ABSTRACT

Title of Thesis:	**MEMORIA EN CAPS (MEMORY IN LAYERS), A 3D PRINTED COMMUNITY FOR THE IMPOVERISHED IN EL SALVADOR.**
	Christian Romero, Master of Architecture, 2021
Thesis Directed By:	Director and Associate Dean, Brian Kelly, AIA, Architecture Program

This thesis targets La Union, El Salvador, specifically the village of Guisquil, a harbor town that faces poverty and unhealthy living conditions. The goal is to build a safer, cheaper, and more sustainable home alternative for impoverished communities by using 3D printing technology as the main construction method. The homes will respect the culture by using native materials mixed with concrete to contour new homes that employ phenomenology or an architectural approach that concentrates on the study of consciousness and the objects of direct experience with a focus on light, vegetation, water and air. Traditional home building methods are inefficient, wasteful, and cost much more. The 2001 earthquake, economic turmoil and political unrest has affected thousands of families and this thesis focuses on how the layered home can serve as a modular beacon that encourages tranquility and stability within the community. The technological advancements will be used in a humanitarian way to protect this community through the architecture of homes.

MEMORIA EN CAPAS (MEMORY IN LAYERS)
A 3D PRINTED COMMUNITY FOR THE IMPOVERISHED IN EL SALVADOR

by

Christian Omar Romero

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Advisory Committee:
Brian Kelly, Chair
Lindsey May, Committee Member
Joseph Wiliams, Committee Member

Dedication

I dedicate this thesis to my grandmother and grandfather in El Salvador. To those who are living in unjust conditions. Thank you for constantly being an inspiration in everything I do.

Acknowledgements

Special Thanks to my thesis chair Brian Kelly and my thesis committee for pushing this thesis further than I would have done on my own! Special thanks to peers who participated in designing their homes using the catalog provided. Special thanks to members of the social media platform who participated in major design decisions using polls through Facebook and Instagram.

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Chapter 1: Welcome to Grandma's House

Background

What do you remember when going to your grandmother's house? Knitting? Cookies? My memory of visiting my grandmother (pictured in Figure 1) is of her using buckets to remove water that was flooding her living room. I remember the heat of the summer and not being able to cool down. I remember having to use the bathroom outside and having to use a bowl to bathe.

Visiting the impoverished country of El Salvador, my family showed me firsthand how blessed we were to have the home we had. I was taught to appreciate the walls that protected us from the elements. I remember the homelessness, the leaky corrugated steel roof, the soft mud floors, concrete cinder block walls and the blistering heat. It was a memory of happiness and gratefulness to be alive. This is a shared memory between thousands of first-generation Latin Americans. When thinking about Memoria en Capas or memory in layers I am asking you to remember the layers surrounding your memory, the subconscious layers that gave you the entire picture.

Due to the 2001 earthquake, economic turmoil, and political unrest two million now live in disheveled homes and 500,000 are homeless. How can these layered homes serve as a modular beacon that encourages tranquility and stability within the community? With an average income of $3,500 annually families struggle to build traditional homes. It is simply inefficient, wasteful and costs much more that 3D printed structures. Capa por Capa or Layer by Layer, the concrete home alternative will seek to build more sustainably, cheaper, and safer. The homes will use

a mix of native materials and concrete to contour new homes that employ phenomenology with a focus on light, vegetation, water and air...just a few layers of a home to positively impact the greater layers of the community like safety, entrepreneurship, education, and HOPE.

Figure 1 - Collage of Dominga Romero in her home, neighborhood, and country.

Early History of El Salvador

The Salvadorian identity is much more than the negative connotations the current United States president makes them out to be. The country has a rich and deepening history that explains a lot of the issues they currently face. El Salvador was occupied by a mix of indigenous people way before the Spaniards arrived in the 16th

century. The territory was rich in Mayan peoples including the Pocomam, Chortí, and Lenca. The Mexican Aztec peoples were also predominant in the area, known as the Pipil. Some towns founded by indigenous people still exist to this day including the town of Sonsonate and Ahuachapán.[1]

The colonial period began in 1524 when Pedro de Alvarado led troops from Guatemala. Overpowering the Pipil people and their city of Cuscatlán and founded the city of San Salvador in 1528 and still exists today.[2] The territory that would form El Salvador became the agricultural lands for the Guatemalan cities. Spaniards found wealth in the export of cocoa during the 16th century and in indigo in the 1700's. The exportation of indigo led families to create large estates and sophisticated the commercialization of agriculture in the area. Ultimately leading to the planter families uprising and agitating the idea of Central American Independence.

Long held hostility toward Guatemalan merchants who controlled the economy of San Salvador as well as the independence of pastoral services led to an uprising in the early 1800's led by Delgado Acre. Faced with defeat late in 1822, a Salvadoran congress sought adoption of a resolution providing for the province's annexation to the United States but later abandoned in 1823. Meeting in June of that year in Guatemala City, a Central American constitutional convention chose Delgado as its president, appointed Arce as a member of the provisional executive triumvirate, and went on to draft a constitution, which was completed in 1824. The state created

[1] Minority Rights Group International, World Directory of Minorities and Indigenous Peoples - El Salvador, September 2017, available at: https://www.refworld.org/docid/4954ce3623.html
[2] Ruiza, M., Fernández, T. and Tamaro, E. (2004). Biography of Pedro de Alvarado. In Biographies and Lives. The Biographical Encyclopedia Online. Barcelona, Spain). Retrieved from https://www.biografiasyvidas.com/biografia/a/alvarado_pedro.htm

was now called the Federal Republic of Central America. The new state of San Salvador later called El Salvador in 1842, played an important part in the affairs of the Central American federation. The new country experienced increased civil strife and international conflict from 1841 to 1863 often meddling in exterior country conflicts.[3]

Coffee, War and the Economy

Late in the 19th century, a substantial shift in the country's economy became essential when the development of synthetic dyes severely reduced the income normally generated by the export of indigo. Salvadorans solved this problem by means of a "coffee revolution." New lands had to be opened to cultivation which meant the sale of the land of indigenous people. The coffee planters developed a highly efficient system of plantation enterprises and formed a closely knit elite that used its growing economic strength to ensure that the government served its interests.

In the 1920's and 1930's, coffee exports alone totaled 90% of all the country's exports. However, the global depression of the 1930's pushed El Salvador to the brink with coffee prices dropping to one-third of previous levels, coffee producers cut wages by half while others dismissed their workers altogether. Coffee rotted in the fields, while rural unemployment skyrocketed. Rural discontent turned to anger and for three days in January 1932, tens of thousands of peasants organized an open insurrection in western El Salvador. Their actions were met by bullets resulting in

[3] Jesse, Seth Micah. "Indigo and Indigeneity in El Salvador." Indigo and Indigeneity in El Salvador | Inter-American Foundation, June 2018, archive.iaf.gov/resources/publications/grassroots-development-journal/2012-focus-native-americans-and-their-resources/indigo-and-indigeneity-in-el-salvador.html.

thirty thousand peasants killed in ‘La Matanza’, El Salvador’s worst massacre. As historian Thomas Anderson suggests, ‘La Matanza’ is a way of understanding the whole political labyrinth of El Salvador. The combination of the strong grip of a coffee plantation class and a desperate rural proletariat proved to be as volatile in the 1970’s and 1980’s as it was fifty years earlier. The coffee industry managed to survive and even prospered after the Great Depression. El Salvador became known as one of the most advanced producers of coffee by introducing modern technology on the plantations and sophisticated systems in the coffee processing. By the 1970’s, El Salvador had become the world’s fourth largest exporter of coffee. With that being said, neither the landed aristocracy nor the modernizing faction of the elite showed any interest in addressing the poverty and dislocation associated with the coffee trade. For the small producers and laborers, coffee was the only way to survive.

Figure 2 – Salvadoran Woman, Iris Mendoza spreading coffee grains to be dried at El Borbollon coffee mill in Santa Ana, El Salvador in 2018. Photo Credit: Jose Cabezas/Reuters

In the 1960's and 1970's, the rural areas backed by progressive catholic clergy became discontent and began to create worker unions. The Salvadoran elite, especially the coffee barons, opposed their efforts and formed various vigilante groups, or the National Guard to violently suppress these movements. Fearing a communist domino effect in the region, the United States stepped up military aid and advisors in the late 1970's to confront the guerrillas.

The United States also pushed a social reform agenda intended to erode the popular support of the insurgency. Key to the agenda was agrarian reform: expropriating large landholdings, returning land to the tiller and fomenting agricultural cooperatives. Under pressure from the U.S. government, the Salvadoran government declared the first phase of an agrarian reform program. Practically overnight, plantation workers were declared owners of cooperatives (with thirty years to pay for the land). Despite this newly acquired land ownership however, the former coffee pickers were given very little, if any technical assistance, bank credits, or trainings in administration and management. The 1980 land reform was an anathema to the coffee barons, and they opposed the measures both vehemently and violently. The violence reached such proportions that human rights activists launched a boycott against "death squad coffee" from El Salvador.

The country was plunged into a civil war that would last for the next 12 years. The military's loss of the monopoly it had held on the direct exercise of governmental authority for nearly 50 years and a change in the relationship between the military and the country's propertied elite were some of the main consequences. The elite group felt it could no longer rely on the armed forces for protection and sought to broaden

its base of support by the formation in 1981 of a new political organization, the Nationalist Republican Alliance, led by retired major Roberto D'Aubuisson Arrieta. By the late 1980's, the modernizing sector of the Salvadoran elite including the processors and exporters, wanted to expand their control of the Salvadoran economy and diversify their holdings. They joined other sectors in urging a negotiated settlement to the civil war. They knew that the war had to end if they were going to be able to further economic development and implement their policies of corporate globalization. In 1989, the right-wing modernist candidate, Alfredo Cristiani, who was a prominent coffee grower and banker, was elected President. In 1992, the government and the FMLN reached a peace agreement brokered by the United Nations. The loss was catastrophic, seventy-five thousand people lost their lives in the twelve-year war, but the promise of a new era of peace and prosperity brought hope to the country. For a country recovering from war and facing overwhelming poverty, high foreign debt, low education levels and other development challenges, coffee presented an opportunity to reap a new kind of wealth, socially distributed wealth. Coffee still accounted for half of El Salvador's GDP in 1988. Towards the 1990's, 78% of coffee farms and 40% of the total area were in the hands of small producers. Furthermore, coffee trees represented most of the forested land in the hemisphere's second most deforested country, and coffee provided direct employment for 155,000 Salvadorans.[4]

[4] Hernández Navarro, Luis. "To Die a Little: Migration and Coffee in Mexico and Central America" Americas Program, Interhemispheric Resource Center, December 13, 2004.
Paige, Jeffery M. Coffee and Power: Revolution and the Rise of Democracy in Central America. Harvard University Press: Cambridge, Mass., 1997.

Earthquake Impact: Interview with a Local

On Saturday January 13, 2001, El Salvador suffered a major earthquake measuring a 7.6 on the Richter scale. The epicenter of the earthquake was about 105 km south-south east of the capital, San Salvador. The earthquake caused major damage in the departments of San Miguel, Santa Ana, La Libertad, La Union, La Paz and San Salvador. The most heavily affected area was the neighborhood of "Las Colinas" in the suburbs of Nueva San Salvador, where the earthquake triggered a landslide covering an estimated 400 houses entirely in mud. There was a far broader impact as rural areas across the country were severely damaged, resulting in the displacement of whole communities. This earthquake resulted in 844 people dead, 4,723 people injured, 108,226 houses destroyed, more than 150,000 buildings damaged and 1.5 billion dollars (USD) lost.[5]

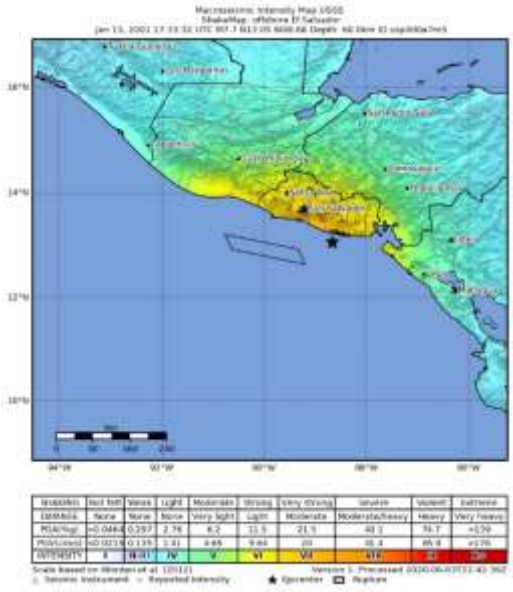


Figure 3 – Shakemap of 2001 Earthquake in El Salvador. Source: earthquake.usgs.gov

[5] Platform, International Recovery. “El Salvador Earthquake, 2001 - Countries & Disasters.” International Recovery Platform, 2019, www.recoveryplatform.org/countries_and_disasters/disaster/30/el_salvador_earthquake_2001.

Another one of the country's worst natural crises was Hurricane Ida in 2009, which left an estimated 125,000 in worsened states of poverty and caused thousands of dollars in material losses. The excess of water created irregularity caused major damage in rural areas. Since a big percentage of the people in rural areas survive from what they plant, or work at plantations as day laborers, this produced uncertainty about getting food in the future. The Ministry of Agriculture estimated a loss of $70 million dollars in crops after the hurricane.

The aftermath and displaced families are still struggling today. I was fortunate enough to have a phone call interview with a local fisherman, Manuel Sibrian, who was willing to share his experiences and life story with me after the earthquake. Manuel grew up his entire life in the small village of Guiscil in La Union, El Salvador as a fisherman with his father. He explained to me that he was not able to go to school after grade school because he needed to provide for his family. It is typical for a family to stay together when you are at an elderly age. The family grows and stays together. Unfortunately, due to the earthquake of 2001, their more 'stable' home was demolished, and were forced to build a makeshift home elsewhere. Using oyster fishing as his main source of income he was able to save enough for a steel corrugated roof that cost him two thousand dollars as well as enough cinder blocks to build a seven foot perimeter and a square footage of about 700 square footage. After asking what he would like from a new home, he said the heat is unbearable at times and access to electricity would be a luxury as he has to travel an hour to just get some Wi-Fi or charge for his phone. He explained that having all his needs in one space like the kitchen and bathroom all within the home would be super beneficial

especially to his elder parents. They hand wash their clothes in the sink and also clean most of their catch and meals from there. They also reused a chain link fence to keep his chickens and occasional calf in the backyard. He explained that the community sticks together and share resources. His neighbors provide milk, and he provides eggs while others provide bread and even corn. The sense of communal entrepreneurship is strong and keeps the community involved. He wished there were a center for it all to be in one location where all members of the community can come together and sell to one another.

