into its context. Public markets' reach does not stop at its defined boundaries. The presence of the market radiates to nearby areas, increasing their commercial success potential. Streets adjacent to the market and open areas outside the market boundaries become indirectly connected to the activities that take place within the market. Embracing such influence evolves the market experience.

Nearby landmarks and attractions are essential to advertise the market, especially if such landmarks are culturally significant. The most prevalent type of structure to be associated with public markets are structures of religious significance. While such a connection was associated with the open plazas in front of churches, markets quickly became associated with religion and nationalism. In the case of Oman, Masjids are the prevalent religious structures that stand as cultural landmarks. With the five daily prayers, Masjids fill up daily five times a day, bringing many people within the public market's proximity. Other than the convenience of high traffic flow, Masjids host rich architectural significance and a powerful presence to an area in which the public market connects to amplifying its presence.

Unlike Shopping malls and supermarkets, most public markets are open to the elements. Such an approach aids in reducing operational costs and allows for flexible layouts and

modifications to spaces with minimal construction works. Reduction in mechanical equipment for climate and comfort control enables vendors to rent spaces much lower. The challenge with open air space in Oman is the extreme heat of climate temperatures. ASHRAE 90.1 - 2016 classified Oman's environment as OB zone, Extreme Heat, and Dry nearly all year round. For a public market to succeed, responding to climate challenges is necessary to elevate comfort levels. Due to cost and affordability concerns for businesses and merchants, integrating passive systems into spaces is the optimal strategy to reduce operational costs since they do not require power to operate.

## Site Selection

Public market in Oman existed for centuries and still maintains their activity despite the climate and infrastructural challenges. The form of market perceived today results from eons of social influences and shifts in economic and political developments. Most markets' designs are based on existing commercial activities backed by a social and cultural system that supported the emergence of a market (Morales, 2009). Any public market depends on multiple factors that contribute to either its success or failure. Persisting public markets results from a successful formula that supports its function from a social, economic, and cultural perspective. What makes selecting a site to develop a new public market

CATEGORY	LANDMARKS	ACCESS	PUBLIC SPACE	RESIDENTS	AREA	MERCHANTS	MARKETS	SPECIALTY
PIKE PLACE MARKET	3	✓	✓	✓	36,400 m <sup>2</sup>	✓	✗	SEA FOOD
CAMDEN LOCK MARKET	4	✓	✓	✓	2,240 m <sup>2</sup>	✓	✗	WARES & ACCESSORIES
SANTA CATRINA MARKET	2	✓	✓	✓	7,000 m <sup>2</sup>	✓	✗	STREET FOOD
GHENT MARKET HALL	2	✓	✓	✓	N/A	✓	N/A	LOCAL GOODS
ROTTERDAM MARKTHAL	2	✓	✗	✓	5,500 m <sup>2</sup>	✓	✗	DAIRY PRODUCTS & LOCAL FOOD
MUTRAH DARK MARKET	3	✓	✓	✓	> 150,000 m <sup>2</sup>	✓	✗	FABRICS & TAILORS
NIZWA FORT MARKET	2	✓	✓	✓	85,000 m <sup>2</sup>	✓	✗	SILVER & JEWELLERY
RUSTAQ SITE	0	✓	✗	✓	35,300 m <sup>2</sup>	✗	✓	N/A
AL-MUDHAIBI SITE	1	✗	✓	✓	955 m <sup>2</sup>	✓	✓	GENERAL MARKET
MUSCAT, AL-HAIL SITE	3	✓	✓	✓	150,000 m <sup>2</sup>	✓	✗	STREET FOOD

fig 4.02 | Site Evaluation Principle applied to the three potential market sites. For comparison, Famous market around the world, and historical markets in Oman are also evaluated.

challenging is to determine whether a site can be successful. The previous chapter of this research discussed the three principles of public markets program design. Of the three, the first principle evaluates a site's compatibility to function as a public market. To further study the feasibility of the 'Site Compatibility Principle,' public markets from different countries and regions along with some local historical public markets in Oman will also be analyzed (*fig 4.02*).

Three potential locations are selected as potential public market development sites. Each site has its characteristics and advantages to develop into a public market. The first is located in Rustaq, a newly developing area next to public institutions, parks, and a large masjid, acting as the site's religious structure. The city of Rustaq is known to be an area with historical importance in crafts and tourism. Easy access to the city and an increase in population are advantages that support the development of a public market in the region. However, the existence of an old market nearby and the lack of existing activities are hindrances against placing a public market in this region.

The second potential location is in Al-Mudhaibi city. The suggested location hosted a public market in the past that perished with the emergence of automobiles which allowed easy access to Sinaw's public market, 18 kilometers away. Recently, the market was revived in a much simpler form under its old name 'Suq Al-Masilah,' meaning 'The Market on

the Gravel.' The market became an active place, especially during events and celebrations. The most significant disadvantage of this market is its inaccessible location, small potential development area, and tribal control of the region, preventing any major developments in the city.

The final site is located in the capital of Oman, Muscat, in North Al-Hail Region. The proposed location is parallel to the beach next to a preserved natural biological formation around a large tide pool. The area is part of a government-owned area held for future developments. Muscat's local municipality developed the beach area in recent years to serve as a recreational trail and parking space for people visiting the beach. The new beach development attracted residents to use the space more often and street vendors to set up their businesses along the trail. With the completion of the large masjid 'Jamea Sayyida Fatima bint Ali' in the area, the beach became a busy destination for families, athletes, tourists, and many more. However, aside from the strong street food community taking root in the area, no other existing commercial activities occur within proximity to the site.

In the case of the selected site in Al-Hail, the number of street vendors increased since 2017 by more than twice. The increase was due to economic challenges impacting the work market in Oman. As a result, many young individuals who just graduated from college or lost their jobs started



fig 4.03 | Site proximity to residential areas, tourists' spots, and main roads.

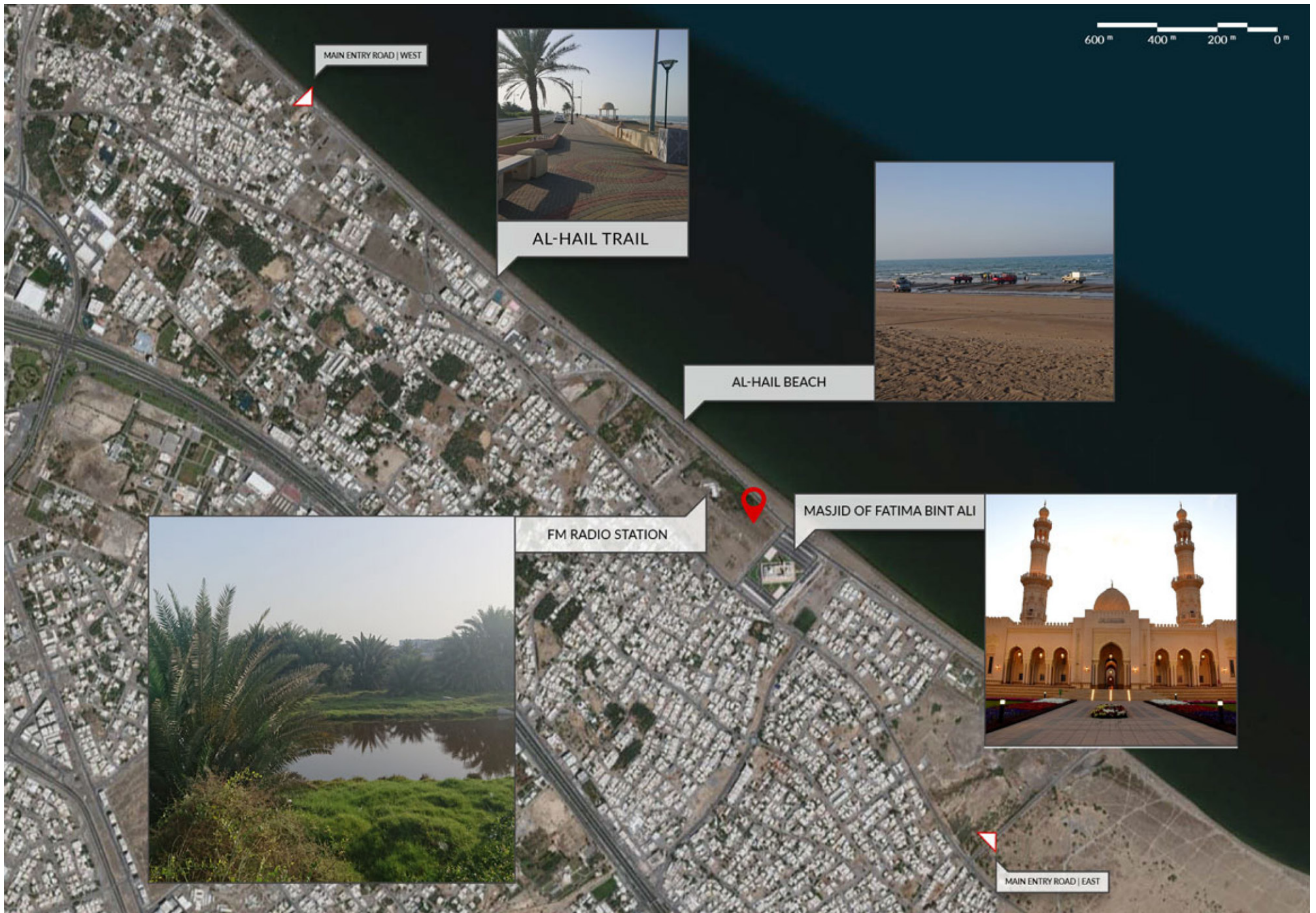


fig 4.04 | Site proximity to nearby context, and main roads.

seeking alternative income sources. New businesses emerged from unemployed individuals, including the rise of street food vendors. Initially, they were scattered along streets and commercial districts seeking potential customers. However, due to the competition from restaurants and shops in the area, street food vendors were unable to attract enough customers. With time, they relocated around recreational areas, such as parks, beaches, and valleys where the competition is thinner. Al-Hail beach area is especially popular with a strong presence of street food culture. This is due to the popularity of the space amongst locals after the local municipality developed the beach to be a recreational trail. Some visitors travel more than twenty kilometers to spend their afternoon on the beach with their families. The high flow of people captured the interest of street food vendors, making them set up shop next to the main entries and along the trail path to take advantage of the concentration of people in the area.

Despite the perceivable long distance from the site and the residential areas, due to automobiles being the primary method of transportation, people tend to travel further in a short time. Three main highways run parallel to the shoreline leading to the site region (*fig 4.03*). The market site is accessed through two roads; the main road runs along the beach trail and the inner road that crosses the residential area. Proximity to Muscat International Airport and Al-Mouj Complex gives the site a strong potential to be a tourist destination. The site and

beach area are relatively flat, with an elevation of 5 meters from sea level at the site's highest point. A protected dense vegetation area grows in a tide pool located in the northern part of the site referred to locally as Khour (*fig 4.04*). Such an area cannot be modified or disturbed but can be expanded or integrated into the design.

