Vernacular Desert Architecture and Contemporary Applications For a Changing American Southwest

Sebastian Elverskog

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Primary Advisor: Dr. Paul Chinowsky

Outside Advisor: Dr. Scott Ortman

Honors Council Advisor: Maryanne Fantalis

"In response to people who say you can't go back. Well, what happens when you get to the cliff? Do you take one step forward or do you make a 180-degree turn and take . . . one step forward? Which way are you going? Which is progress?"

-Doug Tompkins-Founder and CEO of the North Face

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Abstract

As the planet contends with the changing climate, architects are tasked with envisioning the homes of the future. This study takes one approach to addressing this challenge by looking to the past for solutions. Specifically, this study is an examination of prehistoric housing systems in arid environments and their key elements. This exploration in "Paleo-Architecture" seeks to address contemporary problems of climate change, resource management, and urban density in the context of the American Southwest. Through the analysis of archaeological sites and historical texts this research will identify the principal elements of indigenous habitations to guide solutions for contemporary housing issues. Using modern fabrication and construction techniques, new applications of these ideas are presented to create modular elements of architecture for a series of paleo-inspired housing.

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Research Question

How can historic examples of vernacular desert architecture provide value to an anachronistic housing model in the American Southwest?

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Research Contribution

The research provided herein offers a framework for future models of residential housing design in the American Southwest. This project argues the benefits of traditional housing models using case studies in similar climactic settings to that of the Southwest. The research provides design recommendations for a shifting understanding of what constitutes acceptable housing models. These design recommendations are intended to be suitable to contemporary lifestyles and interchangeable with existing technologies. The research seeks to provide a framework that can be utilized by architects, local housing authorities, policy makers, and non-profit organizations. The research argues that using more traditional building methodologies is the best approach in creating more sustainable housing solutions while also addressing anthropogenic climate change. At the same time, the proposed model would be the most affordable. The research will be more specifically engaging architects and policy makers in offering affordable and low-income housing solutions. To see changes on a large-scale in such a dominant industry like real-estate development, there must be an initial effort through more accessible means, such as local housing authorities, who are developing affordable housing projects. Additionally the research will encourage a larger movement of architects to embrace the traditional housing typologies, as there is a growing movement of "paleo-living" in the United States. The architecture proposed will complement the already successful movement and diet of the Paleolithic Epoch.

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Research Objectives

The objectives thus far are to explore historical examples of existing vernacular architecture and synthesize the existing solutions with contemporary climate data to identify the optimal architectural elements that can be applied to modern residential housing design. By using historic models and archaeological data in addition to using design from contemporary vernacular housing solutions, this research synthesizes the benefits of traditional housing options. In addition, this research will look at existing case studies that examine the contemporary applications of vernacular buildings. The case studies selected will be sited in similar climactic areas with similar population densities as the American Southwest. These case studies will be used in combination with historical precedents to create the framework of design recommendations.

To begin we must define what makes the housing model in the American Southwest vulnerable. To frame the existing problems within the housing model, this study synthesizes the climactic data and suburban sprawl research and interjects solutions found within vernacular desert architecture. The research then continues to elaborate on the essential questions that must be answered for the design recommendations to be justly applied. This research will be split in three primary objectives. First, what are the most essential elements of prehistoric architecture that create sustainable and efficient solutions? Second, how can we adapt these elements to the specific problems facing housing in the American Southwest? And lastly, how can we create value in these outdated housing typologies in a rapidly advancing world? This synthesis will help guide the creation of a framework for building residential designs that address climate concerns, resource management, and energy use.

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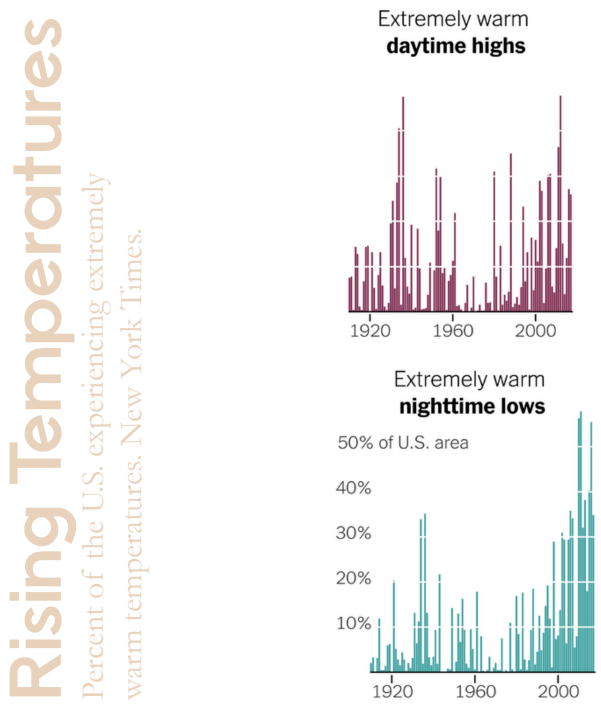
Introduction

The impacts of climate change are becoming increasingly visible, from wildfires in the American West to water shortages in Africa and violent storms in Asia. These extreme weather events are forcing designers and architects to build more resilient and sustainable products that work with the ongoing changes in the natural world. (Mann et al. 2017) In this regard, the American Southwest is one of the most at-risk regions for the effects of climate change. (Gonzalez et al. 2018) It is also one of the places that has experienced the most suburban growth since the Second World War. (Parker 2010) The expansive suburbs and exurbs that dot the desert landscape of the American West are in disagreement with the delicate and harsh landscape they occupy.

The climatological data showing the potential impacts of climate change in the southwestern United States are both consistent and harrowing. While the Inter-Governmental Panel on Climate Change has shown that a global temperature increase of 1.5 degrees Celsius is imminent (Masson-Delmotte et al. 2018), more regional studies of the Southwest have shown that temperatures will increase even more. (Gonzalez et al. 2019) In fact, the Southwest will be one of the most heavily impacted regions as a result of global warming. In particular, on account of extreme heat waves, ecosystems and especially water resources will be pushed to the brink of their operable limits. This is not only projected for the future, but reflects realities today. For example, heat-related deaths in Arizona have increased sharply: in 2014 there were 76 deaths attributed to extreme heat and that number grew to 235 in 2017. (Flavelle and Popovich 2019)



Henderson, Nevada. South of Las Vegas. Google Inc.

Given the extreme health risks posed to residents by these high temperatures, many people in Phoenix have adapted to doing most of their activities at night to better cope with extreme summer temperatures. (Peterson 2019) Thus if the threats to human health and safety are becoming so great that normal life cannot occur uninterrupted, our design choices must be reevaluated and adapted to these contemporary conditions.

The post-WWII universal housing model of suburban homes as a rule has ignored the regional climactic differences found throughout the world. Thus, a real-estate development in Massachusetts will most likely share the same characteristics as a suburb outside of Phoenix or Tucson. (Greystar LLC. 2019) In this way the radical differences in everything from heat to light to temperature and aridity are overlooked in favor of a uniform and mass-produced design. Climate change is making evident that these realities of the natural world cannot be ignored. The premise of this project is therefore to suggest that a symbiotic relationship between the natural world and the built environment needs to be developed.

To this end, this research effort proposes that we should draw on the design practices of native peoples who lived in extreme desert environments for thousands of years and thereby built, designed, and refined spaces suitable for such extreme climates. Indeed, vernacular architecture from around the world can and should inform contemporary housing designs that address the increasingly volatile climate and thereby create more sustainable models of housing that correspond to local environments.

Vernacular inspired building in Jordan. Rory Gardiner.

The indigenous architecture throughout the world's deserts serves as examples of different technological adaptations to create comfortable spaces for humans in such extreme environments. From primitive cooling systems (Vefik 1991), to interior lighting strategies (Bille 2017), to larger urban forms (Alabid and Ahmad 2014), native designers and builders have refined and improved systems for millennia to create sustainable and efficient systems to effectively support human life. And thus, the idea that we can learn from them is not a novel one. Rather, even such towering figures of modern architecture like Corbusier appreciated the value of using prehistoric architecture in contemporary design. (Richards 2015)

Yet at the same time, it is important to recognize that we are now at a critical inflection point. The old modernist idea that nature was static and could be readily controlled by humans has been challenged by not only decades of scholarship, but also lived experience. Nature is not static, and as the daily news makes clear, we are now more than ever at its mercy. Architects and designers therefore need to take such facts into consideration in all of their projects. One way to do so is to look at how native peoples adapted their built environments to earlier climactic changes. Archaeologists have shown that in the Southwest there have been several major climate events that have shaped both human migrations and altered the built environment. (Ingram and Gilpin 2015) Thus, through the study of archaeology, history, and anthropology, we can use past events to better our future built environment.

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Review of Literature

The research supporting climactic change on a global scale is pervasive in all realms of environmental studies. Thus, to establish an understanding of how to build sustainably in the Southwest, the climactic issues facing the region must be understood so as to best adapt traditional designs to contemporary problems. Furthermore, the shifts in human lifestyles from prehistoric urban developments to contemporary trends of sprawl and urbanization have created a plethora of problems that change the way architecture relates to domestic life. As a result, both climate change and these domestic shifts need to be considered when we explore how primitive habitation design can solve contemporary housing issues. The literature review presented below examines the existing findings on climate, suburban sprawl, and indigenous habitation to establish a basis for further synthesis and design recommendations.

Climate

The planet's ecosystems and weather systems are being altered by human activity. The rapid rising of the planet's temperatures is cause for alarm. (Masson-Delmotte et al. 2018) The Inter-Governmental Panel on Climate Change reports that global temperatures have already risen 0.8 to 1.2 degrees centigrade, yet by mid-century temperatures will have likely increased by 1.5 degrees. The implications of this increase are wide-ranging and will affect all organic systems as a result. Additionally, the effects of climate change will have far greater impacts in already extreme climates like the American Southwest. (Gonzalez et al. 2018) (Vose et al. 2017). The increasing severity and regularity of extreme weather events will be amplified in this unyielding climate. (Mann et al. 2017) As a result of these climatic changes, human health, native ecosystems, and food production will all be tested, and will either have to be forced to adapt or fall behind and be replaced. (Gonzalez et al. 2018)

The impact of anthropogenic climate change on the American Southwest is best represented numerically as it shows the true proportion of the reality of the issues at hand. The Southwest is already one of the hottest regions in the world as it already regularly receives temperatures exceeding 98 degrees Fahrenheit throughout summer. (Kunkel et al. 2013) Furthermore the Southwest has experienced more hot nights and fewer cold nights, with the coldest night increasing 4.1 degrees Fahrenheit since 1990. (Vose et al. 2017) Additionally the hottest temperatures on record in the Southwest have been recorded in 2012, 2014, 2015, 2016, and 2017, showing that the time is now to act on anthropogenic climate change. (Gonzales et al. 2018)

The extreme temperatures in the region are just one facet of the issue, with the most pressing concern being water. Since the start of the century, the region has experienced longer and more pronounced drought, with some years experiencing more significant water shortages. As a result of climate change, the mean rainfall in these areas is 22-25% lower than the 20th century mean. (MacDonald 2010) However, while the average amount of rainfall is decreasing, the population in the southwest continues to grow. From the onset of the 20th century to the 21st century, the population of the American Southwest grew from 2,100,000 to over 50,000,000 people, with census estimates expecting 62,000,000 by the year 2030. (MacDonald 2010) In addition to this threatening natural systems and the human populations that inhabit the Southwest, it is also a threat

The drop in the high-water mark in Lake Powell, Arizon, in 2015. Wilking.

to the economic productivity of the Southwest. For example, of the annual $36.1 billion in revenue that California produced in agricultural products it was found that $308 million was lost yearly to drought. (Macdonald 2010) While drought is one of the most discussed, there are a range of other factors limiting the survivability of the Southwest.

One of the most important aspects is the increasing longevity and consistency of forest fires. These fires threaten native ecosystems and human health. (Abatzoglou and Williams 2016) Additionally, projected increased droughts in the arid west will not only threaten human life, but it will critically affect agricultural production and native species. (Fyfe et al. 2017)(Mote et al. 2018)(Pierce et al. 2008) While organic systems have the most at stake when looking ahead to the impacts of climate change, anthropogenic systems will also be forced to adapt due to changing climate and weather.

Extreme temperatures and weather events will place great stress on man-made systems in the southwest region. As the region continues to grow, the stresses placed on natural systems for human survival will only intensify. (U.S. Census Bureau 2017) (Parker 2010) The increased number of heat-related deaths in the Southwest is one of the most visible changes due to climate change. (Flavelle and Popovich 2019) (Eisenman et al.

The hoover dam in Nevada. Nirian.

2016) These deaths are only one of the impacts that will affect the survivability of the American West. Hospital visits were found to increase by 7% during periods of extreme heat. (Guirguis et al. 2013) As extreme temperatures threaten human health due to increased risks of dehydration and heatstroke, residents throughout the Southwest are reserving physical activity for evenings when temperatures drop. (Peterson 2019) Temperatures at night have increased 10 degrees since 1948 due to urban heat island effect, yet evenings still serve some respite for physical labor. (Arizona Department of Water Resources 2014) Construction jobs, recreational exercise and other daily errands are being reserved for midnight and early morning hours. (Holloway 2019)

Nocturnal living is not the only consequence; energy production will be drastically diminished given climate changes. Current estimates show a loss of 15% productivity across the Southwest by 2050 from current energy production sources. (Gonzales et al. 2018) Hydroelectric power, which supplies a majority of the southwest, has been reduced by two-thirds as river flow has been decreased due to drought. (California Energy Commission, 2018) Non-renewable technologies are also affected; higher temperatures reduce the cooling effectiveness of power plants and have thus shown to lessen production by 15%. (Van Vliet et al. 2016) Thus, as the Southwest continues to grow, housing and energy demands will increase; however, these electricity shortages will become commonplace in the near future if current systems are not changed. (Bartos and Chester 2015)

Suburban Sprawl

In the wake of the Second World War, the emergence of automotive-based suburbanization has been one of the most environmentally destructive experiments in human history. (Larco 2009) (Cutts and Minn 2018) Using Phoenix as an example, the city exploded in the post-war period as a result of local politics, technological advancement, federal grants, and national advertising campaigns. (Di Taranto 2015) In 1940, Phoenix was the 95th most populous city in the nation, yet in 1970 it had climbed to the 12th most populous, and is currently the fifth largest city. (U.S. Census Bureau 1980) (U.S. Census Bureau 2019) Among many other reasons for this explosive growth, one surprising factor is the fact that Phoenix had more urban planners per capita than any other city in post-war America. (Kelso 1961) This rapid growth in combination with a misguided foresight has created a range of resource management complications as well as wide-ranging consequences for the area's ecosystem and human health.

The immense energy requirements of large, low-density suburban developments far outweigh those of housing in urban centers. (Estiri 2016) A study of suburban Phoenix found that energy consumption was three times higher in low-density suburban developments than in high-density centrally located developments. In addition, the study found that residents in suburban developments produced twice the amount of carbon dioxide from routine activities. (Guhathakurta and Williams 2015) Not only are HVAC requirements high, but transportation to and from city centers for work are also far higher per capita than in urban areas. (Perkins et al. 2009) A study of Phoenix residents found that energy needs were 200% higher for exurban residents of Gilbert compared to urban Phoenix inhabitants. (W. Zhang 2016)

Water consumption is also incredibly high in Southwestern cities, where water resources are already critically low. Phoenix averages above 200 gallons per person per day, whereas urban cities like Boston or New York use just under 100 gallons per person per day. (USGS 2005) The hot climate, in addition to landscaping requirements, has created this disproportionate usage pattern. (Gammage 2016) Landscaping mandated by homeowner associations require green lawns in suburban areas, creating a far higher demand on water resources than necessary. (Cutts and Minn 2018) (Larson et al. 2009) Regardless, studies show that even if growth in the Southwest was reduced by 50%, and water for outdoor landscaping and pools were cut completely, it would still not

Suburb Southwest of Las Vegas, Nevada in 2009. MacLean.

ensure sustainability even under optimal rainfalls. (MacDonald 2010) To more accurately understand "sustainability" in a broader context, this research uses the definition of sustainability as defined by the Brundtland Report of 1987: "meeting the needs of present generations while not compromising the ability of future generations to meet their own needs." (Brundtland 1987) If this is the definition of sustainability, how could we ever allow these metropolises to exist in such hostile environments as the desert? Yet such extreme examples of resource mismanagement are not the only consequences of suburban developments.

Physical and mental health is also shown to be far worse in suburban developments than urban cores. (Guite et al. 2006) (Dannenberg et al. 2003) (Sturm and Cohen 2004) The physical effects come from a range of problems like inactivity, ozone levels, and traffic deaths, all of which are prominent when discussing suburban lifestyles. This has led to an increase of 7% in hospital visits during heat waves. (Parker 2010) Less visible consequences of suburban developments are the mental aspects. Higher stress levels are found in suburban areas from greater fear of crime given the spacing between homes and less visible homes. (Foster et al. 2010) These health issues are shown to only be a relatively recent phenomenon, and thus by looking back at historical examples, we can identify ways to eliminate some of these modern afflictions.

Indigenous Habitation

Gradually, as humankind developed, archaic peoples began migrating across the planet and settling in a range of diverse climates. As a result, early humans created a plethora of housing solutions to protect them from local environmental and climatic conditions, and ultimately increase survivability. (Oliver 1997) This vernacular architecture has long been overshadowed by what is considered modern or contemporary in architectural history; however, beginning in the 20th century, modern architects began looking to the past for design inspiration and solutions. (Richards 2019) This may have been a reaction to the growing modernist movement, a sort of rebellion that sought to return to more traditional ideas of architecture. This return to traditional architecture is noted by the publication of Sur les Quatres Routes (On the Four Routes) by Corbusier, which drew on traditional architecture to address contemporary issues. In particular, Corbusier marveled at the old cities of M'Zab and Vézelay, which, although he deemed them antiquated, he also found to be beautiful. (Richards 2019) Thus, even though Corbusier was the founder of CIAM (Congrès internationaux d'architecture moderne) – the governing body which dictated the homogeneity of modern architecture – in Sur les Quatres Routes, Corbusier actually advocated a return to traditional architecture.