People and The Need

Severe economic conditions complicated by the civil war that began in 1981 caused dramatic changes in El Salvador's demographics. It is estimated that about one-fifth of the population left the country, departing into neighboring countries and the United States. My family for one left during the civil war and gained citizenship here in the United States to provide a better life for myself and my family. Among the remaining population there was massive displacement characterized by a general movement of people from the conflict zones in the north and east to the central cities. Nevertheless, overcrowding remains a severe problem.

The intermarriage of Spanish settlers with the indigenous population of the territory has resulted in a largely ethnically homogeneous people. Almost nine-tenths of the population is mestizo or people of mixed indigenous and European ancestry, according to their census, the remainder consists of indigenous peoples. Spanish is the official language of El Salvador. About one-half of Salvadorans are Roman Catholics. Since the 1990s Evangelical Protestantism has been particularly popular among the

poor and by the 2010s more than one-third of Salvadorans were Protestants. More than three-fourths of the Salvadoran population lives in the intermontane basins of the central highlands. These areas supported large communities of indigenous people dependent on the cultivation of crops such as corn (maize), beans, and squash. The overpopulation in the central highlands has resulted in out-migration to the coastal plain, which since 1945 has been transformed by extensive cotton farming and cattle breeding.

El Salvador's economy was predominantly agricultural until industry rapidly expanded in the 1960s and '70s. Despite its traditional concentration on agriculture, the country is not self-sufficient and must import food. At the root of this problem is the disproportionate distribution of land, which favors commercial crops and leaves many peasants landless and unable to grow subsistence crops. During the civil war years, in the 1980s and the early 1990s, the U.S. government supplied El Salvador with large amounts of military and economic aid in order to counter the guerrilla army. The war had destroyed the country's economy and infrastructure. El Salvador began to recover from the effects of war until after the peace accords of 1992.

By the mid-1990s El Salvador had expanded its service industry, and in the early 2000s it increased its amount of agricultural exports and number of reconstruction projects. In 2004 El Salvador signed a free-trade agreement with the United States that further boosted its export income. However, in the late 1990s, these accomplishments had been offset by high oil prices, natural disasters like the earthquake of 2001, and a decline in the number of exporting manufacturing plants. El Salvador remains stuck in paying off its external debt and continues to rely partly

on foreign aid.[6] More than one million Salvadorans living in the United States are helping by giving back to families at home and boosting their economy a bit. El Salvador does not have a national minimum wage, but it does have minimum wages that change depending on an employee's industry, including: $242.40 a month for retail employees, $237 a month for industrial laborers, $202.80 a month for apparel assembly workers, and $113.70 a month for agriculture industry workers. The population as of 2020 is 6,486,205 and roughly one third of the population lives below the poverty line.

Chapter 2: The Culture in the Built Environment

Rural Living

The Salvadoran society in terms of culture, language and ethnicity is usually divided into three regions including east, west, and central regions. All three regions consist of temperate and warm lands with tropical vegetation and more mountain like areas more up north with pine forests. Valuable wood is obtained from the cedar, mahogany, laurel, nispero, and madrecacao trees and is used for the manufacture of furniture. The trunk of the balsa tree yields excellent lumber as well as resin that is used in the manufacture of antiseptics and medicinal gums. The main power sources, meeting most of the country's needs are the hydroelectric projects on the Lempa River 35 miles northeast of San Salvador and are administered by a government agency. All three areas have main urban cities, such as Sonsonate and Santa Ana in the west, San Salvador in the center, and La Union in the east. These main

[6] "El Salvador Compensation & Benefits Outsourcing: Global PEO Benefits Services." Globalization Partners, 20 Apr. 2020, www.globalization-partners.com/globalpedia/el-salvador-employer-of-record/compensation/.

metropolitan areas are surrounded by smaller towns and villages. These smaller towns are also surrounded by states or homesteads. Combined with high year-round temperatures and abundant rainfall, El Salvador provide favorable conditions for plant growth and agriculture.

In rural areas, homes are a mixed construction. Most houses are made of mud or adobe bricks. The structure is reinforced with pieces of wood as columns on the corners, and the roof is usually straw or aluminum if the family manages to get used aluminum sheets (figure 4 below). The mud floors are patted down and lined with flat rocks. The floor plans are usually a square of about 20 feet by 20 feet, and sometimes they make a division in the middle to get two bedrooms or split to make one bedroom and a family living area. Public gathering areas are usually reunited on the outside of the home instead of the inside because of the high temperatures. There is often no access to a sewage system so pit latrines are common.

Figure 4 – Mother and Son in Rural El Salvador. Corrugated roof and walls are a common cheap building material. Photo Source: Nora Diaz/Blog Compassion

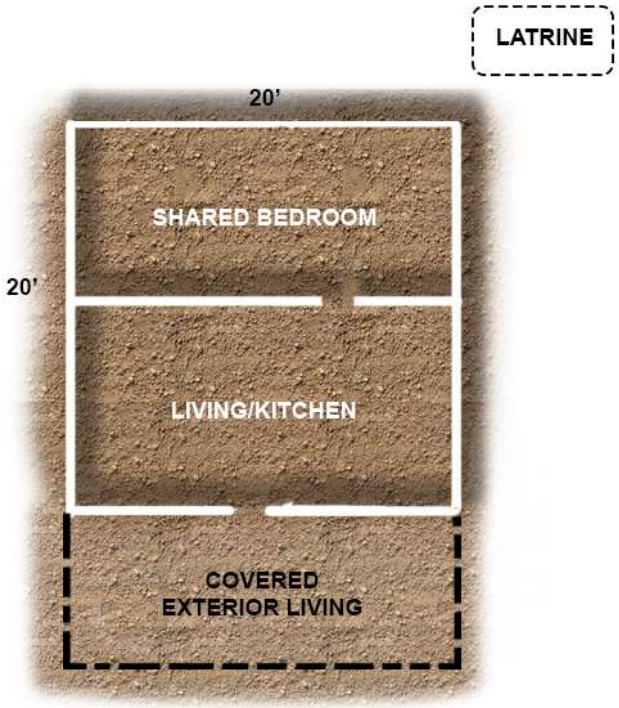


Figure 5 – Floor plan Diagram of split home and program.

Urban Living

The metropolitan areas face different challenges than those experienced in rural areas. Extortion is a big problem for people living in metropolitan areas because of spikes in gang activity and other activities under the radar. Safety is a serious issue that many families worry about and many are often fleeing their homes to escape gang activity. These criminals extort a lot of middle to low income families. People exposed to these threats express that extortionists usually know about their work, their children, and places they go. The lack of police enforcement, safety measure and lack of community surveillance means these low-income villages are always at a threat. The extortion affects small stores in commercial downtowns in the big cities, as well as the public transportation business. Gang violence has led to emigration. Twenty percent of the population lives abroad, with 2.3 million Salvadorans in the United States. Homicides are currently dropping sharply since the government

employed police and soldiers to fight extortion. The murder rate in 2019 was the lowest since the country's civil war that ended in 1992.

Figure 6 – Streets of La Union, El Salvador. Photo Source: Santos Romero

In urban settings, the typical materials are bricks and cement. There are two common methods of construction. The first is called "casa de pasaje" or alleyway houses. These are the houses for low-income families. They are small, about 480 square feet, and the rest considered a patio or open area. There is no air conditioning but does have access to some sewage lines. Half the space is considered the living room/dining room/ kitchen. The other half accounts for the two bedrooms and a bathroom. These types of homes have only one floor and are inexpensive to build. Sometimes two families share one home with a thin layer of brick dividing the two homes. The other type of construction in urban areas are slums. In El Salvador, these are called "zonas marginales," or excluded zones. In this type of 'neighborhood',

most houses are huts made of aluminum sheets, plastic, and cardboard. The floors are often soft mud floors and are susceptible to the elements.[7]

Figure 7 – Slums of El Salvador. Photo Source: Jesus Flores

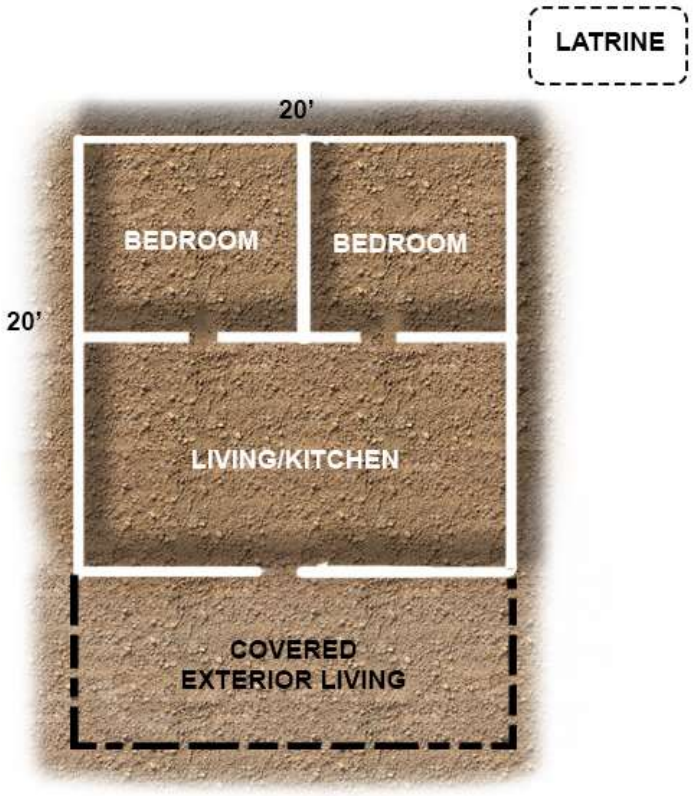


Figure 8 – Diagrammatic Floor plan split with 2 bedrooms.

[7] Reynoza, Nestor. "This Is What Life Is Like in Rural El Salvador." Compassion International Blog, 19 Feb. 2020, blog.compassion.com/el-salvador-facts-what-is-life-like-in-rural-el-salvador/.

Cultural Identities

Most El Salvador's cultural institutions are located in the capital. The most significant of these are the state-supported National Theatre and the Presidential Theatre. The Presidential theater offers performances of works by contemporary playwrights. Museums, also in the capital of San Salvador, include the Natural History Museum of El Salvador and the David J. Guzmán National Museum, which specializes in history and archaeology. These are about a three to a four-hour drive from La Union, El Salvador. Public libraries and schools are scarce and hard to reach to for many children and communities and the public transportation is often corrupted with extortion and unsafe. These children are offered to join a violent and harmful lifestyle instead of the spirit to choose life, education, and multicultural pride.

The migrant architecture in El Salvador is another building type where those who migrated bring back an idea of success to rural territories. More than 25% of the country's population lives abroad and sometimes build impressive new homes. Also known as remittance homes with money earned in the United States end up changing the rural landscape and mixing the identity even more. Remittances homes are symbols of migrant success and their importance in their country of origin. Achieving what would have been unattainable without migration, many of these aspirational homes are in a style that looks foreign.

Figure 9 – An American Flag on an El Salvadorian Home. Photo Source: Walterior Iraheta

These homes are built for a brighter future that dot the countryside. They become memorials or testimonies to the families who remain far away.[8]

Figure 10 – Children playing near a slum in La Union El Salvador. Photo Source: Nora Diaz.

Typical homes for the rural poor in El Salvador are another view of mixed architecture with references to indigenous building methods as well as a gathering of any reclaimed material. Also known as "Bahareque" homes, they are mostly made with bamboo, mud and sticks. This traditional form of construction is still practiced and are seen more and more as we encounter drastic climate change and consequences. These homes are increasingly dangerous and susceptible to falling due to the environment.

[8] Lopez, Sarah Lynn. "The Migrant Architecture of El Salvador." ReVista, 2016, revista.drclas.harvard.edu/book/migrant-architecture-el-salvador.

The frame of the homes is typically made of bamboo that are sliced lengthwise down the center. The bamboo is then filled in with mud and sticks to strengthen the rigidity. Palms can also be used to cover the gap between the walls and the roof, often composed of metal sheeting or clay tiles. The roofing systems rely heavily on reclaimed materials from the aftermath of natural disasters. The inside of the home feels much like the outside: hot, cold, windy, rainy, or damp. There is no relief from the elements. With this comes the dreadful implications of welfare especially to the more susceptible to illness. Children are more likely to suffer fevers and colds. The home is so insecure that rodents, insects, animals, even people, can easily enter uninvited. During heavy rains, bahareque homes flood and their walls crumble, resulting in constant fear of homes falling on their families.[9]

Figure 11 – A Typical home for the rural poor in El Salvador. Photo Source: April Simpson

[9] Simpson, April. "A Typical Home for The Rural Poor in El Salvador." A Typical Home for the Rural Poor in El Salvador, 21 Feb. 2018, www.blogforthepoor.org/a-typical-home-for-the-rural-poor-in-el-salvador/.

Chapter 3: Precedents and the Future of Building

Case Study #1 Al-Borde

Figure 12 – Photo source: JAG Studio, albordearq.com

AL BORDE started in 2007 in Quito – Ecuador by Pascual Gangotena (Quito, 1977), David Barragán (Quito, 1981), Marialuisa Borja (Quito, 1984) and Esteban Benavides (Quito, 1985). "Doing with little" has been their motto that symbolizes the solution of doing more with very little. Al Borde's design process is based on participation in all planning and construction phases, and on the systematic exploration of the local context. From the Nueva Esperanza School (2009), a rural school in the coastal town of Cabuyal, to the Culunco house (2014), a semi-buried family house, and the House of Beds in the Air (2017), a renovated heritage property

in the city of La Esperanza, each of their projects is made up of vernacular practices and materials that are recycled or available on site.[10]

Used to working with low construction budgets, their projects are made up of vernacular practices and recycled or available materials on site. "Al Borde is a collaborative and experimental study that is characterized by seeking consistent solutions to ordinary and current problems. The work is carried out from the specific complexity of the problem but with a comprehensive perspective, an exploration that has led them to interdisciplinary collaborations with musicians, artists, theater workers, designers, publicists, etc. The community is involved from the inception all the way to construction and ultimately involved in building on their own.

Key concepts of this project were the continuous expansion of the beginnings of a school called new hope school in chile in 2009. Located in a coastal town in chile with a community of fisherman this project was hope two, an expansion to the growing needs of the community. In 2014 they were tasked with using similar building methods with the same materials that the locals used every day but with a new sense of pride.

Figure 13 – Al Borde, Hope Two, Photo Source: JAG Studio, albourdearq.com

[10] Zeichner, Baruch. “Escuela Comunitaria Nueva Esperanza: Aprendizaje En Las Escuelas Del Siglo XXI.” Escuela Comunitaria Nueva Esperanza | Aprendizaje En Las Escuelas Del Siglo XXI, Nov. 2018, escuelassigloxxi.iadb.org/escuela/escuela-comunitaria-nueva-esperanza?fbclid=IwAR2jafErAr3rm99HhsPvvRMxWx1woYQGd9MgMndNc1vNy-LkLsqfYCw-ev4.

