Te Makeke Ao Rii Vaka kite Wale/Whare/Fale/Hale/Are
The Binding Strength of the Vaka to the House
Indigenous Māori Architecture – from Pukapuka and Rarotonga, Te Moana Nui o Kiva

Sustainable Resilient Futures: Unearthing Indigenous Maori Architecture from the Cook Islands (Pukapuka and Rarotonga) Te Moana Nui o Kiva

Romani Katoa

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in fulfilment of the requirements for the degree of
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School of Art & Design
Auckland University of Technology

E lolominga no Ngake

Yitiki ki te uka mai lunga
E ati te wale, koa niniva
E tuki te peau koa nonoke
E kayiva te u ii te katea
E nokenoke, e vaka Lakawanga
Ke yaeatu te muavaka
E mapipipipi a na wainga
E uila mata takemo ake
E wakakekeyu ki te puapua tau konekone mai Lakawanga
E wakatau ai au tuta
Koa pu wa, koa pu lima
Pe te pu ui mai Lakawanga
Na weniti, koa makavokave
Te kalaka kula e, na pae mai ngake nei
Keukeu kou a e

Chant by Ngake (eastern village of Pukapuka)

Tie (the house, woman symbol) with sennit above
Thatch the house, (the sides are) sharp
The rough waves pound, it is splendid (firm)
The pearl shell lies on the starboard side (of the canoe, woman's symbol)
It is splendid, the canoe of Lakawanga
Let the front of the canoe be torn open
Wide open in the wainga (a word with a double meaning, ‘’making’’, and ‘’copulating’’)
Eyes of lightning flashing (and blinding me)
It looks fine (made) of puapua wood, spotted (wood) from Lakawanga
I fit on the joints, it has four holes, five holes
Like the pearl-shell hole in Lakawanga
Thick (the sennit, the pubic hair), it hangs in a fringe
The red kalaka seeds (vagina) drifted from the east
It is perfect, perfect

Te Tukinga Mua - Abstract

This research delves into the untapped wealth of traditional Māori architecture existing in Pukapuka, Cook Islands, addressing scarce historical records to revive traditional Māori building principles. With a focus on climate-resilient solutions, the study aims to bridge traditional knowledge with contemporary practices. Examining historical design principles and their evolution, the project engages directly with living 'Taunga' master builders passed down by 'father to son' and employs indigenous research methodologies to explore evolving design principles, cultural nuances, and structural efficiencies honed over thousands of years in the Moana Nui o Kiva.

Anchored in traditional oral pragmatism, the research seeks structural efficiency within Polynesia while delineating distinct influences within East Polynesia, connecting Pukapuka, and Rarotonga to Aotearoa. By blending historical perspectives with contemporary challenges, the project aims to pave the way for sustainable futures rooted in Māori architectural heritage.

The project incorporates 'Te Papa Tau' or 'The Solid Foundation,' building the platform through genealogical, traditional oral knowledge guided by the spiritual and natural world of 'Mana Tangata' and 'Mana Māori.' Repatriation efforts and synthesis of comparative understanding strive to maintain and enhance cultural and experiential knowledge, ensuring the preservation and adaptation of traditional techniques for future generations.

Why Pukapuka?

Pukapuka's unique location between West Polynesia and East Polynesia was the bridge way-point or 'bus stop' in the initial migrations during the Fiji-Tonga Tui Tonga empire expansion across Upolu to Tau and Manua with Pukapuka being the furthest motu. With the expansion of the Tui Tonga 500-1000 years later Pukapuka was used as the reference point (bus stop) to locations such as Manihiki, Rakahanga, Tongareva, in northern Cook Islands, Nuku Hiva, Hiva Oa in the Marquesus group, the Tuamotu group, Kiribati, onwards Hawaii, Huahine, Tuamotus, Raiatea, Rarotonga, Tahiti, Rapa iti and Rapa Nui. This calculated mind map of islands in our ancestors' minds of forever remembering where we were going and where we came from. Pukapuka was a bridge forgotten and is one key to unlocking the to its perserva. Its strategic location maintains its importance in the resistance to dramatic modernisation change.

'Kia mau, kia opu, e kia kite pakari i to tatou ao nei'

Figure 1: Yimu paiokiole, 7 braid

Papanga Tuanga Wowolo - Contents

Tataanga Kopapa - Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the Acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning

Signed……………………………………………………Date…………………………………………..

Wakauyunga Manako Atawai - Acknowledgements

Firstly, I would like to extend my deepest gratitude to my supervisor, Fleur Palmer, for her unwavering patience, mana, and guidance throughout this research journey. Your support and wisdom have been invaluable, encouraging me to persist even in moments of doubt. To Mark Orams, thank you for your guidance and insights, which have helped shape and refine this work.

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To the people of Pukapuka, I am forever grateful. Your knowledge, stories, and resilience have been the foundation of this research. This work is as much yours as it is mine. A big atawai wolo to the Ulu Aliki Wolo, Pepeu Aliki Makirai and High Council of Chiefs, the Mayor and Konitara for your continued support and maintaining the pathway for our traditional systems addressing matters of custom and

To my metua angai —Willie Katoa, your wisdom and teachings have been my guiding light, shaping not only this research but directding towards the world of the built environment and the way we see ourselves in it. Never lost in my thoughts and prayers, mama Molingi, papa Pareura and mama Tetiare. To Lesley, Pareura, and Pepai, thank you for simply being you, for keeping me grounded, and for always being my watu in the forever changing of tides of the ocean.

This journey has been one of re-remembering, reconnecting, and reclaiming. I stand on the knowledge of my ancestors, guided by the voices of those who have come before me. Meitaki ma'ata e kia manuia.

Te me mua, ko winangalo wua au ite velo tonu atu i toku wakayaunga manako ki te Matua Yaa, no ana maawutu, wanewane, peia te maloyi na maka pewu ina mai ki lunga iaku. Na lotokono ma te lololoku au ke wowou it e manatunga nei mai te taime na yanga ai au I lunga to tatou wenua I muli te ulia Martin ite 1998. Na manatu lai au ke onoono mai tai tuanga ke koikoi mai inaa mawutu ma na kite ote kau a tatou te maani wale. Te wii taunga takele ote vaia na ngangalo, eia na manatu mai ilelia au ke wetupu tai yanga ite tautulu te wenua no loto ite maani wale makemake no te ulia i Pukaouka nei ma Ongalewu (Nassau). Ko te manatunga wolo ke paletua ake inaa yanga wenua a te wui tupuna peia o taatou maatutua na naumate ai ke wotu wua te yulan ga o na maawutu o te wenua tangata nei, enei na mantua ai ke wowou ake ki loto nei ke waingataa ake it e kakai e te maka vave in a maawutu motu tawanga wua nei. Enei te maua nga e te tuku mai ki loto nei, peenei e wolo atu naa toe kiai na tukua mai ki loto.

Ko kave atu taku aka-atawai wolo ki te kau naa paletua mai it e wowou nga o te yanga nei, naa tukutuku mai i o laatou maawutu in aa konga waingataa iaaku; kia kotou e te Tuaine Williams, Coruse Neiao, Tewola Jack, Lotoika Tengere, Beniamina Williams, Rimapeni Paani, Teopenga Jnr Teopenga, Moko Dariu, Marurai Marurai, Afa Bahn Nooroto, peia ki te kau wowolo o te wenua. Na lava wua ikinei ke. Ke lilo na maawutu i loto nei wai paletua ia tatou noo naa vaaia ki mua.

Atawai wolo yee maneke!

Wakapapanga no te au Tutu - List of Figures

Wakapapanga Wakailo - List of Tables

Wakapapanga Wakailo Tautulu - List of Appendices

Yāyākinga - Introduction

This thesis has been more than an academic endeavour; it has been a homecoming, a journey of re-remembering, re-grounding, and reconnecting with the architectural wisdom that has always been embedded in my lineage. As a child, I would listen to my great-grandmother's stories—tales woven with the sound of the wind through pandanus thatch, the steady rhythm of hands lashing sennit around beams, and the unshakable knowledge that our homes were more than structures; they were living forms of protection, shaped by the environment, responding to the land, the sea, and the storms.

For much of my professional career in architecture and project management, I have worked within the frameworks of modern construction methodologies, often navigating the demands of Western engineering principles. Yet, the process of writing this thesis has reminded me why I chose this field in the first place. It has been a deeply transformative experience, forcing me to look back at ancestral blueprints that were always designed for resilience, sustainability, and survival. The ability to read the environment—to watch the shifting clouds, feel the wind patterns, and anticipate the ocean's response—was knowledge deeply ingrained in our ancestors, informing the way they built their homes, vaka (canoes), and marae (sacred spaces).

