PLANNING WITH CLIMATE: URBAN DESIGN AS A TOOL FOR ADAPTATION

by

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(Under the Direction of Rosanna G. Rivero)

ABSTRACT

This thesis focuses on the interactions between the urban environment and climate. Using the city of Savannah, Georgia, as a case study, the main goal of this project is to demonstrate how urban design can impact climate, displaying the importance of the acknowledgment of this issue by the planning community. Furthermore, it aims to display how basic knowledge of climate can become a powerful tool for the conception of urban design and aid in adapting cities to climate, in a time when resiliency and adaptation are at the forefront of the discussions in many fields. The results of this study will potentially help shed light to the applicability of climate in planning and point to a practical approach to the incorporation of this theme in city plans and policies.

INDEX WORDS: urban design, climate adaptation, urban planning.

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DEDICATION

This thesis is dedicated to my parents, Marcio Renato Alfonso and Ana Maria Alfonso, for their love, support and for inspiring me to believe in the power of hard work and dedication. And to my husband, Breno de Oliveira Fragomeni, for embarking on this journey with me and lovingly helping me make this dream come true.

"We shall never achieve harmony with land, any more than we shall achieve absolute justice or liberty for people. In these higher aspirations, the important thing is not to achieve but to strive."

(Aldo Leopold)

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CHAPTER 1

INTRODUCTION

Coastal areas, the seemingly most vulnerable areas to climatic change and greatly pressured by real estate development, have begun to demand that planning professionals look at issues related to climate and have displayed what could be a shift in how planning is practiced in the future. Changes being made to the United States Federal Flood Insurance have recently greatly affected coastal communities and have demanded plans that look closely at the issues of stormwater management and sea level rise. These, in turn, are directly correlated to climatic issues and have gained public interest, for the effects are clearly observable. Unlike pollution dispersal, thermal comfort, and wind patterns, precipitation is visual and the impacts of an occurrence, such as flooding, is easily perceived. Such scenario poses a unique opportunity for the incorporation of climate to the planning process, as cities strive to adapt in order to maintain the affordability of flood insurance policies in the short term, but most importantly, to endure the climatic impacts that could come ahead.

The concept of incorporating climate as a design tool is not new to other profession such as architecture and civil engineering, which have long used climatic knowledge for the creation of energy efficient buildings and generating thermally comfortable indoor environments. Studies in these areas of expertise, have developed metrics and created guidelines that translate the goals designs must achieve, in order to adapt to climate.

Yet while architects and engineers drill further into developing climatically adapted buildings, the approach to climate is site specific, addressing but a small portion of a much bigger sphere, the city. In that sense, urban designers have remained rather dormant towards the subject of climate planning and design and are now being brought to the conversation of climate adaptation. With this in mind, this thesis aims to address how planners can incorporate climate as a successful urban planning design tool. Looking at the architectural and engineering design guidelines as a starting point to the development of standards focused on the adaption of cities for the future.

Objective

The main objective of this thesis is to define how urban form impacts climate and how design could aid the process of adaptation. In order to achieve this objective the following issues will be addressed:

1. How climatic factors, combined to the physical landscape characteristics interact.
2. What are the different climatic responses between the built environment and the natural landscape.
3. Identify the key climate factors that have direct impact in climatic perception and effect comfort.
4. Examine design solutions that could improve the effects of the built environment on climate.

CHAPTER 2

CASE STUDY: SAVANNAH, GA

"*The Town of Savannah is built upon an open sandy plain, which forms a cliff, or, as the Americans term it, a bluff by the shore, about 50 feet [15 m] above the level of the river. It is well laid out for a warm climate, in the form of a parallelogram, about a mile and a quarter long [1.6 km], and half a mile wide [0.8 km]. The streets are wide and open into spacious squares, each of which has a pump in the centre, surrounded by a small plantation of trees.*" (de Vorsey apud John Lambert, 2012).

To design with climate one must first understand climatic behavior and its relationship with the urban form. With that in mind this project aims to address the possibility of incorporating climate analysis in the urban planning process as a way of guiding design choices. To demonstrate the issues at hand, this thesis uses the Georgia Coast, in the United States, as a study case. More specifically it looks closely at the city of Savannah, seeking to further analyze how the subject of climate could be incorporated into future plans and aid the city in adapting to possible climatic changes.

The choice of Savannah as a study case, was made for two reasons. Firstly for being the most urbanized area within the coast of Georgia, with significant growth in the past years, as will be presented in the Analysis Chapter of this thesis. Secondly, due to its historic downtown, which presents a unique opportunity to understand the effects of open spaces and tree cover within dense urbanized areas. Additionally, unlike most parts of the Atlantic Coast of the United States, the Georgia Coast has remained fairly undeveloped until now. With that in mind, the use of the city of Savannah as an example of how a more urbanized city could be planned would set an example and aid for more audacious measures in less developed cities along the coast, securing not only resiliency to the community but also to the existing natural environment.

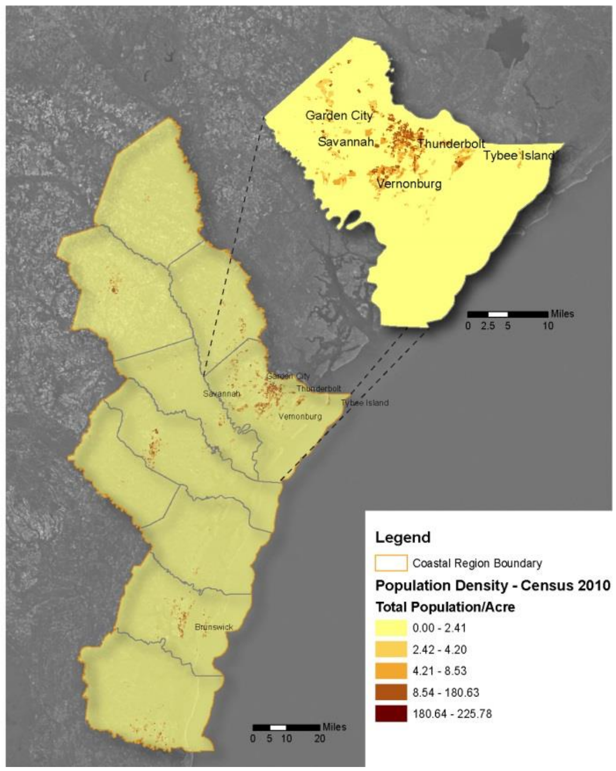

Figure 1 – Population density of the Georgia Coastal Reagion, highlighting Savannah

City of Savannah

The city of Savannah, Georgia, was founded in 1733, on the margins of the Savannah River, approximately eighteen miles away from the Atlantic Ocean and was planned by its founder, General James Edward Oglethorpe. The basic plan consisted of a ward system, 600 feet in the north-side direction and approximately 600 feet in the east-west directions. Each ward was designed as a neighborhood, in which buildings and streets faced a square and allowed for a connection between urban and green infrastructure. In modern times, such design has adapted successfully to the use of vehicles, while still allowing for a pedestrian-friendly environment.

Savannah's Historic District is resilient[1] by nature, planned as the result of an analysis of its surrounding, and more importantly its natural environment. Oglethorpe surveyed the region, observed its natural features and strategically laid out a plan in higher grounds, which would in turn not only keep its inhabitants safe from possible invaders, coming from the river, but also from diseases, such as Malaria, and more importantly from flooding. As a result, such meticulous planning with the environment enables the Historic District to be above water even under a category five storm surge.

Yet as Savannah grew outside of its original plat, it took new form and as time passed and as population increased, like in most cities around the globe, the need to expand suppressed the limits imposed by the natural environment. Which meant that Savannah, populated its flood plains and urbanization reached all the way into the marshes. According to the US Census Bureau, in 2010 Savannah had a population of approximately 136,286 people, and estimated that by 2012 it had 142,022 people. A study by the University of Pennsylvania[2] (2006) forecasts, though, that by 2020 Savannah will have reached a population of approximately 414,895 people. Accounting for the fourth biggest city in the state of Georgia, Savannah is growing at a

[1] The meaning of resiliency in this context is the ability to recover from or adjust easily to change.
[2] This study was developed in 2006, with forecasts based on US Census data from the year 2000. Predictions account for only 75% of the variance in growth experiences between 1980 and 2000, with the other 25 percent explained by "surprise" events.

fast pace and needs to be weary of the quality or location of the urban environments being created as a result of its growth.

Analyzed Sites

In the attempt to better understand how urban design can use climate as a tool for planning, two sites were chosen within Savannah. The first site, situated within the Historic Downtown of Savannah, was selected as an example of a favorable approach to a climatically adapted urban design. Recognizing the importance of the squares in both providing shade and allowing for better ventilation, due to the dense tree canopy cover provided by the oaks that surround them. Moreover, the premise for choosing this site, allows for a better understanding of how planned open spaces can create pockets within the tight knit building network that surrounds it, which may allow wind flows to regain speed and also cause certain directionality within the street grid, theoretically reducing wind turbulence.

The second site selected, was chosen due to its apparent disfavorability, but yet for its potential for being transformed, taking into account that the intention of this project is not only to observe the impacts of urban design choices to climate, but also attempting to suggest strategies for redesign, in order to demonstrate how the basic understanding of climate can serve as a tool for planning. Situated in a growing area of the city, this site has a few lots still for sale and development seems to be occurring at a fast pace. It has attracted some car dealerships, shops, office buildings, storage spaces and is in close proximity to some residential development.

CHAPTER 3

METHODOLOGY

The methodological approach of this thesis takes into account the analysis of the current physical conditions of the case study area in three different scales:

- Regional Scale - defined by the political boundaries that delimit the counties under the administration of the Georgia Coastal Regional Commission, with specific emphasis on Chatham County;
- City Scale - defined by the boundaries of the city of Savannah;
- Site Specific Scale – two sites selected within Savannah, with the objective of comparing the original city plat design to new urban development in its outskirts.

Table 1 – Methodology used for each scale of analysis

Themes	Regional	City	Sites
Landscape and Natural Environment	Topography Land Cover Vegetation	Topography Vegetation Solar Radiation	Open Spaces
Flood, Wind, and Stormwater Management	Floodplains Surge Maps Wind Patterns	River Basins Flood zones Wind Speed and Direction Solar Radiation	Wind Turbulence
Development Patterns	Built Density	Future Land Use Land Use Zoning	Impervious Cover Building Height

The purpose of evaluating the studied area in three scales is to cross-reference the landscape to climatic characteristics, in other words, map the physical aspects and evaluate the impacts to climatic responses, looking closely at solar radiation and wind flow. The regional scale analysis looks at understanding the broad context in which Savannah is inserted in, including an evaluation of the design strategies suggested by the United States Department of Energy for the climatic zone in which the state of Georgia is inserted in. The city scale was used to determine the chosen sites and also to analyze climatic behavior, based on data collected from the Savannah International Airport, weather station 722070. Lastly the analysis compares the responses obtained from the selected sites, contrasting issues that arise from both wind flow and solar radiation. This document will then discuss how the analysis could aid in the development design strategies and performance standards that could serve as guidelines for planners within coastal communities such as Savannah.