The ending of this project was to leave the community with a self-sufficient way of building. The goal was to teach them how to be aware of the surrounding reality. To analyze the abstract and make into a reality. Transforming these ideas into space. By understanding the reality of spaces, the need to understand the materials was imperative. Many children of the neighborhood had no schooling and was in dire need of a space for teaching and independent growth. The interior and exterior of the spaces are undefined and boundaries are blurred so that the program intersects and engages the rest of the building. The blurred lines and the open concepts were a metaphor for the children to arrive and to easily move onto to the next stage in life and explore the world. It is designed to inspire. The roof is made bundled sticks and tied together with rope. The roof frame is lined with straw for its insulation properties as well as its ability to repulse water. The fisherman of the local area uses it to plan and to meet with fellow community members.

Figure 14 – Makeshift model (top), Interior view (bottom), Photo Source: JAG Studio, albourdearq.com

Case Study #2 Elemental

Figure 15 – Verde Housing, Photo Source: Suyin Chia, elementalchile.cl

Just like Al-Borde, the Latin American based firm ELEMENTAL also focuses on housing needs in less developed nations. Elemental was founded by Chilean architect Alejandro Aravena (born on June 22, 1967) and is known as one of the most socially engaged architects to receive the Pritzker Prize. Aravena shows how the quality of a design does not necessarily depend on costs but on the design's intrinsic meaning. Aravena explains that "We don't think of ourselves as artists. Architects like to build things that are unique. But if something is unique it can't be repeated, so in terms of it serving many people in many places, the value is close to zero." The firm's primary goal is to improve people's way of life by assessing both social needs and human desires, as well as political, economic, and environmental issues. They focus on the resources available and ensure sustainability by designing forms that respond to the potentials of nature, common sense, and self-construction.[11]

[11] Chatel, Marie. "Spotlight: Alejandro Aravena." ArchDaily, ArchDaily, 22 June 2019, www.archdaily.com/789618/spotlight-alejandro-aravena.

The Verde housing project in figure 15 above showcases the use of incremental design to positively grow with the community it serves. Contacted by a forestry company, Arauco, a forestry company called them in 2009 to develop a plan to support their workers in the process. The current housing policy for Fondo Solidario de Vivienda I was to have units up to 600 UF or US$25,000 without debt and for FSV II units up to 1,000 UF or US$40,000 with a bank loan. These designs would be a contribution of the company to their workers, a kind of subvention, so that housing committees could use them when applying for the regular system of public funds.

The typology was innovative and competitive and would broaden the possible contribution to social housing. The typologies of incremental building allowed the families to fill the voids from families based off of needs. The principle of incremental construction and prioritization of the more complex components. These innovations were possible because of the direct funding of Arauco, but also because the volume of the potential demand was big enough to absorb the costs of such research. The plan estimated a total of 9,000 units in 30 different towns.

Figure 16 – site plan of homes, archdaily.com, elemental

Most of the projects were intended for towns and villages of between 10,000 and 20,000 people. In

places of such scale, housing projects, for good or for bad, do have a major impact. It is in these types of towns that the worst urban standard is found. The incremental narrative was planned with an initial and final growth scenario of higher standard: from 57 m² (initial area of each unit), they can grow up to 85 m².

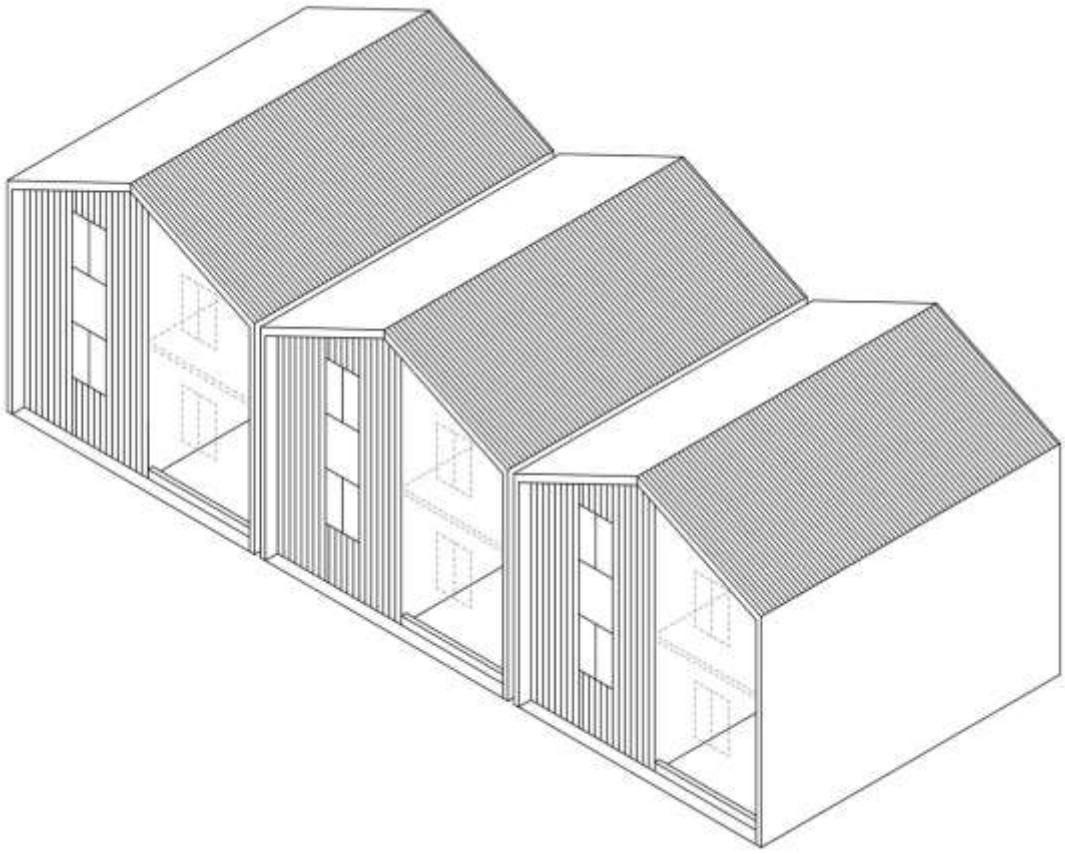


Figure 17 – axon with possible additions, archdaily.com, elementalchile.cl

Case Study #3 Icon

Figure 18 – Icon homes in Tabasco, Mexico, Photo Source: Joshua Perez, Dwell.com

The idea of building with less is an important aspect of this thesis as the resources are few and far between. That does not mean that the innovation of newer technologies should be limited. The use of outside technology such as 3D printing combined with the need of the community and the number of resources available can be seen in this instance with the company Icon.

The mission of ICON is to revolutionize homebuilding. Founded in collaboration with New Story, they joined passions in sustainability, technology, and software to provide a new way of building. Icon homes can be built in 48 hours (according to their website), that is a testament to their innovation. They utilize a robotic 3d printer that is adjustable in width and can print about 2,000 square feet of concrete. Controlled through tablets, remote monitoring, and simplicity of set up and operations allow easy and quick building.

In Tabasco, Mexico, several families are living below the poverty line and are invited to apply for a future 3D home. A 3D-printed, 500-square foot structure with two bedrooms, one bath, a wraparound cement patio, and an awning over the front porch can be built for less than $3000 in material. The minimalist off-white exterior is complimented by breeze blocks and sits firmly on the cement pad, with a compact contemporary feel. The main printer used was ICON's Vulcan II printer in around 24 hours across several days and was finished with traditional labor by local nonprofit organization ÉCHALE. The cement pad doubles as a patio, multiple windows provide ample light to the interiors, and breeze blocks above the windows allow for ventilation. [12]

Figure 19 - Icon homes being printed in Tabasco, Mexico, Photo Source: Joshua Perez, Dwell.com

"As we spoke to the community members, we realized that a single house design doesn't respond to the needs and expectations of everyone," explains renowned

[12] Reggev, Kate. “How ICON Is Building the $4,000 3D-Printed Homes of the Future.” Dwell, 14 Feb. 2019, www.dwell.com/article/icon-3d-printed-homes-for-4000-dollars-23d715bf.

designer Yves Béhar of fuse project, who worked alongside ICON and New Story for the prototype designs. Each home will come with two bedrooms, one bath, a kitchen, and a living room.[13]

Figure 20 – Modest kitchen and Living, Photo Source: Joshua Perez, Dwell.com

With ICON's technology, New Story is proving that 3D printing can provide homes to families like the ones in Tabasco, Mexico. ICON's Vulcan II printer was specifically designed for the rigors of remote, rural printing, where limited resources, unpredictable weather conditions, and unreliable power make traditional construction near impossible. New Story has built more than 2,700 homes for over 15,000 people using traditional construction methods in Bolivia, Haiti, El Salvador, and Mexico.

[13] "Technology." ICON, 2020, www.iconbuild.com/technology.

Case Study #4 - Vincent Callebaut's 5 Farming Bridges, Iraq

Figure 21 - Vincent Callebaut Architectures, Rendering by the firm.

Though the initial prints may seem elementary and limited, the exploration of the technologies explored by Icon can be endless. The idea of having a new tool in the arsenal of builders is just another way innovation can be brought to the building culture and reshaping identities. This case study examines how the architect Vincent Callebaut employed 3D printed technologies with Drones to rebuild a war ridden country, Iraq. "According to the Iraqi government, more than $1 billion will be needed to rehabilitate basic services throughout Mosul and prepare a resilient urban plan to welcome the war refugees and internally displaced persons to the country with dignity," said Vincent Callebaut in a project description online. "The 5 Mosul bridges connecting the west and east districts across the Tigris were destroyed to encircle ISIS." The main concept is to rebuild them as inhabited bridges by building the new city over the old city.

The inhabited bridges will be printed in 3D using debris from war ruins and rubble. The units compose of modular units that add up to more than 53,000 units. The firm tried to incorporate sustainability as well by covering the rubble with urban farms and agricultural fields dedicated to permaculture to guarantee food autonomy to their inhabitants and doubles as a thermal inertia to the built environment. Urban farms and orchards will be irrigated by water from the Tigris, plowed by Archimedes screws. Gray water from bathrooms and kitchens will also be recycled and filtered by plants in lagoon waterfalls connected with the river. Biomass composters will feed their orchards and vegetable gardens suspended in biological fertilizers.[14]

Figure 22 - Vincent Callebaut Architectures, Communal corners rendering by the firm.

The design is directly impacted by the nature surrounding us, specifically the honeycomb and muqarnas, the famous, ornamental honeycomb pattern, used in Islamic architecture since medieval times. Stacking these typical houses in a space

[14] Contents, WA. "Vincent Callebaut's 5 Farming Bridges Will Feature Thousands of 3D Printed Housing Units in Iraq." World Architecture Community, World Architecture Community, 4 Dec.

creates a corbelled structure consisting of thousands of stalactites, which redescend the structural loads towards the bridge piers. The typical houses are made up of 2, 5, or 10 modules, respectively forming dwellings of 25, 65, and 120 square meters. The constructive system responds to different habitable capacity requirements, according to the size of the Iraqi family to be accommodated. Stacked in large groups, the typical houses form quarters with ocher toned facades, and, over the years, a dense, green, and sustainable village above the Tigris. The facades are reminiscent of the ziggurats with their succession of superimposed terraces, distanced with respect to each other.

The unusual construction method is theoretical and supposed to build efficiently and fast. Five 3D printers in the form of articulated spiders will allow the construction of 30 houses per day, or nearly 55,000 housing units in five years spread over the five bridges. "All debris will be transformed into resources. To feed these 3D spider printers, drones will continuously bring them construction materials coming from the districts in ruins; previously crushed and transformed in recycling centers," explained the firm. "Equipped with an industrial precision robotic arm, the spiders print the housing modules by directing any building nozzle such as those used to pour concrete and insulation materials, or those using a milling head."[15]

Figure 23 - Vincent Callebaut Architectures, Modules rendering by the firm.

[15] Contents, WA. “Vincent Callebaut's 5 Farming Bridges Will Feature Thousands of 3D Printed Housing Units in Iraq.” World Architecture Community, World Architecture Community, 4 Dec.

Chapter 4: Benefits of 3D Printing Technologies

The Technology

Figure 24 – Icon's Vulcan concrete printer, Source: fortune.com

The future of building is getting more advanced, as it should which means that new solutions to decades old problems can be re-evaluated. Printing with this new technology ensures that the build speed is cut down by fractions of the time of normal stick and stone frame construction. The cost of material is significantly cheaper as the number of different materials is reduced. Aside from the low cost and high build speed, another benefit of concrete 3D printing is that nearly no material is wasted during the production process, making it more environmentally friendly than traditional techniques.

3D printing can be used to produce homes for people that lost their homes in an unfortunate natural disaster, create cheap homes for the homeless, and handle

geometries that would be difficult for traditional construction techniques to handle. Forms can be made to handle tough environmental challenges. The printed homes can be built on site or in a factory and shipped out to site. While concrete 3D printing will not fully replace traditional building techniques completely, the advantages of the technology are undeniable.

Figure 25 – Printer Specs provided by Icon.com, all3dp.com

The technology like all technology has its limitations. First and foremost, a concrete 3D printer must be quite substantial in size. The average build height of a printer is 8 and a half feet tall and 28 feet wide span and weigh up to 3,800 pounds. The printer itself must be large enough to cover a suitable square footage that is acceptable for its inhabitants. However, concrete 3D printers are usually portable, enabling construction in many locations using just one machine. This also means that the communities cannot be built tall and are subject to a height limitation. Since the architectural design can be 3D printed on the spot, there is no need for construction

companies to make molds and can be directly built by the community. The exposed concrete walls and geometrically complex roofs more popular can be printed individually and serve as incremental component that can be used when the community needs it. The modularity of being able to add onto the forms makes it ideal for growing families.[16]

Thermal insulation can be tackled on a site to site basis and can be mixed with the concrete. Certain mixes of concrete including mixes with straw, coffee, hay and more have a high thermal mass which results in energy efficiency. Foam and other insulation materials can be integrated into the concrete walls if needed. To achieve such great performance, the concrete mix must contain perfect amounts of chemicals and superplasticizers. Superplasticizers are used to reduce water in a concrete mix. Manufacturers also improve the strength of the concrete by adding fibers into the mix.