This knowledge is not lost; it has simply been obscured. In modern times, we have witnessed the consequences of neglecting Indigenous climate-responsive architecture. When Cyclone Martin struck Manihiki in 1997, it flattened nearly every modern house, but the few remaining traditional structures—elevated on platforms, flexibly lashed rather than rigidly fixed—stood their ground. This was not coincidence but centuries of environmental adaptation at work. Colonial interventions replaced flexible, storm-resistant architecture with rigid, Western-style houses that failed under extreme conditions. In moments like these, the urgency of reclaiming our architectural heritage is undeniable.

To date, there is minimal information provided recently or historically regarding the vernacular-built environment within the Northern and Southern Group islands of Rarotonga the Cook Islands (Smith, 2020)[1]. The Northern group is established as being the elder (tuakana) of the two outliers with Rarotonga being the younger (teina). Throughout the last 200 years since the arrival of Europeans and Missionaries, not much was conscribed detailed with the built environment, arts and craft and the culture of the Māori people (Wood, 1967)[2]. Although several artefacts and items of interest were sent back the London Missionary Society headquarters in England, very little was recorded until 75 years later. Oral and generational transfer of indigenous traditional knowledge of building structures and spatial arrangements was passed down through the male descendants as well as the knowledge of design and building of vakas, weapons, agriculture and everyday objects.

The island of Pukapuka, remains the last in the Cook Islands, where buildings are still constructed in the traditional manner (Smith, 2020)[1]. This suggests that Pukapuka may hold valuable insights into the indigenous design knowledge that was once prevalent throughout the region. In contrast, Rarotonga, the most recently discovered and colonized island, serves as a "petri-dish control" to understand how quickly traditional knowledge was destroyed and replaced with Western colonial design and architecture.

This study seeks to address several key questions: (Smith, 2020) (Boulton et al., 2021)[3].

1. What is the indigenous design knowledge of Pukapuka?
2. How and what of this knowledge got lost?
3. Have any of these indigenous design principles crossed over from Rarotonga to Aotearoa?
4. What can be done to regain and incorporate this old knowledge for future generations? (i.e., building a replica, writing this thesis, repatriation)]
5. How does Māori indigenous architecture hold climate resilient solutions for modern building and design in the Moana Nui o Kiva?

Embracing Traditional Practices and Validating Indigenous Knowledge: An Indigenous Autoethnography of Architectural Adaptation and Resilience in the Cook Islands

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[1] Smith, H. (2020, January 1). Collaborative Strategies for Re-Enhancing Hapū Connections to Lands and Making Changes with Our Climate. University of Hawaii Press, 32(1), 21-46. https://doi.org/10.1353/cp.2020.0002

[2] Wood, B L. (1967, December 1). Geology of the Cook Islands. Taylor & Francis, 10(6), 1429-1445. https://doi.org/10.1080/00288306.1967.10423227

[3] Boulton, A., Allport, T., Kaiwai, H., Potaka-Osborne, G., & Harker, R. (2021, April 30). E hoki mai nei ki te ūkaipō—Return to Your Place of Spiritual and Physical Nourishment. Multidisciplinary Digital Publishing Institute, 5(2), 45-45. https://doi.org/10.3390/genealogy5020045

The current research explores the realm of Indigenous Autoethnography, focusing on the traditional practices and indigenous knowledge within the island of Pukapuka in the northern Cook Islands. The broader context of this study encompasses the architectural adaptation and resilience to climate change and the geographic environments within Pukapuka. Pukapuka stands out as the sole island in the Cook Islands that continues to construct buildings in the traditional manner, a practice that was once discouraged under New Zealand's Raupo Houses Ordinance Act 1842, similar to the challenges faced by Māori architecture in Aotearoa.(Rinehart, E, R., 2018)[4]

This research aims to establish a baseline of indigenous Māori architecture from the Cook Islands to Aotearoa, and consider the potential application of Māori indigenous architecture and artificial intelligence to climate-resilient solutions for modern building and design in the Pacific.(Brown, D., 2002)[5]

It considers how Indigenous principles of sustainability—from the passive cooling systems of open-air thatched homes to lashing techniques that flex instead of fracture in storms—can inform contemporary climate-resilient architecture.

Equally important is the recognition of the validity of mātauranga Māori (Māori knowledge) and the need to attend to creative ways that kaiāwhina (caregivers) rework this knowledge to inform their capacity to provide healing contexts and interventions for tamaiti atawhai.(Tupaea, M., Grice, L, J. and Smith, F., 2022)[6]

The historical treatments of various Indigenous peoples continue to impact the form and tenor of critical Indigenous research, emphasizing the importance of respect, reciprocal respect, and cooperative behavior in Pan-Pacific Indigenous research.(Rinehart, E, R., 2018).

My own upbringing in the Northern Group islands of the Cook Islands has deeply embedded within me the rhythms of the ocean and the language of the winds, especially as they manifest in the architectural forms of our thatched roofs. My lineage extends across the vast expanse of Te Moana Nui o Kiva, linking me to the Pae Tokelau (Northern Group islands), Pukapuka, Nassau, Rakahanga, Manihiki and Tongareva, the Pae Tonga (Southern Group islands), Rarotonga, Mangaia, Tahiti, and Rapa Iti and Nui. These connections are not merely genealogical – they are structural, environmental and spiritual.

This research has allowed me to return to the essence of why I pursued architecture in the first place. It has reminded me that our ancestors built with the land, not against it. That their homes were not just shelters but embodiments of environmental intelligence. That to build resiliently is to listen – to the land, the sea, and the wind.

Rarotonga, on the other hand, illustrates the swift displacement of Indigenous architectural practices by Western colonial influences. Missionaries introduced Blue Laws, which prohibited essential aspects of Māori culture such as religious practices, tattooing, and traditional agricultural methods, exemplifying the profound impact of colonization. These historical disruptions, from the early encounters with Captain Cook to the pervasive influence of missionaries, reveal the enduring consequences of colonialism on our societies.

This thesis is not the conclusion of my journey—it is the beginning of a larger effort to integrate Indigenous Pacific architectural wisdom into modern practice. It is a bridge between ancestral knowledge and contemporary application, ensuring that our Māori and Pacific architectural legacies continue to evolve, inform, and inspire.

As I move forward with this research, I do so with the deep conviction that our ancestors left us everything we need. We only have to re-remember

Justification for Autoethnographic Methodology

This research employs an autoethnographic approach rooted in my personal experiences and the traditional knowledge I have inherited and actively practised throughout my life. As an insider within the communities under study, my work provides an authentic account of the lived realities and cultural practices of my people. The insights and data are drawn from my own experiences, observations, and ancestral knowledge, without involving external participants or interventions that would require formal ethical approval. By utilizing autoethnography, this research honours Indigenous epistemologies and challenges colonial narratives that have historically marginalized Māori architectural practices.

Autoethnography is particularly relevant for Indigenous research as it aligns with decolonising methodologies prioritising Indigenous voices and ways of knowing. Linda Tuhiwai Smith, in *Decolonizing Methodologies: Research and Indigenous Peoples*, argues that conventional Western research paradigms have often been complicit in colonising Indigenous knowledge systems. Smith

[4] Rinehart, E., Robert. 2018. "New Critical Pan-Pacific Qualitative Inquiry" SAGE Publishing 11 (1) : 28-38. https://doi.org/10.1525/irqr.2018.11.1.28.
[5] Brown, Deidre. 2002. "Nga Paremata Maori: The Architecture of Maori Nationalism" Taylor & Francis 12 (2) : 1-17. https://doi.org/10.1080/10331867.2002.10525166.
[6] Tupaea, Morgan, Jade Le Grice, and Fern Smith. 2022. "INVISIBILISED COLONIAL NORMS AND THE OCCLUSION OF MĀTAURANGA MĀORI IN THE CARE AND PROTECTION OF TAMAITI ATAWHAI" 11 (2) : 92-102. https://doi.org/10.20507/maijournal.2022.11.2.1.

emphasises the need for Indigenous researchers to reclaim their narratives, stating, "Research is probably one of the dirtiest words in the Indigenous world's vocabulary" (Smith, 2012, p. 1)[7]. This reflects the historical context in which research was used as a tool of imperialism, extracting knowledge from Indigenous communities without consent or reciprocity.

This research resists colonial frameworks and validates Indigenous epistemologies by adopting an autoethnographic approach. Autoethnography enables me to draw from my cultural identity and lived experiences as a Pukapukan, offering an insider's perspective on Indigenous Māori architecture. This approach is consistent with Smith's advocacy for "researching back" (Smith, 2012, p. 7), where Indigenous scholars challenge colonial narratives by reasserting their cultural knowledge.

Manulani Aluli Meyer, in *Ho'oulu: Our Time of Becoming*, articulates the significance of Indigenous epistemologies rooted in lived experience and cultural practices. Meyer emphasizes the concept of "body-mind-spirit integration" (Meyer, 2003, p. 54)[8], which recognizes knowledge as embodied and relational, rather than objective and detached. This resonates with my own experiences of architectural practices that are deeply intertwined with cultural identity, spirituality, and environmental stewardship.