Traditional, rather than primitive architecture, as Richards states, has long been ignored by modern architects. Indeed, the trend has been to use technological advances to solve routine climate concerns, yet there are countless examples of primitive technological systems that are potentially better for human health, more efficient, and far more sustainable. (Vefik 1991) The importance of climate specific design has long been overlooked as real estate empires carve up unclaimed swathes of land. (Greystar Worldwide LLC 2019) Climate specific design not only increases comfort of spaces, but it can also help create beautiful spaces as well. (Varzaneh et al. 2014)

Historic examples of vernacular architecture are thoroughly detailed in archaeological records and thus are able to inform current and future climatic and architectural problems. Their nuanced responses to extreme historic weather events are critical for designers to understand as they contend with contemporary issues of climate change. The varying responses to drought and desertification throughout history provide a useful starting point in which to create robust housing models that could

A modern housing development outside of Tehran, Iran. Kuzu Grup.

aid in the creation of housing typologies that are resistant to climate change. (Ingram and Gilpin 2015) The return to traditional design has shown promise in less developed areas in the Middle East and North Africa, where economic conditions limit the accessibility of technological adaptation to climate change. Neo-Vernacular designs in Libya have shown promise when modern architecture fails in extreme climates like the Siwa Oasis. (Ahmed 2015) Other, more engaging methods to introducing traditional architectural designs are seen in Balat, Egypt. The participatory method of teaching traditional modes of construction allows residents to not only understand vernacular architecture but also encourages inhabitants to construct their own dwellings, thereby empowering them to take control of their housing. This teaching not only educates residents, but it also allows for more attractive amenities, as traditional development is cheaper. (Dabaieh 2013) The notion that modern materials and architecture are equivalent to socio-economic development is not unique to more rural areas like Balat. Recent studies show that traditional town and city planning is far more favorable to residents than suburban subdivisions. (Bitter 2014)

The resistance to and hesitation to adopt vernacular and traditional architecture is not unique to Balat. This is a common narrative seen throughout the world in industrializing nations. The understanding of vernacular architecture being inherently ugly because it lacks a formal architect is being challenged as an increasing number of local architects begin experimenting with traditional

Yves Saint Laurent Museum in Marrakech, Morocco. Glasser.

materials and modern construction and fabrication techniques to create avant-garde structures. This dialogue has expanded as many architects see this as the most responsible way to integrate projects within their contexts. Modern vernacular architecture has proven successful in Paraguay, Morocco, Jordan, and South Africa, to name a few. (Syder 2020) (Baldwin 2019) (Abdel 2020) (Ziyal 2020) One of the most interesting cases of modern vernacular architecture this study has identified is that of the Musée Yves Saint Laurent Marrakech. Completed in 2017 by Studio Ko, the 4,000 square meter museum features works from the French high-fashion label. The museum uses local materials and geometries to blend seamlessly within its context. The beautiful building contradicts the narrative of mundane traditional architecture, and highlights the possibilities moving forward with vernacular architecture. If even the world's most elite and style-conscious companies like YSL are willing to shift the typology of their architecture to house their pieces, there is no reason that this shift could not happen on a larger scale with a proper narrative in place.

It is not just a question of aesthetics. It is also critical to preface architectural elements with large-scale urban plans in order to create housing solutions that are environmentally sustainable, promote social wellbeing, and conserve transportation resources. Traditional examples of Anasazi urban planning and community organization can help influence design choices regarding density and layouts that promote walkability. (Morrow and Price 1997) Learning from native American landscape

Site Museum of Paracas Culture, Peru. Attali

architecture that places immense value on natural systems in urban settings can help construct a more nature-first urban setting in areas like the American Southwest, where undeveloped land is becoming increasingly rare. (Price and Morrow 2006) (Fowles 2010)

Additionally, prehistoric human habitation has a wide range of unique divisions of space for varying societal and cultural differences. Thus, even though contemporary lifestyles have completely different needs and uses, these historic divisions of labor and living spaces can help inform some aspects of forthcoming housing solutions. (Bienkowski 1985) (Riggs 2007) Even though society and labor requirements have drastically changed throughout the recent centuries, building materials still hold the same value. For desert climates, adobe and mud-based housing are the best thermal regulators as they reduce material transportation emissions. (Moquin 1994) (Acosta et al. 2010) (Baggs et al. 2006) Of course, in much of the developing world, there is a general resistance to mud construction as it is considered inferior and reserved for lower classes; however, such an approach to housing is subject to reexamination. (Dabaieh 2013) In fact, vernacular architecture has been proven to be the most efficient and healthy option because it contains less artificial insulation and other toxic materials. (Mortada 2016)

There are several elements of traditional housing that are less applicable to contemporary housing issues, but that still have the possibility to inform great design. Bedouin lighting design is intended to create hospitable interiors that shield guests from the extreme

exteriors and help create a sense of safety. (Bille 2017) Irrigation and food production in Paleolithic communities could provide insight into how to promote small-scale community oriented gardens as a part of prospective housing solutions. (Smith 2003) (Scarborough et al. 2018) While these two examples seem rather disconnected, they provide insight into the range of solutions that have been created throughout the many iterations of vernacular housing typologies, and suggest the range of possible uses of vernacular architecture.

While the majority of the world's energy consumption due to housing is roughly 40% of overall energy consumption, in extreme desert climates this percentage is far higher as cooling technologies require far more electricity. (Taleb and Sharpples 2011) Desert housing climatization strategies have been refined for millennia and are perfectly in tune with local climate conditions and thus serve as excellent models for future housing systems. (Benyoucef and Razin 2018) Recent studies in Libya comparing modern housing systems with traditional cooling systems to those with modern HVAC systems found that these archaic systems function just as well if not better than forced air ventilation systems. (Alabid and Taki 2014)

Traditional architecture will always

Retro-Futuristic arhictecture, Iran. Forouzanfar.

have some flaws that can be solved through limited technological intervention, yet as a whole it poses a sustainable and efficient system for contemporary housing issues.(Cook 1996) (Nabokov 1989) Energy retrofits in traditional and historic housing are sometimes necessary to maintain normal levels of comfort. (Webb 2017) Additionally, quadrangle adobe construction can be improved using advanced insulating construction and layouts. (J. Zhang et al. 2016) Ultimately the thermal properties of adobe are excellent when considering cost and availability. The spectrum of paleo-architectural elements that make effective housing for future climatic as well as social change is hard to gauge; however, ensuring human comfort and preserving resources should be at the forefront of all design decisions.

Rendering of retrofitted pueblo architecture. Budget Direct.

Point of Departure

The lessons learned regarding domestic habitation throughout history are evident in the usage and longevity of design applications. As a result, key elements used in a variety of arid regions provide promise for contemporary housing issues. Framing these elements within a contemporary framework, however, is critical in proving their effectiveness and suitability on a large scale.

Climate change is shifting ecological systems in drastic ways. Human lifestyles are therefore changing to better adapt to these climate extremes. Yet, as we adapt as a species, so must our built environment. Past examples from extreme desert climates can inform designs that provide sustainable, efficient, and economical solutions to these climactic extremes. As such, we need to recognize that the failure of previous trials in this regard have been occurring because these approaches were not modernized to create desirable solutions that show "progress" as it were. Since past experiments in human habitation were developed under far different circumstances, there must be a modernization of historic examples. To create a truly effective model of neo-vernacular design, there must also be a changing narrative of what is primitive design and how it can be beautiful and modern while remaining true to its original design.

The research presented herein provides a framework of how we can best adapt historic designs to present-day quandaries regarding habitation and human survivability. Climate change, regression in urban developments, and resource consumption outline the most important aspects of future housing considerations. The next step is synthesizing the data to create a systematic approach that applies primitive design to present-day residential developments, which can thereby shift the narrative of what is considered progress in terms of residential housing design.

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Methods and Case Study Procedures

The question this research is trying to answer is how historic examples of desert architecture can inform contemporary housing design, and if so, how they can be adapted to contemporary constraints. Thus, being an exploration of historic architecture, this research is framed by the existing and recorded examples of indigenous vernacular architecture. Specifically, it examines successful forms of urban desert architecture through the use of case studies. In doing so, however, the first step needed to begin such a case study selection is an identification of the issues influencing the designs. These issues will thereby frame the problems and provide a context for researching suitable case studies of historic architecture. In particular, the issues of climate change, resource mismanagement, and urban growth will be used as guides to find appropriate historic examples that address each of these problems in specific ways.

Case Study Selection Methodology

Case studies were the selected methodology for this project due to the value provided by individual cases. The limited resources and time available for the undertaking of this project determined that case studies would provide the most holistic and comprehensive information in providing guidelines for the future development of the American Southwest. Cases were selected following the below set of criteria, in the process of trying to answer the problems outlined in the existing literature.

The case studies of vernacular architecture used in this project will examine the environmental, economic, and social benefits of existing examples. The case studies informed a comprehensive, qualitative analysis

of successful uses and adaptations of traditional building methods and models. The selected case studies will range in their effectiveness and issues addressed. As the cases are each informing different issues, a set of criteria must be created in an effort to ensure that a coherent set of issues are addressed. The criteria established are as follows: location, construction, zoning, and time period. These will be the essential measures for an analysis of the viability of adopting a particular form of vernacular architecture. The completed criteria are presented below.

The criteria were established based on the issues identified in the initial research. The criteria presented above are arranged in order of importance in answering the question posed in this research. The location, construction, zoning, and time period, were selected due to the problems this research is trying to answer. The location and construction criteria will address climactic concerns, which threaten the sustainability of the region. The construction and zoning criteria will address the problems of suburban sprawl that have been shown to only exacerbate the issues within the Southwest. Lastly, the time periods selected will be used in framing an argument that vernacular desert architecture has been effective throughout time and is desperately needed in our current climate debacle.

The first criterion in this specific research is the location of projects. Choosing cases with an arid climate that closely resembles that of the American Southwest will help in adapting these examples to address current climate issues. Furthermore, selections should be closely related to a city so as to address issues created in suburban housing developments. In addition, the siting of the case studies is an essential first step in selecting examples, whereby a further exploration in the form and function of the buildings must be done to narrow the selections that will appropriately address the issues presented by contemporary housing in the American West.

The second criterion is broken into two separate categories: construction and zoning. In the construction component, one of the most important distinctions is the materiality. Using local materials is essential in creating what is easily recognizable as a vernacular building. In addition to sourcing materials locally, a truly vernacular building will also be built using construction methods that are endemic to the region. The methods of construction can also be expanded

to include the participation of local peoples. The involvement of native people in construction is a key piece of what defines vernacular architecture.

Traditionally, of course, the majority of home construction was done by the individuals that would eventually inhabit those structures; however, as the industrial revolution progressed, home construction, like many other products, became mass-produced. The participation of inhabitants in construction of homes is slowly entering the dialogue of contemporary architecture with the rise of digital fabrication techniques. In addition to the participation of local peoples in construction, an important aspect is the cultural relationship to the people and structure. Vernacular structures are commonly identified by the details and form of a building that relate to specific cultures. Furthermore, beyond the construction and form of the building, the selection of structures must also address the function of the building. The function is a necessary element to identify that will aid in addressing problems related specifically to housing.

In terms of zoning, the literature examined shows the issues associated with the current housing typology throughout the Southwest. The cases selected will primarily be zoned for housing, as they most accurately address the question posed. Certain examples might fall outside of the housing component, but they will still inform the question posed by this research. For example, of the housing that is selected, the majority are selected due to their proximity to an urban center and thus was constructed for the purpose of housing multiple families. Multi-family housing addresses more complex issues than single-family housing, and is thus more suitable for selection given that vernacular housing is to be adapted to the American Southwest. Additionally, a distinction between the chronologies of certain vernacular projects must be made in an effort to clarify the issues addressed as well as the framework for construction.

As this is a historically informed project, this research will explore past examples of vernacular desert architecture. Yet, in addition, the research will also draw on a variety of successful examples of contemporary, regional residential designs. Using examples from Egypt, Yemen, and Peru, as well as local solutions from Native American peoples, these samples will create an overview of the possibilities of paleo-architecture in addressing the climactic restrictions of the American Southwest.

Continuing the focus on chronology, the survey of possible selections will include an examination of altered historical structures. This section of analysis will include retrofitted structures, and other adapted historic buildings that have been modified from their original form. Lastly, I will conduct an analysis of contemporary structures that have been built in a way such that they resemble vernacular structures. These three separate categories will provide a clearer understanding of the range of examples that can be examined for their successful characteristics and adapted to an urban context in the American Southwest.

The final piece in solidifying a case study selection is the documentation available. The scope of this research emphasizes well-documented structures, and thus the cases selected must have sufficient documentation to include the necessary data to be used in this study. The documentation may originate in popular press, trade press, and scholarly press. This breadth of availability will ensure that there is enough information to accurately respond to the research question. The documented sources will be recorded and reported for validity concerns in addition to allowing further researchers to trace the literature available.

Criteria	Description
Location	1. Climate To establish climates that are acceptable for case study selection, a sample of existing climates in the Southwestern United States must be presented to exclude eccentricities. First, however, a definition of the Southwestern United States must be established to clearly eliminate irregularity. The U.S. Census Bureau asserts that the region is defined as the states of: Arizona, California, Colorado, Nevada, New Mexico and Utah. Texas and Oklahoma are included in the definition of the "American West." (U.S. Census Bureau) The Southwest includes a variety of climates ranging from the Pacific coast to lowland deserts up to high deserts and alpine meadows and forests. The Sonoran Desert, Sierra Nevada Mountains, and Rocky Mountains are the notable macroclimates in the region. It is these climates that will determine the location and ultimately the selection of cases. (Gonzalez et al. 2018) 2. Relationship to a City Given that this project is seeking to answer questions on a macro scale addressing questions of the architecture and urban design in the American Southwest, it is critical to use examples that are not geographically isolated. Rather, it is imperative to use examples that are integrated within the surrounding urban forms. Given the chronological breadth, determining what defines an urban center is dictated by the location and dating of structures. Once again this research uses the definition outlined by the U.S. Census Bureau, which states that an urban area is a core of 1,000 people per square mile with surrounding areas with a density of 500 people per square mile. (U.S. Census Bureau) As this is a contemporary definition, it can be adapted to allow for more dated cases when the global population was much smaller, and thus urban centers were less populated. The key to defining urban examples is understanding the density of the case in relation to surrounding areas of habitation. In addition to the density, this research is looking for traditional markers of urban forms such as evidence of commerce, cultural centers, and social networks. This ensures that examples have sufficient substance to inform contemporary urban design.

Criteria	Description
Construction	1. Materiality The criterion of materiality is the most important in identifying what constitutes vernacular architecture, and as such the definition of permissible uses of materiality in selected cases is unyielding. Selected cases use inexpensive organic materials that are locally sourced and crafted using techniques indigenous to that specific region. Exceptions were made to the requirements of locally sourced materials used in minutiae of cases as ornamentation. In addition, selected historical cases that are contemporarily active and have been modified from their original forms will be allowed to have non-local utilities and fenestrations that have been added since the progress of industrial technologies. This same exception will be given to contemporary structures that utilize modern utilities; however, the majority of the construction massing and exterior form is required to have been constructed using vernacular materials that have been used historically. 2. Methods The methods of construction are co-related to the eventual form created by vernacular architects. The informal structures and forms created are all related to local adaptations and evolutions of architecture to create systems that adapt to local climates. The selected cases are all built using traditional techniques primarily by hand using limited technical advantages. Exceptions were made for contemporarily occupied structures that have access to modern construction systems. Yet, the use of mechanical advantages is limited in poorer and rural cases that have limited resources and thus much of the architectural forms are still maintained by local artisans. The extent of modern construction is analyzed on a case-by-case basis to ensure that the most accurate examples of vernacular desert architecture are selected to ensure suitability for study. 3. Cultural Relationship Vernacular architecture is always in part informed by the indigenous culture responsible for the creation of these structures. Architecture always reflects the people who inhabit it, and thus a key piece in separating contemporary architecture from vernacular architecture is that in vernacular construction, local cultural considerations are given far greater concern than in modern mass-produced universal designs that have dominated the architectural discourse since the mid-twentieth century. Identifying remnants of local cultures in architectures is critical in selecting cases that are truly vernacular and can be serviceable in the study of desert vernacular architecture.

Criteria	Description
Zoning	1. Utility The utility of selected structures was determined by the research question in trying to answer how urban desert vernacular architecture can be used today. Selections are determined by the primary function being housing. The urban forms are bound to have a range of structures with a variety of programming; however, all selections are rooted in providing habitation. The specific typology of habitation this study chose to identify and analyze is that of multi-family housing. A high density of housing will ensure that results inform issues of density and resource management within the American Southwest. 2. Scale The scale used in determining cases for selection is dictated by the scale in which these examples will be applied to that of the metropolises of the American Southwest. Thus, the scale of cases must be large enough with a fully autonomous urban form that can support itself and has applicable nodes and features that can be duplicated in a contemporary city. Once again the U.S. Census Bureau determines the scale of cases selected, constituting that a city has a population of 1,000 people per square mile. (U.S. Census Bureau) Rather than focus on the physical area occupied by the cases, it is more important to focus on density as it is more replicable in urban forms that do not mimic the original examples.