Street food flourished in the area with a high amount of traffic around their food trucks and kiosks. In a recent conversation with a street food business owner, he expressed his desire to better and improve his business practice. However, the only available option is to rent a space and open a restaurant. The issue with such a step is that street vendors are expected to lose more than gain by abandoning the street food vendor practice. Not necessarily in capital and profit, rather in social exchanges and communities built around his street food practice. The mobility of a food truck, the community of street vendors, and recognition as a street food vendor will all be lost. According to street food vendors, reputation is their most valuable investment.

From a capitalistic perspective, the biggest problem is the shift in business practice requiring a new set of management skills and hospitality criteria to ensure that a business is consistently performing well. Compared to street food, communication is informal and more fluid with locals. Rent is the biggest problem and obstacle with street food. The fear of not succeeding and having to commit to an annual year

contract is a risk many are unwilling to take since many lack the experience of running an established restaurant. Public markets offer flexible solutions since they provide areas designed specifically for each business and their operational needs without strict requirements. In a public market, street food vendors can have various options to set up their businesses. Some can be in the form of a designated open-air spot to park food trucks and take advantage of surrounding areas by expanding their operational space, either by service or setting up equipment. The other form uses food kiosks where each business only has to manage its operations and cooking space and take advantage of the market's layout and seating spaces. For potential more significant expansions, the market should also accommodate rentable areas with the potential of providing a whole restaurant experience.

## Program Zoning & Commercial Layout

Varieties of offered products in public markets present an organizational challenge to maintain health and safety standards. Commercial layouts of public markets must consider the byproducts of their sold goods and any potential consequences. Odors, noise, and visuals impact visitors' experiences and merchants in running their business. While positive impacts from odor and noise are desirable and can be used to market some businesses, food vendors prominently, foul smells result in a disturbing and uncomfortable experience if it expands beyond a designated space. Livestock, fish, and poultry are sources of such odors requiring designated areas to control the odors spread and contain any unsanitary microorganisms from spreading. Designing for a specific type of business depends on the presence of such business activity in a local region and whether a demand exists. The total



- MAIN ENTRY | PUBLIC AREA**  
NATURAL PARK  
INTERACTIVE SPACE  
EVENT SPACE
- FOOD AREA | ZONE 1**  
STREET FOOD  
RESTURANTS
- PARKING**
- RETAIL SPACE | ZONE 2**  
CLOTHES  
ACCESSORIES

fig 4.05 | General programming of the market,

area of the public market plays a factor in determining the zoning of the market and if a product with foul odors can be included as part of the market.

To understand the range of foul orders resulting from a fish market, an experiment was conducted to determine the impact of smells and at different distances. The test location was in Sinaw's fish market hall on Friday morning during peak activity. At a distance of less than 400 meters, the smell was intense and challenging to get accustomed to for a long time, especially for those not intending to be at the fish market. Beyond the 400 meters radius, the stench is noticeable and recognizable, but it does not persist or bother people. At a 700 meters radius, the smell is unnoticeable due to other ambient odors overpowering it. Despite the limited activity in the fish market due to COVID-19 Lockdown regulations, the stench of the fish market traveled

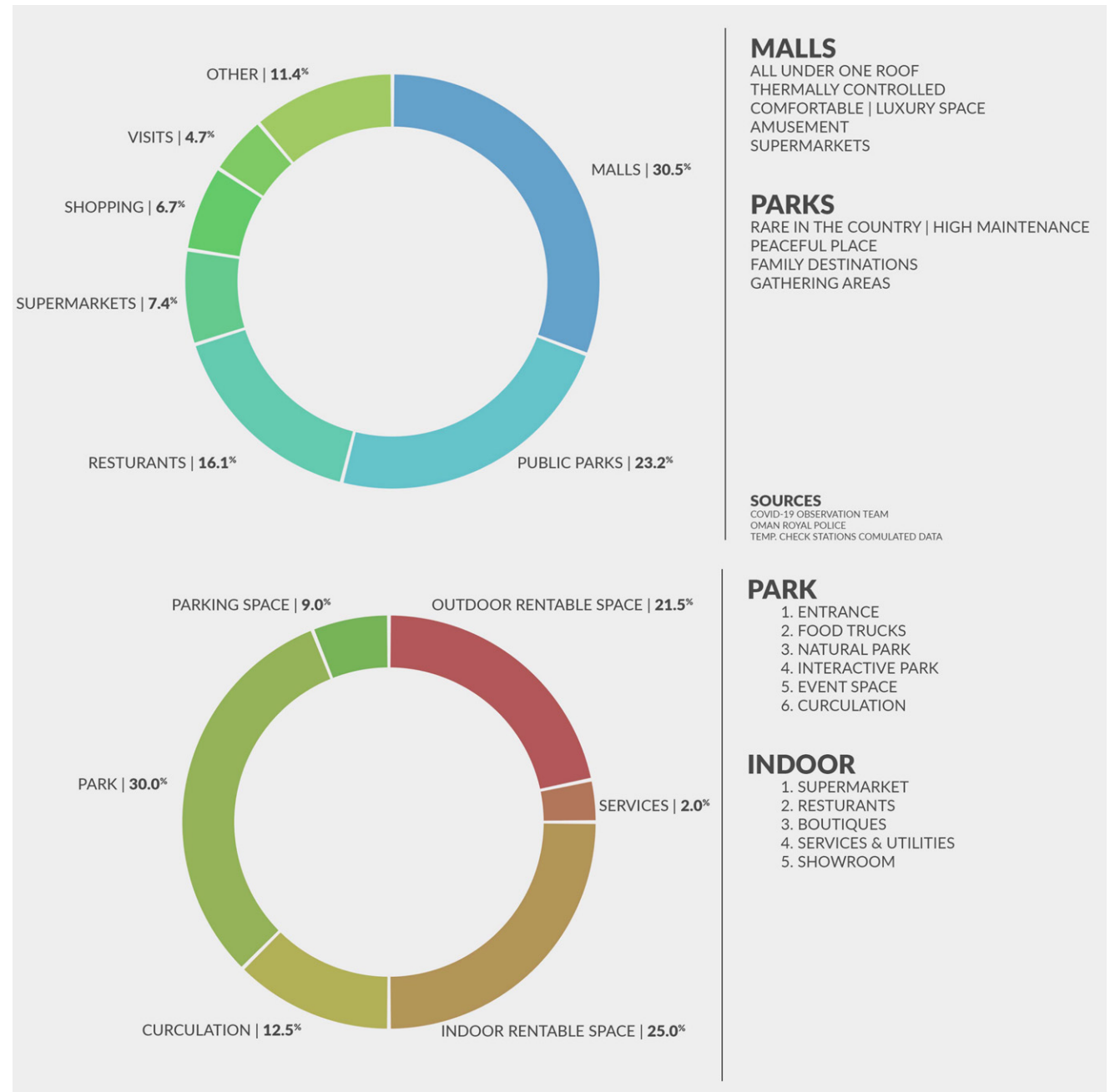


fig 4.06 | Top graph represents data collected at popular area when COVUID-19 lockdown is lifted. Bottom graph is an estimated distribution of how spaces are utilized in the public market.

a long distance. Combined with the proposed passive thermal control solution, discussed later in the chapter, including a fish market in the design is not recommended since wind can transport powerful odors to nearby residential areas.

By utilizing the second of the three principles to program the public market ‘commercial layout,’ the market will be formed of two main zones (fig 4.05). The first zone specializes in prepared food and food ingredients, while the second will house a wide range of retail shops. Each zone is also further divided to create a versatile public market hosting more than commercial activities. The third principle, Experience Development, is utilized to create non-commercial spaces, expanding the functionality of the public market, including required facilities such as management offices and restrooms. Other additions can be integrated into the market to enhance non-commercial activities to elevate the market’s overall experience. The selection of such facilities

depends on the cultural practices of the region and the site characteristics (fig 4.06).

## Climate Analysis & Challenges

Designing for comfort through climate response is the most significant contributor to the success of the public market in the region of Oman. Due to the high level of heat in the region from April to September, outdoor spaces are intolerable most of the day, more so for a shopping experience. Historical public markets in Oman integrated passive strategies to maintain a comfortable level through shading and natural ventilation. For example, Mutrah market is built to cover sunlight with wooden roof structure that blocks sunlight and channels sea breezes throughout the market’s corridors. Since the design of the public market in the selected site will be in a semi-outdoor open space, the market design must respond to its location and climate

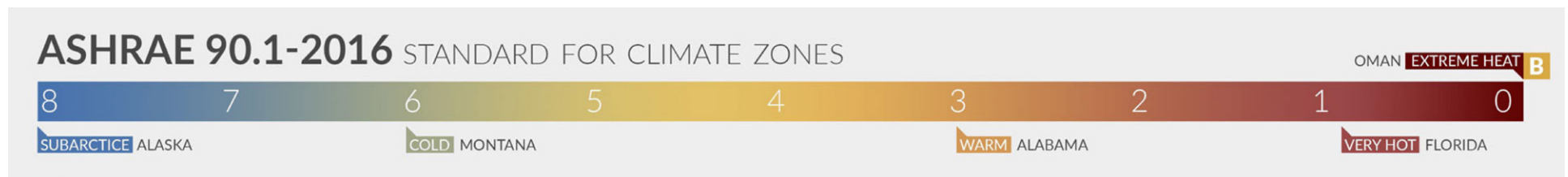


fig 4.07 | Oman’s ASHRAE 90.1-2016 Climate zone in comparison to some states in the U.S.

MUSCAT INTERNATIONAL AIRPORT WEATHER STATION  
DATA PERIOD | 2003 - 2017

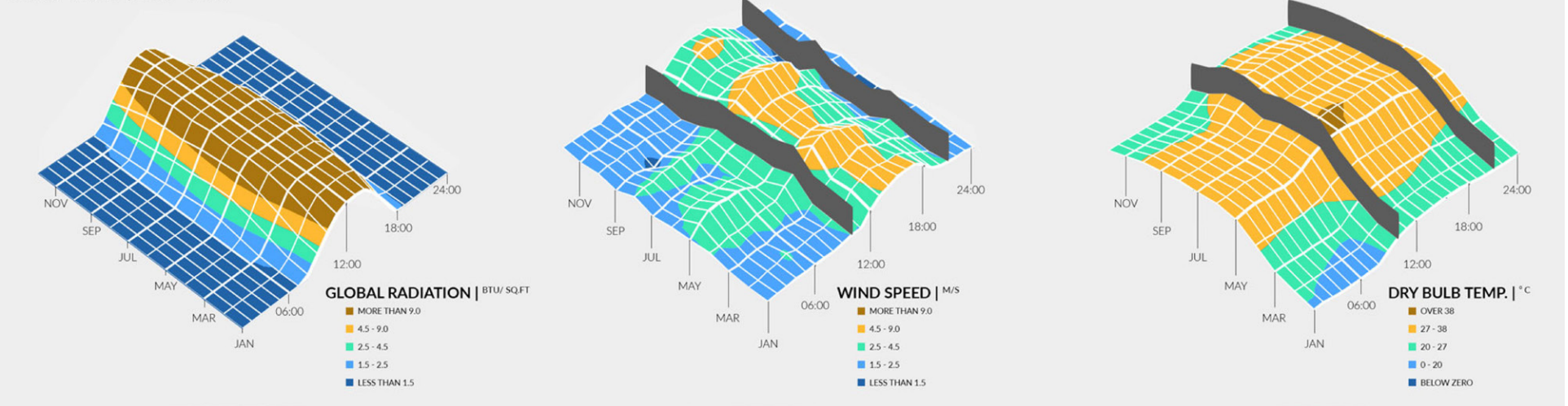


fig 4.07 | Climate data from Muscat International Airport collected from 2003 - 2017, representing monthly averages of , global radiation, wind speed, and dry bulb temperature.

condition.