In Pukapuka, architectural knowledge is not merely technical; it is experiential and spiritual, passed down through oral traditions, storytelling, and hands-on practice. For example, the lashing techniques used in vaka (canoe) and wale (house) construction are not only structural solutions but also cultural symbols of unity and resilience. Autoethnography allows me to convey this embodied knowledge, preserving the nuances of cultural practice that might otherwise be lost in conventional research methodologies.

Meyer's framework of "knowledge as relationship" (Meyer, 2003, p. 45) supports the use of autoethnography by emphasizing interconnectedness between the researcher, the community, and the environment. This is particularly relevant for examining Māori architecture, where design principles are informed by the rhythms of the ocean, the language of the winds, and the ancestral knowledge embedded in the land.

Autoethnography not only centres on Indigenous voices but also disrupts colonial narratives that have historically misrepresented Māori architecture. Western architectural historiography has often framed Indigenous structures as primitive or unsophisticated, overlooking their ingenuity, sustainability, and cultural significance. This colonial bias is evident in Rarotonga, where Western colonial practices rapidly displaced Indigenous architectural wisdom through the imposition of Blue Laws and missionary influences.

Linda Tuhiwai Smith argues for the necessity of "decolonizing knowledge" (Smith, 2012, p. 20) by reclaiming Indigenous narratives and methodologies. Autoethnography empowers me to challenge colonial misrepresentations and reposition Māori architecture within its cultural and environmental contexts. This approach enables a re-examination of traditional building techniques, such as the cyclone-resistant wale in Pukapuka, not merely as artifacts of the past but as innovative, climate-resilient solutions relevant for contemporary architectural practice.

As an insider—culturally embedded within the communities of Pukapuka, I possess an intimate understanding of the cultural contexts and meanings embedded in Māori architectural practices. Autoethnography legitimizes my position as both researcher and cultural participant, allowing me to engage with the subject matter authentically and respectfully.

Smith emphasizes the importance of Indigenous researchers speaking "from within" (Smith, 2012, p. 137)[7] their cultural contexts to provide nuanced insights that external researchers may overlook. Similarly, Meyer's concept of "talking story" (Meyer, 2003, p. 66)[8] reinforces the importance of narrative as a culturally resonant method of knowledge transmission. Through autoethnography, I am able to weave personal narrative with cultural analysis, ensuring the authenticity of the research while maintaining the integrity of Indigenous knowledge systems.

Autoethnography necessitates reflexivity, requiring me to critically engage with my positionality and acknowledge my dual role as both researcher and cultural insider. This reflexive stance aligns with Smith's advocacy for "researcher accountability" (Smith, 2012, p. 137)[7] to the community being studied. By situating myself within the narrative, I maintain transparency about my biases, cultural influences, and the subjective nature of my interpretations.

Reflexivity also enhances the credibility of the research by acknowledging the complex interplay between personal experiences and cultural analysis. This approach ensures that my narrative does not merely serve as anecdotal evidence but contributes to a deeper understanding of Indigenous architectural practices.

[7] Smith, L. T. (2012). *Decolonizing Methodologies: Research and Indigenous Peoples* (2nd ed.). Zed Books.

[8] Meyer, M. A. (2003). *Ho'oulu: Our Time of Becoming*. 'Ai Pōhaku Press.

While autoethnography offers a powerful decolonising framework, it also presents limitations. The subjective nature of personal narrative may be critiqued for its perceived lack of objectivity or generalizability. However, Meyer challenges this notion by arguing that Indigenous epistemologies prioritise relational and contextual knowledge over universal truths (Meyer, 2003, p. 45)[8].

Ethical considerations are also paramount, particularly concerning cultural sensitivity and community consent. Although this research is grounded in my personal experiences and does not require formal ethics approval, it is conducted with deep cultural responsibility and accountability to my community.

Autoethnography in this research is both a methodological choice and an act of cultural reclamation. It aligns with Linda Tuhiwai Smith's decolonizing methodologies by challenging colonial narratives and repositioning Indigenous Māori architecture within its cultural and environmental contexts. Additionally, it resonates with Manulani Aluli Meyer's framework of Indigenous epistemologies that prioritize embodied knowledge, relationality, and cultural authenticity.

Autoethnography allows me to weave my lived experiences with cultural analysis, providing an insider's perspective on the architectural practices of Pukapuka. This approach preserves the integrity of Indigenous knowledge systems and contributes to the broader discourse on sustainable and resilient architectural practices in the Pacific. By grounding this research in my cultural identity and ancestral knowledge, autoethnography serves as a powerful vehicle for unearthing the sustainable and resilient futures embedded in Indigenous Māori architecture.

Chapter 1 Kapi Mua: Where is Pukapuka?

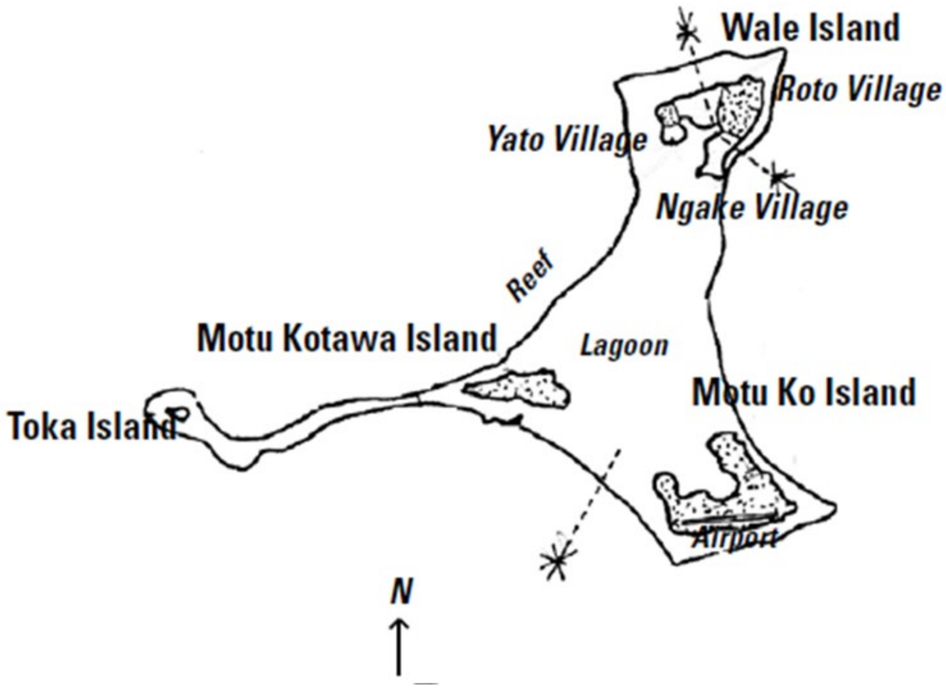

Figure 2: Map of Pukapuka

Pukapuka, the westernmost island of the Cook Islands archipelago, is a place of profound significance, steeped in history and natural beauty. Situated approximately 1,150 kilometres northwest of Rarotonga and 656 kilometres from Tutuila in American Samoa, this remarkable atoll is distinguished by its unique 'manta-ray' structure. It comprises three islands covering nearly 1,300 acres of diverse terrain, including coral, swamp, and lush tropical landscapes (Weigelt et al., 2013)[9].

The main island, Wale, holds a special place in my heart, shaped like a horseshoe at its northern end. The coastal perimeter rises swiftly to 2 to 3 meters above sea level, strikingly contrasting the inland landscape. Dominated by taro swamps (uwi), this area lies at or below sea level, rising to 4 meters in certain areas (Marshall et al., 2017)[10]. These taro swamps serve as a crucial food source that has sustained our community for generations despite the island's vulnerability to cyclones and storm surges.

Pukapuka's geographical location exposes it to cyclones that typically form west-northwest of the island and then track east towards the northern Cook Islands before veering southeast towards the southern Cook Islands (Findlay & Katoa, 1998)[11]. These cyclones present significant challenges to us, the island's inhabitants. Over the years, we have developed coping strategies deeply rooted in our connection to the land(McLeod et al., 2019).