Figure 26 – Yavapi College 3D printed proto-type, Source: asme.org

Concrete 3D printers have not eliminated the need for construction workers, but it has made their job easier and safer. This allows for locals who have not had the proper training an opportunity to grow a new career for their community. Local workers need to deposit specially designed rails for the printer. They then, put the printer on the rails, set up the pillars and check all three axes. The nozzle and a robotic arm are located on a horizontal

[16] D., Jamie. "3D Printing: The Future of Construction." 3Dnatives, 31 Jan. 2018, www.3dnatives.com/en/3d-printing-construction-310120184/.

metal beam that is put across the pillars of the concrete 3D printer. When the 3D design of the house is ready, concrete comes to the construction field in a normal concrete truck and is connected to the printer's nozzle.[17]

Cost Difference

Examples of house framing costs

To help you better estimate your costs, here are some examples project price breakdowns from a Thumbtack pro:

Expense	Cost per square foot
Hardware (nails, hangers for the trusses, Simpson connections, etc.)	$4
Lumber only	$5–$10, depending on the type of wood
Labor and lumber	$9–$21, depending on the type of wood

Example project: Custom 5,000-square-foot home

- **Total cost**: $35,000
- **Cost per square foot**: $7

Figure 27 – information for chart from thumbtack.com

Framing is the process of erecting the structural outline of a new building. It is a critical step in any building construction project. This structural outline will be what holds the walls, siding, windows, doors, and roof. It is also where the plumbing and electrical wiring is concealed. The frame can be made of lumber, concrete, brick, or steel, but most residential homes in America are built using lumber, Central America uses more cinder blocks to frame their homes. After the foundation is layer, the home gets its framing. In El Salvador, the foundations or compacted mud floors. A lot of

[17] Greguric, Leo. "Concrete 3D Printing: How It Works & Applications." All3DP, Aug. 2018, all3dp.com/2/concrete-3d-printing-how-to-do-it-and-application/.

the times the walls are not perfectly plumb, and the joists not exactly parallel which results in a weakening of the strength and integrity of the frame. The national average cost of framing a house is between $3,500 and $35,000, depending on the size. House framing costs are generally priced by square foot and your total price will depend on the house's floor plan, site elevation, design of the home, and regional material and labor costs. The disheveled homes in El Salvador are usually made of recycled woods and cinderblocks that are bonded together by concrete. The 3D printed homes use no traditional framing as the structure is purely the exterior concrete walls.

According to HomeAdvisor.com, the average cost for insulation per square foot is between $0.64 - $1.19. So, for a 500 square foot area, the estimate will vary between $145 to $200, without labor. The homes closer to the city have some insulation but most of the homes have very little to none in El Salvador due to the tropical climate and humidity. A lot of the disheveled homes are open to the air with a gap between the walls and the roof to allow air circulation. The concrete printed modules print in hollow patterns to allow for the insertion of native materials like hay and adobe with clam shells with high thermal properties.

According to roofingcalc.com, the average price for a simple asphalt roof can cost between $5,000 to $8,000. This can reach up to $9,000 to $15,000 for higher end materials alone. The homes in these impoverished communities use recycled corrugated steel panels as their roof as they can not afford traditional building methods. The 3D printed roofs can be printed itself as a base and attached to the structural walls or can be made of local recycled materials saving on costs. Average fixed windows can go anywhere from $65 to $500. Doors can also average about the

same as windows. (The numbers projected above are as of 2020 and may increase in the later years as everything does).

Figure 28 – 3D printer juxtaposed to adobe bahareque home in el Salvador. Photo source: all3dp.com

Icon's 3D printer the Vulcan can print a home much cheaper. At 350 square feet, the 3D printed prototype they made was far cheaper than the average tiny home, which has a price tag at around $25,000. According to their website, they project that it could build a 600- to 800-square-foot home in just 24 hours for $4,000 or less. When it comes to producing an average-sized home — around 2,000 square feet — the savings are not quite as stark. A year after releasing its $10,000 prototype in Austin, Texas, Icon told the Wall Street Journal that printing a 2,000-square-foot home would cost around $20,000. The Company's printer (The Vulcan II) is now for sale and can be used anywhere and by anyone.[18]

Accessibility

Icon's Vulcan II only requires four to six people on-site to operate and oversee the entire process. In terms of interface, a built-in CAD tool and print planning platform translates floor plans into print jobs within minutes and provides

[18] Bendix, Aria. "These 3D-Printed Homes Can Be Built for Less than $4,000 in Just 24 Hours." Business Insider, Business Insider, 12 Mar. 2019, www.businessinsider.com/3d-homes-that-take-24-hours-and-less-than-4000-to-print-2018-9.

pre-print visualization. All components are IP66-certified, which means they perform well under all weather conditions. Additionally, the printed house sits on top of an ultra-reinforced foundation made to withstand any seismic activity. The Vulcan II prints exclusively with Lavacrete, which was developed by Icon to have the properties of concrete, but the stiffness required to be extruded from a nozzle. In other words, Lavacrete holds its shape once it is extruded. Such a massive 3-D printer in the developing world is tricky though because power outages are commonplace in El Salvador, and the terrain is sensitive to flooding and earthquakes.

Figure 29 - US military 3D printing a Concrete Barrack. Image Source: Rima Sabina Auof, dezeen.com

The Vulcan plugs into an outlet or runs on a battery, but when the electricity starts flickering, its backup, built-in generator kicks in. The 1-inch layers of concrete hardens quick enough to reduce interference from exterior powers like debris. The printing process happens in one fell swoop, allowing the Vulcan to build homes in

under 24 hours. It prints homes at about 600 to 800-square feet–just enough for a three to four-person family–and capable of protecting people from natural disasters. 3-D printers lay out the structure of the home first, so someone must go in and add the small fixings. These companies need to investigate digital fabrication, which combines the efficiency of 3-D printing with computer-aided design (like CAD or BIM). It will take more time, but the process ensures that each nook and cranny fit securely into the structure.

Figure 30 – US military 3D printed Concrete Barrack. Image Source: Rima Sabina Auof, dezeen.com

Once Printed these structures are stable and rigid. In a world first, the US Armed Forces has 3D printed a barracks out of concrete on site at an army base, in less than two days. The Marine Corps Systems Command constructed the 46-square-metre building in 40 hours at the US Army Engineer Research and Development Center in Champaign, Illinois. Captain Matthew Friedell, a project officer from the additive manufacturing team said, "People have printed buildings and large structures, but they haven't done it on-site and all at once." Usually, to construct a

barracks manually out of wood would take ten marines five days. Friedell said the technology could also advantage communities when the military was on humanitarian or disaster-relief missions. Used as shelters these homes can save thousands in times of need and prevent a repeat of what happened to El Salvador in 2001.

Chapter 5: Phenomenology

According to archinect.com, Phenomenology in Architecture relates to your sensory reaction to a built space. How does the building or space make you feel? Some architects use materials, textures, and colors to produce phenomena while other architects use the building itself to achieve the same effect. Architecture that incorporates phenomenology is calculated from the very beginning to engage all your senses. A lot of modern-day homes have become so cluttered and full of distractions and peel and stick material that we lose our connection with the walls that we live in. This project aims to redirect this attention to our senses using the layers of the building technology to tie us back into our homes and be proud of where we live.

Neil Leach an architect from Michigan once said “There's a tendency to associate architects whose work engages the senses (vision, touch, sound, smell) with phenomenology, but I think one of the key things to phenomenology is that: basically, space is physically experienced, but is *not just physical space*, it's mental too. In other words, our experience of a space happens in our imaginations as much as in physical reality. It's that, there is a very real meaning to space, that because we are basically animals that are spatial, space as it is conceived and interpreted and understood through the experience of the occupant is as real as the physical built "bricks and mortar". Physical space is linked to a mental space through human

experience. Good architecture generates an invisible complex of expressions, sensations through movements, weight, tension, structural dynamics, and rhythm.

Concrete

Figure 31 – Koshino House by Tadao Ando. 1984

The use of concrete and layering is an important impact into the haptic sense. The body images through haptic and oriented experiences happen early in life and then our visual images happen later in life. Touch is the sensory mode that integrates our experiences of the world and of ourselves. Design is an embodied and tactile journey, guided by the hand and feelings of the body, as it is a visual and intellectual enterprise. In addition to problem solving, profound architecture evokes experiential and existential values.

The seemingly primitive material and the durability that it provides is a perfect reflection of the status of El Salvador. Though it can be roughed up and shaped through different boundaries, it remains strong and resilient. Concrete is a

common material that can be found anywhere in the world which consists of sand, stone, and cement. The emotional power in architecture comes from how we introduce natural elements into the architectural space. Simple geometries to draw delicate yet dramatic plays of light and shadow in space directly impact the lives of those who inhabit them.

Light

Figure 32 – Peter Zumthor's Thermal Baths, 1996. Image from archdaily.com

Architects like Steven Holl or Tadao Ando are great examples of the intelligent use of light. James Turrell an artist that uses color and light allows its inhabitants to feel the light and sense the space by using light. Light is a constant source of miracles and natural building material that often gets ignored. The Use of light is a key element in producing a heightening sense of space and form. The porosity and importance of transparency in light are important in promoting safety

especially in an area known for the dangers of gang violence. Light connects people to the rest of the community and connects people to nature. It is a psychological method to wellbeing; it affects us physically and mentally.

Water

Figure 33 – Glenstone Museum, Thomas Phifer and Partners. Photo from Iwan Baan.

Water is an elemental part of our lives and it is a primary source of life. It makes up seventy percent of our bodies and it directly affects our brains! According to author Wallace Nichols, seeing and hearing water releases neurochemicals in your brain that promotes wellness and increases blood flow to your heart and brain which creates an intimate sense of relaxation. Water is awe-inspiring and reflective which allows for people to meditate and contemplate. It is a perfect building material for promoting tranquility and safety within a community or space. Not only is water good for your soul, but it can also be collected sustainability and reused. It is an opportunity for rainwater collection and even for potable water. Water has an important role in the Salvadorean culture especially in La Union as the harbor

provides a source of life and means of living for fisherman. It is a beacon of purity and beauty for the community and allows for the growth of the farmland surrounding the city.

Air

Figure 34 – Mipibu House, Terra e Tuma Architects 2018, Image from Nelson Kon.

According to the CDC, humans can only live up to three minutes without breathing. Now imaging living with 4 others in a single bedroom home with fumes from the fire all through out the home with no real ventilation. Many irritants and unhealthy gases are not easily detectable by smell, but they affect millions of people around the world and negatively impacts their health. The poor indoor air quality in El Salvador is another challenge that the communities face and it is important to tackle when designing. Poor indoor air quality can lead to a variety of health defects

like headaches, fatigue, allergies and long-term effects like respiratory disorders and cancers. Natural ventilation and daylight have been shown to improve mental health and even improve child behavior in schools. A lot of schoolteachers believe that the poor air quality can lead to missed workdays and decreased teaching enthusiasm. Natural ventilation can eliminate costly mechanical equipment and ductwork while providing lower running costs. Another way to promote good air quality is by incorporating the nature and plants such as green walls that can filter carbon dioxide and harmful chemicals out of the air. Air pollution is today's most prevalent environmental killer, especially in developing countries, with approximately 7 million deaths annually worldwide.[19] It is the duty of architects and designers to design new spaces that prevent any more deaths and our duty to create clean spaces to breathe in.

[19] Schires, Megan. "How Designing for Air Quality May Determine the Outcome of Your Meeting." ArchDaily, ArchDaily, 26 Mar. 2020, www.archdaily.com/916314/how-designing-for-air-quality-may-determine-the-outcome-of-your-meeting.

Vegetation

Figure 35 – Japanese Zen Garden, Photo from interiorzine.com

Vegetation is not only natures filter, but it provides so many important factors into our lives. Plants are scientifically proven to bring happiness to people. As mentioned before, vegetation improves air quality, but it also lowers blood pressure, reduces stress, boosts immune system, creates a positive mood and improves sleep. The subliminal effect of plants brings a sense of nature and brings the energy of the outdoors indoors. Biophilia is a subject many architects are using to connect people to nature, and it is for a good reason. Plants also improve sound quality by taking the impact of busy urban living or noises occurring outdoors. Living green walls can act as extra insulation with a layer of air between the plant and the wall and can reduce the noise levels by reflecting, refracting as well as absorbing acoustic energy.

Chapter 6: Site Analysis

Site Selection

The entire thesis began with a specific site in mind, my grandmother's home. Though the memories of the site are not the best, the potential is there due to the heart and soul of the people and the culture that they bring to it. Though it is an unstable financial location, the people endure and find ways for living. The streets do not even show up for the homes on the outskirts of the main city center. With influences from colonial Spanish traditions through the law of the indies and then urban sprawl that comes out of it, the small villages that form have endured earthquakes, hurricanes and worst of all, human on human violence. The site is west of the main city center with agriculture to the south and a clam harbor the north. The site covers roughly 5,500,000 feet squared or roughly 130 acres as seen in the google maps image below.

The site is on the outskirt of the city center because of the lower regulations the residents currently experience. The lack of investment on the outskirts are alarming and must be addressed. These areas experience less political involvement which means less money being invested in these areas. It is important to understand why we are building and for whom we are building. Since there are no four seasons in the area it is important to use as much local resources as possible. It is important to create a new sense of pride in the area and plug-in new innovations like greenhouses while reusing resources like recycled windows to build sustainably. The importance of creating commitment with municipality to work with views and safety issues is also important because the low-technique solutions for these communities also means important keep up and maintenance from a governed body. The reality of the site is

that the site must create solutions through designing moments and communities and not external influences. This is done by utilizing the nature and framing it. Trading and being conscious of traditions and cultures. Trying to involve as many people and trades as possible. Being knowledgeable of the embodied carbon. Americans can live the way they do because they live off the backs of those that can't. If we all lived the way, Americans do we would need to have two and a half earths. The thesis is only one layer of the entire piece, the architectural layer, while the builders, the culture and community are all the other layers.