Regional Scale

Using Geographic Information System (GIS) software, the regional analysis consists of an overlay of maps that enable a thorough understanding of the characteristics of the landscape. Initially, United States Census block data was used to determine the area with the most demographic concentration, which led to the choice of Savannah as the actual study area. Once that was established, the analysis then focused on understanding the interrelations between Savannah and the region, seeking to identify characteristics of land cover, floodplains, and urban growth patterns that could collaborate to climate change. Mapping wind patterns in this section was particularly difficult due to the lack of available to data pertaining to directionality and speed. Data found covered the whole country, and data specific to the state of Georgia and the coastal region focused solely on wind speed.

City Scale

From the GIS analysis stand point, the transition from regional scale to city scale is subtle, focusing on capturing the increase in buildings over a 27 year span and identifying the direction of growth within the city boundaries. This analysis set the foundation for determining the two sites to be evaluated in the next phase, aiming to compare climate interactions within the historic downtown urban network and a recently developed area. In this scale climate data was incorporated, using the Climate Consultant 5.5 software[3], with some auxiliary analysis done using Ecotect Weather Tool. In both, programs a Typical Meteorological Year 3 (TMY3)[4] data set, retrieved from the Savannah International Airport weather station, is used as input to generate graphics and charts that display the characteristics of the climate during a typical year, in other words, overlooking extreme weather events. It is important to point out that both Climate Consultant and Ecotect are software created and used for building simulation, yet it is the intent of this study to demonstrate that such tools could be

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[3] Climate Consultant 5.5 is software developed by University of California's Energy Design Tools Group.
[4] TMY3 is a data set of hourly values of solar radiation and meteorological elements for a 1-year period, developed by the National Renewable Energy Laboratory. It is widely used in computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different designs, and locations. They represent typical weather conditions and are not used to simulate extreme weather occurrences.

adapted to suit the urban design needs and could also serve as initial guiding factors for the proposal of design solutions.

Site Specific Scale

As previously mentioned, two sites were selected within Savannah, as a way of drawing comparisons between the climatic interactions in the historic district, representing the Oglethorpe Plan, and recent urban patterns formed in newer areas in the city. The choice of Wright Square was due to its relatively central location within the historic district, allowing for an evaluation of effects of surrounding squares on the studied site, particularly looking at wind flow. The second site was derived from the overlay of built environment maps from 1985 and 2013, seeking to look at development that occurred in recent times, thus representing contemporary form of urban growth patterns. Once both areas were defined a quarter mile radius was designed, stipulating the area as a parameter for comparison of both sites.

For this scale, analysis consisted of creating 3D models of both sites, using AutoCad software, which were then simulated in Autodesk Vasari and Ecotect software for the interpretation of possible wind and radiation responses in both sites. This section was the most challenging, as both software programs, though powerful bioclimatic design tools, are intended to simulate performance of single buildings and their interactions with small clusters of buildings. The issue of scale in this case made both programs slow and generated several inconsistencies in results, generating a several delays and requiring constant revision of the results obtained.

CHAPTER 4

LITERATURE REVIEW

Looking back in time, before the advent of technology, it is clear how human settlements were developed in conformance to the natural environment, taking into account the characteristics of the land and its climate. In his book Architecture without Architects, author Bernard Rudofsky states "There is much to learn from architecture before it became an expert's art. The untutored builders in space and time – the protagonists of this show – demonstrate an admirable talent for fitting their buildings into the natural surroundings. Instead of trying to "conquer" nature, as we do, they welcome the vagaries of climate and the challenge of topography." Rudofsky (1987) Though very much focused on illustrating the different types of vernacular settlements, this book depicts a few examples of how climate and terrain determined where and how cities would grow.

The first historic recording of construction guidelines in ancient times are found in 1st century BC, a book written by Roman architect and engineer Marcus Vitruvius Pollio, rediscovered and translated during the Renaissance period, known as the book De Architectura. In its 6th Chapter Vitruvius states: "If our designs for private houses are to be correct, we must at the outset take note of the countries and climates in which they are built. One style of house seems appropriate to build in Egypt, another in Spain, a different kind in Pontus, one still different in Rome, and so on with lands and countries of other characteristics. This is because one part of the earth is directly under the sun's course, another is far away from it, while another lies midway between these two. Hence, as the position of the heaven with regard to a given tract on the earth leads naturally to different characteristics, owing to the inclination of the circle of the zodiac and the course of the sun, it is obvious that designs for houses ought similarly to conform to the nature of the country and to diversities of climate." Though both Vitruvius and Rudofsky discuss specifically on the subject of Architecture it is safe to say that the impacts of creating singular buildings results in a composition that is the urban form, thus the formed network would in fact be responsive to climate and terrain.

The discussion of urban form from the climate perspective is a complex one and there has been very limited literature produced by planners in the past, with the intent of truly depicting how urban design can be applied in order to reduce impacts to climate. Much of this resistance is a result of a professional trend that has led planners to refrain from taking a design oriented approach and focused more on the prescription of policies and the determination of suitable land-uses and the fragmentation of cities into zones. In her book *Arquitetura Bioclimática do Espaço Público* (Bioclimatic Architecture of the Public Space) Marta Bustos Romero names what are considered the predecessors to the subject of planning with climate. Introducing initially what she considers to be the three classic studies in the field and the precursors to what is the subject of climatic responsive design. The first one being the study developed by Hungarian architects Victor Olgyay and his brother Aladar Olgyay, who in the book

Design with Climate develop a regional approach to climate, a rational method of considering the variables of place and the conditions to defining settlements, into a quadripartite conception – climate – biology – technology – architecture. Later, in 1968, the brothers developed a bioclimatic graph in order to evaluate climatic elements (temperature, relative humidity, nebulosity, precipitation, wind and solar energy) with the built environment, taking a closer look at the relative importance of effects such as shading and radiation, created through this interaction. "With the registry of these elements, conditions of incorporating climatic recommendations exist with regards to site selection, urban fabric, public spaces, landscape and vegetation, in a general level, and as for housing typology, floor plans – form and volume, orientation and color of external surfaces – at a specific level" (Romero, 2001). The second study described by Romero was done by Israeli architect Baruch Givoni who took into consideration climatic elements, such as solar radiation, air temperature, wind, atmospheric humidity, condensation and precipitation to better understand the heat exchanges occurring between man and the environment, the physiological and sensorial responses to thermal pressure and the biophysical effects of environmental factors. Givoni, authored a book called Man, climate and architecture, in which not only does he describe the aforementioned findings but also looks at the relationship between the built environment and the direct effects of climatic variables, through thermophysical properties of buildings, such as thermal conductivity, conductance and surface coefficient. He also studied the applicability of design principals and material selection as a way of adapting buildings to climate, yet recognized the impracticality of devising elements specific to each type of climate, due to variability, and thus proposed the application of principles in a macro level, for the following types of climate: hot-dry (desert), hot-humid (equatorial and maritime tropical) and mediterranean (subtropical). Lastly Romero mentions the studies developed by Povl Ole Fanger, an engineer who specialized in the interactions between man and the indoor perception of thermal comfort, an influential study which is used widely in the HVAC industry as a guide for controlling indoor temperatures.

Among the three classic studies suggested by Romero, two truly deal with the issue of urban design and climate, yet both in general terms, and with little recommendations from the perspective of form, as most of the design oriented guidelines focus on the prescription of solutions for new constructions and aim at production of comfortable indoor spaces. Romero expands her analysis and goes on to cite what she describes as the Climatic Lineage – Urban Climate group, in other words reflects on authors that have looked closely at the practice of urban design with a focus on environmental planning and the effects of urbanization on the atmospheric environment. The author goes on to mention a few precursors of this line of research, with emphasis on William P. Lowry a biometeorologist who wrote a book called Atmospheric Ecology for Designers and Planners with the purpose of closing the gap between the subjects of meteorology and urban design. She goes on to mention landscape architect Ian McHarg and urban planner Kevin Lynch as two important figures in the introduction of variables relative to terrain and natural resources in the planning practice as a form of improving the urban environment. Yet she points out that Lynch's take on the subject emphasizes the image of the city as a form of interpretation and the orientation of the process of design, while McHarg looked closely at the natural environment and sought ways of defining solutions that promoted the conservation of green infrastructure. Romero also remarks the importance of the 1984 Urban Climatology Conference, held in Mexico City, which produced recommendations and proposals that were condensed in the 1988 WMO (World Meteorological Organization), n.652, and counted with the contribution of several world renowned authors, including Givoni, focusing on the urban design with climate, yet not taking into consideration solutions that sought to prevent only catastrophes resulting from natural disasters.

Though Romero names a considerable amount of authors, whose publications reiterate the preoccupation with the interactions and impacts of the urban environment and climate, it is quite clear that there still much to be seen on practical approaches to the subject. In fact, the author recognizes that most studies made on the subject of urban design focus very little on the complex problems inherent to it, preferring to discuss the ideology of relationships between individual buildings, neighborhoods and cities, but not truly diving into issues of form and design as problem solvers. "Jeffrey Cook (1991), for example, shows that the space in books dedicated by several authors to the theme of city planning and urban design is very small." As a footnote, she goes on to state: "To cite an example, Koenigsberger, Ingersol, Mayhew and Szokolay dedicate six pages out of 320 of the book Manual of tropical housing and building to the subject of settlement planning" (Romero).

The fact of the matter is that very little practical examples of the application of climatology in the city planning exist. The first known example of a plan with such emphasis was developed in Stuttgart, Germany. A particularly special project, thought to be one of the precursors to the incorporation of urban climatology into planning, with the introduction of an atmospheric meteorologist to the city's Environmental Planning Agency, in 1938. The concept of understanding the importance of climate in the planning process came as a way of guaranteeing the quality of life in cities, as with the increase in pollution in urbanized cities, there was an increased awareness on the need to secure the health of urban dwellers. With the beginning of World War I in the following year, the existence of a meteorologist among the team proved to be even more important, as fear of possible attacks using lethal gases demanded studies on wind patterns, leading to the understanding of how gases could dissipate within the urban form, through road networks and underground ventilation and pipelines. Such development led to a number of studies that determined how wind flows occurred within the city, as a result, by the time World War I and II were over, studies had enabled planners in Stuttgart to understand which areas of the city were particularly important in maintaining and improving the city's climate. This is to date the most successful example of the incorporation of climate in urban planning, as the continuous study has led to the design of plans that allow the city to develop and grow while conserving areas and maintaining green infrastructure that are important for the improvement of the quality of life and ensuring less impacts to the city's microclimate.