Our community's ability to adapt and thrive in the face of such adversity is a testament to their enduring spirit and resilience(McLeod et al., 2019). Pukapuka's unique atoll structure, with its natural protective features along the northern coast, offers some respite from the cyclonic activity threatening the island(Findlay & Katoa, 1998). By understanding the impact of these cyclones on our local eco-system and community resilience, we have harnessed traditional ecological knowledge and adapted to the changing environmental conditions(Findlay & Katoa, 1998)(McLeod et al., 2019). This knowledge and adaptability ensure that we continue to thrive, preserv-ing our way of life for future generations

Despite initial perceptions of coral atolls as fragile and uninhabitable, as Kirch (1988) suggested, my own experiences and the stories shared by my ancestors paint a different picture. Growing up in Pukapuka, I was immersed in the oral traditions, chants, historical

[9] Weigelt, P., Jetz, W., & Kreft, H. (2013, September 3). Bioclimatic and physical characterization of the world's islands. National Academy of Sciences, 110(38), 15307-15312. https://doi.org/10.1073/pnas.1306309110
[10] Marshall, K., Koseff, C., Roberts, A L., Lindsey, A., Kagawa-Viviani, A., Lincoln, N K., & Vitousek, P M. (2017, January 1). Restoring people and productivity to Puanui: challenges and opportunities in the restoration of an intensive rain-fed Hawaiian field system. Resilience Alliance, 22(2). https://doi.org/10.5751/es-09170-220223
[11] Findlay, R A., & Katoa, R. (1998, August 20). Cyclone Management Report for Pukapuka Atoll, Cook Islands. Iowa State University, 1(#1), 29

accounts, and genealogies that have been passed down through generations. These narratives revealed a rich history of traditional lifestyles and cultural practices, often overlooked by outsiders.

I recall my great-grandmother's tales of how our people have lived harmoniously with the atoll's unique environment for centuries. She would explain how the seasons, winds, rising of the stars, what time of the day or night, tide, and phases of the moon and sun determined the success of our fishing and harvesting of crops. Scholars like William Alkire have echoed this, providing ecological perspectives highlighting the intricate relationship between us and our surroundings. In more recent years, Indigenous oral historians, such as Kauraka Kauraka, have played a crucial role in preserving and transcribing these oral narratives. Their work provides an insider's perspective on atoll life, enriching both academic and popular literature.[12]

Archaeological excavations across various atoll groups, including ours, have unearthed well-preserved cultural layers and stratigraphic sequences. These findings have validated our oral histories and highlighted the potential for further research into atoll life and human-environment interactions. I've seen firsthand how these discoveries depict the challenges of atoll life and our ancestors' innovative approaches to managing social and ecological systems.

Pacific Islanders, including my community, have adapted to natural environmental impacts for thousands of years. We have developed practices to accommodate periods of environmental fluctuations McLeod et al. (2019)[13]. Despite being relatively understudied initially, our region provides significant opportunities for testing and refining adaptation responses at scale. Many of us are now implementing climate-smart agriculture and revitalising traditional practices that utilise drought-tolerant species and leverage the benefits of nature. Scholars like McLeod et al. (2019) and Bridges & McClatchey (2009)[14] have documented these efforts, demonstrating our resilience and ingenuity.

As the pace of environmental and climatic changes increases, our community's resilience is evident. We continue to maintain and modify traditional practices, adapting to new challenges. Our rich indigenous knowledge of biodiversity and soils has enabled us to respond effectively to fluctuating economic and cultural contexts, challenging the often pessimistic view of our future.

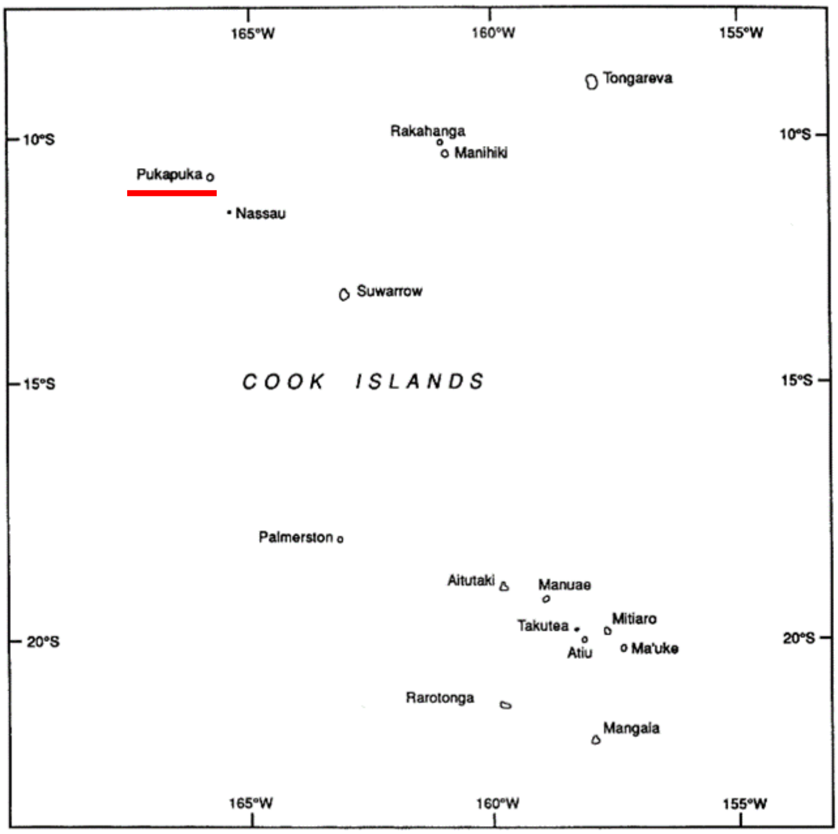

Figure 3: Map of the Cook Islands

[12] Gough, K V., Bayliss-Smith, T., Connell, J., & Mertz, O. (2010, March 1). Small island sustainability in the Pacific: Introduction to the special issue. Wiley-Blackwell, 31(1), 1-9. https://doi.org/10.1111/j.1467-9493.2010.00382.x

[13] McLeod, E., Bruton-Adams, M., Förster, J., Franco, C., Gaines, G., Gorong, B., James, R., Posing-Kulwaum, G., Tara, M., & Terk, E. (2019, June 18). Lessons From the Pacific Islands – Adapting to Climate Change by Supporting Social and Ecological Resilience. Frontiers Media, 6. https://doi.org/10.3389/fmars.2019.00289

[14] Bridges, K W., & McClatchey, W. (2009, May 1). Living on the margin: Ethnoecological insights from Marshall Islanders at Rongelap atoll. Elsevier BV, 19(2), 140-146. https://doi.org/10.1016/j.gloenvcha.2009.01.009

Te Papa Tango -The Foundation

Pre History of Pukapuka

Pukapuka holds a pivotal role in the cultural history of Moana nui a Kiwa (the Pacific), not solely due to its strategic geographical position, but also owing to its rich cultural heritage that intertwines with both Western and Eastern Polynesia. Linguistic analysis places Pukapuka within the Proto Nuclear Polynesian languages of the Outliers and Western Polynesia, as evidenced by research conducted by Wilson 2021. Moreover, linguistic evidence reveals borrowings from Eastern Polynesian languages, further underscoring the island's unique linguistic and cultural fusion. This blend of influences highlights Pukapuka's significance and role as a cultural crossroad between West and East Polynesia.

Pukapuka's main god was Mataaliki who sprouted from a rock from the bottom of the ocean. The gods involved with the formation of Pukapuka were Tongan gods. Mataaliki's wife, Te Vaopupu was also Tonga, promoting at the time of early settlement in Central Polynesia, that is the islands east Fiji Lau group, Tonga, Samoa, Tokelau, Uvea and Pukapuka. Tangaloa/Tangaroa is considered a lesser god in comparison to other Pukapukan elemental gods.

Pukapuka Origins

The Pukapukan origin myth offers a fascinating insight into the interplay of gender, kinship, and cosmological narratives. Figure 1.3 represents the initial filiative link of male-male with the gods taking on paternal roles in relation to Mataliki and the initial male-female dyad of male autochthone-female outsider (Hecht, 1977)[15].

The original chiefly line of Pukapuka derives from an incestuous union between the older son and older daughter of Matāliki and Te Vaopupu. A second incestuous union, between their younger son and younger daughter, is seen as the origin of the matrilineal moieties. Thus, in the myth, two brothers and two sisters become instead two husband-wife dyads (see Figure 1.3).

To make some sense out of the myth, the implicit mayakitanga 'sacred maid' has been added, although she is not taken into account in the text. The chiefly line replicates the initial male-male filiation link (gods-Mataliki) by sacralising the sister, thus not only obviating incest but also eliminating the sister's children as the progeny of another male. Because of the yanga kikino 'evil works' of their parents, said to be all this incestuous propagation, Mataliki struck the land with lightning and forced the children of Punga and Punga Momoto to flee. Those who sheltered from the storm on the land became the matrilineal moiety, the Wua Kati or Land Creatures. The rest were sheltered in the sea and became the other matrilineal moiety, the Wua Lulu or Sea Creatures.

Through his punishment, Mataliki divided his grandchildren into matrilineal moieties, which presumably were initially exogamous categories. Kati also means 'fishing line', is associated with uila 'lightning' and has connotations of maleness. Lulu, like wua, has the denotation of 'female generative organs'. The Wua Lulu has strong connotations of femaleness and is said to be "more wua" than the Wua Kati. Because of this, the moieties are often referred to in discourse as the "Wua Lulu and Kati", leaving the wua off the Wua Kati.

