Title: Designing a living barrier fortifying the coast against extreme climate events to reharmonize the identity of people, land, and water on the Island of Efate, Vanuatu

by

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authors declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public

abstract

On the Pacific island of Vanuatu, the connection the islanders have nurtured with the land and water is both evident and fundamental to their conception of life and legacy -the spirits of their ancestors are thought to inhabit the island's minerals and express themselves through the waves. Climate change has begun to sever the sacred unity between nature and themselves. This thesis will examine the severe impacts of climate change on island systems, riparian, coastal, and marine ecosystems. In evaluating these long-reaching effects, the thesis will provide insights into the following lines of inquiry, informing the solutions and recommendations arising in consequence. An island of people is at risk of losing their homes and who they are as a nation. While exploring the island's history, the far-reaching effects of colonial influence and their reckless disregard for the natural environment will become evident. This thesis dedicates a large section to the research on the island, identifying a limited problem and then providing a larger-scale design solution. How can implementing foreign architectural systems improve the lives and conditions of all species on the island while ensuring that design remains unintrusive, that the natural environment is utilized sustainably, and that critical lessons can be made transferrable to other contexts? In the presence of chaos, how can designs leverage disorder to create a safer environment for adaptation? Natural living systems and geotextile design have been widely explored within the field of architecture, and precedents in their usage have been discovered, whether by intention or chance. However, the interfacing between these will become a key component in designing a natural floating geotextile ecosystem that begins to counter some of the physical effects of climate change on the designated site.

Through the development of cell systems within the geotextile fabric, this thesis will begin to reintroduce a chain of ecosystems from land to ocean, supporting adaption in the hopes that the island will begin to heal itself, grasping the design intervention when grievous moments take place. Understanding the existing life systems within the island facilitates a turning point in the analysis, where the very assets threatened by climate change, the terrestrial and marine ecosystems, become the answers to addressing this threat. By analyzing these enfeebled ecosystems - their stories, art, facts, and texts -a holistic design addressing existential needs while respecting essential boundaries in the social and natural fabric can emerge into being. This story will be told through drawings and model simulations that articulate the solution to creating a resilient environment capable of seamlessly merging with the island, becoming the minerals in the soil, ceasing to exist but leaving a trace of history. The island's dramatic edges will cease to exist, with the design working to blur the edge boundaries separating land, water, and people. By exploring native and external design concepts, this thesis aims to work with the land without disrupting local influences, utilizing natural design techniques to bring these three sources of nature together - land, people, and water.

acknowledgments

When thinking of how this thesis came to life, a handful of people have made it possible for me to be here at this moment writing these words. Though unneccasry to write a long acknolwedgment, I feel it may be the only place within this text to express the trials I have faced coming to this point and how these handfuls of people in my life have made it possible. My dreams are a reality because of all of you. As covid hit at the end of my undergrad, I posed a question to myself, should I embark on this journey of self-exploration, or should I take some time to myself and gain some more experience in the world. The decision to continue school in a covid world was not easy, classes were online, and the same motivation that lives within the studio space at school needed to be converted into a tiny bedroom corner.

As Covid began, the world entered a dark period where all we heard or saw was death, pain, and suffering. The world shut down and joined a pandemic where we did not know the end of that bright light guiding us through. Every day living in fear, wondering when is it my turn, will I be ok? Why should I bother doing school if the world and my loved ones are in constant fear of their lives? What is the purpose?

However, "***Education is the passport to the future, for tomorrow belongs to those who prepare for today***" Malcolm X.

As I reflect upon the tumultuous events of recent times, I am filled with an unwavering determination to pursue my education and advocate for the pressing need to care for our planet both today and tomorrow. Through the unwavering support of my family, including my late father Tim and my mother Adriana, I have been instilled with the drive to strive for the best education and pursue my passions beyond limits I had never imagined. Their unwavering commitment to education and their love for learning has been an unparalleled source of inspiration in my life.

My brother Iv has been a constant source of light during my darkest days, always there to offer love, laughter, and motivation to push me forward. Without the love and support of my family, I would not be here today.

I extend my heartfelt gratitude to my esteemed committee members, John McMinn and Philip Beesley, for their unwavering support, guidance, and motivation throughout my academic journey. This thesis project has been transformed into a work of inspirational design that would not have been possible without their passion and expertise.

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My dear friend Uarda, who accompanied me on my undergraduate journey, has been a source of inspiration and a reminder of the beauty of life, even amidst stress and chaos. To my childhood friend Dessi, who has always been a sister to me, thank you for your constant love and support that has helped shape me into the person I am today. And to Amanda, a fellow graduate student whose drive and passion have motivated me to push past my limits, thank you for being a rock during my master's program.

I am truly blessed to have such incredible people in my life.

dedication

To my Mother

I owe my whole life to you, you are the reason my dreams are coming true through your support and drive I found mine.

To my Father

You taught me dedication with ease that comforted me to survive is chaotic fast paced times, you taught me how to slow down and appreciate moments

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style of thesis and intent

This thesis unfolds itself in a narrative where the story is fictional; yet the facts and details within the text remain nonfiction. It is at the reader's discretion whether they wish to be confronted with the sobering realities of the facts or simply engage with the broader strokes of a vision yet to be. The world has changed and continues to change rapidly, sometimes seemingly overnight. Climate-related impacts have slowly crept into our lives, and we have only just begun to notice the devastating effects they have had on so much of our world. As quickly as societies began to rally around the looming threat of climate change, the world was thrown into an even more immediate calamity that fundamentally transformed our conception of life. Illness and death overtook the world, and life in a pandemic became a new normal for many. This story is written in a world scarred and recovering, reeling from climate disaster and the ravages of the coronavirus pandemic, all these events have shaped this thesis into the book printed today, continuously changing even after this is written. What was once the exclusive realm of dystopian and post-apocalyptic fiction seems to be becoming a reality by the day—the constant fear of becoming exposed and ill, endless economic spiraling into recession, and professional and ultimately spiritual resignation. It is hard to imagine that this story could be the same if the events of the past two years had not transpired. In the backdrop of such global upheaval, this is a story of healing at the local scale: a story of protecting and revitalizing archipelago islands in a far-off land. The story unfolds through the eyes of others who have been to Vanuatu and smelt the fresh air there. The narratives extrapolate many facts about the island through videos, poetry, songs, and essays produced by other people. The story told about the Island of Vanuatu begins to expose the existing consequences of climate change that were foolishly dismissed for so long by so many.

The main focus of this thesis is to tell a story about how climate impacts our planet and how that story could begin to draw out a climate solution at the local scale. Drawing on the voices and individual experiences of the people of Vanuatu to inform a solution that accounts for the unique aspects of life on the Island, to extract a design from my findings. Part one of the book is represented graphically on one side, which narrates vivid imagery for the reader -the left side of the book contrasts the novelty of a story grounding the work with facts and historical evidence.

At this point, the reader can decide which route they would like to take through this thesis, either focusing on the story of spiritual resilience on the Island of Vanuatu or the grim reality modernization is causing our planet. In the first portion, the reader is guided on reading this thesis as a story, through photography and images guiding one through the island. The reader ultimately comes to an understanding of what the island is made of and all of the woven systems and analysis. Part two addresses the severity of climate impacts on the physical island state and the continuing threat of industrialization on many island nations' historical, social and cultural character through a sequence of maps, diagrams, and analysis. Once this story unfolds, a design solution is proposed to address some of the highlighted threats at the local scale. The design begins to tie ideas of climate change's physical and cultural aspects in delicate design.

At its essence, this thesis book seeks to address a global problem at the local scale by assessing what is going on, making sense of it, telling the stories of those most affected, and serving as a warning to those that will be affected.

indigenous acknowledgement

This thesis was written from beyond the boundaries of the island, where I rely on the stories and studies being told by people who have experienced the island in contact. I am a Canadian Albanian, not Ni-Vanuatu, where I claim no authority or authenticity in the stories I tell. Nor have I been on the island and experienced its cultures or traditions. The thesis is guided through an exploration of the island's customs and cultures, where their imbricated cultural beliefs are laced with the existing ecological systems.

As mentioned, I am not an islander native; I attempt to tell the islander's stories through design development. Utilizing the existing ecological systems to tie the thesis to the geographic location of Efate Vanuatu. The island of Vanuatu posed a unique position within the ring of fire, an archipelago of islands located in the south pacific, which currently is one of the most extreme impact zones due to climate change impact. The island's cultural identity is one I do not follow; this raises questions about cultural rights and the ability for myself to even write a story questioning the loss of identity. I was beautifully drawn to the island's connectivity to land, which became a significant focal point.

I have not been in the South Pacific, and my interactions with aquatic life is limited to the Caribbean ocean during events of scuba diving and snorkeling. Therefore, much of this thesis understanding is based on research to understand all the aspects of the island.

I have tried my due diligence to be sensitive in telling the stories of the Ni-Vanuatu people, though I understand it is not my story to tell. This thesis was written for the purpose of this thesis and to explore the potential design that may influence our architectural systems.

position

Architecture is a composition of force differentials between competing, sometimes complementary elements. This thesis investigates this tension between adjacencies by redesigning the **liminal space** between land and water. Architecture designed in response to the surrounding cultural and terrestrial systems becomes architecture that balances people and their context harmoniously. Current climate impacts have begun to sever the relationships between people and the natural world, resulting in essential identity and terrestrial loss. When choosing the island of Efate, it is crucial to understand that what the island is facing imposes severe cultural and natural implications.

The far-reaching impacts of modernity and modernization are resulting in fatal implications for many parts of the world, including the South Pacific Ocean, where climate impact is the most extreme. Uncovering the design potential of the liminal zone creates an opportunity where design can blur the edge between land and water through the implementation of design influences ranging from mythological to mathematical. The exploration of such a fertile context becomes the essence of this thesis—designing a living wall that begins to respond and rehabilitate the people, land, and water, integrating them into a seamless, once again functional ecosystem. Through a woven system of interdisciplinary systems, this thesis is structurally divided into several parts: architectural design, mineral accretion, and mangrove rehabilitation sections.

Architecture must be a realm where design not only begins to respond to human needs and activity but is reactive to existing ecosystems, creating a utopian ecosystem that persists through a feedback loop between design and user.

On the island of Efate, through this book, one will see the physical damage done to the coastal region and community and begin to better understand and empathize with the identity crisis of the Pacific nations. Roughly 80% of the villages on the island live along the island's riparian zone. Due to the island's volcanic formation, the coastal zones on the archipelago are the most suitable rounds and soils allowable for farming conditions. Many villages on the island grow their food and harvest the crop used in their daily lives here. The degradation and probable destruction of these areas thus pose an existential threat. Protecting and rehabilitating the coast is essential to the physical survival of the island's natives, but also the survival of their very identity. Relocation inland poses a significant issue as the grounds are not suitable for farming conditions; thus, the villages lose a vital part of their life, their food source, which is grown within a village system.

The Ni-Vanuatu have lived in balance with nature for the span of their entire lineage, their stories and roots deeply interwoven with natural physical properties. Current climate disasters have threatened the core of their beliefs, the islanders stating,

"We are afraid of the water"

Liminal space: The transitional or in-between space between two defined areas, such as land and water.
Cultural and terrestrial systems: The social and natural systems of a place or region.
Climate impacts: The effects of climate change on a region, including rising sea levels, extreme weather events, and other environmental changes.
Modernity and modernization: The process of becoming modern and adopting modern technologies, practices, and values.
Ni-Vanuatu: The indigenous people of Vanuatu, a South Pacific nation.

Seeing stories of islanders afraid of the very myths and legends they believe in, stripped of their cultural identity, the people of Efate begin to mistrust and fear the same spirits that were once protagonists of their stories. These stories are ancestral ties that keep alive the memories and histories of the islanders, where (it is believed) their ancestor'; very souls exist in the rituals and celebrations the islanders partake in; water dancing, land diving, and sandroings. Some of the most significant traditions expressed on the island hold a deep connection with the water the women drum on, the sand that runs through the fingers of the drawer transferring kinetic energy, the vines on land diving towers with strength sufficient to hold the weight of these men who have faith in their ideologies. The islanders keep their traditions, spirits, and identity active by partaking in such celebrations.

Understanding the adaptive capacity nature has when aided by low-tech design becomes the foundation of this thesis, where architecture is designed to restore ecosystems while serving multi-purpose programs, creating a design that's capable of catering to ever-changing functions and readapting according to ongoing changes and the lifecycle of the building.

Loss is evident, transformation is constant, and the planet is, unfortunately, changing for the worse. We see factual proof that coastal regions are being destroyed, we have substantial soil erosion encroaching on coastal zones, becoming a massive hazard to low-lying island regions. Loss is proof that there are issues within our world; however, loss isn't just numbers and evidence, but the loss of one's self should make us a world. As designers think about how we can aid in understanding a different way of designing, where the life of this planet is a focal point and social interactions, such amenities must begin to interlace with one another, sharing the space provided for us to live.

Coastal regions are highly vulnerable in the South Pacific. Through low-tech design that has studied and attempted to utilize cultural and mythological practices, the rehabilitation center focuses on restoring the island's coast while drawing in the islanders to create s system of rehabilitation of spirit and land.

The villages aid in rehabilitating the coast through an interwoven lattice of mineral accreted pods layered with mangrove roots, creating a robust coast grounding to defend the islanders against storms. Mangroves are a natural barrier, and rehabilitating this plant focuses the design on a restorative program that allows this design to create moments of design prototype opportunities and architecture that responds. The balance of nature has tipped, as actions have consequences, and nature's reactions are being confronted with brute force in many coastal regions on this planet. In the hearts and minds of the inhabitants of Efate, many storms and destructive climate forces have mythological ties, which begins to scare the islanders into questioning their commitment to living in harmony with nature and why current events and situations are happening to them.

Mythological and mathematical influences: sources of inspiration for design.
Mineral accretion: a process of growing limestone on steel structures in the ocean, which can help mitigate the effects of climate change on coral reefs.
Mangrove rehabilitation: the restoration of mangrove forests, which provide critical ecosystem services, such as coastal protection and carbon sequestration.
Ecosystem: a complex network of living organisms, their physical environment, and their interactions.
Feedback loop: a process in which the output of a system feeds back into the input, creating a cycle of cause and effect.
Riparian zone: the transitional area between land and a river or other body of water.

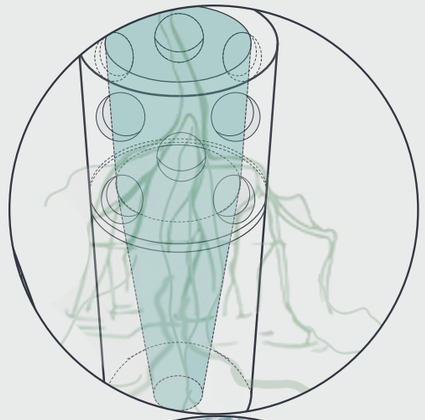
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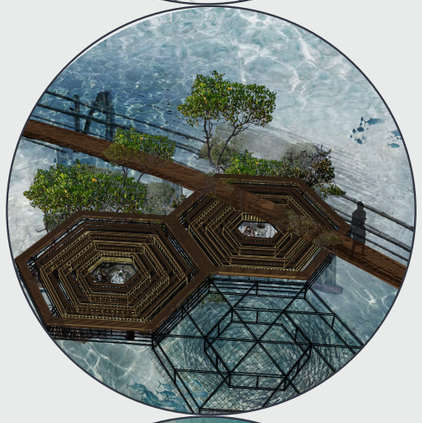
It is grounding itself through design, centralizing around the rehabilitation of mangroves through the islanders' efforts to reclaim their identity. In turn, the planet responds and begins its restorative journey, thanking the islanders for bringing back that severed connection between people and nature. The design on the northeast side of Iriwiti Lep, a small uninhabited island located on the southeast facing of the island of Efate, is significantly impacted by its exposure to open waters. The limitation in the documentation on the island has posed issues in moments of research where the specific name of the village located just above Iriwiti Lep is unknown at this stage of my research. To understand the story of this design, the village is to be known as the village of Iriwiti Lep, creating a link between the village coast and the island through design and aquatic restoration.

Designing an interdisciplinary system that aids in addressing multiple layers of restorative design between islanders and the planet. Through architectural design, mineral accretion, and mangrove rehabilitation, this thesis works as an ever-changing design adapting to critical environmental disasters. Elevated above sea level rise utilizing the island's vast Bamboo fields, the islanders begin to construct a utopian lattice of programs. Mineral accretion cells are knotted within one another in a hexagonal ornamental lattice of rebar spreading over the seafloor with minimal material composition grounded through limestone extracted from the island. The mineral cells are layered with developed BooPods, a prototype designed to direct the design through the lifecycle of a mangrove. The restorative process in fortifying mangrove roots and coral pods creates the possibility of an ecosystem interlaced with roots, mineral-stabilized waters, and grown tropical corals, a promising direction in restorative design. The design tectonics are drawn from the design's form and lattice, resulting in design structure, ornamental balance, and dependency. Additionally, designing to blur edges between form and structure, where transformation in tectonic size played a role in deciphering critical moments in the design.

The internal core of the project is focused on a program that responds to direct climate-impacting events. The design, first and foremost, becomes a structural barrier that shields the village against large storms. Becoming a structural buffer that physically diffuses storm becomes a moment within the next two years that are critical to the design's restorative integrity and the village's increased chances for resistance. Through interwoven structural trusses, bamboo, vines, and knots become significant design factors, drawing from mythological ties in weaving, bringing that ornamental lattice to the very structure of the design. The program is centralized around the restorative lifecycle of mangroves and its journey from seed, into BooPod, into nursery then finally transported into the mangrove pods, which become the fortifying barrier that might give the people and the ecosystems around them a chance to restore their lost identities.

Rehabilitation: The process of restoring something to its original or improved state, especially in the context of physical or mental health.
Mangroves: A type of tropical tree or shrub that grows in salty or brackish water, characterized by tangled roots that can trap sediment and protect coastlines from erosion.
Identity: The characteristics, qualities, beliefs, and values that make a person or group unique and distinguish them from others.
Aquatic restoration: The process of restoring and improving the health of aquatic ecosystems such as rivers, lakes, and oceans through various means, including habitat restoration, pollution control, and other measures.
Interdisciplinary system: A system that draws on knowledge and expertise from multiple fields of study, including social, natural, and physical sciences, to address complex problems.
Restorative design: A design approach that seeks to improve the health and resilience of ecosystems, communities, and infrastructure through sustainable and regenerative methods.







Mineral accretion: A process that involves the use of electrical current to stimulate the growth of minerals on artificial structures, such as coral reefs.
Utopian: Referring to an idealized or perfect world, often characterized by social or political harmony and a lack of conflict.
Tectonics: The study of the Earth's crust and the processes that shape it, including the movement of tectonic plates.
Lattice: A structure composed of interwoven or intersecting elements arranged in a regular pattern.
Ornamental balance: A design principle that involves achieving visual harmony and balance through the use of decorative elements.
Structural barrier: A physical structure that provides protection against external threats, such as storms, floods, or other hazards.
Structural buffer: A component of a structure that absorbs and diffuses external stresses or impacts to prevent damage or failure.
Trusses: A structural element composed of interconnected triangles that is used to support roofs, bridges, and other structures.
Lifecycle: The series of stages through which an organism, product, or process passes from its beginning to its end.
Fortifying barrier: A physical barrier designed to provide protection against external threats, such as storms, floods, or other hazards, by strengthening and reinforcing the structure of the barrier.

introduction

Located in the southwestern pacific ocean, the republic of Vanuatu consists of a chain of 13 principal and many small islands spreading about 650 km north to south in the form of an irregular Y. The Republic of Vanuatu achieved its independence in 1980, where the island's name means "Our Land Forever" in many local Melanesian languages. This research focuses on the island of Efate in Vanuatu, the capital and largest city in the archipelago. There is a comprehensive history tied to this land, intrinsically connected to the stories of its people. The islands are built on sedimentary, coral limestones, and volcanic rock, with coastal terraces and offshore coral reefs. Additionally, several underwater volcanic groups spread active volcanoes throughout the islands. The Republic of Vanuatu is home to the indigenous population called Ni-Vanuatu. The Ni-Vanuatu are Melanesian; however, some of the outer islands in the archipelago have a Polynesian population. [1]

Understanding that the islander's identity is connected to their ancestral windows passed throughgenerations of rituals and beliefs coincidentally associated with their daily practices. Environmental harmony has always been the way of life for the Ni-Vanuatu; through small-scale indigenous traditions, the islanders have kept their ancestral spirits alive. However, due to colonization, a cultural focus shift began to suffer as 'modernity' began to creep slowly, affecting many aspects of the islanders' lives; homes, culture, and technology. Where we read in a passage written by Epeli Hau'ofa discussing how the islanders' ways and cultures began to be belittled and slowly taken apart through non native settlement

> *"The other level is that of ordinary people, peasants and proletarians, who, because of the poor flow of benefits from the top, skepticism about stated policies and the like, tend to plan and make decisions about their lives independently, sometimes with surprising and dramatic results that go unnoticed or ignored at the top. Moreover, academic and consultancy experts tend to overlook or misinterpret grassroots activities because they do not fit with prevailing views about the nature of society and its development...In Oceania, derogatory and belittling views of indigenous cultures are traceable to the early years of interactions with Europeans. The wholesale condemnation by Christian missionaries of Oceanic cultures as savage, lascivious, and barbaric has had a lasting and negative effect on people's views of their histories and traditions. In a number of Pacific societies people still divide their history into two parts: the era of darkness associated with savagery and barbarism; and the era of light and civilization ushered in by Christianity...A direct result of colonial practices and denigration of Melanesian peoples and cultures as even more primitive and barbaric than those of*

1 Adams, Rom. "New Hebrides, Republic of Vanuatu." Encyclopædia Britannica, Encyclopædia Britannica, Inc., 5 Oct. 2022, https://www.britannica.com/place/Vanuatu.

> *Polynesia can be seen in the attempts during the immediate postcolonial years by articulate Melanesians to rehabilitate their cultural identity by cleansing it of its colonial taint and denigration. Leaders like Walter Lini of Vanuatu and Bernard Narokobi of Papua New Guinea have spent much of their energy extolling the virtues of Melanesian values as equal to if not better than those of their erstwhile colonizers...The drive from Kona to Hilo was my "road to Damascus." I saw such scenes of grandeur as I had not seen before: the eerie blackness of regions covered by recent volcanic eruptions; the remote majesty of Maunaloa, long and smooth, the world's largest volcano; the awesome craters of Kilauea threatening to erupt at any moment; and the lava flow on the coast not far away. Under the aegis of Pele, and before my very eyes, the Big Island was growing, rising from the depths of a mighty sea. The world of Oceania is not small; it is huge and growing bigger every day."* [2]

The blend between matrilineal descent rules and patrilineal rules creates a complex culture within the island. "Land is to ni_Vanuatu what a mother is to a baby" [3] traditional land tenure systems exist on the island, which roots a strong sense of cultural identity and attachment to the land. Thus providing a spiritual and physical link to the land, where all have access to it despite different beliefs, nature was their common. External religions changed the role of women on the land. Modern male-centered ideologies crept slowly into the culture and influenced women's roles. Women's power in an equal society was distributed by modernized ideology. [4] That reconnection to their roots and power is heavily deepened by the land and water surrounding them. "Water is everywhere around this tiny dot on the map, and for those who have made it their home, water influences almost every aspect of life." Water music originated from a tiny village on the north coast of the island, where we see the cultural practices strengthen their very identity; in 2019, a journalist named Aude-Emilie witnessed the water dancing ritual and described the experience, "In Vanuatu, women draw strength from the rhythm of the ocean." [5] Water that once connected the islanders to their beliefs now is the very reason they are losing their homeland to climate resulted in impact. The foundation of their beliefs is the cause of such pain and heartache now, as the pacific islanders lose their physical home and identity.

2 Hau□ofa, Epeli, et al. A New Oceania: Rediscovering Our Sea of Islands, School of Social and Economic Development, The University of the South Pacific in Association with Beake House, Suva, Fiji, 1993, pp. 149–151.

3 Stege, Kristina E., et al. "Land and Women: The Matrilineal Factor The Cases of the Republic of the Marshall Islands, Solomon Islands and Vanuatu." Pacific Islands Forum Secretariat, 2008. (93)

4 Stege, Kristina E., et al.(95)

5 7 Dorion, Aude-Emilie. In Vanuatu, Women Draw Strength from the Rhythm of the Ocean. Arti cle. Earth Journalism Network, June 7, 2019. | https://earthjournalism.net/stories/in-vanuatu-women-draw-strength-from-the-rhythm-of-the-ocean

framework analysis

This thesis aims to develop a holistic design approach that prioritizes the study of natural forms and systems and combines multiple disciplines to create a regenerative environment for the people of Vanuatu. The research will explore the use of mythology, ornamental design, architecture, bio-design, construction infrastructure, geotextile design, science, and technology to create a design that addresses the impacts of climate change on the island's riparian, coastal, and marine ecosystems. In addition, the use of mineral accretion, a process that promotes coral growth, will be investigated to repair damaged marine ecosystems. Finally, the molecular level of natural forms and systems will be examined to better understand their mechanisms and apply them in design. The analysis will explore the island's history and evaluate the impacts of colonial influence and reckless disregard for the natural environment. The goal is to identify a limited problem and provide a larger-scale design solution that improves the lives and conditions of all species on the island. The research will explore how foreign architectural systems can be implemented unintrusively, sustainably utilizing the natural environment, and provide transferable lessons for other contexts. The design will leverage disorder to create a safer environment for adaptation and work to blur the edge boundaries separating land, water, and people. By exploring native and external design concepts, the design will work with the land without disrupting local influences, utilizing natural design techniques to bring the three sources of nature together - land, people, and water.

Examining the existing life systems on the island and use this understanding to develop a design that addresses existential needs while respecting essential boundaries in the social and natural fabric. The thesis will culminate in a set of drawings and model simulations that articulate the solution for creating a resilient environment that seamlessly merges with the island. The design will help the island begin to heal itself by reintroducing a chain of ecosystems from land to ocean, supporting adaptation in the hopes that the island will begin to heal itself, and grasping the design intervention when grievous moments occur. By focusing on the natural environment and applying compatible techniques, the design will help the islanders of Vanuatu reconnect with the land and water that is fundamental to their conception of life and legacy.

Chapter One

identity

Storytelling became the way lineages passed on their traditions through generations; stories of the past, new lessons, and spiritual importance to such stories and their underlying meaning. Stories of traditions and beliefs have survived colonization where the past trials have formed such a resilient community of people, yet they are still continuously threatened. As music and art tell stories of their own, they become an intrinsic aspect of the cultural and mythological life on the island. The kinetic energy passed on from the waves in the music and the sand in the art, these moments are where islanders unify land, water, and their very beings. The spirit of this community is founded on its connection to land and water -its very identity is inextricable from its surroundings. However, global warming effects directly affect the relationship islanders have with nature. They are losing their sense of identity, cultural tie to their land, and the very foundation of what they believe in, threatening their livelihoods.

Due to colonization, the religious views of the island have changed within the last century. In 2009, the Bureau of Democracy from the Human Rights Department released a report discussing the main religious views on the island, where 83% of the population identifies as Christian.[6] Resilient to worldly impacts, the Ni-Vanuatu or Ni-Van held onto their roots and celebrated their traditions and storytelling rituals, further developing and expressing them through myths, tales, art, craft, poetry, and song. A source of storytelling is traced to the island of Vanuatu, where it is believed that sand drawings may be the oldest form of art using natural elements, creating a kinetic transfer from body to sand.[7]

6 Released by the Bureau of Democracy, Human Rights, and Labor. International Religious Freedom Vanuatu. Archive. U.S. Department of State, 2009.

7 United Nations Educational, Scientific and Cultural Organization, 2008 | https://ich.unesco.org/en/RL/vanuatu-sand-drawings-00073

"Water is everywhere around this tiny dot on the map, and for those who have made it their home, water influences almost every aspect of life. "The Ëtëtung [or water music] shows the close connection that exists between the Oceanian peoples and the sea," says the eldest woman of the Leweton Women's Water group, the local water drumming troupe. For millennia, water in this distant part of the world has united and divided, connecting people as much as it has set them apart. There is no stream more closely bound up with the life of a people, more important to Pacific Islands nations than the ocean. Moreover, in a predominantly male-oriented society, the water drumming comes as a woman's way of telling their stories. "We have found a path that is effective and balanced to communicate in our realm," says Hilda Rosal Wavales, founder of the Leweton music group. In indigenous traditions here, myths and rituals aim to explain the world's origins and remind people of their place in the cosmos and their connection with the past. Because the islands' economies are based on fishing, which is taboo for women, the music group has been a useful way to empower women in both the social and economic spheres since they now bring in money from their performances that support community projects."

"In Vanuatu, Women Draw Strength from the Rhythm of the Ocean." Nature is the heart of the culture within the Pacific Islands. The rituals show a reciprocal relationship between the land and water and its impact on the people; their way of life revolves around nature's most fierce forces. Climate change has upset the balance of nature in many ways, yet seeing nature as sacred has remained a view and way of life for The Pacific Islanders.[8]

8 Dorian. (2019)

Grievous anthropogenic climate change has become a life-threatening force, where events of increased periods of drought and flooding are disrupting all ecosystems on the island. Coastal flooding and erosion have increased heavily within the last few years, and the affected ecosystems have caused water and food scarcity. Ni-Van has become defenseless in the eyes of climate events, rendering them fearful for their physical livelihood and spiritual connection with nature. The results of such events have caused the harmony they once had with nature is now the source of their existential plight, as nature itself seems to turn against their way of life.[9]

Due to extreme events, crop fields are being salinated, soils tarnished, and mangrove trees are being ripped from the riparian zone exposing the island to extreme flood and cyclone events. Mythology has a considerable influence on the island's daily structure. Understanding a more mythological mindset facilitates a deeper comprehension of the everyday problems and potential solutions already available on the island. Due to the strong influences exerted by colonization, there is a great diversity of languages and religions on the island. Nevertheless, the native culture and rituals have endured within the Pacific Islands, showing a deep-rooted connection to their past and a strong sense of self.

9 Campbell, J. R. 2006. "Traditional disaster reduction in Pacific Island communities," GNS Science Report 2006/38 46 p.

"A design movement to rebuild an understanding of indigenous philosophy and vernacular architecture that generates sustainable, climate-resilient infrastructure."

Architecture creates a moment where the effects are both immediate, longer-lasting and begin to affect the islanders, their culture, and the spirit of the land. It is essential to develop a sense of reciprocity with the land and forge a design that does not hinder culture or people but the lasting implications of the design on land. In ***"A New Architecture of the Heart"*** [10] Julia Watson described how we need to begin to conceive a novel relationship between place, nature, and the physical spaces we inhabit. In her book Lo-Tek Design by Radical Indigenisim; she states,

"we recoil from the forms that are transparently ugly, conceived in greed, constructed in a fever of unconsiousness. Lo-TEK suggests that there is an option, a way out, a means to imagine anew the relationship between place, nature and the physical spaces we construct and inhabit for the most of the houses of our lives. A new architecture of the heart, informed by beauty and pure design, with materials as simple as the sun, that yield new possibilities. With forms so delicate, so functional, and so perfectly aligned with the axis of the spirit, they will inspire a totally new dream for the Earth." [11]

Although in his theory of evolution, Charles Darwin asserts that "extinction happens slowly," when we look at our planet today, we can witness the catastrophic repercussions of modernization, where sixty percent of the world's biodiversity has vanished in the last forty years. Modernization created a frenzied ambition to conquer nature, where only a tiny fraction of the ideas and technologies which existed during The Enlightenment period were valued and brought forward. However, this set our planet back, sweeping local contributions to design away in favor of modern societies' need to control nature in the name of progress, contrasting indigenous beliefs in working with it.1 Evolving humanism with Radical Indigenisim begins to develop a new methodology concerning design practices and technologies.

10 Julia Watson
11 Julia Watson

REGENERATIVE CHAOS

Architecture that fixates on a dual purpose of building function begins to forge a design that centralizes on the ecological domain and protective barrier, where the social realm becomes a program aiding ecological restoration. The design serves as a defensive structure to the village inland while restoring the built-in habitats. Evolving into a hybrid design of limestone, sand concrete, woven bamboo and pillars to defuse tropical storms and internal pods to help regenerate land and reefs through mangrove regrowth and mineral accretion. Aiding in land regeneration through a hybrid low-tech ornamental design merged with necessary industrialized materials, where understanding the site's limitations creates a material palette for the design. Bamboo, limestone, concrete, roots, and steel generate a method to restore the balance between nature and people on site. Through an integrated strategy of pods with various programs, this project aims to create a safe space for islanders to connect with nature while open to travelers to gain a deeper understanding of the monumental challenge the islanders must contend with in protecting their lands from climate-impacted disasters while experiencing the artistic diversity of the land.

Advanced into a geotextile grid system, the outer shell of concrete serves as the first barrier to fierce storms. Utilizing heavy industrialized materials, when used in proper design methods to aid the land, allows designers to utilize the material for a purpose over pleasure. Within the shells, a system of metabolic ecosystems begins to generate through the mineral accretion process, restoring coral reefs and reef ecosystems on the island to enhance soil and water mineral properties. This process of chemical evolution will allow the steel frames rodes molding over limestone barriers to begin and calcify into synthetic reefs known as "biorock" or "seacrete." As minerals crystalize by the current through the steel frames, fish school ecosystems can start to stabilize alongside the island due to the expansion of livable habitat ecosystems. Limestone pods protect the mangrove fields where bamboo meshes are embedded within the limestone barriers, creating a protective hold securing the mangrove roots to the ground during tropical storms. Mangrove rehabilitation becomes a central focus in restoration, as mangroves are robust plants serving a vital role in the coastal protection of land and water., thus the design of the 'tapgrove.' Due to the frequency of exposure to tropical storms, the island's coastal ecosystems have deteriorated to the point where mangrove fields cannot adapt to the current levels of climate change. While full gown mangrove forests are known to live through storms, embedding their roots deep and securely into the ground is a tough challenge. As the limestone, pods and bamboo firmly hold the growing mangrove in place during storm season, the mangroves begin to grow through the bamboo mesh, embedding the roots and creating a lattice of limestone, bamboo, and mangrove roots. The secondary social programs serve to aid in the rehabilitation of the site through maintenance and continuous work of building practices. The embodied energy of the social realm creates an environment for knowledge and a strong sense of grounding, one is faced with the gravity and monumentality of a structure destined to take the full brunt of the effects of climate change.

VERNACULAR CONSTRUCTION

"In March 2015, the island of Vanuatu was hit hard by Tropical Cyclone Pam, the second most powerful tropical cyclone ever recorded in the south Pacific Ocean in terms of sustained winds and one of the worst natural disasters in Vanuatu's history. Thousands of people were displaced, and numerous homes, schools, and businesses were destroyed. However, something surprising emerged in the wake of the disaster. During a government-led Post-Disaster Needs Assessment (PDNA) conducted with the support of UNESCO, the European Union, and the World Bank, traditional knowledge, particularly traditional building techniques, emerged as a key factor in Vanuatu's resilience to the disaster. More specifically, it was found that the island's traditional nakamal buildings constructed with modern materials and techniques were more severely affected by the cyclone than nakamals constructed using local materials and traditional building skills."

"As climate change results in more extreme weather events, traditional knowledge can be a vital means of promoting the resilience of communities to natural disasters." [12]

"***Vanuatu***" itself is national identity. In 1980 the Vanua'aku Party invented the term after they led their first independent government, to replace 'New Hebrides' to 'Vanuatu', where Vanua means ***land*** in many of Vanuatu's one hundred and five langages.[13]

Nakamal means *"the house of men,"* a traditional place for chefs and community members to gather, holding great significance to the islanders as it plays a significant role in functions such as customary court sessions and ceremonies.' Nakamals play an essential part in Vanuatu culture, as mythological knowledge and traditions are taught within the space, making the building significant in islander cultural heritage. The Nakamal protects the cultural importance of heritage and mythology and also provides physical protection from the elements to the villagers who live within. These dwellings are designed with roofs reaching the ground, ensuring the villagers' safety from high winds and cyclones. This is in stark contrast to the modernized buildings in more urban areas that have adapted contemporary design and lost the importance of cultural creation and traditional construction techniques.[14]

The Enlightenment was so revolutionary a historical period that few technologies exist that predate it. Indigenous and traditional design is one notable exception and, despite being considered primitive, has been found to possess a wealth of advantages compared to its more modern counterparts. The solutions to our global situations may lie within the knowledge of the past -we certainly cannot solve today's problems with the same ideology which caused these problems to emerge in the first place. The opposition between the modern and the primitive is varied and manifold. However, one significant distinction is that while modern societies, rooted in scientific positivism, sought to conquer and master nature, indigenous cultures were content with working within the boundaries and constraints nature imposed.

12 https://en.unesco.org/news/vanuatus-traditional-architecture-makes-community-more-resilient-face-climate-change-related
13 Prospects and constraints of post cyclone housing reconstruction in Vanuatu PDF
14 https://ich.unesco.org/en/individual-case-study-00988&id=00026



Nakamal Roof Structure - islanders pull their roofs close to the ground to stabilize structure and resist storms

VERNACULAR CONSTRUCTION

"By using **living roots**, this condition that cuts the lifespan of conventional timber bridges is prevented. Over time, the living root bridges **instead grow stronger**. As they **age** they are bale to carry more load, better withstand the **high level of erosion** caused by continuous rain, and provide **habitat** for different species. The living infrastructures are **low in cost**, **maintenance**, and **embodied energy**. By adapting to seasonal cycles and the natural flow of rivers, these are the only bridges that can **withstand the strong currents caused by monsoonal rains**."[15]

The island is continuously under severe natural hazards due to its precarious location. This ongoing exposure results in a constant post-disaster reconstruction process for the islanders, creating a feedback loop. The question then becomes whether traditional construction methods are more resilient than modern approaches to design. The housing typology on the island is prevalent in three main styles; traditional, hybrid or semi-permanent, modern or permanent.

Organic materials are used when building traditional homes, primarily from palm trees, grasses, bamboo, and timber. These homes are located primarily on the island's rural parts and outer perimeter, compensating for roughly 40% of the housing stock.

Hybrid and semi-permanent homes are prevalent in areas of low income, such as informal settlements, and recently have increased within rural areas; 30% of the housing is hybrid and semi-permanent. Structured by a versatile combination of materials such as organic/ traditional and industrial/ modern products, i.e., corrugated iron (CI) sheet.

Urban areas are mainly developed as modern/ permanent housing, built by "concrete block walls, corrugated iron sheet roofing, and milled timber framing, with a level of formal professional involvement." With a final 27% of the homes built of 'modern' material.[16]







15 Julia Watson (pg 55)
16 Prospects and constraints of post cyclone housing reconstruction in Vanuatu PDF (pg 1-3)



Homes in Vanuatu are hand built, hand tied, using local tying traditions

CHILDHOOD

The “Vanuatu National Child Protection Policy” was developed as a 10-year policy for 2016-2026 to protect the island’s children from abuse, exploitation, neglect, and violence. “Our children must be able to grow up in loving and caring environments. They must have time to be children with all the wonder, happiness, and innocence that childhood should bring. Children’s rights are intrinsic and universal, and their dignity must always be protected.” [17] Growing up in Vanuatu has its beauty but also its sadness. In recent years, child abuse and violence have increased along with climate change impact creating an unstable environment for children. The Vanuatu National Child Protection Policy is dedicated to creating a strengthened environment for children living in Vanuatu.

Currently, 38% of the population are between the ages of 0-14; due to the island’s isolation and poverty rate, education is very scarce, causing a large number of Vanuatu children to begin work at a very young age. Forced labor for children under 23 is forbidden, except on family-owned agricultural fields, resulting in most children growing up on the fields.[18]

Unfortunately, the island’s poverty rate correlates with the island’s exposure to natural disasters, resulting in economic shocks through the island.3 Cyclones and floods are causing massive destruction to cities, villages, homes, and farmland, resulting in a disconnect between the children and the rituals and beliefs they are taught, as these events result in a raised percentage of children exposed to poverty.[19]

17 https://mjcs.gov.vu/images/policy/Vanuatu_National_Child_Protection_Policy_2016-2026_FINAL_Nov16.pdf

18 https://www.humanium.org/en/vanuatu/#:~:text=Children%20in%20Vanuatu%20generally%20begin,of%20them%20help%20their%20parents.

19 https://www.unicef.org/pacificislands/media/1281/file/Situation-Analysis-of-Children-Vanuatu.pdf



Children on the island are heavily impacted from the cultural loss due to a disconnect between the islanders and their identity crisis

“What’s the Time Mr Wolf”

The kids go around in a circle like a clock. They say:

One, two, three, four, five,

What’s the time Mr. Wolf?

On each number they take a step.

Mr. Wolf responds with a time that comes after the last number the kids said:

“It’s six o’clock!”

The game continues counting higher and higher until the last time they do it as follows:

One, two, three, four, five,

Six, seven, eight, nine, ten, eleven,

What’s the time Mr. Wolf?

Then Mr. Wolf responds:

“It’s eat o’clock!”

Then Mr. Wolf chases the group and tries to catch someone. If s/he catches one of the kids, that kid becomes the new Mr. Wolf. Then the game starts all over again.

Walking through the island's streets, you see a multitude of different road conditions. Due to the island's location, its frequent exposure to severe weather conditions impacts the roads; on the island of Efate, Port Villa is the only location where the roads are paved and sealed by barriers against flood. As a result, road conditions over the island are typically narrow and damaged from constant impact, creating difficulty in transportation.