Climate analyses and data are collected from weather data files produced from Muscat International Airport weather station, approximately 7 kilometers from the site. The information represents monthly averages of collected data recorded from the year 2003 to 2017 (fig 4.07). Since heat is the main issue to address, temperature, wind, and radiation data are studied to design suitable passive systems to control thermals and light levels. Temperatures in the area shift dramatically between the day and night cycle. At its extremes, recorded temperatures peak at 49° C during the day and drop down to 29° C that same day. The average delta in temperature of summer months is 9° C, more than winter months.

Wind is a valuable resource to be utilized and assist in ventilating the market and reducing reliance on mechanical cooling systems. Faster wind transfers heat faster and encourages evaporative cooling in the area. Since the site faces the sea, wind flow direction is consistent most of the time, blowing northeast, south, and west. Since cooling is desirable during hot months from April to September, and during the day, from 7:00 to 18:00, wind data will be studied for the aforementioned period (fig 4.08). At the selected period, wind blows from the northeastern side of the sea at 62% of the specified time hours with speeds of an average of 8 m/s and 67% humidity at 35° C. Calculating for a specific cooling effect is complicated, especially with the inconsistency of wind flow in a large market (fig 4.09). An



fig 4.08 | Climate data from Muscat International Airport collected from 2003 - 2017, representing prevailing wind direction at different time periods specified by Month and hours.

estimation can be derived from Newton's first law of thermodynamics of bodies exchanging heat through Newton's cooling law:

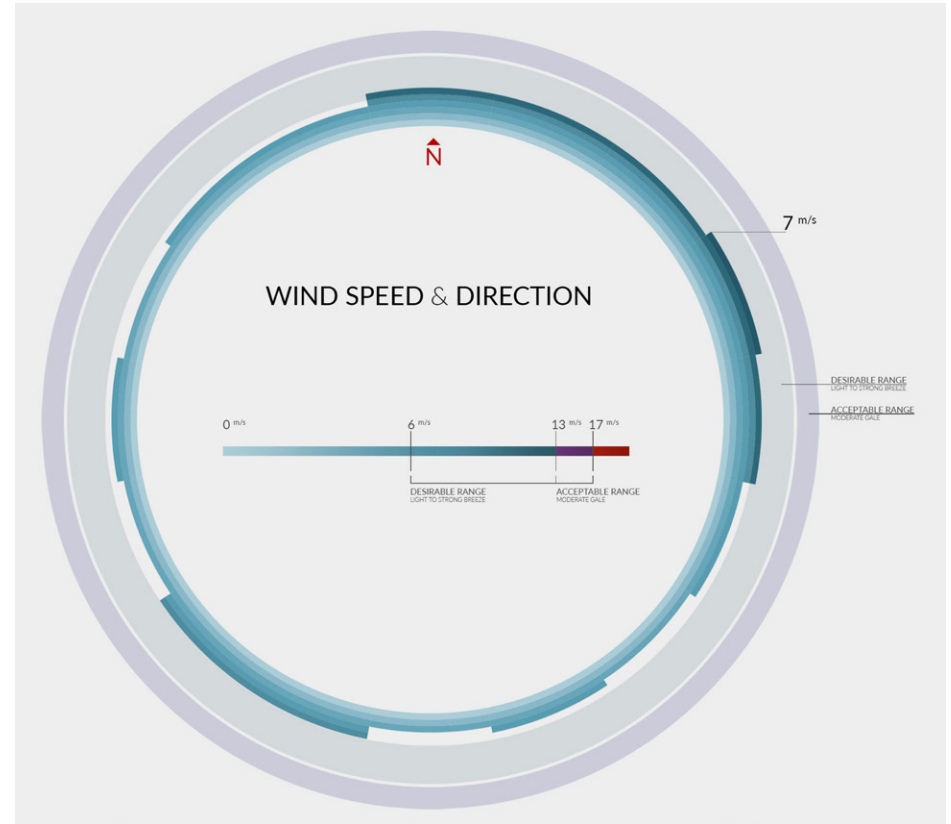
$$dQ / dt = hA\Delta T(t)$$

Another contributor to cooling is the phenomenon of evaporative cooling, where heat is absorbed by water when it transforms from liquid to vapor. Studies on wind cooling effects have been conducted but not quantified for hot areas. Windchill is a more prevalent study of wind cooling effect, but it only provides data for temperatures below 5 C. The cooling effect with ventilation only is approximately 2° C per 1 m/s at 50% humidity. However, wind cooling effect is limited if not combined with other methods such as shading and evaporation.

The main causes of heat in the region are the sun position due to the geographical location of the region at 23.5° North and the extreme lack of sky cover. Recorded data indicate that sky coverage averages at 12% annually,

causing large amounts of radiation to heat the surface. Hourly global radiation averages at 443.5 W.h/m<sup>2</sup> during the hot months period. The illumination average range is relatively consistent throughout the year, with an average deviation of 9% at the low levels and 6% at the maximum levels. The typical practice in the region to manage high solar radiation levels is by blocking direct sunlight. Direct solar gain is desirable to generate energy by utilizing photovoltaic panels. Due to the sun angle range from 88.5° N to 43.8° S, the optimum solar panel tilt is 24° South. Such placement allows for up to 91% production annually of the solar panels rating at optimal conditions.

The comfort level of the market is visualized by zoning a psychrometric chart and daily shifts in temperature and humidity. ASHRAE 55 defines a comfort zone for indoor spaces within 23° - 27° C; however, this initial zone can be safely expanded since the semi-open market. Heat in the areas allows for a more tolerable comfort zone to be extended to 30° C. Implementing passive cooling strategies, ventilation, shading, and evaporative cooling expands the comfort zone to cover 76% of the market's operational hours 7:00 to 23:00 (*fig 4.11*). Suppose wind is accelerated through a wind harvesting system to reach 14 m/s, and the evaporative pools are cooled. In that case, the cooling effect of ventilation is further enhanced to cover 88% of the market's operational hours (*fig 4.10*).



*fig 4.09 | Climate data from Muscat International Airport collected from 2003 - 2017, representing wind speed direction during the day from APR - SEP. Center bar represents desirable wind speed range.*

## Project Programming, Site Development, & Concept

The design and form of the public market respond to the site's existing characteristics, including wind directions, existing ecosystems, movement patterns, and space's program and zoning. The market space needs to be placed within defined boundaries to create a clear area where visitors and merchants integrate into the market

MUSCAT INTERNATIONAL AIRPORT WEATHER STATION  
DATA PERIOD | 2003 - 2017

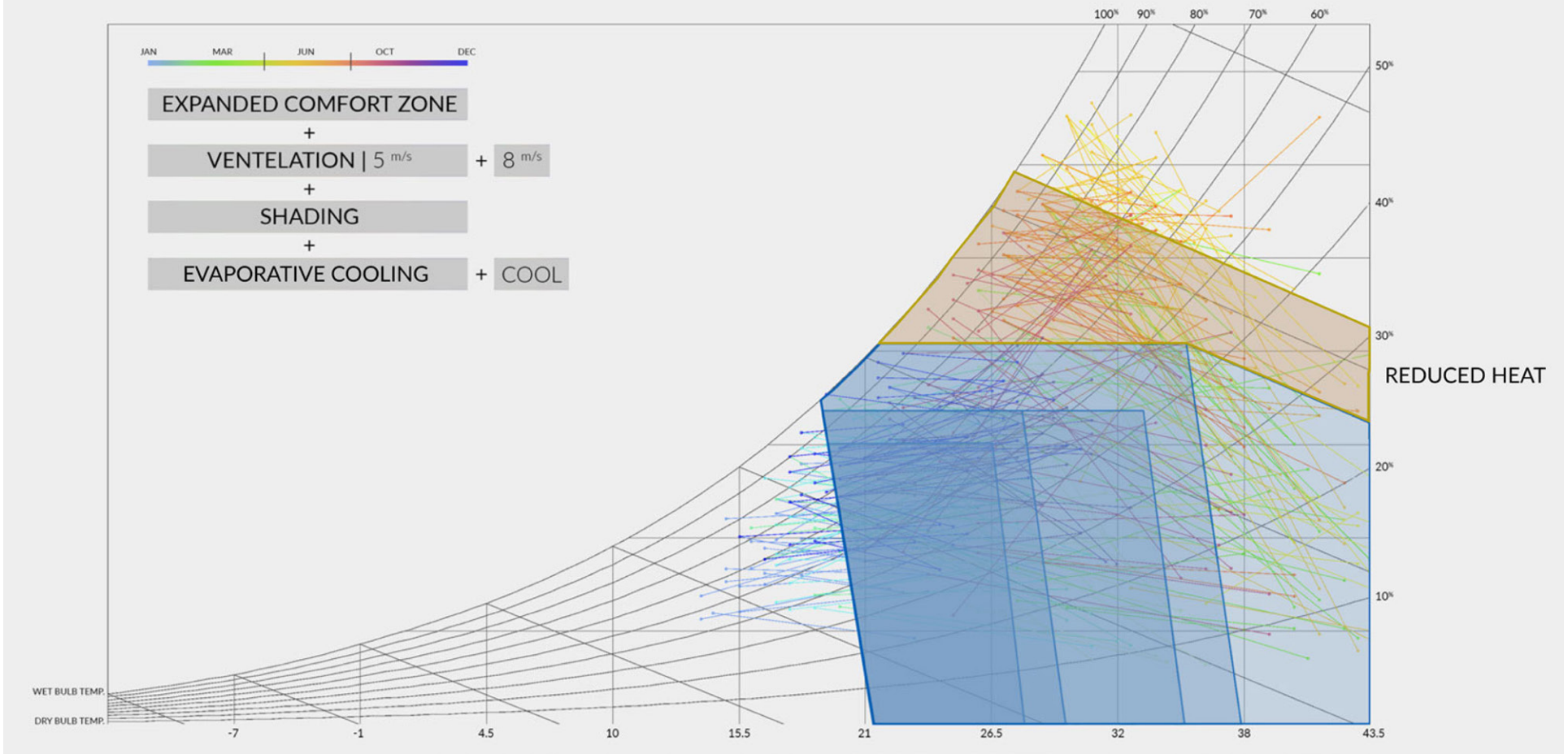


fig 4.10 | Climate data from Muscat International Airport collected from 2003 - 2017, in a psychrometric chart with comfort zones expanded by the implementation of each passive cooling strategy.