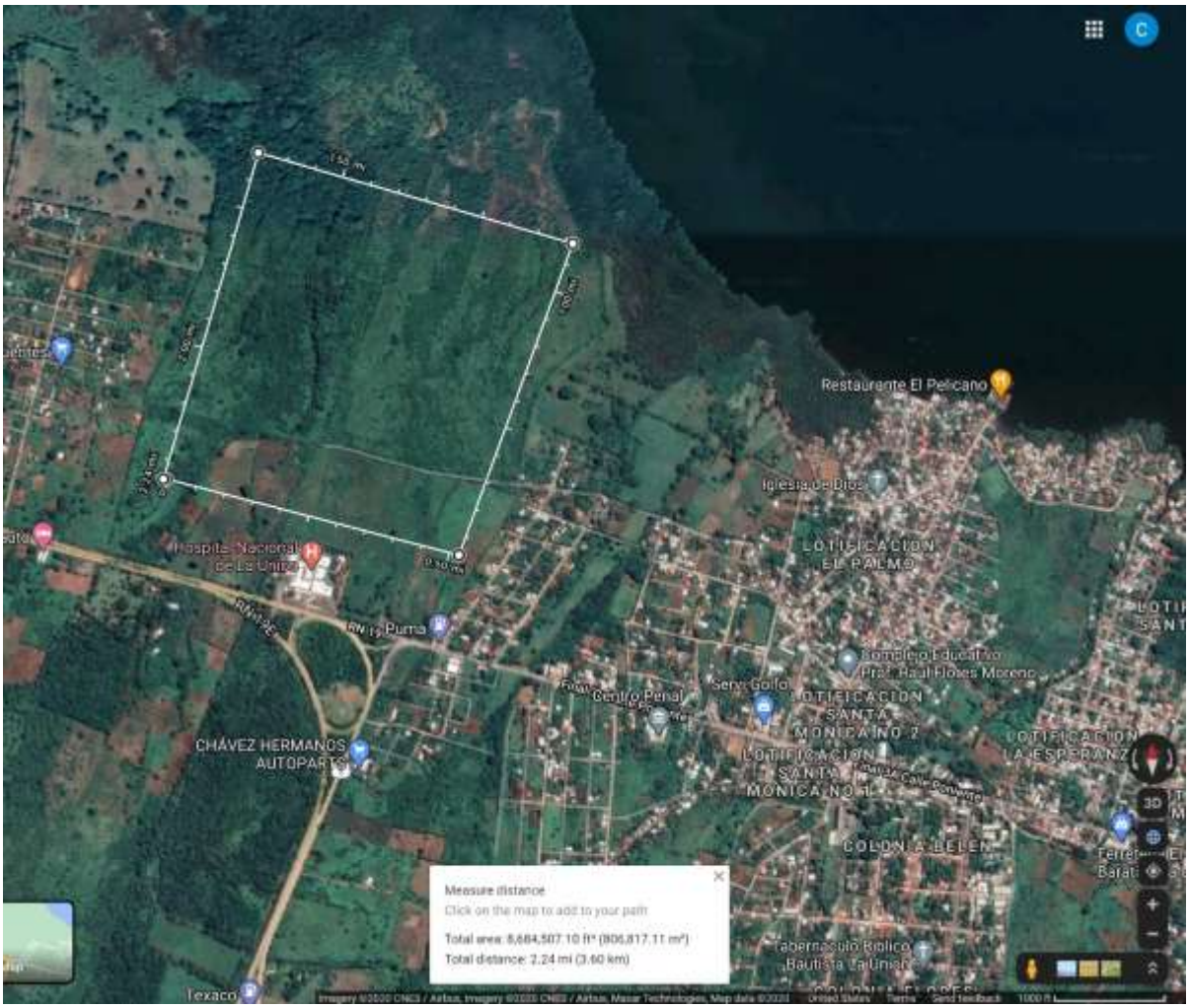


Figure 36 – Site Selection near La Union, El Salvador. Image from Google Maps.

Scale Comparison

In comparison this site is roughly more than twice the size of the Wharf phase one in Washington DC with a measured shoreline of 24 acres and 50 acres of water. The second phase of building is set to include almost 1.2 million square feet. The current built project is an example of how to use the harbor for housing, commercial and leisure. For comparison, the Wharf project designed by Perkins Eastman on the site provides ample of space for even more development. The image below is an example of the wharf on the site.

Figure 37 – The Wharf overlayed on the Site of future thesis project.

Another site that can be comparable to the low-income demographics are those seen in Baltimore, specifically the inner harbor. The inner harbor overlayed the site shows us the vast amount of opportunity the site presents for the residents. It is important to note the Westport waterfront development that is revitalizing the area in many ways as well. As the basic building blocks of the community, residential buildings must be designed to endure, prevailing through market cycles, life-style changes and design eras.

Figure 38 – Baltimore Inner Harbor, MD USA overlayed the site of the Future thesis project.

Greenbelt historic district in Maryland is another example of incorporating residents to the rest of the fabric of the city through strict guidelines and focus on sustainable mobility. Throughout my childhood I would always walk around this historic neighborhood and wonder why the neighborhood always felt like home even though it was not my home. The smart planning and the integration of all the moving parts made it feel welcoming. Below is a scale comparison of the Greenbelt historic city to the site.

Figure 39 - Historic Greenbelt MD on the Site of thesis project.

Topography

Figure 40 – Site Map of Site, in Central America.

El Salvador borders Honduras and Guatemala in Central America. The specific site of La Union sits in a channel off the Pacific Ocean called the Bahia de La Union where the views are of mountains and Volcanoes. The Image below shows how the city sits just below grade of the mountainous areas. It is tucked at the bottom of the mountains at an elevation of 4100ft above sea level. With tropical climates and being near the coast, the site is endangered of flooding as sea levels continue to rise. Nicaragua recently encountered a tropical storm that caused major flood damages. Honduras also experienced a massive hurricane that led thousands homeless. All within the same year of 2020.

Figure 41 – Terrain Map Diagram of La Union El Salvador.

Figure 42 – 10' Topography of La Union shows the gradual slope change towards the northern end of the city.

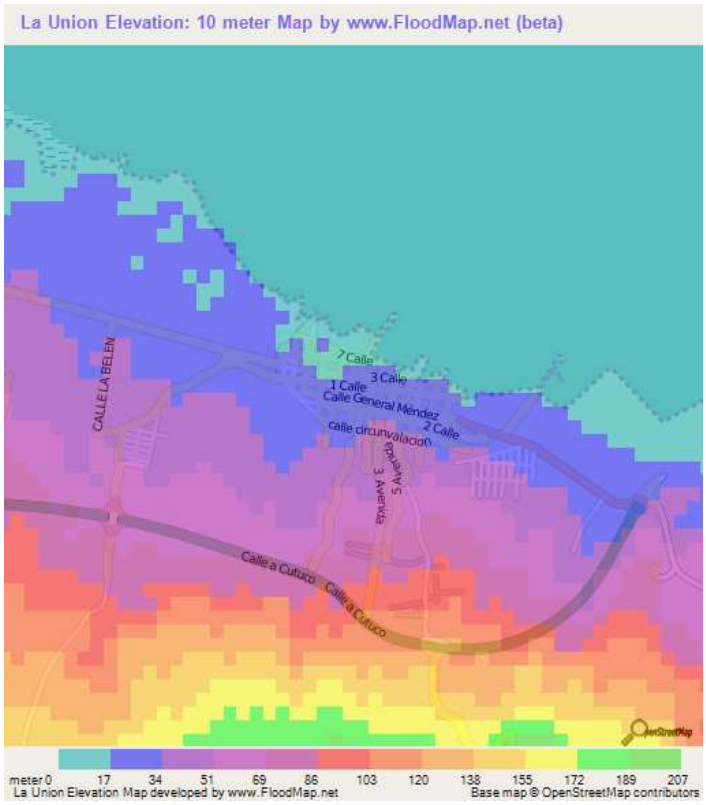


Figure 43 - 10m flood map provided by floodmap.net.

Land Uses

Figure 44 - Average Household Size in El Salvador – provided by arcgis.com

The Hispanic culture shares homes with the elderly and the young. The families often consist of average of at least four people per household. La Union

experiences an average of about 4 people per household. This in turn means a lot of homes are over occupied. The homes of the site are no more than 800 square foot on average with no more than 2 bedrooms. The site experiences a mix of city living, rural living and suburban living. The image below shows how the suburban fabric is centered around the city and becomes more of villages on the outskirts where those that are less fortunate cohabitate the land that is left over from the cities.

Figure 45 - La Union, Land Uses Diagram

Figure 46- La Union, city versus Farmland Diagram

The urban sprawl preceded the trails of the commerce leading to the harbor points. As seen in the diagram below.

Figure 47 - Urban Sprawl down based off of harbor.

Neighboring Urban Fabric

Figure 48- Historical Planning of La Union

The city has expanded based off the production of coffee and use of the harbor as seen in the 1969 arial image. The incorporation of the highway later capped the growth of the city more south. The elevation changes and the highway created a bubble known as La Union as seen in the parti below. With influences from early Spanish colonial planning including laws of the indies, the city focused a lot of the planning on the integration of the harbor and focuses on church.

Figure 49 - La Union Street Network

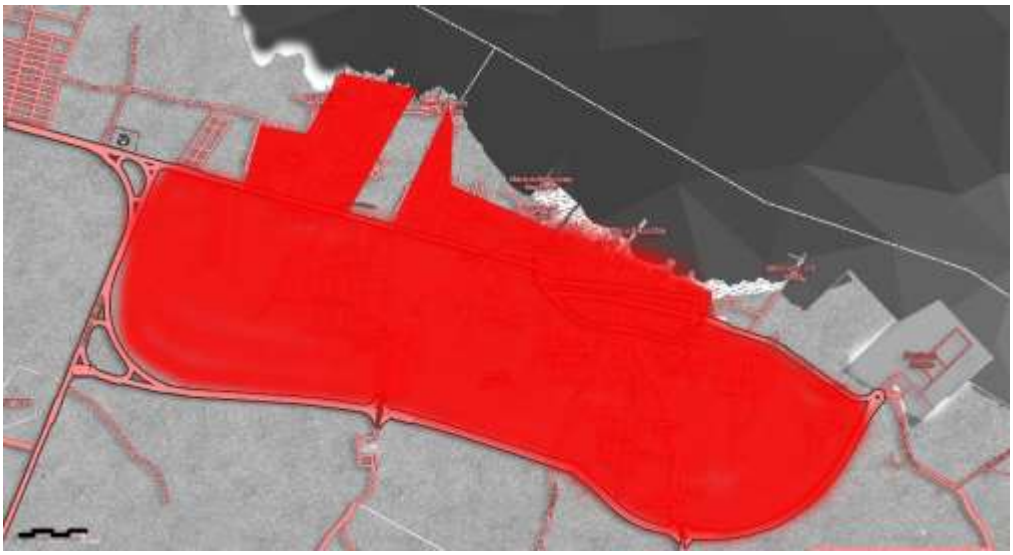


Figure 50 - La Union City Parti.

Seen in the town of Belen in La Union the city focuses routes down the harbor path with focusing direction and views towards churches. This is a direct translation of colonial planning.

Figure 51 - Colonial Planning, Town of Belen

Compared to the walled city of Manilla, the elements of colonial planning can be easily seen in towns in La Union.

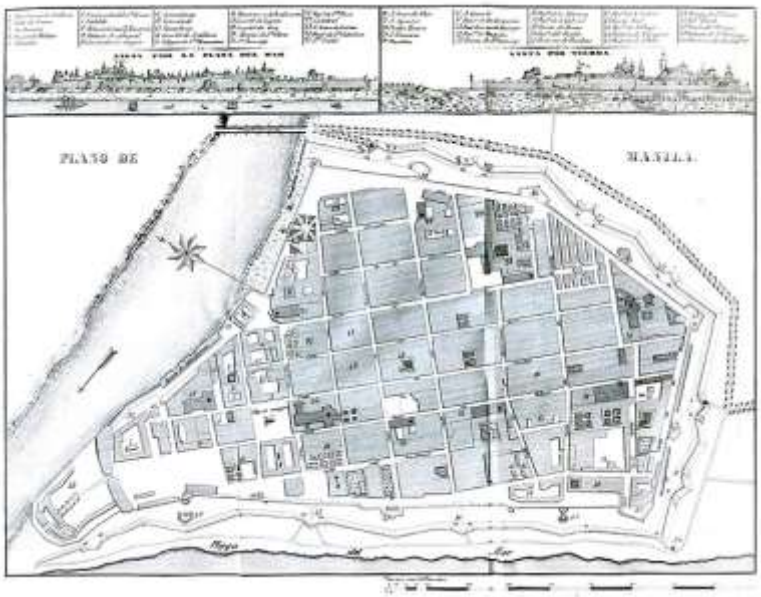


Figure 52 - Plan of city of Manila. Image Source- Britanica.com

It is important to understand the early colonizer planned many cities the same way. They used about 148 different regulations when it came to planning. The creation of a central square and rectilinear grid of streets gave order to the people. Below are some of the laws that the city of La union currently employs today[20].

- Have Fertile Soil and plenty of land for farming and pasturage. Have fuel timber and resources.
- Have fresh water, a native population, ease of transport, access and exit be open to the north wind or to the harbor.
- No building near marshes (west of La union Site) and not near lagoons which poisonous animals and polluted air and water breed.
- All the buildings should be of one type as much as possible.
- Within the town the commons should be delimited and large enough that if the town expands there should be enough space for people to raise cattle or go for recreation or for prayer.
- Placing the slaughterhouses, fisheries and businesses that produce filth away from the city centers.

[20] NOAA, PS. "The Spanish Colonial Town: Planning Flexibility in Spite of the Grid." Not Only About Architecture, 2013, www.patriciasendin.com/2014/06/the-spanish-colonial-town-planning.html.

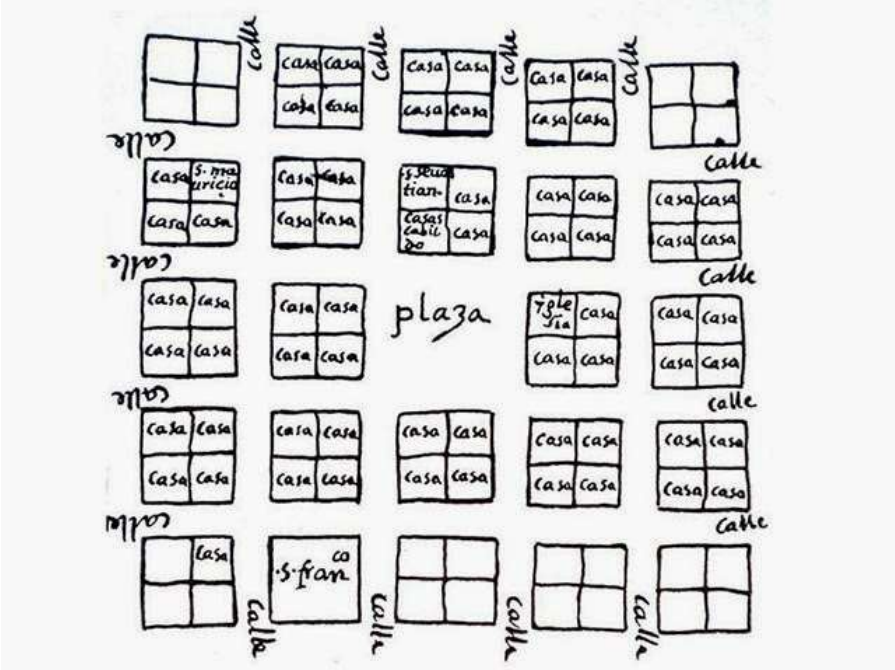


Figure 53 - Juan Matienzo Colonial Spanish Plan.