INFRASTRUCTURE

Infrastructure and the environment continue to be the main focus of the islanders and neighboring governments such as the Australian government. In 2017 the Government of Australia's worked alongside the Government of Vanuatu (GoV) to develop a public works department focusing on infrastructure. Australia co-founded the Port Vila Urban Development Project (PVUDP) alongside the Asian Development Bank.

PVUDP *- "ADB is helping Vanuatu expand access to basic services in the capital, Port Vila, and surrounding areas in Shefa province. The project will improve drainage, roads, and sanitation systems. It will contribute to climate-resilient and sustainable urban development in and around Port Vila"* [20]







"Vanuatu is geographically located in the **"ring of fire"** *and the* **"cyclone belt"** *of the Pacific. The country is extremely vulnerable to natural disasters and is the world's most vulnerable out of 111 countries, as assessed according to the Commonwealth Vulnerability Index. It is at risk from a wide range of climate-related hazards - more than most other Pacific countries. These hazards include coastal erosion, tropical cyclones, floods, landslides, and drought, which are expected to increase in severity and frequency as a result of climate change, warranting emphasis on climate-proofing of infrastructure, policy and institutional capacity building for disaster risk management, and improving climate resiliency."* [21]

Improving the island's road network has become a high priority for the GoV, approximately 2100km. The focus of restoring or developing these roads is to allow access throughout the island, predominantly in rural areas, linking to schools, medical facilities, and commercial transport. Their social and economic well-being and resilience to natural disasters and climate change depend significantly on the accessibility of the road network. [3] Transportation and infrastructure play a crucial role in linking the villagers with the rest of the island on Efate, especially in facilitating that link to the central city of Port Vila, which provides access to income, agriculture, and domestic and international goods and materials. Currently, on the island of Efate, only 10 percent of the roads are sealed against climate impact, with the majority of the roads located within the capital city of Port Vila. Additional roads are being sealed on the cyclone path southeast of the island in an attempt to preserve their integrity against harsh climate disasters.

20 *Port Vila Urban Development Project. 2011*

21 *Port Vila Urban Development Project. 2011*

“Mass selection was used with inter crossing. After a period of yield observations, the best palms in a population were crossed with each other. This required the hand pollination technique, which is much more labor-intensive than selection with open pollination, but more efficient in terms of the expected geneic progress”



AGRICULTURE

Researching the existing farming impact on the island provides an islander's perspective on the effects of these ongoing disasters and their effect on the quality of life. The island is home to various crops cultivated on the land; however, for this thesis, only a few will be discussed. The focal crops will be centered around cultural and socio-economic importance.[22]

Manihot Esculenta (Manioc), also known as cassava, is a shrub belonging to the Spurge family of plants that grow in tropical climates. This edible root must be detoxified before eating. *"Bitter manioc can be toxic to humans if chronically consumed without proper removal of the cyanide through a labor-intensive precooking process"* [23] domesticated in the amazon 7000-9000 years ago, this plant was introduced into the pacific islands in the 1850s during European contact. Manioc isn't a plant grown in large fields on the island of Vanuatu; instead, this crop has become a homegrown crop for every farmer throughout the villages. Harvesting may begin at 8-10 months; however, the plant is still tender; thus, the full harvest season is 10-14 months. The harvesting of manioc in every home garden is primarily due to its believed pharmaceutical qualities. Juice of manioc is boiled down to a syrup and given as an aperient medicine. Used in *"folk remedies for cancerous affections, condylomata, excrescences of the eye, and tumors. Reported to be antiseptic, cyanogenetic, demulcent, diuretic, and poison, it is a folk remedy for abscesses, boils, conjunctivitis, diarrhea, dysentery, flu, hernia, inflammation, marasmus, prostatitis, snakebite, sore, spasm, swellings, and testicles"* .[24] Soil salination has affected the fertility of soils and the nutrients, thankfully not affecting such a main root on the island, "poor man's crop'. This is because it does not need high fertile soil to grow and produce good tubers. Therefore, the plant can develop and thrive in sub-optimal soil conditions and fertility.

22 https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/CC%20and%20Agriculture%20in%20Vanuatu.pdf

23 Dufour, D. L. 1988. Cyanide content of cassava (Manihot esculenta, Euphorbiaceae) cultivars used by Tukanoan Indians in Northwest Amazonia. Economic Botany 42: 255–266.

24 Sardos, Julie & Mckey, Doyle & Duval, Marie-France & Malapa, Roger & Noyer, J & Lebot, Vincent. (2008). Evolution of cassava (Manihot esculenta Crantz) after recent introduction into a South Pacific Island system: The contribution of sex to the diversification of a clonally propagated crop. Genome / National Research Council Canada = Génome / Conseil national de recherches Canada. 51. 912-21. 10.1139/G08-080.



AGRICULTURE

Impomea botatas (Kumala), also known as sweet potato, belongs to the world's top seven most important crops, with various hybrids belonging to the dicotyledonous plant family. Over 70% of the population on Efate grows sweet potatoes, especially in most rural areas, where farmers depend on their *"traditional agriculture to provide for their dietary needs and income."* 4 in 2015 when Cyclone Pam hit the island of Vanuatu, it was clear the catastrophic effects climate was having on the mere chance of survival on the islands. All crop fields and facilities were destroyed, and the islanders had to start from scratch, returning the soil, stabilizing the balance, harvesting, and planting the crops. *"Climate change will continue to have adverse impacts on the crops of Vanuatu, but for now, climate solutions are being developed by local experts to respond to the threats to the livelihoods of Ni-Vanuatus."*[25]

93% of the households on the island located in both rural and urban areas have reported owning food gardens on their land, 69% of the food cultivated was for subsistence living, 23% was for subsistence and for sale, and under 1% of the islanders, food gardens were for sale purposes only.[26]

25 https://www.huffpost.com/entry/vanuatu-develop-drought-resistant-crops-in-response_b_58dd9bd5e4b0efcf4c66a744
26 https://www.fao.org/3/bc654e/bc654e.pdf



BAMBOO

Bamboo has been continuously celebrated, from harvesting fields to building cultural structures for rituals, simple home construction methods, and elevated posts and farms during flood season. As a result of the island's climate status, the United Nations launched a program in 2018 titled the United Nations Industrial Development Organization (UNIDO) Bamboo Training Program, dedicated to training locals on the island in an extensive education program on bamboo harvesting, treatment, and construction design methods, and furniture designing.[27]

Creativity prospered through the strains of their reality, forcing them to adapt and create systems integrated with the new climate events. For example, more substantial, robust huts were constructed through layers of bamboo framing built on elevated concrete floors raised on stilts to avoid flooding within the dwelling. As seen on the island during the Bamboo training excursion program, bamboo has become one of the island's most sustainable and mass-used materials. "They recognize that harvests are no longer as abundant as they used to be, so they see there is a problem. We stayed in a lovely bamboo hut with an elevated bamboo floor. We slept on the floor on a bamboo mat and rigged up our mosquito netting."2 the lavish minerals that were embedded in the ground through burning and regrowth of fields have posed a new issue on the island as the soil is not growing fast enough to keep up with the local population or containing the same minerals—resulting in composting being introduced to the villages.

"They loved making a compost pile; they thought it was very funny to use cow manure (which the village children were told to collect, and was brought to us in palm leaves…)."[28] Using palm and bamboo leaves on top of the compost piles to prevent topsoil wash away during large rains storms.

27 https://doi.gov.vu/index.php/projects/unido-bamboo/14-projects
28 https://www.permaculturenews.org/2014/09/12/permaculture-vanuatu/



LEGENDS

Legends within the island suggest two worlds between the physical and spiritual worlds living within ours. Believing that the spiritual world is tied to our natural world creates an obligatory understanding of pleasing the spirits and respecting their environment in their everyday lives.

Vanuatu's traditional arts are separated between men's and women's arts; following a traditional matriarchy, the art of weaving has been entrusted to the women passing on the knowledge and skill to the next female generation.1 Mythological stories are tied to every aspect of the natural world; basket weaving is not exempted. 'Sapai and Mouga are the original weavers from green coconut leaves and dry bamboo leaves believed to be the foundation of weaving. As a part of the weaving ritual, Sapai and Mouga would go for a swim in the sea, performing a ritual dance, 'splashing the water surface with their hands', as a performance to the sea creature Fatukanu which blessed the women with the knowledge of weaving - Ni hlaga.[29]

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29 Natuoivi, Eric. "Art / Weaving: The Origins of Futunese Kato (Baskets) through Folklores, Beliefs and Traditions of Futuna Island, Vanuatu." Pacific Cooperation Foundation, 15 May 2016.



TIPPY TAP

From 2013-2016, World Vision introduced a “Water, Sanitation and Hygiene” project in Vanuatu, aiding the islanders in the collection of clean water supply. Due to water shortages, authorities on the island asked World Vision to focus on a village in southwest Tanna, which recorded the highest occurrence of malnutrition and illness in the archipelago. The introduction of Tippy Taps on the island was to help promote hygienic practices within the villages; in addition to the Tippy Tap, villages were taught to build bush toilets.

The Tippy Tap is a system that integrates plastic bottles that fill with water; the bottles are attached to a string and placed near the bush toilets to be used after. Though the introduction of such hygienic procedures has positively responded to the archipelago villages, it still poses issues. Tom Yaken has a pivotal role in developing innovative technologies within the island systems, where the Tippy Tap provoked a series of innovations, focusing on the bamboo Tippy Tap.

Though the introduction of Tippy Tap ‘may’ be considered a positive solution, you begin to wonder if this is the ‘best’ solution for the islanders. Was the introduction of plastic bottles the most promising solution and the right direction for sustainable design? Is there a problematic solution to the plastic Tippy Tap, such as chemical bleeding into the water collected through deterioration and constant use?

Tom Yaken, a simple farmer and father of two, did not have water bottles to assemble such a system; sparked by the idea, he began to think about how he could provide a clean water collection for his family.

“I remembered my grandfather used to fetch water with bamboo when I was a little boy, so I decided to create a tippy tap using bamboo for my children to wash their hands” [30]

Through memories of his past, Mr. Yaken recollected how his grandfather would collect water in bamboo, transforming the Tippy Tap into an economical and sustainable alternative to the Tippy Tap, allowing his family to have a plentiful supply of materials (bamboo) but all islanders. A hybrid bamboo system that withstands the chemical leakage deterioration of the water bottle in which the Tippy Tap is exposed is recycled back into the land to decompose, reintroducing nutrients in the ground and continuing the feedback loop. The simplicity in the construction of the Bamboo Tippy Tap follows utilizing the natural structural form of the bamboo rod, removing the inside nodes from the bamboo and drilling a small hole at the bottom that is plugged to hole the water, where the plug is pulled, and the children proceed to wash their hands.

30 World Vision International. “Bamboo Tippy-Tap in Vanuatu: Innovation for Clean Hands.” World Vision International, 2019, https://www.wvi.org/article/bamboo-tippy-tip-vanuatu-innovation.



CUSTOMS

Located 160km north of Efate, a village named Olal famously holds a yearly traditional yam festival showcasing the islander's ceremonial activities, those being; "pig killing and traditional and kastom singing and dancing, sand drawings and different kinds of ritual magic and the legendary Rom dances all telling stories of how yams are sacred ".[31]

The traditional song and dance performed during the festival are dedicated to the "Majikijiki," the spirit which blesses their harvest. In addition, crops such as bananas and taro are gathered during the days leading to the Yam Festival to give thanks and offer to the spirit.

Yam harvesting is woven with the islander's beliefs in magic or animistic practice, where the plant's life cycle - planting to harvesting- relies on the village's commitment to traditions. These traditions are known as 'kastom,' including fasting and honoring spirits and members of society through the manipulation of elements and rituals. Contrasting to western society, the islanders believe that the harvest's fate depends on the whole community, not just the individual, creating a sense of intense accountability for straying away from traditions. In October 2003, UNESCO proclaimed 28 cultural expressions "Masterpieces of the Oral and Intangible Heritage of Humanity." [32]

The islander's traditions are being empowered and preserved against modernizing cultural authenticity. For example, Sandroings (sand drawings) and land diving are traditions dating back to original art and structure, now proclaimed two of the 28 cultural expressions in this world, where preserving these rituals is vital to the islanders' connection with their spirits and their predecessors.

31 "Yam & Magic Festival." Answer the Call to Vanuatu, Vanuatu Travel, 31 May 2022, https://www.vanuatu.travel/en/provinces/shefa-province/efate-port-vila/efate-events/event/226-yam-magic-festival. Accessed 16 Oct. 2022.

32 Alivizatou, Marilena. "Debating Heritage Authenticity: Kastom and Development at the Vanuatu Cultural Centre." International Journal of Heritage Studies 18, no. 2 (2012): 124–43. https://doi.org/10.1080/13527258.2011.602981.



LAND DIVING

Every year village elders organize a ritual to secure the gods' favor. Thus land diving was born in Vanuatu to pay tribute to the deities. Men and boys as young as five climb the bamboo tower wrapped in banana leaves and rope harnessed together in a study tower. Only two vines save the jumpers from crashing into the ground, an ancient precursor – bungee jumping. Vine jumping becomes a symbolic tradition between the islanders and their gods, where this ceremony is considered a sacrifice for the community's survival. The chief proceeds over the village ceremony.

"When they climb the tower, they have no fear because it is their culture. The man's faith helps him put his fear away, and then take action and jump." [33]

Land diving dates back 15 centuries, where the origin is obscure yet tied to the local religion and spirits. Originally, divers would perform after the yam harvest to thank the gods and pray for another fruitful crop year. These land diving towers are still used in rituals every year. During the ceremony, men volunteer to dive; it was believed that the higher the jump, the greater the blessing. So if men were brave enough to dive from the top, they could secure a yam crop and prosperity for the community.

33 NationalGeographic, director. Land Divers. YouTube, National Geographic, 18 Oct. 2007, https://www.youtube.com/watch?v=l0Mq6rCfYtU&ab_channel=NationalGeographic. Accessed 21 Apr. 2021.



LAND DIVING

Close your eyes, and try to visualize the moment's intensity; the air is filled with traditional chants and locals whistling; standing in front of the islanders is a 30m tall wooden structure built through logs and vines and considered a traditional scaffold, where a man stands at the top of the frame with his hands in the air towards the sky. In these moments, the men who jump are tied to the vines integrated within the structure, arms in the air, praying to their spirits to survive the fall; he jumps.

"Within a second, he hits the ground. You can hear the vines tension and his contact with the ground from over 50 meters away." [34]

Vanuatu land diving is known as the birthplace of modern bungee jumping. The legend says a woman caught her husband cheating on her. She ran away up a coconut palm tree, being chased by her husband. Torn and confused as the wife reached the top, she jumped, and the husband followed. The wife tied vines to her legs and survived, contrasting the husband's grime fate. The land diving festival marks the beginning of the yam harvest, where the more suitable jumps reflect better yams.

The land diving tower is 30 meters high from the diving platform. The frame has several platforms starting at 10 meters and going up to 30 meters, where younger children jump from the lower platforms, and jumpers from previous years' ceremonies may jump from higher. The ceremony ends with the final jump from the most elevated platform.[35]

34 "Naghol Land Diving, Vanuatu's Craziest Tradition." The Lost Passport, July 17, 2018. https://www.thelostpassport.com/naghol-land-diving/.

35 "Naghol Land Diving, Vanuatu's Craziest Tradition."



SAND DRAWINGS

Complex geometric drawings known as sand drawings are made from a single uninterrupted line that starts and ends at the same point, forming a closed loop. This indigenous form of art is taught to the village's men, where it is essential to understand that sand drawings are layered with history and meaning being passed down through generations. As the men draw, surrounded by a larger group on the ground, this becomes a memorable occurrence during village meetings as the layers in the drawing reveal stories, where the act of the drawing becomes more important than the final image itself.[36]

There are four layers embedded within these drawings; few studies exist to understand the specific meanings of forms and curves to be understood by foreigners; however, the islanders have kept much of their traditions and prophecies in this art secret;

Layer one, the superficial layer - an unmistakable visual layer known as the primary form of the drawing

Layer two, geometric layer - guiding and orienting the foundation of development for the drawings; this layer utilizes mathematical patterns to convey stories discussing relationships between order and chaos

Layer three, connectivity - this layer connects land and water; where in this scientific layer, we study the nutrient transfer between the land, soil, and water

Layer four, horizon level - this layer tells stories where only the elders can read the more profound meaning within the drawings and their spiritual importance

36 Zagala, Stephen. "Vanuatu Sand Drawing." Wiley Online Library. International Council of Museums, June 24, 2004. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1350-0775.2004.00455.x.



mythologies

The importance of the next section is to understand and see how the specific climate natural reactions result from the actions the islanders have on the land. The interlaced connection between the two is what is causing the disconnect between identity and one's self.



MYTHS

"IRA-WHAKI and his wife Taranga had five sons, whose names were: Maui-mua, Maui-taha, Maui-pae, Maui-roto, and Maui-Tikitiki-o-Ta- ranga. Maui-Tikitiki-o-Taranga, the youngest, was prematurely born, and, as the custom was in those days, he was cast into the sea. His mother, before doing this, wrapped him up in the topknot of her hair. Hence his name Maui-Tikiti-ki-o-Taranga (Maui—who-was-wrapped-in-the-topknot-of-Ta-ranga's hair). Tangaroa (Neptune), the god of the sea, took pity on the shapeless mass of Maui, and thus Maui was brought up by him till he reached matured manhood. Then he was told about his birth and origin, after which he longed to go to his own people. He appeared at a gathering of musicians and dancers where his mother and brothers were.

Now, it was the mother's custom to count her children be-fore ret ring to rest, and this evening when she counted them there were five instead of four. Maui revealed himself and was acknowledged by his mother as being her lastborn child. His brothers became jealous of him because their mother show-ered her love on Maui. The mother used to disappear every day. Maui-Tikitiki, having noticed this, determined to find out where she went, and so, one night he hid her cloak and de-layed her considerably till it was quite daylight. Then he fol-lowed her and found her disappearing beneath a tuft of wiwi grass. After she had gone for some time he lifted up the wiwi and found it was the entrance to a large cave.

Transforming himself into a pigeon, he followed his mother till he came to a new bright world, and there he sat on a tree. The inhabitants of this new world all exclaimed, "He rupé, he rupé!" ("a pigeon, a pigeon"), and all began to pelt him with stones. His father, luckier than the rest, struck him on the breast. He came fluttering to the ground, but, lo! when they went to lay hold of him he transformed himself into a man, and so his mother made him known to his father.

37 World Mythology and Religions, Director. Legends of Maui: Hero of New Zealand; Polynesian Mythology. Youtube, Youtube, 15 june 2021, https://www.youtube.com/watch?v=k3v62zy4kqy&t=999s&ab_channel=mythos%26logos%e2%80%93worldmythologyandreligions. Accessed 6 jan. 2022.

38 Pomare, Maui, and James Cowan. "The Legend of Maui Tikitiki-o-Taranga — HIS SEARCH FOR HIS SISTER HINA." LEGENDS OF THE MAORI, Vol. 2, Victoria University of Wellington Library, pp 134–137. New Zealand Texts Collection.



Now, Maui had a most beautiful sister, Hina by name. She was married to Ira-Waru. Maui and his brother-in-law one day went a-fishing. Ira-Waru caught all the fish, which irritated Maui to a great degree. Eventually, their lines became entangled, and Maui claimed the fish as being on his line, while the brother-in-law protested the fish was on his. However, when Maui pulled in the fish he found to his great surprise that his brother-in-law was right. In unhooking the fish he noticed that his brother-in-law's hook had a barb and his had none. When they got ashore Maui said to Ira-Waru, "You get under the outrigger while I lift the canoe." But as soon as he perceived that Ira-Waru was well under he jammed the outrigger on to him. Then, by rnagic, he prolonged his nose into the snout of a dog, and his backbone into a tail, and thus Ira-Waru became the progenitor of dogs. When Maui reached home his sister asked him as to what had become of his brother-in-law, and in reply Maui said: "You go down to the canoe and help him bring back the fish, and should he be out of sight, you call to him in this wise, 'Moi, moi.'" So Hina went down and did as she was bidden, and lo! Ira-Waru, her husband, answered her call by crying, "Hao, hao, hao!" and when he appeared he began licking her hand and wagging his tail.

When Hina discovered this vile deed she committed suicide by throwing herself into the restless sea. Now, Maui-mua wept and longed for his lost sister, and being consumed with grief, he sought aid from Rehua, the deity, whose habitation was in the Tenth Heaven. When he reached Naherangi he said to the god, "O great Rehua, in thy musings hast thou heard murmurings from the worlds below?" and Rehua answered and said, "Yea, even so, from Motutapu, the Sacred Island." Maui-mua, changing himself into a pigeon, pursued his noiseless flight through the ten heavens to the abode of Hina, his sister.

39 World Mythology and Religions
Pomare, Maui, and James Cowan. "The Legend of Maui Tikitiki-o-Taranga"



Hina, after throwing herself into the sea, was for many days buffeted by the waves, and she was wafted by the wind to Motutapu. Two brothers, Ihu-atamai and Ihu-weriweri, found her and, with the aid of incantations and the sacred fire, she was restored to her former beauteous shape and looks. Tinirau, the overlord of the Island, hearing of her great beauty, sent for her and made her his chief wife. This naturally led to dissensions in is household. Consequently, Hina was badly treated by the other wives. It was at this time that Maui landed on the window-sill of Tinirau's house, where all the people exclaimed, "He rupé, he rupé ("a pigeon, a pigeon") and they began to throw spears. But "Rupe" dodged all the spears, and then he transformed himself into a man, thus revealing himself to his sister, whom he took with him to the Tenth Heaven to offer his thanks to the Supreme Being.

Now, Rehua had a son, Kaitangata by name, who became enamoured with Hina. Maui, in building a latrine for Kaitangata, put in the post of Whaitiri loosely, so that when Kaitangata took hold of the post it became uprooted and he, falling over the cliff, was killed. That is why-even to this day-when a Maori beholds the blood-red skies in the west, he exclaims, "Ka tuhi Kaitangata"

Pomare, Maui, and James Cowan. "The Legend of Maui Tikitiki-o-Taranga"



THE ABAIA

According to Melanesian mythology, the Abaia is a giant eel that dwells at the bottom of freshwater lakes in the Fiji, Solomon, and Vanuatu islands. The Abaia is the mother of all aquatic creatures, considers all residences in the lake its children, and protects them furiously against anyone who would dare harm or disturb them.

It is also said that those who are foolish enough to try to catch the fish from a lake containing the Abaia are immediately overwhelmed by a large wave caused by the thrashing of the Abaia's powerful tail. Some legends narrate that if someone were to harm a creature living in the Abaia's home, the Abaia would cause a great rainstorm to flood the land, drowning those who had caused them harm. x

These legends tell the story of a man who one day discovered a lake in which were many fish, and at the bottom of the lake, there lives a magical eel, presumably the Abaia. However, the man was not aware of the creature's presence. He caught much fish and celebrated with the town folk. Not satisfied, he greedily returned the next day with the people from his village, who he had told about his discovery, and they were all very successful at catching a lot of fish. One woman even went as far as attempting to lay hold of the great eel, Abaia, who dwelt in the depths of the delta. Of course, Abaia escaped and was incredibly infuriated. He was angry that his fish had been caught and that he had been seized. He caused a massive storm to fall during the dark of night, and the waters of the lakes rose continuously until all the people drowned. Except for one woman who had not eaten the fish and saved herself by climbing on top of a tree.

41 https://www.youtube.com/watch?v=wFJ8Waqwvz0&ab_channel=Mythology-FolkloreA-Z



Chapter Two

introduction

The biophysical world has become a rich area for research, where abiotic and biotic substances make up the living on this planet. Understanding the relationship and harmony within the biophysical world will allow a greater understanding of survival, evolution, and regeneration. When dissecting Vanuatu's biophysical world, it is important to address that biophysical varies from microscopic scale bleeding into a global one. Due to the global similarities between environments worldwide, this thesis proposes a fundamental developed cell system introduced in areas around the world where the value of life is guided as the islanders of Vanuatu. Vanuatu's island becomes a theoretical site where the design goes beyond a more universal, context-insensitive solution and begins to draw upon the island's mythological practices, thus anchoring it to a specific location.

Developing a fluid connection between three different ecological conditions; ocean, riparian and terrestrial ecosystems creates the opportunity for enriched biodiversity that will result in island and planet regeneration. These three ecosystems work in concert to control the process and promotion of enriched biodiversity through recycling nutrients and energy. All while investigating integrated layers of urban fabric that begin to blur the edge condition of coastal regions. Bringing the water inland using resilient and reusable material to further safeguard the island from natural disasters. Furthermore, these cells will act dynamically, like anchors or floatation devices reacting to the detrimental climate impact of severe floods or cyclones. By creating a robust connection between these three ecosystems and introducing systems to protect them during such events, life will take its natural course and begin its regeneration process to aid the land in adapting to current climate conditions.

Understanding the island's myths gives an in-depth insight into what is important to the people of Vanuatu and what makes them happy. Aude-Emilie Doiron, a journalist, wrote in the earth journalism a compelling story of the women on the island and the connection they have to water, called "In Vanuatu, Women Draw Strength from the Rhythm of the Ocean." This article may have been the most impactful within part II of the catalogue. A quote within the article states that "The ritual shows the reciprocal relationship between the land and the people. And while climate change has upset that balance in many ways, seeing nature as sacred has remained not just a view of life, but a way of life as well." Reflecting the sacred connection between nature and life, the proposed project should begin to repair the water from the destruction of the first world while addressing climate impact on the island's agriculture and way of life. The island's people must rekindle their relationship with the land and water, as the fear of climate change has not only affected the physical state of the island but has also frayed the emotional ties of its people to it.

There is an abundance of information drawn from the riparian zone, which becomes this thesis's main focal point. The liminal space between land and water is the threshold that ties these broken ecosystems into one. Understanding energy flows between land and water can be achieved through the analysis and concentrated study of abiotic and biotic factors. The riparian zone is the first impact zone during floods and cyclones, acting as a barrier by dissipating water energy. Within this ecosystem, there is a blend of habitats that live both within water and land that aid in energy and nutrient transfer, water purification, and erosion control. This thesis will begin to link damaged components and aid their rehabilitation to create a robust liminal zone through research papers on physical and chemical components and analysis of these broken ecosystems. Extending the riparian zone into several moments within the geotextile cell system will render the edge condition of the island unknown, creating a blend between ecosystems creating potential integrated occupation possibilities for species and humans. This linkage of ecosystems will allow for rehabilitation at the location of the intervention and impact the ecosystems on all four edges, creating a bleed-out zone. The design will be located in several moments along with the island's riparian zone, resulting in a natural linkage extending the initial design's impact zone over a longer time frame.

TIMELINE

Settled **3000** years ago | between 1,100 BC and 700 BC | Melanesian People
1606 - European landnig Pedro Fernandez de Quiros
1768 - Louis Antoine de Bougainville names the islands Les Grandes Cyclades.
1774 - British explorer Captain Cook charts the islands, calling them the New Hebrides.
1800s - Thousands of ni-Vanuatu are kidnapped and forced to work on sugar and cotton plantations in Fiji and Queensland, Australia.
1865 - European settlers begin to arrive on the islands.
1887 - Britain and France established a Joint Naval Commission
1906 - Britain and France make the country a Condominium. Each power is responsible for its citizens, but both countries look after indigenous New Hebrideans. Non-New Hebrideans choose which country they want to be governed by.
1963 - The NaGriamel political movement emerges in Espiritu Santo. Fol lowers advocate the return of land to the ni-Vanuatu people and a return to traditional ways.
1971 - NaGriamel, anxious that foreign missionaries, planters, and traders now own more than 36% of the New Hebrides, petitions the UN to prevent further land sales to non-indigenous people
1977 - Representatives of the New Hebrides and governments of Britain and France agreed an independence plan for the islands in 1980 following a referendum and elections.
1978 - A measure of self-government introduced
1980 - June - Jimmy Stevens, the leader of NaGriamel, declares Espiritu Santo independent of the rest of the New Hebrides, renaming the island the Independent State of Vemarana. Papua New Guinea troops, backed by the Australians, put down the insurrection.
1980 - 30 July - New Hebrides attains independence within the Common wealth under the name of The Republic of Vanuatu.

42 "Vanuatu Profile - Timeline." BBC News, BBC, 12 July 2017, https://www.bbc.com/news/world-asia-16426561.

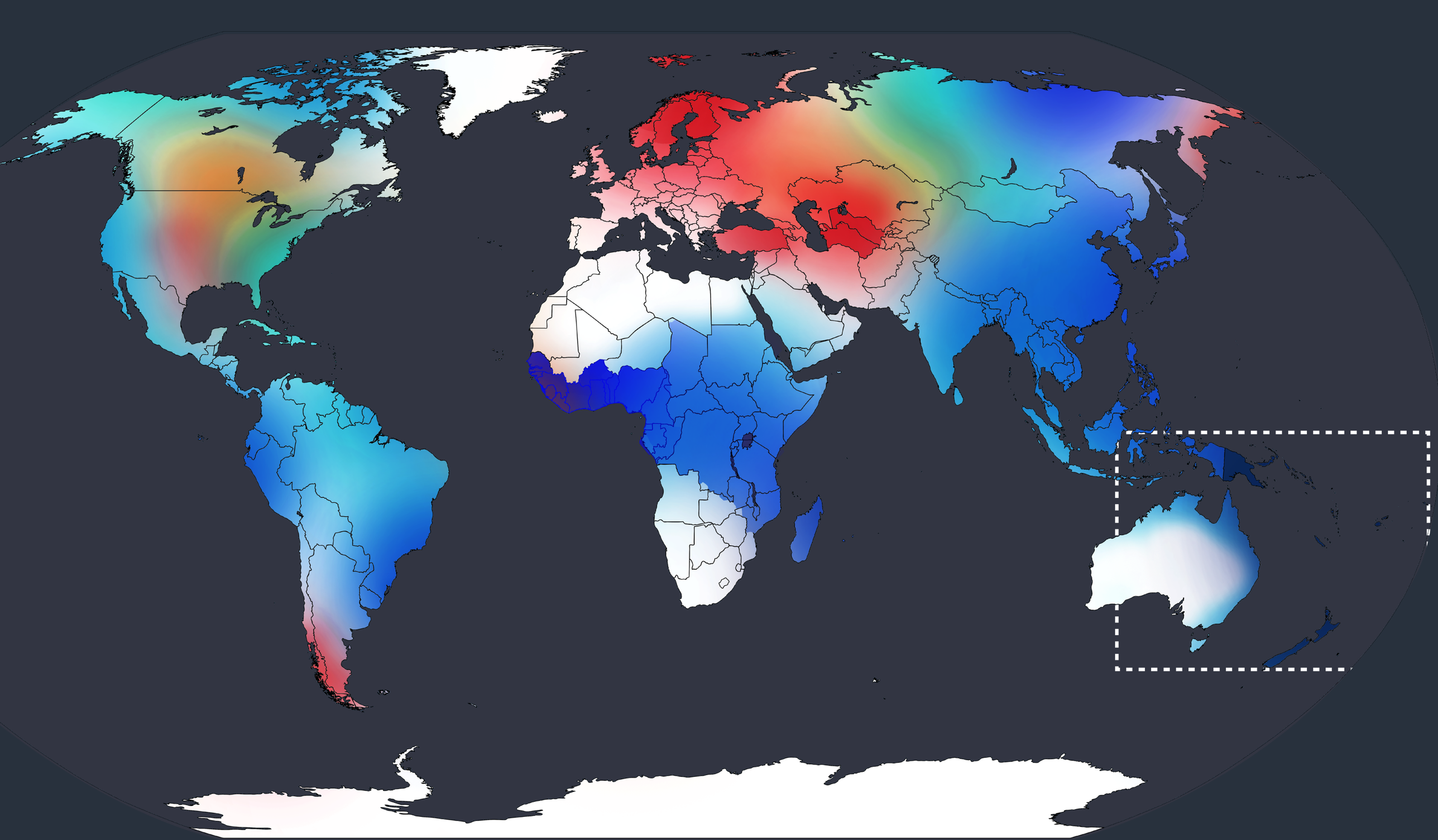
The Republic of Vanuatu is an island country in the southwest Pacific Ocean, surrounded by harsh storms and unforgiving seas. The archipelago is located roughly 1,770 km east of northern Australia and was original of volcanic origin, now extending north-south roughly for 650km and the form of an irregular Y. Melanesian people originally inhabited the island, then boarded by the first European expedition led by Portuguese navigator Fernandes de Queiros in 1606. However, in the 1880s, France and the united kingdom claimed part of the archipelago. Later in 1906, both [France and United Kingdom] settled on a framework for concurrently managing the archipelago through an "Anglo-French condominium of the New Hebrides" [43].

A movement of impedance arose from the islanders in 1970, achieving independence in 1980; the land of Vanuatu, meaning "Our Land Forever" in many of the local Melanesian dialects, was now the Republic of Vanuatu. Since gaining independent status, the country is now a member of various organizations, becoming a member of the United Nations, Commonwealth of Nations, Organisation Internationale de la Francophonie, and the Pacific Islands Forum. [44]

The arrival of Europeans during 1606-1906 had an everlasting stain on the islanders. In detail, the contact began when Pedro Fernández de Quirós (1606) landed on the archipelago, then followed by French navigator Louis-Antonie de Bougainville (1768) and Britsih captain James cook (1774), giving the name New Hebrides. Missionaries and tradesmen began settling on the island's coasts in 1840, claiming their impact on the indigenous people was "minimal." But do foreigners genuinely understand the significance of the seaside to these islanders? In addition, a significant time in the Republic of Vanuatu was in the 1860s, when thousands of ni-Vanuatu men and women were ripped from their lands and forced to work in plantations in Fiji, New Caledonia, and Australia began their voyage back home. In 1887 the British and French governments formed a rudimentary political control over the island with a Join Naval Commission, protecting the interests of British missionaries and fresh planters. They succeeded in 1906 by an Anglo-French condominium where residing commissioners in the capital, Port-Vila, retained responsibilities over their nationals and jointly 'ruled' the indigenous people. [45]

During the second world war, the islands became a significant Allied base. After the war, many local political initiatives began to organize the overturn of land ownership, losing claim to more than one-third of their land to foreigners. Finally, on July 30, 1980, the Republic of Vanuatu became independent within the Commonwealth.[46]

43-46 "Vanuatu Profile - Timeline"





https://www.geographicguide.com/oceania-map.htm

Hiw
Tegua
Torres Islands
Lo
Toga
Vot Tande
Ureparapara
Banks Islands
Motalava
Vanua Lava
Sola
Mota
Torba
Gaua
Jolap
Merig
Merelava
SOUTH
PACIFIC
Sakao
Big Bay
Port Olry
Sanma
Espiritu Santo
Malao
Lataro
Mavea
Aese
Luganville
Tasiriki
Aore
Tutuba
Malo
Bougainville Strait
Marino
Betarara
Maewo
Longana
Aoba
Penama
Abwatunbuliva
Pentecost
Ranputor
New Hebrides
Coral Sea
Leviamp
Lakatoro
Craig Cove
Ambrym
Malakula
Maranata
Malampa
Lamap
Lfro
Paama
Lopevi
Ringdove
Epi
OCEAN
Tongoa
Puele
Tongariki
Boloa
Émaé
Shepherd Islands
Makura
Mataso
Shefa
Nguna
Émao
Moso
Lelepa
Mele
Forari
PORT VILA
Efate
Unpongkor
Port Narvin
Erromango
Tafea
Aniwa
Lowital
Tanna
Isangel
Ireupuow
Futuna

Ringdove
Epi
Tongoa
Puele
Tongariki
Boloa
Émaé
Shepherd Is
Makura
Mataso
Shefa
Nguna
Émao
Moso
Lelepa
Mele
Forari
PORT VILA
Efate

Systems

Existing ecology section dissect the more tactile issues and the existing conditions of the island such as natural hazards due to climate change, existing typology and ecology on the islands, and the impact climate change is having on these different sectors. An American writer and editor named John R. Campbell wrote a GNS report known as the “Traditional disaster reduction in Pacific Island Communities” where he dissects the climate impacts on each of the island nations of Oceania. Due to the location of the islands in the south western Pacific Ocean, they are exposed to some of the harshest climate change impacts; from serious floods to 100-year storms occurring a few times within two decades. Within the study there are four clusters of coping measures that can be tackled due to climate impact on the island. Additionally, due to the intricate composition of some of these islands, they are hit with a few of these clusters’ zones creating a very unstable living environment. Climate change has affected the islands vegetation on many levels, some of those being rearing temperature and crop production. Temperature is in fact a key determinant in evaporation and transpiration demand, which is especially important within tropical islands. Changing the physical maximum heat by creating higher temperature increases heat stress on crops and water loss by evaporation. High temperature stress may continue to exacerbate by the high relative humidity found within the islands. Additionally, crop productivity becomes increasingly vulnerable when there is more than one abiotic stress, this drought and heat stress begin to affect crops in a short period of time by not allowing plants to employ their regenerative capabilities and thereby causing plant degradation and infertile soils.

ecological

The section begins to specify the types of vegetation on the island and how vegetative zones are individually impacted by climate change, which is important for me to understand if I want to try and develop a geotextile system that will help promote new birth and development of the islands vegetation system where I can create an ecosystem to rehabilitate the island. A report written in 2012 becomes an important piece of literature as is addresses many layers within the ecological systems of the islands. Written by a group of activists, it is titled the “Climate Change and Pacific Islands: Indicators and Impacts” report, created for the 2012 Pacific Islands Regional Climate Assessment program (PIRCA). This report discusses the diversity of ecosystems on the island which are now being threated due to climate impact and potential solutions that can restore the region to its original form. The riparian zone is a focus for this catalogue as I want to study where the limen is between land and water, and how to merge the two in one, forming a system that obscures the boundary between island and water.

EFATE

The island of Efate is the most populated island within the Republic of Vanuatu, roughly 45,000 inhabitants, predominantly Melanesian with a small population of Polynesian, Asian, Australian and European (French and British). The island's area is 899.5 sq.km. making Efate the third largest island within Vanuatu. During the second world war, Efate became the base for the United States Naval military, who gathered many soldiers within the pacific islands to attack Japan after Pearl Harbor. This battle was essential to the Pacific Island Regions. It was the first major offensive and decisive victory for the allies, allowving control of the islands back from Japan. After Vanuatu became independent, Efate is governed by the Port Vila Municipality and the Shefa Provincial Council, where the legal limits extend only to the island's borders.

Efate is a **tropical rainforest climate**, that being wetter and drier months. Located within the Pacific Ocean, the island is prone to **heavy flood storms** and on a regular **cyclone paths**. With climate change becoming more extreme, the island climate and habitability is becoming more hazardous. Port Vila is Vanuatu's most important harbor. The Republics' trade leader poses a severe hazard to the economy's survival if these islands due to the climate impact on Efate. **Agriculture** and **fishing** are Efate's major industries, where tourism also holds a small part.



LAND CLASSIFICATION

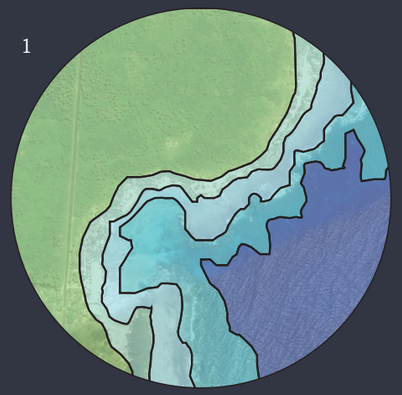
1. Built-up areas: All urban and rural areas with clustered housing/building (all densities), including home gardens and urban parks /green areas
2. Infrastructure and transportation zone
3. River and riparian zone:
4. Terrestrial coastal (beach) zone: sand and gravel cover
5. Agricultural land 5,719 ha
    - 5.1 Pasture land and grassland including coconut trees over pasture and degraded pasture land with >50% grass cover
    - 5.2 Crop Land including horticulture and tree plantations (other than coconut)
    - 5.3 Areas of active subsistence gardening (away from built-up areas; bush gardens')
6. Water bodies:
    - 6.1 Lake
    - 6.2 Swamp/wetland (not riparian)
7. Forest 11,217 ha
    - 7.1 High density forest (tree canopy >75% total canopy cover)
    - 7.2 Low density forest (tree canopy 40–75% total canopy cover) and thickets
    - 7.2.1 Lowland low density forest (tree canopy 40–75% total canopy cover—disturbed human forest for older bush gardens)
    - 7.2.1 Thickets, scrub or fern (tree canopy <40% canopy cover and grass <50% canopy cover)
8. Marine coastal zone 831 ha
    - 8.1 Coastal mangroves
    - 8.2 Coastal seagrass
    - 8.3 Coastal nearshore reef areas

47 Blaschke, Paul, et al. "Port Vila Ecosystems, Climate Change and Development Scenarios." Secre tariat of the Pacific Regional Environment Programme, 2017.