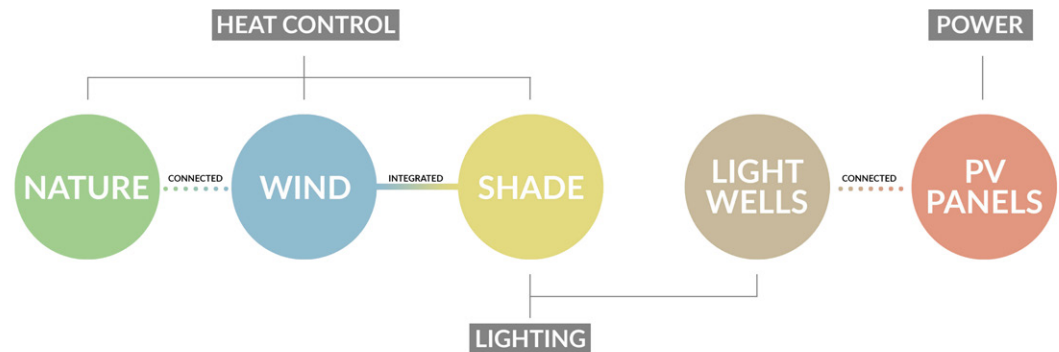


fig 4.11 | The graph represents system strategies and their contribution to the public market. Each strategy connected to another or integrated with another system.

environment. A marketplace boundary is defined to create a sense of transition from daily life routines into a place of social interaction and enjoyment. Entry points are the main contributor to creating a sense of transition from one space to another.

Due to the dominance of travel via automobiles in the region, entry points need to accommodate parking spaces. These parking spaces can utilize existing parking spots along the beach road and the adjacent masjid. Commercial zones do not necessarily have to be separated. Overlapping areas can assist in advertising other businesses encouraging the

movement of visitors throughout the market. Through the analysis of potential commercial activities to take place in the market, the program will utilize a two-zone commercial layout. The first zone, specializing in prepared food and food ingredients, is placed closer to entry points, parking spaces, and next to roads parallel to the market's perimeter to attract visitors with food's aroma.

The general retail zone will be placed in the market's center to encourage social interaction since retail is a slower shopping experience than eating. Transition spaces in between markets need to have non-commercial specs



fig 4.12 | Alleyways formation in old Omani villages and their effect on wind and cooling, and how such concept is integrated into the public market's design.

for resting and experiencing the market space from a non-shopping perspective. Such spaces can have educational, artistic, or visually appealing installations and activities.

Supermarkets have become places of necessities in the modern age, making them irreplaceable for people to get affordable daily necessities. Therefore, the inclusion of a supermarket within the overall site will attract more people to the public market. However, the market plan will be divided into two areas, one with the public market itself hosting local businesses, and the remaining areas will be supporting areas that extend the functionality of the core public market. Supporting spaces include the supermarket, the natural tide pool ecosystems area, and an extension of the natural ecosystem to form an interactive park. The park area will also be utilized as a space where street food vendors can set up their businesses to take advantage of the park visitors.

The main market space's form is inspired by the design of alleyways of historical villages in Oman (*fig 4.12*). Villages in Oman were designed to take advantage of the wind to cool homes and spaces in between. Alleyways were intended to be inconsistent in width to create shifts in wind pressure as it passes through. Widening corridors create negative pressure

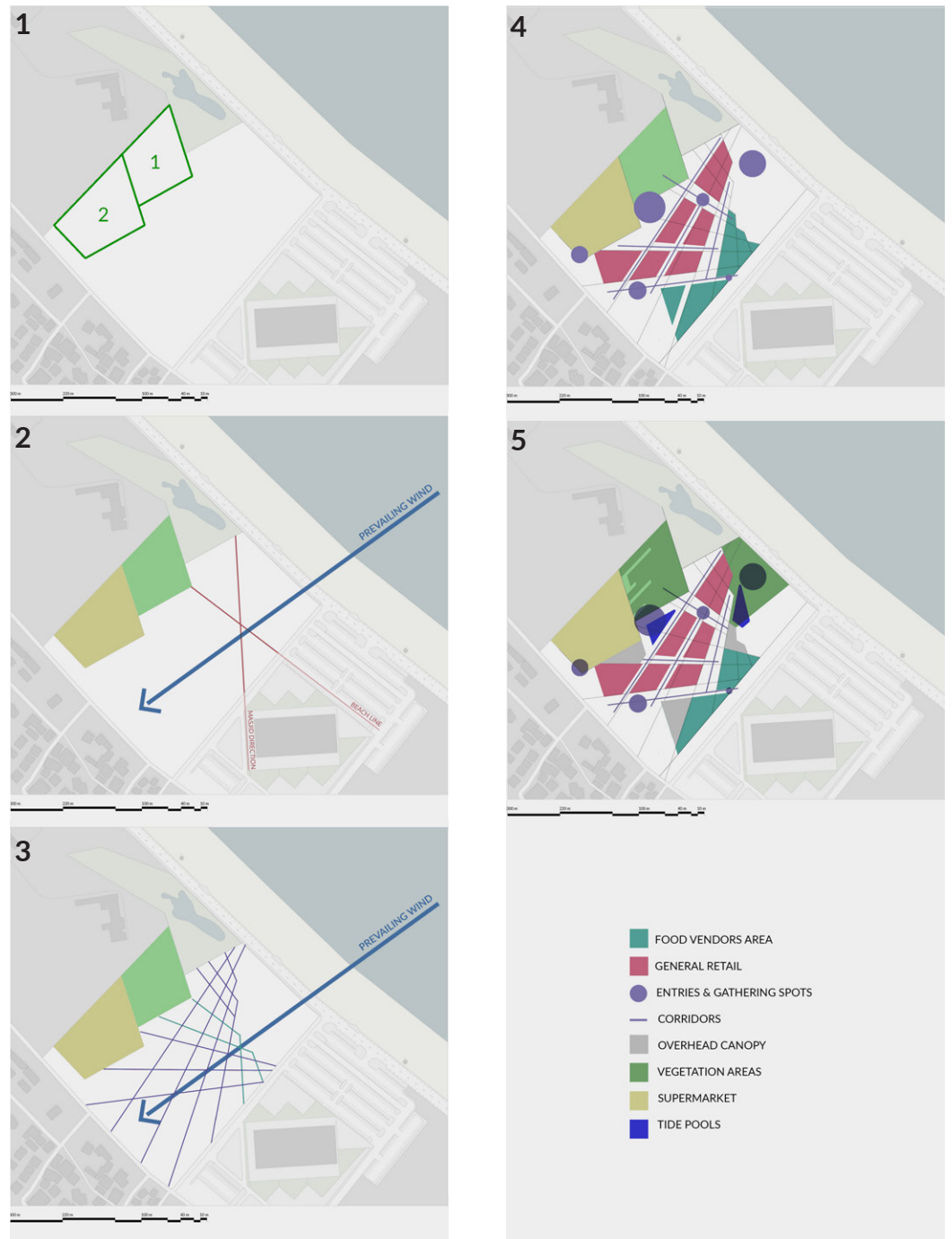


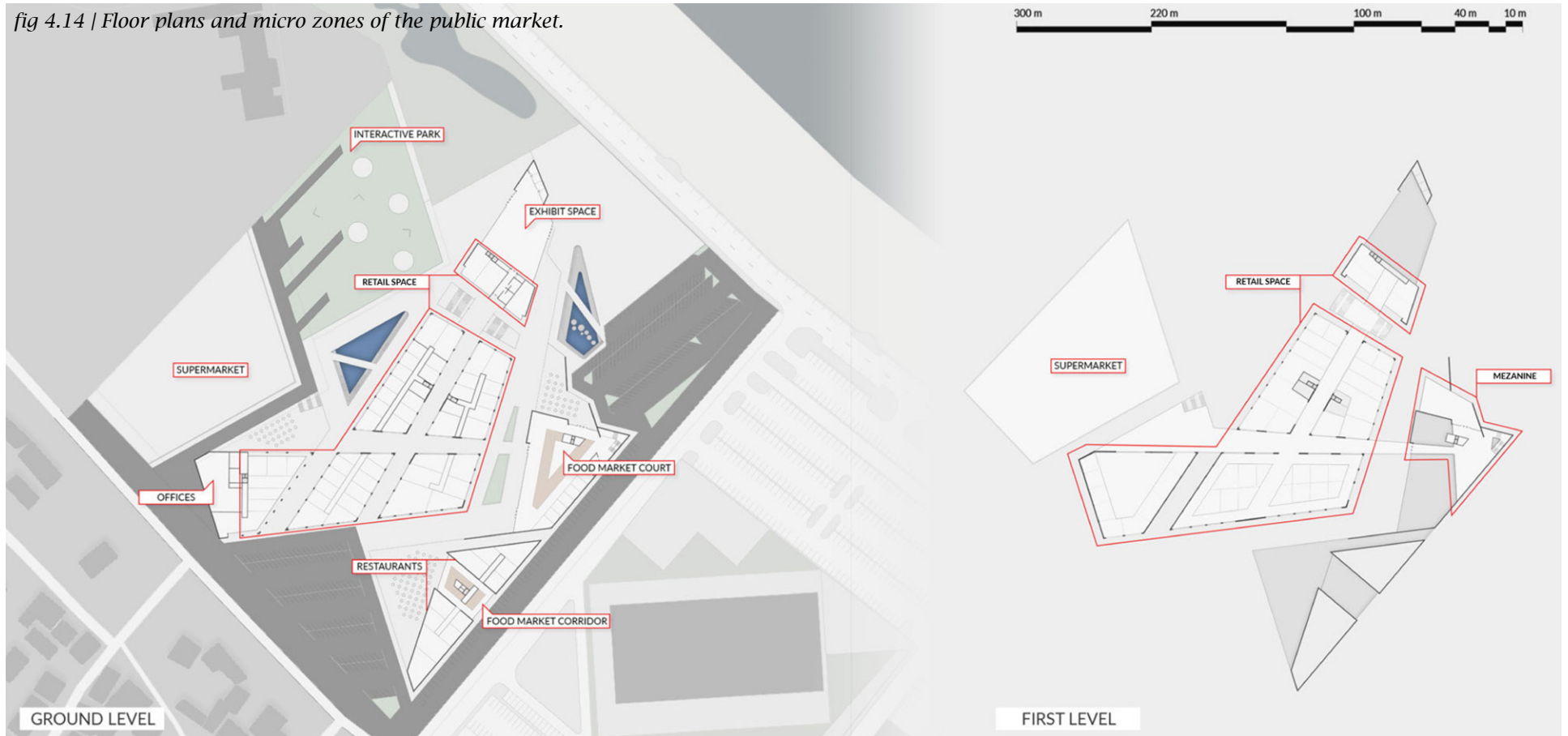
fig 4.13 | Concept development of the public market layout and zones.

allowing for cooler air to be pulled down to where people move, while narrowing passageways increase wind pressure causing the wind to accelerate and improve the cooling effect. The design of the market utilizes similar principles but extends its wind functionality by combining both concepts, accelerating wind and harvesting cooler air. The main market corridors are designed to widen in the direction of the wind allowing for more air to be pulled into the market spaces. The wind is also accelerated by the incorporation of a shading device that

collects wind into the market's main passageways (*fig 4.13*).