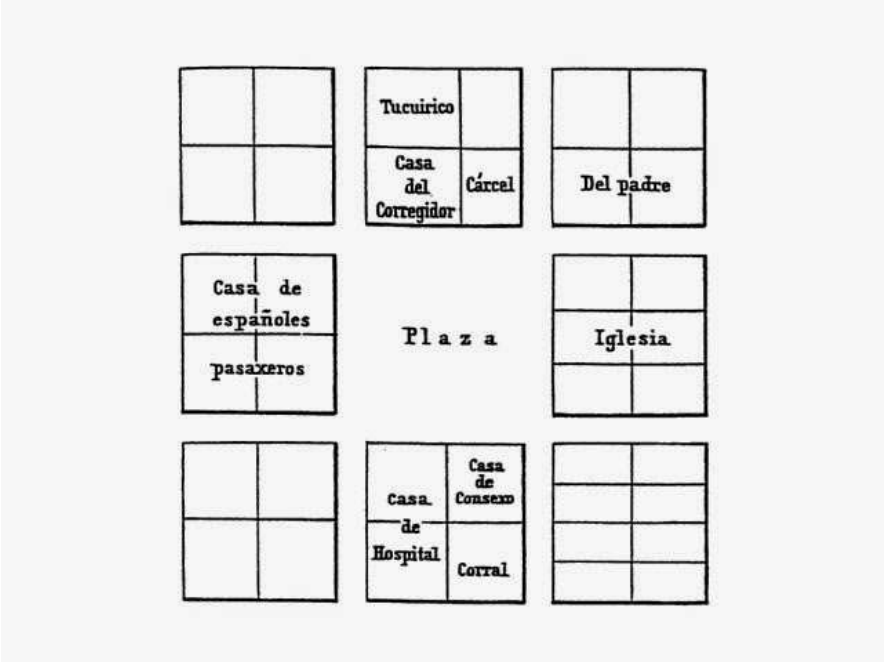


Figure 54 – The ordered Village by Juan De Matienzo, 1567, image from patriciasendin.com

Figure 55 – Buenos Aires, Argentina in 1580 plan. Photo from patriciasendin.com

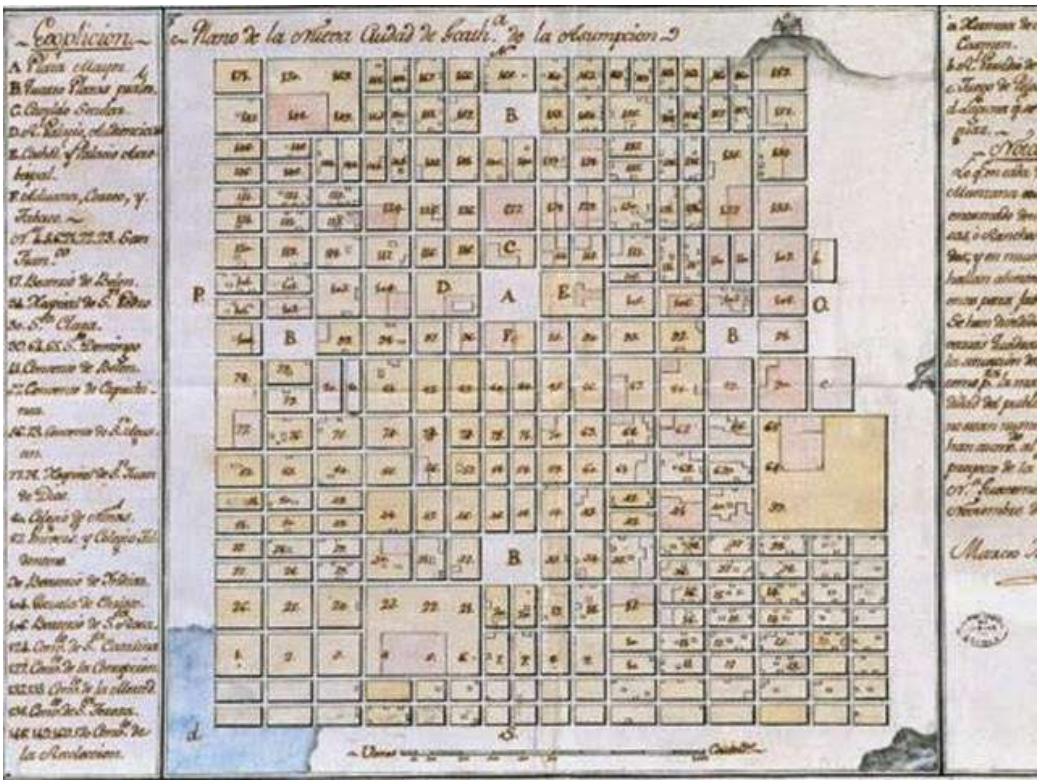


Figure 56 – Nueva Guatemala de la Auncion, 1776, photo from patriciasendin.com

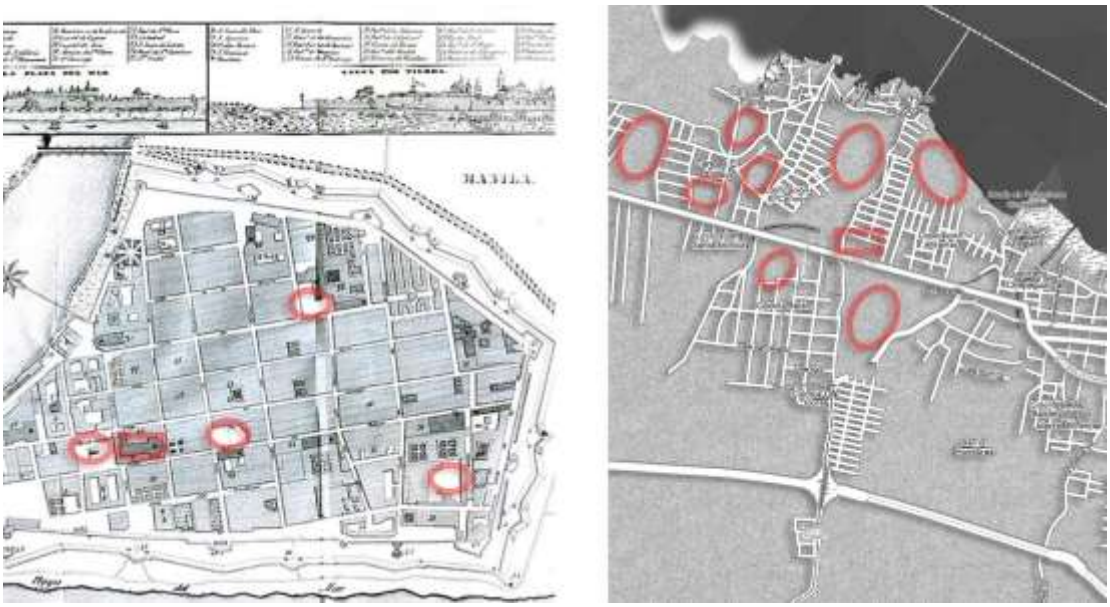


Figure 57 – Spanish Plan compared to La Union site with similar nodes and city grid.

Figure 58 – Bogota Columbia on left compared to Huisquil El Salvador on right.

Currently the site is experiencing the lack of community spaces such as recreation clubs, schools or even transit. For you to find such community amenities you must travel eastward towards the city and even then, it is difficult to find what you may find in normal American towns. There are three churches near the site, and you must cross a busy highway and try to catch a bus to the city to be able to go to a library or

school or even to just play ball. A lot of communities sell food from their own home and can even see cyclist salesmen selling bread. Grocery stores are in need as well. The harbor is host to several restaurants for tourists but is lacking the infrastructure to better the rest of the city. Unlike the Spanish colonial planning examples, this city lacks a use for central plazas and become empty wasted spaces.

Figure 59 - Community amenities targeted in city center.

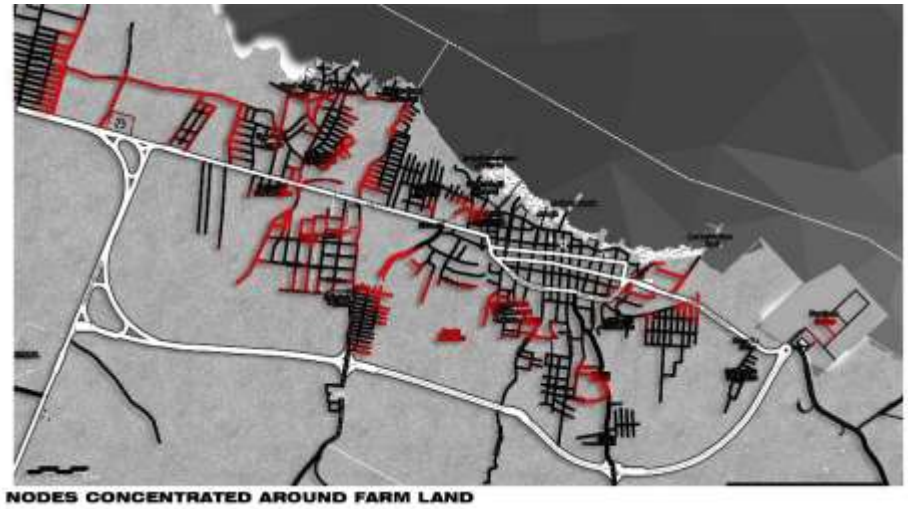


Figure 60 - City fabric creates nodes around farming land but has no solid use for the community.

Chapter 7: Site Design Approach

Figure Ground Analysis and Integration

The site's figure ground includes a major highway system south of the site that is respectfully apart from the site. The secondary roads include a connection that leads to the harbor but does not interact with the site directly. The tertiary roads are a footpath that forms a cross into the site. The city fabric lays east of the site and the rural conditions lay on the west of the site. The typology in the surrounding context are split through the gap creating an opportunity for development to bridge this divide.

Figure 61 - Figure Ground Analysis including road systems and typologies.

The gap in the site signifies a larger drive time for the residents in the rural areas. The walking distance amounts to over a 30-minute walk to get to the harbor city. The site has a relatively flat slope with a high point of 45' and a low point of 35' leading down to the water. There is a forest canopy on the left side of the site, and it becomes more sparce to the right. The design intends to maintain the forest canopy minimizing destruction and demolition. There are two small ridges towards the middle and the right side of the site where the site design intends to take advantage of the water travel.

Figure 62 - Existing Site Topography and Vegetation diagrams.

The chosen site sits on the gap between the rural and city centers. The existing roads lead to the harbor and dictate the orientation of the site. The marshland sits at the bottom of the hill and caps the site from continuing forward. The site serves to bridge the rural and harbor city disparity.

Figure 63 - Figure ground diagrams showing gaps in the site.

To bridge the design will extend the street grid by using the existing streets that lead seemingly nowhere. We then attach the cul-de-sacs to these new major roads. The existing ridges dictate where the homes will not live and where the storm water management pools will live. The natural boundaries like the tree canopy will dictate where community parklands will live.

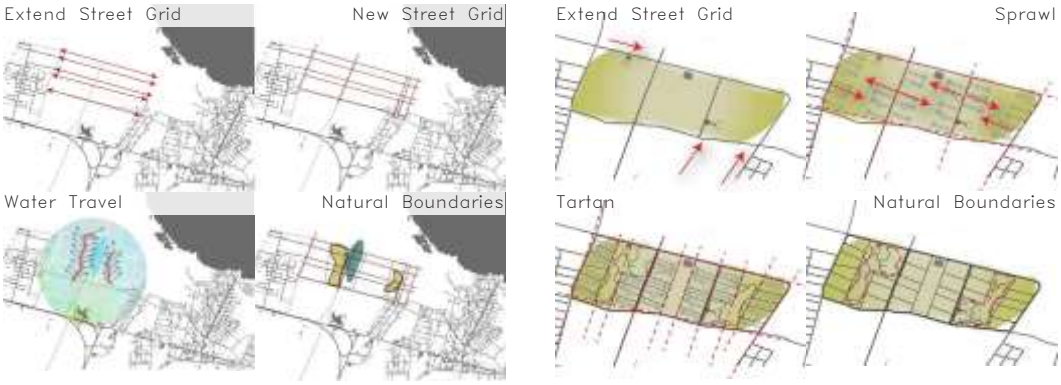


Figure 64 - Site Development Diagrams.

The site decisions were influenced by site precedents that harnessed the power of the polls. These precedents were chosen based off of what the la union community preferred. Some historical examples such as Greenbelt District in Maryland, Prospect park in New York City and even Garden cities all focused on walkability, community engagement, safety, storm management and enterepeneuralship.

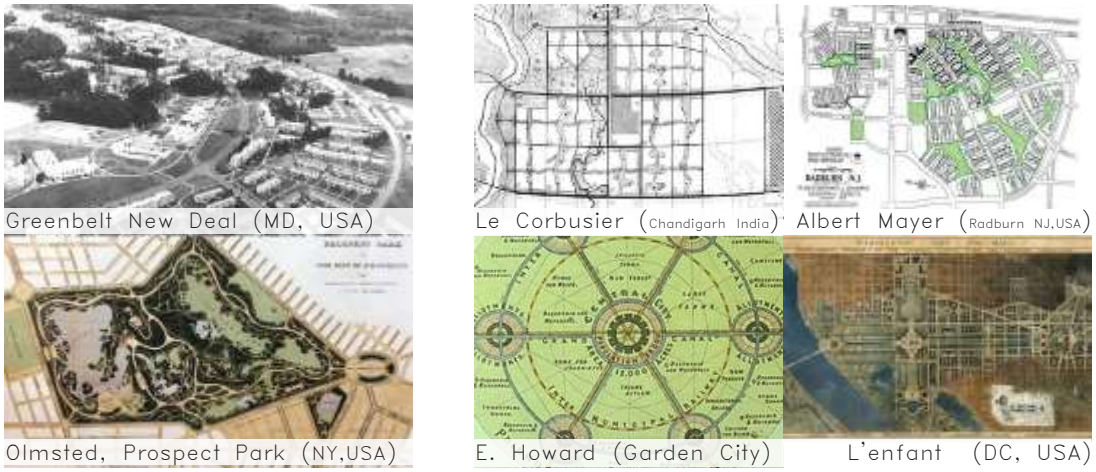


Figure 65 - Site Precedents.

Social Media Design Decisions

These homes are to be inhabited by La Union residents and it was imperative to get their input as much as possible. However, the state of the world meant that there was no more physical access to the site. Unprecedented times calls for unprecedented ways of thinking. The only way to connect to the locals was through mutual engagement of social media. The decision to reach out to the La union Facebook group was to get their ideas on paper and provide options they can visibly see through their phones. There is very little access to wi-fi access, but they do have mobile phones. Instagram polls were given as visual options of what they preferred in a community and implemented design decisions and options based off their feedback.