Criteria	Description
Time Period	1. Historically Isolated Structure In selecting cases that have both the most information and are most complete, this study chooses to use sites that have been protected by UNESCO. These selected cases are examples that have been preserved in their original form. Understandably there will be decay and a lack of human activity to inform the true uses of such examples. In addition, being historically isolated allows for an understanding of primitive architecture uninterrupted by the technologies brought about by industrialization. An example that is historically isolated is one unaltered from its original form and free from industrial technologies. The examples selected for this research are uninhabited, abandoned, or preserved for educational purposes. Keeping a site preserved is an incredibly arduous task, and thus this research chooses to rely heavily on sites that have been preserved by governmental organizations that have sufficient oversight to keep sites unaltered. 2. Active Historical Structure The 'Active Historical Structure' cases are examples of architecture and urban forms that were initially constructed prior to industrial technologies and manufacturing techniques. These cases, however, have been modified from the original form, and retrofitted with more recent technologies that were not conceived in the time of initial construction of the site. The active cases are required to have an active human population currently occupying the historical structures. The modifications to the structures are regulated to assure that the building is still functioning in its original state and has not become overly reliant on industrial technologies. Retrofitted technologies are limited to plumbing, electricity, and contemporary windows and doors. This study ignores retrofitted structures with advanced HVAC systems that have since replaced the original design features of the structures. 3. Contemporary Structure Contemporary structures selected are broadly speaking selected from the 20th century and beyond. Cases in this category are built after the effects of the industrial revolution have established a modern approach to architecture and housing design. This group of selections is outfitted with modern amenities and built using advanced construction techniques. This group of cases are all required to have current occupants; however, the amount and longevity of habitation is flexible in much newer cases.

Criteria	Description
Documentation	1. Popular Press A presence in popular press allows for a broader understanding of how cases fit within their individual siting and context. The popular press sources used to inform the cases are all from informative and well-established newspapers and magazines. The documentation among popular press excludes any publication deemed a tabloid or otherwise sensationalist and exploitative. The prevalence in popular press is not as critical a criterion, as this is an academic study and more emphasis is placed on trade and scholarly press. 2. Trade Press The breadth of issues and locations used in this study encompass a range of interests, from archaeology, history, architecture, urban planning, and sociology, and thus a breadth of trade literature is accepted in informing the analysis of selections. Given this breadth of fields being examined, acceptable trade press is vetted to ensure only the premier publications within each discipline are used to create the most informative and relevant study possible. 3. Scholarly Press Scholarly press used in this study, like the trade press, shares many parallels among fields and this study will include peer-reviewed journals, books, and articles from a range of academic publications. This study will only include the most relevant information from these publications to address the relevant issues most aptly. The only caveat in selecting scholarly press is the date of publication. Most sources used in this study are from recent circulations of journals, typically within the last ten years, to most accurately address contemporary issues. Historical journals and primary evidence found in dated sources will be examined, as these sources typically have longer viability in the examination of historically isolated and active structures.

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Data Findings and Analysis

The criteria and methodology created in the previous section allowed for a detailed and precise selection of case studies and case study analysis. This section will present the cases and provide a background in addition to arguing for their inclusion. Once the cases have been introduced, a qualitative analysis will be conducted to identify the most important elements that can be extrapolated from each case. These identified elements were synthesized to create a broad framework of how these specific elements can be introduced into housing typologies in the American Southwest. This synthesis will ultimately inform a new generation of designers, civil servants, and planners who are faced with the actualities of anthropogenic climate change.

Following the criteria developed in the methodology portion of this research, the cases below were vetted and ultimately selected as serviceable examples of vernacular architecture that could provide value to a compromised American Southwest. The cases are introduced below to provide a context and a framework for understanding, and will then be qualitatively analyzed for relevant technologies and construction strategies.

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Shibam Hadhramat, Yemen

Shibam, Yemen is a UNESCO heritage site and one of the oldest examples of a gridded and multistoried urban form. (UNESCO, 2020) Although it is today known as the "Manhattan" or "Chicago of the desert" – on account of a 1930s report by the British explorer Freya Stark – the historic city of Shibam actually dates back to the third century. However, the majority of the buildings that are visible today were constructed in the 16th century, when the city functioned as a commercial hub that was then a common stop for merchants on the Arabian Peninsula.

In fact, due to the centralization of economic resources in Shibam, a defensive structure was created to protect the city from attacks of nearby rivals. This ultimately determined the urban form of Shibam. Specifically, in order to accommodate the population within the city's walls, the housing was made vertical; restricted by the city's walls, the "urban planners" decided to build upwards. As a result, the city's buildings today average roughly five stories with the tallest being eleven stories.

The buildings are all constructed with mud brick and are the tallest standalone mud structures in the world. Moreover, unlike many other such vernacular structures – like the Taos Pueblo in New Mexico – Shibam is still a thriving a city with a population of roughly 4,000 people. Restoration and preservation projects have been successful in promoting growth in the city that it won the 2007 Aga Khan Award for Architecture. (AKDN 2007) Yet, the ongoing civil war in Yemen is threatening the survival of Shibam. It has even been subject to attacks by Al Qaeda. Nevertheless, it still remains a UNESCO heritage site, and due to the conflict, it is categorized as an "at risk cultural site."

Aerial view of Shibam. Helovi.

Background

The current rendition of Shibam is built upon the earlier remains of the city after it was destroyed in a flood in 1532 AD. The multi-storied housing, while more recently constructed, is predated by two civic structures that have served the city: the Friday Mosque built in the 10th century and the castle, which was finished in the 13th century. (MacLeod 2019) Renovations have happened throughout history, such as a rebuilding of the wall surrounding the city in the 19th century by traders coming through the region. (UNESCO 2020) The city was thus constantly changing due to human intervention in addition to natural phenomena; however, ultimately, the basic form of Shibam has remained largely unchanged since the 16th century.

And, as noted above, the particular urban form of Shibam was ultimately determined by the economics and political rivalries of the region. Most notably, the walled city was built to be a defensive structure, with narrow streets and tall buildings that made attacks by outsiders difficult. Yet, the height of the buildings was not only determined by defensive strategies, but rather it was also a reflection of the wealth made by locals through their central location in the expansive networks of trade across the Indian Ocean. (MacLeod 2019)

The city of Shibam was not only a merchant destination. It was also an agricultural hub since the city was located centrally in a flood plain. The elaborate irrigation system crisscrossing this plain

creates valuable farmland surrounding the city that is utilized by residents to provide for those living in the surrounding region. Indeed, it was precisely this relationship between agriculture, water, and the mud it produces that was critical to the urban development of Shibam. For example, the wall surrounding Shibam was not only a defensive wall against attacks by humans; it also prevented the city from being washed away by seasonal floods.

Of course, due to the torrential rains and floods of the monsoon season, the mud structures of Shibam need constant repair. In Shibam, the problem is addressed by the process of removing mud from the farmland after crops are harvested, and repairing exteriors and fenestrations inside the city. (Khan 2017) Furthermore, to keep the whole system sustainable – from agriculture to building maintenance – a sewage system is used that separates liquid and solid waste, which is then transported to the farmland to fertilize the soil. (Lucarelli 2012)

In summation, the city of Shibam is an example of a successful desert city that is constructed and maintained using entirely vernacular methods. Its long history also strengthens the argument that these vernacular cities – and their positive feedback loops of environmental integration – provide sustainable alternatives in dealing with extreme climates. As such, the city proves invaluable in understanding the development and organization of cities in desert climates that create unique opportunities fordevelopment and design.

Selection

The criteria created in the previous section outlined the proper identifiers that would allow for the selection of ideal cases that answer the greatest range of issues facing the Southwest. These criteria begin with location and continue on to construction, zoning, and time period were all addressed by the city of Shibam. It is the perfect example in understanding dense city planning using vernacular technologies. In addition, given that it has largely been in existence from the 16th century, the literature surrounding Shibam is dense and will inform this research in the most complete way.

Addressing each criterion individually will validate the selection of Shibam as a case study to answer the question of reimagining housing in the American Southwest. Located in central Yemen, high in the Sarawat Mountain range, the climate is similar to that of the high deserts of the Southwest. Thus, in addition to meeting the location criterion, Shibam

also addresses issues of construction and zoning. The construction is entirely mud brick similar to what is called adobe in North America. Thus even though there are some recent buildings that have been built using more globally available materials, the majority of the buildings are still made using local materials using locally refined construction methods. Beyond the materials, the forms of the buildings are built in a vernacular architectural style that is common throughout the Middle East. Lastly, Shibam was selected due to the fact that the majority of the multistoried buildings are all residentially zoned. This city structure and development is similar to many modern cities and will thus serve as a comprehensive example of vernacular residential architecture that has withstood the test of time.

The chronology of Shibam was the final criterion that makes it such a complete case. Shibam will be used as a retrofitted example rather than a historically isolated one, given that it has been occupied continuously since the third century. Currently, however, given the civil war in Yemen, many people have been migrating away from Shibam, yet nonetheless it remains occupied. The documentation of Shibam and the amount of literature surveying the city will add to the data collected in arguing for the validity of such an example in the American Southwest.

Analysis

The application of a town like Shibam to the American Southwest might seem dubious; however, Shibam offers several lessons that are applicable to some of the largest issues that must be addressed in the building of new urban forms. The contributions from Shibam range from the density of structures and verticality of the urban form, to the closed loop water and agricultural system, and even the mixed-use planning of the city that creates a walkable urban landscape. The combination of all these elements have created a viable high-density model of urbanism that has lasted over 500 years, something the American Southwest has failed to do over the last 50 years.

The most striking and notable feature of the urban form of Shibam is the vertical scale of most of its structures. Thus, even though this design was created for reasons no longer pertinent, namely defense, it is certainly the case that building up is far more sustainable than building out. Indeed, one of the fundamental problems in the American Southwest is urban sprawl and all its attendant environmental problems. So in order to address this problem, we need models that provide both viable and successful alternatives, which is precisely what Shibam does in this regard. This verticality

allows the city of Shibam to house 3,500 individuals in an area of roughly 20,000 square meters. It shows not only that verticality is possible using vernacular design, but also that those designs actually address many of the issues facing designers dealing with a warming planet.

The first of these concerns materials. In particular, the case of Shibam highlights the viability of organic materials replicating the achievements of steel-frame architecture. Of course, this is not to suggest that architects, designers, and urban planners should start advocating for the use of mud or adobe in their high-rise buildings. It does however, suggest the possibilities of organic materials in building taller structures, which is currently already happening with engineered lumber. Thus when conceptualizing new housing designs for the American Southwest architects should clearly explore the possibilities of sustainable alternatives in order to minimize the all too easy reliance on other highly carbon intensive building materials such as steel and concrete. Shibam therefore offers a powerful example of tall buildings made from organic materials that have lasted for centuries.

The tapering, almost pyramid-like buildings are impressive achievements in informal architecture and limited materiality. This is especially interesting given that the "architects" were informally trained. Regardless of formal schooling, they amassed an impressive knowledge of engineering knowledge to improve the living conditions for all Shibami. The coordination between inhabitants and craftsmen created a flexible system of architecture that adapted a range of solutions to meet the individual needs of the inhabitant. This specificity in design has arguably helped preserve the local culture throughout time. (Baeissa and Hassan 2010)

The knowledge of local artisans is most visible in the verticality of the urban form of Shibam. The height was achieved through the local development of incredibly strong bricks. Bricks are harvested from surrounding agricultural land. Mineral-rich soil in addition to being saturated with water help improve the bricks' strength. (Mehta 2007) Shibam is also unique in the fact that it has an abundance of agricultural land unlike the rest of Yemen. The agricultural land is fertilized by human and animal waste from Shibam, helping create a closed loop system of agriculture and architecture. The nutrients from the soil are eventually returned to fields during rainstorms that erode the mud structures.

Lastly, the verticality of Shibam was achieved in the tapering of buildings, with wider bases leading to smaller upper

Women pick clover outside Shibam. McCurry.

floors, creating an urban form unlike any other. These "tower houses" were built to house one to three closely related families. With social structure being one of the most important factors in the design, it is reflected in a number of design decisions. The first way Yemeni familial values are shown in the architecture is in the system of stairs in the center of buildings. The staircases are built in such a way as to allow for vertical expansion if the need of additional space arises. The growth of families is a main feature of Yemeni familial structure and is thus an important aspect in the physical representation of buildings. (H. Al Sabahi 2005) Opportunity for functional growth is also found in the common feature of rooftop terraces. (Baeissa and Hassan 2010)

The roofs of homes in Shibam are often left walled in, with the opportunity to be roofed if the number of occupants of the building increases. Moreover, the walled-in enclosures provide protection from the sun as well creating a private enclosure for residents. And as a result, these spaces are a key piece in the social lives of residents, since they provide an area for informal gatherings of families and neighbors. These spaces are also used as gardens for residents providing daily herbs and vegetables for cooking. The application of the rooftop terraces is also expanded by fact that many residents sleep there during summer months in order to cool down after the extreme daytime heat. (H. Al Sabahi 2005) Cooling is also addressed through the larger urban form taken by Shibam.

Once again, the verticality is an

important factor in addressing climactic issues. The tall buildings along with narrow streets create almost constant shade for residents. These narrow streets were also a practical measure as space is a commodity in the small area of the walled city, and thus allow for more habitable construction. (Baeissa 2013) That's not to say that public space is neglected. Shibam features a total of five public squares, which is an element of Middle Eastern architecture that is present throughout the region. The squares in Shibam are almost all adjacent to mosques and help serve as a social space. The urban planning features of small narrow streets and open squares are also used in addressing environmental circumstances.

Roads and plazas are thus not limited to the circulation of people and goods; they are also a key piece in the cooling of buildings. The zig-zagging roads, for example, while a common element of informal planning, aid in the containment of cold air. This cold air is stored overnight in the streets and plazas and help cool buildings during the day. (Baeissa 2013) Additionally, throughout the evening and night, hot air is emitted from the clay buildings eventually cooling down and becoming denser, thereby creating an airflow upwards into the building of cooler air. The influx of cold air also pushes out existing hot air, which is a feature that is most effective in the lower levels, where cooler air also ventilates during the day. This is done through a series of openings on the ground floor that allow for privacy, yet still allow for new air to enter.

The streets of Shibam. Jialiang.

The buildings of Shibam are built with central openings surrounding the stairs, that allow for cooler air to circulate upwards and thereby cool the homes. These openings also allow sunlight to enter and provide light in interior spaces. These openings are known as Al-Shammasah. Derived from the

Arabic word shams meaning sun, these openings are a common feature in Islamic architecture. (Baeissa 2012) The sun heats the upper areas of the structures and encourages the convection of air to occur. The air enters buildings on the ground floor in small holes in the storage areas, and travels upward eventually escaping via the roof, promoting the process of cooling. This complex understanding of thermodynamics is critical in creating suitable housing without the advances of industrial technologies. This understanding of thermal characteristics is also found in the minutiae of the designs of Shibam.

Windows, for example, are made from local ilb trees and are beautiful geometrically decorated pieces that adorn the exterior facades. In addition to being the primary form of decoration, the window screens also address issues of heat. The screens limit the amount of sunlight that enters the buildings and regulate the movement of air currents. Windows are opened or closed to encourage or limit the flow of hotter air to the cool shaded exterior. (Baeissa 2012) Windows are also often made using colored glass, another technique in the limitation of direct sunlight.

Another element of climactic design that initially appears decorative is the use of lime in the covering of buildings. The white lime that adorns many buildings is first and foremost a functional application. It serves to waterproof the mud buildings and protect against rainwater and floods during the monsoon season. (Baeissa 2012) It thereby increases buildings' longevity and limits required maintenance. (Mehta 2007) Given this use, most buildings are lime washed on the upper stories, which are most susceptible to erosion. The white lime is also highly reflective and thus reduces the direct sunlight absorbed by the buildings. Additionally, lime-washed surfaces are very heat-emissive, aiding in the transfer of heat gained by the mud during the day. This once again contributes to the flow of cool air into interior spaces. (Baeissa 2013) The use of the lime is limited, however, to wealthier households that can afford the treatment. (Al-Masawa et al 2018)

This vulnerability of mud architecture highlights the need for a broader discussion of its possible applications. Thus, while the thermal properties of mud construction are a constant point of merit of organic architecture, there are clearly other downsides. Yet, at the same time, Shibam as a case study highlights a range of broader benefits of mud architecture.

Mud architecture has proven its viability throughout the millennia; however, in Yemen it is a source of cultural pride. The prevalence of mud-

A man repairs a wall in Shibam. Ullstein Bild.

based architecture is not limited to Shibam; rather Shibam simply highlights the technical ability and creativity of local craftspeople. This understanding and practical application is a skill that has passed through generations and remains a highly sought-after skill. (Al-Masawa et al 2018) Regardless of its cultural standing in Yemeni society, there are no formal schools or available literature in learning the local processes of mud architecture making all training informal. (Mehta 2007) Thus small brick-farms are operated by a group of five, led by the master craftsman. Yet, even though mud brick companies are viable in Shibam, they are not able to expand their expertise to contemporary development projects in the country.

Yemen remained relatively isolated throughout the twentieth century due to internal strife and as a result failed to adopt modern construction methods until recently. Just as in many developing nations, popular notions dictate that progress is identified by the inclusion of modern architecture using non-native materials. Yet these modern buildings often fail to provide the same quality of life regardless of superficial appearance. Given that imported materials comprise 60-70% of the construction costs in Yemen, cost reductions are thereby made by lowering the quality of construction; eliminating or minimizing the consultation of technical and engineering expertise also reduces costs. This lack of knowledge

results in poorly implemented designs, resulting in the excessive use and waste of materials. (Sultan 2008) Moreover, the use of imported materials like concrete fails to insulate like mud, ultimately requiring artificial cooling to maintain comfort, a luxury afforded to few in the region.