The direction of the prevailing wind is the main driver of the performative aspect of the market. By making the passageways and main circulation paths parallel to the wind direction, air will pass through to cool spaces without much turbulence, allowing for constant airflow. The market concept will also utilize wind direction as the main central axis in developing the overall layout concept. By connecting the main axis to the existing site lines of both the beach

*fig 4.14 | Floor plans and micro zones of the public market.*



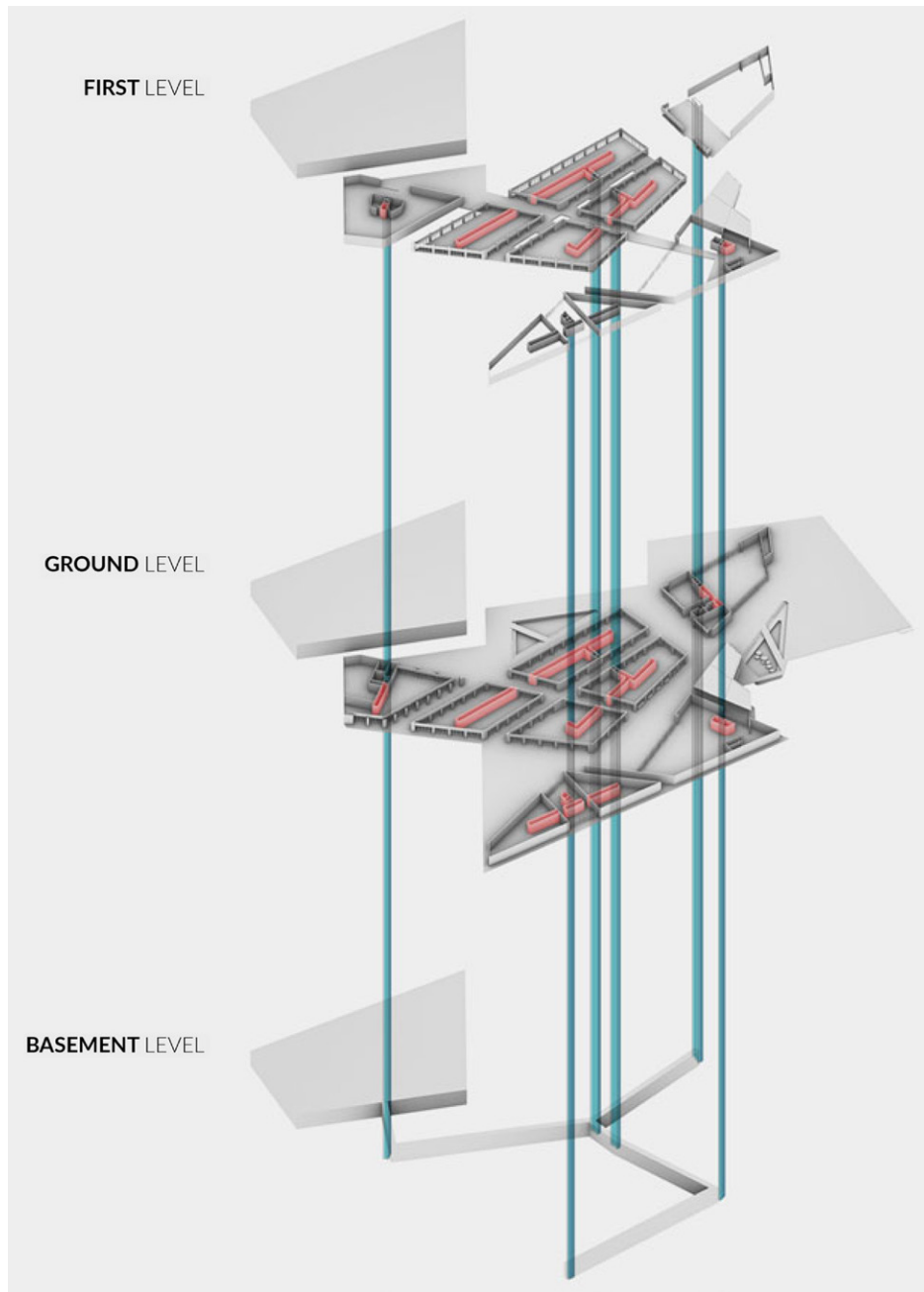


fig 4.15 | Freight elevators across the different levels of the market.

and the direction of the masjid, and mirroring them along the prevailing wind direction, a partial weaving grid pattern emerges.

Duplicating the same line along the central axis of the wind direction and deforming it to create a sense of directionality creates a grid to be utilized for the market's zoning program. Along the grid, the wind direction forms the main movement paths, while the spaces in between create the two zoned commercial areas. A road connecting the residential neighborhood on the southwestern side of the site and the beach areas are added to make movement between both sides. With both commercial areas defined and adjusted for wind flow, each zone is further partitioned into smaller microzones by adding corridors, passageways, and open non-commercial spaces to create smaller rentable commercial spaces and spots of social interactions. To further enhance the cooling effect of wind, fountain pools and vegetation are placed in the direction of the wind's entry points at the front of the market's main passageway.

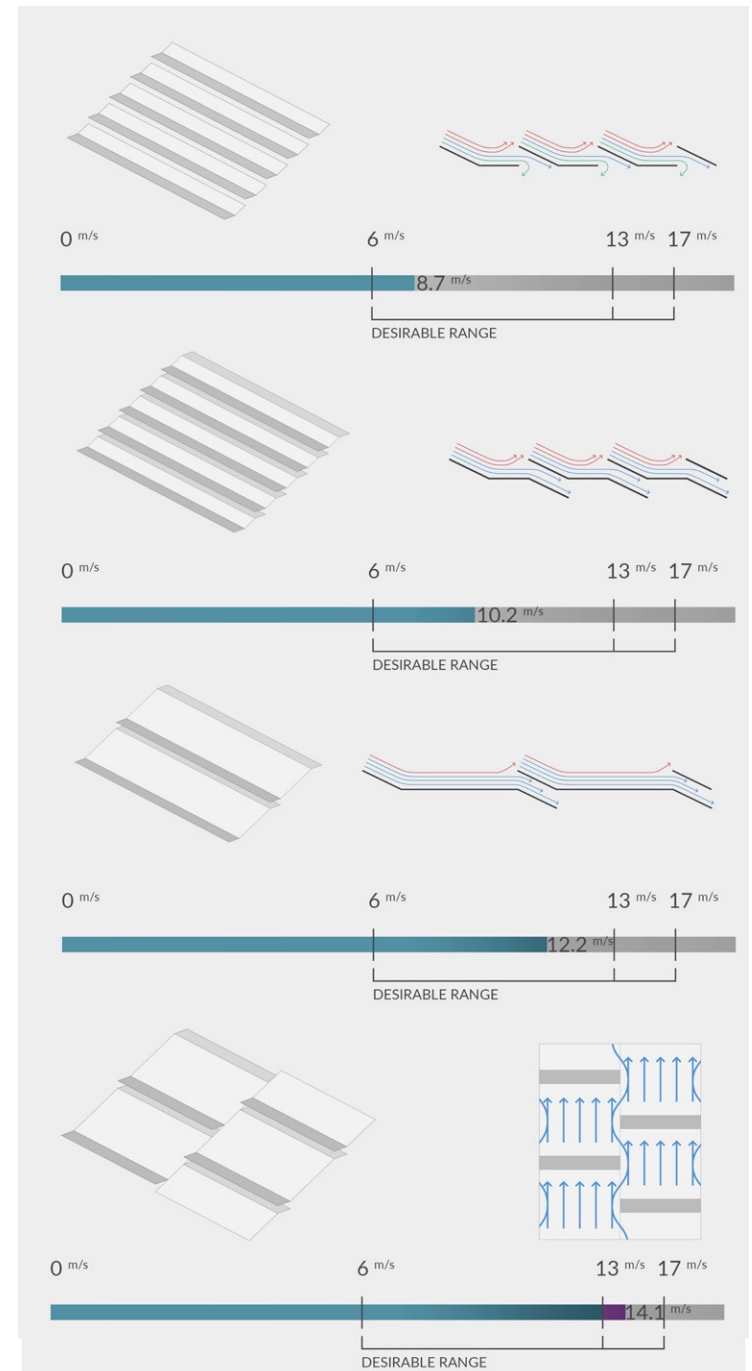
Specialized areas, such as exhibition spaces and management offices, are added to the market's program making it more versatile and capable of hosting local events (fig 4.14). A second level is added with stairs and elevators connecting both levels to added more commercial spaces for more business. Logistics corridors are added to each commercial microzone, hidden from visitors but connect

rentable spaces to one another. These corridors are utilized to function as storage spaces for rentable spaces and connect to freight elevators (*fig 4.15*). Each freight elevator leads to an underground level leading to a parking level under the supermarket space. The utilization of freight elevators and storage spaces allows merchants to manage and maintain their businesses away from visitors, helping them and the public market to maintain an organized operation and a clean, attractive appearance.

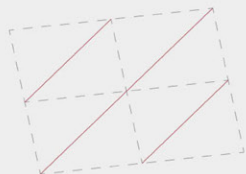
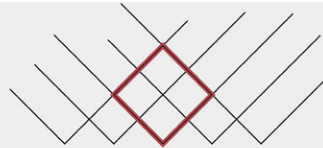
### Climate response, Wind, Light, and Solar Power

The design of the market utilizes shading systems, landscaping, and wind in passive systems to maintain a comfortable environment for its users. From the previous studies and analysis on wind characteristics, the average wind speed reaching the market corridors is not sufficient to cool occupants from March to September when heat levels start rising. Accelerating wind provides a cooling effect, but it should remain within given parameters to not become troublesome. Wind speed, intensity and impact are divided into five main categories, Calm, Air, Breeze, Gale, Storm. Calm wind is still air with no wind, while air is not very noticeable with speeds of up to 2 m/s. Breezes fall within the most desirable range, with speeds ranging from 2 m/s for a light breeze and up to 14 m/s for a strong breeze. Gales describe faster winds that can push trees and provide difficulty in movement. The desirable range within the site to have a noticeable cooling effect falls between 7 m/s to 14 m/s.