The reasoning behind the incorporation of the subject of climate was rooted on both a meteorological and medical understanding. There is a context as to why Stuttgart was the first city to use urban climatology as a guide to planning for the future. In 1937, Pater Albert Kratzer published a book entitled "The Urban Climate", which focused on the influence the built environment can cause on air and climate quality. Kratzer's studies called the attention to the importance of the study of urban climatology and need to understand microclimates within cities. Immediately after World War I, tuberculosis became a severe problem in many countries in Europe, along with rickets, which affected particularly children due to a vitamin D deficiency, the outspread of such diseases pointed to, not only poor nutrition, but also environmental conditions factors to increase in the spreading of illnesses. Such observations allied with Kratzer's publications helped establish a demand for better illumination, ventilation and exposure to sunlight in cities and directly impacted the decision making in the planning realm.

Yet the issue at hand is not the importance of the incorporation of concepts of urban climatology into urban design, as it has already been established, rather the discussion is why such a subject has not been embraced by planners. Seeking to answer this question, a study in Sweden sought to further determine whether or not knowledge of climate was used by planners. The conclusion of such article stated that, "[t]he results showed that Climate Knowledge had low impact on the planning process. This proved the formulated hypothesis. However, a majority of the respondents say that they use climatic data. I think that this contradiction depends on the fact that most planners are very uncertain about their own knowledge of urban climate" (Eliasson, 2000). In other words, it is not a matter of being unaware of the importance of climatic interactions in urban spaces, but the lack of confidence in applying such concepts and, furthermore, using this knowledge as a design tool. Therefore the question remains, as to whether or not there is a true way of using design as a planning tool that most definitely addresses climate and the natural environment. In order to bridge the subject of design and climate, one has to return to the question that our ancestors had to answer to build the first urban settlements, which is, how does the natural environment determine which places are suitable for development and how to conform the urban form to the existing terrain and climate?

However, the truth of the matter is that much has changed since the creation of the planning profession, and truthfully a planner can be guided by the understanding that climate and physical characteristics of the terrain can determine how land can be used, but is faced with yet a much bigger challenge, the fact that in many cases land that should not have been developed on is already built upon. In which case, in order to guarantee resilience, design must be an aid in the process of mitigation and solve problems caused or worsened by urbanization. Thus it is the interpretation of the impacts of the built environment on the natural environment, its resources and the climate and determining ways of restoring or reducing damages. In recent times, the vulnerability of cities has become more apparent, and planners have been pressured to take part in building what are called resilient communities. The term resilience planning comes from the science of Ecology and is considered by some ecologists "to be a measure of how fast a system returns to a state of equilibrium after a disturbance; however, Holling (1973) defined it as a measure of how a system could be perturbed without shifting to a different regime. Walker et al. (2002) describe resilience as the potential of a system to remain in a particular configuration and maintain feedbacks, functions and an ability to reorganize following disturbance-driven change. It is the capacity of a system to experience shocks while retaining essentially the same function, structure, feedback and, therefore, identity (Walker et al. 2006)", though for both Eraydin and Tasan-Kok resilience "depends upon three central features of resilience (Berkes et al. 2003 : 6): (1) the ability of a system to absorb or buffer disturbances and still maintain its core attributes , (2) the ability of the system to self-organize and (3) the capacity for learning and adaptation in the context of change" (Eraydin and Tasan-Kok). The proposition of a new paradigm for planning is very interesting and demonstrates a new trend. The book Resilience Thinking in Urban Planning by authors Eraydin and Tasan-Kok display through study cases in Portugal, Sweden and the Netherlands, how cities are being planned using the methodology presented by resilience planning. Yet, while much of the analysis occurs through mapping and understanding the physical aspects of each city, determining what are constraints and opportunities, the end results are, for the most part, focused on the creation and change in policies, in other words, there is very little done from the design perspective, directly impacting form.

Coastal areas, the seemingly most vulnerable areas to climatic change and greatly pressured by real estate development, have begun to demand that planning professionals look at issues related to climate and have displayed what could be a shift in how planning is practiced in the future. Changes being made to the United States Federal Flood Insurance have recently greatly affected coastal communities and have demanded plans that look closely at the issues of stormwater management and sea level rise. These, in turn, are directly correlated to climatic issues and have gained public interest, for the effects are clearly observable. Unlike pollution dispersal, thermal comfort, and wind patterns, precipitation is visual and the impacts of an occurrence, such as flooding, is easily perceived. With urbanization there are clear changes to the water cycle, the accumulation of water due to run-off is a consequence of the increase in impervious surfaces. During some rainfall events drainage and capture of water can become insufficient, as a result, flooding becomes recurrent and a constant cause for concern. The solution for such problems is in the hands of planners, not only in the determination of what areas can and cannot be developed on, but also in the creation and design of structures that can serve as capture points. Changes in street patterns and increase in vegetation can drastically reduce stormwater problems and can only be established through a carefully thought out plan and design concept. "Decentralized stormwater management approaches were identified as a way to recreate the natural hydrologic cycle promoting sustainable water resources and healthy ecosystems, (…) These and other [Green Infrastructure] GI practices retain stormwater close to its point of generation and release it at slower rate through infiltration into the soil, evaporation and transpiration into the atmosphere, and controlled release into the traditional gray infrastructure system. (…) GI reduces runoff volume, peak discharge, and pollutant loading. Permeable pavement may have the longest record of documentation research among the variety of GI practices"(Burian & Pomeroy, 2010).

Stormwater Management and Green Infrastructure

The prospect of the incorporation of an issue such as stormwater management in urban design can also aid in the full commitment to the use of urban climatology as a tool for planning. Many other issues should be addressed in design concepts and plans in order to promote quality of life and attain truly resilient communities. Urban heat islands (UHI), for example, have been a phenomenon thoroughly observed and documented in urbanized areas, and there are reports pointing to the deadly effects of heat strokes caused by UHIs, posing a risk especially to children and elderly citizens. "For example, in 1995, a mid-July heat wave in the Midwest caused more than 1,000 deaths. While it is rare for a heat wave to be so destructive, heat-related mortality is not uncommon. The Centers for Disease Control estimates that from 1979 to 1999, excessive heat exposure contributed to more than 8,000 premature deaths in the United States.18 This figure exceeds the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined" (Division, 2008). Not only that, but following the Stuttgart example, wind patterns need to be understood as well, from the formation of canyons along streetscapes to the dissipation of pollutants, physically mapping out the flow of air movement in urbanized areas can allow for the design of neighborhood parks, strategically planned to support air flow and even limit the spacing and height of buildings in order to establish the continuous flow of wind through the urban network.

Truthfully, many solutions have been tested with successful results have been obtained in regards to increasing green infrastructure and stormwater management, yet little application has been seen with the use of the use of alternative materials, which could reduce radiation, or the use of vegetation as a form of maintaining wind flow within urbanized areas. While architecture has evolved in the design of net zero buildings, constructed with materials with low reflectivity and even incorporated aerodynamic features, urban planning timidly dabbles in the subject. Design wise, most solutions appear to be localized, implemented in small scale plans, such as neighborhood and very often in sub-division planning. In the larger scale, though climate may be taken into consideration in the analysis phase its implications lead to land-use related policies and future land use plans, that in some in cases are disregarded due to the fact that in many states in the United States such plans are not bound by law, but a mere guideline for local governments to use when found appropriate. The objective here is not to invalidate the importance of planning policies in the framework of urban planning, but yet to shed light on the need for the incorporation of design oriented solutions, particularly in the city scale, as a way of adapting urbanized areas to climate and attaining the formation of resilient communities.

CHAPTER 5

ANALYSIS & RESULTS

According to the climate region map[5] (Figure 2) developed by the U.S. Department of Energy's Building America Program, the state of Georgia can be characterized by two climatic regions: Mixed-Humid and Hot-Humid.

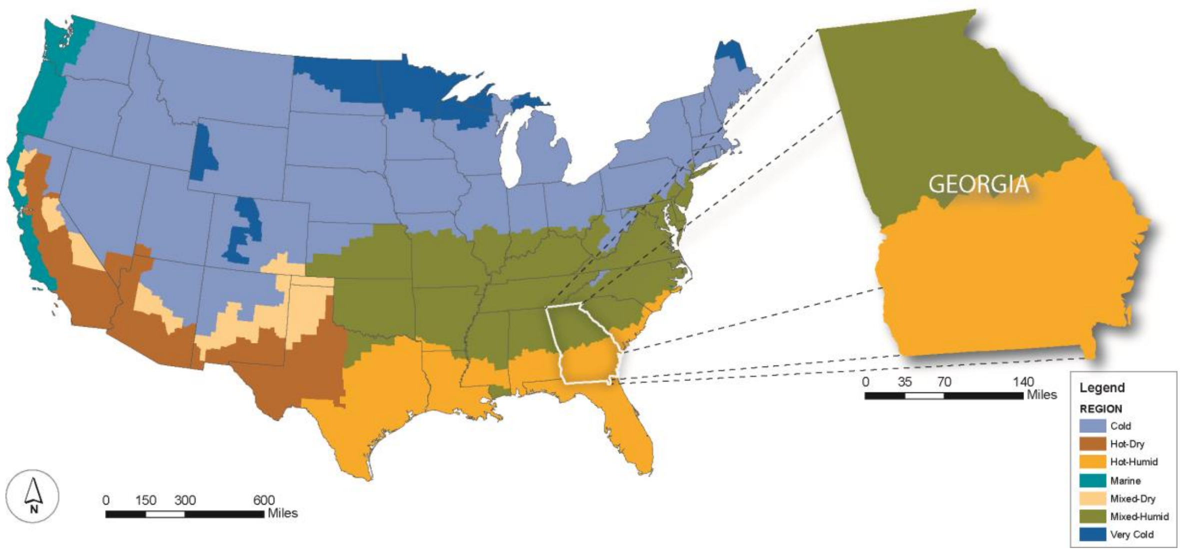


Figure 2 – Climate Zone Map, displaying classification for the state of Georgia within the context of the continental U.S. (DOE, 2011)

The coastal region of the state is characterized by a Hot-Humid climate, which in accordance to the Building America Program can be defined as "a region that receives more than 20 inches (50 cm) of annual precipitation and where one or both of the following occur:

[5] U.S. Building America climate regions are based on the climate designations used by the International Energy Conservation Code (IECC) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It intends to provide a simplified, consistent approach to defining climate for implementation of various codes; it was based on widely accepted classifications of world climates that have been applied in a variety of different disciplines. (DOE, 2010)

- A 67°F (19.5°C) or higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- A 73°F (23°C) or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year." (DOE, 2011)

The understanding of climate region classification, from the architectural stand point, has been used as a form of establishing design guidelines, which can respond to the local climate, seeking to create an energy efficient and comfortable indoor environment. Such guidelines aid designers in establishing goals, and to a certain extent, simplify the incorporation of climate in the design process. From the urban design perspective, such guidelines have also been created, yet have not been widely incorporated by the urban planning community as an initial decision making factor.