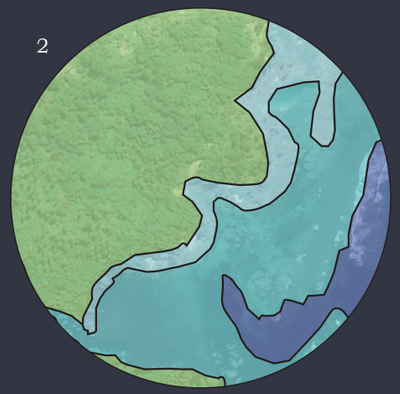


RIPARIAN CONDITIONS

1

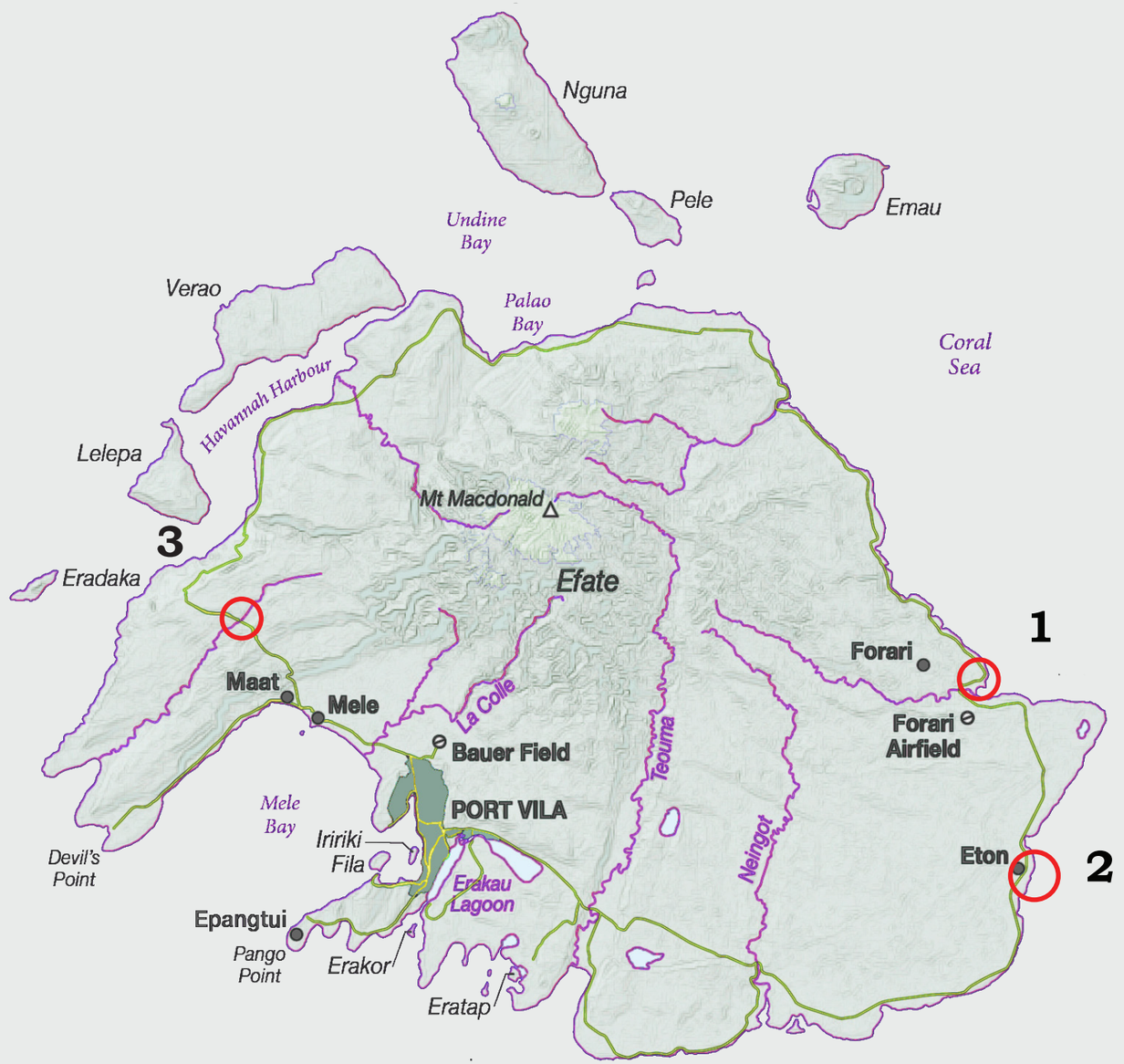


2



3





GEOLOGICAL CONDITIONS

Efate is located within the southern part of the Vanuatu arc, marking the present subduction of the Indo-Australian plate eastwards beneath the Pacific Plate, current underthrusting at about 12 cm yr $^{-1}$.

The island is located on the southern margin of the D'Entrecasteaux Collision Zone. Efate islands are comprised of trachydacite-dominated volcanic centers, where the predominant unit is "Efate Pumice Formation, a >0.5 km thick sequence of siliceous pyroclastic and volcaniclastic rocks forming elevated hills in the central part of Efate" [48] The silicic lithologies of Efate are overlain by basalts of basalt Volcanoes Formation, which erupted in two episodes.

Episode one comprised of subaerial and shallow subaqueous lava, breccia, and intrusive rock, and the second episode was comprised of subaerial pahoehoe lavas, autobreccias, and pyroclastic rocks.[1] The more visible geological formation on the island is comprised of basaltic lavas and breccias, modern alluvium, quaternary limestone terraces, pumicous sediments, pumice breccia, and reef limestone formation.[49]

48 The central North Fiji basin and New Hebrides arc, and the D'Entrecasteaux ridge and West Torresplateau, pp. 272–273

49 Stewart, Robert & Nemeth, Karoly & Cronin, Shane. (2012). Is Efate (Vanuatu, SW Pacific) a result of subaerial or submarine eruption? An alternative model for the 1 Ma Efate Pumice For mation. Central European Journal of Geosciences. 2. 306-320. 10.2478/v10085-010-0020-9.

LAND COVER

The island's surface area equated to 899 sq km and a height of 637 meters. 3 Efate is an intertropical island covered in dense forest, mainly located at the island's center, where these closed forests are inaccessible. Farm fields are located within the island's lowlands, where vegetation can grow. The Southeastern part of the island is predominantly covered by Savanah, which is interesting to point out that the southeast part of the island receives brute force or cyclones, storm surges, and extreme weather events, as located within the ring of fire. Using Very High-Resolution Optical Data (VHR), researchers could get accurate analyses of the land mass and land surveys.[50]

The biophycial world of the island can be categozized by the following;

1 Ocean - Pacific Ocean and coral reefs
2 Water - Open water surface area, e.g. river, lake, marsh
3 Beach - Sandy and rocky mineral surface area
4 Road - Roads and dirt paths
5 Urban zone - Constructions and artificial surface areas
6 Cloud Cloud cover
7 Shadow Shadows - not linked to clouds that cannot be differentiated
8 Bare ground - Ground without any plant cover
9 Closed forest - Closed forest that has not been modified by human activities over the past few decades
10 Secondary forest - Mixed forest (closed, medium, sparse) that has been changed by human activities
11 Open forest- Breaks in the closed forest, e.g. those due to fire (where Meremia vine can usually be found).
12 Isolated trees - Trees completely surrounded by savannah
13 Shrub savannah - Savannah made of bushes. Generally these are transition zones between forested areas and grassy surfaces.
14 Grass savannah Savannah, fields, cattle pastureland
15 Coconut grove Coconut stands (as crops or abandoned)

The island has roughly 900 flowering species that have been identified.

50 Aubert, Maelle, and Marc Despinoy. Integrated Coastal Management GERSA Project (Spatial Approach – Remote Sensing). CRISP - Coral Reef InitiativeS for the Pacific , 2008.

Systems



sealed roads



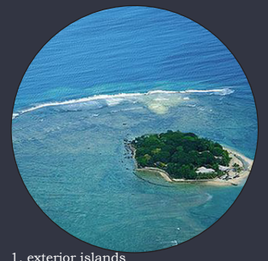
rivers



unsealed roads



tracks



1. exterior islands



2. island hills



basaltic lavas and breccias



modern alluvium



quaternary limestone terraces



pumiceous sedi-
ments

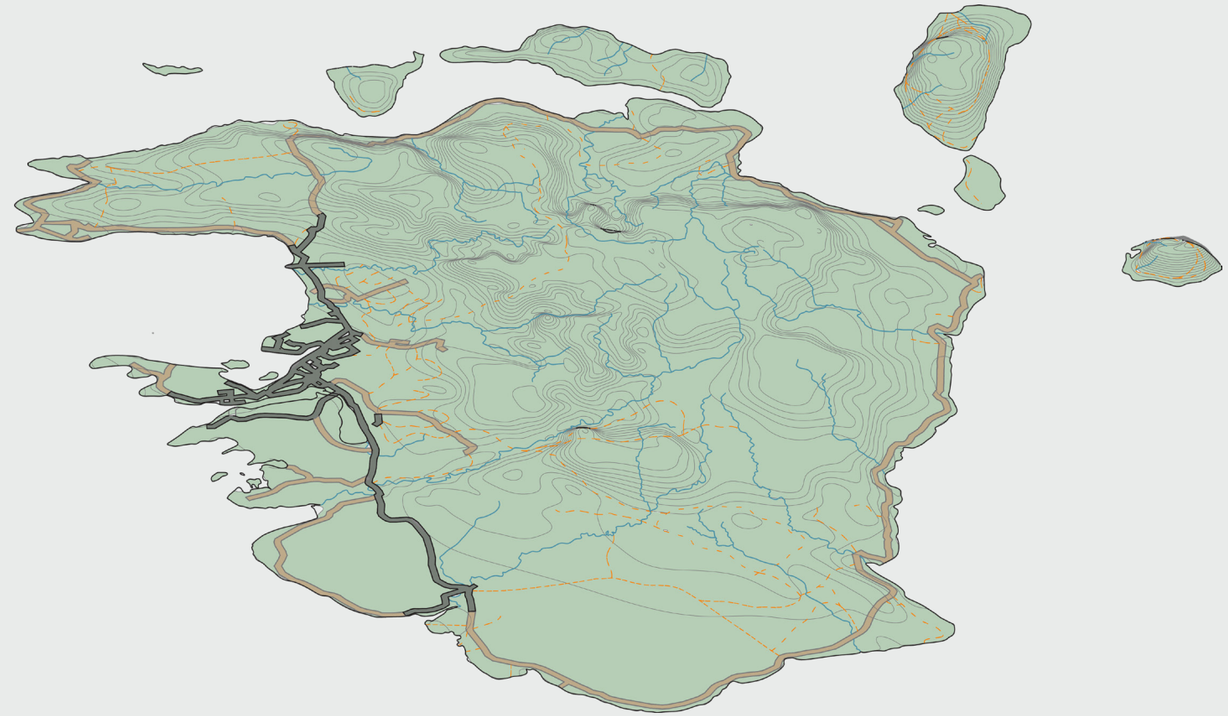


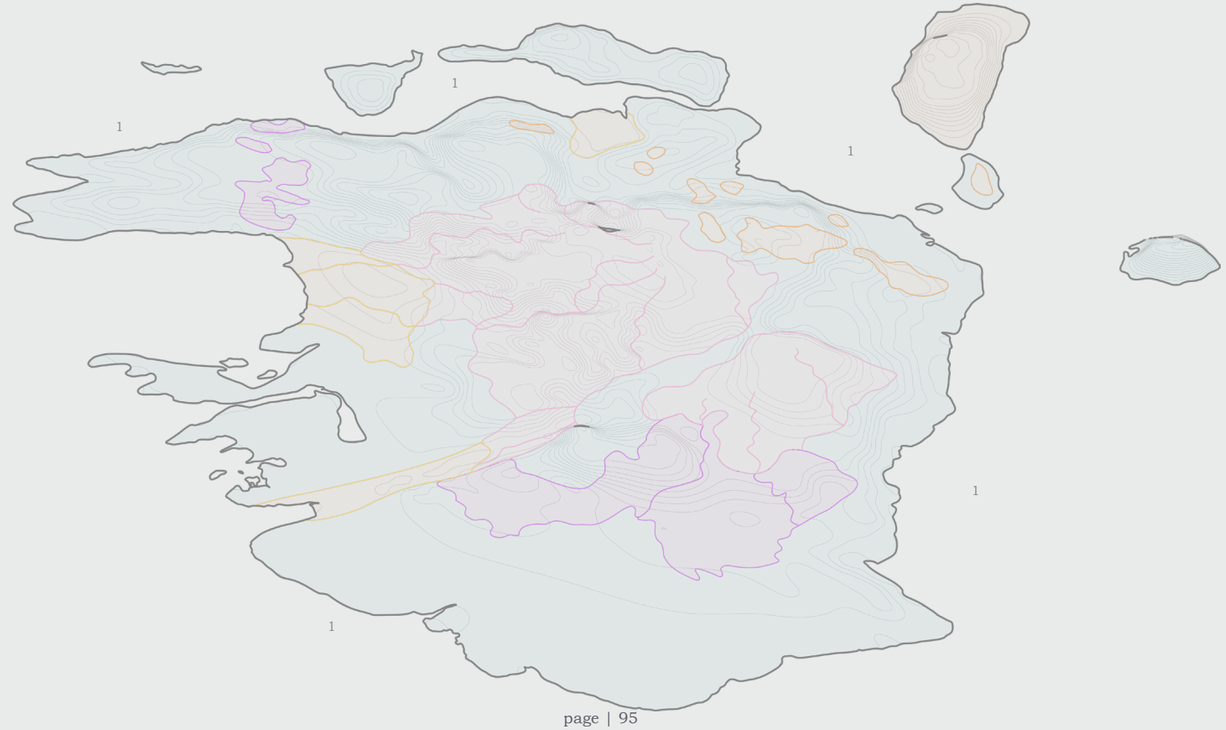
massive pumice breccia



1. coral shoreline

ecological





LAND VEGETATION TYPOLOGY



shrub



cultivated plantations



thicket



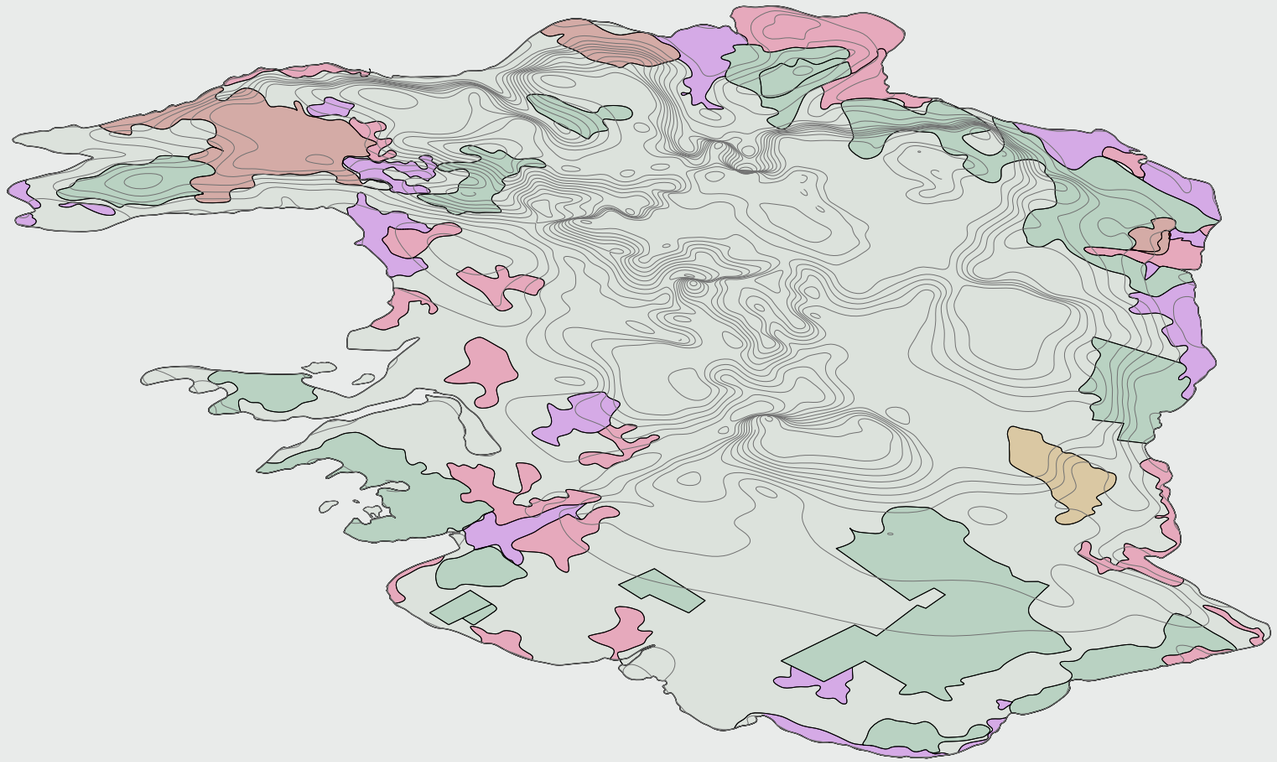
vegetable plantation



cultivated annual crops

Systems

ecological



MANGROVES | HYDRODYNAMICS

There are roughly 80 different species of mangroves that generally grow within liminal zones of islands—growing in low-oxygen soil elevated from the ground allowing water and sediments to travel through the mangrove roots, posing a unique moment for sedimentation accumulation. The majority of mangrove forests reside along the tropics on the equator. Mangroves are exquisite barriers of nature that serve as habitats and shelter for aquatic life, living underwater and above water conditions able to survive, their roots sinking deep into the soils and resting above the surface break of the ocean, the stilts of water. Dense mangrove groups are known to dampen tidal waves and promote the stabilization of coastal regions reducing erosion from:

Strom surges
Currents
Tides
Waves

Mangrove types

Fringing Forest – swamps along the shoreline face the open sea and are exposed to extreme sea configurations such as tidal waves and storms. Terrestrial runoff is low; soil conditions are poorer, with up to 20-25cm of soil. Typically can grow up to a height of 15 meters.

Reflecting on basalt and volcanic ash in soil conditions, introducing mangroves to these soil-enriched conditions may increase root cell strength.

Rivine Forest – floodplains along river channels or tidal creeks flood during high tides and are exposed during low tides.
Basin Forest – stunned mangroves, typically located within the interior of islands. Impounded depressions are seldom inundated by high ties during the dry season but inundated by high spring tides during the wet season.
Overwash Forest – islands frequently washed over by tides. More and more propagule stands grow, and roots eventually trap sediment. Sand flats are found inwards in island zones and typically grow up to a height of 7 meters.

Inundated- Flood



MANGROVES | HYDRODYNAMICS

5 Zones mangroves live in
1 Highly exposed seaward side inundated during all high tides
2 Less dynamic, less exposed, seaward sides inundated by high tides
3 Central well-developed mangroves inundated by normal tides
4 Landward/freshwater-influenced zone inundated by spring tides
5 Zone occurring the brackish to most fresh streams and/or casually inundates by exceptionally high tides.

Zone One Design Focus
Highly exposed mangroves occur on the seaward side of mangrove belts and are inundated by all high tides. Although this habitat is devoid of all species except Rhizophora mucronate, the high-risk zone requires that the mangrove crown remains above water.

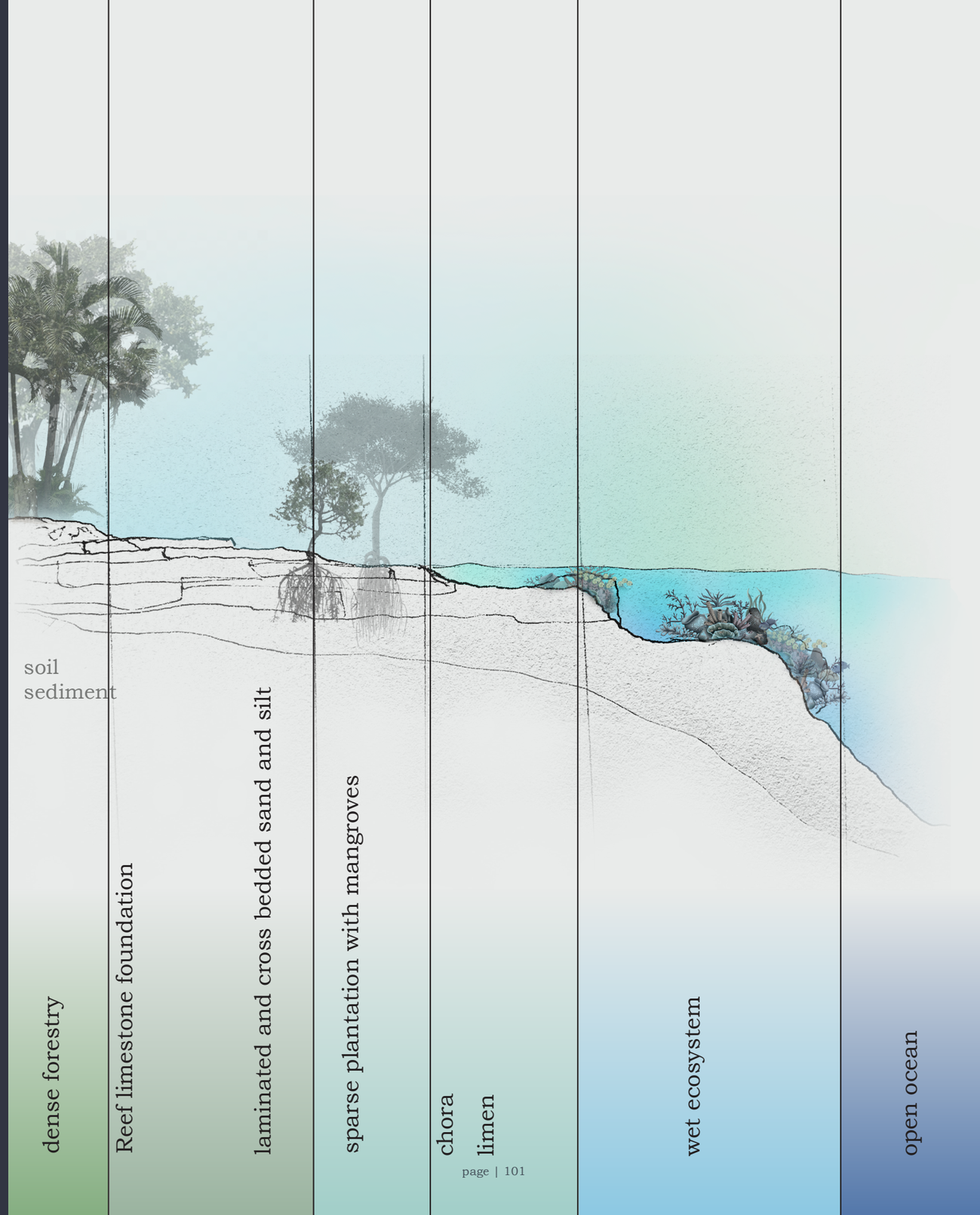
Mangrove ecosystems cover 2,500-3,500 ha roughly 0.2% - 0.3% f the total land area in Vanuatu. On the island of Efate, roughly 10 ha of mangrove forests grow at 92,300 ha at 0.1% land cover. An absolute small number reflects the island's exposure to the horrific climate.

13 major mangrove tree species have been identified in 8 families
Mangrove forests are essential to the protection of low-lying coastal islands. Providing many of the island's essentials in;
Flood Protection
Fuel | Wood
Building Material
Medicine
Shellfish | Fish

General description of the physical, hydrological, and ecological features of mangrove wetlands [51]

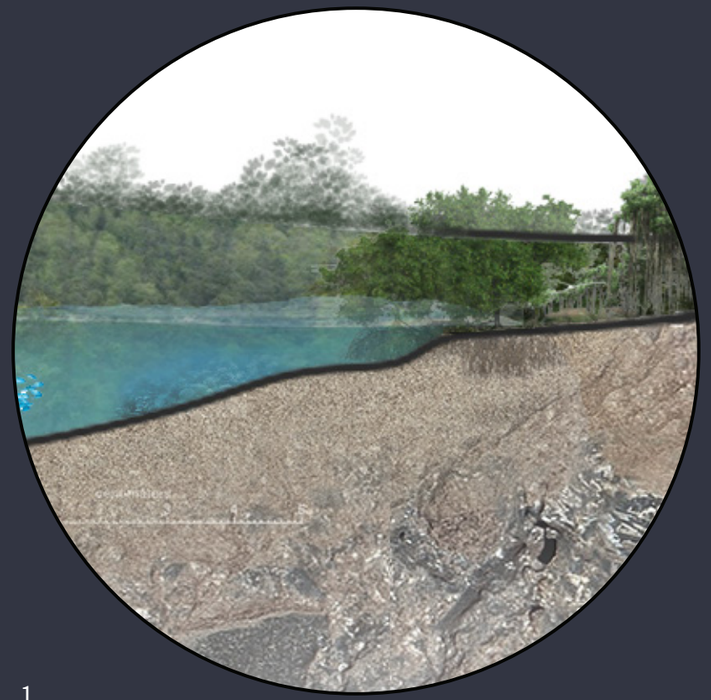
- Bushes/trees grow between love and high tide, mark "intertidal zone"
- Mangroves name by definition means
  - Individual tree
  - Group of mangroves | community
- 2 types of mangrove environments
  - River environment
  - Marine environment FOCUS
    - Coastal or in estuaries that have little freshwater input. Most of the water in marine mangrove systems comes from the sea, and water purification happens as water flows up estuaries inland.

51 Tari, Trinison, and William Naviti. "Vanuatu - Mangrove Ecosystems." Https://Www.sprep.org/, Secretariat of the Pacific Regional Environment Programme, 5 Dec. 2018, https://archive.iwlearn.net/sprep.org/att/IRC/eCOPIES/Countries/Vanuatu/2.pdf.



ISLAND LIMINAL ZONES

Due to the island's characteristics and exposure to rainfall, Efates rivers are mostly made of raised reefs, which flow only during heavy rainfall. The uplifted coralline limestone substrate creates very porous ground conditions, which do not allow for much surface water. The island is full of beautiful, unique cascade waterfalls, blue lagoon swimming holes, and beachfront coastal zones which a few freshwater lakes.



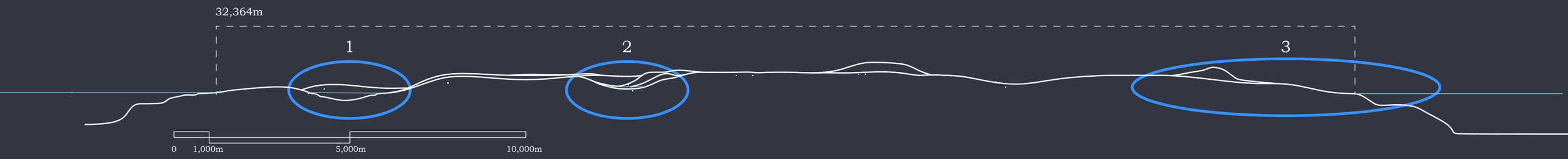
1



2



3



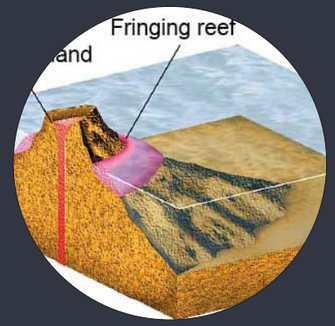
ROOTS

Examining deeper into the liminal zone and unpacking the island's rich soils to see if Efate, a volcanic island, created moments for nutrient transfer between volcanic ash deposits and the soil around the liminal zone. Do any nutrient transfers exist? Can this be something that can be enhanced to create a system that aids in strengthening the coast down to the molecular level rather than only more extensive surface fortifications?

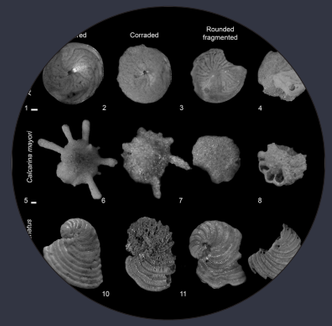
Diving into the chemical properties of basalt and ash, the mountain increases the exposure the coastal soils have to potassium [K], silicon [Si], calcium [Ca], and micronutrients. Enhanced root strength and yield are possible due to the chemically rich soils, improved pH levels, nutrient supply, and physical conditions.

The carbon cycle flows through the nutrient process from basalt and ash traces into the liminal zone soils, exposing the roots to reactive chemical properties. The silicic acid, calcium ion, and calcium bicarbonate in the volcanic deposits aid in fortifying the root cell. Additionally, carbon dioxide from deposition and sequestration aids in the living conditions of roots, aiding in stimulating a stable environment. Finally, the decomposition process of plants continuously transfers the nutrients back into the soil to create a feedback loop carbon cycle filled with immense nutrients for cellular growth and resilience.[52]

Extracting the idea of molecular change through ion compounds begins to be a design strategy utilized to restabilize the biotic ecosystems within the island's coastal zone.







basalt and ash from mountain creates exposure to potassium [k] and other nutrients

carbon dioxide from respirator of roots and other soil organisms

$CaSiO_3 + 2CO_2$

weathering

deposition and sequestration

$H_4SiO_4 + Ca^2 + 2HCO_3$

silicic acid + calcium ion + calcium bicarbonate

strengthen cell walls + cell growth + from limestone neutralize soil acidity

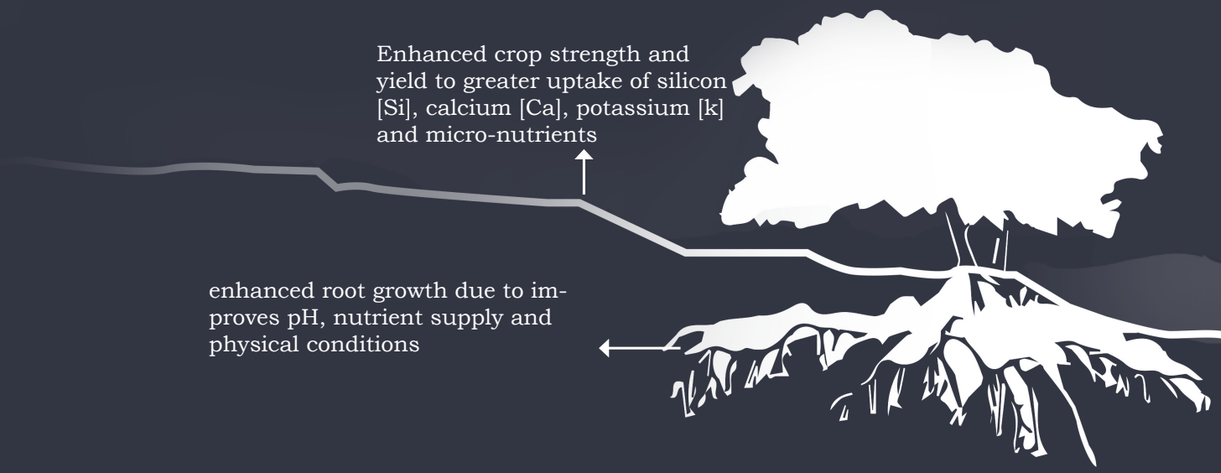
$CaCo_3 + SiO_2$

calcium carbonate + silicon dioxide

neutralize soil and supply calcium [mainly the limestone] + strength in cells plus improved tolerence from other abiotic stresses

Enhanced crop strength and yield to greater uptake of silicon [Si], calcium [Ca], potassium [k] and micro-nutrients

enhanced root growth due to improves pH, nutrient supply and physical conditions



enhanced ocean alkalinity and growth of diatoms and corals as a result in pH balance from soil

weathering products in surface and ground water runoff

52 Rajput, Vishnu D., Tatiana Minkina, Morteza Feizi, Arpna Kumari, Masudulla Khan, Saglara Mandzhieva, Svetlana Sushkova, Hassan El-Ramady, Krishan K. Verma, Abhishek Singh, Eric D. van Hullebusch, Rupesh Kumar Singh, Hanuman Singh Jatav, and Ravish Choudhary. 2021. "Effects of Silicon and Silicon-Based Nanoparticles on Rhizosphere Microbiome, Plant Stress and Growth" Biology 10, no. 8: 791. https://doi.org/10.3390/biology10080791

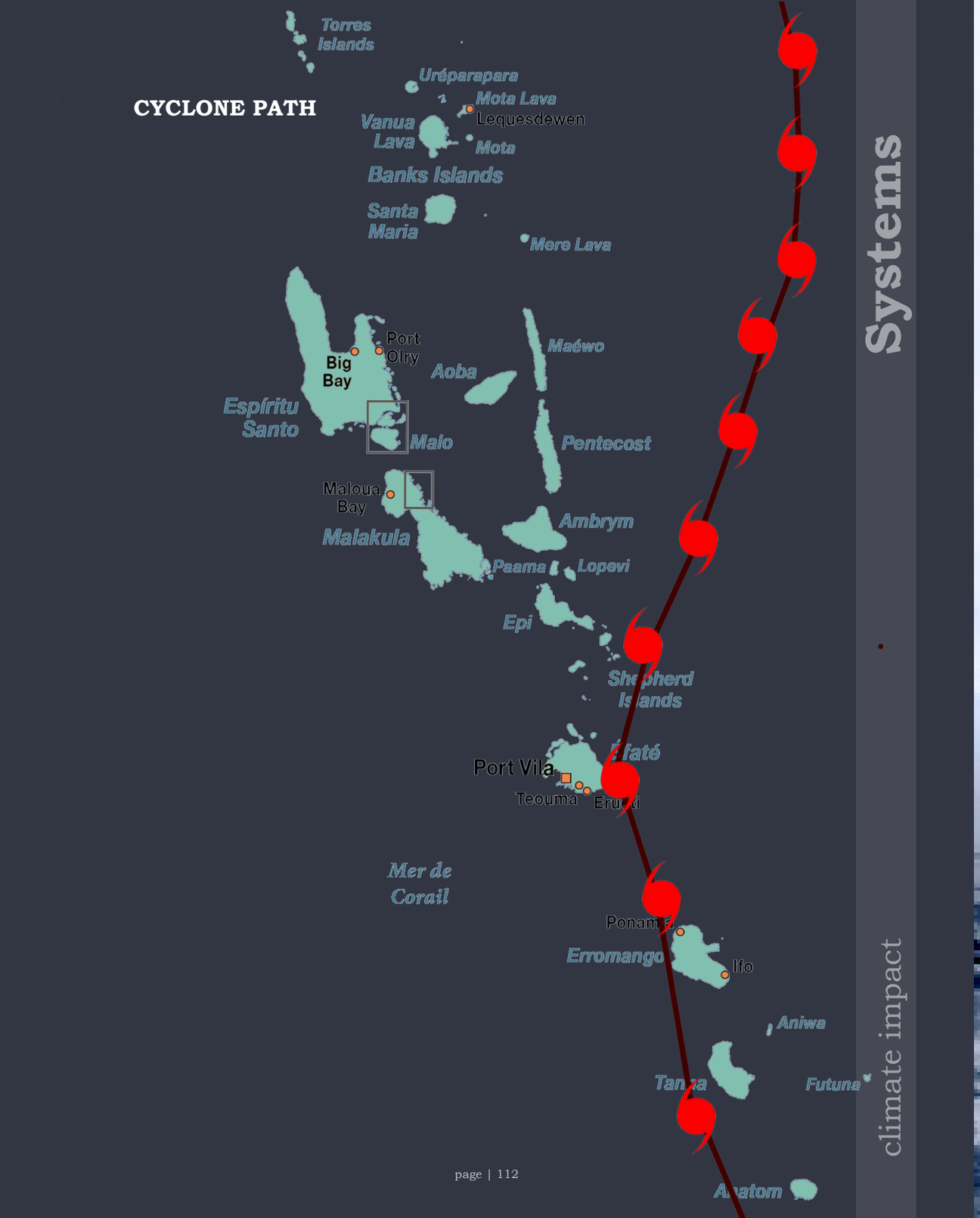
Authors illustration; moment mineral accretion ignites

climate impact

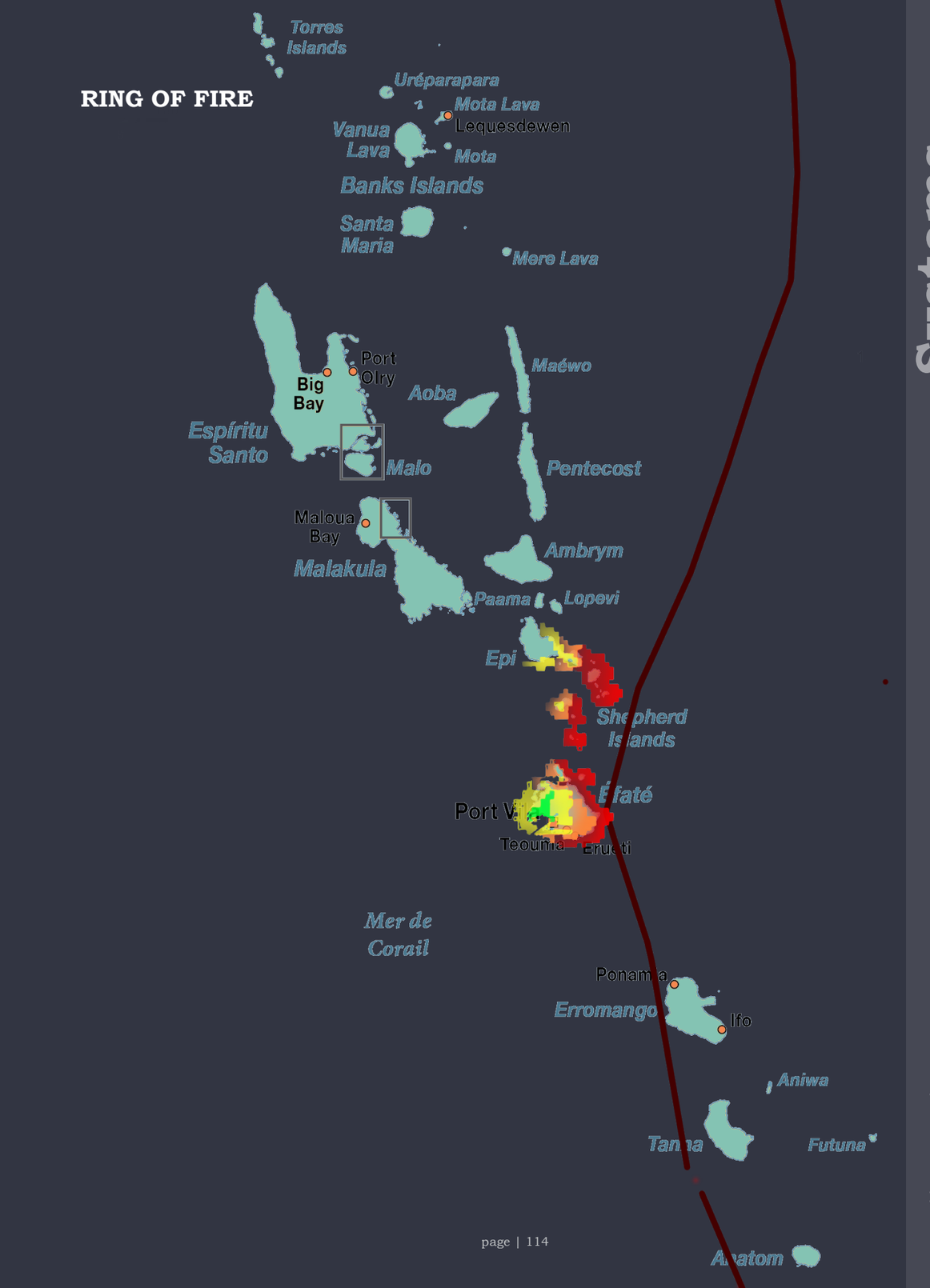
In the heart of the island of Vanuatu, the existing implications of climate change on the island and its various ecosystems become readily observable. Identifying the natural hazards and understanding their impacts on ecosystem growth makes it possible to design a solution merging disparate aspects into an integrated whole. Studying not only land-based but marine-based ecosystems is essential to blur the boundary line where the riparian zone exists. The existing ecology section dissects the more tactile issues and the existing conditions of the island, such as natural hazards due to climate change, existing typology and ecology on the islands, and the impact climate change has on these different sectors. An American writer and editor named John R. Campbell wrote a GNS report, “Traditional disaster reduction in Pacific Island Communities,” where he dissects the climate impacts on each island nation of Oceania. Due to the islands’ location in the southwestern Pacific Ocean, they are host to some of the harshest climate change impacts, from severe floods to 100-year storms occurring a few times within two decades. Within the study, four clusters of coping measures can be implemented to tackle climate impact on the island.