The commercial hub of Shibam maintained relevance until the middle of the twentieth century when it was eventually eclipsed by the opening of nearby Seyoun Airport. Due to the lack of markets, currently 80 to 90% of the city lives in poverty (Mehta 2007) and this number is expected to rise given the ongoing civil war. (Al Jazeera 2019) Thus, perhaps unsurprisingly, this situation has resulted in mud brick construction being used in this part of Yemen. (Mehta 2007) And the economic viability of mud-brick companies may even be possible. In fact, development goals presented by the Yemeni government with the aid of international non-profits have identified mud-brick architecture as a potential solution to economic growth and sustainable development.

Agenda 21 for Sustainable Construction in Developing Countries states that "the developing world is still under construction and every minute means the construction of buildings, roads, dams that will in all likelihood not support the principles of sustainable development." (United Nations 1992) Sustainable construction as described by the European Union states that it will "enhance the quality of life," "offer flexibility and the potential to cater for user changes in the future," and "maximize the efficient use of resources while minimizing wastage." (United Nations 1992)If these are the criteria of the future of the built environment then the mud-brick architecture of Shibam addresses each of these needs. Issues presented are solved through locally sourced materials, passive ventilation systems, closed loop agricultural systems, and informality of construction. The informality of construction is a key in addressing sustainability goals.

Mud-brick companies are commissioned by residents in the construction of individualized homes. Typically, clients will come to the master craftsman of the company with a design of the house already drafted. The craftsman and client agree on an estimate and then apply for a building permit from the local Ministry of Public works. Following the approval, construction begins lasting between one to eight months. (Mehta 2007) This informality in "architecture" and construction, also allows for a certain degree of flexibility not found in modern architecture. Needs are addressed on a case-by-case basis and thus reduce

material and spatial waste. Adaptability is also addressed in the minutiae of design. Homes are easily outfitted with modern amenities like plumbing and electricity.

Yet even so, while culturally significant, mud-brick architecture is still rarely the preferred choice; instead most in the region insist on modern architecture. This misaligned consumer demand needs to be addressed and recent initiatives are beginning to protect these construction companies. The German Society for Technical Cooperation (GTZ), for example, was initially tasked in the creation of the Shibam Urban Development Project (SUDP). GTZ therefore worked with local governments to draft a legal mandate that was intended to increase the demand of mud-brick construction. GTZ hopes the drafted mandate will establish protection mechanisms for the industry. (Mehta 2007) This is done through the creation of entrepreneurial non-governmental guilds for craftsmen. Membership in the guild provides exclusivity in construction projects within the walled city of Shibam. While this has helped sustain this localized system of architecture, it will only survive into the future if further steps are taken. Such steps range in scale from the creation of a collectivizing agency amongst builders to changing individual opinions about traditional architecture. Viability is further questioned given the civil war, and the effects of climate change.

Climate change is a certainty; however, the implications for a city like Shibam are just starting to be understood. Two notable consequences are the most pronounced. The first, which is universal, is the increase in temperatures. Increased temperatures will test the capabilities of the passive cooling systems in Shibam like never before. This begs the question if artificial cooling will eventually be required to make Shibam habitable. Extreme heat will also limit the agricultural yield in the area, thereby beginning a conversation about future emigration from the region. Beyond the increased temperatures, the IPCC reports an increase in heavy rainfall and floods. (Masson-Delmotte et al. 2018) Increased precipitation will threaten the structure of cities like Shibam.

The possibilities of destruction in the region are best illustrated in the 2008 flood of the Hadhramat Valley, in which Shibam is located. During this storm, an average of 50cm of rain fell over a 40-hour period, in a region where 7.5cm is the annual total average. (Al-Masawa et al 2018) The storm highlighted the impacts of climate change and importance of new systems that address new concerns. Much like the survival of the mud-brick craft, the survival of entire cities of mud relies on the implementation of government policies.

Chaco Canyon, New Mexico

Chaco Canyon is arguably one of the most well-known artifacts of the Puebloan culture in the American Southwest. Located in present-day New Mexico, the site was the core of Pre-Colombian Puebloan culture, serving as a religious and economic hub for the surrounding network of Pueblo villages in the region. The height of Chaco was during the eleventh and twelfth centuries AD, reaching an urban scale that was unseen in North America outside of contemporary Mexico. (Lekson, 2007) The scale of Chaco in such a harsh climate has inspired a generation of archaeologists to explore its function and surrounding society. In this work, they have greatly benefited from the fact that Chaco Canyon has been well preserved after being recognized as a national monument in 1907, then a national park in 1980, and ultimately being recognized as a UNESCO world heritage site in 1987. Yet, in terms of this project, what Chaco Canyon offers are its architecture and passive infrastructure systems, which provide an excellent precedent for urban architectural forms in extreme desert climates of the American Southwest.

Aerial image of Pueblo Bonito. NPS.

Background

Chaco Canyon was an urban center that existed from the mid-ninth to early thirteenth centuries CE, and reached its cultural and economic peak between 1020 and 1110. (UNESCO 2020) This peak came to an end, however, on account of extreme drought conditions that began in 1130, which ultimately pressured the inhabitants to migrate to more lush areas. The abandoned site was left open to the elements and has decayed significantly since. Regardless of the decay, many Native peoples still hold the site in reverence.

The importance of Chaco, architecturally speaking, is its density and passive use of sunlight. Of course, that is probably not how the original "urban planners" conceived of their project; rather, they built the site according to religious and especially astrological beliefs. Indeed, the arrangement of structures in relation to cosmological significance is not unique to Chaco Canyon, as it is found in vernacular architecture across the globe. However, researchers agree that the cosmological orientation of Chaco Canyon is particularly sophisticated, so much so that some have claimed the "great houses" functioned as "occult engine[s] powered by the cycles of the cosmos." (Lekson 2007) This may indeed be true, but in the process of engaging with metaphysical realities, the builders of Chaco Canyon also provide insight into the passive use of sunlight.

Chaco Canyon is of value not only in terms of dealing with light and the sun in

a desert environment, but also in terms of scale. Most notably, it was one of the largest multistoried urban structures in the United States until the 19th century. This fact, as well as the scale of Chaco Canyon, is best evidenced in the case of Pueblo Bonito, one of the best known and photographed sections of the canyon. Unfortunately, one of the most impressive images of Pueblo Bonito is from 1878, which is a reconstruction of the original architecture.

William Henry Jackson's famous sketch ushered in a wave of increased study of the area. Although early mapping of the site began in 1850, more extensive and systematic archaeological excavations began only in the 1890s. These early expeditions began re-constructing the lost history of the Puebloan culture and the architectural forms of this gem of pre-Colombian history in the American Southwest. Since then the study of Chaco Canyon – as well as pre-Columbian history as a whole – has greatly expanded; however, many mysteries remain surrounding Chaco Canyon. Like many other 'pre-historical' sites, we may never fully understand their complete social and historical significance; nevertheless, a range of lessons can still be learned from Chaco Canyon that are applicable to contemporary issues of housing in the American Southwest.

William Henry Jackson's sketch of Pueblo Bonito. Wikimedia.

Selection

The selection of Chaco Canyon as a case study was primarily derived from its location in the American Southwest. To answer the question of how vernacular architecture can be applied to the Southwest, it is imperative to have a local example proving successful implementation. The location of Chaco Canyon in Northern New Mexico features a climate that is comparable to a majority of the region. Furthermore, given the population estimates and scale of Chacoan urban developments, it is fair to say that while not meeting contemporary standards of a city, in its context it was a major urban center. Population estimates are quite difficult to gauge, with many arguing seasonal migration was possible and the numbers range from 2,000-6,000. (Neitzel 2007) Many archaeologists and anthropologists argue that the

urban form developed primarily as an economic and religious center, but much of the architecture still served a primary purpose in housing its inhabitants.

The architecture in Chaco Canyon is relatively primitive compared to other examples selected, and while it does predate most examples on this list, the limited development can be attributed to a limited labor force. The architecture of Chaco Canyon lacked the beasts of burden used in other examples and thus primarily all labor was done by hand. This labor-intensive process does address the question of the suitability of construction methods. Although construction in Chaco Canyon is the most primitive form of human habitation, it reaches a scale that is rarely seen in other similar examples

This scale achieved using locally available resources and materials proved to be a durable example of urbanism in the American Southwest. While there are many other examples of urbanism in the Southwest from Pre-Colombian societies, Chaco stands out amongst the rest as the largest, and predates many other examples. The enigma of Chaco Canyon as a complex society that seemingly vanished overnight has puzzled historians, archaeologists, and anthropologists since its discovery. As such the mystery of Chaco has created an entire field of people devoted to understanding its complicated and rich history. This depth of knowledge produced over the last century has answered many questions about the site, and allowed for a greater understanding of the pinnacle of Puebloan urbanism. This understanding can then inform a comprehensive study of the elements that made it a successful yet complex and misunderstood site.

Analysis

Understanding any case without available texts or existing artifacts proves incredibly difficult. Thus, in understanding how Chaco Canyon can apply to the modern American Southwest, any analysis must be rather reserved in the assumptions made. Regarding the original purposes, scale, and function of Chaco Canyon, serious reservations were made when drawing conclusions and applying lessons learned to our site of the Southwest. The disagreement amongst scholars that have informed this analysis have been measured and compared to provide the most accurate information. Furthermore, unlike other selected cases, the elements used for analysis are the most observable elements of the indigenous architecture, rather than the engineering minutiae that

allowed for perfect built environments in extreme desert climates.

As such, the applications of Chaco Canyon to the American Southwest are limited, but provide some insight into the larger themes that must be addressed in the creation of vernacular-inspired design. The siting of Chaco Canyon in New Mexico proves that large-scale urban developments using vernacular materials and systems are possible. Yet direct applications of such designs become problematic due to its eventual failure. From this failure, lessons of resource management and social hierarchy can be surmised. Thus, the lessons learned focus rather on the larger issues surrounding the canyon rather than the physical design pursued.

One of the primary reasons this study understates the value of the construction and architecture of Chaco Canyon is because it is relatively primitive in comparison to other examples. The architecture of Chaco Canyon, while incredibly impressive for the time and location in which it existed, lacks the technological innovation that other examples in this study have. This is not to say that the great houses or any other built form were out of tune with the native environment, because they were well adjusted and served this large population center well for several hundred years. Though Chaco Canyon may not provide the most impressive solutions to its surrounding environment, it still provides a local context in which to build sustainably.

Chacoan architecture as seen in the great houses and other surrounding dwellings is much like desert vernacular architecture globally. The Pueblo people used primarily local resources, with most construction featuring cut stone and clay mortar. The cutting of stone was incredibly time intensive as was much of the rest of construction, being done almost entirely by hand with little help from any tools. This was no easy task considering the thickness of the walls needed for the multistoried buildings. (Lekson 1984) The stone walls, like many other examples in this study, provided great thermal comfort and regulated temperature in the high New Mexican desert.

The first step in construction was the laying of a building foundation. Walls were then outlined and construction began. (Lekson 1984) Given the length of occupation of Chaco, it is observed that walls were modified and opened or closed based on changing conditions. Change was possible due to the relatively flexible and mutable building materials. Given the intensive process of building the great houses, it makes far

more sense that interior changes were more easily achieved than entirely new construction. Even so, this changing of the architecture allowed for new social dynamics, such as population shifts, to be dealt with rather easily. This allowed for a very flexible and sustainable structure.

Yet the buildings at Chaco were not entirely flawless. One element of the architecture while organic, yet problematic, was that of the wood support beams. Unlike in Shibam, Chaco Canyon achieved verticality through the extensive use of wooden lintels. Wood was used in the floor structure, doorway construction, and in the roofs. The current site of Chaco Canyon lacks any trees, and this may be due to populations prior to the Bonito Phase in the AD 900s deforesting these supplies for fuel. Given this circumstance, trees were imported over an estimated 80km distance. (Wills et al. 2014) This is incredibly impressive given that Pueblo Bonito's construction required roughly 50,000 tree beams. (Neitzel, 2007) This transportation was likely done manually as well, using the system of advanced roads developed by the Puebloan people. (Matteson 2018) While this may not have been the most efficient construction method, it allowed for the creation of the scale that one sees today.

Yet there were other, more

Wooden construction in Pueblo Bonito. Education Images.

ecologically sound technologies implemented by the "architects" that aided the habitability of Chaco Canyon. Indeed, one of the most essential features of Chaco Canyon is its siting. Since it was fundamentally a religious center for those in the region, the siting of Pueblo Bonito features a range of astronomical alignments that likely relate to religious ceremonies. Relating to the sun, moon and cardinal directions clearly had significance in the existing culture. (Neitzel, 2007) The siting of Pueblo Bonito in a semi-circular shape facing to the south was arguably made with solar considerations and passive heating ideas in mind. Additionally, buildings atop the windswept mesa are built to protect public plazas from prevailing winds. (Lekson 1984) Beyond responding to the natural elements, the siting of Chaco was critical in the agricultural development

and support of the large population.

The canyon features no perennial stream that could be utilized for irrigation; however, other processes were utilized to sustain the population. This was done using the natural features of the floodplain, slope wash, and floodwater farming. Agricultural yields proved steady. These natural features were also aided through the use of terracing, dams, and a series of canals. (Scarborough et al. 2018) It is this successful agricultural production that arguably contributed to the population growth at Chaco. (Wills 2017) Yet the agricultural techniques in use for a millennium prior to the evolution of the area were not enough to sustain this new development. Thus, to increase agricultural yields, new technologies were implemented to increase production.

Agricultural intensification in Chaco required higher density planting, more distribution of limited water resources, and the use of field gridding. Documenting and identifying these elements has proven incredibly difficult due to natural deterioration and later agriculture and ranching in the area. Therefore, estimates of scale and ubiquity throughout the site are hard to judge. (Wills 2017) The most agreed-upon feature is that of water management canals that redirected water. These canals served a multitude of functions, providing water for consumption, construction, agriculture, and preventing erosion to existing structures. A more prevalent understanding of the sustained agriculture utilized a gridded field system. This water-control system harvested water from tributary runoff and fed water via canal to be stored in small reservoirs. Terracing was utilized in a limited fashion. Only two observable terraces exist and arguments have been made that these are more likely roadbeds. (Wills 2017) Lastly, check dams were used manage water flow during floods. This rather complex system ultimately required a large labor force and management to operate.

The agricultural intensification pursued in Chaco Canyon has become a point of debate. Recent arguments have emerged arguing that food could have been imported. Given the place of Chaco Canyon as a religious and economic center, it is arguable that seasonal population increases could have brought with them food grown non-locally. (Scarborough et al. 2018) Subsistence agriculture was likely possible given the size of the site, yet the labor requirements already directed to construction in addition to agriculture are extravagant. (Wills 2017) Thus, similar to the wood beams used in

Artifacts found in Pueblo Bonito rooms. Mickens.

construction, it is entirely possible that the area relied on imported food.

The trade that allowed Chaco to flourish was only possible through the advanced system of roads throughout the region. Puebloan roads were impressive feats of engineering. The roads were notably well constructed featuring formal ramps, stairs, walls, and berms. (Lekson 2007) The massive network of roads created another demand for immense human labor. It has been argued that these roads were overbuilt as a means of displaying of wealth and power since they were far wider and more geometrical than what was necessary for travel alone. (Matteson 2018) This vast transportation infrastructure allowed for the importation of both essential resources like food and construction materials, but also for luxury items.

Goods such as macaws and parrots from Mexico, shells from California, copper, and turquoise have been found in excavations at Chaco Canyon. (Neitzel 2007) This trade required the local production of goods for trade with migrating populations. The production of local crafts was another time-intensive process that was likely alternated with agricultural labor. (Hagstrom 2001) Limited recorded exports note that a gift-giving society may have existed. This could have been related to agriculture, resources, and luxury goods. This also extends to the cooperative nature of the labor used in construction projects.

The scale of the canyon architecture required entirely manual labor. There is no evidence, however, that any of this was coerced under threats of force or the withholding of essential

resources. (Matteson 2018) Rather the social system created in Chaco was one entirely separate from ours and was vaguely utopian, engaging in large-scale public works in a cooperative manner rather than mandating projects as in other early societies. This unique social development also may have related to the reverence held by local peoples for Chaco Canyon itself. If the architecture, infrastructure, and social systems in place in Chaco Canyon were seemingly sustainable and justified in their context, how ultimately did this project fail?

Many early arguments suggested that extreme drought was the ultimate cause of migration from Chaco Canyon; however, recent research is highlighting that there are several flaws with this argument. The migration of people away from Chaco was relatively prolonged and not immediate, suggesting there were alternative motivations for abandonment. (Wills et al. 2014) Furthermore, given the already imported food supply, there is no reason to suggest that failed crops resulted in desertion. It is more likely that the drought was simply a factor that increased existing climactic stressors. Berger argues that the intensity of the drought in combination with the construction requirements led to a failed trust in the leadership guiding the settlement. (Berger 2009) This is further proven given that migrants from Chaco Canyon settled in relatively similar locations that would have exhibited the same extreme drought. (Matteson 2018) These newer settlements, such as Mesa Verde, did not replicate the developments of Chaco, arguably consciously choosing to reject the system they had witnessed failing in regard to the current environmental situation. Thus the pueblos developed after Chaco "created a more productive infrastructure, greater economic diversity, and a more egalitarian community" ultimately rejecting the model of growth used during the Chaco Anasazi era. (Stuart 2014)

Given this end to one of the greatest Pre-Colombian civilizations in the United States, it becomes an example full of structurally sound vernacular technologies with flawed social systems that failed to sustain a large population. Thus, returning to the contemporary Southwest and vernacular architecture, even if the most sound environmental systems are in place, environmental stressors can cause systemic failures resulting in mass migration away from the Southwest. Indeed, migration is already a commonly discussed consequence of global warming, and will require the proper policies and social systems to best maintain normalcy.