Figure 66 - Progression of Design Decisions.

With over hundreds of votes on Instagram and Facebook polls, it is important to understand who these people voting are. For example, 65% are actual La Union residents. Eighty percent of the voters were Central American. The folks who voted also include a wide range of workers. Some types of work included mechanics, self-employed, farmers, teachers, bakers and more.

Social Media Design Percentages

La Union Resident Percentages

Figure 67 - Voter Demographic Diagrams.

The Voters voted for a larger backyard, a more pedestrian neighborhood, a cul-de-sac plan, preferred community centers instead of shopping centers and preferred an accessible neighborhood to a gated community.

Intergrative Design Solution

Using the power of social media and invisible connectivity to decide major moments of importance for the site. Over Hundreds of Votes decided the plan layout. Participants included a mixed bag of US citizens, El Salvadorean Citizens near the site and design oriented peers.

Figure 68 - Integrative Design Polls.

El Pueblo De Capas

With all the design decisions brought forth by social media. The following image is the result.

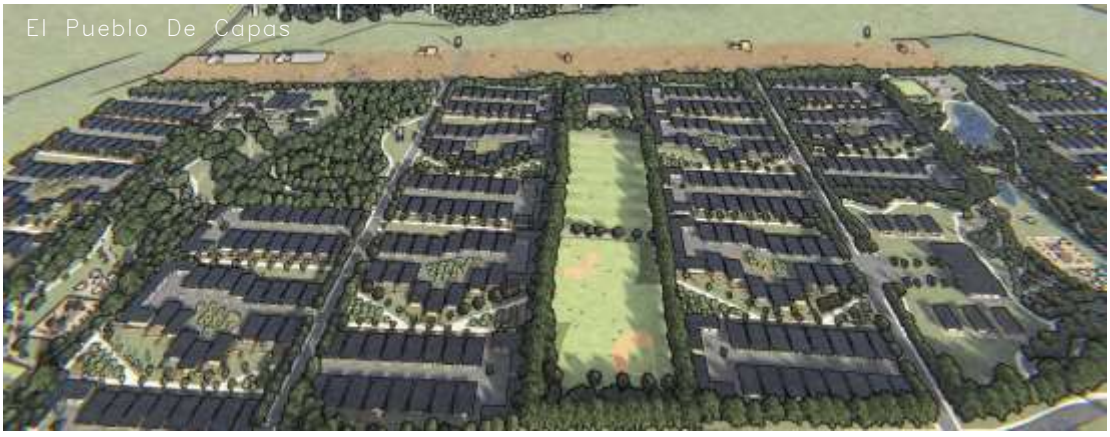


Figure 69 - El Peublo de Capas.

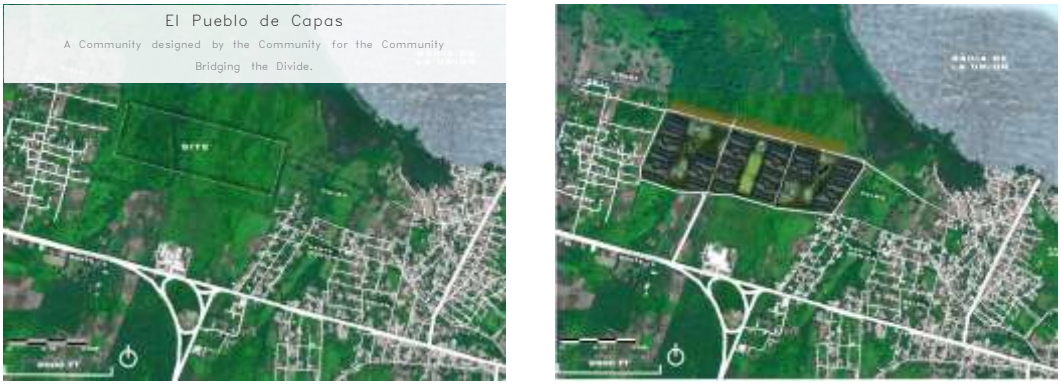


Figure 70 - El pueblo de Capas now proudly sits in the gap seen on the left. It is a community designed by the community for the community.

Like garden cities this neighborhood values the open space and ensures that every cul-de-sac has access and a pathway to the community parkland. Each home has its private realm that can be opened to a semiprivate space. The pathways encourage walkability and interaction and the cul-de-sac layout respects individual home boundaries.

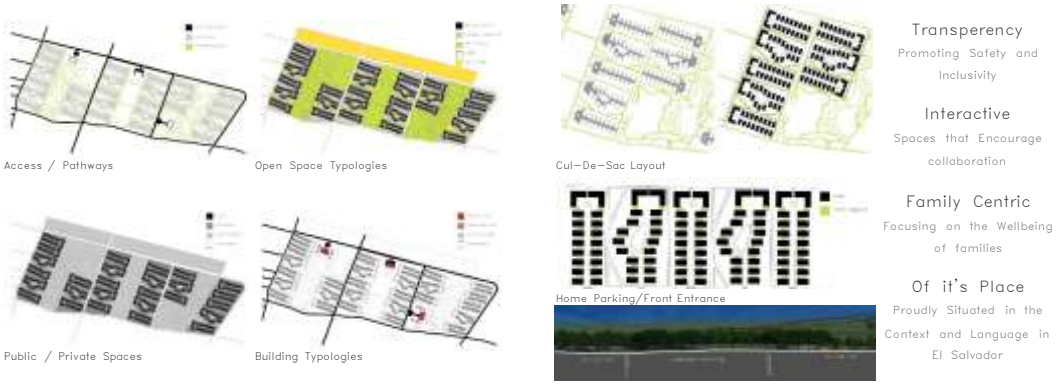


Figure 71 - Pueblo Site Diagrams.

Figure 72 - Pueblo De Capas – Moments.

Site Blocks in El Pueblo de Capas include the Forest Block, The Sports block and The Garden Block.

Figure 73 - 3 Blocks found in El Pueblo.

Forest Block Moments.

Figure 74 - Forest Block Moments.

Sports Block Moments.

Figure 75 - Sports Block Moments.

Garden Block Moments.

Figure 76 - Garden Block Moments.

There are two different types of cul-de-sacs in the neighborhood that include a farming cul-de-sac and a typical cul-de-sac. The typical layout includes 16 printed homes plus 2 generational homes.

Figure 77 - Typical Cul-De-Sac Layout.

The typical farming cul-de-sac layout has the 16 printed homes plus 2 generational homes but also includes a central communal gardening area in the street medium for shared harvesting.

Figure 78 - Typical Farming Cul-De-Sac Layout.

Typical Site Plans within the Cul-De-Sac. The individual home site plans within the cul-de-sacs includes a backyard and front yard as well as a covered porch on the side of the homes. At the ends of each cul-de-sac the site introduces two generational homes that are essentially two printed homes under one shared roof. These home site plans include ample spaces for parking plus a shared covered backyard porch.

Figure 79 - Typical Home Site Plans.

Chapter 8: Community Center Designs

Form Building Decided by Polls

With local influences such as Mayan temples and volcanoes in the area, an initial designer instinct is to celebrate this and introduce a circular home and typology like those made by Wasp in the U.S. The Instagram polls showed that the residents in EL Salvador did not want that. In actuality, 93% of the polls preferred the more contemporary style of printed homes seen in Icon's homes in Mexico. This led to an exploration of a smaller scale printer using a commercial desktop printer called Ender Pro 3 and found that the residents who will inhabit these homes were right all along. The dome prints take longer to print, requires more material and costs more than the idea of attaching a roof later. A former La Union resident also explained that giving responsibility such as a building a roof provides a micro economy for the residents and gives them a higher sense of participation.

Figure 80 - Poll Decides the form. Diagrams of form implications.

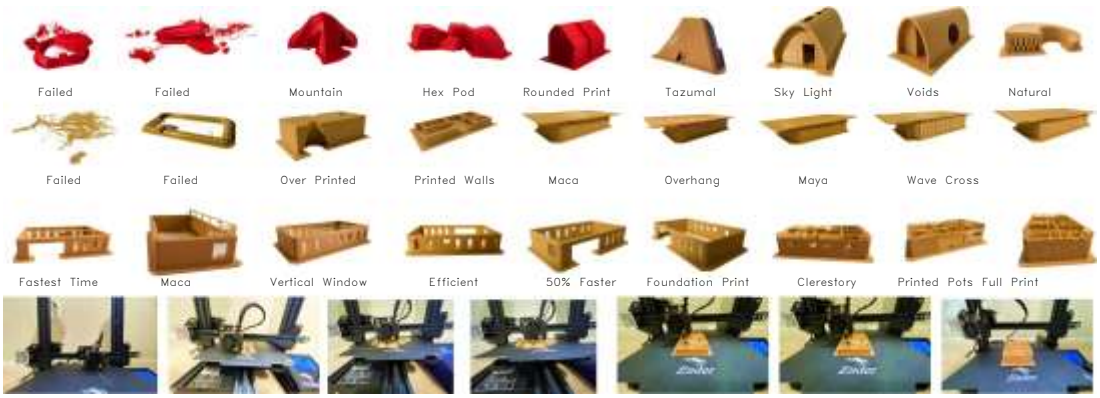


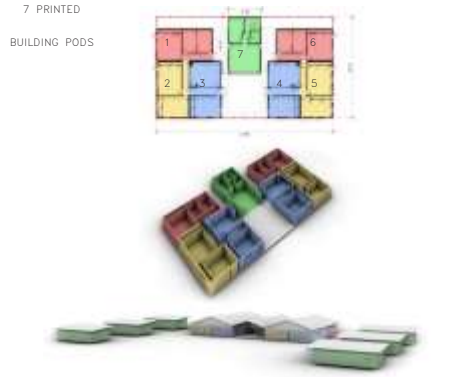
Figure 81- Small Printer Explorations.

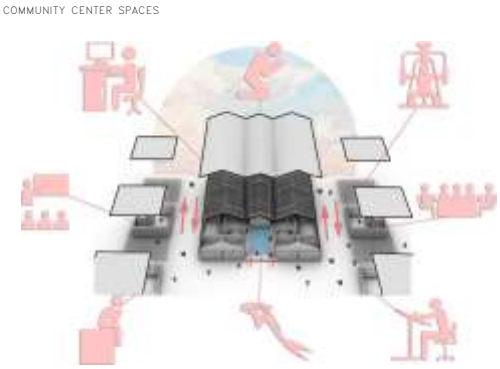
As seen in this matrix, several forms were printed in a series of different shapes and forms to prove that the Instagram polls were lying. However, it rang true as the conical shapes seen at the top row required more time and material than the examples at the bottom rows where the roof is attached later.

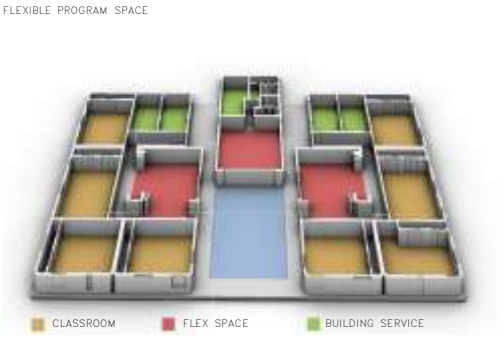
Community Centers

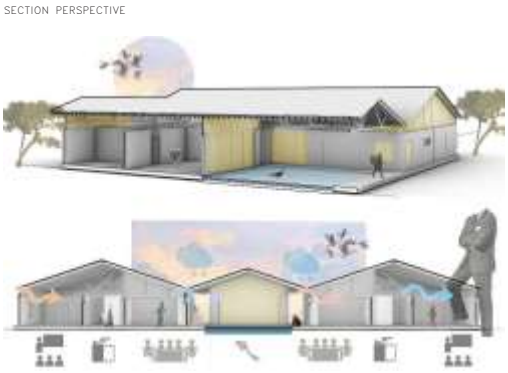
Figure 82 - Community Center Perspectives.

The community centers are open to the public for a variety of tasks. It is the glue between the three different community blocks. There is one center in each of the 3 blocks in the community. They serve as building block for each community to benefit from.









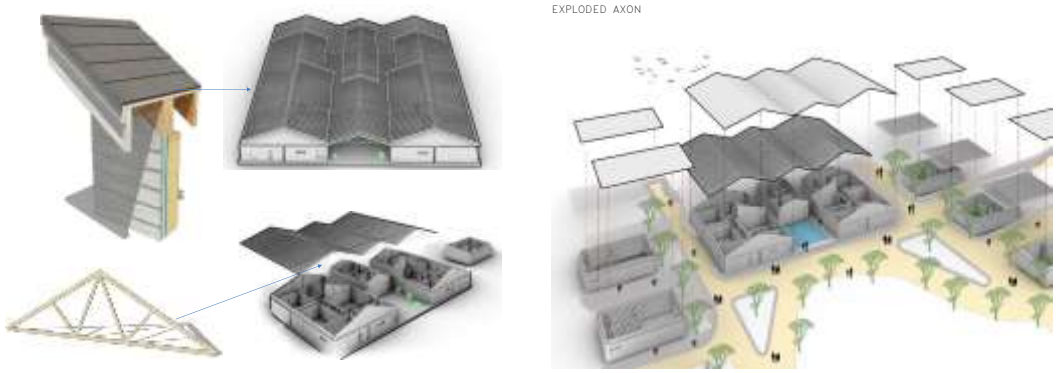


Figure 83 - Community Center Diagrams.

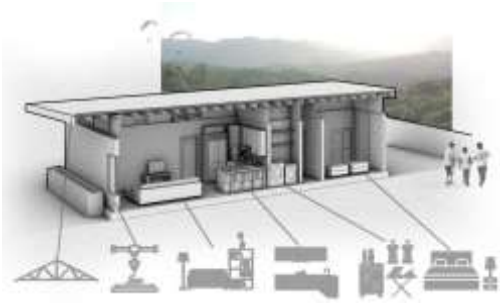
The centers are designed to be flexible in program using operable walls to open to house larger events. The clerestories are designed to open to allow natural ventilation and daylight. The pitched timber roofs are designed to rewrought stormwater into the retaining pools. The large roofs are supported by timber posts that is separate from the printed walls. The fink trusses add additional support. The centers also include 6 additional printed spaces on either side for additional classroom/flex space.