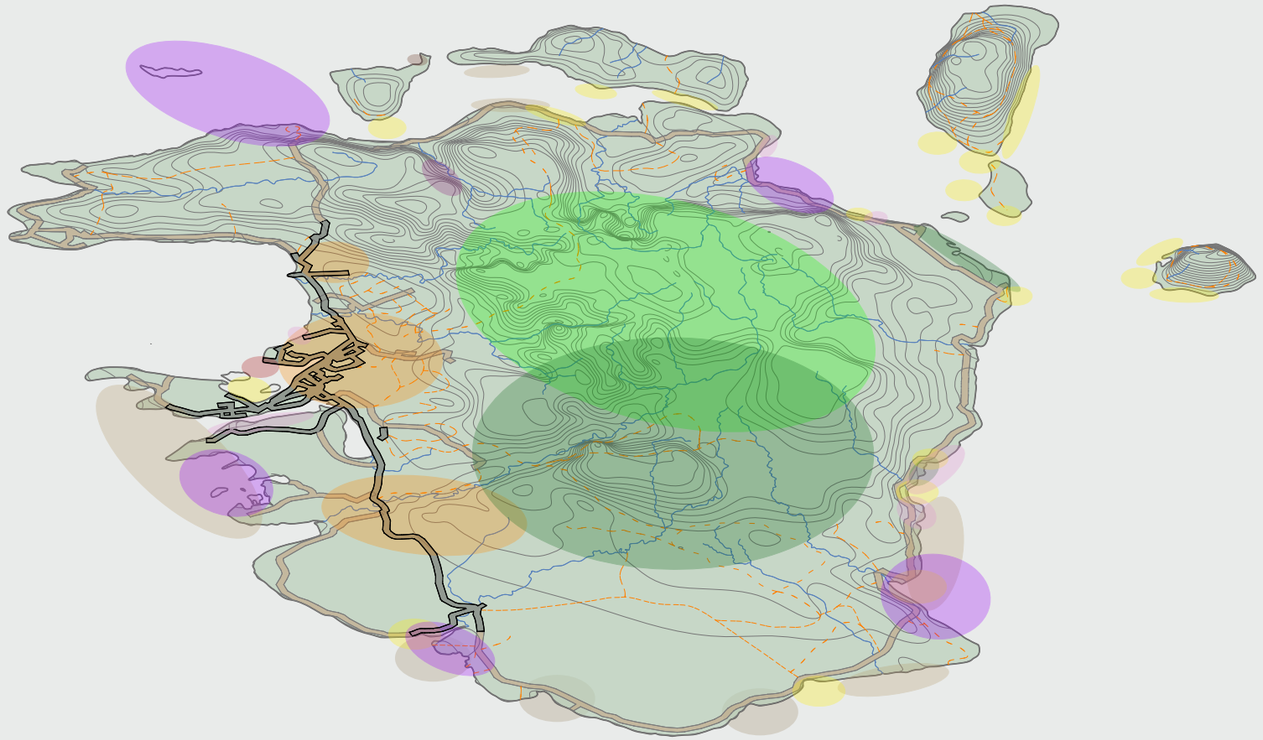
Additionally, due to the intricate composition of some of these islands, they are hit by a few of these clusters’ zones, creating a highly volatile living environment. Climate change has affected the island’s vegetation on many levels, some of those being rearing temperature and crop production. Temperature is a key determinant in evaporation and transpiration demand, which is especially important within tropical islands. The rise in average temperatures year after year increases heat stress on crops and water loss by evaporation. High-temperature stress may continue to worsen by the high relative humidity found within the islands. In addition, crop productivity becomes increasingly vulnerable when there is more than one abiotic stress; this drought and heat stress affects crops over a short period by preventing plants from regenerating, causing plant degradation and infertile soils. Further on, the section begins to specify the types of vegetation on the island and how vegetative zones are individually impacted by climate change, which is important to understand in order to develop a geotextile system that will help promote new birth and development of the islands vegetation system.

A report written in 2012 became essential to understanding the many layers of information and complexity within the ecological systems of the islands. Written by a group of activists, it is titled the “Climate Change and Pacific Islands: Indicators and Impacts” report, created for the 2012 Pacific Islands Regional Climate Assessment program (PIRCA). This report discusses the diversity of the island’s ecosystems, now under threat of climate impact, and potential solutions to restore the region to its original form. The riparian zone is a focus for this catalogue as it is key to understanding where the limen is between land and water and how to merge the two, forming a system that obscures the boundary between island and water.


CYCLONE PATH
Torres Islands
Uréparapara
Mota Lava
Lequesdewen
Vanua Lava
Mota
Banks Islands
Santa Maria
Mere Lava
Port Olry
Big Bay
Aoba
Maéwo
Espíritu Santo
Malo
Pentecost
Maloua Bay
Ambrym
Malakula
Paama
Lopevi
Epi
Shepherd Islands
Éfaté
Port Vila
Teouma
Mer de Corail
Erromango
Ifo
Aniwa
Futuna









forest clearance



population growth



degraded mangroves



sand mining



damaged reef

threats

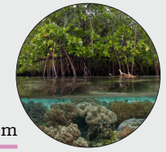
solution zones



marine conservation



heritage area



mangrove ecosystem



wetland



turtle nesting

wet ecosystem

limen

sparese plantation
with mangroves

wet ecosystem

limen

sparese plantation
with mangroves

2150

2100

2050

dense forest

island lagoon

mangroves


dense forest
fresh water river flow
into ocean
mangroves
wet ecosystem

Chapter Three

design

ENTRANCE

Design

This thesis design is a symphony of science and art, an ode to the beauty and resilience of the coastal zone. The aim is to compose a harmony of protection, preservation and resilience for the island of Efate, Vanuatu. The shore, like a melody, is guarded against the crescendo of sea level rise and storm surge by the mangrove's symphony of roots, a living barrier wall that adapts to the changing climate. The design is an exploration of the internal and external influences of the island, a study of the interconnectedness of social and natural systems, a search for balance and structure. The proposed design is an integration of local vernacular construction techniques, layered with the living roots of mangroves, like a symphony of culture and nature. The focus is on biophysical restoration, using mineral accreted cells and mangrove rehabilitated pods, as a means to address the dissonance of extreme climate change in the liminal zone between aquatic and terrestrial worlds.

The coastal zone is a concerto of waves and winds, a harmony of sand dunes and mangroves. The rehabilitation of this fragile land is a work of architectural poetry, a delicate balance of form and function. The mangroves, like a symphony of green, stand tall as sentinels against the storms. The rehabilitation center, designed to nurture and protect, to reconcile man and nature.

Rehabilitation: The process of restoring something to its original or improved state, especially in the context of physical or mental health.
Mangroves: A type of tropical tree or shrub that grows in salty or brackish water, characterized by tangled roots that can trap sediment and protect coastlines from erosion.
Identity: The characteristics, qualities, beliefs, and values that make a person or group unique and distinguish them from others.
Aquatic restoration: The process of restoring and improving the health of aquatic ecosystems such as rivers, lakes, and oceans through various means, including habitat restoration, pollution control, and other measures.
Interdisciplinary system: A system that draws on knowledge and expertise from multiple fields of study, including social, natural, and physical sciences, to address complex problems.
Restorative design: A design approach that seeks to improve the health and resilience of ecosystems, communities, and infrastructure through sustainable and regenerative methods.

The center is programmed with a focus on mangrove rehabilitation, with workspaces that are flexible and adaptable, like a living organism. The BooPod generation, seedling plantation, and mangrove nursery are all crucial elements in this symphony of design. The construction shop is also used to develop and form mineral accreted cells and to explore local construction techniques, such as roof weaving and vine weaving, which are woven seamlessly into the fabric of the structure. The site is not only a space for restoration but also a space for community, where the islanders can gather and connect, where the kitchen becomes a cultural hub, and the bathrooms are an extension of the living landscape. This design is a symphony of nature and culture, an architectural ode to the beauty and resilience of the coastal zone.

Mineral accretion: A process that involves the use of electrical current to stimulate the growth of minerals on artificial structures, such as coral reefs.
Utopian: Referring to an idealized or perfect world, often characterized by social or political harmony and a lack of conflict.
Tectonics: The study of the Earth's crust and the processes that shape it, including the movement of tectonic plates.
Lattice: A structure composed of interwoven or intersecting elements arranged in a regular pattern.
Ornamental balance: A design principle that involves achieving visual harmony and balance through the use of decorative elements.
Structural barrier: A physical structure that provides protection against external threats, such as storms, floods, or other hazards.
Structural buffer: A component of a structure that absorbs and diffuses external stresses or impacts to prevent damage or failure.
Trusses: A structural element composed of interconnected triangles that is used to support roofs, bridges, and other structures.
Lifecycle: The series of stages through which an organism, product, or process passes from its beginning to its end.
Fortifying barrier: A physical barrier designed to provide protection against external threats, such as storms, floods, or other hazards, by strengthening and reinforcing the structure of the barrier.

Strategy

DESIGN INFLUENCES

This thesis has developed from the surface idea, which can be considered a restorative geotextile lattice on the riparian zone, into much more profound work than I ever hoped to achieve. Through problematizing the main idea, many branches of research opened up, which this thesis desires to explore. However, understanding that covering all aspects of such a problematic research design topic is impossible. It is essential to understand that there is no one solution, only 'the shallow' where the ideology of the problem lies and how diving deep into the supports, a discovery is made which alters design and research.

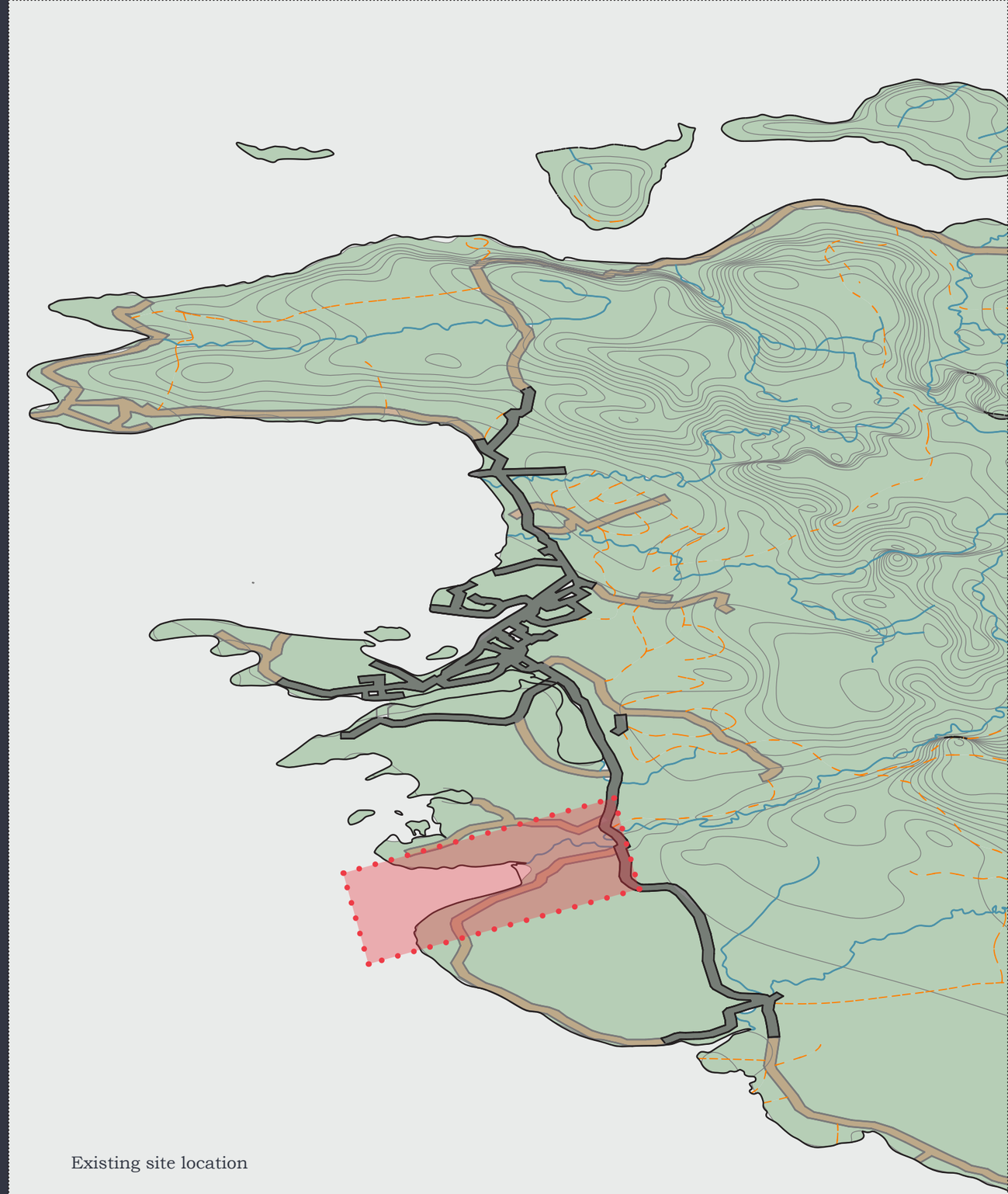
shallows

In depth research



supports

Progression by the resolution of contradictions, where tension is resolved through design.



Existing site location

Purpose vs Cause
Chemical Evolution vs Biological Evolution
Synthetic Materials vs Organic Materials

“ This terror then, this darkness of the mind, must needs be scattered not by the rays of the sun and the gleaming shafts of day. but by the outer view and the inner law of nature; whose first rule shall take its start for us from this, that nothing is ever begotten of nothing by divine will. Fear forsooth so constrains all mortal men, because they behold many things come to pass on earth and in the sky, the cause of whose working they can by no means see, and think that a divine power brings them about. Therefore, when we have seen that nothing can be created out of nothing, then more rightly after that shall we discern that for which we search, both whence each thing can be created, and in what way all things come to be without the aid of gods.

...that nature breaks up each thing again into its own first-bodies, nor does she destroy ought into nothing,» For if anything were mortal in all its parts, each thing would on a sudden be snatched from our eyes, and pass away. For there would be no need of any force, such as might cause disunion in its parts and unloose its fastenings. But as it is, because all things are put together of everlasting seeds, until some force has met them to batter things asunder with its blow, or to make its way inward through the empty voids and break things up, nature suffers not the destruction of anything to be seen.”[53]

53 BAILEY, CYRIL, translator. LUCRETIUS ON THE NATURE OF THINGS, OXFORD AT THE CLAR ENDON PRESS, 1948, pp. 31–35.

“For infinite time and the days that are gone by must needs have devoured all things that are of mortal body. But if in all that while, in the ages that are gone by, those things have existed, of which this sum of things consists and is replenished, assuredly they are blessed with an immortal nature; all things cannot then be turned to nought.

And again, the same force and cause would destroy all things alike, unless an ***eternal substance held them together, part with part interwoven closely or loosely by its fastenings****.*

For in truth a touch would be cause enough of death, seeing that none of these things would be of everlasting body, whose texture any kind of force would be bound to break asunder. But as it is. Because the fastenings of the first elements are variously put together. And their substance is everlasting. Things endure with body unharmed. Until there meets them a force proved strong enough to overcome the texture of each. No single thing then passel back to nothing. But all by dissolution pass back into the first-bodies of matter.” [54]

Does the purpose of things determine what they are, or does what they do form their purpose? Where the purpose is then quotes in an interwoven lattice.

54 BAILEY, CYRIL

LOCAL INFLUENCES

Extracting existing strategies on the island allows for a culturally reflective design that integrates current living practices into the design. Celebrating construction techniques and ornamental design creates an exciting opportunity for the thesis to fortify the island while reflecting a culturally influenced structure.

Land diving influences the design in the extraction of the lattice structural design. Trees are freshly cut to construct the tower, and tilling the soil around the base of the diving tower creates a soft ground for the insertion of the structure. Freshly cut trees allow for a robust system; poles and scaffolding are tied together using vines and roots to create a sturdy high tower. The inner lattice of the tower is drawn into the design, creating cells where internal lattice roots binding into a secure structure.

Sandroing is an artistic expression of history and culture, where extracting the ornamental form begins to shape the footpaths and access the design.

The weaving technique becomes an essential layer in design, where the woven lattice becomes the roof structure knotting the project into one whole piece. Additionally, translating those weaving techniques into accretion cells allows for the local development of the pods drawn from the ocean myths.

Islanders have already begun to elevate their homes roughly 1-2 meters above the ground, allowing flooding to destroy them. In addition, elevated farms have started to appear as the sea level rises, increasingly flooding crop fields and salinating the plants and soils.



The Church of Jesus Christ of Latter-day Saints. (2020, February). Overcome Your Fear of the Future. New Era. https://www.churchofjesuschrist.org/study/new-era/2020/02/overcome-your-fear-of-the-future?lang=eng



Tim Brookes. (n.d.). Avoiuli. Endangered Alphabets Project. from https://www.endangeredalphabets.net/alphabets/avoiuli/



Sivahari. Vallom 1 [Image]. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Vallom_1.jpg



Beswick, J. (2019, September 5). Ambryn Island on the remote Pacific archipelago of Vanuatu. The Architectural Review. from https://www.architectural-review.com/places/jon-beswick-visits-ambryn-island-on-the-remote-pacific-archipelago-of-vanuatu-and-describes-its-traditions

FORM FOCUS

Sea turtle hunting and consumption have been centuries of tradition, though subsistence agriculture and fishing are a source of livelihood. Turtle hunting is a young man's fishing tradition that begins his journey into a young man, propelling him into the transformation of a man. Turtle hunting is not only culturally essential but socially, where there is a symbolism in the arts and crafts, utilizing all of the turtle and shell. Turtles become a crucial source of protein, especially for sizeable unplanned event feeding such as funerals, known as symbolic meals. Hunting enabled the islanders to connect back with the water, hunting in the vernacular ways of their ancestors, connecting them to their past. However, due to colonization, sea turtle hunting has become a fishing job versus traditional hunting for family. [56]

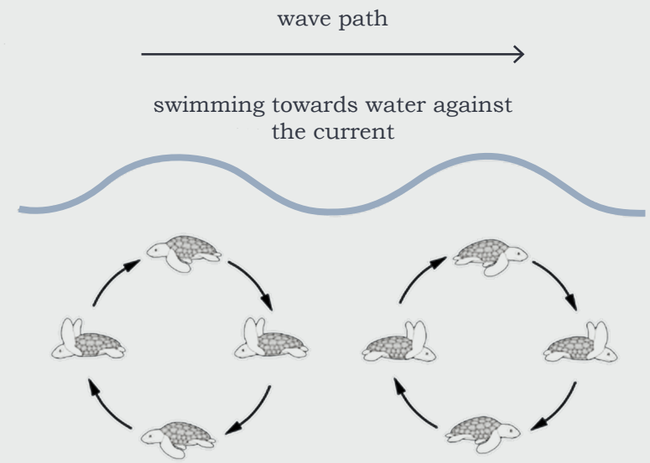
Traditional
Wrangling turtles by attracting them through burning torches from canoes.

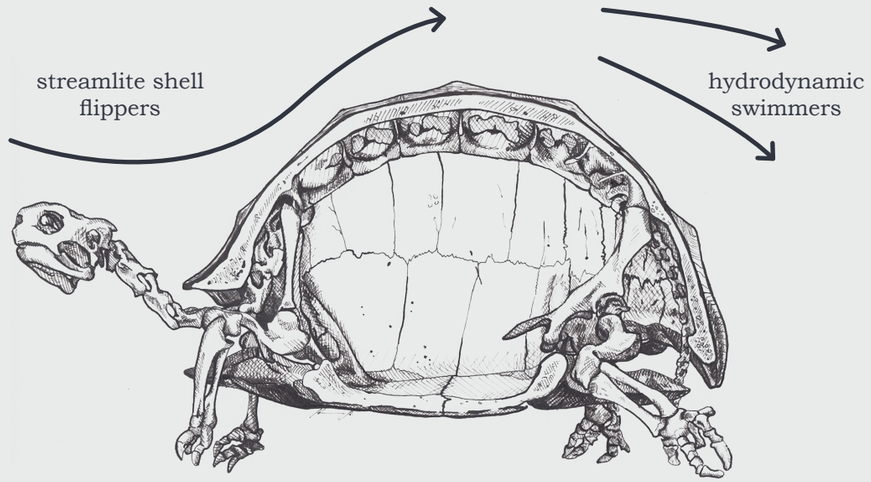
Influenced
Night fishing is when fishermen search for sleeping turtles at night in deep water on the reeds and wrangling them up to their boats.

The contrast between the respect for nature from traditional hunting to mass production hunting. Traditional hunting was used as a right of passage, where the young men would lure awake turtles by fire, attracting them to their canoes and hunting a turtle with the chance of a fight.

56 Bartlett, Christoher, and Tasaruru Whitely. 2015, pp. 5–14, From Sea Turtle Hunting in Vanuatu to Conservation Eco-Tourism Programs with Community Involvement at Nguna-Pele, Vanuatu, file:///C:/Users/ivame/Downloads/From%20sea%20turtle%20hunting%20in%20Vanuatu%20%20to%20conservation%20eco-tourism%20%20programs%20with%20community%20%20involvement%20at%20Nguna-Pele,%20Vanuatu%20(1).pdf. Accessed Sept. 2022.

HAWKSBILL EREMO CHELONIA MYDAS - VANUATU TURTLE





Composite illustration by author through sources
Lohmann, K. J., A. W. Swartz, and C. M. F. Lohmann. 1995. Perception of ocean wave direction by sea turtles. Journal of Experimental Biology. 198: 1079-1085
Sobottastudies. "Cross Section of a Turtle." Imgur, Www.society6.Com/Sobottostudies , 6 Sept. 2015, https://imgur.com/t/cross_section/FqrsgVc. Accessed Apr. 2022.

FORM FOCUS

Focusing on the hexagonal form, extracting wave distribution from turtle shells, this thesis derives many structural properties translated into the 4 design of the rehabilitation center.

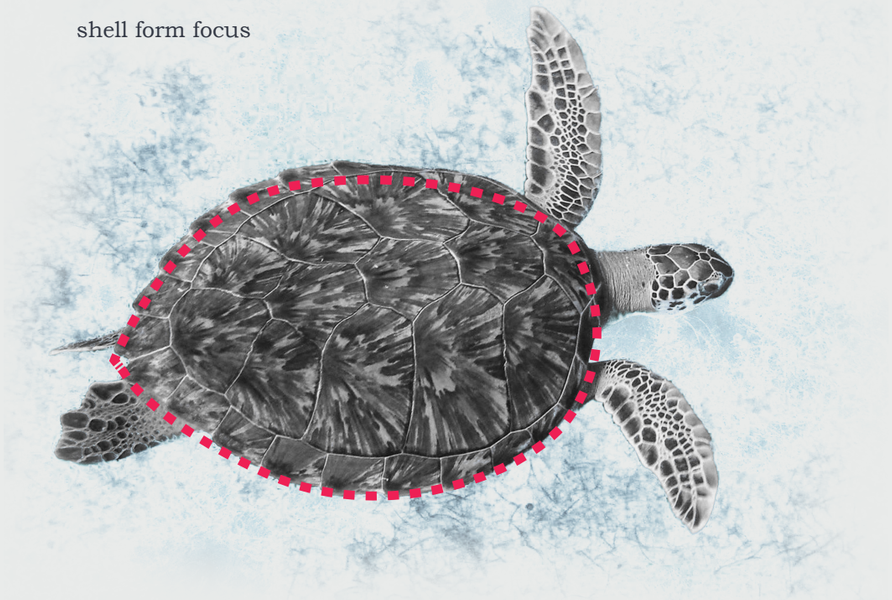
Hexagonal forms show up in many forms of nature

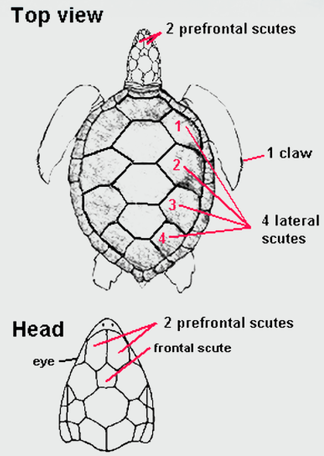
*Basal from volcanic eruptions
Beehives
Corals
Crystals
Snowflakes

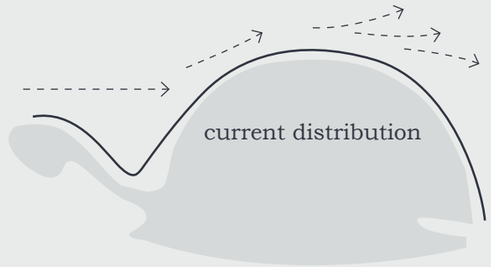
Extracting natural hexagon cells allows the design to utilize the most efficient way of covering a surface with the least amount of material and separating walls, allowing for a significant chain connection. The shape is the most robust in nature, with the lowest total surface tension. The strength of interconnected hexagons can withstand the tremendous forces of nature. Not only is surface tension at its lowest using hexagonal grids, but the grids together react firmly under compression.

Extracting the hexagonal form into a repetitive cellular system separates the program layers in the design. In addition, utilizing the hexagonal shapes form allows for an approach in design that allows for the high degree of efficient repetition required in such a design. Finally, this compact shape allows for the high structural stability the site urges for, building a robust interconnected foundation under the surface.

TESSALATION INFLUENCE









Composite illustration by author through sources

Green Sea Turtle. Marine Conservation Society, 2022, https://www.burkemuseum.org/collections-and-research/biology/herpetology/amphibians-reptiles-washington/green-sea-turtle. Accessed July 2022.
“Information About Sea Turtles: Special Identification Key 3.” Conserve Turtles , Sea Turtle Conservancy, Gainesville FL., https://conserveturtles.org/information-about-sea-turtles-special-identification-key-3/. Accessed Aug. 2022.

THE PORTLAND OPEN SPACE SEQUENCE

Lawrence Halprin Architectural Influence | spatial organization

The incorporation of water drawn into the design is an innovative use of space designed by prominent American landscape architect Lawrence Halprin. Portland Foundation, known as one of his more famous works, is a sequence of spaces in a series of fountains in downtown Portland, Oregon.

Known for his innovative approach to public space within landscape architecture, he believed public space should reflect the needs and desires of the space inhabitants. Pioneering a design focus in interactive participatory design cells.

Focusing on the flow of movement through space and how spatial organization can be designed by interactive natural barriers becomes a focal point for gathering and interactive zones. His works incorporate layers of water, planting, and seating, forging a sense of place and developing a space for social interaction.

One of the critical spatial features in the Portland Fountain is Halprin's emphasis on repetition and incorporation of natural systems within repetition cells. The repetitive design allowed for a cohesive space while spreading across the vast space, developing a sense of unity. The Portland Open Space Sequence has become a beautiful precedent of repetitive design while incorporating natural systems to develop a cohesive design.



Halprin, L. (n.d.). Ira Keller Forecourt Fountain. The Cultural Landscape Foundation. from https://tclf.org/landscapes/ira-keller-forecourt-fountain.

THE PRICE TOWER

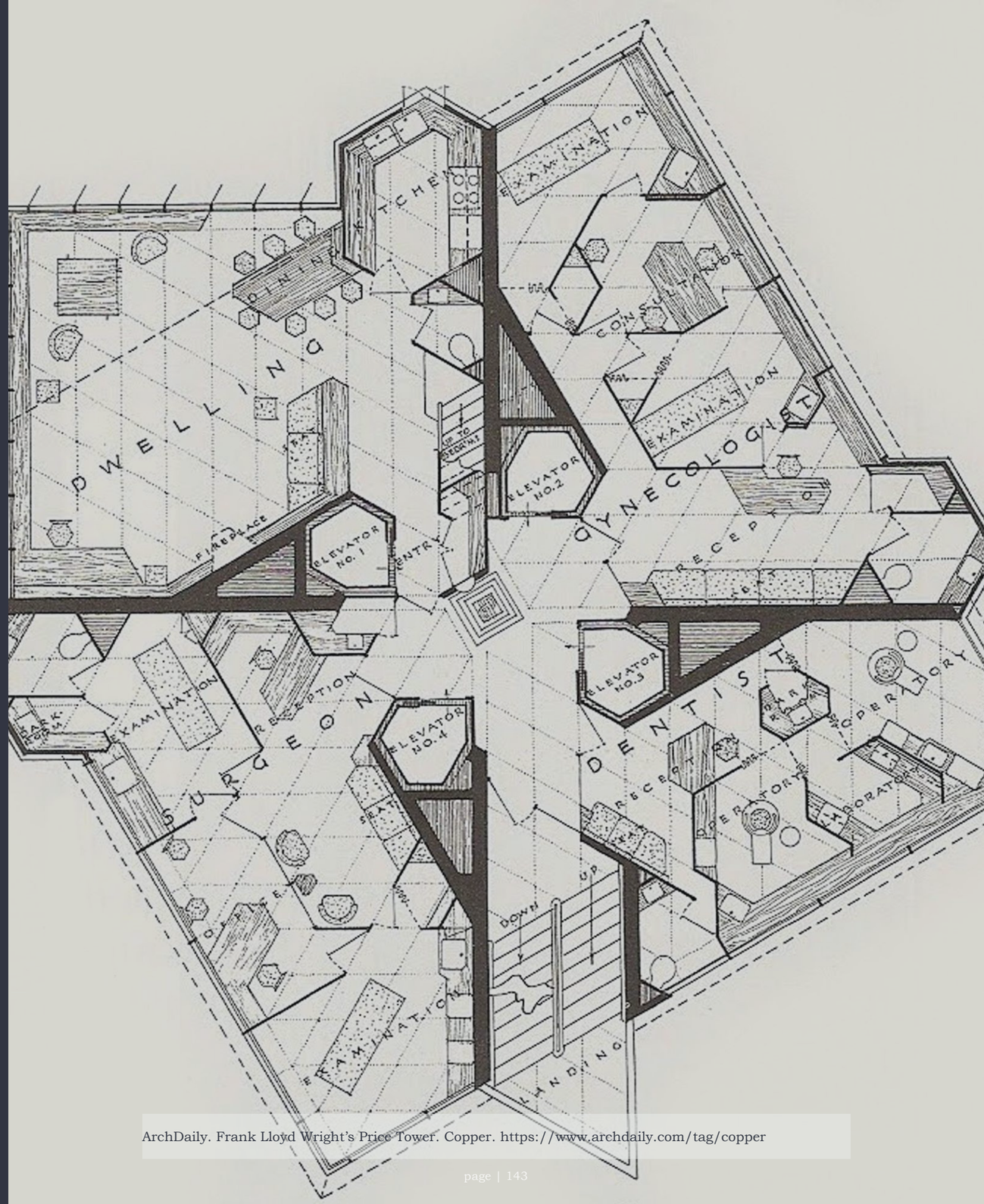
Frank Lloyd Wright

Frank Lloyd Wright was an American architect known for his innovative designs and use of materials. Considered a pioneer of modern architecture, his works have significantly influenced architectural style development in the 20th century. The Price Tower is one of Wright's most famous works, a highrise building in Bartlesville, Oklahoma. The Price Tower is notable for its efficient use of space and innovative design, incorporating repetitive cellular organization. This organization, in which programs are divided into repeating units, also known as cells, is a common feature of modern architecture, developing an efficient and functional building as a whole unit.

Form Affects Physics

The Price Tower was designed to be a highly stable and energy-efficient building, slender in form, resulting in it withstanding and other external forces more effectively than shorter, wider buildings. In addition, the core reinforced by concrete helps further increase internal "foundation" stability.

Designed to be a very functional and efficient building, it has a modular design, with each floor being identical in layout. the repetative design allows for ease in customization in the building interior space, allowing for more flexible future space adaptations.



ArchDaily. Frank Lloyd Wright's Price Tower. Copper. https://www.archdaily.com/tag/copper

CENTRE GEORGES POMPIDOU | RENZO PIANO AND RICHARD ROGERS

Expressive architectural mechanical systems organization frame

The Centre Georges Pompidou, a modern art museum in Paris, France, what designed by architects Renzo Piano and Richard Rogers in 1977. known for its exposed mechanical frame, the Pompidou center is a significant example of an expressive structure, highlighting the primary mechanical system. The expressive frame consists of pipes and ducts full of color, highlighting expressive moments on the facade.

Known for its modern | high-tech exposed facade, highlighting its industrial material use. Constructed from a series of steel modules, allowing for an efficient construction process. Clad in bright aluminum and steel panels. Exposing mechanical systems within structure becomings an exciting expression of architecture, where the expressive frame highlights the importance of building systems.

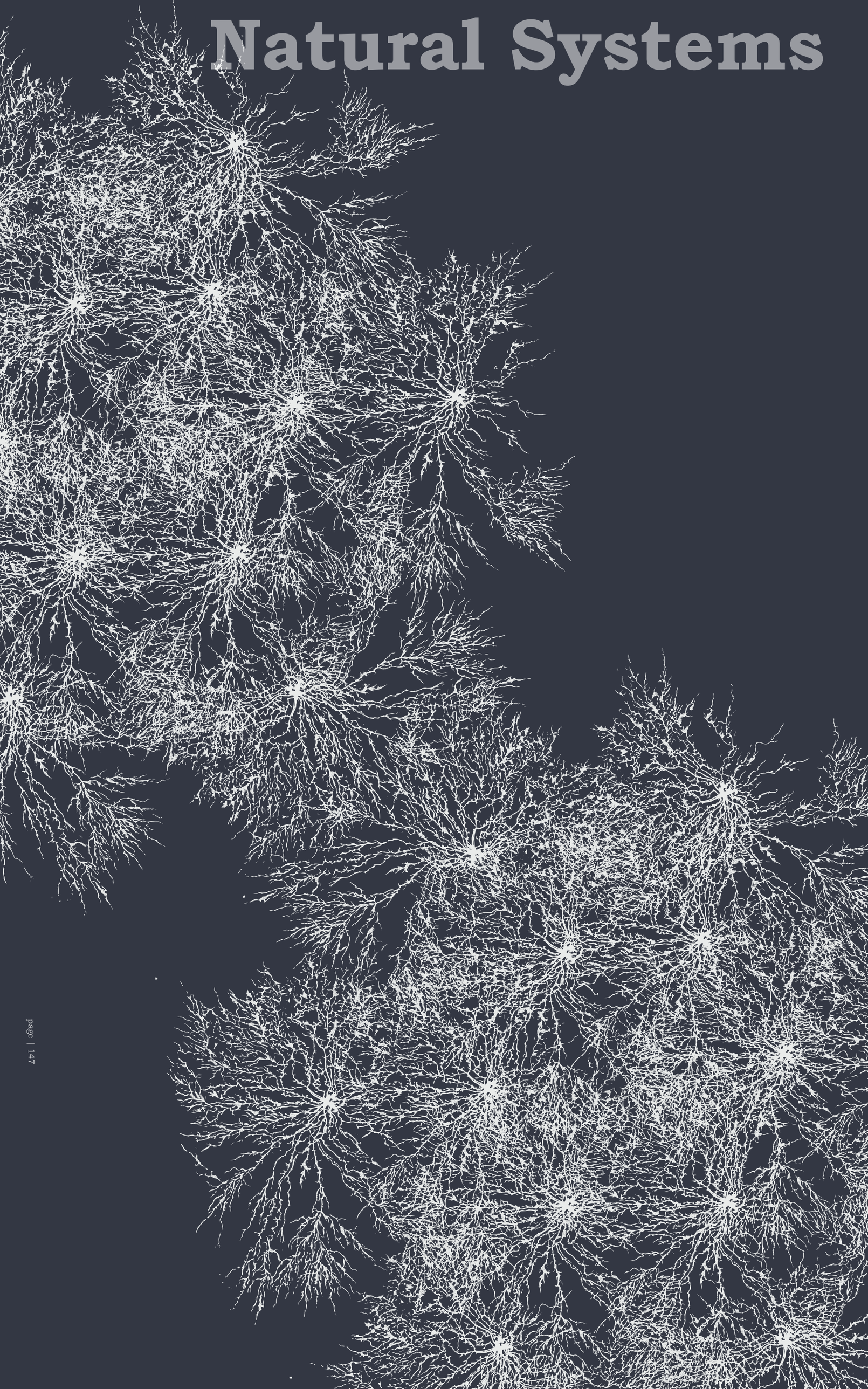
Piano said, “The center is like a huge spaceship made of glass, steel, and colored tubing that landed unexpectedly in the heart of Parid, and where it would very quickly set deep roots.”

The column-free interior allows for flexible adaptability within the interior program, structuring all the central building systems, corridors, structural members, and elevators on the building’s exterior. Making an everlasting statement while occupying the site, the building’s main focus was to allow half of the site location to incorporate public space and social interaction.



The Guardian. (2017, January 8). Pompidou Centre at 40: still cutting-edge or an outdated relic? https://www.theguardian.com/artanddesign/2017/jan/08/pompidou-centre-40-years-old-review-richard-rogers-renzo-piano

Natural Systems



NATURAL DESIGN SYSTEMS

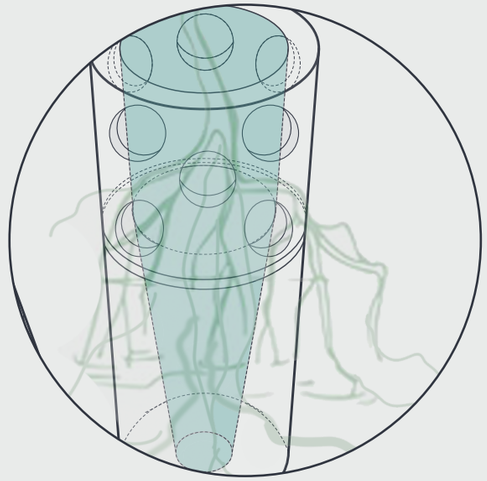
Revitalization is the main goal in the design, where climate events are to the extreme, destroying this planet. Understanding that architecture has the potential to influence the present and future becomes a focal point for this thesis. Architecture that reacts to heal the earth is a driving force in this thesis, aiding in the rehabilitation of the coast.

The BooPod, a designed prototype, is developed as a hybridized intervention to aid and protect mangroves during their first 8-12 months of life.

Mineral accretion becomes the project's backbone, working underwater, hidden away from viewing eyes and 'touristic' design, slowly calcifying and developing a solid foundation to create a fortified living barrier wall protecting the coast, reefs, and aquaculture.

Tying the project into a whole synthesis depends on the roots' growth and fortification. The introduction of living organisms into the design, and higher exposure to volcanic ash, aids in the fortification of cell walls. Additionally, the introduction of electroculture creates a unique moment of tension that begins to expedite cellular growth in plants. Finally, combining the accretion cells and nutrient-rich soils creates an environment for extensive root lattice growth and resiliency. Over time it allows the project to reflect the invasive properties of mangroves, creating a chaotic natural habitat and fortifying the coast while aiding in rehabilitating aquaculture and terrestrial liminal life, becoming one fortified organism.

BOOPOD



MINERAL ACCRETION



LIVING TREES



SINKING VENICE RACHEL ARMSTRONG

Translating natural systems into architectural practices that aid in the restoration of the design is extracted through the ideology that sustainable materials propose a sustainable solution to severe climate events.

Rachel Armstrong is an architect focusing on the use of sustainable materials and design techniques in her work. “Sinking Venice,” was a proposal for a sustainable solution to the problem of rising sea levels and erosion in the city of Venice, Italy.

In “Sinking Venice,” Armstrong proposed the use of a new type of material called “protocell architecture,” which is a self-repairing and self-sustaining material that is capable of regenerating itself. The material would be used to create a series of interconnected islands that would be located just offshore from Venice. These islands would be designed to be able to adapt to the changing conditions of the sea, and they would be able to absorb the impact of waves and storms to help protect the city.

Overall, “Sinking Venice” is an innovative design committed to sustainable design and her belief in the potential of new materials and technologies to solve complex problems. “Sinking Venice” is a proposal for a sustainable solution to the problem of rising sea levels and erosion in the city of Venice, Italy. utilizing “protocell architecture,” a self-repairing and self-sustaining material that is capable of regenerating itself.

These islands would be designed to be able to adapt to the changing conditions of the sea, and they would be able to absorb the impact of waves and storms to help protect the city. The construction process is a combination of traditional building techniques and advanced manufacturing techniques, translating into different uses, including housing, public spaces, and commercial and industrial uses.

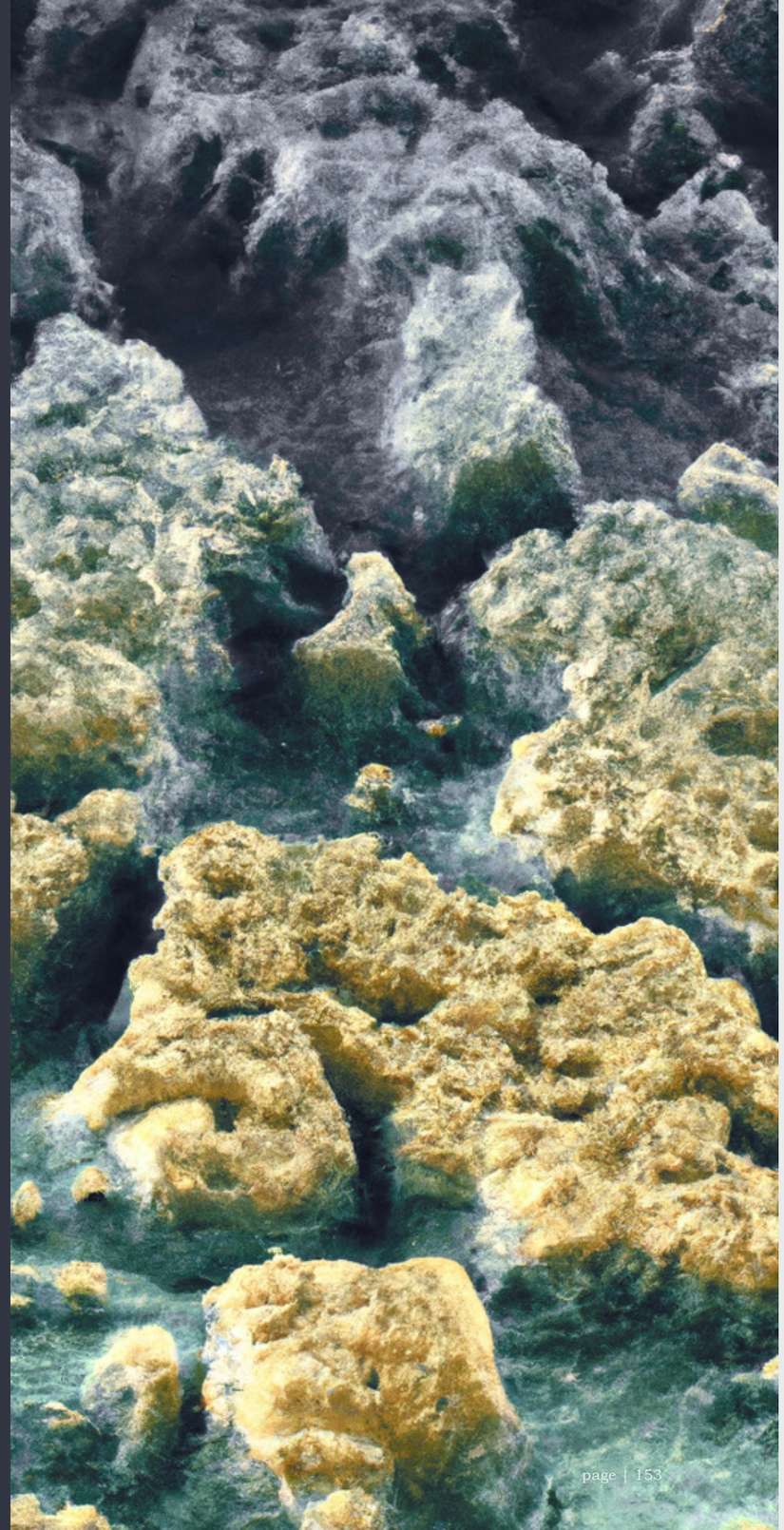


Saving Venice (2009). 200 Year Continuum. https://200yearcontinuum.com/Saving-Venice-2009

SINKING VENICE RACHEL ARMSTRONG

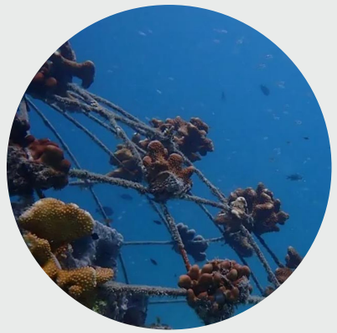
Translating Rachels Armstrong sinking Venice straddling the liminal Intertidal zone into a reef architectural terrace systems utilizing mineral accretion technology.