New Gourna, Egypt

New Gourna, Egypt is a village located on the Nile River in central Egypt. In Arabic it is known as Gourna el-Gedida, and it is a seminal piece of modern vernacular architecture and urban design built in the 1940s. It is the best-known project of Hassan Fathy (1900-1989), a mid-century Egyptian architect. The international fame of the city was in part due to Fathy's 1969 book Architecture for the Poor, which detailed his ideas informing the project. In particular, he highlighted the value of using vernacular materials, architectural styles, and construction methods. Indeed, given its place in contemporary Egyptian architectural history and its pioneering of modern vernacular architecture, it is a protected site by both UNESCO and the WMF (World Monuments Fund). Yet, at the same time, New Gourna is rarely discussed in current conversations regarding traditional architecture because it is often considered a failure given its original mandate by the Egyptian government; however, there are still a plethora of lessons to be learned from this example.

The initial project of New Gourna was to build housing for the Gournii people, who were forced to relocate after the Egyptian Department of Antiquities viewed the Gourniis as a threat to the Pharonic tombs upon which the original city of Gourna was built. (Miles 2006) The original siting of Gourna was atop the Cemetery of Thebes, and thus was replete with artifacts that were valuable on the international antiquities market. The Gournii therefore lived quite literally on top of a gold mine and over time they had become expert tomb raiders, so much so that they even built their houses into the hillside in an effort to protect their tunnels into the Cemetery of Thebes and thus their profits on the black market. (Ahmed and El-Gizawy 2010) By the 1940s, however, the scale of the Gournii's plundering had reached an unacceptable level and thus action by the Egyptian government was taken. In an effort to preserve the ancient history of Egypt and promote tourism to the Cemetery of Thebes, the Egyptian government ultimately decided that it was best to relocate Old Gourna. In an effort to preserve the local architectural aesthetics,

A mother and daughter in the streets of New Gourna. Samir.

the Egyptian government commissioned the architect Hassan Fathy to design and oversee the construction of a new village.

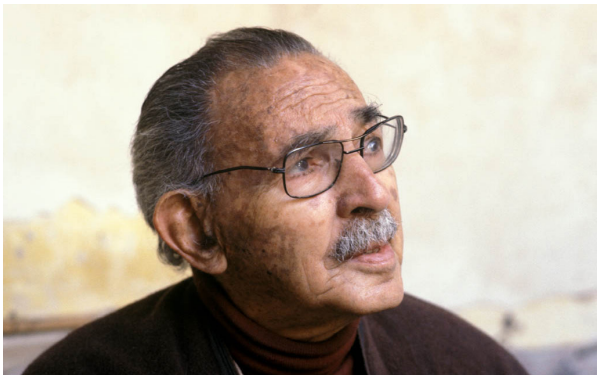
Fathy was greatly concerned with what constituted Egyptian national architecture and served as a perfect figure to lead the construction of New Gourna. In addition, this opportunity allowed Fathy to implement his theories of traditional architecture that he believed promoted environmental and social well-being. (Pyla 2009) Designed between 1945 and 1947, New Gourna would serve as a successful prototype in creating a new typology of Egyptian housing that addressed the economic and social needs of rural communities. Ultimately, however, it was deemed a failure and abandoned by the Egyptian government in 1949, with only 20% of the envisioned project completed. (Miles 2006) Of the planned project, only a residential quarter, a boys' school, market, mosque, and theater were finished when the project was abandoned. The failure was not due to lack of construction; rather it was that the Gournii refused to relocate. Though currently occupied with a stable population, the trial and tribulations of its building have left New Gourna undervalued in discussions of vernacular architecture.

New Gourna offers an invaluable lesson in the relationship between local authorities, architects and the communities they are serving. The architecture of Fathy, while flawed, was not the primary reason the project failed. Rather it was a host of complex social and changing environmental issues that failed to ignite the Egyptian architectural revolution Fathy envisioned.

Background

Hassan Fathy was born in Alexandria, Egypt in 1900. He was a member of the urban Egyptian elite; as a result, he was given a Beaux Arts education. His early schooling allowed him to pursue a higher education in architecture at the University of Cairo. After his time at the university, he began teaching at the College of Fine Arts in Cairo. (Guitart 2014) It was during this time period when Fathy developed his architectural ideas, which was focused on vernacular architecture and tradition. One reason Fathy was interested in indigenous architecture was the British occupation and the attendant growth of Egyptian nationalism. Consequently a rebellion against the British and their "high-modernism" of "faceless housing projects" began to take shape, this led to a re-evaluation of what "Egyptian architecture" might actually entail. To answer this question, Fathy advocated a return to vernacular forms of Egyptian and Islamic architecture. (Pyla 2009)

Fathy's ideology behind social housing in addition to his upper class status and connections with the Egyptian Royal family allowed him to receive the commission for New Gourna. (Pyla 2009) With the original commission being for 900 families or roughly 7,000 people,



Fathy in 1989. The Aga Khan Trust for Culture.

Fathy astounded his contemporaries when he insisted that each house was to be custom built. (Ahmed and El-Gizawy 2010) In creating this new village, Fathy wanted to address the minutiae of each individual family and in doing so rejected the contemporary notions of the time of standardized "new-town" planning. In beginning this project, he initially studied the livelihoods of the Gournii in the old village. Once he had a basic understanding, an initial 20 homes were built to study how the community used them. (Abdelsalam 2010) This attention to societal concerns and individual needs was ultimately all for naught as the Gournii rejected the new project, and the Egyptian government withdrew financial support.

Fathy's efforts to progress humanist architecture utilizing vernacular forms were not entirely lost on the development of New Gourna. He wrote several books that followed his later projects including Architecture for the Poor and A Tale of

Decaying buildings awaiting restoration in New Gourna. Samir.

Two Villages. Architecture for the Poor has been included as one of the "four most serious assaults on the Modern Movement." (Pyla 2009) The others on this list include Jane Jacob's The Life and Death of Great American Cities, Robert Venturi's Complexity and Contradiction, and Aldo Rossi's Architecture and the City. He also touches on ideologies being developed at the same time by Bernard Rudofsky, Ian McHarg, and Victor Olgyay. The popularity of Fathy can also be attributed to his charisma and famous one-liners such as: "It is a sin to put a Swiss chalet beside palm groves." (Pyla 2009) While in the current architectural dialogue this may be seen as somewhat obvious, it highlights the attitude Fathy had for creating environmentally just housing forms.

Regardless of the avant-garde ideology guiding the project and the detailed considerations taken, the project was abandoned with only 130 of the 900 planned families being relocated. This population eventually grew, likely peaking in 2006 with a total of 3200. (Ahmed and El-Gizawy 2010) The building of Second New Gourna – also known as Gournet Al-Taref – was completed in 2006, several miles north of New Gourna, and best explains this peak. This much larger settlement was built to accommodate 20,000 people and was built using entirely modern technologies and materials.

The aesthetics and sustainability of the concrete boxes that were built in the new settlement are nothing like Fathy's designs, although they do provide more structural integrity. As one of the primary reasons for the new

project was the deteriorating condition of New Gourna, the decay of buildings forced many to rebuild using concrete. (Miles 2006) The retrofitting has also included the addition of electricity and satellite dishes, and has created a disconnected reality from Fathy's vision. However, it can be argued that this is the new vernacular of the Gournii people, and the vernacular imposed by Fathy actually hindered the population from accepting it. It is this connection between ideology and execution that is most valuable in understanding New Gourna and its applications in creating a more sustainable Southwest.

Selection

In selecting New Gourna, this study was trying to determine how to successfully implement neo-vernacular design in contemporary settings with no existing urban form. Given the urban setting Fathy was trying to create with a rather large population, it is fair to say that the density is something that is applicable to the Southwest. This rather high density was primarily pursued because agricultural land was at such a high premium and valued more than residential land. This value put on arable land is due to the rather extreme climate of the Nile River Valley. The desert climate is similar to many of the arid regions of the American Southwest; however, there is arguably a more reliable source of water that is more sustaining than anything in the Southwest. This may change when the dams being built on the Nile in Ethiopia come online.

Nevertheless, the construction of New Gourna is also consistent with the vernacular architecture this study is interested in analyzing. The mud brick material used by Fathy was local, and construction was done entirely free from imported materials. In addition, Fathy employed many of the Gournii to actually construct the new village, thereby giving them a new source of income and a sense of ownership of the new community. While some laborers were non-local, they were limited and were quickly rejected by the locals. Thus, the Gournii learned by themselves the methods of construction so as to allow them to be self-sufficient as they had previously been. Lastly, the cultural element of New Gourna is debated, with many arguing that Fathy removed some principal elements that distinguished it from Old Gourna. This discrepancy will be analyzed further as one factor that led to the ultimate failure of New Gourna.

In particular, although the architecture was consistent with the existing regional culture, the zoning and division of space in New Gourna was

based on modern models of planning with more rigid spaces. The urban plan created by Fathy was somewhat irregular, in effect trying to make it feel organic, yet it was still largely rigid and linear. Fathy did, however, preserve the mixed-use model used by many of the craftspeople in the village. In addition, the density and scale of homes was largely preserved, as it was the most convenient form of low-level multi-story housing. The density afforded a tight urban form while still allowing for individual privacy.

Lastly, the documentation surrounding New Gourna is incredibly dense. From Fathy's own writing to the myriad of architects and urban planners that have followed him, there is a dense trove of information regarding every phase of the project. This allows for an incredibly complete analysis examining all stages of the project in hopes of learning from the successes and failures. Through a complete analysis, the lessons learned can hopefully inform the ways in which a neo-vernacular model of housing can begin to be implemented in the American Southwest.

Analysis

Upon receiving the commission to build New Gourna, "the social experiment that Fathy had been mentally piecing together for so long was thus to finally become a reality." (Guitart 2014) In particular, Fathy believed that his plan for New Gourna would create a new vernacular Egyptian architecture that would help revive a post-colonial nation. Most notably, his aim was to create a new form of Egyptian architecture that would not only affirm local identities, but also counter what he saw as the faceless and monotonous nature of modern Western architecture.

As such, his rejection of modern architecture began by rejecting the idea of society or community, and instead he focused on the individual. New Gourna was therefore in various ways not only an architectural endeavor, but also an experiment in social cohesion and the interaction between the state and its citizens. To achieve this goal Fathy therefore began his project by observing the living patterns of the people in Old Gourna for several months. (Sameh 2013) This was done cautiously since not only did the Gournii want to maintain their privacy, but they also did not actually want to move. Nevertheless, in observing the daily lives of the Gournii, Fathy believed he could better understand the necessary elements in creating a successful housing model.

Based on these observations, Fathy began designing and building houses in New Gourna. Yet, only twenty houses were built in this early stage, since these buildings were intended to highlight

the architecture Fathy was intending to create. In addition, they were built to demonstrate to the Gournii how these houses would be structured, which was done because the locals were unable to understand the drawn architectural plans. (Abdesalam 2014) Nevertheless, once these early models were built, and families had occupied them, Fathy once again observed how people interacted with this new architecture. His idea was that he would consult the new inhabitants and try to resolve any issues in the architecture before implementing the plan on a larger scale.

The plan proposed by Fathy was intended to enhance the individuality and organic feeling of the new village. To this end, he designed the master plan with irregular allotments. He believed that these irregular blocks would help create a variation within the housing that would maintain a sense of flexibility. Moreover, these blocks would also help in the creation of personalized housing and social formations. (Ahmed and El-Gizawy 2010) Additionally, he believed these irregular blocks would create broken vistas that would discourage outsiders from entering the more private spaces used by residences. Moreover, given the lack of traffic within New Gourna, the streets within this grid would essentially be an extension of the home and be used as work spaces and social gathering points amongst neighbors. (Guitart 2014)

Yet Fathy did not only consider such basic elements of modern urban planning. Rather, he also paid particular attention to the social realities of Gourna society. Namely, based on his observation, he realized that there were four social groups among the Gourna. As a result, he not only met with the leaders of these four groups to discuss their hopes, but, as a result, in the new project he arranged it so that each of these groups would be situated next to public utilities that matched the name of their tribe. For example, the Ghabat, or forest tribe, was according to Fathy's plan situated next to the park; while the Horobat (warriors) were situated next to the market place, police station, and village hall. (Guitart 2014) His idea was that each of these groups would be given their own public spaces that would serve as a central node and gathering space.

While such ideas may seem admirable and logic, other steps were taken that were less reasonable. For example, one issue was the question of access to water and electricity. Thus, while some argued that the "authentic" model was to deny these amenities to the inhabitants of New Gournii since they had not had it before, others argued that such basic components of modern life were necessary to be included in the design. Yet, oddly, Fathy

argued against the need for running water on social grounds. Namely, he believed that women would be less isolated and generate a better sense of community if they were required to go daily to the village well. (Tawab 2018) Regardless of the validity of this decision, it was much the same with electricity; namely, New Gourna would not have electricity. Yet, in this case, the decision was not based on social values, but rather economics. (Guitart 2014) It was too expensive. Yet these are only some of the more bizarre examples taken to ensure not only the authenticity of New Gourna, but also the means through which Gournii society would be maintained. the comfort of future residents.

Yet, even though such social engineering was foundational to the planning of New Gourna, there was also the flipside: Fathy allowed a lot of local input in design decisions. And one explanation for this local detailing and customization lies within the structure of homes in Old Gourna, where residents were creative and flexible with their home design, which is reflected in the non-geometric shapes and free form style of many of their rooms and homes. Gournii would also traditionally design their own furniture within their homes, sculpting everything from niches, beds, bathtubs, and storage spaces. (Mahmoud 2016) Thus, each house had its own personality and was incredibly unique to its owner's taste and preferences.

In recognizing these local predilections, Fathy rejected to notion of standardization found in modern architecture. And in this quest to create niche architecture, Fathy implemented several unique designs. First, he designed beds with storage underneath and troughs surrounding them to repel dangerous insects. (Mahmoud 2016) (Tawab 2018) In addition, the kitchens were designed to be used in a squatting position as residents found this more comfortable than standing. Laundry rooms were also made carefully as the Gournii were accustomed to doing laundry in the lake, so Fathy tried to replicate this process as much as possible. Lastly, while the houses featured no running potable water, flushing toilets were introduced in order to limit the spread of diseases like dysentery, typhoid, and bilharzia. In addition, in order to deal with these water borne diseases, Fathy also designed protective clothes for the Gournii to wear when irrigating their fields that used linseed oil and recycled car tires. While, these served very specific functions in addressing the problems of the Gournii people, some elements implemented in the architecture were less useful and made residents slightly uneasy.

Fathy's education and privilege had

The roof of New Gourna's mosque. WMF.

enabled him to travel extensively prior to obtaining the commission. In his travels, he had seen architectural elements he believed would be best suited in creating this new architectural style he envisioned. These "foreign" imports include everything from vaulted ceilings, to street design, to courtyards used. Yet the application of these elements was problematic, as the Gournii did not recognize this new architecture as their own and were rather reluctant to accept the new form.

Indeed, the roofing in New Gourna is one of the most notable aspects of the architectural style supposedly "created" by Fathy. Yet, rather than being his own creation, it was borrowed from Nubian architecture and featured catenary vaults and domed roofs. (Gaber 2011) These elements from Upper Egypt were not only unfamiliar to the Gournii, but they also could not build such structures on their own. Regardless, as Fathy recognized, they were functional in that they were built in a way that did not require the use of timber and were therefore more affordable.

At the same time, these imports were problematic because the domed roofs were associated with religious architecture such as mosques and mausolea. (Pyla 2007) For the Gournii, it was almost seen as sacrilegious to live in a building with a similar form as Islamic institutions. More prosaically, however, the domed roofs also prevented the expansion of homes. As with the homes in Shibam,

the eldest sons would typically move onto the uppermost floor with their new families. (Ahmed and El-Gizawy 2010) Thus rather than respecting Fathy's designs, the Gourniis eventually demolished the domed roofs so that they would fit within their own understanding of vernacular architecture. (Pyla 2009)

Within the homes of New Gournii, courtyards were introduced based on traditional Cairene residential architecture. Unlike the domed ceilings, these served a very functional purpose of providing the homes with airflow, interior lighting, and served a social function as well, much like in the case of Shibam. While this was an incredibly important aspect in Shibam and many other Middle Eastern settlements, in an area like Gourna, where land was most valuable for agricultural purposes, the courtyards were deemed a waste of space. (Pyla 2009) In fact, these would later be transformed into animal pens and work places. Another public space that failed to meet Fathy's dream was the public squares, which saw little to no use, as was also the case with Western institutions like a police station and other civic buildings. (Guitart 2014)

In short, these imposed elements were difficult for the residents to accept, and perhaps reasonably so. Indeed, in retrospect, Fathy was just another architect who believed his vision could trump any local concerns. However, one of the few indigenous practices that is generally recognized as a positive element is Fathy's use of mud architecture. As Fathy himself said, "any architect who makes a solar furnace of his building and compensates for this by installing a huge cooling machine is approaching the problem inappropriately." (Fathy 1986) Thus mud was chosen as the primary structural material in New Gourna since it not only preserved the existing culture, while limiting residents' reliance on new technologies and preferring proven methods of sustainable heating and cooling. (Abdelsalam 2014)

Just as was the case with Shibam, mud offers excellent thermal properties, is rather flexible, and is sustainable. In the case of New Gourna, it offers not only a much cheaper alternative to imported materials, but also one that the residents are capable of manipulating and molding to their tastes. Given the Gournii's understanding of mud architecture, it is concerning that Fathy employed a group of trained masons from Aswan. (Miles 2006) Eventually, villagers who believed they were most entitled to the wages and the work eventually dismissed these outside workers. The problems that arose during construction were also bureaucratic.