In his book *Climate Considerations in Building and Urban Design*, author Baruch Givoni (1998) suggests that there are two types of issues to be considered in hot-humid regions: "minimizing the hazards of tropical storms and flooding and minimizing thermal discomfort and cooling energy consumption." He goes on to establish objectives for each of these issues, stating that the for hazards from tropical storms and floods urban design should focus on "minimizing the hazards of floods by water flowing in from areas beyond the city limits (mainly a location problem); rapid disposal of excess rainwater resulting from urbanization; providing rain protection for pedestrians in "commercial" streets." And finally for the issue of thermal discomfort and cooling energy consumption, he states that objectives should focus on "providing shade for pedestrians (on sidewalks); providing shade for outdoor activities, such as children's playing areas; enabling good natural ventilation of urban space (streets, open spaces between buildings, public open spaces, and so forth); providing good ventilation potential for the buildings (airflow conditions around them); minimizing the "heat island" effect in densely built areas."

Such guidelines may seem broad, yet they are an initial starting point for designers to keep in mind while establishing their project objectives and developing plans for the future of cities. The analysis of the existing conditions in all three scales, will take these objectives into consideration, in an attempt to discuss what alternative decisions could be made to incorporate climate to future urban plans.

Regional Scale

As a starting point this phase of the analysis began by looking at the seasonal changes in wind flow and speed. Due to the lack of combined data available for wind directionality and speed, for the entire state of Georgia, and also seeking to understand where major wind currents were coming from, the wind analysis for this phase looked at the continental United States and then focused on the Southeastern portion of the country (Figure 3). In order to compare changes between Summer and Winter seasons, the maps looked at the months of June and December, as representatives of the specified seasons. It is important to point out, though, that changes in direction and speed do occur monthly, furthermore, the ruggedness of the landscape will influence and change these characteristics.

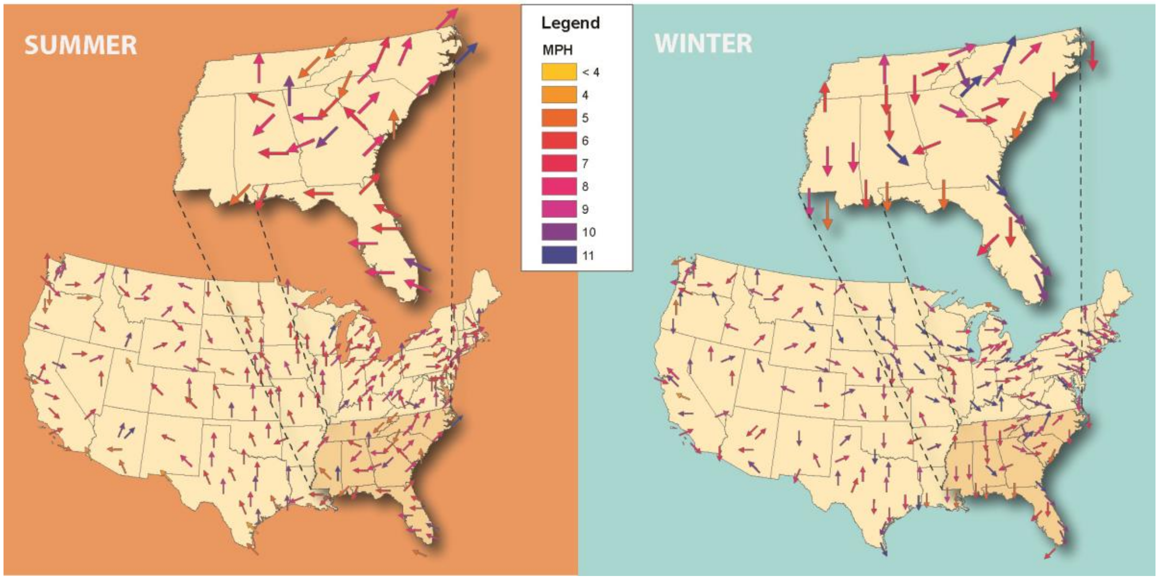
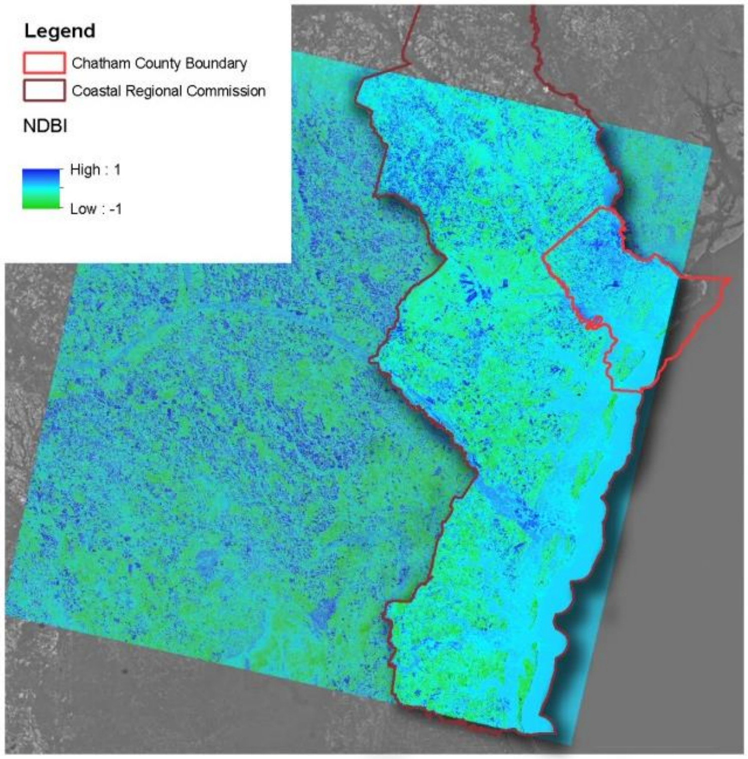
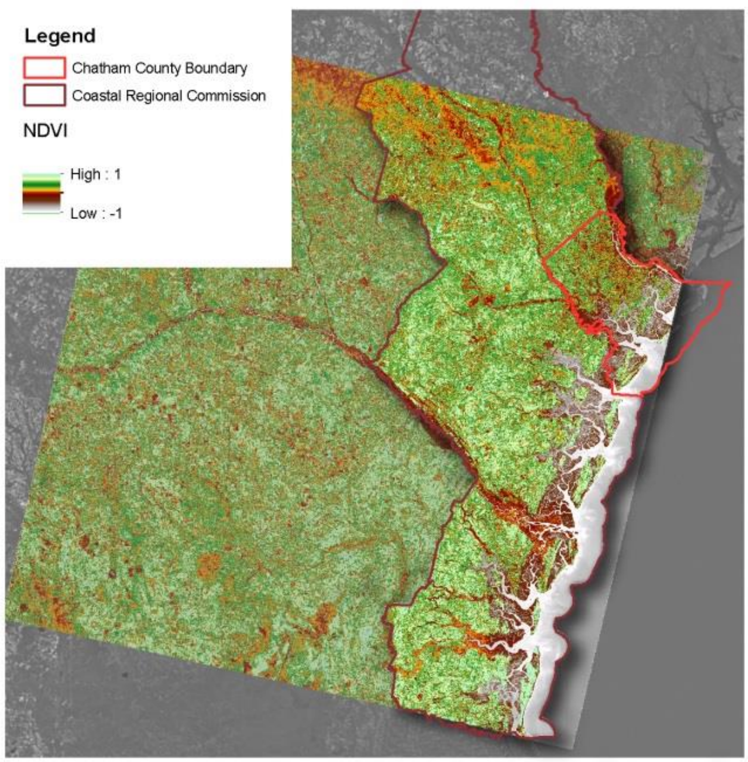


Figure 3 – Wind patterns in the continental United States, with focus on the Southeastern region, demonstrating changes in speed and direction between summer and winter seasons. (NOAA, 2012)

The generated wind maps demonstrate that wind directionality and speeds change significantly from summer to winter. During the summer prevailing winds tend to flow in a northeastern direction with an average speed of 7 mph, and apparently coming from the Gulf of Mexico, into Florida and Georgia. While during the winter prevailing winds flow towards the southeast, coming from the Carolinas and reaching an average speed of 5 mph.

The next step of analysis looked at land cover, utilizing Landsat 7 image to represent Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Built-up Index (NDBI). The use of both indexes intended to visually demonstrate the patterns of vegetation versus the patterns of built environment existent in the region. Land cover was also mapped for Chatham county, also focusing on contrasting existing vegetation to the existing built environment.