Mineral accretion is a natural process that occurs when minerals and other materials are precipitated out of a solution and deposited as a solid. This process is driven by chemical reactions that take place between the minerals, the water, and other dissolved substances in the solution. The minerals that are typically involved in mineral accretion include calcium carbonate, silica, and various other salts. The specific conditions that are required for mineral accretion to occur depend on the type of mineral that is being precipitated. Some minerals, such as calcium carbonate, require specific temperatures and pH levels in order to form, while others, such as silica, can form in a wide range of conditions. The mineral accretion process can occur in a variety of environments, including freshwater and marine environments, and can lead to the formation of a variety of different types of structures, such as mineral deposits, coral reefs, and stromatolites.





Mineral Accretion Rod



Mineral Accretion Pods



Mineral Accretion Cells

MITCHELL JOACHIM OF TERREFORM ONE

visualizing architecture - translating practice into design

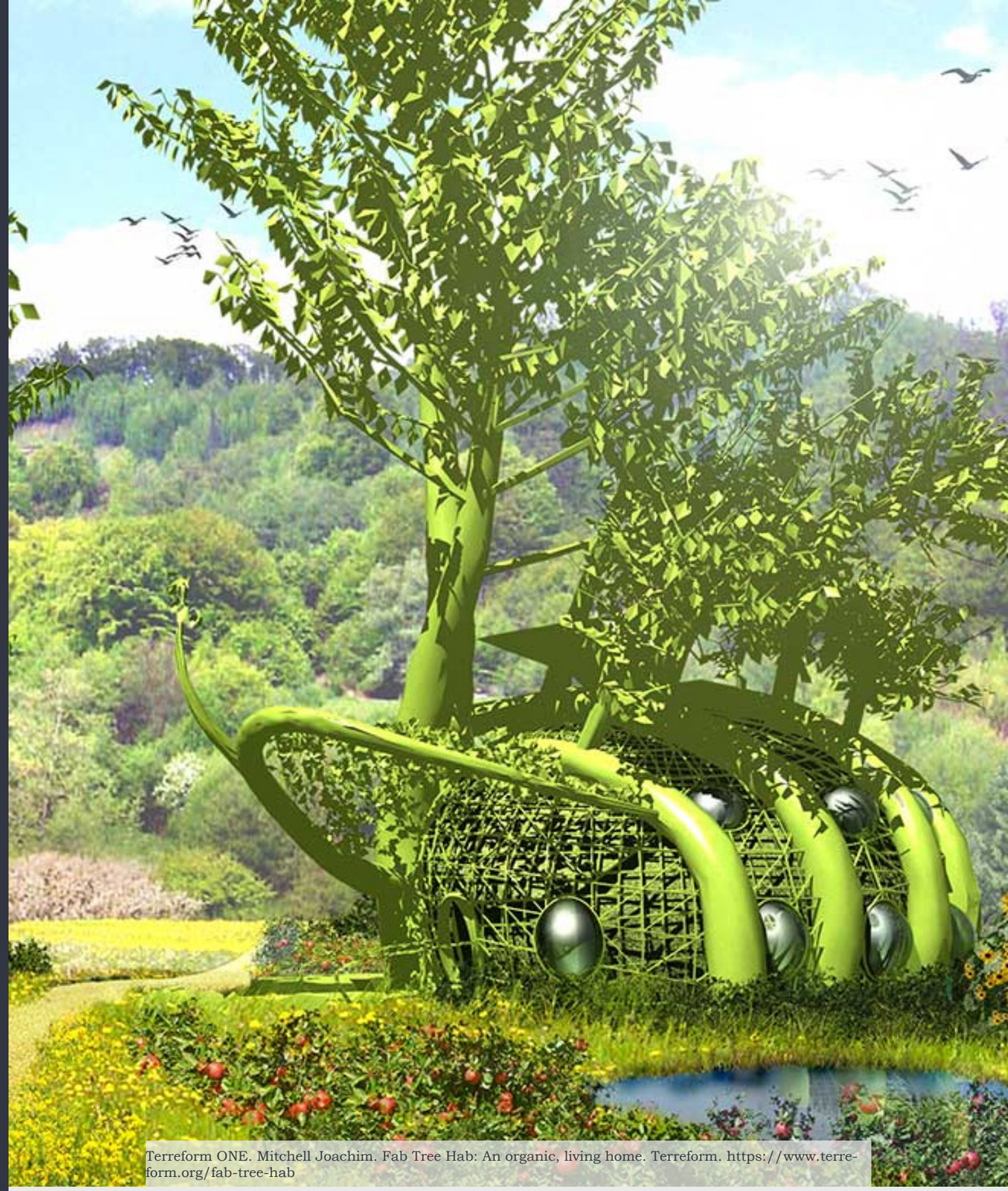
Mitchell Joachim co-founder of Terreform ONE is known for his innovative and sustainable design approach, which often incorporates living trees and plants into his projects.

One of his notable projects is the “Living Tree Tower,” which is a conceptual design for a skyscraper that incorporates living trees and plants into its structure. The building would be constructed using a modular system of prefabricated units made of sustainable materials such as bamboo and hemp. The units would be stacked to create the tower’s structure, and living trees and plants would be grown in between the units to create a vertical garden. The trees and plants would act as a natural insulation for the building, helping to regulate the temperature and humidity inside, and provide fresh air and oxygen. Additionally, the trees would also play a role in absorbing carbon dioxide from the atmosphere, making the building carbon neutral.

This concept is part of a larger research by Joachim, called “Living Architecture”, that aims to integrate living organisms into the built environment, to create more resilient, adaptable and sustainable buildings.

Overall, Mitchell Joachim’s engagement of living trees and plants in architectural design is an innovative approach that seeks to create sustainable and resilient buildings that can improve the environment and the lives of people.





Terreform ONE. Mitchell Joachim. Fab Tree Hab: An organic, living home. Terreform. https://www.terreform.org/fab-tree-hab

The design focuses on protecting and restoring a small village and ecosystems north of Irwiti Lep, located on the island's southeast corner. Due to the island's location within the ring of fire, the village's exposure to cyclones, storm surges, waves, and extreme climate events impacts them more than villages in the island's northern part. Proposals have been thought of in protecting villages alongside the south of the island has been relocation and redistribution of homes more inland, where I question if this solution has been done with thought over convenience and lack of care of oversea parties. In the island's geographic context, relocation becomes a poor solution that would transform the lives of the villagers in both cultural and physical impacts, primarily due to the poor, rocky soil conditions inland not being adequate for farming, and separated from water has a lasting emotional effect on the islanders and their traditions. Relocation is an easy solution on the outside without really dissecting how impactfully harmful the potential is for the islander's identity. The tie the islanders have to their home greatly to centuries of ancestry settlement passed down through a matriarchal lineage, which is becoming more corrupt into a patriarchal system with colonization and external influences.[57]

The story unfolds in a reciprocal relationship between the center and the village, each aiding the restoration of land, water, and culture. The fortification of the coast will take place in phases, focusing on developing the outer barriers, then working inland towards the village, where the village becomes the focal protection point of the design, as opposed to the physical focal area of the mangrove nursery. Developing thresholds that endlessly diffuse climate events enhance the village's resistance to these events.

57 "Twelve Soil Orders." Agricultural Science Laboratory, https://www.uidaho.edu/cals/soil-orders/andisols.



Site Plan

IRIVITI LEP SITE LOCATION

Iriwiti Lep is a small uninhabited island in the Pacific Ocean, part of Shefa Province of Vanuatu. Connected to a freshwater runoff river inland is located on the island's southeast coast. Located north of the delta is a beautiful natural waterhole known as "Eden on the River," a luscious river cove full of mangroves, fish habitats, protective running waterfall pools.

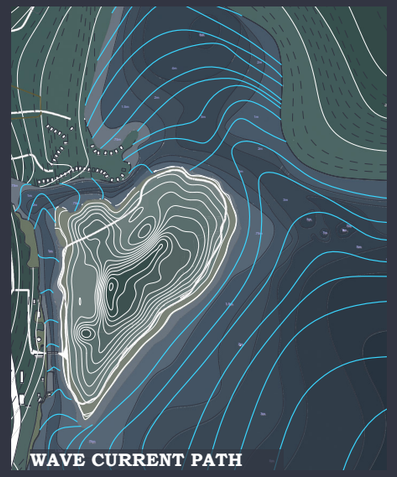


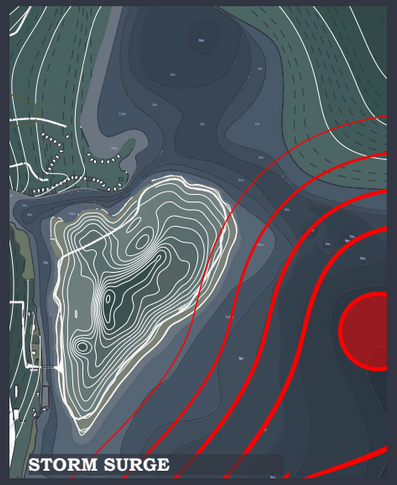


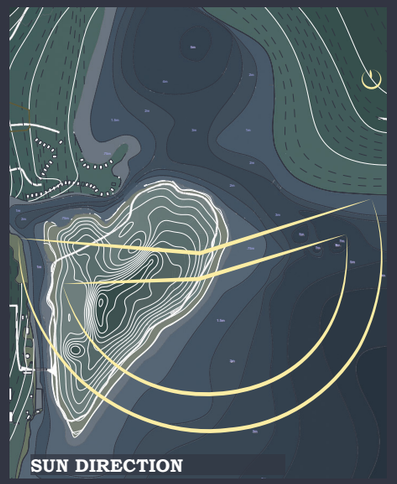
Existing Conditions

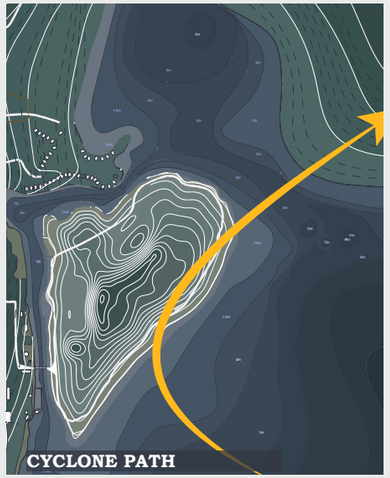
NATURAL SYSTEMS

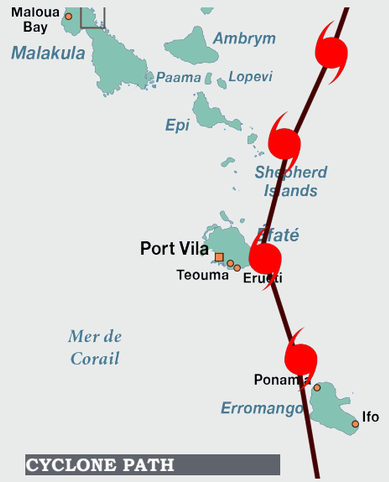
Site Exposure


WAVE CURRENT PATH


STORM SURGE

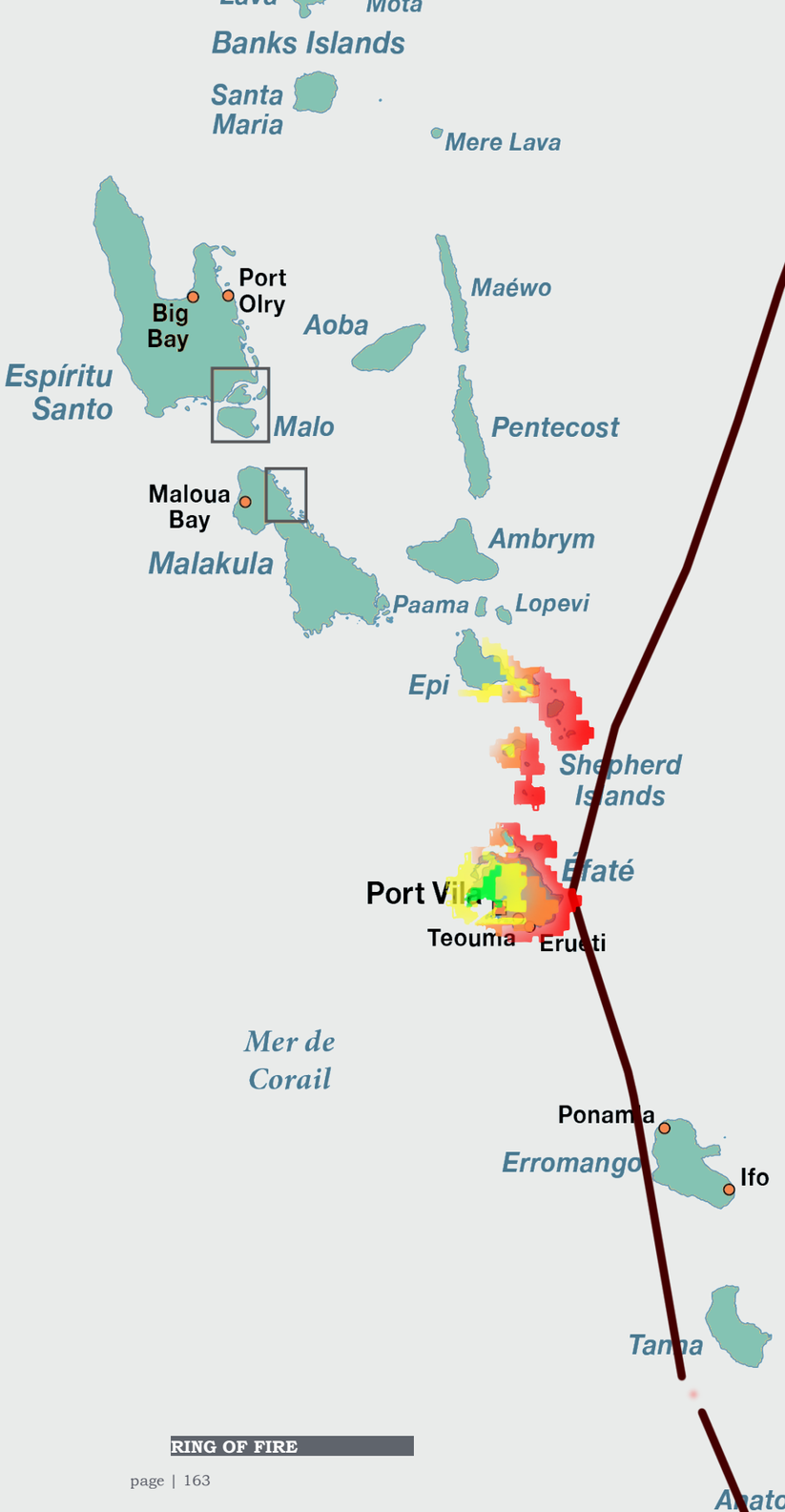

SUN DIRECTION


CYCLONE PATH



CYCLONE PATH


TSUNAMI POINTS



RING OF FIRE

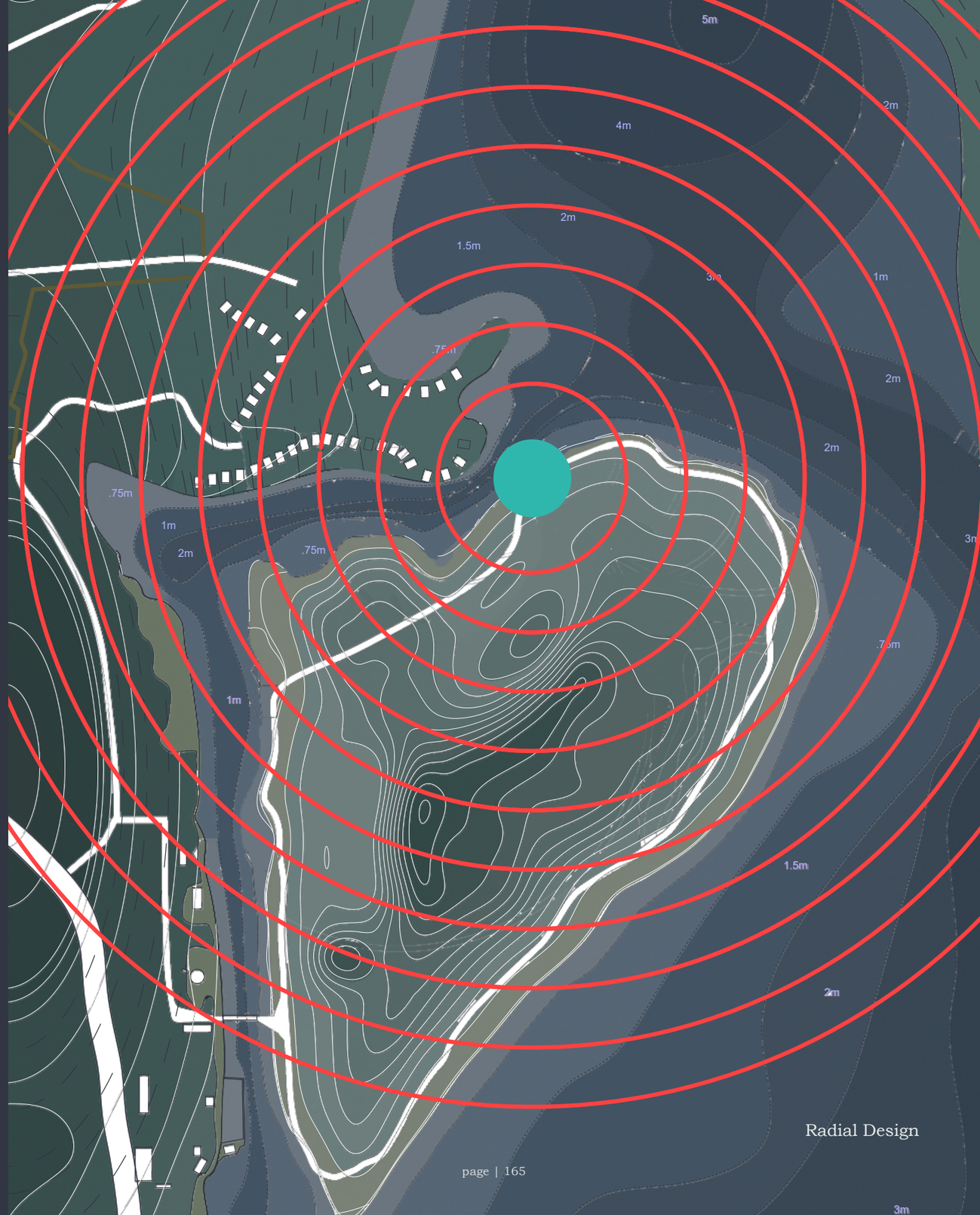
RADIAL PROGRAM

This thesis proposes to fortify the coast utilizing low-tek technology and structure, all while utilizing the island's materials in developing a living fortress. Furthermore, the rehabilitation center serves to diffuse climate events before reaching the village shores acting as a physical to reduce the physical attributes of those events.

The design focuses on radial energy, where all paths lead to the mangrove nursery, stressing the importance of mangroves within this project. Submerged and protected in tranquil ocean water, protected by the rehabilitation structure, the mangrove nursery becomes the heart of the project, pumping mangroves from the nursery into the pods. Within the structure, the village works to produce BooPods, a design shaped to provide a stable structure for the mangrove seeds to be planted. These pods are generated through bamboo rods cleaned, cut, and punctured to serve as a home, allowing the mangroves to grow inside. The mangrove nursery monitors the growth of the seedlings within the BooPods, for their first year prior to the final plantation, nursing their growth in addition to fertilizing the mangroves with andisols, soil forged through volcanic ash, introducing andisols, containing andic properties that fortify their roots, creating a moment of unique chemical and physical properties that promotes high-water retention within plant roots, 1. In open waters, mangrove roots grow vertically, allowing for easy picking and relocation. Once relocated into the mangrove pods, the BooPods are planted, forcing horizontal growth. Naturally, mangrove roots grow to 3m, intertwining within the calcified structure and roots of other mangroves. Once these roots intertwine within the next few months, a lattice of roots is forged within the mangrove pods, becoming a fortified living structure actively growing to fight continuous climate impacts to regrow land and diffuse storms. The mangrove rehabilitation takes a couple of years to grow into a restorative living wall.

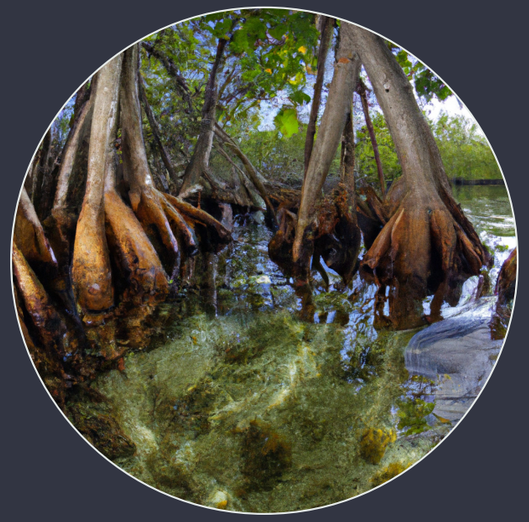
The mineral accretion pods, known as artificial bio rock, are a technology introduced in this design; through low voltage currents, a revival of coral and marine life is possible. The Rehabilitation Center works concurrently as the BooPods are being developed to restore the aquatic life on the island, a vital part of the islander's culture and life. The electrification of these mineral-accreted pods tends to allow reefs to grow 3-4 times faster and endure well above existing reefs against coral bleaching, disease outbreak, and climate disturbances. The rehabilitation center works to restore coral reefs, where corals are grown and monitored during the accretion process prior to coral farming into the pods. [58]

58 "What Is Mineral Accretion Technology?" New Heaven Reef Conservation Program, 2016, https://www.newheavenreefconservation.org/projects/mineral-accretion.



Radial Design

EDGE CONDITIONS



Efate is an island in Vanuatu, located in the South Pacific Ocean. The littoral zone of Efate is the area along the shoreline where the sea meets the land. This area can be divided into the high tide zone, where the water reaches during high tide, and the low tide zone, where the water recedes during low tide. The liminal zone is the transition area between the littoral zone and the land.

Mangroves are trees and shrubs that can be found in the littoral and liminal zones of Efate. They are typically found in areas with high levels of saltwater and tidal fluctuations. Mangroves help to protect the shoreline from erosion and storm damage, as well as provide habitats for a variety of marine and terrestrial animals.

The edge conditions of the island of Efate with respect to the littoral and liminal shoreline with mangroves, would be that the shoreline is relatively stable, due to the presence of mangroves which provides the shoreline with protection from erosion and storm damage. Additionally, the shoreline would be rich in biodiversity with a variety of marine and terrestrial animals that are dependent on mangroves.



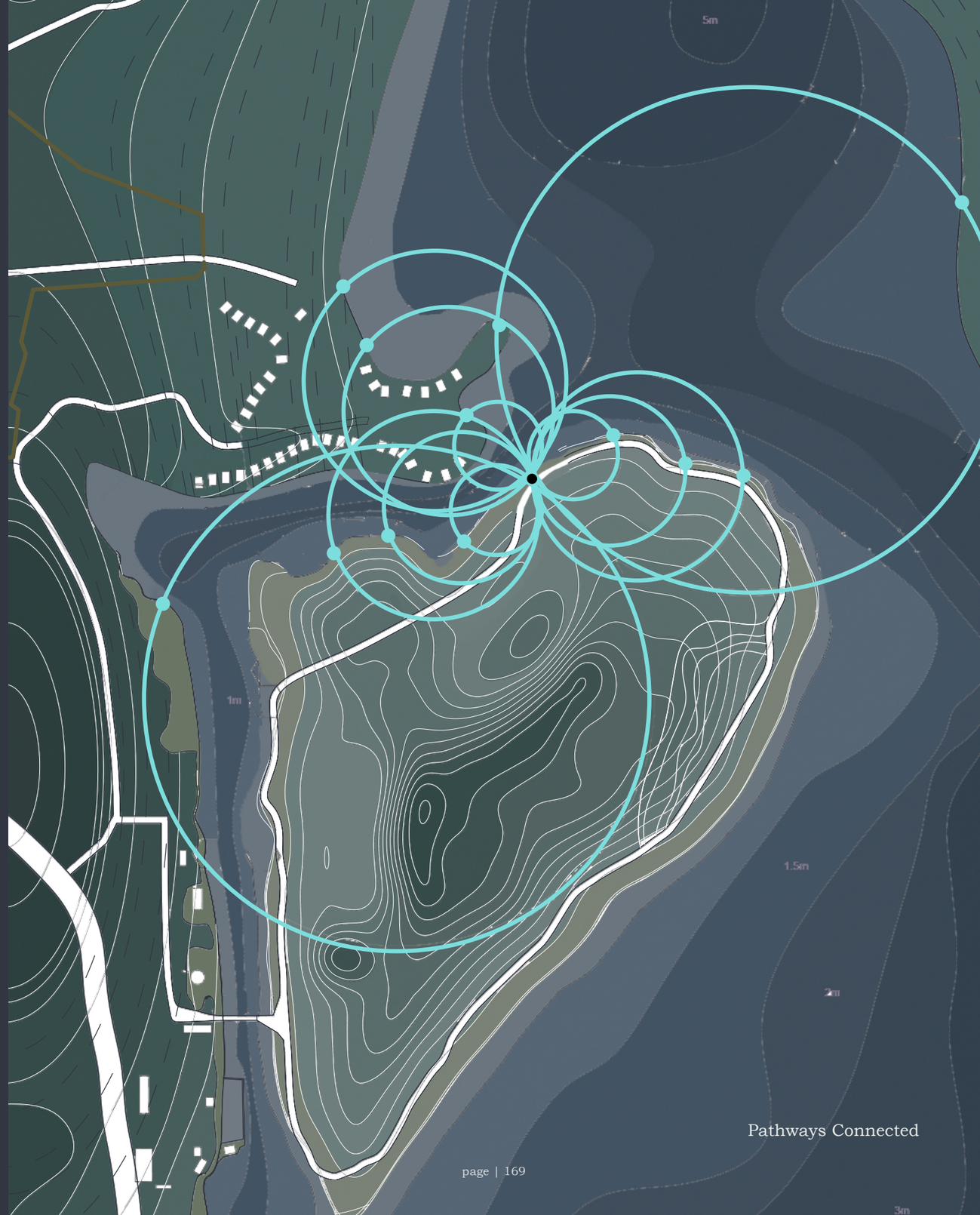
Points of Intersection

CONNECTIVITY



Radial and circular architecture can be a good design strategy against climate disaster events because they allow for natural ventilation and cooling, which can help to reduce the need for energy-intensive cooling systems. Additionally, circular buildings often have smaller surface area-to-volume ratios, which can help to reduce the amount of heat absorbed by the building during hot weather. This can also reduce the amount of energy needed to cool the building. Additionally, circular buildings can be designed to be more resilient against high winds and other severe weather conditions, by distributing the structural load more evenly around the building.

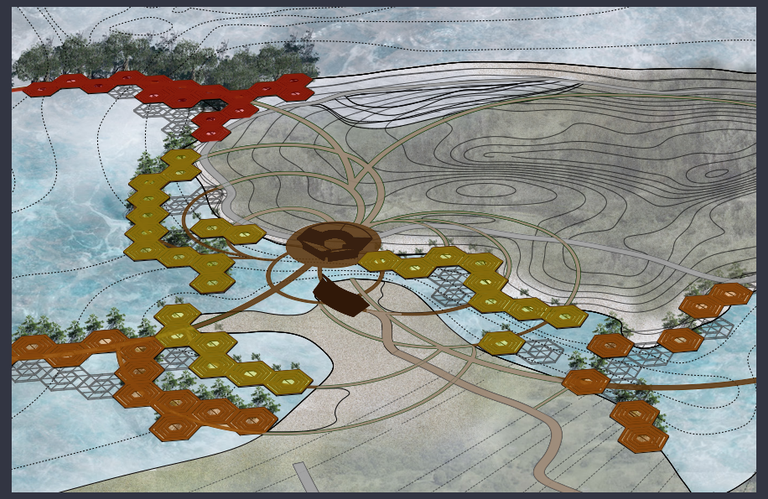
Radial barriers, such as mangrove and natural barrier systems, can work well against natural disaster storms because they act as a buffer zone, diffusing and diverting the energy of the storm as it approaches. Mangroves and other natural barrier systems, like wetlands and coastal dunes, have strong root systems and dense vegetation which can help to dissipate the energy of waves, reducing the impact of storm surges and flooding. The vegetation also slows down wind speed, reducing the impact of high winds. Additionally, these systems can help to reduce erosion by stabilizing the shoreline, and they can also provide important habitats for wildlife.



Pathways Connected

PHASES

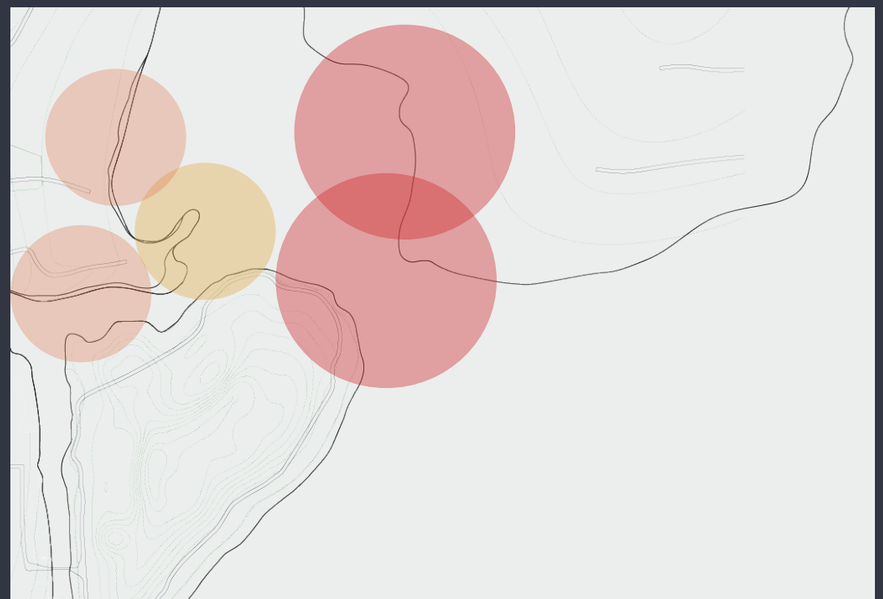






Design

FORM



Mangrove Growth Phase Zone



Pathways



Mangrove Regeneration | Plantation



Mangrove Regeneration | Growth

Understanding that the earth is ever-changing becomes a force in the design. But can that translate into an ever-changing and growing structure? Bioarchitecture creates a unique moment where architecture and living systems layer interwoven, evolving into a symbiotic subatomic design. life is made using 3 main components;

1. information
2. metabolism
3. compartment

Genetic diversity is the key concept to adaptation; as we have seen, natures genetics in the current state cannot keep up with the pollution being dumped into every atom in this world. Creating a system that promotes genetic diversity will strengthen the ground and coastline and the species living within the design borders. One species that will be strengthened will be the human species, where the islanders will begin to reconnect with their land and water, and the design intervention will fortify their grounds, soils, and ecosystems.

Reactive Adaptation

Thus far, the vulnerability the island is susceptible to is rather evident; the focal point in the design will be on the coastal zones, studying a lattice that binds the people, earth, and water. This design is a living system that reacts directly to climate-induced vulnerabilities, layered with functional space that allows for a design with living memories embedded within, functional meets mythological, which develops into an iconographic design typology.

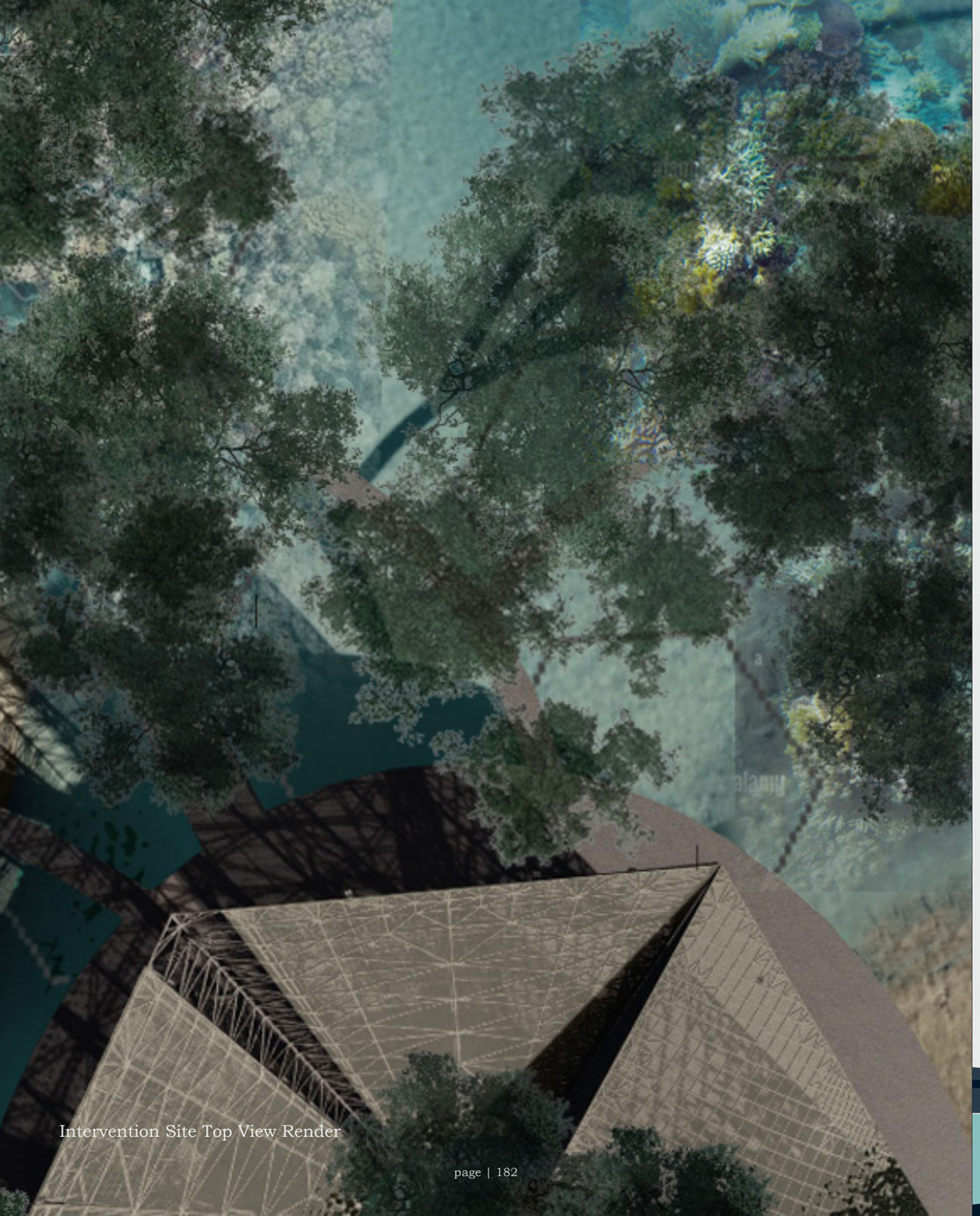
The desire to keep the design purely natural materials was great. Though grappling with understanding the brute force in nature, I concluded that the climate impact is beyond nature's capabilities to restabilize. Thus a hybrid design of sculpted construction and low tek design.

Bioarchitecture: An approach to architecture that incorporates living systems and natural materials into the design, creating a symbiotic relationship between the built environment and the natural world.
Genetic Diversity: The variety of genetic material within a population or ecosystem. Genetic diversity is important for adaptation and resilience in the face of environmental stressors and changes.
Metabolism: The chemical processes that occur within living organisms to maintain life, including the conversion of food into energy.
Compartment: A defined space within a living organism that serves a specific function.
Iconographic Design: A design approach that incorporates symbolic or representational elements, often drawing on cultural or historical references.
Low Tek Design: A design approach that uses simple, low-tech materials and methods, often incorporating traditional or indigenous building practices.