The Department of Antiquities was the original client of the New Gournii

A Gournii man sitting in the streets of New Gourna. WMF.

project, yet relations between them and Fathy quickly collapsed. Fathy was given a limited budget and forced to buy materials with petty cash at which point the project started to fall apart. Furthermore, officials claimed that funds were being mismanaged and employees were supposedly unqualified. (Miles 2006) This disagreement was ultimately the official end for Fathy's envisioned utopia; however, the Gournii also rejected Fathy's grandiose plan. Homes were vandalized when a dyke was cut through the development and the village was flooded. (Guitart 2014) In fact, the combination of the residents' rejection of the master plan as well as such political hindrances was the ultimate source of failure for the project.

Even so, above and beyond these local and political issues, there were other issues that presaged the failure of New Gourna. Most notably, the architectural style that Fathy conceived, which he truly believed would ignite a national architectural revolution, fundamentally failed to meet the demands of the Gournii people. And in part their rejection was due to the imported aesthetic, which were wholly foreign to the local people. Indeed, it is difficult to imagine that imposing this

aesthetic would please them. Even more important than such foreign influences is also the problem of elite ideals of the "natives" and the architecture they should inhabit, this clash of ideals created a gap in the project that was never bridged. In short, the locals may not appreciate the ideas of the educated elite. (Ahmed and El-Gizawy 2010)

Thus, the architecture promoted by Fathy, while incredibly localized and specifically tailored, still could not replicate the organic architecture and the centuries taken to assume that form. Even though he tried to make it "natural," it was still understood by the Gournii as being new or artificial. The Gournii felt that the homogeneity of New Gourna created a sense of "placelessness." (Mahmoud 2016) There was a feeling that the existing culture was lost and a new culture was being imposed, a sort of faux modern Egyptian identity. Moreover, Fathy really never talked with all the Gournii, only the village elders as opposed to those of the other villagers, who invariably had their own ideas. Specifically this could be noted in the differing opinions on the status of women in Gournii society. (Miles 2006) This disconnect made many Old Gourniis feel "socially detached" from the new urban form. (Mahmoud 2016)

In any setting, it is difficult to fabricate an identity, but this was one of Fathy's main goals. Post-colonial Egypt was in need of a new national identity, and as such a single unified understanding of the Pharonic past was harnessed to help guide the country into the modern era. (Guitart 2014) Yet, this national experiment was ill-suited for the Gournii who preferred to live uninterrupted in their historic village. It was also out of touch with larger Egyptian realities, since during this time Egypt was experiencing mass migration out of the countryside. Thus, it was no doubt contradictory to build a model of rural housing as a beacon that all Egyptian architecture could follow at a time when the social reality was the exact opposite (Guitart 2014) Lastly, even if the project had succeeded, the lower-class people of New Gourna would not have had the power or influence available to create the design they desired. Rather, it was always a project designed by the elite, both in Cairo and among the Gournii. And as such it is important to recognize that imposing architecture on anyone – even if it improves their lives – is more than likely to backfire. (Sameh 2013) What ultimately became of New Gourna, after construction halted and a handful residents moved into the new community?

Since Fathy's construction ended, the homes have modernized considerably. Electricity, satellites, and internet have all been added. Moreover, as was mentioned

Decaying homes in New Gourna. Samir.

above, the domed roofs have largely been eliminated and the courtyards have been remade into animal pens. (Ahmed and El-Gizawy 2010) On the now-flat roofs, second stories have been added, this time being built in concrete rather than mud. The abundance of concrete in New Gourna is increasingly due to the growing deterioration of the buildings due to the exposure to the elements. Unlike in Shibam, where residents are accustomed to rebuilding continuously, this is less the case in New Gourna. Additionally, given the expense of concrete, many residents are unable to make renovations, only doing so when getting money from family members working in the Gulf States. (Miles 2006) Many residents have also added air conditioning units that hang on the exterior facades.

Distraught by these developments, Hassan Fathy eventually left Egypt to work in Greece for Doxiadis Associates, a firm primarily interested in "ekistics," the science of human settlement and interdisciplinary approach to habitation. There, Fathy began to codify and create rigid guidelines for the implementation of vernacular architecture. (Pyla 2007) Through his work in Greece, Fathy created a set of quantifiable sustainable criteria for desert architecture, which would lead to his ideas being adopted in places like Iraq, Pakistan, and the Southwestern United States. The Dar al-Islam center in Abiquiu, New Mexico is the only work of his in the US. (Gaber 2011) It was built using the same sustainable and economic features developed throughout his career, originating with the building of New Gourna. The building of New Gourna offers a range of lessons in the application of new urban forms using vernacular strategies. While the rationalization of Fathy in some instances was slightly antiquated, he had a host of other more radical and avant-garde ideas that can serve this study in addressing the needs of a new housing typology in the American Southwest.

Chan Chan, Peru

The abandoned city of Chan Chan, Peru is a marvel of rigorous urban planning and engineering in the hostile desert of Moche Valley of western Peru. The UNESCO heritage site, a former pinnacle of pre-Colombian urbanism, sits along the Pacific coast of present-day Peru, 300 miles north of Lima. The city was once the capital of the Chimu Kingdom that ruled over the Andean coast reaching its zenith in the 15th century. The growth and complexity achieved by the Chimu from the 9th to 15th century are marvels of the New World. Chan Chan is the largest pre-Colombian city, featuring a city center of six square kilometers and a surrounding area expanding twenty square kilometers. (UNESCO, 2020) In addition to the monumental size occupied by the city, at the peak of Chimu civilization Chan Chan was home to roughly 60,000 people with some estimates near 100,000. (Hathaway, 2009) The scale of the city is most remarkable when contextualized in an arid area that averages one-tenth of an inch in average annual rainfall. The hydraulic systems that sustained the city were so complex that Chan Chan has been described as the "first true engineering society of the New World." (Ortloff 2009) The adobe metropolis of this pre-Colombian marvel is not solely a crucial piece in understanding informal urban planning and urban structure, it also offers insight into a complex societal structure that allowed for such a civic project.

Chan Chan ruins from above. TDA.

Background

Before succumbing to Inca rule in the late 15th century the Chimu Kingdom had constructed a complex societal structure, which ultimately motivated the urban form of Chan Chan. The society, like many pre-modern civilizations, was divided into three classes: the urban nobility, artisans, and rural lower class. These three tiers of society are reflected in the primary architectural forms. In the core of the city were ciudadelas, large enclosed rectilinear spaces that housed the nobility. These compounds housed a range of extravagant buildings and programs specifically for the elite. The ciudadelas also housed the artisan class, which occupied less monumental architecture in "U-shaped" structures. (Topic and Moseley 1983) The informal outskirts of the city feature an assortment of "small, irregular, agglutinated rooms" known as SIAR, which housed the agricultural and labor class. (Andrews 1974) The social structure of the Chimu Kingdom was key in developing a sustainable metropolis with successful agricultural yields. The cooperation between the bureaucratic class and lower-class allowed for irrigation and agricultural techniques to develop to such a high level that allowed for such a large scale urban population in an adverse climate.

The flourishing city of Chan Chan and the Chimu Kingdom came to an end in 1470 AD when the neighboring Inca Empire conquered the city and relocated much of the laboring class to their own capital city of Cuzco, Peru. (Hathaway

2009) At this time, the city was largely abandoned. Spaniard Francisco Pizarro noted upon his arrival in 1532 that the city was deserted; however, much of the precious metals and materials that adorned the structures were still intact. All of these, the Spaniard conquistadors looted, whereupon the site was left to the elements and has deteriorated greatly over the last 500 years. (Hathaway 2009) The designation of Chan Chan as a UNESCO heritage site in 1986 has caused restorative projects and archaeological expeditions to begin restoring and preserving the site for further study. (UNESCO 2020) This preservation makes Chan Chan a valuable site in understanding an isolated instance in vernacular desert urban forms. Through studying Chan Chan, we can begin to understand the systems that supported such a large urban development in a remote and extreme environment.

Selection

Chan Chan provides a wonderful set of lessons regarding the administrative and systematic requirements in sustaining a large-scale city in an arid environment. In particular, the massive population that was sustained in an extreme desert is truly a testament to the design and infrastructure that made the city possible. Thus, in terms of selection, while the density was not as much as Shibam, Chan Chan is still comparable to many modern cities, and is arguably denser than most suburban developments. In addition, while the desert environment of Northern Peru is slightly different in comparison to deserts in the southwest in that it is coastally located, it still features similar rainfall and temperature patterns. Finally, beyond the questions of density and environmental factors, the design of Chan Chan is consistent with other vernacular forms.

The adobe construction found in Chan Chan was all locally sourced and built in a traditional method. As such, the architecture seems entirely local with specific designs tailored to the Chimu Empire. In addition to the construction criteria outlined, the zoning is also consistent with other selections. The urban form of Chan Chan is almost entirely built for residential housing, although there are several spaces that function as more cultural and civic spaces. Lastly, the scale of Chan Chan is the most significant factor in its selection as it is arguably the largest on this list. It is even larger in terms of population and area than even the modern city of Masdar, as discussed in the next section. This is incredibly impressive given the relative isolation and antiquity of Chan Chan.

In respect to the chronology of Chan Chan, it is being used as a historically

isolated example since it has been abandoned since the 15th century. As a result of Chan Chan's antiquity there are some limitations as to what can be determined about its original design. Specifically, its vernacular design elements since the ruins of the city have been heavily eroded due to flash flooding. It is thus a rather difficult case to examine. Regardless of this decay, however, on account of its size and location, archaeologists and historians have been fascinated with Chan Chan and there is thus a considerable amount of literature on the development and society of the Chimu people and their capital on the Peruvian coast. The following analysis is based on this literature.

Analysis

Due to the poor state of Chan Chan today, it is necessary to note at the outset that making any sweeping claims – or even analysis – is somewhat difficult. To begin, much of the literature on Chan Chan is fairly dated and thus not engaged with contemporary issues like sustainability and vernacular design. Moreover, most of the recent literature is focused fundamentally on the preservation of the site since it is threatened by increased flash floods due to climate change; given the adobe construction, it is incredibly susceptible to erosion. As a result, the general decay of the site is another element that makes analysis so difficult, as there is little remaining of the physical architecture. Given these limitations, much like the analysis of Chaco Canyon, the lessons learned from Chan Chan will highlight the larger infrastructure systems that supported the development. Indeed, what is perhaps most impressive about Chan Chan is that it sustained this massive population in the Moche Valley even though it is extremely arid. This was only possible through the use of advanced agriculture and hydraulic systems. Thus, this analysis of Chan Chan will highlight the passive systems used to support the population.

The early engineers that developed such large-scale sustainable systems were not entirely unaided; the siting of Chan Chan was in various ways optimal for large-scale human populations. Since even though the Moche Valley receives very little rainfall, it is situated between both the Moche and Chicama Rivers. The seasonal flows between these two rivers were different since the Chicama got water from the Andes Mountains in the North, and the Moche River got water from the Andes in the South. As a result, Chan Chan had access to two different water basins, which allowed for some flexibility in their dependence on water.

Archaeologists excavate bas reliefs in Chan Chan. Bournocle.

In addition, Chan Chan also had access to an underground aquifer, which enabled the building of a "hydrological regime" of wells. (Kolata 1985) Indeed, it was the development of these wells that ultimately enabled the architectural development of Chan Chan, as stable water supplies made possible larger populations and urban developments. Thus, much like Chaco Canyon, its development was entirely correlated with the ability to produce enough agricultural surplus; however, while the origins may have been similar, the ultimate forms were different.

The physical development of Chan Chan was unlike other examples in this study in that it featured almost entirely single story housing. It lacked the density that made the other examples distinctive given their technological limitations. Thus, in many ways Chan Chan is actually similar to modern American cities in terms of urban sprawl. For example, Chan Chan featured a downtown core that was primarily used for commerce as well as housing the Chimu elite. (West 1970) These compounds were closed off to the outside by means of high walls and maze-like entrances. While this urban core comprised roughly six square kilometers, the entire city was closer to twenty, and the majority of citizens resided in this periphery. (Kolata 1985) Since these communities were outside of the linear and geometric urban grid of the urban core, some scholars have called them "slums." (Keatinge and Day 1974) Of course, such a class division is not unique to Chan Chan, as it is found in almost every ancient city, yet in the Chimu civilization this divide ultimately became quite problematic.

Intricate construction details in the core of urban Chan Cha. Houser.

Nevertheless, it was this rigid segregation that allowed for the development of such a large urban project. Millions of human-hours were required in the construction of the downtown, and these laborers were most likely recruited from the settlements outside the formal city center. A system of either corvée or tribute labor was in place that ensured the construction of essential utilities like the irrigation systems and of less essential pieces like the towering walls that surrounded the ciudadelas. (Smailes 2011) This brutal system, like many others in the pre-Colombian new world, also featured ritualized human sacrifice.

Trying to make sense of such practices in our current day and age is no doubt difficult; however, there are some lessons that can possibly be drawn from these realities. In particular, is the fact that architecture seems to have an inherent effect on our psychology and understanding of the world. The various undertakings of urban planners throughout the twentieth century have shown that we are connected with our built environment. Our perceptions of our built world are correlated with how we perceive the non-physical, thus having such a rigid division in a city like Chan Chan could have ultimately contributed to more intense societal divisions that eventually brought the city to its ruin.

Before then, however, it is clear that the development of Chan Chan was premised on the irrigation systems – built by forced labor – that supported the city. Massive labor forces were needed to irrigate the large area needed for subsistence agriculture. An estimated 20,000 hectares were irrigated in the

area surrounding the city. Access to this space was largely achieved by foot, and was farmed by urban residents. There were also an additional 40,000 hectares in the remainder of the Moche Valley that were irrigated and farmed for food production. (Kus 1974) The scale of these irrigation networks was unparalleled by anything else found in the New World.

The Chicama-Moche Canal was the north-south canal that supported the majority of Chan Chan's agriculture. The 74-kilometer canal sourced water from both the Chicama and the Moche Rivers. (Kus 1974) The canal was likely the work of thousands of laborers, requiring a rigid political system that was capable of such organization. Another interesting feature was the availability of public wells throughout the urban core. These wells were simply dug into the ground much like step wells found India. Chan Chan featured a range of public utilities that were ultimately critical to its survival and sustainability. In addition to the canal and these wells, a road network was developed simultaneously in order to connect the urban residents with villages throughout the entire valley.

Yet, even with this entire massive infrastructure, Chan Chan was dependent on imported food. Most notably, the majority of the protein was harvested from the ocean and transported into the

Pre-Chicama remains in coastal Peru.Korobova.

city, with occasional butchering of llamas. However, these imported proteins were only a fraction of the Chimu diet since the majority of calories being consumed from plant sources. (Pozorski 1979) Much of these plants were harvested from outside the city as was the case with Chaco Canyon. Which, once again, shows how this dependence on imports highlights a recurring flaw that these large cities no matter how sustainably built, irrigated, and farmed, will never be able to meet the demands of their large populations.

Masdar City, UAE

The landmark Masdar City in the United Arab Emirates is at the forefront in testing the creation of a carbon neutral and sustainable urban typology. Commissioned in 2006, Masdar City has long been at the cutting edge of technological development and prototyping a new urban form in the heart of the Arabian Desert. The original master plan developed by Foster and Partners (F+P) includes advanced technological remedies, and vernacular forms and systems well proven in traditional Middle Eastern architecture. The urban form of Masdar replicates that of traditional Middle Eastern towns, featuring walkable narrow streets that block sunlight. In addition, passive cooling systems and facades use indigenous understandings of the climate to enhance the sustainability of the project.

The "zero carbon, zero waste" identity envisioned for the prototype of Masdar begins with the naming of the project. In Arabic, Masdar means "source," which is meant to establish Masdar as a source of future development and growth. As a result, it has attracted international expertise in environmental engineering, architecture, and urban planning since its inception. (Masdar 2020) The six million square meter proposal initially included housing for 50,000 residents with plans for 40,000 commuters from neighboring Abu Dhabi. (Goldenberg 2016) Yet the success of Masdar as a replicable prototype hinged on its ability to demonstrate viability and scalability, even with an immense amount of funding and government involvement, the initial project from 2006 has yet to be fully implemented. Accordingly, the ultimate success of Masdar is yet to be written. Nevertheless, at present the city provides an unconvincing case of contemporary experiments in desert vernacular urban architecture.

Master plan of Masdar City. Foster + Partners.

Background

Despite its name, Masdar City, is not an independent entity and is instead a district within the city of Abu Dhabi. As such, Masdar must first be understood within the context of the larger political and historical movements in the United Arab Emirates. The UAE were relatively undeveloped until the discovery of oil in the middle of the twentieth-century. This discovery led to economic growth that was followed by political unification in 1971, which resulted in a range of modernizing projects. (Cugurullo and Ponzini 2018) This rapid development saw the construction of overnight metropolises rising from the desert floor.

This type of rapid urbanization in the region has been referred to as "petro-urbanism." (Griffiths and Sovacool 2019) Petro-urbanism reflects the reliance on the production of oil and natural gas for economic growth and development in Abu Dhabi. Yet, recognizing the finite availability of oil, Abu Dhabi released a new agenda titled Economic Vision 2030 in the early 2000s, which emphasizes the need of diversifying the economic sectors that will enable UAE to compete in the global economy. The agenda also features measures of sustainability. (Cugurullo 2013) As a result, trying to capitalize on the growth of green technology and provide an Arab model of an "eco-city," Masdar was conceived.