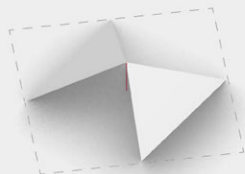
Designing for a wind harvesting system requires aerodynamic tests to determine the system's effectiveness and potential improvements.



*fig 4.16 | Wind system design process and iterations.*



FOLDS AT THE CENTER OF EACH GRID



RAISE THE POINT AT THE CENTER



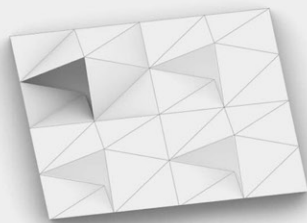
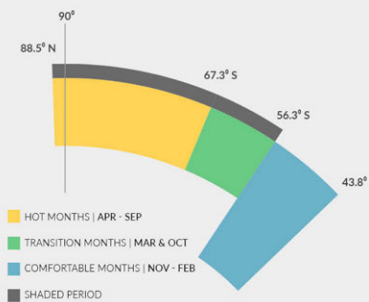
CLOSE THE BACK TO SEAL THE FIN



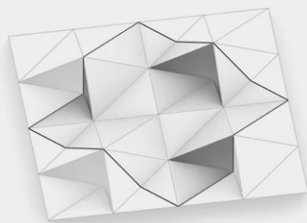
SECOND GUIDE FIN BELOW



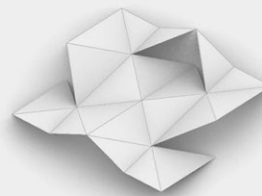
SIDE OFFSET FOR AIR FLOW



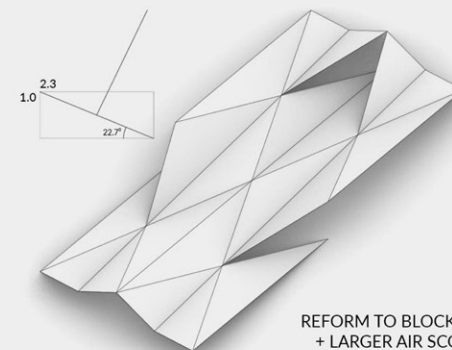
REPETITION & MODULAR



ORTHOGONAL GRID



MAIN UNIT CELL



REFORM TO BLOCK LIGHT + LARGER AIR SCOOPS

fig 4.17 | Wind system modular unit redesign and adjustment to shade the public market space.

Aerodynamic simulations were done with Autodesk FlowDesign, with a northeastern wind at a 38° at a speed of 7 m/s. The first iteration followed a simple fin design with a tilted flat surface spanning the length of the market's corridors. With this iteration, wind speed accelerated up to 8.7 m/s, to reach 124.2% of the natural wind speed. However, most of the wind could not be utilized at the ground level due to backflow and vortices forming at the inner edge of each fin. To solve this problem, guide fins are added to the direct wind in the same direction, which increased the efficiency of the system and increased the wind speed to 10.2 m/s, or 145.7% (fig 4.16).

The system can be further improved by increasing the length of the fin system, specifically horizontal elements, to allow for wind to stabilize after being pushed up from the increase in pressure caused by hitting the fins. Still some amount of air escapes the system's fins through pressure buildup. To counter this problem, instead of having linear fins stacked perpendicular to the wind direction, fins are split into units with an offset placement to one another. The offset fin system collects wind pushed by the fin in front of it, creating a system where each unit utilizes lost wind from other units in a continuous pattern. With such a system, the wind reaches speeds upwards of 200% of its natural speed

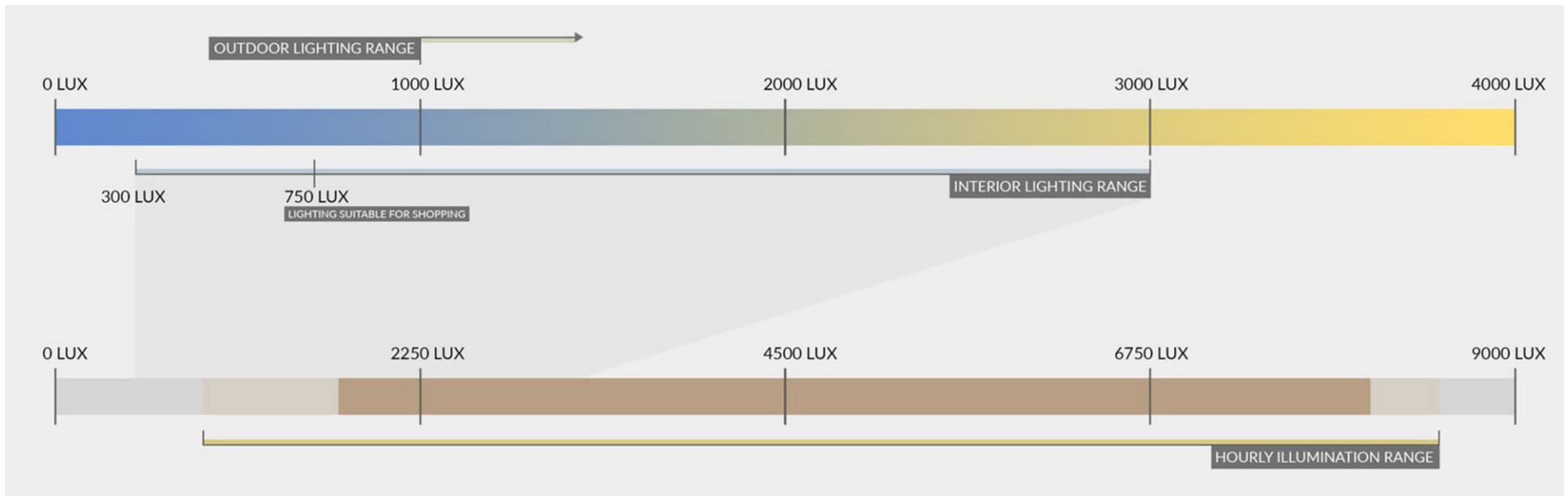


fig 4.18 | Daily illumination range and desirable light levels in the public market spaces.

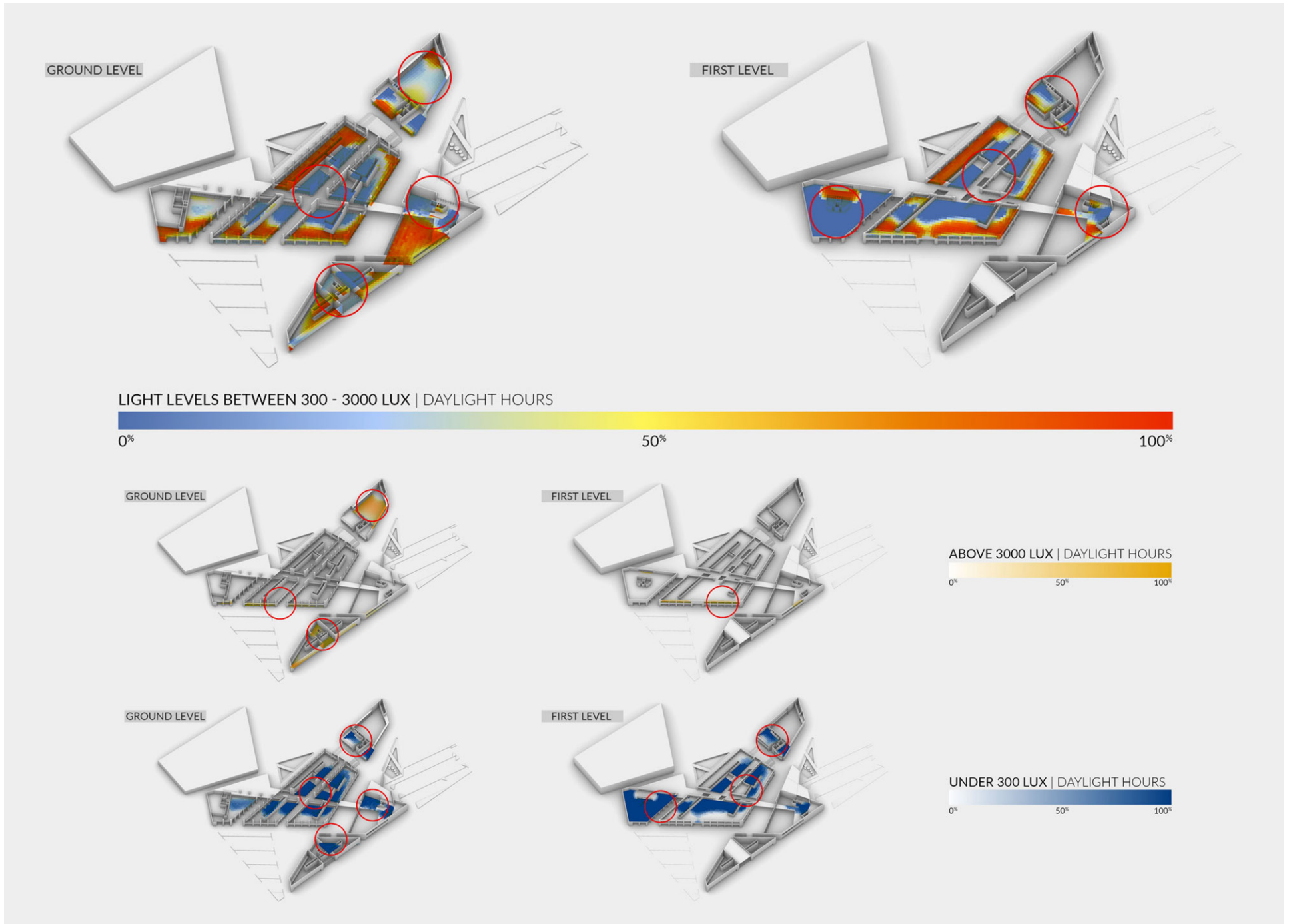


fig 4.19 | Lighting simulation test first iteration. Results represent average useful daylight, over lit and underlit areas.

at 14.1 m/s. Since the market is a place of cultural expression and a place where visitors are meant to spend time and socialize, it would be fair to create an intriguing and artistic form to the wind and shading system. By redesigning the modular fin design utilizing the weaving pattern used originally in the site grid layout.