Intervention Site Plan





Intervention Site Top View Render

SITE PROGRAM

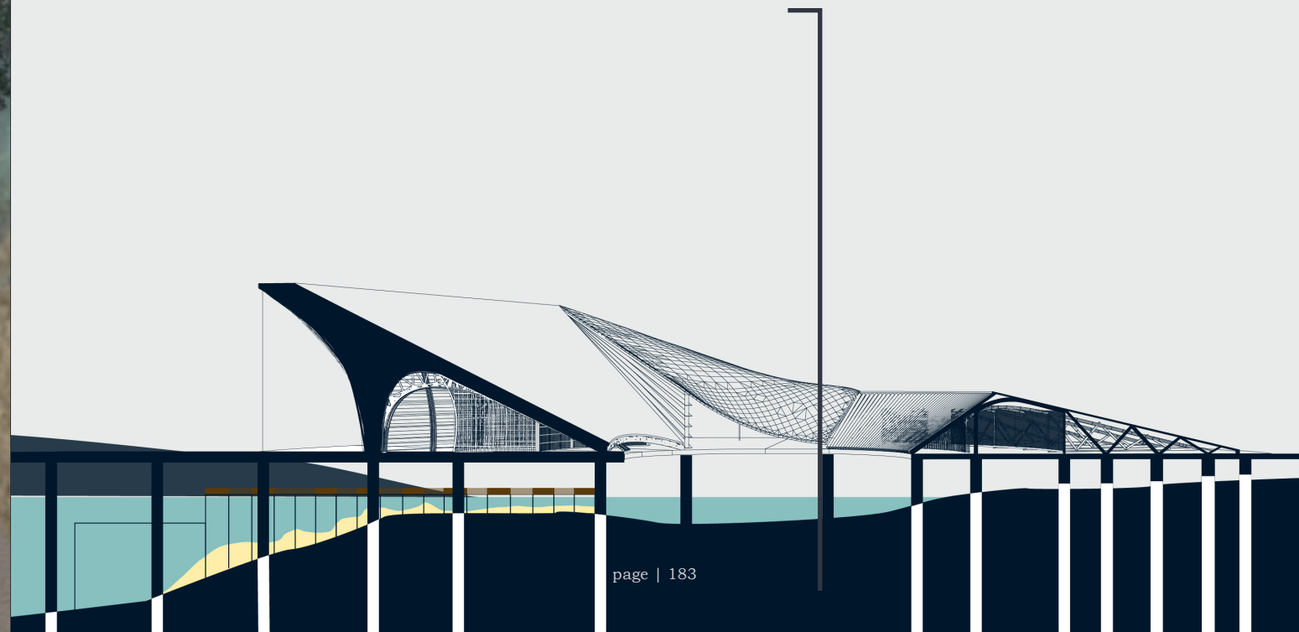
Bamboo Treatment and drying
Mangrove Workroom
- BooPod generation
- Seedling plantation
- Mangrove Nursery

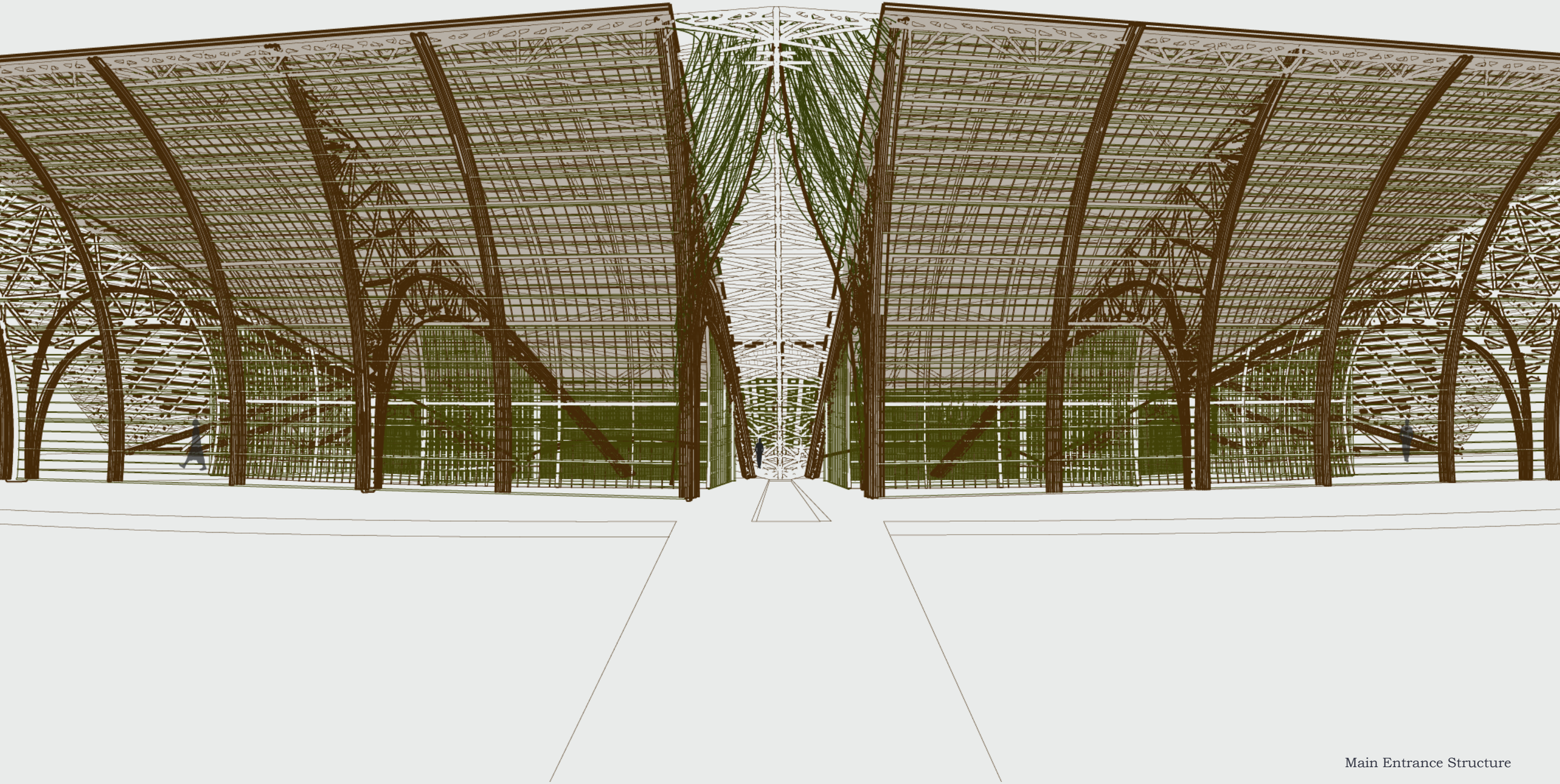
Climate monitoring office
Construction Workshop
- Mineral accretion pods
- Coral rehabilitation tanks
- Thatched roof weaving
- Vine weaving

Back of house
Kitchen
Bathrooms
Open cultural space

Observational monitoring of key indicators is necessary to evaluate success of goals and objectives of rehabilitation or restoration projects and to guide adaptive management and decision-making. Formal experiments, either within an observational before-after-control-impact (BACI) framework (e.g., Stewart-Oaten et al., 1986) or using manipulations with appropriate controls and adequate sample sizes, could improve causal interpretation of observed patterns and identify key processes (Gann et al., 2019).

The story unfolds in a reciprocal relationship between the center and the village, each aiding the restoration of land, water, and culture. The fortification of the coast will take place in phases, focusing on developing the outer barriers, then working inland towards the village, where the village becomes the focal protection point of the design, as opposed to the physical focal area of the mangrove nursery. Developing thresholds that endlessly diffuse climate events enhance the village's resistance to these events.





Main Entrance Structure

CONNECTED THROUGH ROOTS

Layer of imbrication

Mangrove roots forge the course this project took; the unknown chaotic roots create this exciting friction between architecture's rigid edges and nature's bleed into its surrounding contents. Threading roots and vines through the structure allow the network to grow continuously and weave into a solidified dense structure and allows a culturally imbricated layer within the frame of the design.

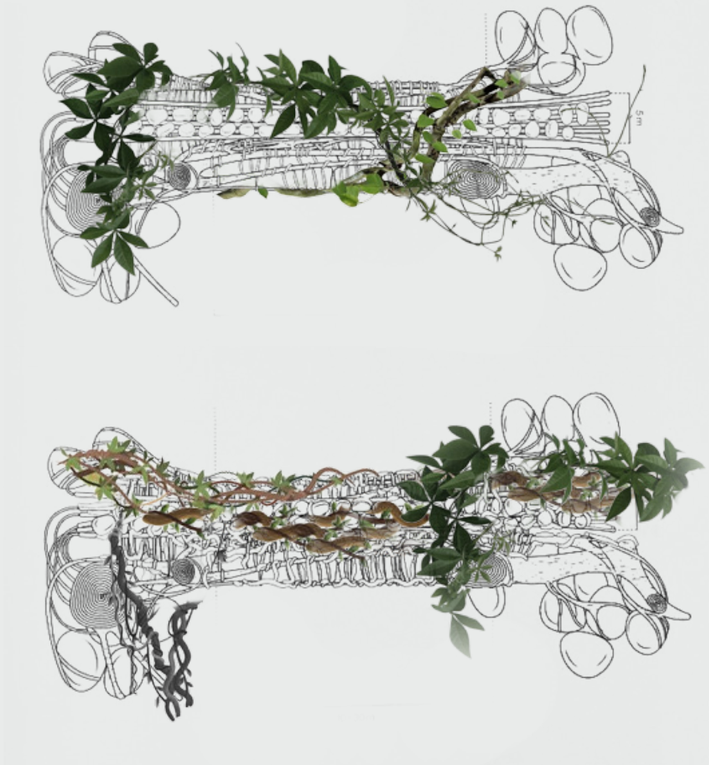
Once the thatched roof and exterior walls are built, the islanders begin to weave the canopy and walls into the existing structure, using weaving patterns passed down through generations; incorporating these malleable roots allows for secured connection points rigidly and tied off into the network.

Moments of ecological infrastructure is a crucial concept when designing for people and nature, where designs focus on rehabilitating people and land together and separately but in harmony. Roots are woven through the structure, trained to grow in directions of load transfer during storms, resulting in a reduction of load stress the rehabilitation center faces during severe climate events.

Mangrove roots have a unique property of their imbricated characteristic, resulting in a structure where mangrove roots thrive through dense entanglement, creating a solidified single organism. as time progresses, this lattice structure strengthens over time, carrying more loads and resisting worse conditions than the island has faced. During the invasive growing stage, the rehabilitation center is used first and foremost as a structure to diffuse storm surges, cyclones, or extreme weather events. The internal program reflects the restorative focus in this design. Devising a heavy structure that withstands storms and strong currents while aiding in the harmonization between the coast and people pushed this design to explore low technology, low maintenance, and low embodied energy infrastructure systems that imbricated together to create a chaotic utopian world.

Reconnecting back to the land creates exciting opportunities for potential future adaptability of the design. First, its chaotic natural materials used within the design begin to forge their own stories, growing chaotically as the rehabilitation center aids and finishes the phase construction of the story; the center then unfolds itself to adapt a story of itself, where islanders and natures species begin to adjust the use of the structure, creating anchoring moments for cultural events, sheltered internal space for cultural gatherings, and habitat of species on the island.

The vines and roots become a layer woven between the structure and the thatched wall to solidify the structural connection between walls and structure. Creating a system heavily involved in ecological technology is a moment that creates unique opportunities for growth and natural strength, additionally explored in the mangrove cells. Through threading vines throughout the archways, the villagers train the vines to grow along the path of the main structure. Over time the vines and roots become a living wall that begins to expand and invade the existing bamboo structure. As time continues, the lattice will grow and solidify, being able to withstand more loads, high levels of rain, and coastal erosion, and grasp onto the roots as a unified wall during chaotic natural disasters.



Composite illustration by author through sources

Watson "Low-Tek. Indegionus Design"

BARRIER
Building Design

Acting as a force to withstand nature's severe storms, the rehabilitation center serves as a barrier strategically to diffuse storms leading to the nearby village 50 meters northwest of the center. Constructed in pieces, layered with living roots, the structure grows into an intertwined singular organism over time. The thatched roof is tied to the structural arches using those natural structural materials woven into the frame; growing with time, the roots are guided, but the arch's pathways become engulfed with a natural lattice. The design evolves into a more robust system with time adapting to rising climate conditions. The 10-meter tall structure reflects the height of the low-lying island, symbolizing the low-rise island typology, using its boundaries to develop a design that not only reacts but reflects the surrounding environment. Separated into two angular barricades, the storms force during impact.

The fortification of the coast will take place in phases focusing on developing the outermost layer, working focusing towards the design development, and protecting the village and coast. The reciprocal relationship between villager and structure becomes the long journey of the design. Programing a cycle where the village yields in the development and continuous monitoring of terrestrial and aquatic growth.

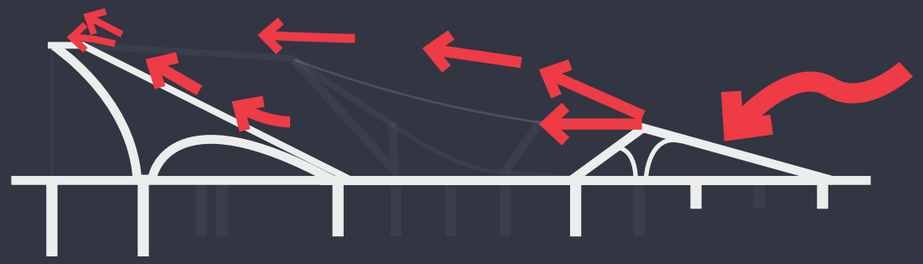
Entering the facility, the pathway leads from the center of the village through the vine archway entrance. The structure purpse serves dually between structure and program, where standing to diffuse against storms and rehabilitative roots through ecological and spiritual rehabilitation.

Within the mangrove rehabilitation office, the prototype BooPods are seeded and placed within the mangrove nursery to grow in a controlled, fertilized ocean environment to strengthen roots through mineral transfer.

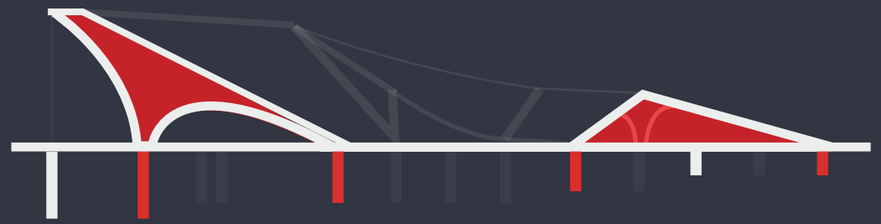
Once pods have been seeded and transferred into the nursery, they float in the nursery for eight to twelve months in a familiar environment based on the mangrove mineral pods. The mangrove nursery is shielded against storms from above and below, stabilizing the nursery environment. at this stage, mangrove roots will grow vertically floating above the water surface, allowing for a large cluster of BooPods to be replicated, once planted into the mangrove mineral-accredited pods. The next phase becomes critical when the mangrove roots begin their imbrication process. Studying current climate paths and patterns within the facility will map out the best period to weave teenage BooPods into the mangrove pods during the dry season. Finally, the mangrove accreted pods serve as coral rehabilitation and mangrove structural pods. As mineral accreted technology calcifies through low current technology, the hexagonal grid is continuously connected, growing below the water surface.



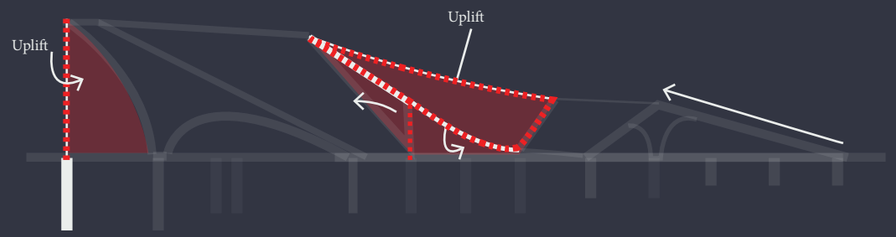
Render Section of Intervention



Wave Diffusion



High Tide Stability
Lateral resistance support connecting main trusses to structural columns on the platform. Connectivity forms a rigid structure intertwined with vines and roots growing throughout high tide seasons



Uplift Support
Woven lattice structural woven support during uplift, north-facing horizontal sun panels used to diffuse uplift and wind tunnel. The tensile cable stabilizes the structural entrance to the arches. Design parti utilizes pulling roofs to the ground away from the ocean and open storms, resisting natural elements.

Render Section of Intervention

MINERAL ACCRETION



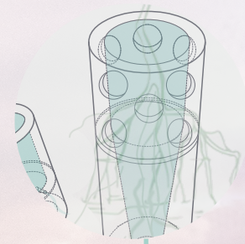


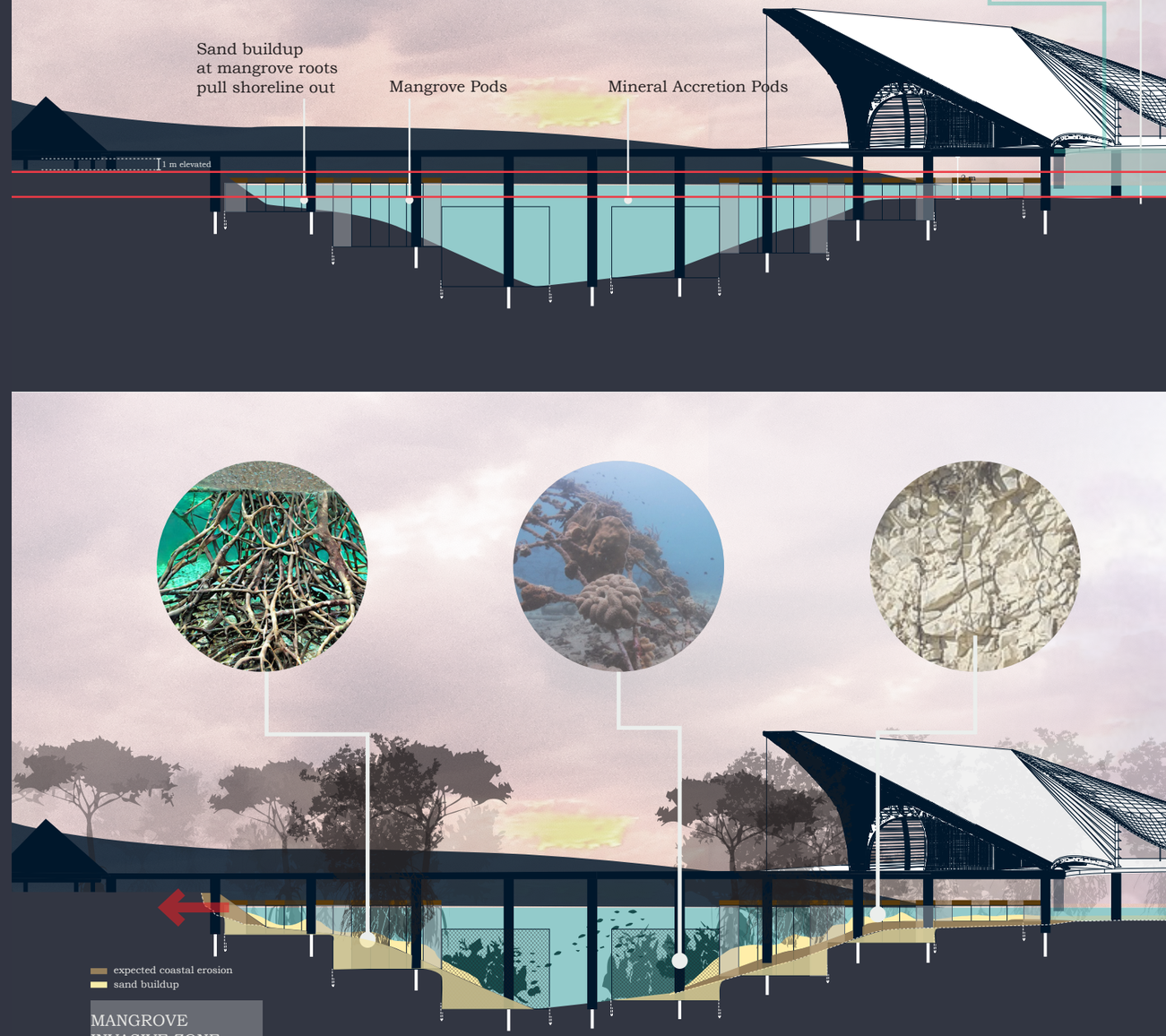
Design

MANGROVE REHABILITATION
MINERAL ACCRETION
ELECTRO-FARMING

TIDES

High Tide	4 am | 4 pm	0.8 m
Low Tide	10 am | 11 pm	0.14 - 0.52 m

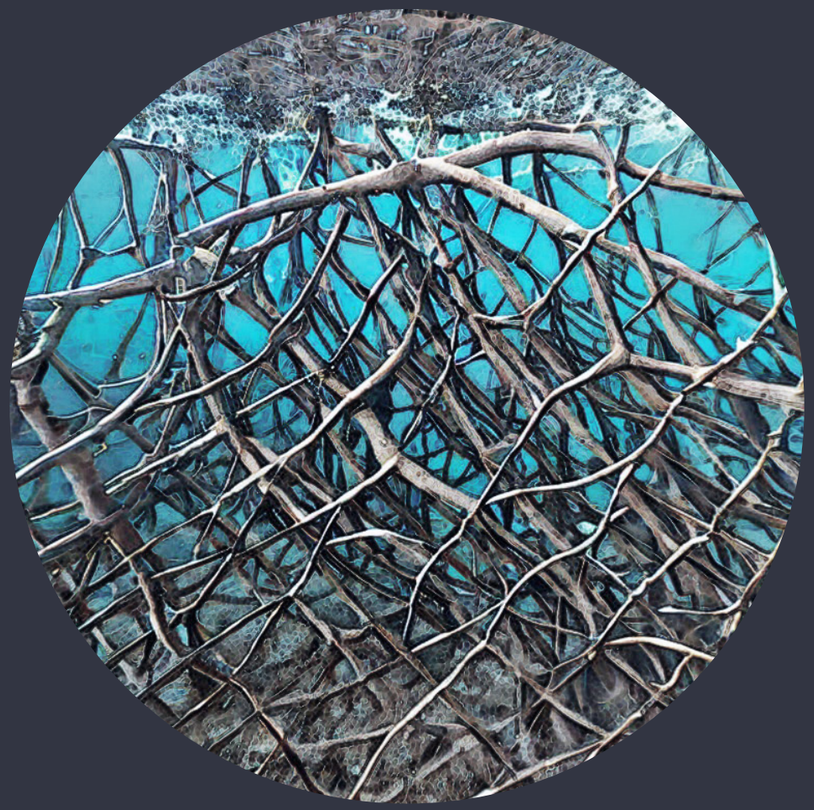


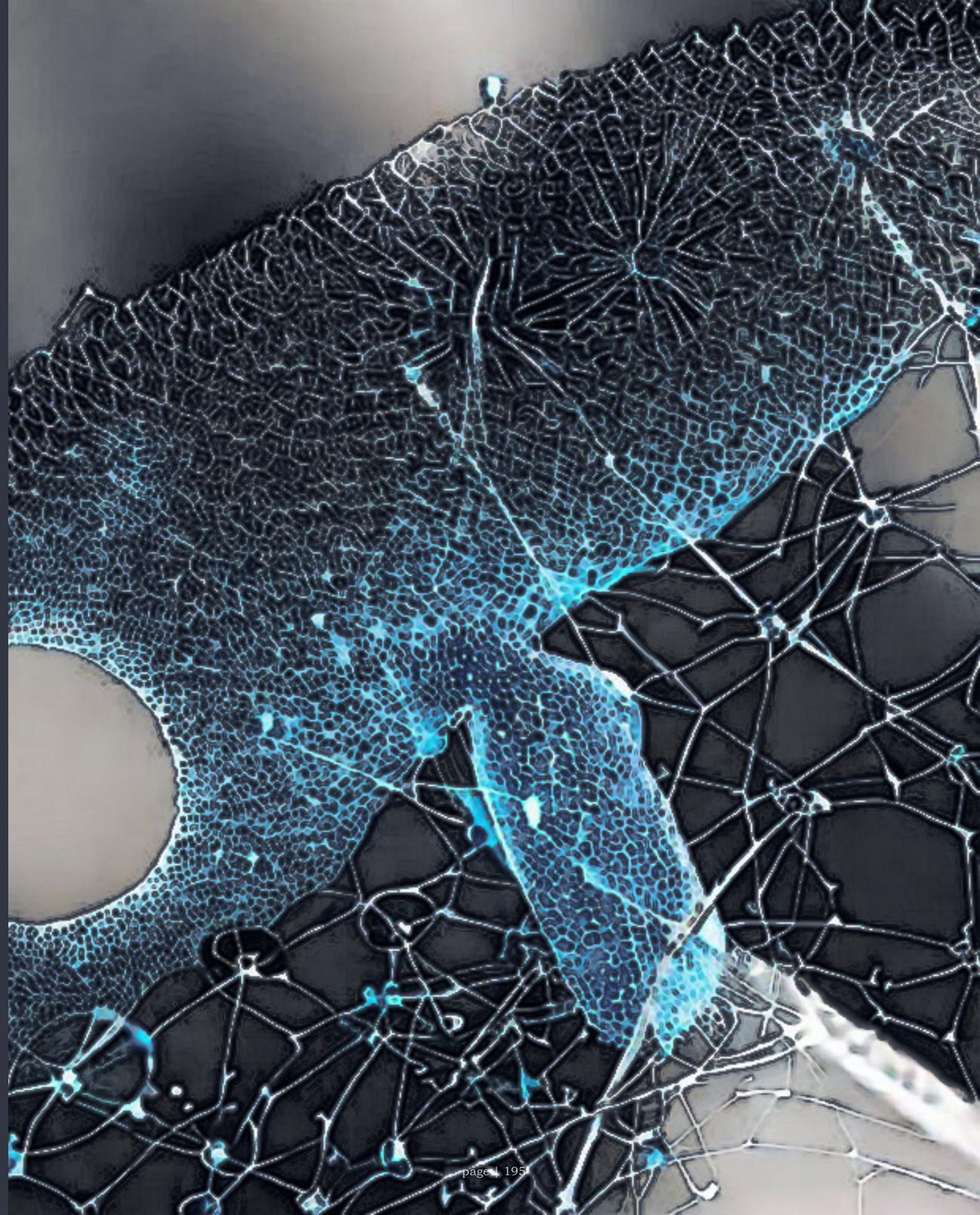


MANGROVE
INVASIVE ZONE
mangroves begin to spread
due to invasiveness
soil coastal build up at root

MINERAL ACCRETION

Mineral accretion is a natural process where minerals are deposited layer by layer, forming lattice-like structures in nature. These patterns, reflecting the orderly arrangement of minerals, are a testament to the beauty of nature and serve as a source of inspiration for architects and designers. By incorporating the lattice design of mineral accretion into their work, they can bring a touch of natural beauty into their structures, resulting in designs that are both functional and aesthetically pleasing. Thus, the process of mineral accretion highlights the potential for combining structure and beauty in architecture and design.





Tippy Tap transformed to the BOOPOD

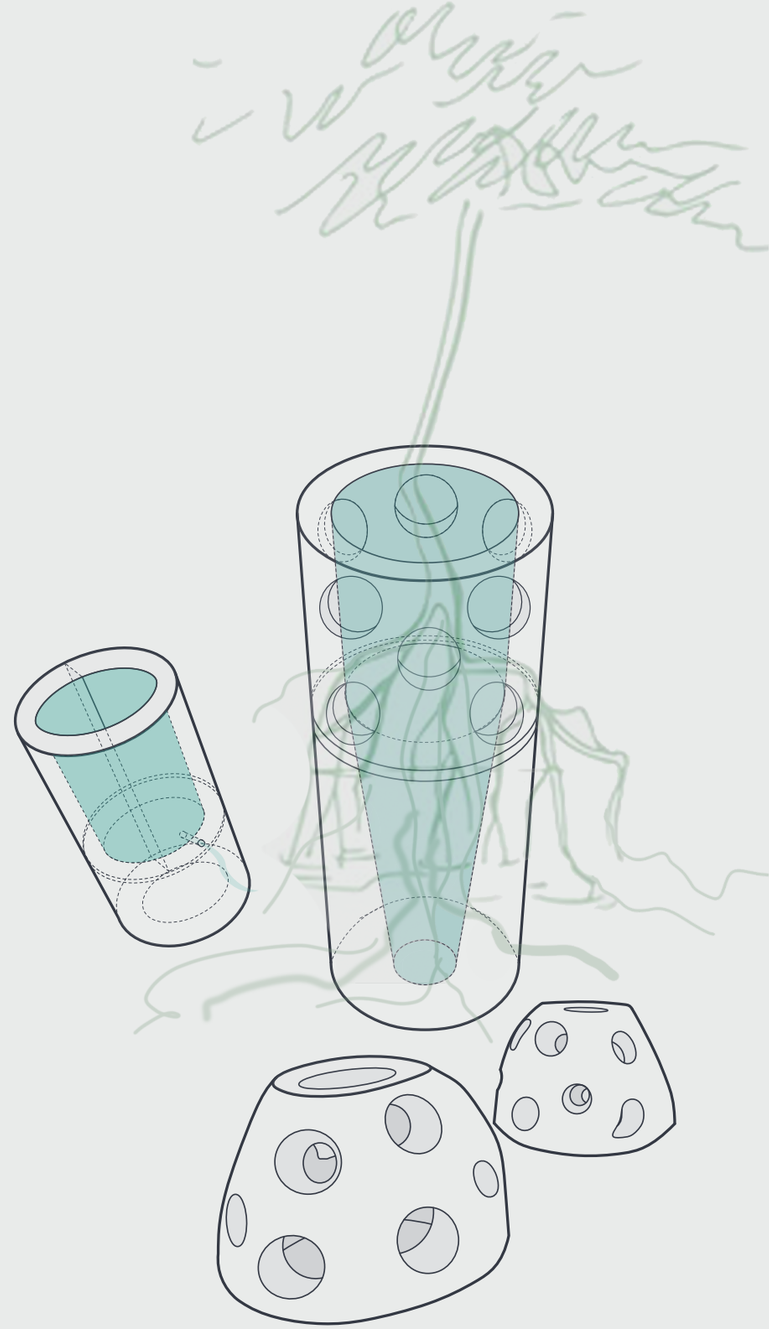
Finding a hybrid system between the tippy tap and reef pods is a starting experiment that leads to the design of the BooPod.

The earlier text we read on mineral accretion uses mesh wires and calcification to create a structured frame. In this process, the frame for the mangrove cultivation pods is formed, where aiding in the regrowth of mangroves becomes a fundamental focus of this thesis. Mineral accretion frames create a barrier weighted down by limestone boulders creating sand beds. Sandbeds collect sand from underwater currents and pour sand into the mangroves' beds. Finally, woven bamboo is wrapped into the framing to allow for seeding of the grown 8-12 months mangroves, allowing installation of the BooPod.

Mangroves, as studied, are critical barriers on coastal shores, and as climate extreme events continue to frequent and intensify, mangrove forests cannot adapt at a pace that allows them to resist these events. The purpose of the building is to create a habitat submerged in tranquil ocean water, protected against extreme events through the building itself.

The design becomes a second layer of defense for the mangrove seedlings in the nursery, allowing the roots to grow. Then 8-12 months into the seedling rehabilitation process, the villagers remove the BooPods and plant them into the woven bamboo mesh tied to the accretion process.
The BooPod prototype utilizes bamboo in the same manner as the tippy tap, where the top nod is removed, allowing for the seedling plantation inside once the holes for the roots are punctured. The nod is removed in an angular cut to allow the mangrove trunk to expand once it grows. The holes support the mangrove roots' horizontal growth, which expands at a radial height of 2-3 meters.

Phase one: seedling implantation process within the nursery 0-8 months
Phase two: 8-12 months, depending on root growth, villagers extract the BooPods and plant them inside the mangrove pods 2 meters apart; roots at this stage have reached a radial of 300-400mm.
Phase three: 1-2 years, mangroves have grown to a height of two to three meters, cultivating a root radial of two to three meters; this promotes the roots to intertwine with one another, creating a firm radial foundation rooted in the ground



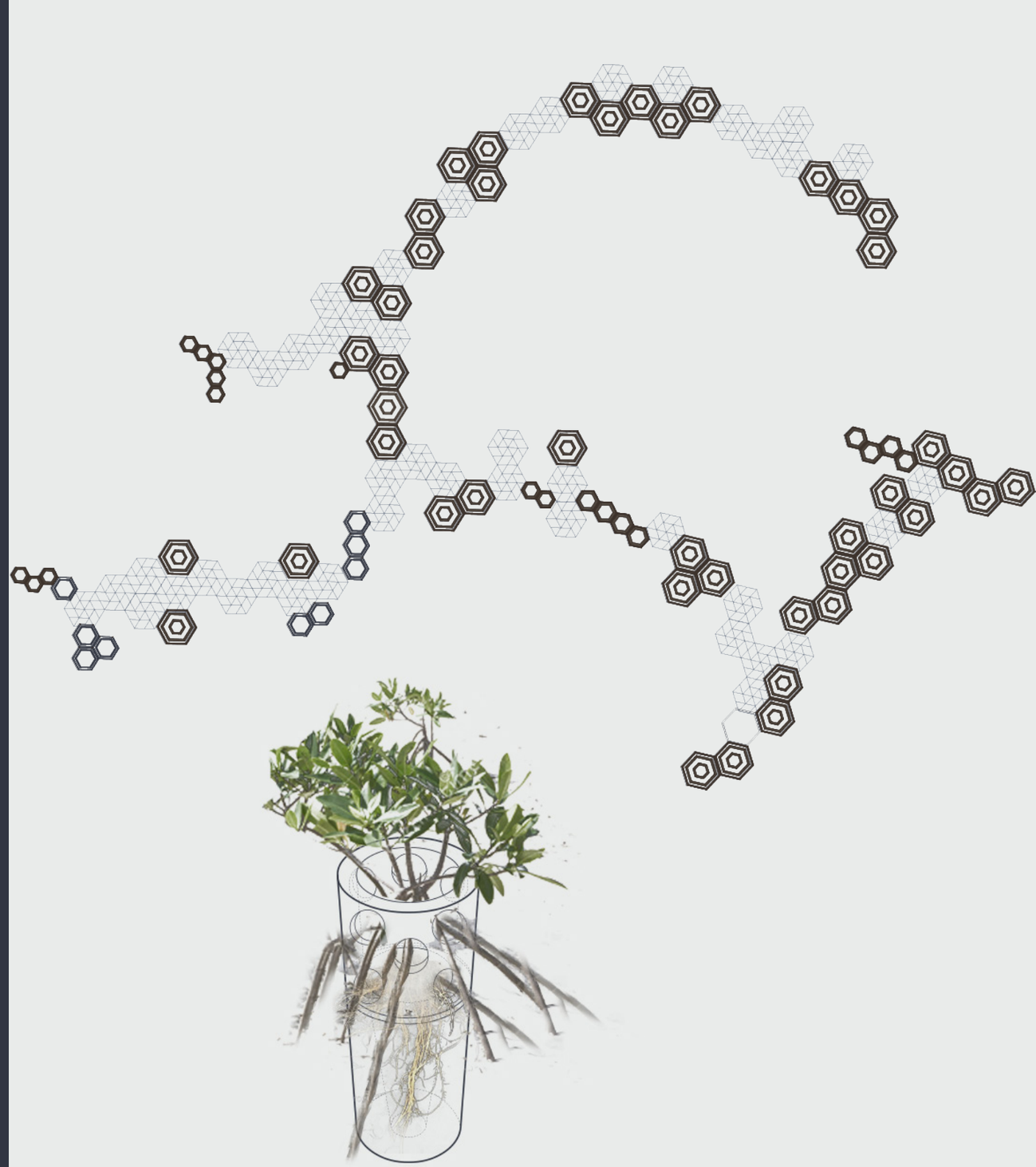
BOO POD

BOOPOD

BooPods are low-tech pods holding the mangrove seed within their shell, protecting the source within its first year of life. Soil, fertilizer, and sand are mixed and placed within the pod's central core. Constructed through slices from bamboo rods, ensure diameters are between 300 - 700 mm when selecting bamboo; finally, look for healthy bamboo, which shouldn't be too flexible and have visible cracks.

Bamboos are cut, ensuring two nodes are in each BooPod, one located at the bottom. Once the bamboo stems are cut, a hole is punctured through the first node. This will create a nesting spot for the propagules.

The BooPod is designed to create a nesting home for the mangrove propagules planted inside the pod. The unique property of propagules seeds versus other seeds is that mangrove propagules sprout while on the tree. Mangrove seeds drop as they reach total growth in the first cycle; once they fall into the soil, the mangrove seeds into the ground and begin to grow. Mangroves propagules characteristics, and seeds dropping directly from the tree categorizes mangroves as an invasive species. Once mangroves are collected from the locals, they are brought to the workroom. The seeds will be placed inside the shaped BooPod for plantation in the mangrove work room and put to soak in the nursery.

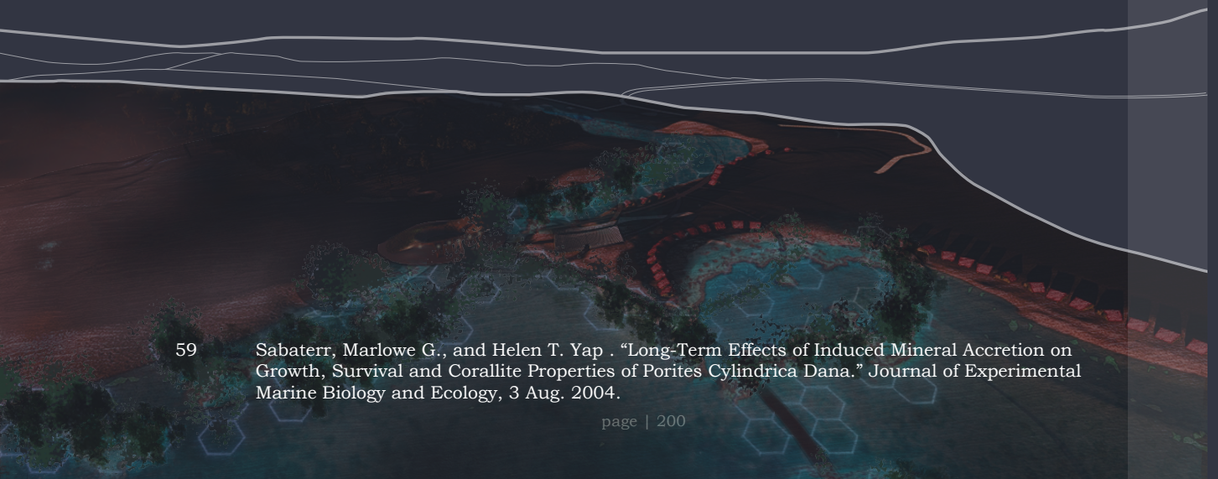


BOO POD

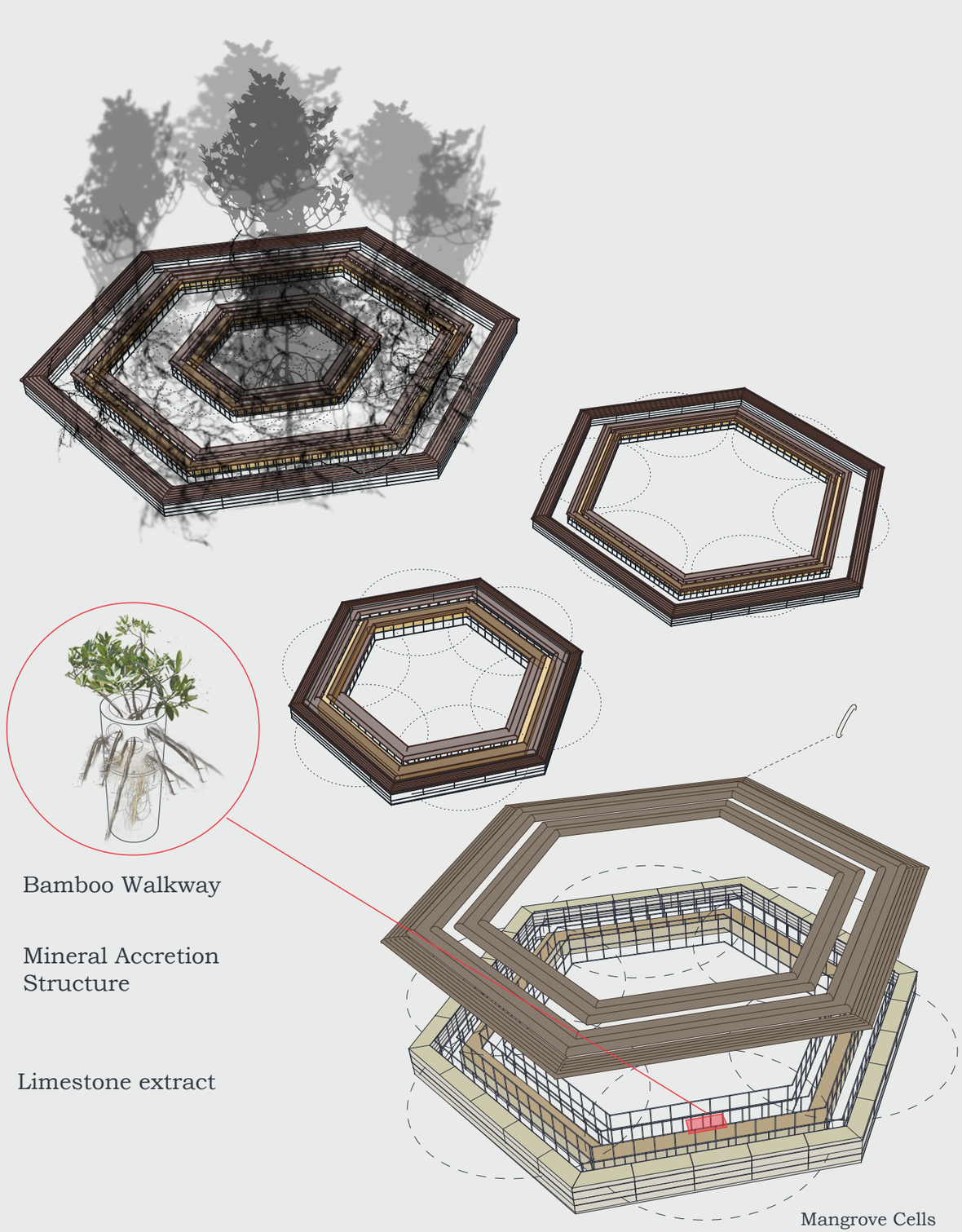
MANGROVE CELL PODS | VARIATION

The mangrove cell pods are the final destination for the BooPods, where they are transported from the nursery planted within the cell pods. The cell pods are woven of mineral accreted technology, creating nodes between roots, ocean salt, and a small spark. Mineral accredited technology (Bio Rock) is low voltage technology piled into the seabed with limestone extracted blocks. The limestone blocks are extracted from the little island of Iriwiti Lep; these barricades are used to protect the seafloor against hurricanes or storm surges that destroy shoreline ecosystems and the sea bed, slowly inducing coastline erosion. Wild storms not only destroy aquatic habitats but creates a change in habitat chemical properties such as reduced water alkalinity.

The Mangrove Cells Frame comprises a hexagonal form, covering the most space with the least amount of material, keeping costs low. A simple rebar framed structure, laced with woven wire mesh, where the design is long-lasting in a corrosive marine environment. Simplistic anchor units are used to solidify the cell's locations, where these pods become mangrove habitats and restorative cells. Once in place, the cells begin their calcification process, where they are continuously connected, allowing for one electric source. The accretion technology works through a low-voltage electric current that's surrounded by salty ocean water. This electric current electrifies the rebar, and it causes dissolved materials ions to crystallize. Wave generators are used to provide the low voltage that sparks the calcification process.[59] A negative charge is run through the cell form, and a positive charge, connected to anodes 7, 10, and 15 arrayed, forming a galvanized cell.