This division also replicates the initial male-female pair for the Wua Kati are sometimes regarded as autochthones and the Wua Lulu as outsiders, or later comers to the island. The usual male-female, outside inside, sea-land contrast appears to be turned about in the associations of the matrilineal moieties but the contradiction is at least partly resolved when it is realised that the genesis thus takes further account of the male autochthone of Pukapuka and his foreign bride, the female from across the sea.

Through this multifaceted analysis, the Pukapukan origin myth emerges as a complex tapestry of gender, kinship, and cosmological narratives, offering a rich resource for understanding the interplay of these elements within Pukapukan culture(Grice & Braun, 2016)[16].

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15 Hecht, J. (1977, June 1). THE CULTURE OF GENDER IN PUKAPUKA: MALE, FEMALE AND THE MAYAKITANGA 'SACRED MAID'. The Polynesian Society, 86(2), 183-206

16 Grice, J L., & Braun, V. (2016, June 1). Mātauranga Māori and Reproduction: Inscribing connections between the natural environment, kin and the body. SAGE Publishing, 12(2), 151-164. https://doi.org/10.20507/alternative.2016.12.2.4

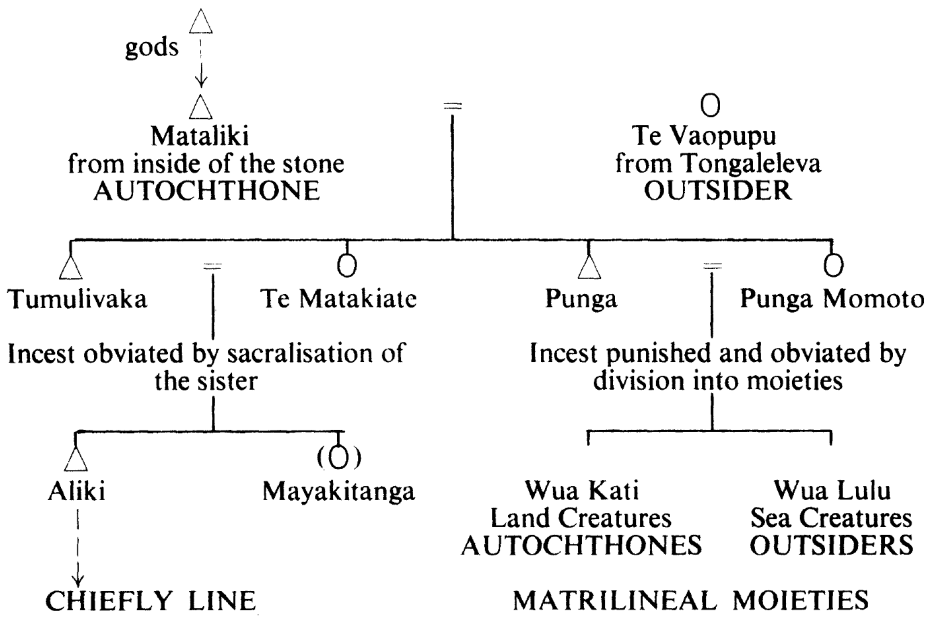

Figure 4: The Pukapukan Origin

MAUI Eeeee

The Coconut tree – the 'Tree of Life' Story

The origin of the coconut is told in the following Pukapukan version of the widespread Polynesian myth as recorded by Beaglehole (Beaglehole & Beaglehole, 1971-1938).

> "Mauieuli and Mauiepopo were a Pukapukan husband and wife and conceived a 'child. Mauiepopo, as is the habit of women at this time and in this condition, craved special and unusual foods to eat, but her cravings remained unsatisfied as she had tasted everything that her husband could bring her. Despite his fishing and foraging efforts, she rejected all offerings, claiming them to be unappetising. This pattern persisted for days, with her husband tirelessly attempting to meet her culinary demands while she grew weaker from lack of sustenance. Eventually, in desperation, he implored her to identify the specific fish she craved, promising to obtain it for her. She replied, " There is one fish only that I desire and that is a piece of the tuna eel".
>
> Determined to fulfill her desire, the man armed himself with bait and hooks and ventured to the tuna's dwelling. He tried various baits without success, until he decided to use the fragrant flower of the wetau (native tamanu/mahogany) tree. While preparing his hook, he chanted, "Mauieuli, Mauiepopo, ta te matau, e matau lave" [Mauieuli, Mauiepopo, (we) prepare the hook, the fast-gripping hook]. With this last attempt, the tuna finally took the bait and became ensnared. The man hauled the fish from the hole, and when he was about to club it to death the fish spoke, saying, "Hear my words before you kill me. When I am dead, cut off my head. Let your wife eat my body, but my bead you must plant in the ground in front of your house." The man listened well to the words of the tuna. Then he killed the fish, cut off its head, and planted it in front of his house. The body be wrapped in leaves, cooked in the oven, and took to his wife. She saw the eel and said, "Here you are at last with just the kind of fish I have been longing for." With these words she ate the fish and was satisfied.
>
> Over time, the planted tuna head grew into a tree, bearing a unique harvest of coconuts. The tree bore one nut on the topmost stem, two nuts on the second stem, and so on, ultimately producing a substantial yield of nuts. As the nuts matured and hardened, they fell to the ground. Mauieuli gathered all the nuts and decided to distribute them to various islands across the Moana Nui o Kiva. He divided the nuts into two groups, one for the western Pacific islands and the other for the eastern ones. He then tossed one nut at a time from the western pile and threw it into the air, calling out the name of an island as each nut landed. When the western pile was finished, he started on the eastern pile, throwing a nut into the air as before for each island in the eastern Pacific. Thereby ensuring that every Pacific island received the coconut. However, after using all the nuts from the tree, he realised, "In this division process, I have forgotten all about Pukapuka, which was neither east nor west. Te Ulu-o-te-Watu has received no nuts from this division." After this omission, he looked around and found a small, withered nut on the ground and declared, "This shall be the nut for Pukapuka." Thus, in the end, all the islands shared in the nuts from the tree that sprouted from the head of the tuna caught by Mauieuli.

In the story of Lata, when Lata divided the huge Tri-dacna shellfish (payua), he forgot Pukapuka in the division and could give the island only the rock to which the payua was growing. Similarly, Pukapuka was the last Polynesian island to receive Christianity and among the last islands for anthropologists to visit

Coconut - Niu

Below is an example of the in-depth Pukapukan language and understanding of every stage of coconut growth. The coconut tree is considered the Tree of Life.

Coconut trees are empirically divided into 17 classes in terms of the bearing qualities of the tree and the shape or quality of the husk:

Niu lakita:	produces nuts that are small but abundant; it sometimes ceases bearing for a long time but usually bears again after this pause.
Niu wata;	bears well and continuously but not abundantly.
Niu tauiti:	does not bear well and is not often planted.,.
Niu koalia :	bears well but the nuts show a tendency to fall from the tree before they are mature.
Niu wuakole:	a non-bearing tree with male flowers.
Niu malie	bears well and has good eating nuts.
Niu mangalo:	bears the sweet eating coconut with edible husk.
Niu laliliki:	bears very small nuts.
Niu lanunui:	very large nuts.
Niu kawa loloa:	nuts with long husks.
Niu kawa nunui:	nuts with coarse thick husks.
Niu kawa lapalapa:	nuts with thin husks.
Niu kawa pukupuku:	nuts with round husks.
Niu kawa liliki:	nuts that are small and have small husks.
Niu kawa pipiki:	nuts of which the husks are tough and hard to remove.
Niu mawakiwaki:	nuts that are enclosed in a soft husk easily removed.
Niu pulu venu :	the best nuts for making sennit.

Coconut trees are also classified in terms of the colour of the nut. Six types are recognised:

Niu uyi:	dark green.
Nu kawa kenakena:	pale green.
Niu kawa melomelo:	brownish red.
Niu melo:	deep brown, almost red.
Niu melo toto:	almost blood-red
Niu kawa uyiuyi:	midway between dark and pale green.

Island Settlement Pattern

Pukapuka – Central Bustop of Polynesia. Gateway between West and East Polynesia. The Tuakana of East Polynesian Languages

In my exploration of linguistic connections within the Polynesian language family, I delved into the historical and comparative linguistics of Pukapukan, Fijian, and other Polynesian languages like Tongan and Samoan. This analysis revealed fascinating insights into the similarities and differences in consonant usage among these languages, highlighting the complex tapestry of our shared heritage.

The languages spoken in Niutao (Tuvalu), Sikaiana (Solomon Islands), and Pukapuka all belong to the Polynesian branch of the Austronesian language family. These languages share several linguistic features, reflecting their common ancestral roots and interconnectedness. Additionally, they show notable similarities with the Tongan and Samoan languages, further illustrating our broader Polynesian connections.