As a result, the system is converted to a rhomboid grid which can be converted back into an orthogonal grid (fig 4.17). The second function of the wind system is to provide shade and enough lighting to not depend on electrical lighting. Due to the high heat levels and illumination in the region, diffused light is preferred all year round. To allow for more diffused sun and blocking direct sunlight, each unit can be reformed and stretched by a 1:2.3 ratio since most of the illumination range

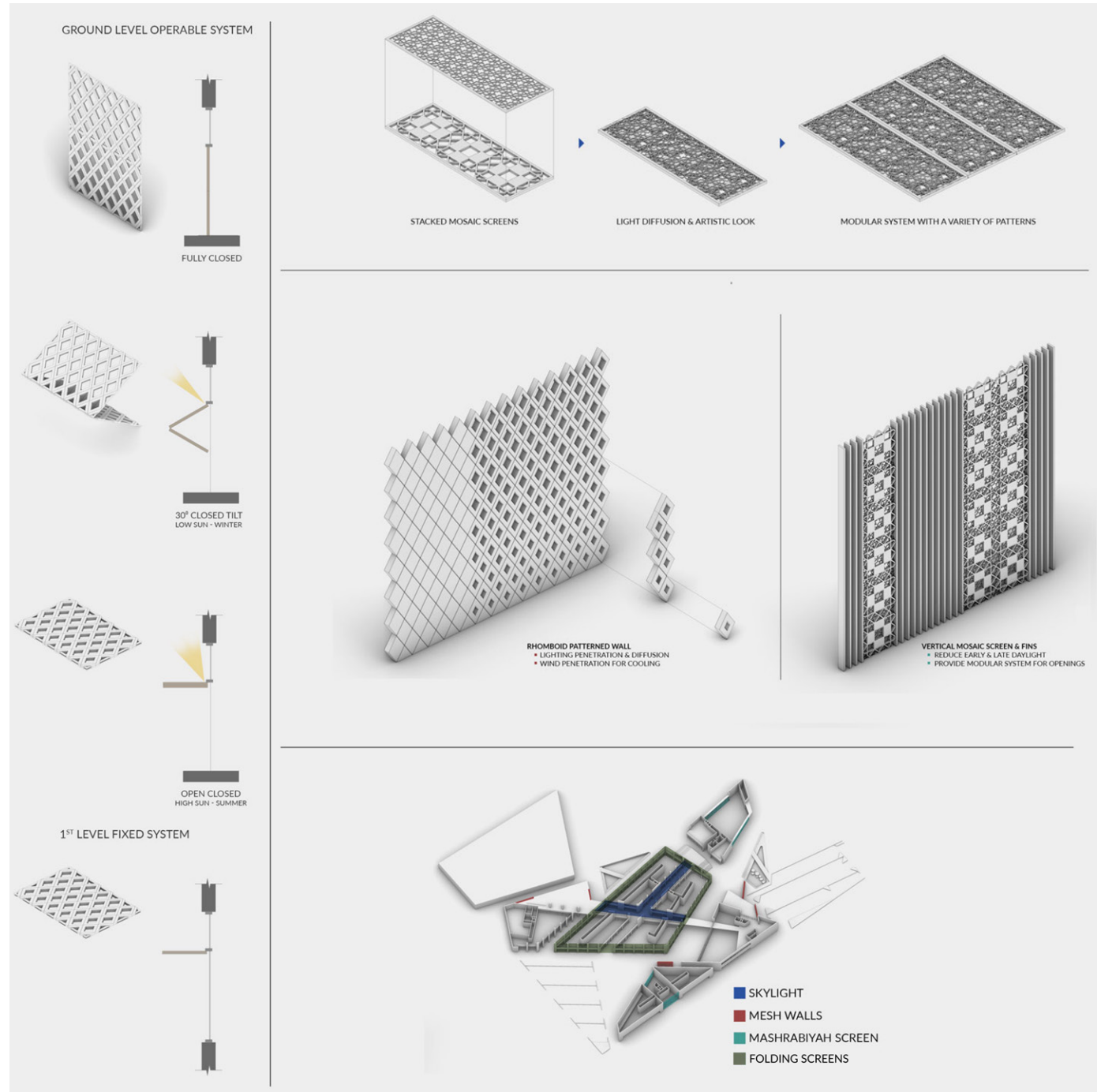


fig 4.20 | Implemented lighting design systems and locations within the market.

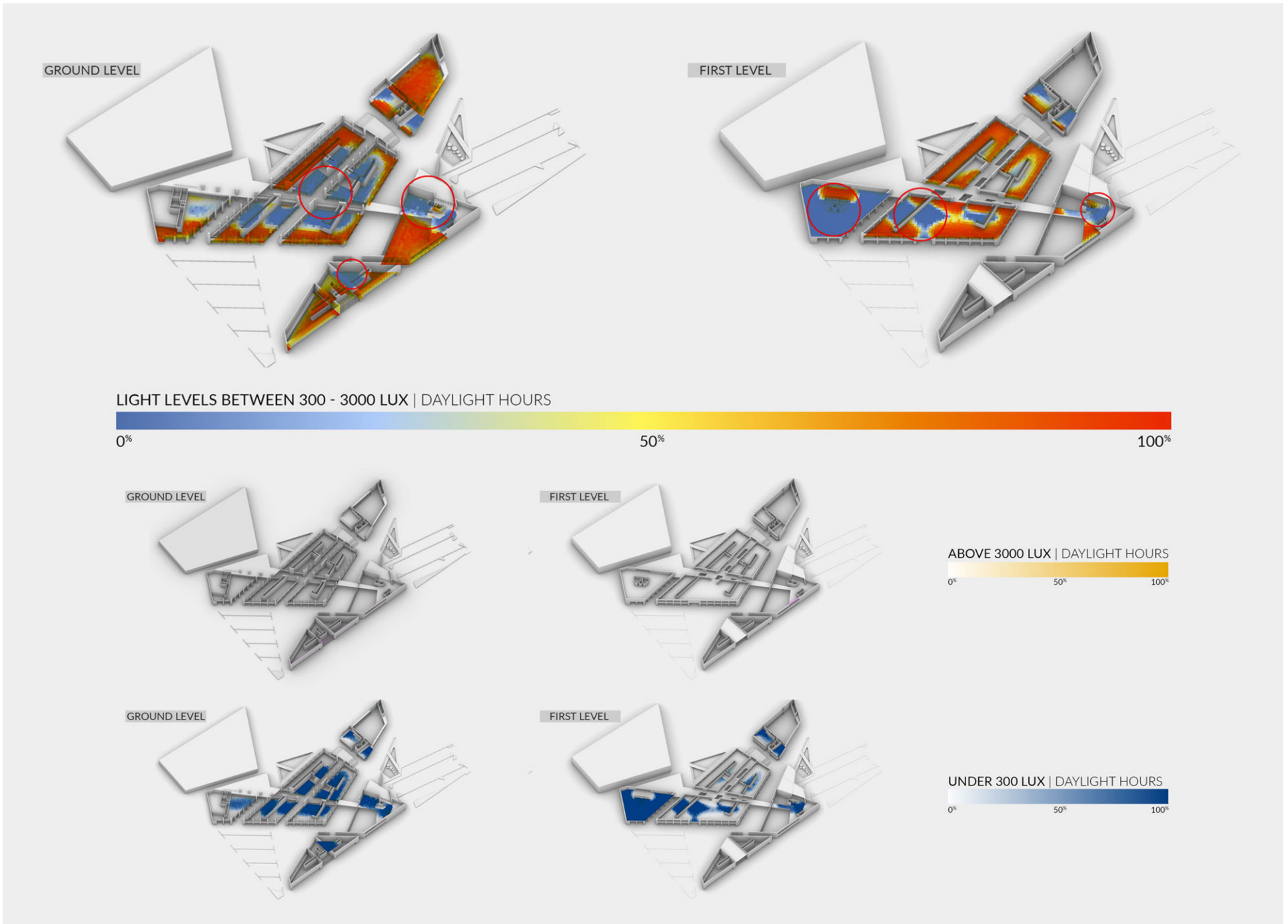


fig 4.21 | Lighting simulation test second iteration. Results represent average useful daylight, over lit and underlit areas.

hits the shading surface at 22.3°.

Lighting within the space utilizes natural light and supplemental electrical lighting where needed. According to the Handbook of Lighting Design, the required light level for retail spaces is 750 LUX. However, due to the shift in natural light levels throughout the day, light levels between 300 LUX to 3000 LUX are acceptable. The goal is to design blanded spaces by reducing glare in overlit areas and increase light

levels in underlit areas through passive systems (*fig 4.18*). Controlling overlit areas takes priority since underlit areas are supplemented with electrical lighting. On the other hand, Glare persists and creates intolerable spaces that are difficult to manage without using active shading systems.

Each iteration to design for the market's natural lighting is tested by a lighting simulation software that utilizes annual climate data. DIVA for Rhino3D is used to simulate