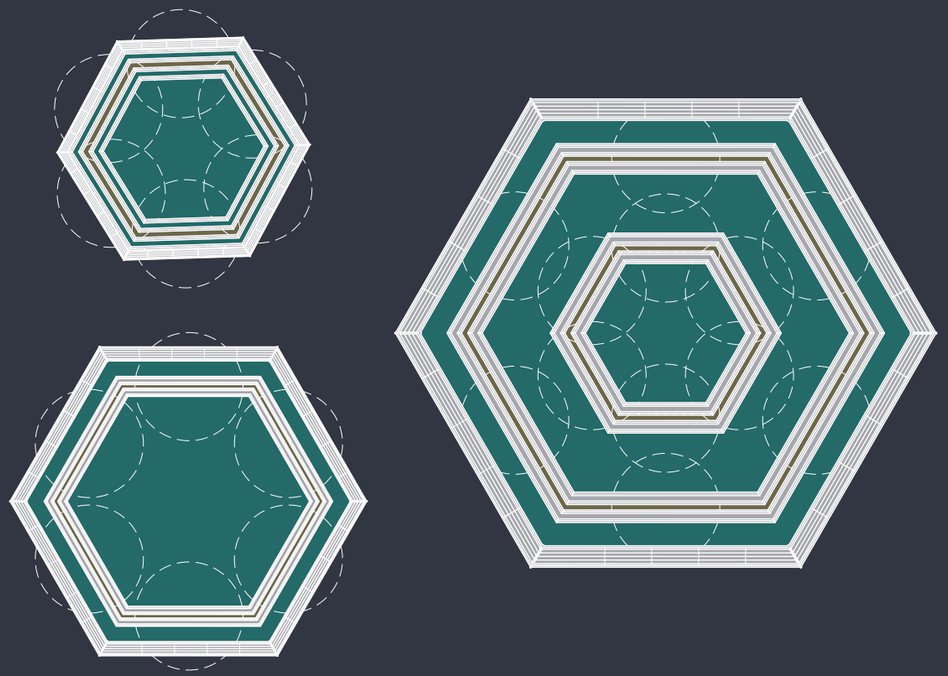


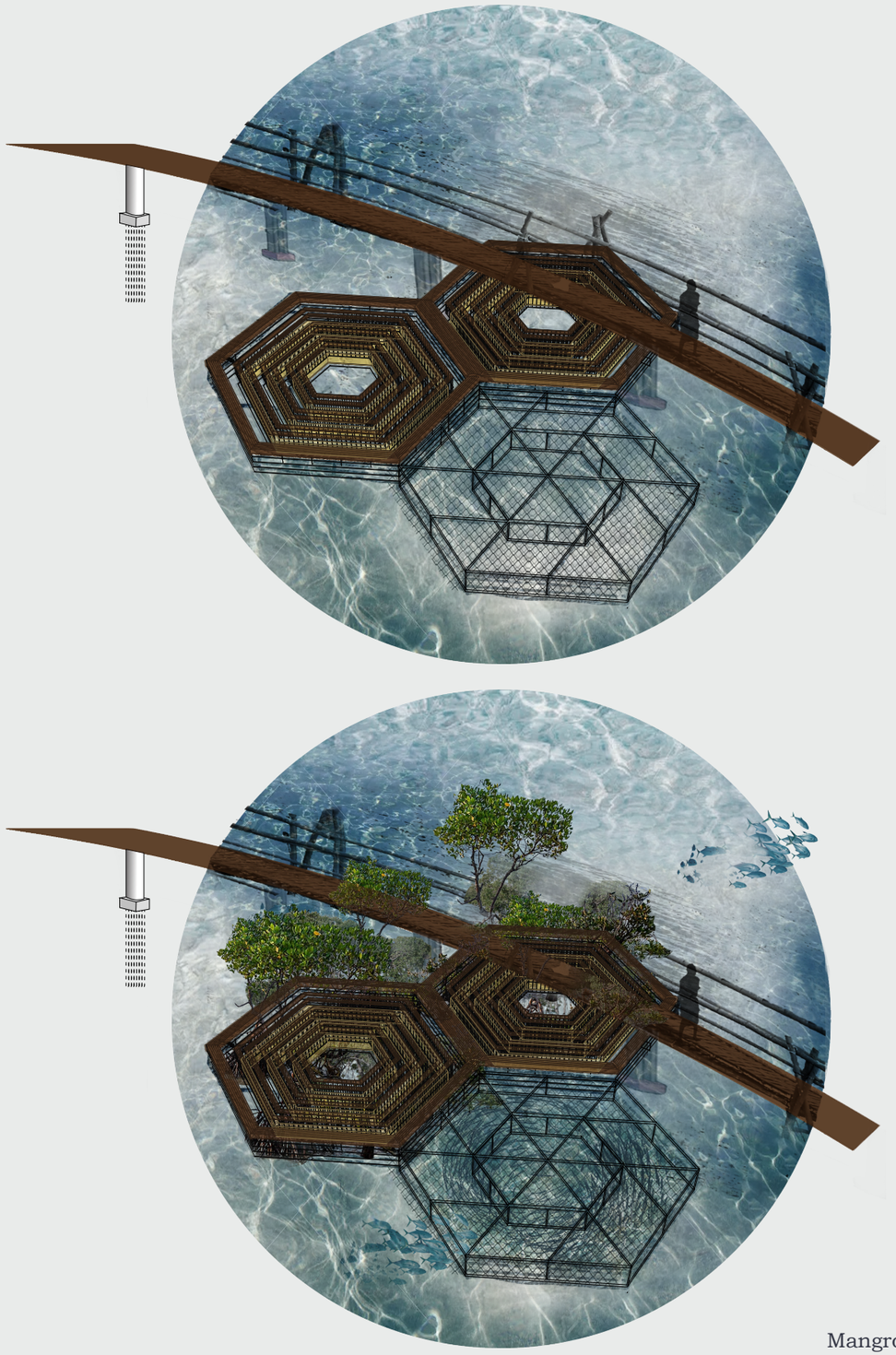
59 Sabaterr, Marlowe G., and Helen T. Yap . "Long-Term Effects of Induced Mineral Accretion on Growth, Survival and Corallite Properties of Porites Cylindrica Dana." Journal of Experimental Marine Biology and Ecology, 3 Aug. 2004.



MANGROVE CELL PODS | VARIATION

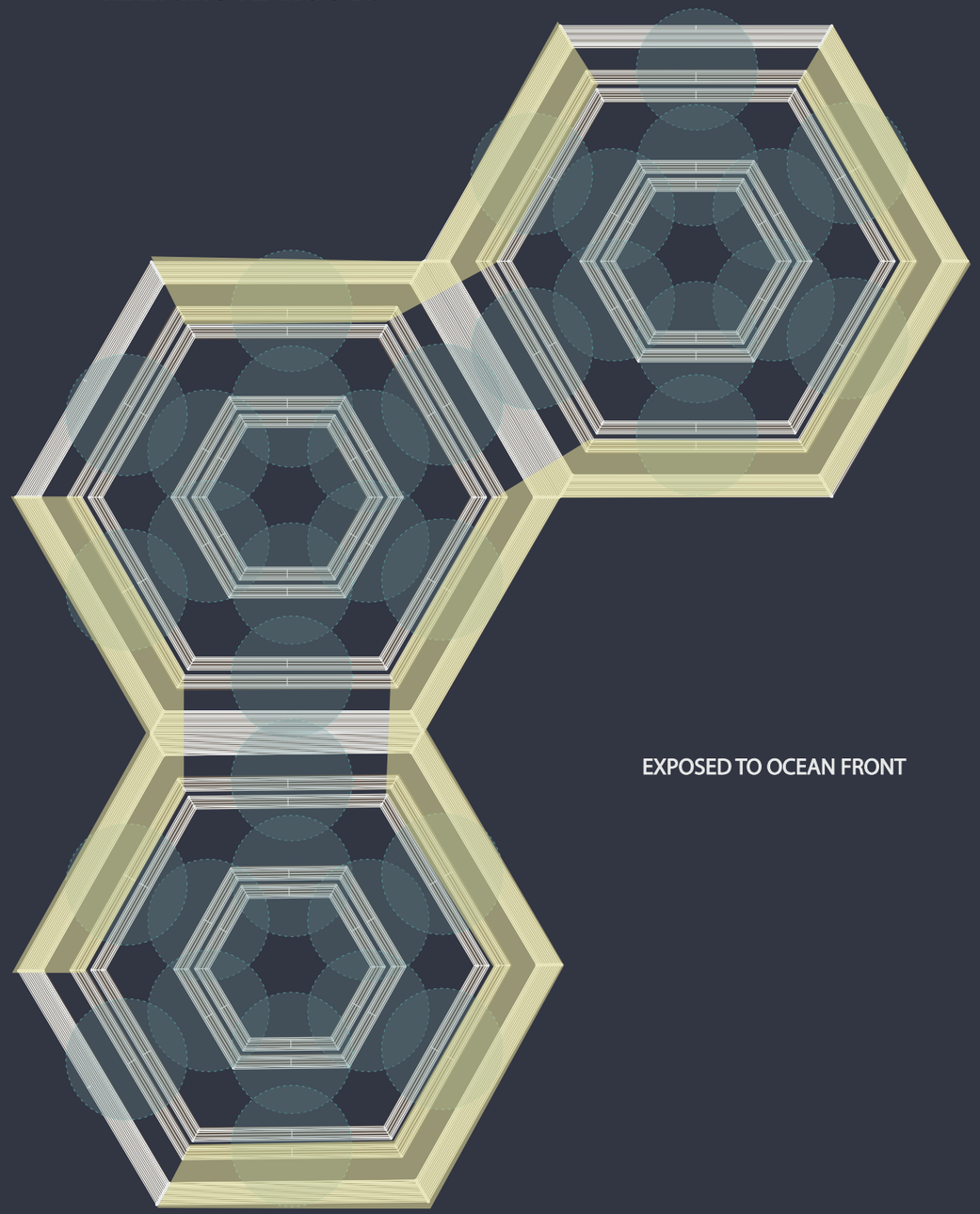
Mineral accreted cells undergo an instant change in the accretion process, attached right after assembly. However, the mangrove cells undergo a period of 7 months of accretion, resulting in a thin coating of biorock speeding the accretion process and protecting the cells from the chaotic intertidal ecosystem. Post voltage accretion, the calcification process continues its natural path of crystallizing. Calcium bicarbonate and Magnesium Hydroxide that resides in seawater react to the voltage ignited on the cells and crystallize to form biorock, a similar composition to coral reefs today laced once calcification is formed in bio-luminous algae, an aquatic magnet to aquatic life drawing them in.





Mangrove Cells

MANGROVE ROOTS



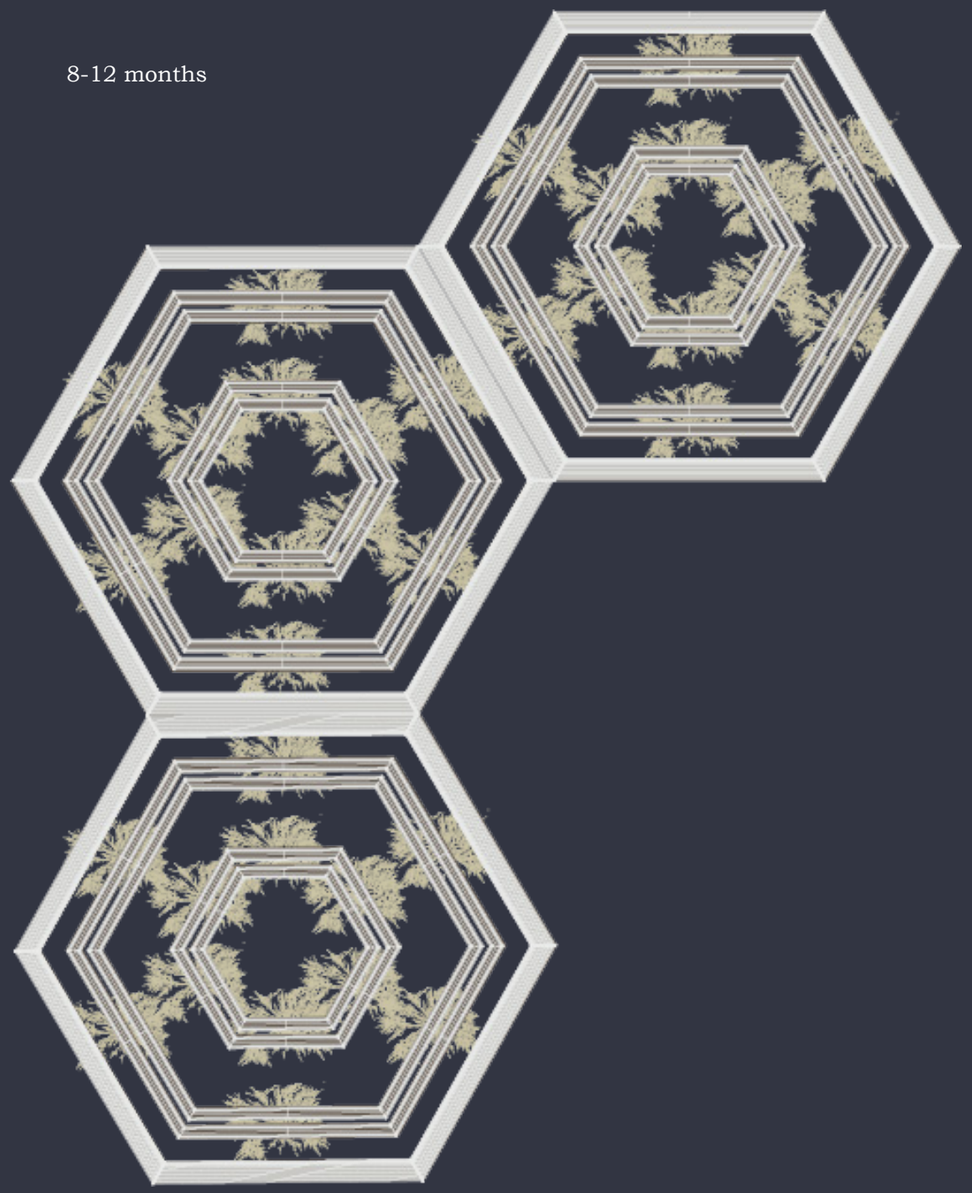
EXPOSED TO OCEAN FRONT

Mangrove roots transfer nutrients in a variety of ways. One important way is through the process of intertidal sedimentation, which occurs when sediment, such as mud and sand, is deposited in the intertidal zone, the area between the high and low tide marks. Mangrove roots are able to extract nutrients, such as nitrogen and phosphorus, from this sediment as it is deposited. Additionally, mangrove roots can extract nutrients directly from the water, and they can also extract nutrients from the air through the process of aerial respiration.

When mangrove roots are connected underwater, they create a strong lattice structure system that is rooted into the sand soils. This is because the roots of mangroves are able to penetrate deep into the substrate, such as sandy soils, and they are able to spread out laterally, forming a dense web of roots. This creates a strong and stable structure that is able to withstand the forces of waves and currents. The roots also create an intricate network of channels and pores that allows water and sediment to flow through, further reducing erosion and helping to stabilize the shoreline.

MANGROVE ROOTS

8-12 months

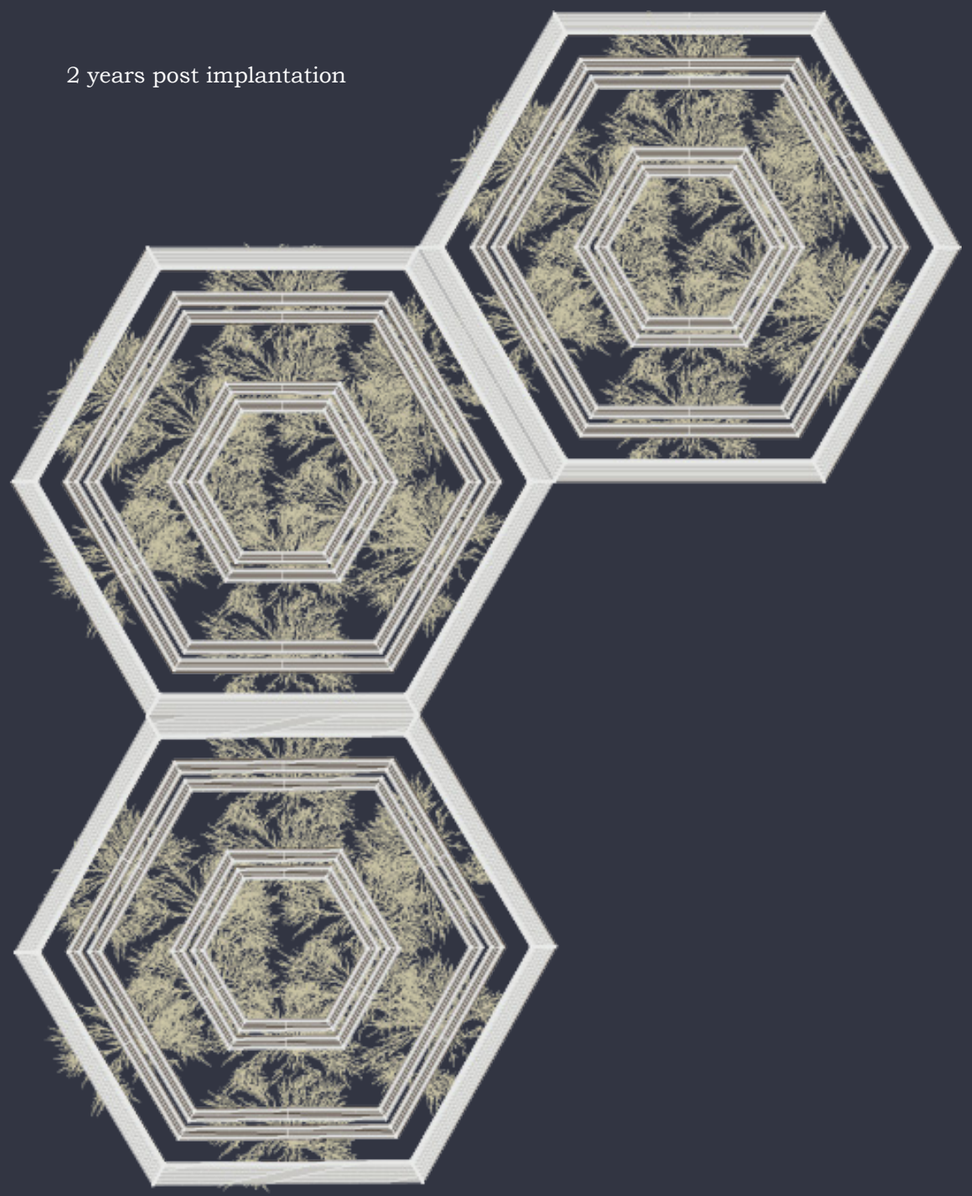


Design

Root Lattice Render

MANGROVE ROOTS

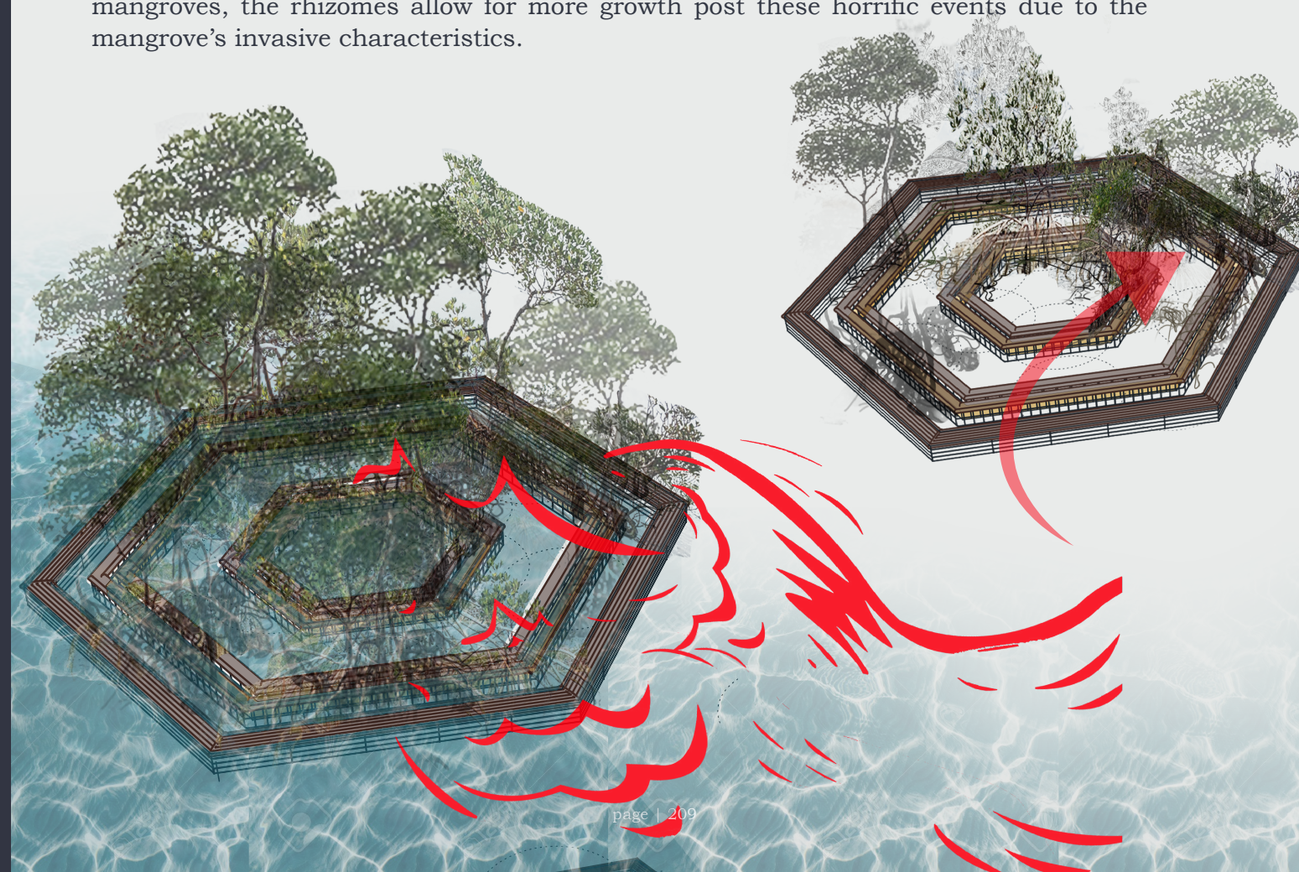
2 years post implantation



CELL STORM DEATH | REACTION

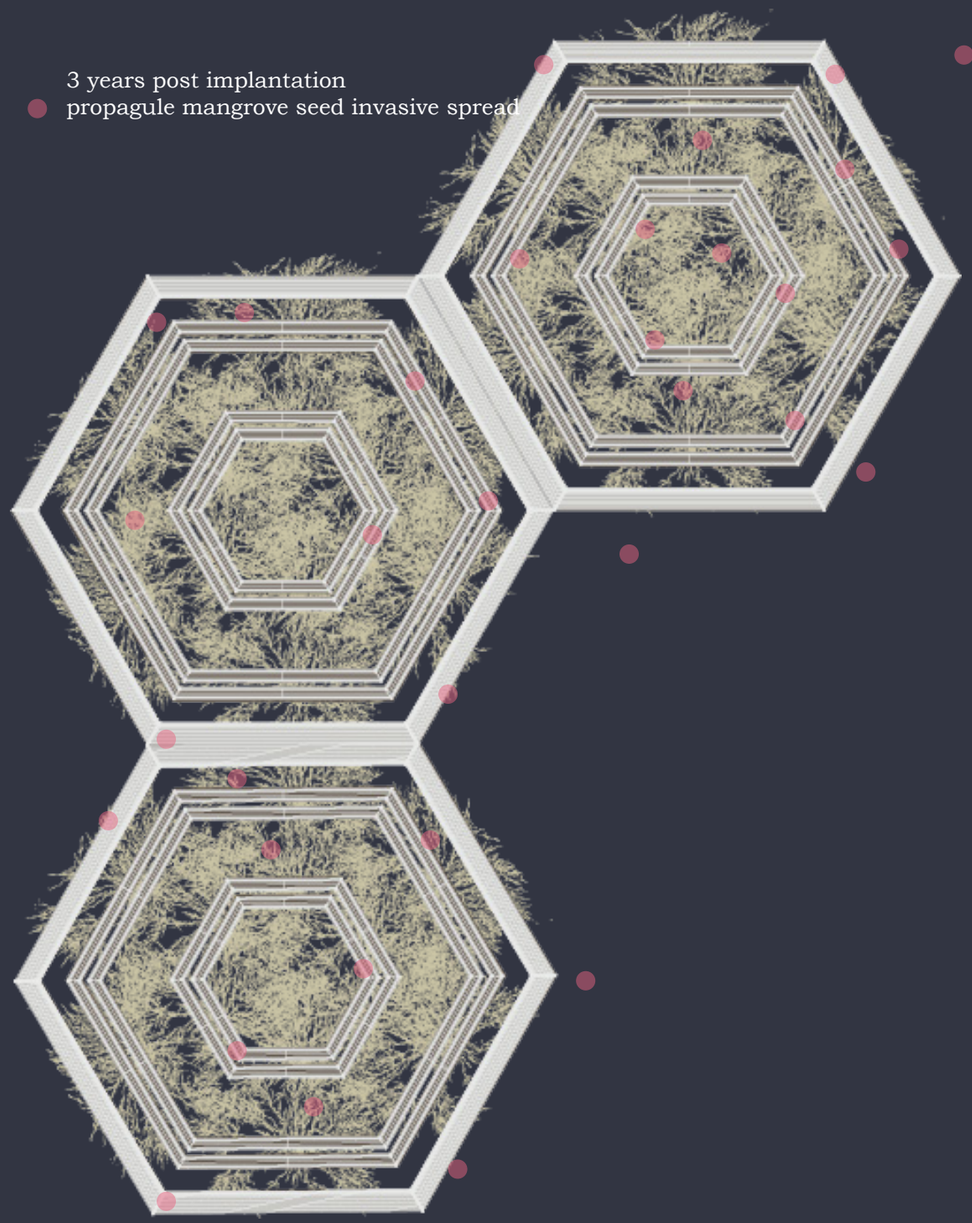
Cell variation reflects in the exact location of the placement of the mangrove cells. In addition, areas of increased exposure to storms require a greater density of mangroves to interlace into one organism to withstand extreme climate events. Understanding that climate impact has exponentially exposed the brute of ocean-drawn tempests into the island, these forces of nature are unbinding at times when not all mangroves will survive these natural forces. Mangrove cell density increase near coastal zones, accumulating more sand debris under the water while aiding in the aquaculture within the liminal zone. Pinning the cells into the seafloor, utilizing low tek technology, momentarily grounded by the limestone barrier. However, due to the ocean's alkalinity, the water slowly erodes the limestone creating pockets and holes within the wall. These moments allow the rhizomes to spread across the ocean floor, following its caged pathway. Additionally, the structure the mangrove mineral accretion cells are structured on creates an opportunity for electroforming. Finally, running a low current through the mangrove roots fortifies the cell structure, aiding in a denser, more robust grown mangrove changing its molecular composition.

Fierce storms are unavoidable; this thesis aims to diffuse storms while understanding these events exist and can be dampened but not completely evoked. As storms destroy mangroves, the rhizomes allow for more growth post these horrific events due to the mangrove's invasive characteristics.



MANGROVE ROOTS

3 years post implantation
propagule mangrove seed invasive spread

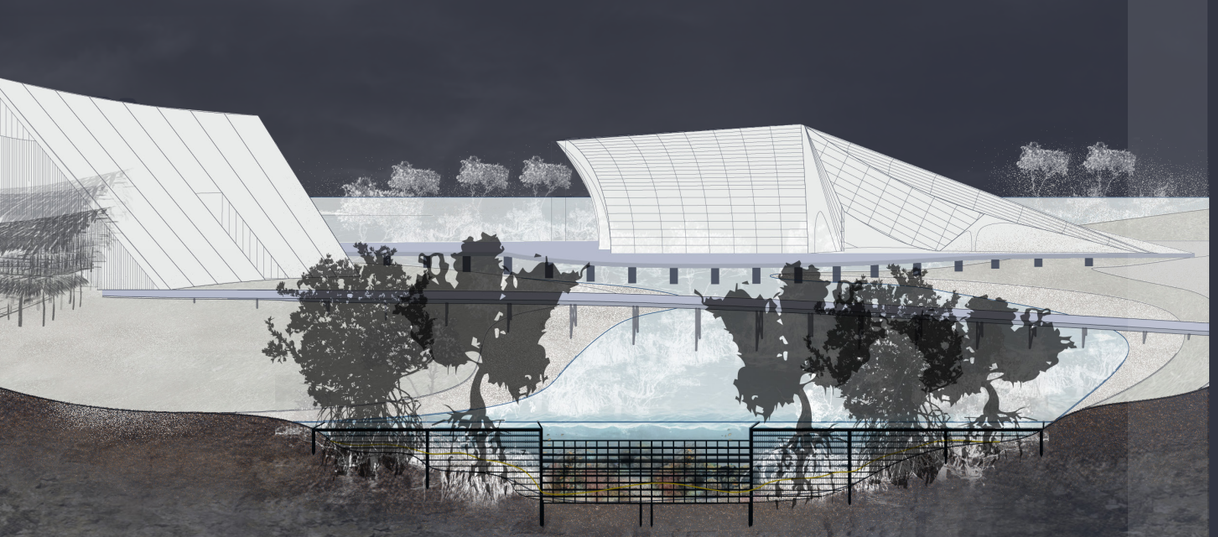


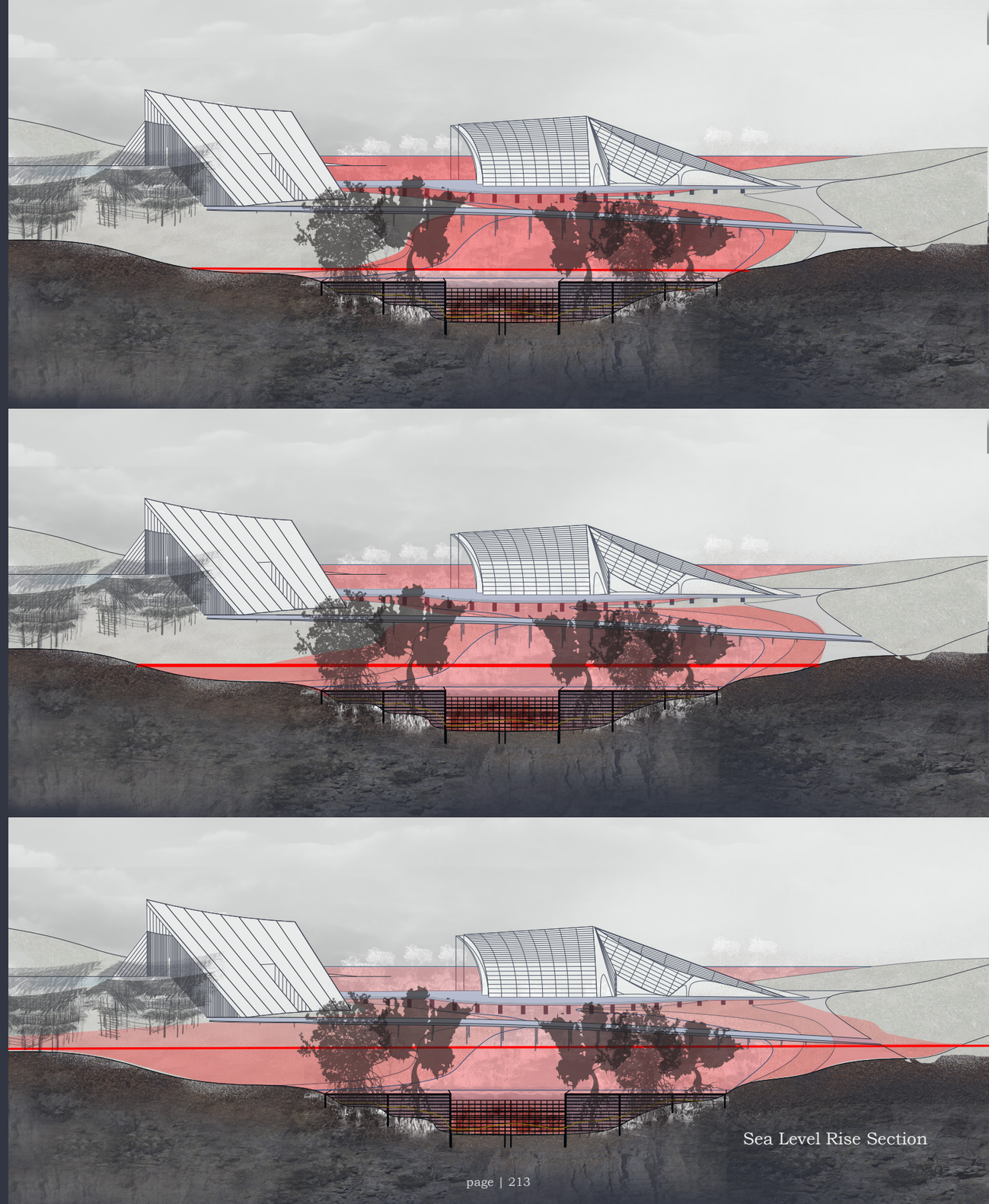


Root Lattice Render

ANTICIPATED SEA LEVEL RISE

Year 2050 Sea level rise .32 m - .45 m	avg .385m
Year 2100 Sea level rise 1 m - 2 m	avg 1.5m
Year 2150 Sea level rise 1.9 m - 3.7m	avg 2.8m





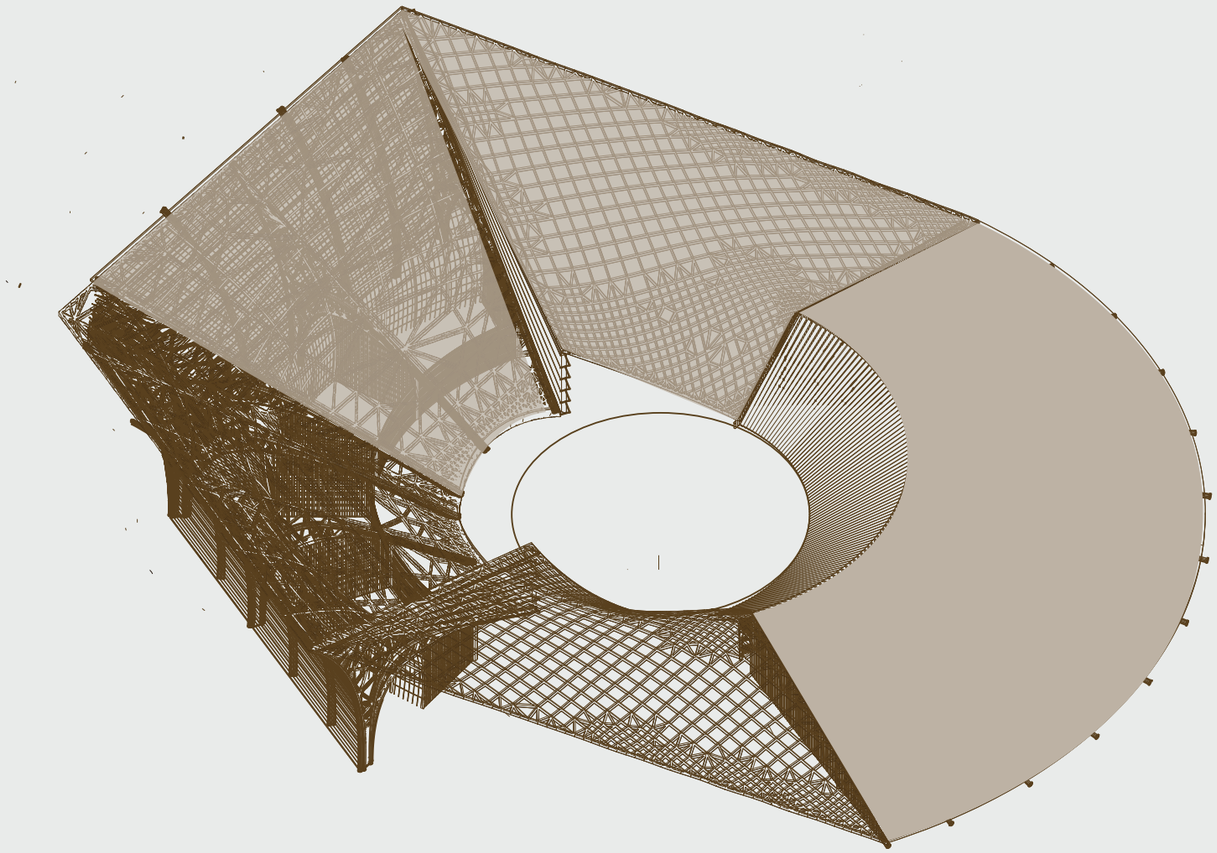
Sea Level Rise Section

BUILDING

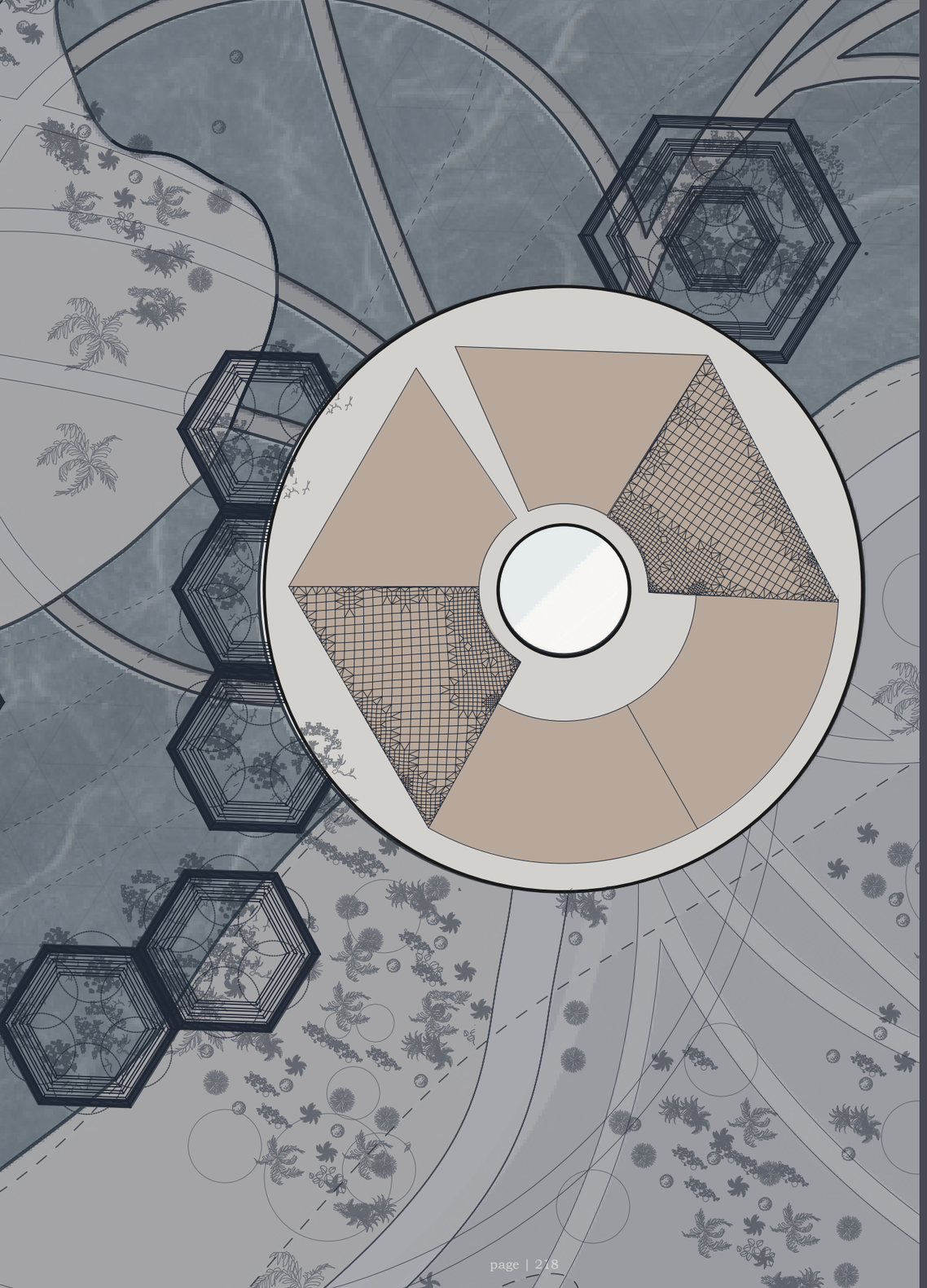
SITE PROGRAM
Bamboo Treatment and drying
Mangrove Workroom
- BooPod generation
- Seedling plantation
- Mangrove Nursery