Growing up in Pukapuka, I often heard the familiar sounds of our language, which closely resemble those of Niutao and Sikaiana. Our languages share a simple yet rich phonological structure. We use a small set of consonants, such as /p/, /t/, /k/, /m/, /n/, and /ng/, and our vowels are just as straightforward, with /a/, /e/, /i/, /o/, and /u/. The length of these vowels can change the meaning of words, a subtlety that adds depth to our conversations. These phonological characteristics are also evident in Aotearoa, Tonga and Samoa, reflecting our common Polynesian heritage.

Our morphology also binds us. Reduplication is a common feature in our languages, a process that adds emphasis or plurality to words. I remember how "waki" (to break) in Pukapukan becomes "wakiwaki" to mean "broken into pieces," a practice mirrored in Niutao, Sikaiana, Aotearoa, Tonga and Samoa. Pronouns in our languages are distinctive too, differentiating between singular, dual, and plural forms, and distinguishing inclusive and exclusive in the first person plural. For example, "au" (I), "taaua" (we two, inclusive), and "maaua" (we two, exclusive) in Pukapukan echo similar structures in Niutao, Sikaiana, Aotearoa, Tonga and Samoa.

Regarding syntax, our languages typically follow a Verb-Subject-Object (VSO) order. I recall sentences like "E inu te tamaiti i te vai" (The child drinks water) in Niutao, reflecting a familiar pattern. In our languages, prepositions denote relationships between words, appearing before the noun, such as "ki te fale" (to the house) in Sikaiana. These syntactic features are also common in Aotearoa, Tonga and Samoa, further linking our linguistic practices.

Our lexicons are filled with shared cognates, like "fale" for "house" in Niutao and Sikaiana, and "wale" in Pukapuka or whare in Aotearoa. These shared words are a testament to our common linguistic heritage. Historical interactions have also led to shared borrowings from other Polynesian or dominant regional languages.

The linguistic similarities between Niutao, Sikaiana, Pukapuka, Tongan, Samoan,Te Reo Māori and Fijian languages highlight our shared Polynesian heritage. From phonology and morphology to syntax and lexicon, these languages exhibit common features that reflect our historical connections and cultural continuities. Understanding these similarities enriches our knowledge of Polynesian linguistics. It underscores the deep-rooted ties among our peoples, weaving a narrative of interconnectedness and shared identity across the vast Moana Nui o Kiva Ocean.

Moreover, the fact that languages are related implies that the people who speak those languages also have a common origin, further illuminating the historical connections between the peoples of a region(Akinnaso, 1985). However, it is important to note that the relationship between language and culture is integral to better understanding linguistic comparisons, which must be interpreted closely and in conjunction with traditional oral histories and genealogical evidence.

In Vakaawi's invocation to his ancestor gods reveals a deep understanding of the geographical and cultural expanse of the Pukapukan world, functioning as both cognitive and performance cartography. His mind map locates Te Atu Tonga, Te Atu Laulau (Samoa), Te Atu Witi (Fiji) to the southwest, and Te Atu Yiva in the Marquesas archipelago. Notably, he omits closer island groups, such as Samoa, Tahiti, and Rarotonga, focusing instead on distant islands with ancient connections to Pukapuka. The invocation empahasises the god's powerful influence, extending from these regions and centering on Pukapuka, indicated by the final directional term "mai", which draws the god;s sphere of activity toward Pukapuka[17]. (See figure 5)

[17] Luka Manuae 1869; manuscript translation by Salisbury and Moeka'a in K. Salisbury 2012

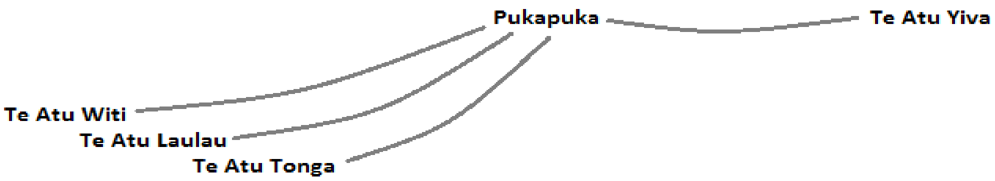

Figure 5: Vakaawi's 'mind map of some Pacific archipelos associated with Pukapuka

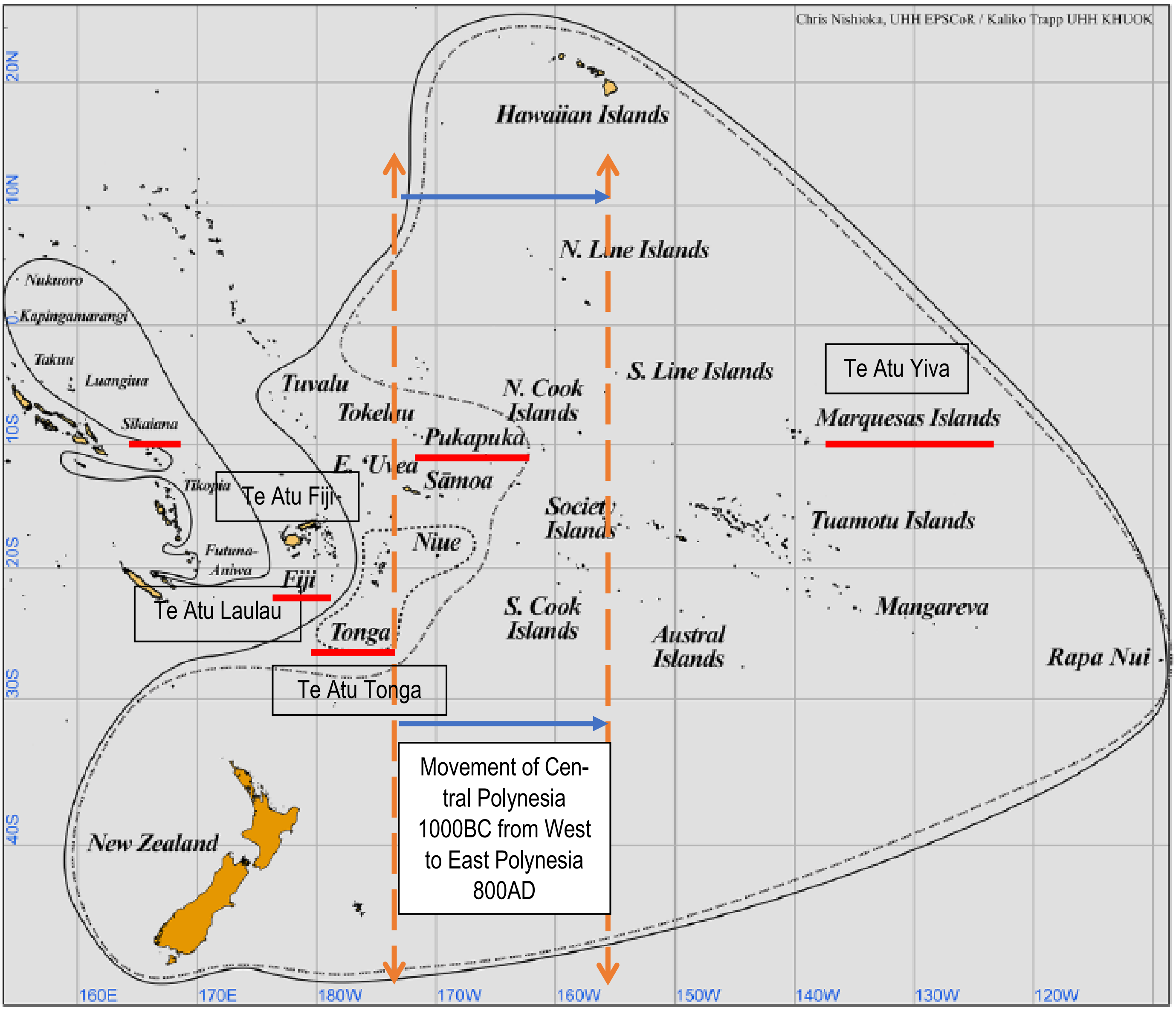

Figure 6 Map of Polynesia and outliers

European Contact

European explorers' discovery of Pukapuka Atoll and Rarotonga marks a significant chapter in the history of Pacific exploration.

The first recorded European contact with the Pukapuka Atoll was made by the Spanish explorer Álvaro de Mendaña. On his second expedition across the Pacific Ocean in search of Terra Australis, Mendaña stumbled upon Pukapuka in 1595. Despite the brief encounter, Mendaña's discovery added Pukapuka to the maps of European navigators, initiating its place in Western records.

Nearly 170 years later, the Pukapuka Atoll and Rarotonga were "rediscovered" by the English navigator John Byron, who was on a voyage of exploration for the Royal Navy. 1765 Byron sailed through the Pacific, documenting several islands, including Pukapuka. His expedition contributed significantly to the European understanding and mapping of the Pacific region.

Byron's encounter with the islands provided more detailed observations and furthered the knowledge initially set by Mendaña's brief visit. This rediscovery was crucial in subsequent navigational routes and the eventual European interest in the broader Cook Islands archipelago.