Legend
Chatham County Boundary
Coastal Regional Commission
NDBI
High : 1
Low : -1


Legend
Chatham County Boundary
Coastal Regional Commission
NDVI
High : 1
Low : -1

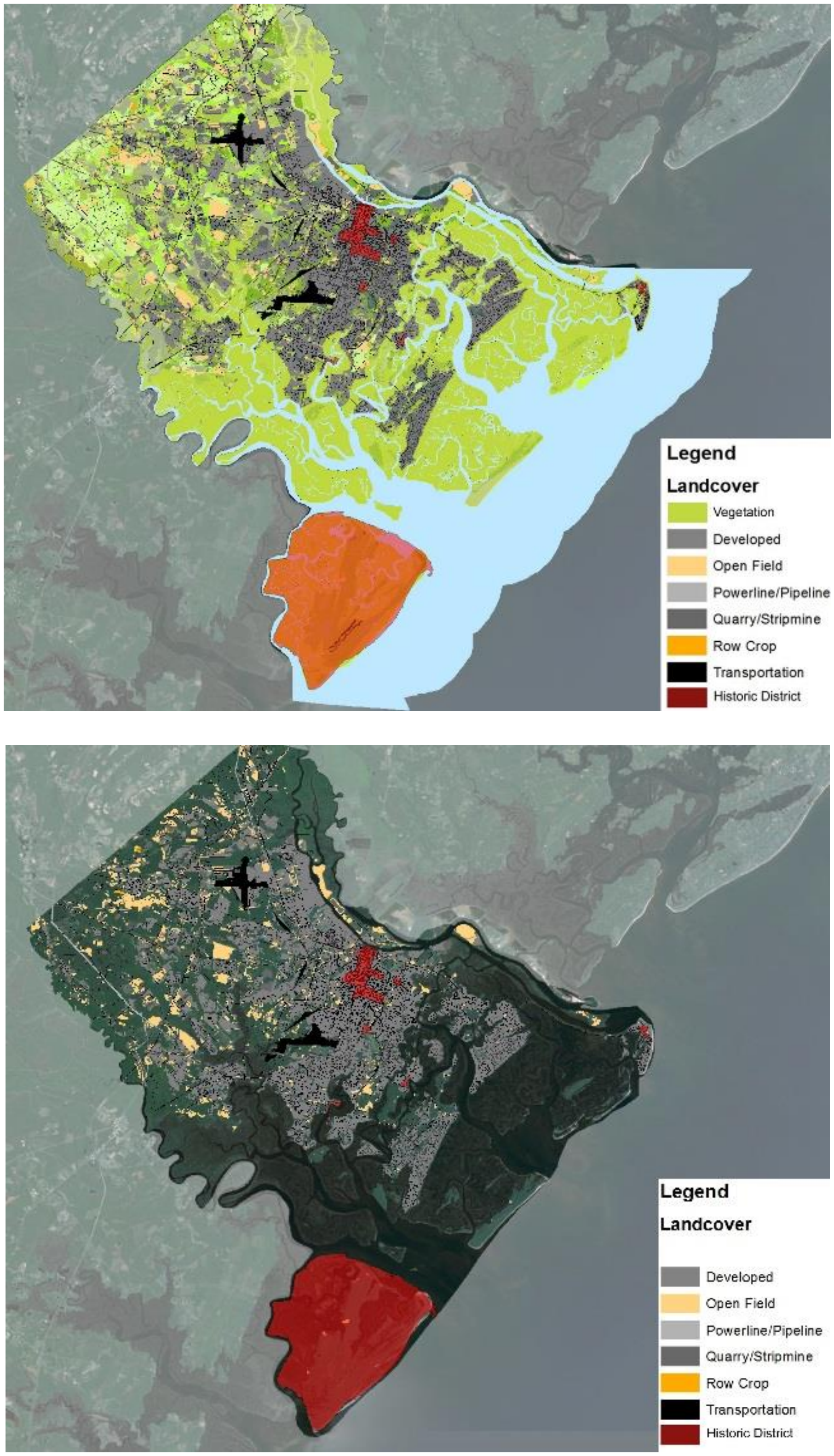


Figure 4 – Land cover analysis using Landsat 7 imagery and data acquired from Savannah Area GIS, for Chatham County.

All four maps generated demonstrate the existence of pockets of urbanization, surrounded by vegetated areas. Savannah is clearly identifiable as an urbanized area, especially in the maps focusing within the Chatham County boundaries. In the developed land map, several unoccupied and unvegetated areas appear, mostly in the outskirts of the urbanized cluster, indicating properties that could be sites for future development or where construction is underway.

Lastly, the regional analysis looked at the issue of flooding, mapping out storm surge categories and elevation specifically for Chatham County. Additionally, the storm surge map was overlaid onto the developed lands map, seeking to display how significant portion of the city is susceptible to flooding and what areas could be affected by severe weather events such as tropical storms and hurricanes.

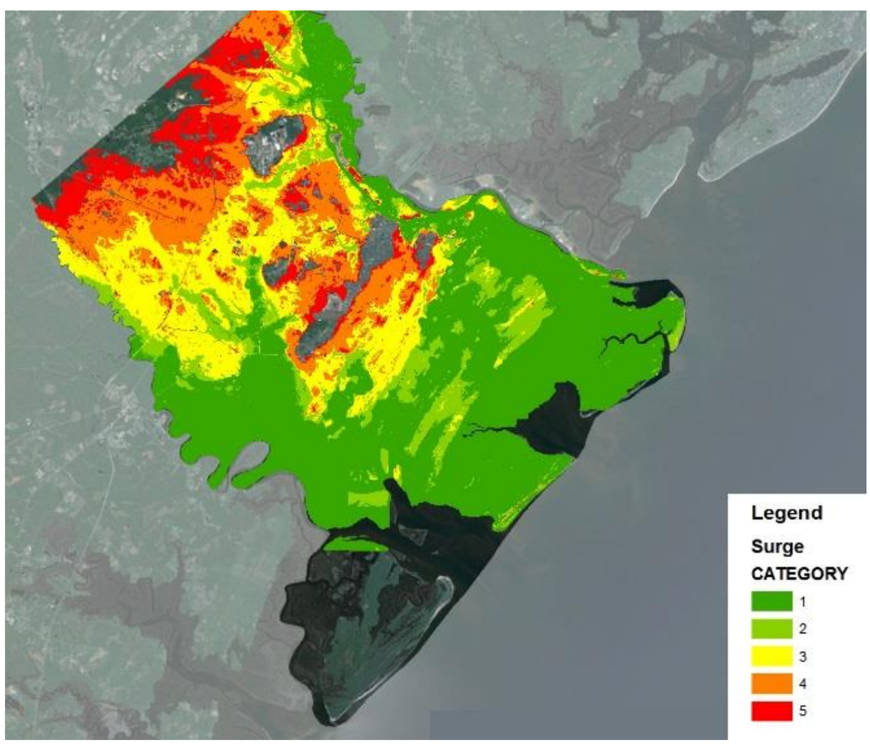


Figure 5 – Storm Surge Map demonstrating the areas affected by surges ranging from category 1 to 5.

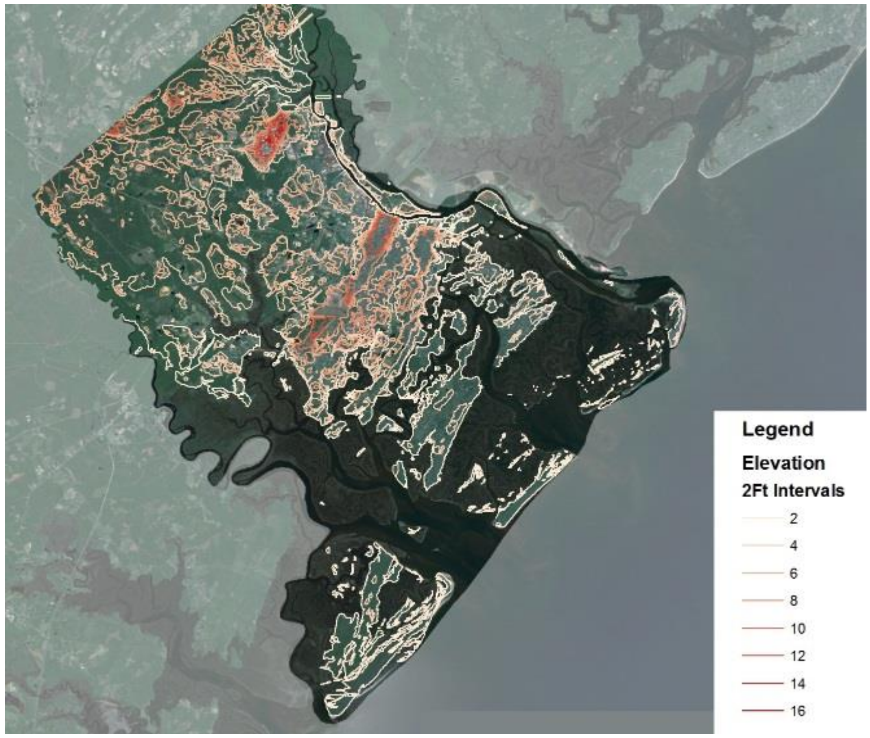


Figure 6 – Elevation map.

Though it was quite clear that, like most coastal communities, Chatham County is very vulnerable to flooding, what becomes obvious from the resulting maps is the strategic positioning of Savannah's historic downtown. As mentioned previously in this document, the Oglethorpe Plan was carefully thought out and designed to ensure the safety of the city, leading to the implementation of the plat where it is today. The maps created aid in strengthening the argument that in the past there was a careful consideration for the characteristics of the natural environment and the establishment of settlements. It also demonstrates that that newer patterns of urbanization have overlooked such issues and have allowed for the increase of impervious cover in areas at high risk for flooding.

City Scale

This phase of the analysis began by studying the growth patterns within the city of Savannah, aiming to comprehend the directions in which the city is expanding towards and how vegetation is being maintained as it expands. In order to do so, a map was created by overlaying building footprints from 1985 and 2012. Once this map was created, an additional layer was added, demonstrating existing tree canopy cover in 2012.

The results demonstrate not only how much Savannah has grown in 27 years, but also how it has become denser and is sprawling towards neighboring cities, such as Richmond Hills. The addition of tree canopy shows a higher density of trees within the historic district and in the outskirts of the city, point out that as the city grows it is losing significant amounts of tree cover.

In addition, to understanding growth patterns, this phase also focused on furthering knowledge on the local climate, seeking to understand the general climatic characteristics that could aid in the development of design guidelines specific to the city of Savannah. This portion of the analysis was done through graphs and tables that summarized the typical yearly climate performance.

The analysis started off by generating wind roses for summer and winter solstices, cross-referencing this data to relative humidity, temperature and rainfall, as well as determining the frequency of wind flows in each direction. With the understanding of local directionality and speed of winds, one may begin to understand the changes terrain causes in ventilation, by comparing the graphs generated with the regional wind map. It is important to note, though, that the climatic data obtained is collected from the Savannah International Airport meteorological station, a vast area with no immediately surrounding building clusters. With that said, one should keep in mind the impacts the built environment causes to wind directions and speed, which are very likely to be less obvious in the obtained data.