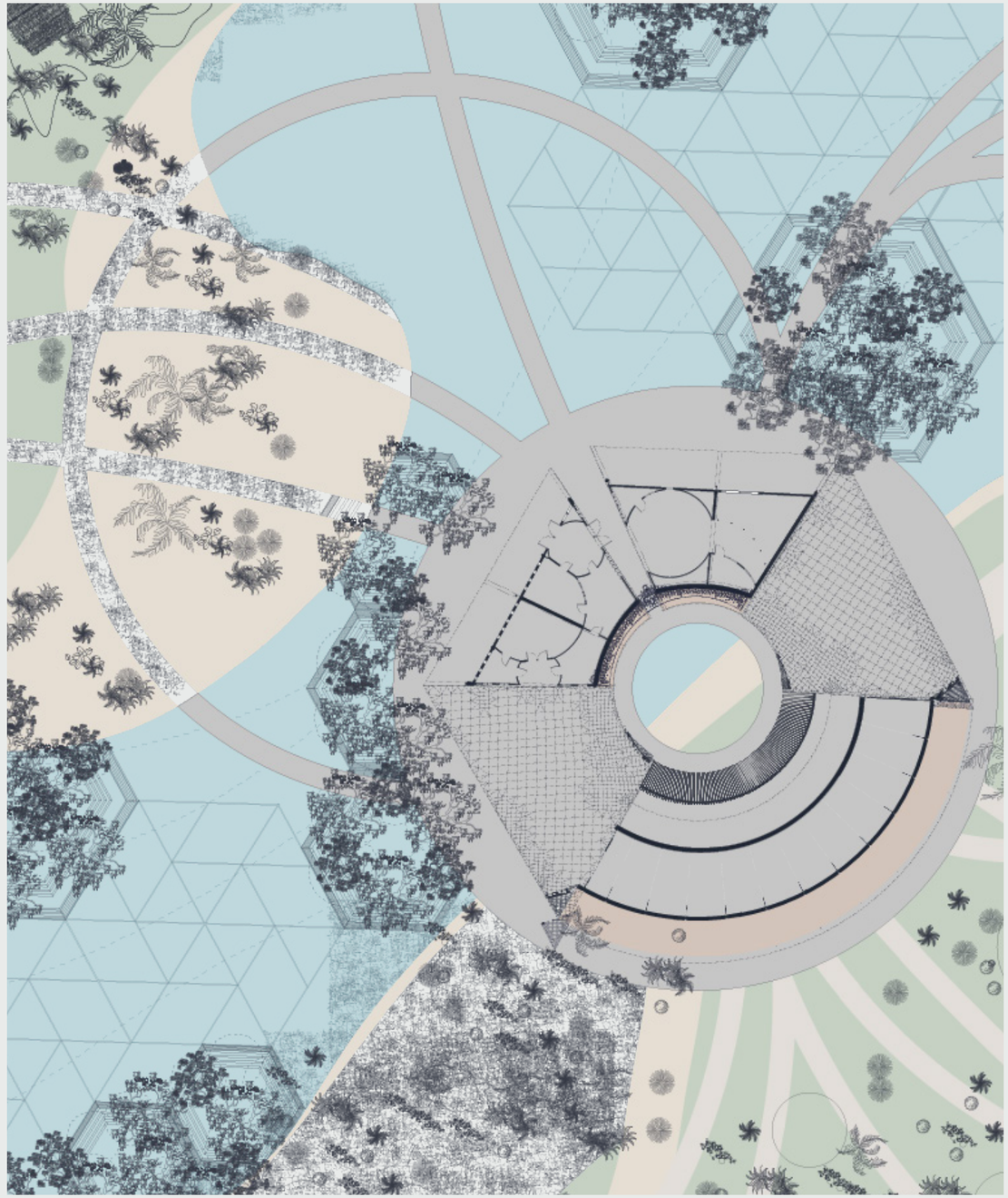
Climate monitoring office
Construction Workshop
- Mineral accretion pods
- Coral rehabilitation tanks
- Thatched roof weaving
- Vine weaving

Back of house
Kitchen
Bathrooms
Open cultural space



Design Axo





Ground Floor Plan

REGENERATIVE FOCUS

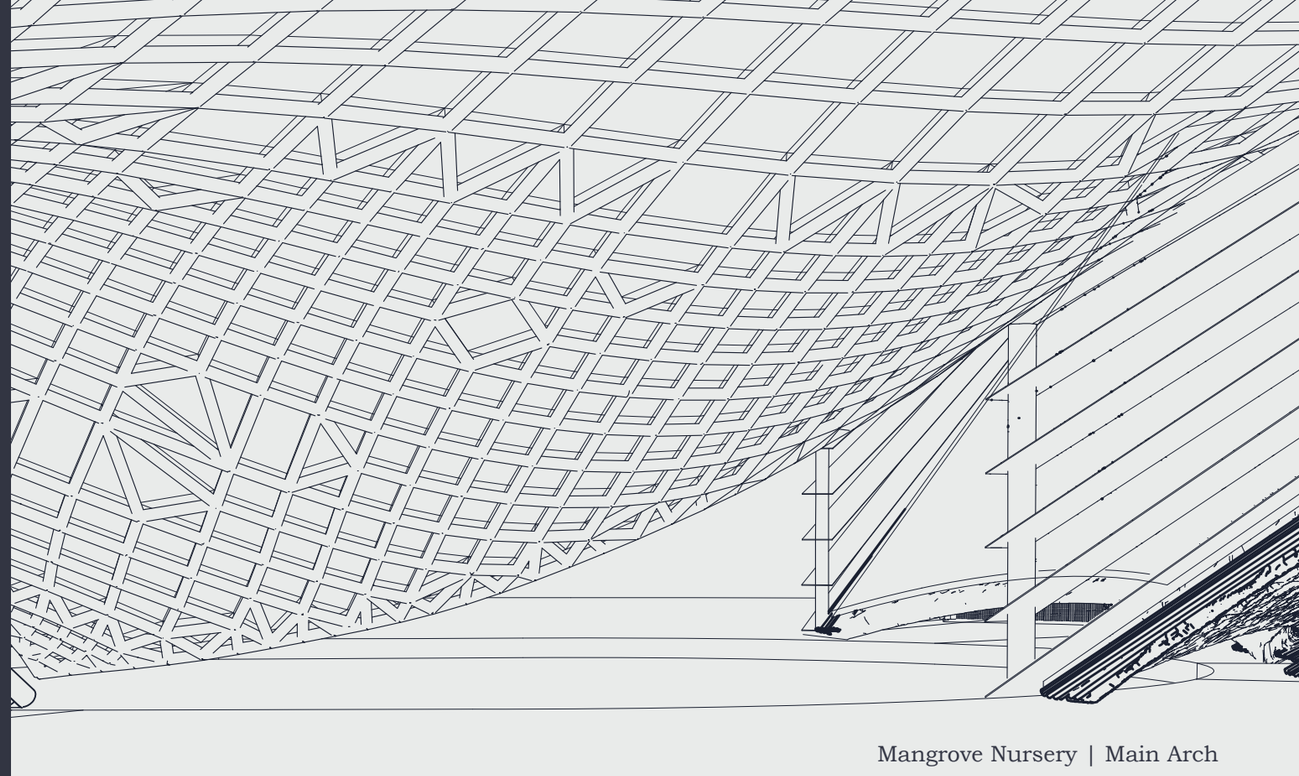
The ocean's ontology isn't just a collection of the past but a living source of life in the present. It is a fertile environment between time, space, and motion. Yet, unpacking the ocean's ontology is a thesis of its own. It is important to remember that water is a source of life and memories that breathes.

Repairing the riparian zone becomes borderline ignorant to ignore. Through coastal erosion, the chora has been encroaching towards urban settlements begging to be restored, and yet time and funding are spent elsewhere. This design draws from the physical obscurity of the shoreline created in moments of high tide, flooding, and natural disaster events. Moments of natural chaos will ground the design to thrive in the physical world, rooting itself firmly in a place where the reality of design unfolds during events of extreme disaster. The obscurity of the limen presents itself within the design - a living tartan grid that spreads across land and water, exploring three different fabrics elongates the phase of liminality;

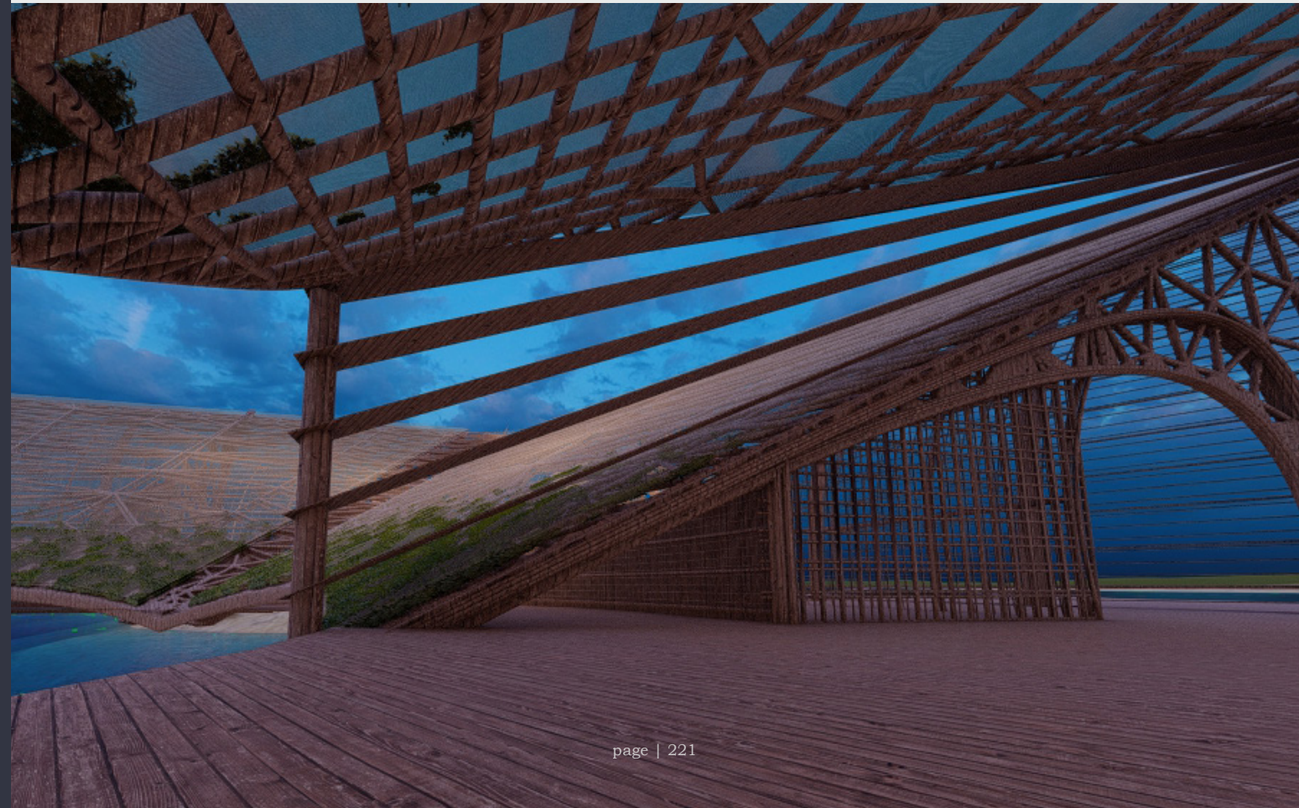
Living Organisms
Social Fabric
Economic Fabric

Where does the limen go-between flood?
Does land hit a liminal state?

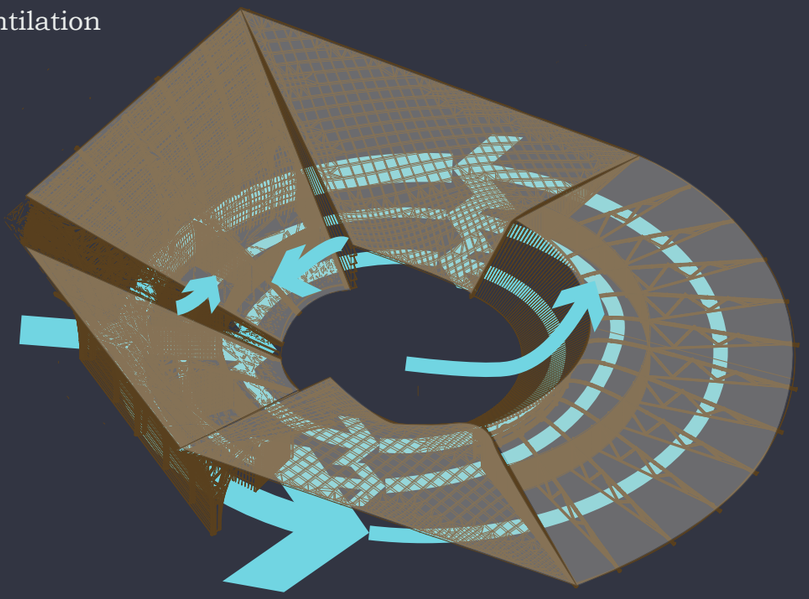
Transforming the land to hit a state of liminality where the design begins to float fluidly in and out of the conscious world. Designing those moments where the chaos in nature thrives allows this hypothesis to physically ground the design. The design exists in a state of unconsio9us reality, where it is stripped from that dream during natural disaster events and awakened by the non-forgiving brute presence of this world. Yet, the idea of fatalism has a significant presence in this research, where on the surface, many might question the purpose of design intervention in such an area; when the doctrine of fatalism is certain events are fated to happen, well, then I suggest one reads this collection of works from the beginning again.



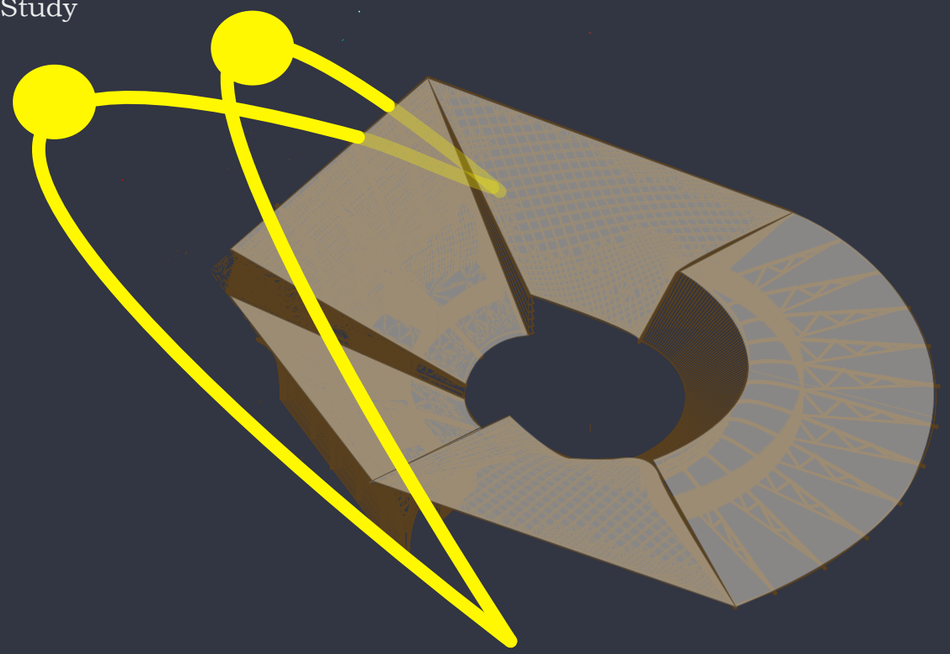
Mangrove Nursery | Main Arch



Wind | Ventilation

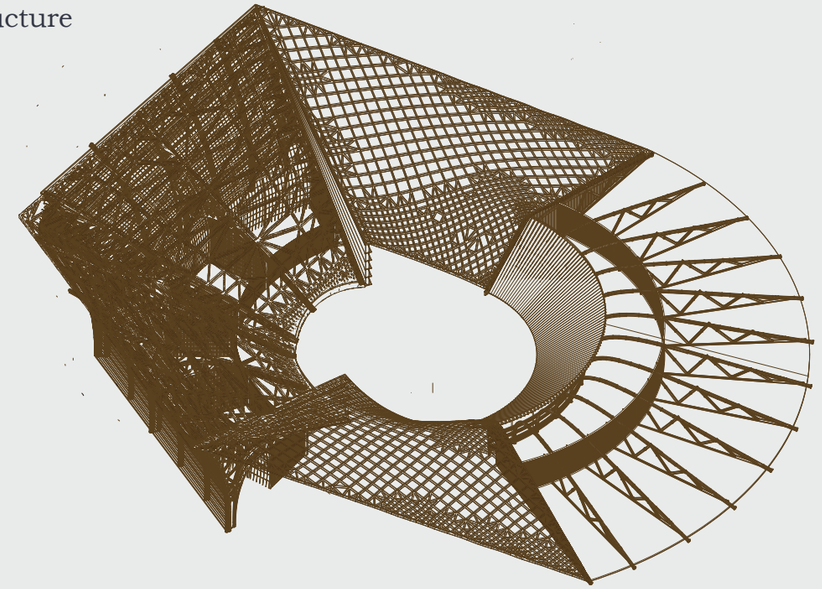


Solar Study

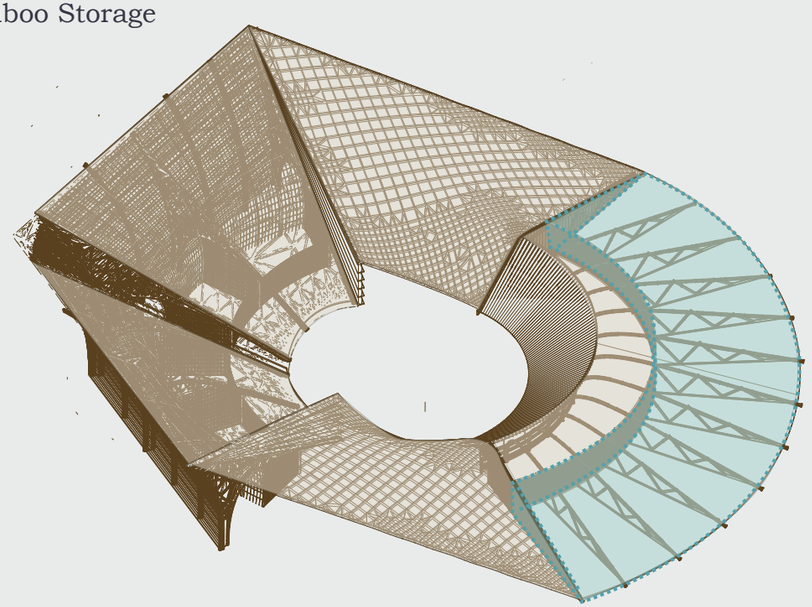


Design

Structure



Bamboo Storage



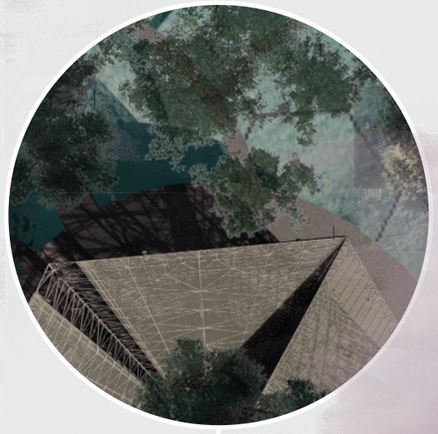


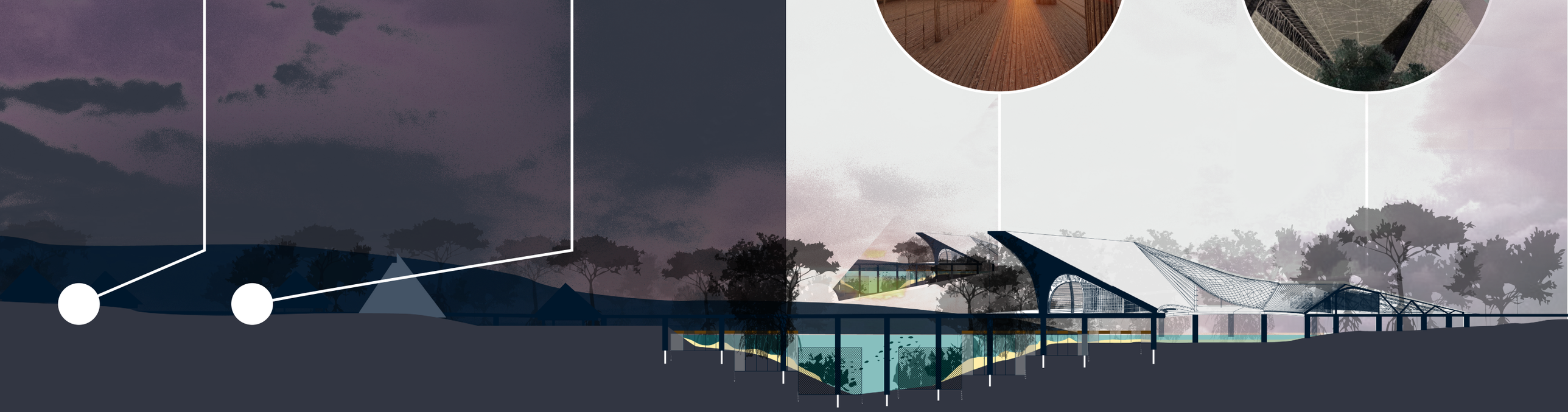


BOAT HOUSE

The structural form of the boat house is to diffuse surges from the south while allowing for internal access and storage for the boats used during the village's fishing season. The boat house is additionally used as a drying building where the islanders can dry their materials, meats, and any vegetation that requires drying. The boat house is opening on the north to allow for natural light and ventilation to keep the structure and boats dry, protecting against mold build-up. The bamboo is treated in the main building through saltwater treatment before construction.







entrance structure



arches structure



CONSTRUCTION PROCESS

Clearing of site location

Harvesting of structural building and rehabilitation materials _ Bamboo & Limestone

Outer structure build for protection and cover

Water and Drying treatment two month submersion of bamboo
(increase structural integrity)
Salination treatment structurally minimizes cracks, decay, fungus and
insect control to structurally chemically processing the bamboo strength

Construction of Rehabilitation Center

Columns
Platform
Structural Arches
Structural Trusses
Thatched Roof
Bamboo Screen | wall partitions
Water Collection
Vined Arches

Bamboo harvesting for BooPods

Phase one mineral accretion pods framing installation

BooPods prototype assembly

BooPods Plantation

Coral Harvesting

Village hut rearrangement and elevated

Boat house development

Plantation of Coral , Biolomiere and continuous BooPod Plantation



Root Lattice Render



Thatched Bamboo Roof

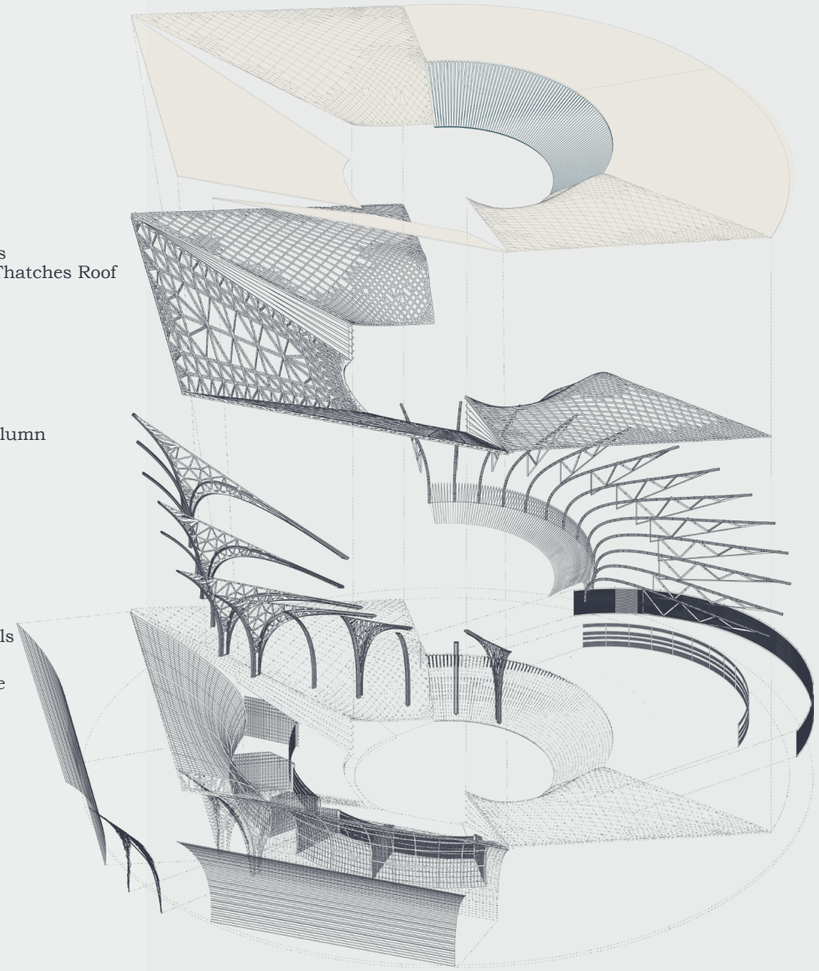
Cross Brace Bamboo Supports
Woven Roots and Vines with Thatches Roof

Bamboo Structural Arches Column

Bamboo Woven Screens
Interior Bamboo Partition Walls

Bamboo Woven Curved Lattice

Tension Structural Cable
Arched Vines Entryway



Structural Assembly

RECLAIMING CULTURAL IDENTITY

Through an adaptive program, structurally and programmatically, the architecture adapts to a program that begins to reflect the cultural and social needs of the islanders. Reclaiming cultural roots and identity starts to root itself in the design. Where telling a story of using rehabilitation as a structural anchor during cultural events. Creating a focal point on the island where the islanders reclaim their cultural events imbricated with existing ecological systems. Tying the diving tower's roots to the center's structural frame becomes the foundation resisting the pull of gravity. Rehabilitation aids not only the liminal zone around the design but the structure itself. Where the natural ecological systems begin to expand in a chaotic invasive manner, starting to interlace the design into one symbiotic organism -

Restoring identity, environmental and aquatic systems

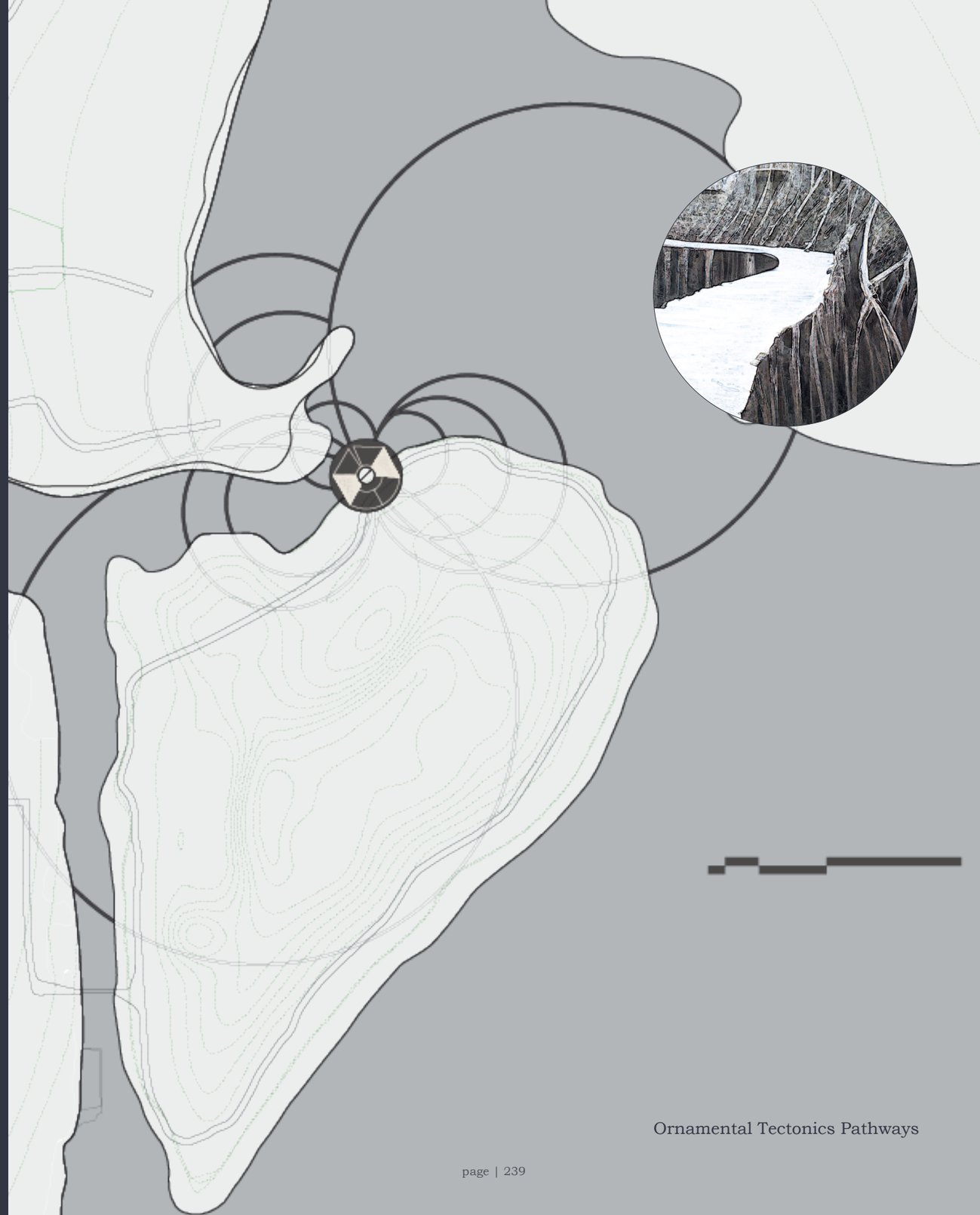
Ornamental Tectonics

ORNAMENTAL TECTONICS DRAWN THROUGH SANDROINGS



Design

Ornamental Tectonics



Ornamental Tectonics Pathways

ORNAMENTAL TECTONICS DRAWN THROUGH SANDROINGS

Sand drawings in Efate, Vanuatu pose unique patterns for construction because they are a form of temporary and ephemeral art. The many layers of sand drawings in Efate, Vanuatu, go beyond just the visual representation of the artwork. These layers include the cultural, social and spiritual significance of the art for the local communities. The sand drawings are an expression of the islanders cultural heritage, stories, and beliefs. These layers also include the use of natural materials, the process of creating the art, and the cultural significance of the location where the art is created.

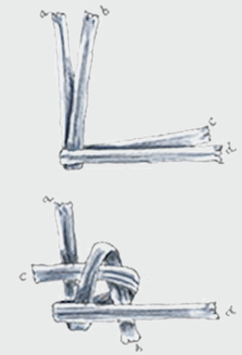
In terms of construction, these unique patterns could be used as inspiration for sustainable, resilient and contextually responsive design. The use of natural materials, the impermanence and adaptability of the art, and the cultural significance of the location could all be incorporated into the design of structures and landscapes in the coastal zone.

It is important to note that any use of sand drawings as inspiration for construction, should be done with respect and in collaboration with the indigenous communities, thus becoming inspired and translating the many layers of design sand drawings encompass translate into the many layers of structure within this theses, striving to make a statement where structure is beautiful and structure should be designed as delicate and throughout as the rest of the project.



Ornamental Tectonics Structure









Ornamental Tectonics Weaving Natural Forms



1



2



Intersection of Structural Components

AN ISLAND POEM | by author

On efate where the sand meets the sea,

A story unfolds, for all the worlds eyes to sea,

Layers of culture, spiriting and lore,

Etched in patterns on the sand, washed away, forever more.

Beyond mere beauty these drawings old, the island a secret treasure beginning to unfold. A canvas for the people of stories untold.

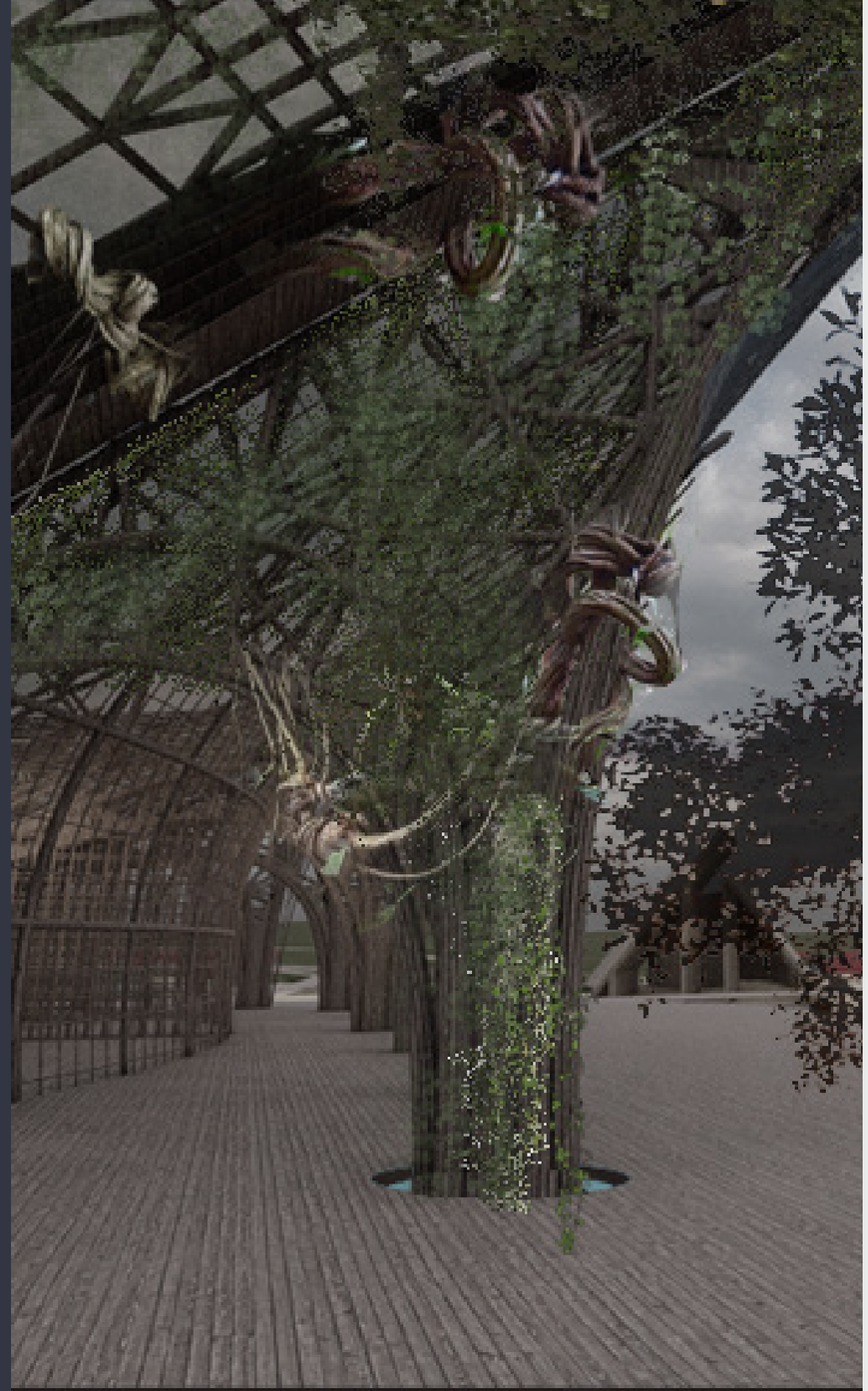
Stories of heritage, beliefs, and order. A treasure, a history of timeless grace.

Drawing energy from the sands, these patterns inspire, designs that are sustainable, adaptable, and designed for a higher space.

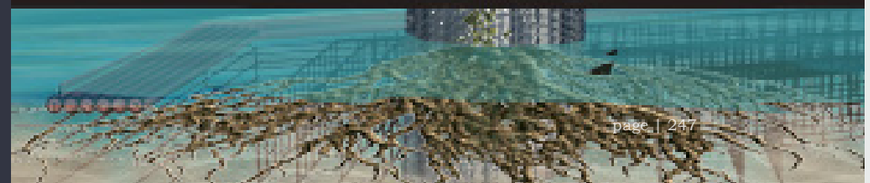
Combining natural materials, force, and culture; structures become both beautiful and bold.

As we design and forge new paths, it is important to collaborate with respect and empathy,

For indigenous communities, hold the key, beginning to unfold structures, that are truly free.



Ornamental structure layer











Connectivity pathways

Below tidal zone - mangrove root lattice

Understanding that the earth is ever-changing becomes a force in the design. But can that translate into an ever-changing and growing structure? Low Tek Bioarchitecture has allowed for explorations in moments where architecture and living systems interweave, evolving into a symbiotic subatomic design.

Where desinging for increaded opportunity for genedtic diversity is the key concept to adaptation; as we have seen, natures genetics in the current state cannot keep up with the pollution being dumped into every atom in this world. This ecological utopian promotes genetic diversity that will strengthen the cells, coastline and the species living within the design borders. Through reconciliation by design the islanders become a focal in reclaiming their identity through the rehabilitation of the coast, where the islanders will begin to reconnect with their land and water, and the design intervention will fortify their identity, soils, and ecosystems.

Reactive Adaptation

Thus far, the vulnerability the island is susceptible to is rather evident; the focal point in the design has been centralized be on the coastal zones, studying a lattice that binds the people, earth, and water. This design is a living system that reacts directly to climate-induced vulnerabilities, layered with functional space that allows for a design with living memories embedded within, functional meets mythological, which develops into an iconographic design typology.

The desire to keep the design purely natural materials was great. Though grappling with understanding the brute force in nature, I concluded that the climate impact is beyond nature's capabilities to restabilize. Thus a hybrid design of sculpted construction pins and low tek design.

Focusing on the liminal space that bridges the world between architecture and nature continues to be an ceaseless problem to explore, yet beginning to tackle small moments in a larger scale roots the prject. Where the limen becomes blurred, experimenting with the human desire for liminality. Theories that bend the norms between reality and illusion, translating themselves into the proposed design, extruding architectural elements into the chora, blurring the edge of nature. This translation into reality is developed through a frame that allows nature to imbricate (network) within itself. Architecture becomes the bridge that links nature with the world. The shoreline meets the oceans abruptly, causing a moment of tension between 2 sublimely different worlds. We see that edge between both worlds obscured during events of extreme natural disasters. This thesis explores the relationship between terrestrial and aquatic life, creating a moment where a detente relationship manifolds itself into a design that brings three separated worlds together into one; aquatic, terrestrial, and humanity. Restoring these ecological systems creates moments of interaction between islanders and elements within their mythological beliefs, allowing for moments of reconciliation to grow as the design strengthens over time.

Diving deeper into this new world, the threshold beyond the physical nature becomes a moment of conflict, where the memories contained in the land and water collide, creating a moment of tension between spirit and nature. Each state branched from a section of metaphysics is forced to confront the effect they cause on individual ecosystems. How does the water feel to be a cause of such destruction when it brings so much life into this world? Where the aquatic world becomes the lifesource for this design.

> *"Water is a medium that is largely not understood by physics and chemistry. Its material nature is tested, studied and understood by physics. However, beyond its physical and chemical qualities also memory and information play a significant role in water, and these build a bridge from the immaterial to the material world. These subtle phenomena are the ground of misunderstanding, and they can neither be studied nor detected by traditional experimental methods.*
>
> *Typical patterns appear for each kind of water itself, depending on the ingredients and history of the water. External effects may overrule these patterns, e.g. things, which are laid in the water or electromagnetic frequencies or acoustic waves that oppose to the water. By the observed patterns, we realize that water has a particular kind of memorizing and storing information of things that it has experienced. From experiments, we can also see that living organisms, like plants, can "read" this information and act with a unique behavior to the information stored in the water."* [60]

60 Kröplin , Bernd, and Regine Henschel . Water and Its Memory - New Astonishing Insights in Water Research. 2017, World in a Drop, https://www.weltimtropfen.de/buch_english.html.

Design

While climate disasters have had extreme implications, we have read that those implications are not only on ecological systems but a cultural identity. The loss of identity and biodiversity will continue exponentially if severe climate disasters are not a design focus through ecological rehabilitation. Globalized infrastructure has had a damning effect on the planet, where accountability lies with the sectors of the world forging these globalized modernizations, not low embodied islands which are at the frontline of such brute climate change. The design focus should be the combination of low ecological technologies in a layered and harmonious design with architectural practices in a structure that responds to the site's environmental and cultural necessities.

The social structure of the design is sectioned on social and ecological sectors; farming, fishery, rehabilitation, construction, and culture.

The convergence of these social programs begins to tie biophysical programs into the islanders' daily lives, interlacing physical, ecological and spiritual programs in one centralized space. This thesis resulted in a utopian harmonization between people and nature and people's nature and architecture. Living low tek architecture begins to complement not only humans' need for a structure that can withstand extreme climate impacts but ecological restoration, where the island's biodiversity can not last or withstand the rate of our changing planet. designing a lattice with multi-performance capabilities, this thesis aims to restore that lost harmony and identity severed by climate disasters the Ni-Vanuatu face through low technological regenerative design.

Low technological cellular grid repetition across the coast draws the extent of the design's rehabilitation potential. The strategy of low-scale environmental multipliers begins to invade to protect and restore coastlines. This design repetition triggers an invasive growth along the island coast. Stimulating such ecological spreads increases the island's biodiversity, increasing resilience. These long imbrications of dense mangrove forests become cluster organisms used to protect and diffuse the island's liminal zone, blurring the sharp edge between land and water harmonizing the islanders with their ancestral pasts, and restoring identity through the rehabilitation of the land.

intention



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13 Prospects and constraints of post cyclone housing reconstruction in Vanuatu PDF

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AN ISLAND POEM | Iva Mema

On efate where the sand meets the sea,

A story unfolds, for all the worlds eyes to sea,

Layers of culture, spiriting and lore,

Etched in patterns on the sand, washed away, forever more.

Beyond mere beauty these drawings old, the island a secret treasure beginning to unfold. A canvas for the people of stories untold.

Stories of heritage, beliefs, and order. A treasure, a history of timeless grace.

Drawing energy from the sands, these patterns inspire, designs that are sustainable, adaptable, and designed for a higher space.

Combining natural materials, force, and culture; structures become both beautiful and bold.

As we design and forge new paths, it is important to collaborate with respect and empathy,

For indigenous communities, hold the key, beginning to unfold structures, that are truly free.