TUPAIA

With the discovery of Tupaia's chart found Joseph Bank's personal collection, now preserved in the British Library[18]. The original drawn by Tupaia's own hand is missing and the copy that exists today was drawn by Lieut. James Cook 1769 has been preserved in the Fig below.

Figure 7 Tupaia's Chart, Anne Di Piazza and Erik Pearthree. Opoopooa underlined

In their meticulous study published in the *Journal of the Polynesian Society*, titled "A New Reading of Tupaia's Chart," Di Piazza and Pearthree delve into the complexities of a novice cartographer's depiction of the Pacific's vast "sea of islands." Although Tupaia listed 130 islands, only 74 were physically represented on the chart[18]. This discrepancy underscores the conceptual nature of Tupaia's work, which was less about precise geographical plotting and more about a navigator's mental map—a map rooted in the deep knowledge of the rising and setting of stars, planets, the sun, and the moon. Directions were traditionally conveyed through the use of wind compasses, tools that were not merely navigational aids but also cultural artifacts embodying the relationship between the people and their environment (D/Arcy, 2006)[19] (Solomon & Tarai, 2022)[20].

[18] Di Piazza, Anne and Pearthree, Erik, 2007, 2008, Di Piazza 2010

[19] D'Arcy, P. (2006, June 5). Significant Spaces: The Role of Marine Ecosystems in Pacific Island Cultures. UTS ePRESS, 1(2)

[20] Solomon, T., & Tarai, T. (2022, December 15). TE VAKA POKAIKAI – Voyage to excellence. , 5(2)

Tupaia, the remarkable Tahitian navigator and cartographer, embarked on a transformative journey in 1769, sailing alongside the renowned naturalist Joseph Banks and Captain James Cook offering a captivating lens through which to explore the intricate world of Polynesian navigation and cartography (D'Arcy, 2006)[19]. Tupaia's intimate knowledge of the Moana Nui o Kiva's intricate waterways and celestial navigation proved invaluable as he charted numerous islands yet to be discovered by European explorers (Perez, 2020) Among these was the atoll of Pukapuka, a significant waypoint for navigators crisscrossing the vast expanse of the Pacific (Torodash et al., 1970)[21] (Buisseret, 2009)[22].

Tupaia's cartographic prowess, honed through generations of ancestral knowledge, allowed him to recognise and document the locations of many islands, including Pukapuka, that lay beyond the Europeans' horizons. As Tupaia's chart was integrated into the expedition's findings, it became an instrumental resource, guiding subsequent voyages and furthering the understanding of the Pacific's complex web of interconnected archipelagos (Buiseret, 2009)[22] (Imperato, 2007)[23]

Pukapuka, in particular, held immense significance as a crucial stopover point for Polynesian voyagers traversing the oceanic highways of the region.(Torodash et al., 1970)[21]. Its strategic positioning, midway between the distinct cultural spheres of eastern and western Polynesia, made it a vital staging ground for those embarking on ambitious transoceanic journeys (Perez, 2020). (Figure 7). By documenting the existence and location of this significant waypoint, Tupaia's contributions expanded the European understanding of the Pacific's navigational networks and the Polynesian seafaring prowess that had long sustained them (Garrett, 1994)[24].

Together, these explorations by Cook, Mendaña and Byron highlight the gradual European colonisation of the Pacific Islands, driven by the Church and State's thirst for new territories and opportunities.

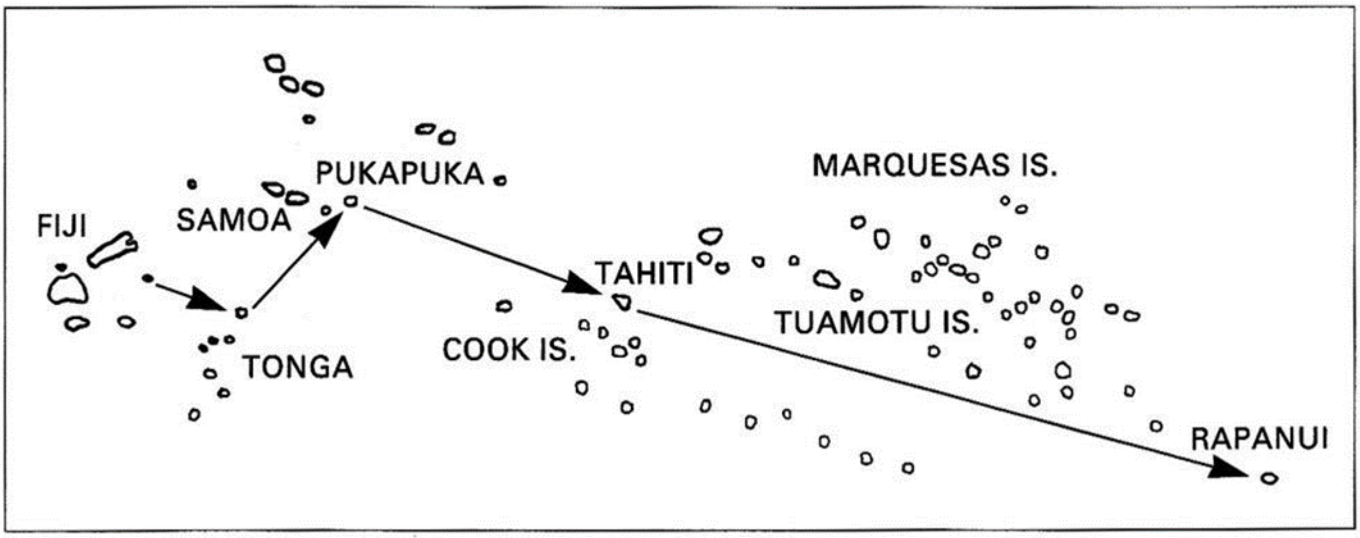

Figure 8: Map 1. Reconstructing Migration Patterns

[21] Torodash, 'Magellan Historiography', 313-318

[22] Buisseret, D. (2009, December 17). Europeans Plot the Wider World, 1500–1750. , 330-343.

[23] Imperato, P J. (2007, April 1). Ian Parker. Jua Kali's Voyage on the Jade Sea.

[24] Garrett, John. "To Live Among the Stars, Christian Origins in Oceania" Institute of Pacific Studies, 1994

The following images show plotting diagrams from Tahiti in the east, extending back to the west using reverse navigation techniques, exemplifying the Indigenous methodologies that Tupaia employed to chart his course across the Moana Nui o Kiva.