Chapter 9: La Casa De Capas

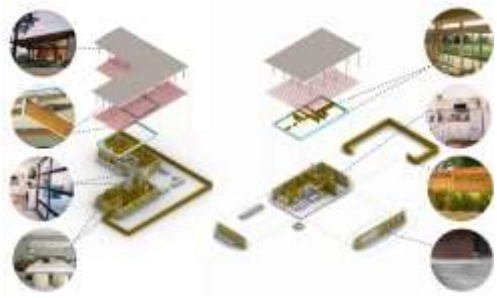
Standard Home Features

Figure 84 - La Casa De Capas Perspective.

All the Casas will include a timber roof, 3d printed walls, a shared living and dining room, a washer dryer, and a covered exterior porch. In an attempt to save on the need for electricity and outsourced power. Operable Clerestories have been designed to sit on top of the interior and exterior walls to maximize natural ventilation and daylight. A timber roof porch has become standard on all the homes in response to the outdoor living culture that currently exists there. This roof cantilevers 10’ to the side and provides ample protection from the elements year-round. The porch is designed to redirect rainwater onto the 3d printed pots for convenient gardening they are intentionally placed on the sides of the homes to maximize sunlight exposure on the crops.



Axón Explotado



Clerestory Details

Typical Home Roof

Generational Home Roof

Roof Porch (Standard on Homes)

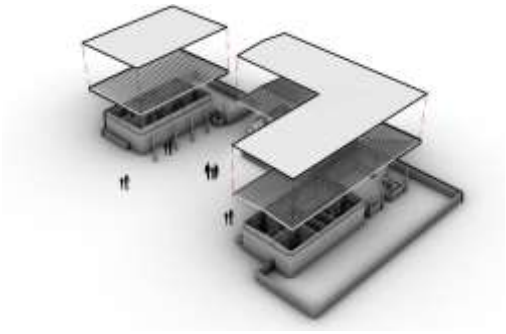
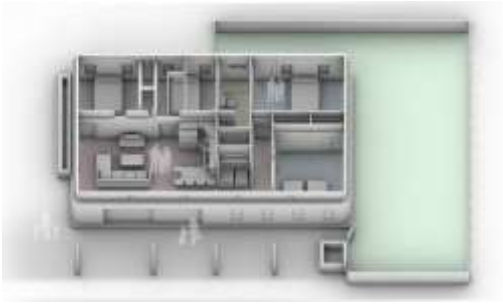


Figure 85 - La Casa Diagrams.

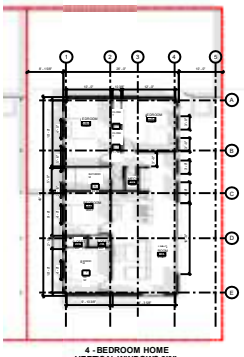
Home Design Checklist

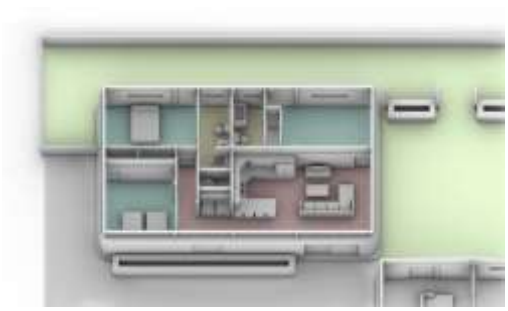
Figure 86 - Design Checklist given to Facebook Group.

Now that the site and community centers are in place, the residents can apply and design their own home. They have the option to choose which block on the site they prefer, as well as which type of floor plan, which façade, window orientation and even their color. This checklist was given to the Facebook la union group as well as peers in school and even family. According to launion.gov, the average household size per home is 3-4 people. With that in mind the floor options can accommodate a range of family types. This option includes a 4-bedroom one bath home. The three-bedroom option includes a printed master bedroom and bathroom, and an additional bathroom for the two other bedrooms. These two operable floor plan options use the 3d printer to print the exterior walls only with the option of 1 or 2 operable walls based off of the residents need at the time. They still include major amenities like washer dryer and indoor bathrooms. The generational family floor plan option is for a family who stays together but still prefers their privacy. This option is made up of two printed pods perpendicular to each other with a shared roof and larger out door indoor exterior spaces in the backyard.

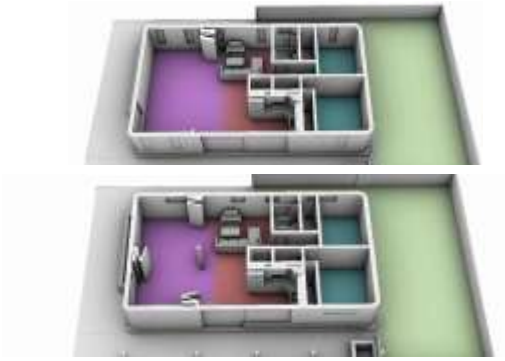


4 Bedroom Floor Plan Option

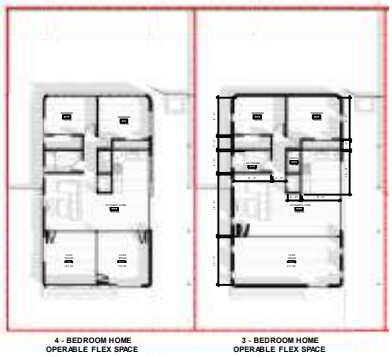


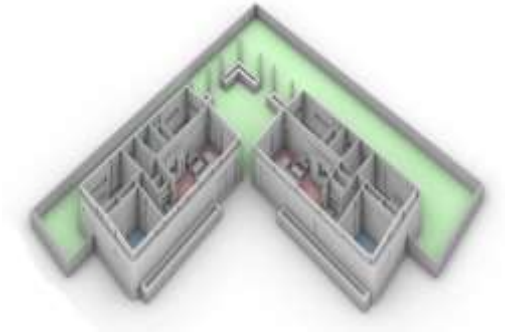


3 Bedroom Floor Plan Option



Operable Floor Plan Options

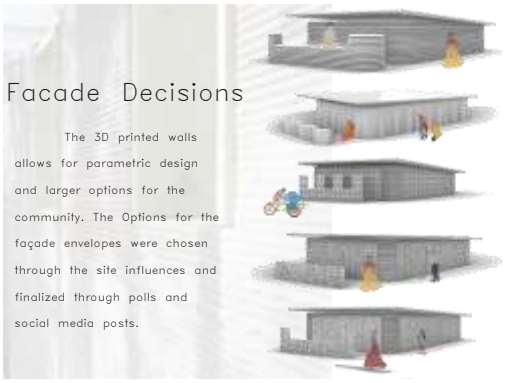


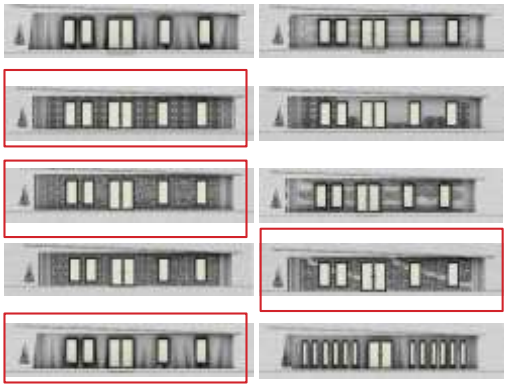


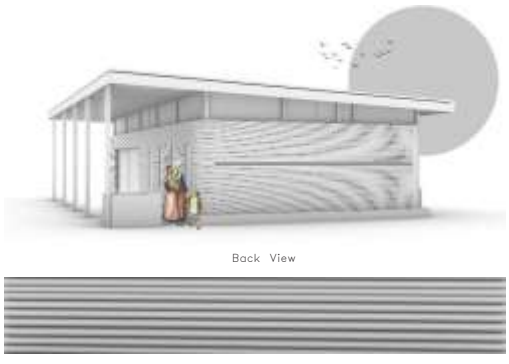
Generational Corner Floor Plan Option

Figure 87 - Home Floor Plan Options.

The 3d printer allowed for parametric designs and almost endless options. The options were designed based off site influences and finalized through polls and social media posts. El Natural option is printed with no façade feature other than the elegant, layered effect produced by the 3D printer itself. El Natural option is for those who appreciate the raw materiality of the concrete itself. This Option is roughly 4 hours quicker to print than the other façade options. The wave option is inspired by the harbor and the Pacific Ocean. The waves sway and ventilate the heat away from the home. This option is for the post-modernist who loves to see the material expressed in motion. La Maca option is inspired by central American textiles, specifically in the hammocks. This diamond pattern can also be found in woven blankets throughout the country, this option is for those who love tradition and prefer to standout in a row of homes. The Mayan option is inspired by the Mayan Temple El Tazumal in El Salvador. The hieroglyphs seen in the Mayan temple have been abstracted and reinterpreted into the façade. This option is for the history buff that is proud of their ancestorial past. The Cross option is inspired by the spiritual connection the site has to the catholic religion. The strong influence of the cross symbology is abstracted and repeated on this façade. This option is for those that are in tune with their spiritual self and faith.







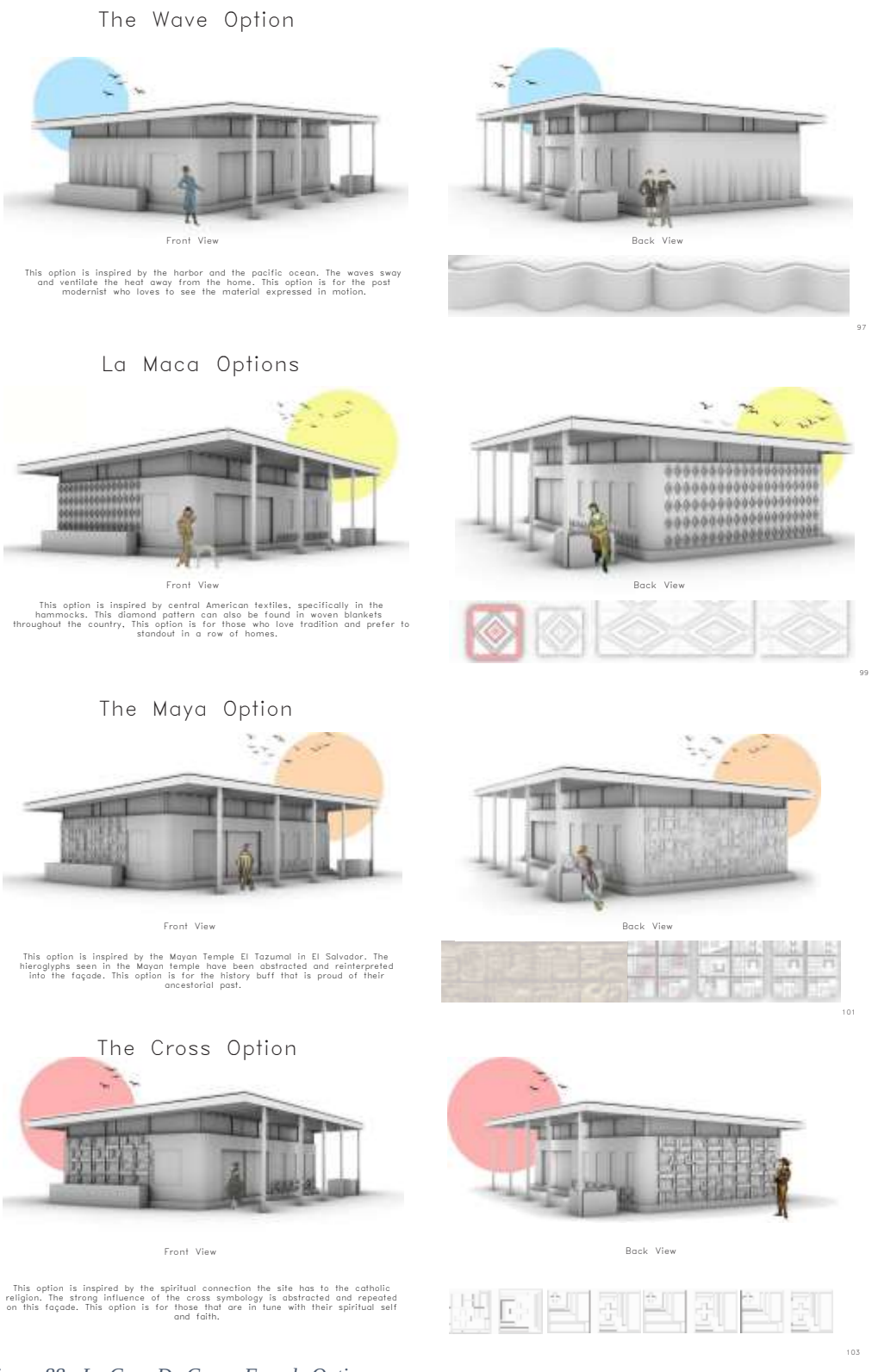


Figure 88 - La Casa De Capas Facade Options.

The Next two options include the window configurations and color of the homes. Based off the existing home language seen in el Salvador today. The residents get to

paint their home during the concrete mixing phase by mixing their preferred concrete dye.

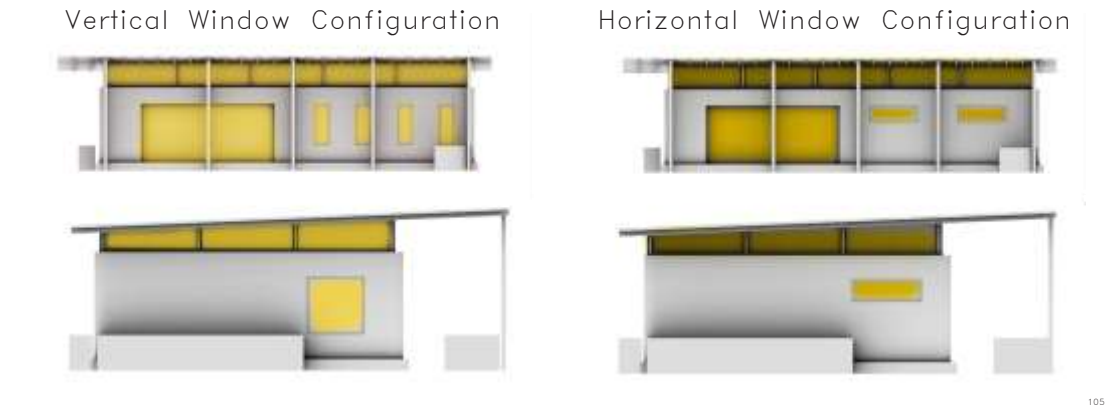


Figure 89 - Window Configuration Options.

Figure 90 - Home Color Pigment Options.

La Casa De Capas Narratives

Figure 91 – A Day in the Life of The Farmer Miguel Angel.

Figure 92 – A Day in The Life of The Generational Farmer.

Figure 93 - A Day in the Life of The Baker Manuel.

Figure 94 - A Day in the Life of La Professora Vilma.

Figure 95 - A Day in the Life of Nana Nicha.

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