Masdar was first and foremost developed as a laboratory for the development of sustainable technologies. Economic diversification was a crucial

step taken in the UAE, and the creation of a new city made entirely from scratch was set to be the testing ground of these new technologies. Introduced to the world as an eco-city, the project initially sought to be a zero-waste and zero-carbon development. The initial unveiling attracted a flurry of international attention. The project was funded by the Masdar Initiative, partnered with a variety of international technology companies interested in developing their technologies in the promising city. In its early inceptions, it was called "a global benchmark for sustainable urban development" by the WWF. (Cugurullo 2013) Due to multiple setbacks throughout the development and construction, however, the motivation and end goals have changed drastically since its inception. Moreover, this state of constant change has drained public support in Abu Dhabi and creates an aura of uncertainty regarding the future and final product of Masdar.

The city of Masdar as it stands in early 2020 is inhabited by only 1,300 individuals, most of whom are students of the Khalifa University of Science and Technology. (Flint 2020) (McArdle 2018) The meager three percent of the proposed population is in part due to the incompletion of the proposed construction phases, with only 10% of the total construction completed as of 2019. (Griffiths and Sovacool 2019) With initial construction begun in 2010, construction is far from complete with most estimates of completion now being in the year 2030. The current state of Masdar therefore resembles the fate of many other "smart cities" that have been built from scratch throughout the world, in places like Tianjin or Dongtan, China. While the future may seem bleak for these cities, the advances and achievements by Masdar are noteworthy, and with the proper steps taken Masdar will teach important lessons for the cities of tomorrow.

Selection

Given that this study is an analysis of vernacular architecture and their contemporary applications in the American Southwest, it is imperative to have a contemporary example with lessons learned. Masdar serves this purpose in that it is an example of contemporary vernacular architecture and is currently occupied. Thus, by addressing the criteria of location, construction, zoning, and available information, Masdar aptly serves this specific study.

The siting of Masdar in the Arabian Desert serves to help illustrate the influence of climate on specific designs. The urban form has been largely adapted to passively address issues of heat. Beyond the desert climate, the location

of Masdar outside of Abu Dhabi helps us understand how the creation of new and independent "cities" impacts the surrounding area. And while the currently small area occupied by Masdar is a point of concern when addressing possible scalability, the density and utilities provided within Masdar are consistent with other Middle Eastern cities, making it suitable in studying new urban forms. The density and utility are just two aspects that are similar to other cities in the region; the construction and zoning are also similar to historic models in the Middle East.

Initially when commissioned as an eco-city, the vernacular urban form already present in the region provided the most efficient solution. Masdar was designed with a relatively high population density, to be achieved through multistoried construction. The ground floors were occupied by businesses with remaining floors all designated for housing. This mixed-use approach helped achieve the high density envisioned. Additionally, the construction borrowed many examples from traditional architecture, from the passive wind cooling systems to the shaded adobe facades. Yet Masdar differs from the original examples, utilizing state of the art manufacturing techniques and technologies to achieve similarly functioning results. These construction processes, while differing from historic architecture, are useful in understanding the future applications of vernacular building strategies. Lastly, the use of this groundbreaking technology addresses the last point of concern for this project.

The presence of top-tier technology companies, along with Khalifa University, has directed much of the current dialogue regarding the creation of eco-cities like Masdar. The prevalence of such outfits within the field allow Masdar to be the focus of much of the current research in understanding how smart cities can actually be built and function organically, while still being inherently inorganic creations. Regardless of the novelty, the potential of Masdar as an example for the future is just beginning to be understood. In that time, many lessons have been learned in the limitations and alternative approaches necessary to create successfully planned urban designs in hot regions of the world.

Analysis

Unlike some of the other examples presented above, the nature of Masdar being a relatively new and inorganic city presents several challenges in analysis. The analysis pursued by this study was done based on the existing literature that discusses the most recent construction and policies guiding future development. As such, there are certain limitations in

this study given the incomplete nature of Masdar. This is not to say that there is a lack of material, but rather that it presents lessons learned in the first stages of the overall Masdar Initiative. It is also clear that further study will be required upon completion of the project and beyond, to understand the full impact and scalability of these new urban design.

As such, the current rendition of Masdar provides a case in point. Many experts argue that it is another failed example, joining a long list of recently developed smart cities. However, a holistic analysis must be conducted to fully understand the implications of Masdar. Through a combination of analyzing both the successes and failures, a case for the application of lessons learned can be developed in the application of similar projects in the American Southwest.

The initial proposal for Masdar was an incredibly ambitious project in a region with no previous precedents. This ambition captured the imagination of industry leaders in renewable and green technology. Goals for development sprang from this early partnership. The unprecedented idea that drove early growth was creating for the first time a city that was both zero-carbon and zero-waste. (Cugurullo 2013) To this end, the Abu Dhabi government commissioned Sir Norman Foster to draft the first master plan. This master plan featured traditional planning elements including narrow streets, natural shading, high-density low-rise housing, public spaces, and an emphasis on walkability. (Ibrahim 2015) These proven traditional elements were aided by the implementation of cutting-edge sustainable technology that would heighten the sustainable nature of the master plan.

The unveiling of Masdar attracted high profile companies leading the development of sustainable technologies. This initial group included General Electric, Siemens, and Schneider. This first group of developers proposed the implementation of technologies like smart utility grids, concentrated solar power, passive wind cooling systems, and electric personal rapid transport (PRT). These technologies in combination with the proven suitability of the master plan and a host of LEED certified buildings were set to create the model eco-city not just for the region, but also applicable globally. Thus we must ask how this incredibly well funded and corporate supported project, utilizing the most advanced technology available, has "failed" according to many?

In essence, this project had all the elements in place for creating a model of new eco-urbanism. To understand this failure, we must examine Masdar as it stands in comparison to its initial goals.

Angela Merkel visits Masdar in 2010. Bergman-Pool.

Most commonly, the failure is discussed in terms of its lack of inhabitants. As a result, Masdar is often referred to as a "ghost town" in an otherwise booming metropolis. (Goldenberg 2016) The so-called failure is also understood in terms of the limited completion of the original master plan, and its reduced ecological performance. Yet, this failure can be explained by the transnational nature of the project, its ever-changing identity, and its lack of social development within the UAE. The failure can also be attributed to unforeseen geo-political events beginning with the 2008 financial crisis.

The financial crisis reduced the budget of many ongoing projects in the Emirates, one of these being Masdar, with the initial investment of $22 billion dropping recently to $10 billion. This drop in budget led to numerous elements of the initial plan being dropped. Thus the project initially branded as an "eco-city" was downgraded to being a "zero-carbon city." This revised status was only in the official development initiatives, Masdar still has the potential to develop as a sustainable eco-city. And more recently this label has again changed to being a "low-carbon city." Yet, after receiving criticism for its failed environmental performance, it was ultimately deemed a "smart city." (Cugurullo and Ponzini 2018) These changing titles highlight not only the deterioration of the city's planned ecological performance, but also brings to the fore another problem inherent in the project. Namely, all these labels were created with the intent of garnering foreign investment through the use of vague, albeit fashionable titles. Thus, while this approach of creating a smart

Navaya Shuttles on display. Bournocle.

city has created much international media fanfare, it has not created the planned-for environmental impact of Masdar.

For example, several of the initially proposed elements have been cut in recent plans. Most notably, the buildings were initially to be built above the level of the city, which would host the entirety of the PRT system. This has been downgraded to a line of autonomous cars known as the "Navaya Autonom Shuttle." (Griffiths and Sovacool 2019) Similarly, there has been a reduction in the amount of renewable energy technologies, so that while Masdar is quite energy efficient, it is still reliant on energy produced from oil. As a result, rather than focusing on being zero-carbon, Masdar is now refocusing on reducing carbon emissions. Similarly, there are other issues that have also been overlooked, such as water scarcity and agriculture. Masdar was meant to engage with all of these, but they were ultimately abandoned to encourage economic rather than ecologic development.

Even so, Masdar has helped in fostering economic diversification in a country almost entirely reliant on the production of oil and natural gas. For example, the testing and development occurring in Masdar provides an excellent product laboratory before commercial launches are made. And once a product is launched and sold, Abu Dhabi receives a percentage of the product's revenue, typically ranging from 30% to 60%. Thus, this relationship is mutually beneficial, providing the opportunity for economic growth of both. , while on one level the eco-modernization pursued by Abu Dhabi has yielded positive results in the creation of new

Siemens building in the business core of Masdar. Robson.

sustainable technologies, this emphasis has failed to address another necessity in urban development: social concerns.

Several key aspects in any urban environment is the social relationships and cultural identity associated with an area which, as much urban planning has confirmed, cannot simply be fabricated. The lack of social concerns addressed in the planning and implementation of Masdar are the largest contributors in its failure to lure inhabitants. This is the same fate suffered by many others like it that fail to create social resilience. Similar cities have been described as "empty infrastructural containers waiting for an influx of residents." (Cugurullo and Ponzini 2018) This rather bleak metaphor highlights the need for social systems, policies, and infrastructure that encourage migration, rather than a focus solely on developing a city's economic potential.

Some of the factors hindering such growth are the lack of cultural spaces, transportation, and affordable housing. The lack of cultural space is due to the emphasis solely on economic issues, and as such the existing downtown is composed solely of office spaces. This absence is highlighted in Masdar, yet this is a feature common in other novel cities. A lack of cultural identity can also be blamed on the numerous foreign influences in the development of the project. Thus, while the foreign investors were key in the initial development of

Masdar City developments from a distance in 2014. Hufton+Crow.

Masdar, they ultimately created a project with no real identity or culture. This is much like the urban form of the rest of Abu Dhabi that is an assemblage of architectural styles and designs being largely built in the last 40 years. However, Abu Dhabi unlike Masdar already had a population of locals with a sense of community and history, something that is hard to transfer to new cities.

Beyond the social gap, there is a physical gap in the form of a lack of transportation system between the two cities. Masdar is located 17 kilometers from the downtown of Abu Dhabi and is currently only accessible via car. Initial plans included a light rail system, yet much like the rest of the project, it has been delayed. Accessibility is key to the success of Masdar as it allows for both economic growth and the planned 40,000 commuters to be able to access the city. As the population estimates of both commuters and inhabitants have gone down, so has the investment of businesses in Masdar. Lowered investments limit the economic approach taken in the development by the Emerati government, smaller investments in turn increase housing costs, reserving much of the city for the wealthy elite of society.

The city has no proposal for a range of socio-economic classes; rather it focuses solely on creating a city of high-income workers. This disparity is best illustrated in the average cost of a one-bedroom

apartment, which is $208,000, while the majority of foreign workers in the Emirate make $250 per month. In a country comprised of 90% foreign laborers, with a majority of these people only staying a few years, a lack of affordable options clearly limits the motivation for anyone to move to Masdar.

To address the failed social element of the project, developers have now shifted to an ideology of connected but unique city blocks, creating a more organic urban fabric. This attempt at creating a more organic form will seek to draw more occupants and progress the project into the next decade with fewer obstacles. How this will develop is clearly unknown; however, we can still ask what Masdar can offer in terms of design solutions for the American Southwest?

One such issue is economic diversification. Thus while the economic approach taken by the developers of Masdar has ultimately hindered growth, the larger shift of the UAE to diversify from an economy based entirely on the production of fossil fuels to one that embraces the future of renewable technology is admirable. It has also inspired other countries in the region to consider the longevity of their economies, and this is relevant to the US as well on account of the current fracking and natural gas boom, which has hampered economic diversification in various ways.

Masdar can also serve as an example in terms of its energy and water efficiency. While the lofty goals initially set were never reached, Masdar consumes 40% less energy and water than Abu Dhabi does (Griffiths and Sovacol 2019) Masdar thus does reveal the possibilities of sustainable urban planning and technologies, but it is another question of how it would it be applicable to other cities, and would it be possible to scale?

In thinking about this issue, it is important to recognize that Masdar is unique since it was built from scratch. Thus, while this lack of context may have hindered growth initially, it also allowed for the testing and creation of otherwise extremely difficult designs. Yet it would be very hard to retrofit other pre-existing cities, Masdar allows designers to understand the steps necessary in creating sustainable cities. Similarly, the incredibly high costs per square meter in addition to the expensive technology used in the infrastructure are not replicable in other contexts. As a result, when looking at the practicality of Masdar, the limitations of implementing some of its designs in older urban spaces must be recognized.

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Lessons Learned

The analysis provided by the study of these five sites offers valuable lessons regarding how vernacular desert architecture can be modified to solve the problems in the contemporary American Southwest. These lessons were generalized and separated into five categories. The five primary lessons are density, materiality, infrastructure, flexibility, and policy. Through an understanding of the ways in which these elements can be applied to the current unsustainable model of suburban development, we can begin to address and solve some of the existing problems. Once these larger lessons learned were identified, the individual cases were synthesized to highlight the more specific problems they addressed. After this initial synthesis was done, each case was investigated to explore how it can provide valuable information to address the issues facing the future of urban development of the American Southwest.

Lessons Learned	Shibam, Yemen	Chaco Canyon, New Mexico	New Gourna, Egypt	Chan Chan, Peru	Masdar City, UAE
Density	X	X			X
Materiality	X	X	X	X	
Infrastructure	X	X		X	X
Flexibility	X		X		
Policy	X		X	X	X

Shibam Hadhramawt, Yemen

Shibam provides a range of lessons that can be used to inform the urban design and architecture of the American Southwest. Verticality is an element of Shibam that has broad reach in addressing the failures of the suburban housing model. The verticality achieved in Shibam is unique in that is done solely through mud-brick construction, yet it lends itself to a larger dialogue. Experiments in engineered lumber are now beginning to inform the future of skyscrapers. Thus, the possibilities of an urban structure like Shibam using engineered organic materials are cause for discussion in creating a new urban typology.

In this regard, designers need to pay attention to local materials since they have the potential to provide better thermal properties and limit energy consumption. Additionally, using local materials is essential in reducing the overall carbon footprint of structures by reducing transportation distances. Reduction of energy can also be found in the passive cooling systems of Shibam. Of course, the viability of any passive cooling system may be questioned given the extremity of global warming; nonetheless, it does provide inspiration for creating passive systems.

Flexibility and allowance for growth are another piece of sustainability that is just beginning to enter contemporary architectural dialogue. The main buzzword being used is "multi-family housing," which has been adopted as a catch-all for all forms of adaptive housing. In this regard, Shibam is again interesting because of the inherent connection between the family and the built space. Whether such connections are viable in the US is open to debate, but the rise of "multi-family housing" hints that the single-family suburban ideal is beginning to be questioned. If traditional social organization is changing in the US, the design of houses in Shibam may provide examples of how to build such residences. For example, is one solution to growth the inclusion of features in upper levels of buildings that allow for vertical growth as in Shibam?

The informal relationship between residents and craftsmen in Shibam is another avenue of exploration. While this level of informality may not currently be possible in the US, other approaches could be taken to increase suitability between the home and the resident. The rigidity of contemporary home design, suited for single families, ignores trends of changing social structures. Accordingly,

an approach to more flexible housing should be explored, utilizing current technological applications. Recent technological advances are allowing for every facet of contemporary life to be individualized. From online shopping, to music and film, the next frontier could be residential architecture. In this new technologically aided architecture one could imagine how an app or website could allow for a more personalized and flexible system. It is unknown how such an application would be integrated with local building codes. Clearly there would have to be some oversight of such a market, yet how individual local governments would react to such developments will require a push from residents demanding a novel architecture tradition. So, before a more traditional vernacular architecture is adopted, a consumer market must be created.

The case of Shibam is again instructive since even there, resistance to vernacular architecture is already reducing the number of new buildings made in this style, even given their historical and cultural prominence. This resistance is most likely to be exacerbated greatly if a similar typology were to be adapted in the American Southwest, a region that is already struggling to implement superficial changes in its urban form. The green lawns that dot the landscape are one of many other problems with these suburban developments. Thus if people in the region are unwilling to yield their lawns for xeriscaped landscapes, how would they react if a new local typology were to be introduced?

Much like in the case of Shibam, there need to be policies that encourage designers to implement local materials, passive cooling systems, and flexibility in design for the Southwest. This could also be encouraged if successful models were first developed in the region proving viability. In the opinion of this author, given the affordability of materials, an experiment could be conducted addressing the needs of affordable housing. If the project ultimately succeeds and creates a favorable popular opinion of the comfort of the homes regardless of the appearance, vernacular inspired architecture could begin to expand and inform a more universal housing model.

Ultimately, the current housing model of the American Southwest is unsustainable given global climactic change. Addressing the issues with the use of technological advances will not solve the entirety of the issues. The Southwest is becoming unlivable and action will need to be taken. Consequences will likely involve mass migration, a commonly agreed upon outcome of our current situation. To mitigate this impending

humanitarian disaster we need to begin to create more cooperative urban forms that limit the impact on the environment. The case of Shibam provides one approach in urban technologies and architecture that are inherently cooperative with the surrounding environment and could prove useful given impending climactic shifts. Like the creativity that inspired the Shibami architects of old to build up, a new generation with that same creativity must address the circumstances of climate change.

Chaco Canyon, New Mexico

The lessons learned from Chaco Canyon include the importance of local materials, transportation infrastructure, passive agriculture systems, density, and lastly social and public policies that are responsive to climate realities. These are all applicable lessons that, if implemented properly, can bring about a more sustainable model of urban development in the American Southwest.

The existing model in the Southwest is one that is almost entirely dependent on the importation of materials, resources, and agricultural products. And what Chaco Canyon most importantly demonstrates is that this is not simply viable. Thus, while the early inhabitants of Chaco were able to live with relative ease based on local environmental realities, problems started when these constraints were no longer considered. Similarly, the same phenomenon is happening today, when rather than developing local systems, the solution is to get materials from global supply chains.