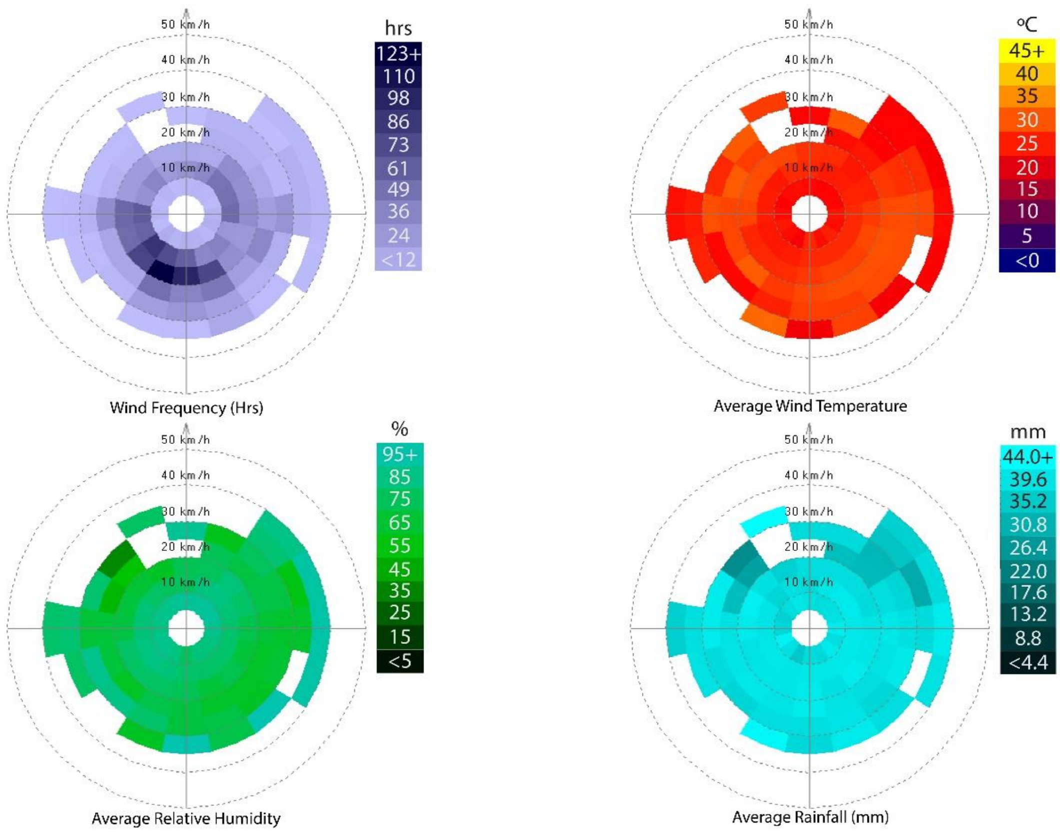


Figure 7 – Wind analysis summary for the city of Savannah – GA, during the Summer season (Ecotect, 2014)

According to the generated wind roses, during the Summer season winds flow more frequently from the south and southwest, at approximately 6.2 mph (10 km/h) in average, but reaching up to 24.85 mph (40 km/h). Wind temperatures vary between 86°F to 95° F (30°C to 35°C) in all directions, but southern winds are slightly warmer.

Humidity tends to be over 75% and average rainfall is over 1.4 inches (35.2 mm), yet curiously winds flowing towards the northwest tend to be dryer, and consequently, carry less rainfall.

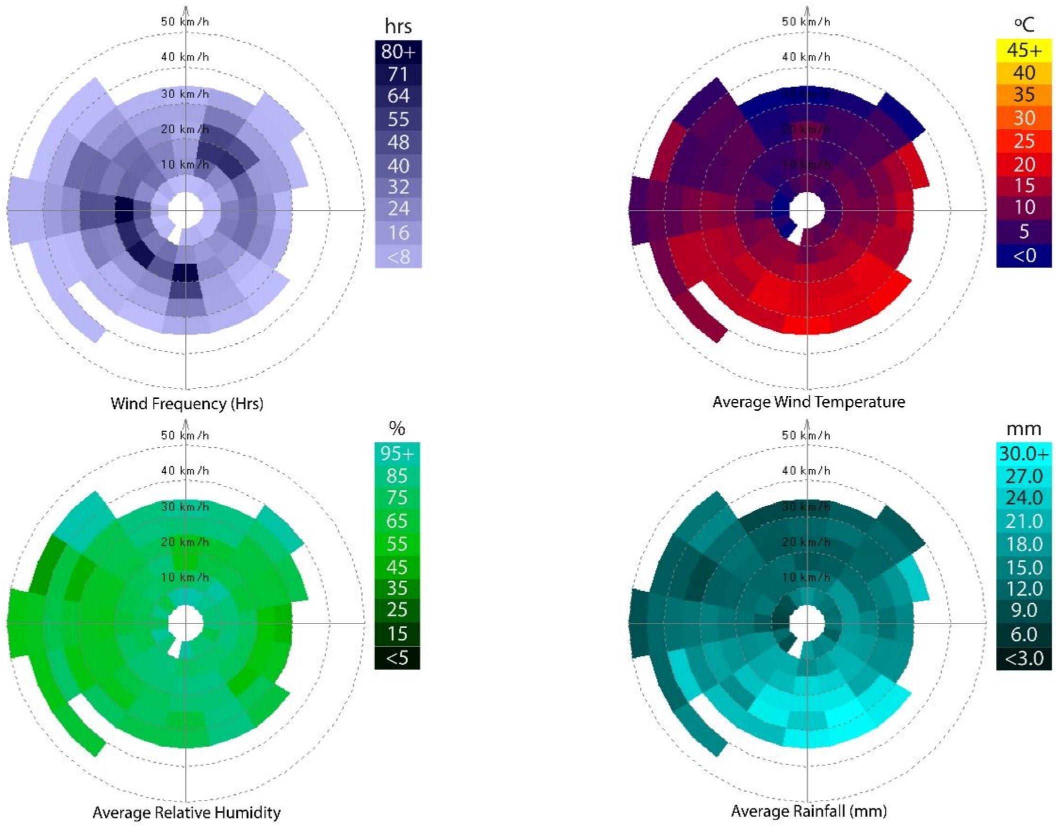


Figure 8 – Wind analysis summary for the city of Savannah – GA, during the Winter season (Ecotect, 2014)

Similar to the Summer season, during the Winter season winds flow more frequently from the south and southwest, yet there is also significant wind flow from the northeast as well, with speeds at 9.3 mph (10 km/h) reaching up to 31 mph (50 km/h). Wind temperatures vary most frequently between 50ºF to 59º F (10ºC to 15ºC), but southern winds are slightly warmer. Humidity tends to be over 75%, but can reach as low as 55% and average rainfall is frequently lower than 0.7 inches (18 mm), while as previously seen winds flowing towards the north tend to be dryer, and consequently, carry less rainfall.

Using the same TMY3 data files used to generate the wind roses in Ecotect, the analysis went on to use Climate Consultant 5.5 to develop a psychrometric chart[6], that will display the amount of hours in a year in which a person will most likely feel comfortable. Additionally, the Climate Consultant 5.5 interprets the hours outside of the band of comfort introducing design strategies. Though these are intended to aid architects and engineers determine guidelines for indoor environments, the results obtained should be very similar to the strategies previously presented in the beginning of this chapter. The reason for expected similarity is due to the fact that it was Givoni who proposed the establishment of the sixteen strategies for building design guidelines widely used by architects and engineers, and used as reference by software, such as the Climate Consultant 5.5 and Ecotect.

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[6] The Psychrometric Chart is a tool that presents the relationship between air temperature and humidity in graphical form, and helps describe the climate data and human thermal comfort conditions.

WEATHER DATA SUMMARY

LOCATION: SAVANNAH, GA, USA
Latitude/Longitude: 32.13° North, 81.2° West, **Time Zone from Greenwich** -5
Data Source: TMY2-03822 722070 WMO Station Number, **Elevation** 52 ft

MONTHLY MEANS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Global Horiz Radiation (Avg Hourly)	82	107	130	141	145	139	143	133	122	117	97	82	Btu/sq.ft
Direct Normal Radiation (Avg Hourly)	101	118	133	127	119	99	97	93	89	123	126	109	Btu/sq.ft
Diffuse Radiation (Avg Hourly)	37	44	49	56	61	66	69	68	63	46	38	36	Btu/sq.ft
Global Horiz Radiation (Max Hourly)	214	255	297	324	327	320	313	314	284	261	217	191	Btu/sq.ft
Direct Normal Radiation (Max Hourly)	303	314	318	309	300	274	263	263	262	302	303	309	Btu/sq.ft
Diffuse Radiation (Max Hourly)	104	116	147	161	170	162	158	174	155	132	105	98	Btu/sq.ft
Global Horiz Radiation (Avg Daily Total)	841	1159	1534	1814	1986	1968	1986	1759	1496	1309	1005	816	Btu/sq.ft
Direct Normal Radiation (Avg Daily Total)	1028	1284	1561	1622	1633	1395	1357	1226	1080	1378	1303	1084	Btu/sq.ft
Diffuse Radiation (Avg Daily Total)	383	482	592	724	834	939	963	901	780	524	394	359	Btu/sq.ft
Global Horiz Illumination (Avg Hourly)	2646	3403	4129	4538	4684	4577	4692	4382	3984	3722	3068	2592	footcandles
Direct Normal Illumination (Avg Hourly)	2730	3288	3712	3548	3299	2627	2522	2375	2325	3373	3386	2900	footcandles
Dry Bulb Temperature (Avg Monthly)	48	49	58	64	72	78	80	79	75	66	60	50	degrees F
Dew Point Temperature (Avg Monthly)	41	36	45	51	59	69	70	71	67	55	51	41	degrees F
Relative Humidity (Avg Monthly)	79	65	65	66	66	76	73	77	78	71	75	72	percent
Wind Direction (Monthly Mode)	250	30	180	230	210	200	210	150	40	50	50	180	degrees
Wind Speed (Avg Monthly)	9	9	9	8	7	7	7	6	6	6	8	8	mph
Ground Temperature (Avg Monthly of 3 Depths)	56	54	55	57	63	69	73	75	74	71	66	60	degrees F

Figure 9 – Summary of monthly weather data compiled by the Climate Consultant 5.5 software and used as a basis for the generation of a psychrometric chart for the city of Savannah, GA.