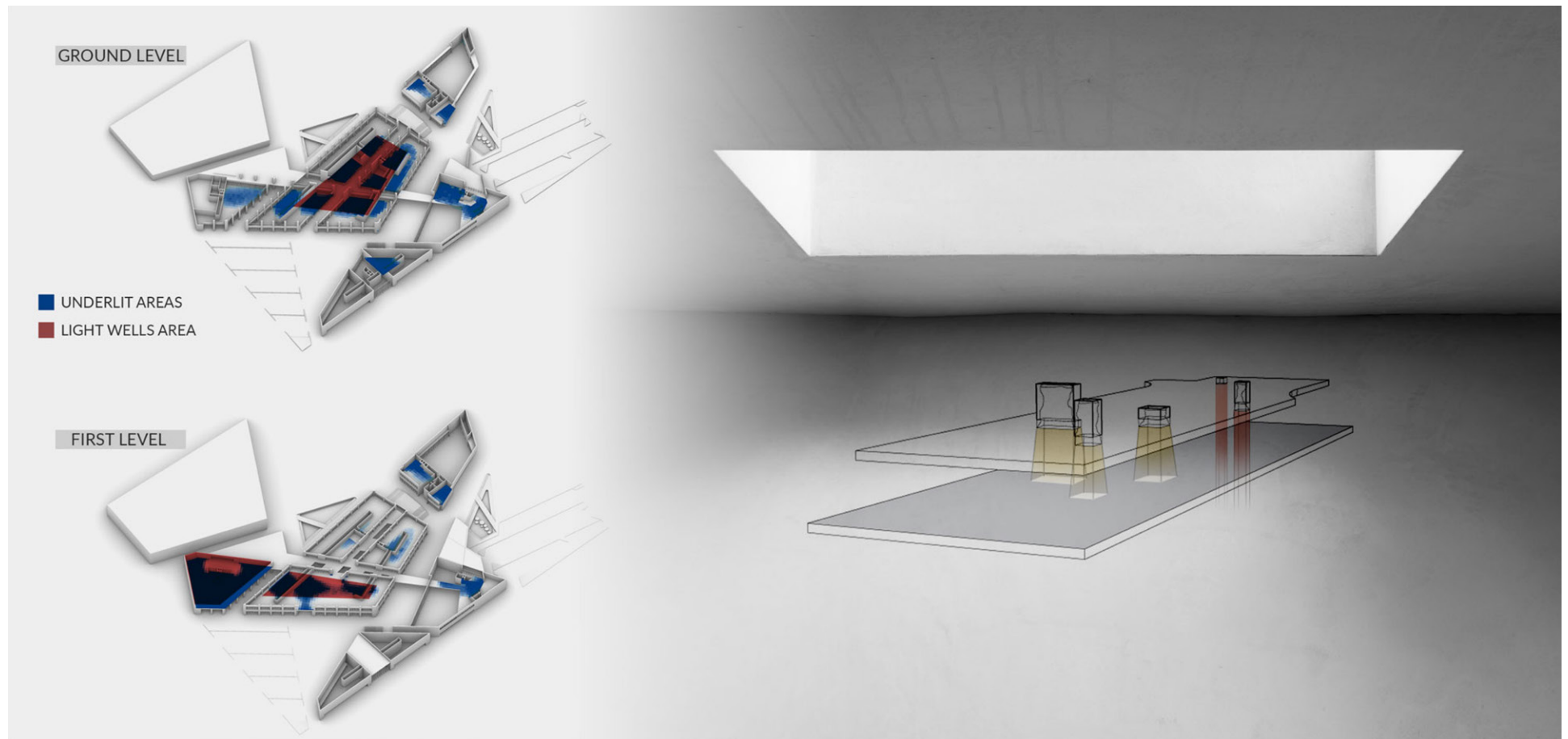
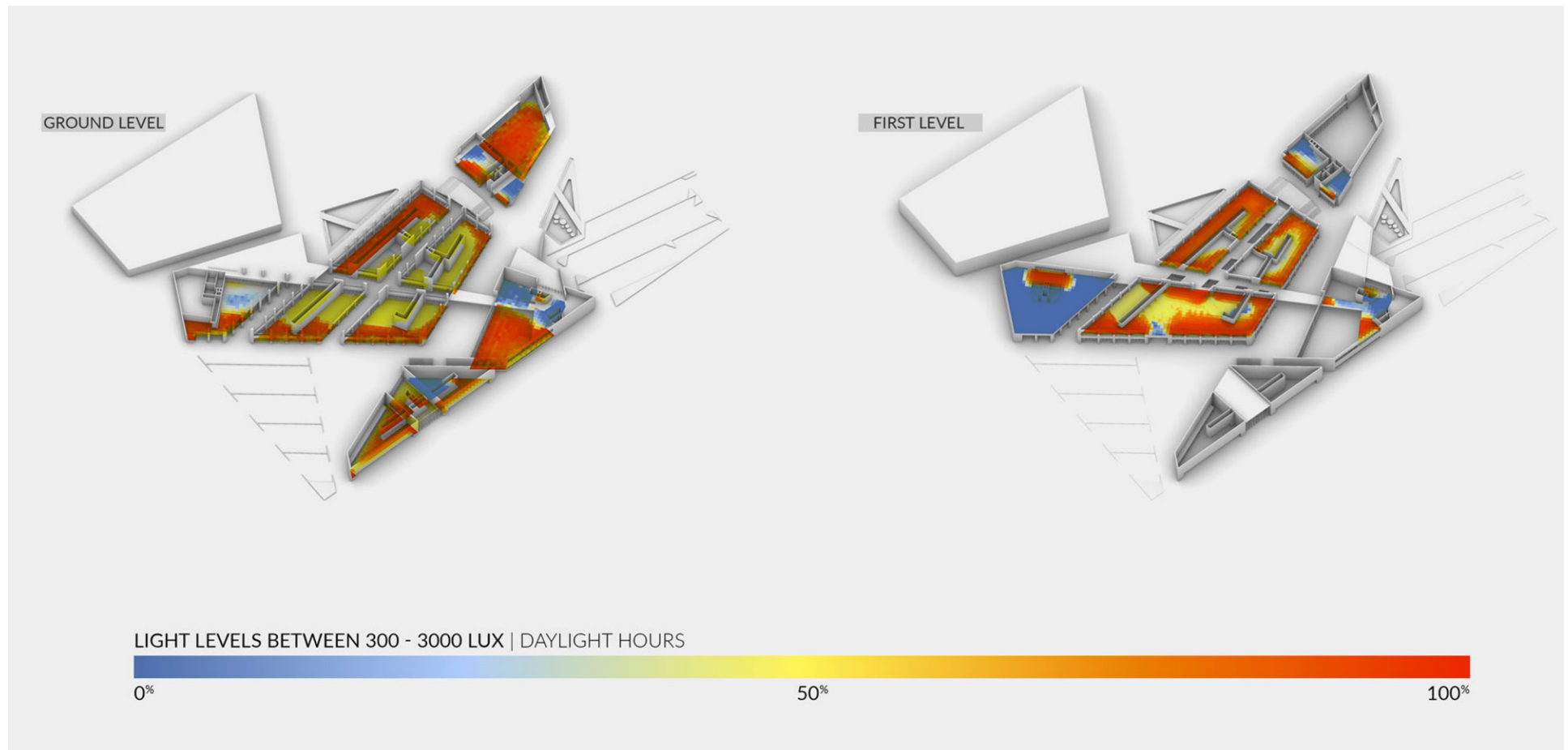


fig 4.22 | Lightwells systems and implemented locations to manage underlit areas.

light levels through a climate-based lighting simulation to test for the ratio of usable daylight hours annually. The collected result shows the percentage of hours in which light levels indoors are within the desirable range of 300 LUX to 3000 LUX, below the desirable range for underlit areas, and above the desirable range for overlit areas. The first iteration was conducted to understand daylighting behavior with the wind and shading system (*fig 4.19*).

Areas within the perimeter of the wind shading systems receive the highest levels of desirable lighting levels. In contrast, areas with large glazed surfaces and vertical walls facing directly south without shading devices are overlit. Underlit areas are concentrated at the core of the market, far away from glazed surfaces.

The main issue to resolve is within the overlit areas. A folding screen system with a rhomboid pattern to the grid



*fig 4.23 | Lighting simulation test third iteration. Results represent average useful daylight, over lit and underlit areas.*



fig 4.24 | Public market design visualized scene from the main entry corridor facing the beach.

layout design is placed along the perimeter of retail spaces where they block and filter direct sunlight when opened. Mashrabiya and vertical fins with decorative Islamic mosaics are placed along the eastern and western sides of each glazed surface to reduce direct sunlight from interior spaces (*fig 4.20*).

To provide more daylight to underlit areas, a skylight system is placed along the main circulation path in the retail area. However, to prevent direct sunlight from overlighting and heating the space, a similar mosaic pattern system is placed to diffuse and provide a cultural presence relative to local architectural practices, as seen in masjids. The result of the previous additions and changes is an evenly lit first level in most of its spaces with near 100% useful daylight all year round (*fig 4.21*). Overlit areas are no longer receiving excessive amounts of sunlight, with close to 100% useful daylight results. The ground level of the retail space remains underlit due to the lack of access to skylights. Light shafts offer a potential solution where daylight is channeled from roof areas in a system similar to a skylight by directing light through a light shaft. The challenge is in the length of the light shaft, where there is a lack of systems that channel light for more than 1 meter (*fig 4.22*). Simulating for such systems is also unreliable, as light bounces within a light shaft occur tens or hundreds of times, which the simulation software is incapable of producing. The illustrated result is based on small-scale simulation tests that

mimic the proposed system integrated within the market. Placing light wells on the roof of the market and channeling light levels to the ground levels through light shafts resolves part of the problem, elevating the useful daylighting levels up to 50% useful daylight hours annually (*fig 4.23*).

Old public markets were dynamic and ever-changing in their emergence. This adaptive nature of public markets is due to a slow process of evolutionary design, where space improves and grows with demand. Today, the process is compressed, and structures are more complex and limited in size (Alexander, 1970). The adaptability of modern markets and expansions are more challenging and unlikely to occur. For the public markets, open space is integral in creating areas to be utilized for a multitude of events. The design of a public market should not be program-specific. Instead it needs to be a frame that drives commercial practices through social interactions (*fig 4.24*) (*fig 4.25*).



fig 4.25 | Public market design visualized scene from the main entry corridor facing food zone.

## CHAPTER 5

### CONCLUSIONS

In conclusion, public markets are a unique type of place that offer a unique experience through complex interconnections but commerce, social interaction and local cultures and heritages. A public market has been misunderstood to be a low class form of supermarkets and shopping malls, rather it offers an experience with a different system that does not exist in other commercial establishments. Focusing on profit gains when designing a public market results in an incomplete public market program. Integrating the local culture into the market space through design and programming elevates the market experience to be a place of interaction, expressions, and commerce to create a unique presence and identity. A strong experience of space creates a sense of belonging where users are part of the space and contribute to the success of it.

Public markets are ever-evolving and require a new approach of thinking to make a suitable space fit for its time. Designing for a public market using old principles of design or referencing historical markets contradicts modern living standards. Construction methods, business practices, social systems are all shifting and improving through time. A public market design needs to respond to such changes to generate a place fit for modern standards and fit for modern needs. Breaking away from the norm and designing welcoming spaces that break away from work and daily routines is an attractive element of market places. They result in a cheerful positive environment where people want to be rather than need to be.

Successful markets globally adapt to a similar approach of tuning markets for modern life standards by integrating infrastructure and designing for a new generation. Each market differs from one another through their response to their context from a cultural, commercial, social, and environmental perspective. There is no fixed standard unified way to program and design a public market,

rather they adapt to the existing practices in the region. Local knowledge is a necessity in understanding the needs and requirements in designing a public market.

The main factor in the differentiation of public markets from other commercial establishments is in the management of such space. Supermarkets and shopping malls have a team of specialists and capital power to maintain operation and manage the longevity of their businesses. Shops in public markets are often managed by individuals or families with limited financial capabilities. Marketing for such businesses relies on their communities and users of the space through a slow process of social interaction and building a reputation. Designing public markets to increase social interaction through non-commercial spaces is an indirect way of market businesses within the market.

An appropriate climate response for a semi-open public market in the region of Oman is a necessity due to the high levels of heat all year round. Managing heat and creating a comfortable environment to maintain a large number of visitors is essential in the success of the market. The main challenge with such an approach is the lack of design standards and solutions to hot outdoor spaces. Despite the potential increase to higher temperatures while in an outdoor environment, hot areas require cooling methods to manage and maintain a suitable environment for space users.

Utilizing passive systems in a public market is ideal

to reduce operational and construction costs. Shading is an essential strategy in reducing heat gain by blocking direct sunlight from entering spaces. Such passive systems can have multiple functions in managing spaces. In the proposed public market design, the main shading system is combined with a passive wind harvesting system. Wind is a valuable resource to ventilate and cool spaces, which can also be more effective if combined with other cooling strategies. The potential for passive strategies in hot areas is an important topic to be explored further as it presents an untapped natural resource in cooling spaces.

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