Indeed, it is precisely this disconnect that Chaco Canyon brings to the fore when thinking about design in the Southwest. Namely, there needs to be not only a recognition of local environmental realities, but also the larger socio-political systems that decide how development is to proceed. For example, the intensive labor required in the maintenance of Chaco Canyon was simply unsustainable, and many within the system began rejecting it. Thus, in terms of applying this to the contemporary US, at what point do the measures taken to ensure survivability in the American Southwest become too extreme for the local inhabitants? We are already witnessing nocturnal adaptations during the summer for outdoor activities, and there are probably ranges of other impending consequences given the extreme climate that we are unprepared to handle. As a result, urban environments in extreme climates need to be recognized as vulnerable and thus looking back at the structuring

of Chaco Canyon and its ultimate collapse it is important to recognize that we are in an eerily similar situation.

All great civilizations before ours have fallen, thus it is arrogant to think we are not susceptible to similar circumstances. Chaco Canyon is therefore an exemplar of what not do, such as building a civilization premised on resources that may not be readily available, and avoiding the realities of climate change. Indeed, all the stresses that brought Chaco Canyon to an end are similar to realities today, so it provides us with a cautionary tale. Chaco proves that we are not above the laws of nature and we must act accordingly if our cities are to survive.

New Gourna, Egypt

The lessons provided by Hassan Fathy's experiment in the desert highlight the opportunity afforded through social housing. Fathy was able to introduce a host of humanist ideas surrounding the creation of neo-vernacular architecture following a more modern execution. His ideas, while cutting edge and theoretically sound, ultimately failed to be adopted on a mass scale as he envisioned. This problem lies in the lack of political support and in the overall rejection by the Gournii people with limited fault to Fathy himself. Through the analysis of New Gourna, this study has identified several aspects of the project that would greatly help in the development of more sustainable and traditional urban models in the American Southwest.

Arguably the most important element introduced by Fathy that is serviceable in our context is that of the societal concerns addressed. The cookie cutter housing presented by CIAM and others are becoming increasingly rejected. Fathy meticulously designed the individual homes, and while he was aided by a more free-flowing master plan, it still required a great deal of work. Given the new era of technological development and individuality, the customization pursued by Fathy is possible in future housing developments. Furthermore, his social explorations involved the creation of a national history. This could provide useful in an area like the Southwest where much of the urban development has been erected in the last seventy years without any connection with past realities. Creating a regional history could help in creating a more welcoming urban form, one that is less sterilized than the version we see today.

The humanist approaches taken in the creation of New Gourna were still not enough to create a viable new option for the Gournii. This highlights two main problems with the development of neo-vernacular architecture. The first is that

creating any organic form in a short period of time is rather difficult. Entirely new urban forms are not only incredibly hard to execute, but it is also hard to convince people to leave their traditional homes for these new supposedly "better" proposals. As we will see in the case of Masdar City, there needs to be a market or other factors driving people to these new projects. This lack of motivation to leave Old Gourna highlights the second element necessary in the successful implementation of new urban forms, which is the creation of a market or a demand for these new forms. The Gournii were perfectly content with their traditional housing model, it was simply the pressure applied by the Egyptian government that created this dialogue in the first place.Thus it becomes clear that if any new urban typologies are to be implemented in the Southwest, it must be one accepted or adopted organically; it cannot be imposed from above (whether by architects or the state).

In the relationship between governments, citizens, and architects, New Gourna shows how invaluable agreement between all parties truly is. No matter how brilliant a project is, unless it has "buy-in" from all involved, it is unlikely to succeed. Thus if a new urban typology is introduced in the American Southwest that is far more sustainable and viable in the long-term, it needs to be not only acceptable to the local inhabitants, but it will also need to be supported by local governments in terms of zoning, tax laws, etc.

The fields of urban planning, design, and architecture have all become acutely aware of the impending consequences facing humanity due to climate change. The measures being taken by these fields individually will not solve the larger overarching issues in the urban plans of the Southwest. There must be buy-in on all levels to create a more successful model utilizing the proven methods found in vernacular architecture. New Gourna offers insight into what can go wrong with entirely new projects and how we can resolve those issues in the future.

Chan Chan, Peru

Chan Chan provides a rather interesting, but also limited view of the possibilities for large-scale vernacular urban development in a desert climate. It is the scale of Chan Chan that is the most important element that can help inform our contemporary models. Thus, while our cities are struggling to survive into the next century – on account of the same issues faced by Chan Chan – it was able to survive in an arguably more arid environment without any technological advantages. It is these

support systems in Chan Chan and the larger political vision to implement them that are most important when adapting these models to our current situation.

For example, the agriculture developed around the city of Chan Chan can guide us in conceptualizing new, more urbanized agriculture. In other words, rather than importing everything, how is it possible to integrate the city – and its water systems (especially sewage and gray water) – with the surrounding agricultural lands. Clearly the food needs of the Southwest will not be solved by rooftop gardening – or other such innovations (valuable though they are) – rather, much as with Chan Chan, there needs to be a larger political vision in order to integrate the systems of irrigation and agriculture. There seems to be a notion that desert agriculture is only attainable using extraneous amounts of water, but Chan Chan proves otherwise. And these ideas need to be engaged in trying to address our current climactic conditions.

Thus, much like the xeriscaping of lawns, our diets also may need to be reformulated so as to be structured more around localized agricultural products. And this is not out of line with movements like the farm-to-table ideology that is steadily growing. Indeed, everyone, but especially those in the Southwest, needs to realize that the pressure on water resources is currently extremely high, but also that the carbon footprint from the constant import of fresh fruit and vegetables from global markets is a significant contributor to overall pollution rates. And while this is ultimately a larger issue that must be solved by people outside the realm of design, we as designers can still do our part in addressing this issue by providing community garden spaces and encouraging local agriculture.

Agriculture was not one of the primary problems initially outlined that needed solving, yet as this is an exploration in vernacular architecture it needs to be noted that the two are inherently interwoven. Most notably, the disconnect between modern cities and their food sources is incredibly concerning, yet the hypothesis that this would not be the case with historically isolated examples like Chaco and Chan Chan was false. Both of these cases relied heavily on imported agricultural products to support their populations, which were obviously considerably smaller than modern cities boasting populations in the millions. And thus, as with Chaco and Chan Chan, we really need to ask whether these modern desert cities are inherently unsustainable?

Of course, advances in agriculture and transportation have made it possible for a city like Las Vegas to survive entirely without locally produced foods.

Yet this experiment has yet to be tested as almost all other Southwestern cities rely almost entirely on imports. And while this is definitely an area of research that is far beyond the scope of this project, it does need to be noted that it is ultimately crucial to creating sustainable cities in the American Southwest.

Lastly, in terms of the sharp class divisions in Chan Chan, it is interesting to reflect upon how reminiscent this division is to that of a modern city. The elite in both cases have "gated communities" that separate them from the rest of society. Moreover, as was the case historically, this division has shown to be problematic. Healthy cities need a mixture of classes to ensure both viability and equitability. Healthier cities are the ones that integrate people of all strata of life. Thus, while Chan Chan may have been able to survive using extremely rigid and oppressive political systems, it's fate does not bode well for America's increasingly segregated society. This is not only a social, economic, or political issue, it clearly needs to be addressed by architects, designers, and urban planners as well.

Chan Chan was initially selected due to its immense scale in an extreme environment, and while it highlighted a range of problems and solutions, it ultimately fell short. The study of Chan Chan has been so limited in recent years given its extreme decay that it is almost impossible to reconstruct any viable piece of its history. Almost all the current work being done is to simply preserve what we have left, rather than bother reconstructing what is already lost. Thus, in summation, Chan Chan proves that large-scale desert cities are possible to do sustainably, yet the ways in which it is approached vary given our technological advancement.

Masdar City, UAE

Masdar City introduces contemporary lessons in the application of vernacular design with the utilization of high-tech systems. The development presents the challenges of creating entirely new urban environments that are disconnected from other population centers. It also highlights the financial challenges associated with large-scale urban development.

The "smart city" approach taken is not only incredibly vague in the development of concrete goals, it also overemphasizes the possibilities to be achieved through technology. The expensive energy saving and producing technologies that were at the core of the project have been continuously cut, leaving a shell of the original project. These technological expenditures have also limited the funding for other aspects of the project. This is not said to villainize technology, as

it offers plenty of solutions that can help address anthropogenic climate change. Rather, it is to highlight the fact that it must be used strategically in terms of both cost and environmental impacts. This is ultimately to argue that the most successful aspects of Masdar – walkable narrow streets, passive cooling systems, and indigenous facades – are precisely the "low-tech" vernacular inspired technologies found in places like Shibam, Chaco Canyon, and Chan Chan. These vernacular approaches are far cheaper and can potentially yield the same results.

In this regard, the issue of financing and slowed development of Masdar also lies in the scale pursued. Creating a city, even in a controlled state like the UAE, is an incredibly difficult task. Cities are the physical manifestation of human interaction and organic social structures that cannot be replicated in the short term of ten years as was initially proposed; rather it takes time and thought. If vernacular design can teach us something about the implementation of design, it is that it should be individualized and be done on the smaller scale. Remodeling the Southwestern city will be most effective if pursued by individuals with the assistance of local governments. This changing model will also require time, and in addition, considerations for the surrounding urban form must be made to create a cohesive environment that encourages occupation.

Changing the physical model of the Southwest is not the only important aspect to address; Masdar most effectively highlights the need to shift economies. There are countless examples of areas in the US that have been decimated due to a main economic provider ageing out. The Southwest hosts a range of mining activities and if this highly populated region is to thrive, the structure of the existing economy must be addressed and shifted towards more sustainable sectors through government initiatives. Government-assisted programs will also be required to develop more sustainable housing.

If even the avant-garde Masdar failed to attract people to live there, how will experiments in vernacular inspired housing fair in the American Southwest, with less funding and international support? This demonstrates the need to create a demand, and this is where Masdar might offer a solution in the creation of other successful models. The Masdar Initiative has inspired a host of Gulf States to create more environmentally sustainable housing solutions. Thus maybe a solution to creating a market for the model of vernacular housing is to create a flashy and cutting-edge version on a smaller scale that can serve to encourage other developments.

Conclusion

The future application of these ideas will ultimately be determined by their eventual adoption by architects, urban planners, real-estate developers, and local housing authorities. This study hopes to prove that vernacular architecture is not only a source of inspiration for the physical architectural elements that can be implemented, but also the range of policies and support systems that make an urban environment livable. As such, even though there is conclusive evidence that the model of urbanism in the American Southwest is incredibly precarious given the already extreme climate and future projections, there still must be public support for the adoption of such ideas.

New Gourna and Masdar City have highlighted that regardless of the funding and extensive planning behind a project, it will ultimately require public support for the large-scale implementation needed to address anthropogenic climate change. The creation of this market must come from below as New Gourna has shown. It is axiomatic that even if an alternative option is superior, nobody will voluntarily abandon their existing model. Thus the question becomes how can architects, planners, and bureaucrats work together to convince their communities that more sustainable models will need to be adopted to ensure long-term survival?

The first step begins with education and information regarding the current model. Highlighting the issues and climate projections for the future will increasingly draw attention to the flaws in the current system. Once these flaws are outlined, discussion can begin in how these problems are to be addressed. In answering how this can be possibly be

done, this study provides a plethora of useful information that can help guide the development of more sustainable urban forms. This is not only in terms of the physical architecture, but also in relation to the phasing. Creating entirely new communities within the context or existing areas has shown to be fairly problematic in the cases of New Gourna and Masdar. Thus, there must be some medium that allows for progressive steps to be taken to prove the viability to citizens.

One common tactic for radical design ideas is initially implementing them in communities that have no alternative, thus the neo-vernacular experiment could begin as an affordable housing project. The affordability of vernacular materials, construction, and utilities allow it to be a fairly responsible alternative to modern housing. Yet approaching social housing as a testing ground for more radical ideas has proven problematic in the past. Just look at the range of failed housing projects in urban centers throughout the 20th century. Yet, even so, it needs to be recognized that unlike modernist visions, vernacular architecture has sustained human life in some of the most extreme environments for millennia and has done so efficiently. Thus maybe the best solution to convincing the consumer market of the suitability of traditional architecture will be a two-pronged approach.

One of the problems encountered by Hassan Fathy was that his project in New Gourna was only adopted by the poorest members of Egyptian society, the rural poor. If there had perhaps been more buy-in from the elite in Cairo, we could have seen a larger shift to traditional architecture. This draws attention to how to convince the elite within American society to adopt what many see as an aesthetically unpleasing and primitive form of habitation. These notions are problematic yet can be changed through education and marketing campaigns. Once people begin to understand the problems they are solving and the improvements to not only the planet's well-being, but also to their own, we could begin to see a shift occur. While it could be debated whether the trend amongst influencers is to support environmental movements or act complictly, what cannot be ignored is the popularity of fads like the paleo-diet.

The paleo-diet has created almost a whole culture of "caveman living" around it. This niche yet increasingly mainstream market shows that people are willing to abandon modern conventions and return to proven methods. In the case of the paleo-diet, people are consuming food that has been proven to be life sustaining and far healthier to the modern mass-processed alternatives. It does provide a suitable metaphor that many could

relate to in understanding a new housing vernacular for the American Southwest. If even a small percent of the elite and influential could buy into not only the benefits, but the need to rethink our current housing model, a market could be created.

Yet even if a large-scale market is created, the next question that must be asked is how to phase these ideas into the existing framework of Southwestern cities. Admittedly, this is where this research fails to be of value, and where further research is required. This study was the first step in identifying the existing problems and solutions in vernacular architecture, yet it does not answer how moving forward these ideas should be implemented.

Of the contemporary examples analyzed by this research, New Gourna and Masdar have both been supported in theory, although they have failed in execution. The initial hypothesis at the beginning of this research was that vernacular architecture was almost flawless and that contemporary applications had been relatively successful, given how lauded and praised projects like Masdar have been in the public sphere. This research has ultimately proven that the implementation of vernacular architecture with contemporary society has been problematic. This is ultimately where further research is needed to fully understand how we can redevelop massive cities without causing more harm than benefit. One starting point for this research could be within the development of informal settlements throughout the world. Informal settlements, more often referred to as "slums," hold a powerful lesson in the growth of cities in organic and traditional ways.

Informal settlements are essentially the new vernacular, built using available materials and local knowledge of construction. Yet what is most interesting is the systems used to mitigate the gap between these organically constructed neighborhoods with the more rigid modern infrastructure systems. If a greater understanding of these systems can be developed, maybe informal development in the United States could become a reality. As of right now, however, the US is far too rigid and bureaucratic to allow for organic vernacular development. The future of development is uncertain given the rapid advancement of technology; however, the dynamic of informal settlements the world over could provide promise as a mediator to allow for individually phased projects that substitute the existing developments.

The study of informal settlements and the approach taken by local governments to integrate these communities, and their populations into the formal infrastructure linking the two will help guide similar applications in the US. This study has

identified a range of flexible housing systems, largely used as alternatives to rigid affordable housing projects. These systems like those developed by Chilean architect, and Pritzker laureate Alejandro Aravena, and his firm ELEMENTAL are initiating the dialogue of formalized informality. Aravena's most notable work is that of "Half of House" a project that provides residents with a fully built half of a home that includes necessary utilities, while leaving the other half empty with support structures that allow for personalized growth. In a true utopian spirit Aravena released the plans, so that they are now entirely open source. Thus tackling the problems of decaying homes in many vulnerable cities. While, initially intended as affordable housing, there could be a shift to make these more formalized and customizable for the middle class.

Take for example a website that would allow users to pick a base home model that included general utilities such as a kitchen, bathroom, and bedroom, but then would allow greater flexibility with the addition of bedrooms and other rooms. These separate units would be custom blocks that would be built using the building codes of local areas, to help bridge the gap between more informal housing and local governments. Creating a world with fewer traditional architects, yet replacing them with more citizen designers. This will hopefully create a system that is less wasteful, and begins the conversation of creating a more flexible housing model.

Ultimately anthropogenic climate change is one of the greatest threats to human survival we have ever faced. A total collapse of ecosystems and organic processes will place untold strain on human populations; as a result we must begin acting now to mitigate our impact on the environment. Given our inherent need for habitation, the retrospective approach of using vernacular architecture to answer the questions of one of our species' most basic needs provides guidance in an uncertain time. The ultimate implementation of these ideas on the large scale necessary has yet to be done successfully, yet the future holds great promise given the growth of technology and fabrication techniques. At this point, it is most important to reflect on the past before we drift aimlessly to the future.

While it is inspiring to dream about the possibilities of architecture in the digital age, we must first ensure our survival into the next century and beyond. Vernacular architecture has provided us with the tools and lessons about how we can survive almost indefinitely in the extreme arid environments examined in this study. We must adapt these lessons to fit within our society and culture, and perhaps modify the forms to fit our aesthetics

and spatial needs. In addition, we must identify how to best integrate them into the existing urban landscape without creating entirely new forms that waste the current structures we have. Compromises will be made, and while it is hard to believe that a pure neo-vernacular urban environment is possible in our lifetimes, we must begin to take steps toward more sustainable cities. The sacrifices made now to preserve our cities will be small in comparison to those forced upon us when the realities of climate change truly drastically alter our lives.

The time to act is now. A unilateral effort from urban planners, architects, engineers, developers, and consumers must begin to shift the dialogue away from the single-family housing model that has proven to be so problematic. This study hopes to guide the steps forward in addressing these large issues using passive and proven methods without relying heavily on unproven technology as was done in the 20th century. Human history has provided the tools for survival, yet we have ignored them for the past 200 years, and as we enter a critical inflection point, it is time to revisit these ideas that enabled our survival for millennia. It is through the analysis and observation of proven and historic architecture that we can ensure the survival of our Southwestern cities into the next centuries.

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