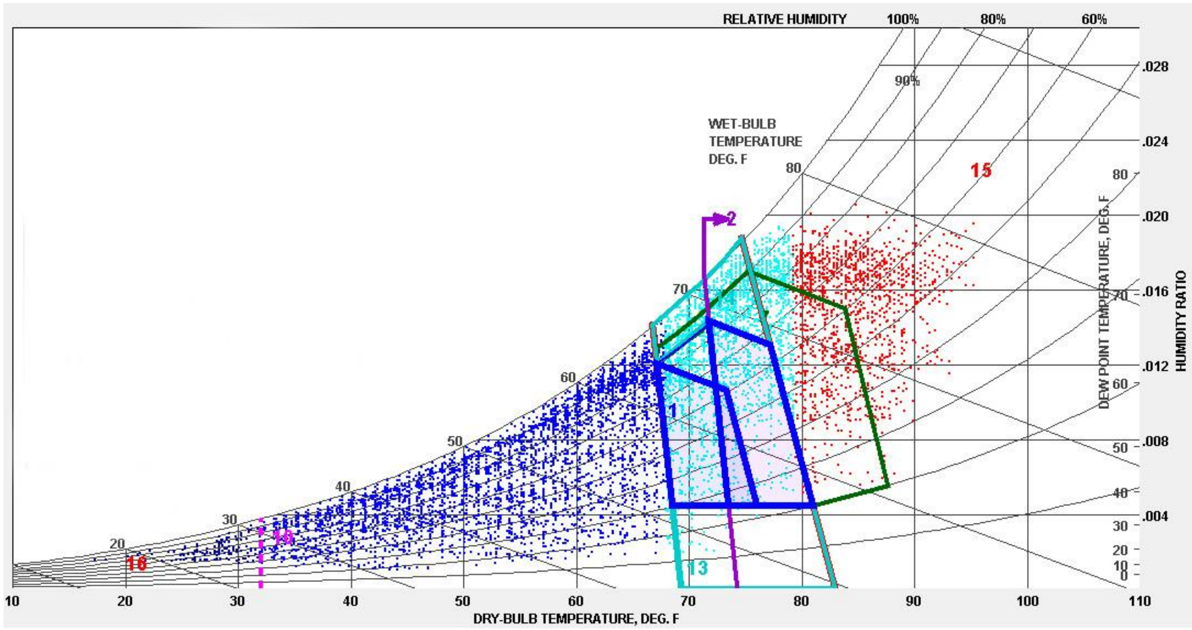

Figure 10- Psychrometric Chart for Savannah, GA.

DESIGN STRATEGIES: JANUARY through DECEMBER

12.4%	1 Comfort(1087 hrs)
17.9%	2 Sun Shading of Windows(1570 hrs)
	3 High Thermal Mass(0 hrs)
	4 High Thermal Mass Night Flushed(0 hrs)
	5 Direct Evaporative Cooling(0 hrs)
	6 Two-Stage Evaporative Cooling(0 hrs)
12.6%	7 Natural Ventilation Cooling(1104 hrs)
	8 Fan-Forced Ventilation Cooling(0 hrs)
	9 Internal Heat Gain(0 hrs)
8.3%	10 Passive Solar Direct Gain Low Mass(731 hrs)
	11 Passive Solar Direct Gain High Mass(0 hrs)
	12 Wind Protection of Outdoor Spaces(0 hrs)
0.3%	13 Humidification Only(22 hrs)
14.6%	14 Dehumidification Only(1280 hrs)
20.7%	15 Cooling, add Dehumidfication if needed(1809 hrs)
39.4%	16 Heating, add Humidification if needed(3454 hrs)

100.0% Comfortable Hours using Selected Strategies
(8760 out of 8760 hrs)

Figure 11 – Design Strategies derived from the psychrometric chart, in which the text is color coded in accordance to the graph, as a way of correlating strategies and climatic factors.

The results obtained from the psychrometric chart point out that only 12.4% of the hours of a year will tend to be perceived as comfortable by people in Savannah, all other hours will need to be improved upon, through the use of design strategies.

According to the simulated results, the introduction of shading and ventilation as design objectives for hot periods of the year could boost thermal comfort to approximately 43% of the hours in a year. Yet in an urban environment, unlike with designing a building, the designer is unable to use artificial means of cooling, heating and also dehumidification, which in this case account for the remaining hours of the year that are predicted to cause discomfort. Such discomforts may be reduced when the design is developed for specific sites, but in the city scale it is particularly difficult do establish guidelines that will guarantee comfort during all hours of the year.

Site Analysis

The last phase of the analysis process looked closer at two distinct sites in the city of Savannah to evaluate how the two different urban settings can respond to climate. Taking into account that strategies for a Hot-Humid climate are to allow for ventilation and shading, simulation program Autodesk Vasari was used to analyze both wind and solar radiation interactions. The intent of this phase is not only to visualize the differences between the urban patterns, but also to raise the discussion of how such knowledge could be used to change design choices and enable planners to develop future plans that can adapt to climate.

The first step of simulation was to analyze the performance of each site with regards to direct solar radiation. The evaluation sought to look at how density and proximity of buildings could impact solar radiation and how impervious and non-vegetated open areas in the urban network would perform without shading.

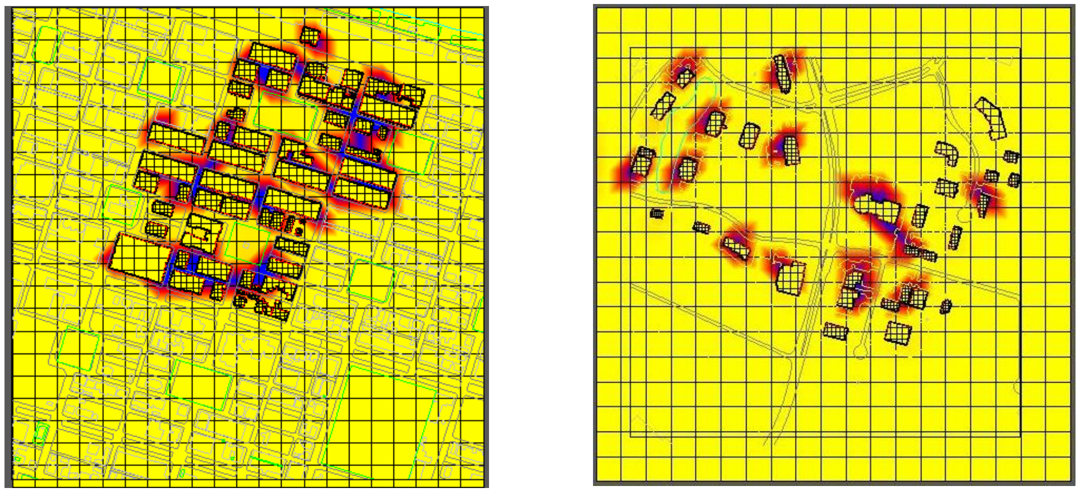

Figure 12 – Solar radiation analysis comparison between the two selected sites. (Vasari, 2014)

The results obtained were not surprising, and demonstrated a higher solar radiation emitance in areas considered to be non-shaded, but pointed out that areas in between buildings in the Historic Downtown tended to collect less direct solar radiation. What is important to point out, though, is that buildings could in fact reflect solar radiation, which in turn could lead to the formation of heat islands. Another important issue to reflect upon in this analysis is that vegetated areas, covered with trees, would in fact, react differently, and generate a blue coloration within the squares, which would drastically change the performance of radiation in this setting. The analysis on the second site, on the other hand, calls the attention to the potential increase in radiation due to additional impervious covers areas due to the existing parking lots.

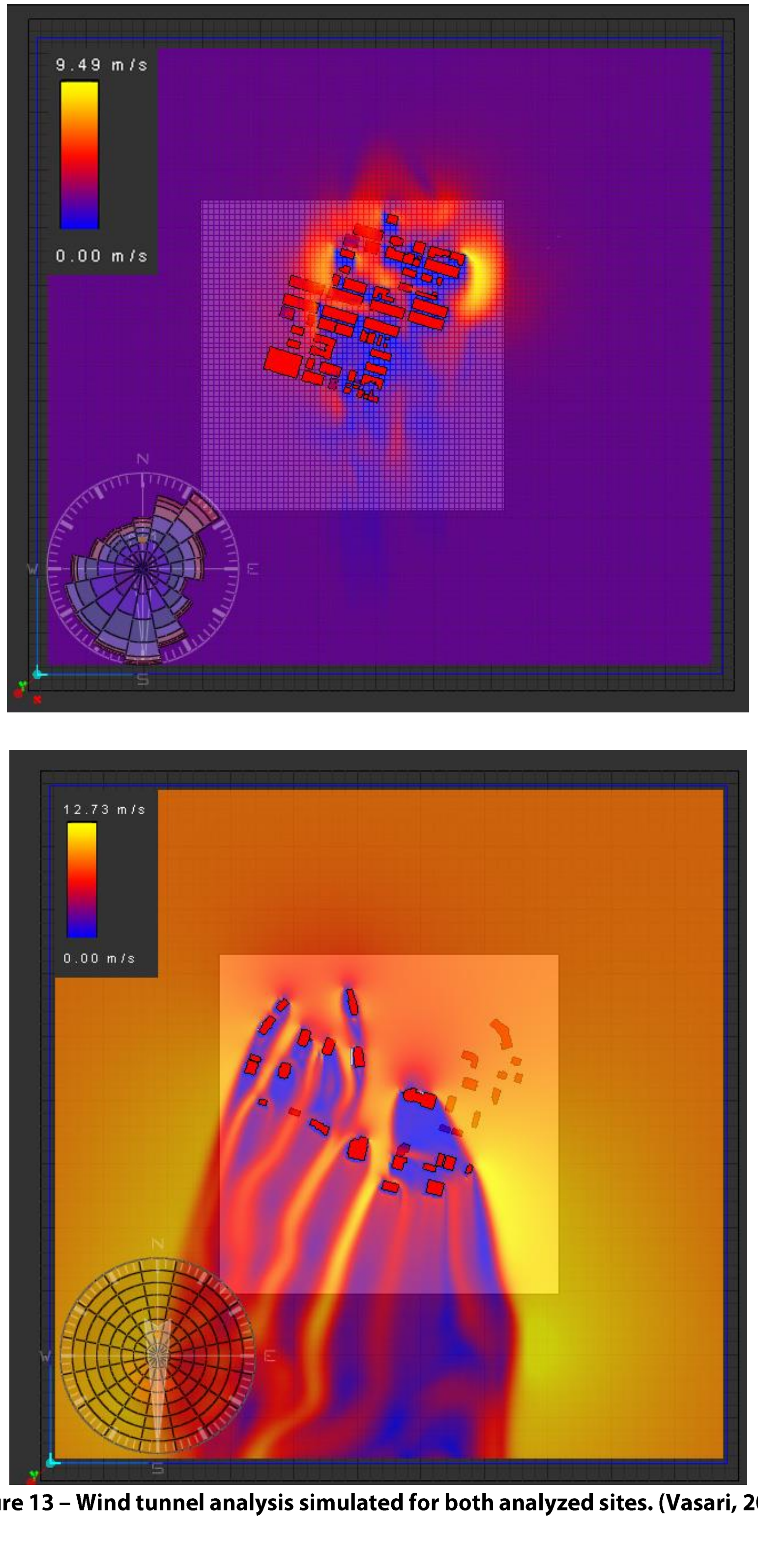

Figure 13 – Wind tunnel analysis simulated for both analyzed sites. (Vasari, 2014)

The wind flow analysis was also generated in Autodesk Vasari and takes into account the directionality and speed of wind. A wind tunnel simulation interface creates a 2D and 3D rendering of the wind patterns, displaying how the built environment change the direction and speed of air as it moves. In order to understand wind flow, one must acknowledge that as a fluid wind behaves similarly to water. Buildings function as pebbles in a stream, as water encounters a pebble it moves around it in order to return to its natural course, creating small turbulences immediately after the pebble. Based on that analogy it becomes easier to understand the changes in speed and the dust like appearance that occur along the edges of the buildings, demonstrating slight shifts in directionality.

Results and Proposals

The overlay of information gathered from the three scales of analysis allow for a better understanding of the relationship between the built environment and climate. As a starting point the regional scale served as an introduction to the physical characteristics of the area. Most importantly, the use of land cover data allowed for the comprehension of the extent of urbanization within the region and the composition of vegetated cover that encompasses the built environment. From the design perspective, however, this scale is much too broad and does not allow for further understand of how vegetation is in fact distributed and incorporated to the built environment.

In the city scale, unlike the regional scale, designing with climate becomes a possibility. It allows for a closer look at street networks, which combined with the understanding how wind patterns, can allow for the stipulation of how air can be conducted within the city. Additionally, evaluating the effects of building heights and the existence of gaps between street blocks can also aid in the creation of designs that preserve the natural air flow. From the shading perspective, the city scale can be very effective in documenting existing tree canopy cover and its distribution within the city network, which may lead to the identification of potential areas for the implementation of urban forests, neighborhood parks and greening along streets. The use of tree canopy cover as a design mechanism could also aid in the reduction of the effects of radiation. The creation of tree covered open spaces will form pockets in the urban network, this in turn could enable wind flows to pick up speed and diminish turbulence.

The choice of conducting site specific analysis envisioned the depiction of representative typologies of urban patterns in Savannah, seeking to better illustrate the differences in the performances of two different design approaches. On the one hand a densely built environment permeated by tree covered squares, and on the other a sprawling area with buildings sparsely distributed and a significant area of impervious cover composed both by buildings and surface parking lots.

As a pilot for the presented analytic approach, the study of Savannah leads to the relevance of tree canopy cover as a tool for successfully adapting to climate and ultimately establishing resilient communities. Such conclusion, though, is only made possible after careful evaluation of all three scales of analysis, but brought to light through the analysis of the existing urban typology.

In the presented sprawling typology, radiation is the main cause of concern, due to the large concentration of impervious surfaces created from the combination of buildings and surface parking lot. The insertion of trees as shading mechanisms could reduce the effects of radiation, as well as controlling stormwater run-off. Unlike the downtown typology, where density becomes an issue, in areas similar to this wind directionality and speed suffer less impacts, as buildings are spread farther apart. In denser areas, such as the downtown, wind patterns suffer more changes and turbulence occurs frequently. This is where Savannah is unique, for the typology presented by its historic downtown incorporates tree cover in its design, demonstrating the benefits of using trees as mechanism for climate adaptation. The question that rises from the studied examples is what can be done in denser urbanized areas, where there are no trees and there is little space for their incorporation.

Furthermore, in order to adequately use tree canopy cover as adaptation mechanism a metrics must first be created, which in turn could be set as a performance standard to aid planners in both evaluating and designing adaptation plans. Currently cities quantify tree canopy strictly by establishing the percentage of cover, yet with climatic design the use of tree canopy cover is directly correlated to the distribution of coverage inside the urban network. Therefore, the correlation of the percentage of coverage must be associated to a measurement of area, in other words, design guidelines should establish a percentage of tree cover per square foot, to be attained as a reference to adequately designing with climate. However, in the neighborhood scale or site specific scale, such metrics will then have to be correlated to the percentage of existing impervious cover, shading and reflectance, seeking to ensure that sites will not constrain tree covered areas to surround the built environment, as opposed to incorporating trees in the urban design.

Though, stormwater has not been the focus of the research, it is important to point out the relevance that the increase in tree cover has in reducing run-off and directly responding to the issue of flooding. With that said, it is also important to point out that Stormwater Management Utilities do not utilize the increase of tree canopy cover as a strategy for reducing flood impacts. The incorporation this strategy could serve as a boost for adaptation and aid cities in effectively becoming resilient to climate both from the thermal and flooding perspectives.

This study also demonstrates how sprawling areas have a considerable advantage to adapting as opposed to densely established urban areas. This affirmation, however, is not intended to state that it is advantageous for sprawl to occur in the first place, yet it points out the possibility of reconfiguration with adequate incorporation of climate as a tool. In this urban conformation buildings tend to be scattered allowing for adequate permeation. To adapt these areas the use of tree canopy cover should be allied to the stipulation of setbacks and spacing between buildings, oriented in such a way that can secure natural wind flow within the urban network even as infill occurs and density increases.

Lastly, while using thermal comfort as a guiding factor to the establishment of design strategies, this study points out to the potential of better involving and educating not only planners, but also the general public on issues such as heat island effect. The fact of the matter is that the discussion of climate change has overwhelmed the general public and establishing a connection that demonstrates effectively how climate is changed by urbanization is a challenge. The discussion of flooding has begun a process of perception that could go even further by seeking to convey to the public the issue of thermal perception. Analyzing human comfort levels could serve both as an educating mechanism, asking the public to reflect on how hot or cold they feel in certain areas, but could also serve as metrics for establishing performance standards that aim to promote comfortable outdoor spaces. Such metrics would also go hand in hand with the promotion of walkable environments and healthy communities and can be directly correlated to programs promoted by agencies such as the Agency for the Aging, under the administration of the Georgia Regional Commission, seeking to promote a healthy environment and protecting the more vulnerable from possible climate stressors.

CHAPTER 6

DISCUSSIONS

"I started looking to ways human beings imitate nature. And so one of the things I studied at the time was the idea of the prosthetic device. (…) And what occurred to me is that the prosthetic device has to integrate with a host, an organic host body, which is the human body. It then occurred to me that in a similar way to that everything that we build, equivalent to prosthetic devices and our host organism for our built environment is the earth, is the biosphere. And the successful integration is the eventual success of the earth, and the green future." (Ken Yeang, 2006)

It is difficult to approach the issue of incorporating climate adaptation to planning and urban design without challenging planners to dive deeper into the subject, and expecting a much profound and more technical knowledge of the issues at hand. Yet in many ways planners have been delaying having to deal with such issues and for the most part have not truly committed themselves to the understanding of how urban design and future land use plans can be affecting climate. Most of the discussion of climate change, and climate mitigation, until recently, did not involve planners, and while the effects of urbanization are a clear cause to much of the climatic changes we have seen, the truth of the matter is that planners have not yet stepped up to the plate.

Initiatives in the urban sphere have come from architects, landscape architects and engineers, who inspired by the concepts and rating systems such as LEED, have been seeking to produce green buildings and sites that are less impacting to the natural environment. Such a trend has brought about an understanding of the natural environment, focusing on reducing impacts to the natural water cycle and the incidence of heat island effects. While these actions have great merit in reducing the impacts to climate, they are very small when compared to what could be done in a city or regional scale, which is inevitably the planning realm. Additionally, cities planned to adapt to climate can give an even greater opportunity for the design of sites that are better adapted to climate. Buildings and sites are currently planned through simulations that rarely take into account their surroundings, and rely on unrealistic climatic data, collected in airports and areas with little to no building density surrounding it. In other words, many green buildings could be performing better if only the city was responding to climate as well. Planning with climate could give sites an even better start and policies can push for a more effective approach to reducing impacts.

Coastal communities, have been the first to realize the effects of urbanization and have begun to perceive the importance of acknowledging the need for adaptation. The eminent danger of flooding along with major changes to the National Flood Insurance, have brought an urgency to planning for resiliency and making sure cities can reduce risks when faced with extreme weather events. Yet as planners, much of our focus has been solely on water, and the importance of protecting flood plains, ignoring the fact that this is only a small part of the climate discussion. There is a unique opportunity at hand for planners to use urban design as a tool for adaptation, to adequately respond to more than flood management. Questions such as: "What factors are collaborating to social vulnerabilities?" or "How comfortable people feel in urban environments?", need to be asked and addressed. Moreover, there is a clear juxtaposition between planning for flooding and planning for climate, since flooding is a result of climatic interactions, planners need only broaden the scope of analysis. Such juxtaposition can also be seen between planning for social equality and climate, the incorporation in this case can occur in seeking to create more comfortable and healthy environments, that promote the reduction of vulnerability for certain social groups.

From the planning perspective the establishment of healthy communities has been intertwined to the concept of promoting walkability. In order to achieve such a goal, people need to feel comfortable outside. In this sense, climate can be a useful tool in order to ensure a healthy urban environment, which promotes a condition that enables people to engage in outdoors activities during a higher percentage of hours during the year.

Though the importance of adapting cities to climate and reducing the impacts of urbanization has been established, planners must find a practical approach to dealing with the subject and making sure cities can continue developing while seeking adaptation. In the case of Savannah, and all of the coastal communities in Georgia, there is a unique opportunity to incorporate issues of climate to the established

Coastal Regional Commission's rating system, currently under revision in order to incorporate flood management strategies as a way of responding to the recent changes in the National Flooding Insurance. This assessment tool has potential for becoming a strong form of implementing a practical approach to climate planning. It can combine climatic issues under not only flood management, but also through the evaluation of quality of life, and reducing vulnerabilities to an already established aging population.

This project leaves the opportunity for furthering studies on how incentives can be created to incorporate climate planning. Studies must be developed to understand how plans can be evaluated and furthermore rated, as a way of stimulating long term plans that aim at reducing the major effects of urbanization. Additionally, there must be an establishment of the types of tools and information that must be made available to planners in order to both educate and enable them to effectively plan with climate.

Fortunately, there have been many advances in research in this field, and much can be learned from other professions on how to design with climate. Planning is inherently a multi-disciplinary field, and planners have always been faced with the challenge of learning a little bit of "everything" as a result of attempting to grasp the many issues involving the urban sphere and the natural environment. To take on the challenge of climate is to acknowledge that humans have drastically changes landcover and adapting is insuring that we do not continue making the same mistakes.

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