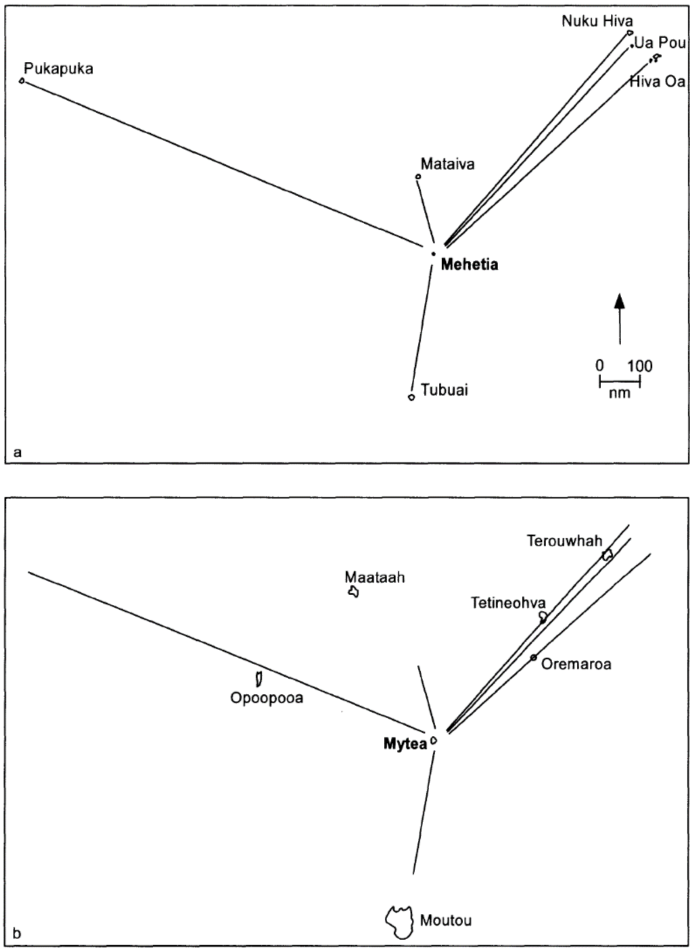

Figure 10: Plotting diagramme centred on Mehetia

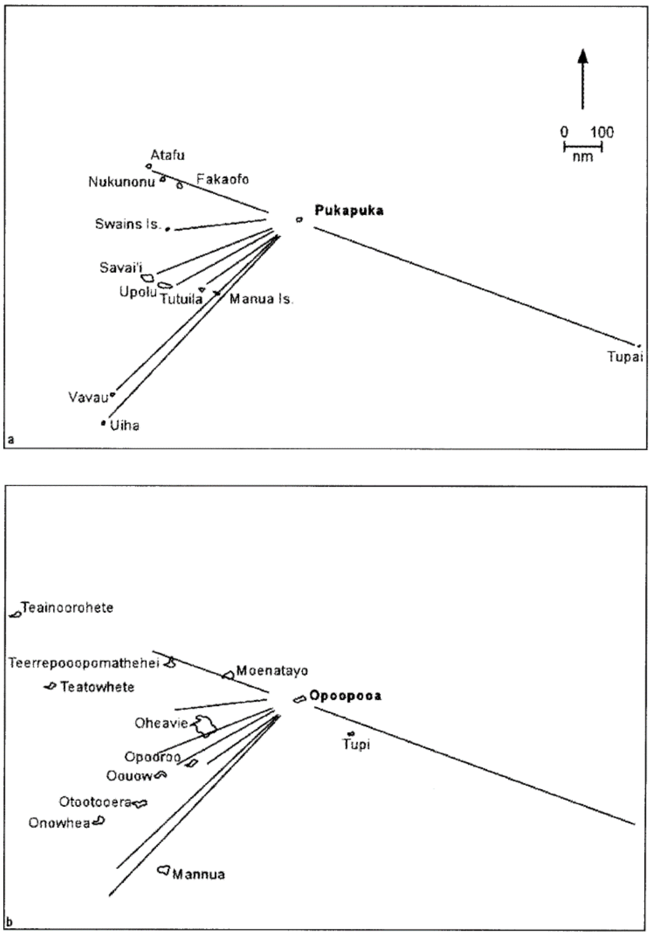

Figure 9: Plotting diagramme centred on Pukapuka

a) True bearings from Mehetia to the Tuamotus, Marquesas, Australs and Northern Cooks
b) The same bearings superimposed on Tupaia's Chart, rotated -3º

a) True bearings from Pukapuka to the Society Islands, Tonga, Samoa and Tokelau
b) The same bearings superimposed on Tupaia's Chart, rotated +62º

Table 1: List of target islands whose bearings from Pukapuka match those on Tupaia's Chart

Class	Target island	Name from Tupaia's chart
Class 1	Savai'i	Oheavie
	Upolu	Opooroo
	Tutuila	Otootooera
Class 2	Manu'a	Mannua
	Vava'u	Oouow
	Uiha	Onowhea
	Tupai	Tupi
Class 3	Fakaofo	Moenatayo
	Nukunonu	Teerrepooopomathehei
	Atafu	Teainoorohete
Class 4	Swains Is.	Teatowhete

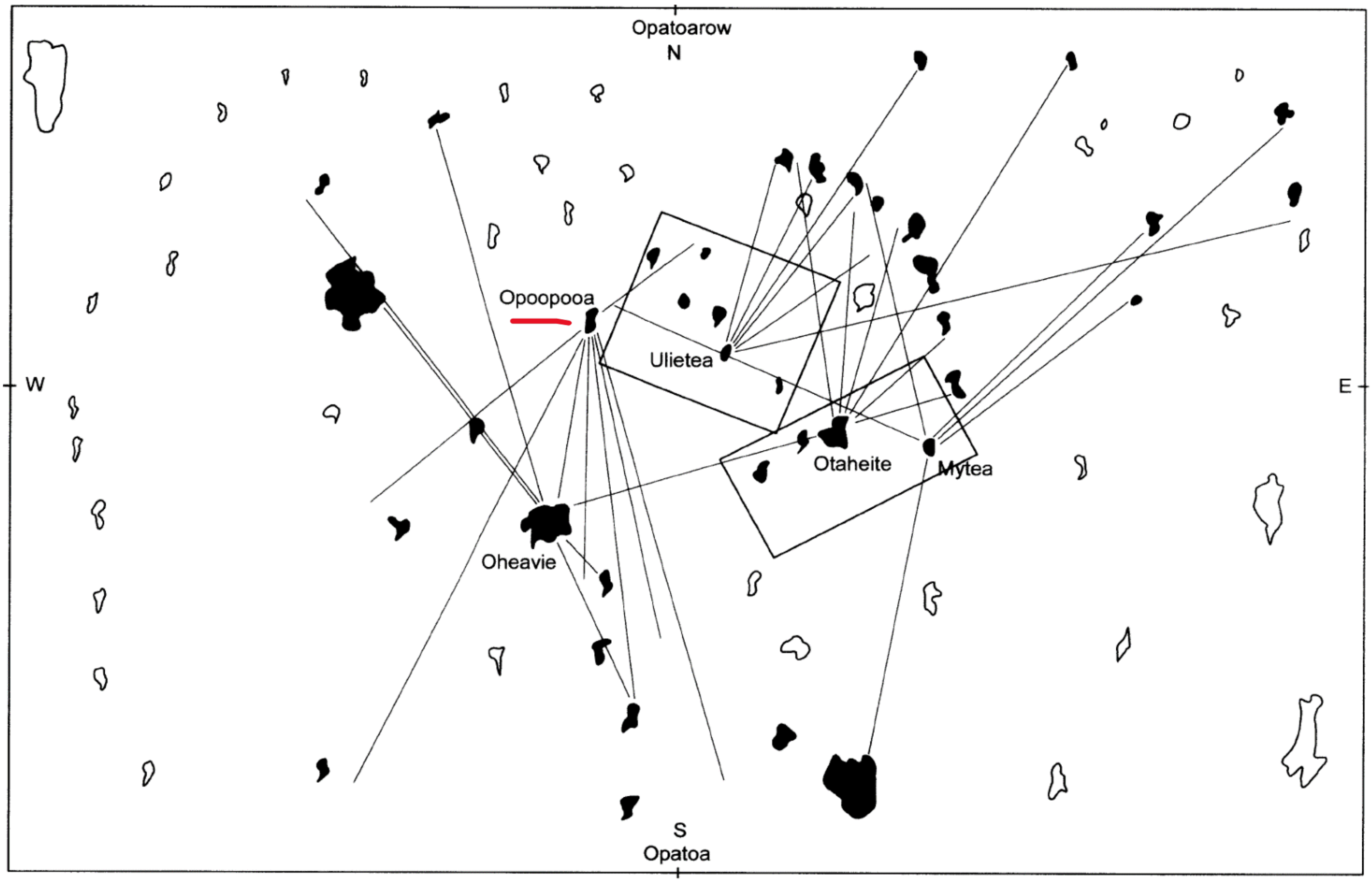

Figure 11: Tupaia's Chart showing the reconstructed plotting diagrammes and maps of the Leeward Society Islands. Highlighted islands are discussed in the text.. Note the name ***Opoopooa*** *references Pukapuka*

Missionary influence

Due to Pukapuka's remote location, it remained largely untouched by outside vessels and was the last of Rarotonga to be evangelised in 1857[25], when the London Missionary Society dispatched teachers from Aitutaki and Rarotonga in the southern Cook Islands. Luka Manuae of Aitutaki reported the initial contact in his detailed account titled "No te taeanga o te tuatua a te Atua ki Pukapuka" ("The arrival of the Word of God at Pukapuka"), dated August 1869. Initially, the lineages of Ngake and Loto harboured hostile intentions towards the newcomers, seeking retribution for a previous incident. However, Vakaawi, chief of the Yālongo lineage in Yato, intervened and safeguarded the missionaries. Subsequently, the island embraced Luka's Christian teachings, partly influenced by a purported resurrection witnessed during an encounter.

The influence of Europeans reached its zenith following the conversion of the populace to Christianity. This transformation occurred in 1849 on Manihiki-Rakahanga (then a unified community), in 1854 on Tongareva, and lastly on Pukapuka. European missionaries, along with resident agents such as mission pastors and teachers trained at the Takamoa Theological College in Avarua on Rarotonga, immediately assumed a profound influence in local affairs, surpassing even the authority of the chiefs (ariki). They were esteemed and revered as possessors of secular knowledge, believed to hold the key to worldly success and salvation in the afterlife.

By 1862, Rev. William Wyatt Gill[26] noted widespread adoption of Christianity among the island's inhabitants and newly introduced diseases.

In 1863, Pukapuka became a target for recruitment by Peruvian slave traders after unsuccessful attempts at Manihiki atoll 532km to the north east. The recruiter Paddy Cooney, aided by generous offers and promises of repatriation, managed to recruit 85 islanders, including the mission teacher Ngatimoari. Despite subsequent attempts by other Peruvian ships, the vigilant islanders evaded further

[25] Luka Manuae, (2012) "The arrival of the word of God at Pukapuka", *Journal of Pacific History*, Dec.

[26] Gill, Rev. William. “Gems from the Coral Islands” Te Rau Herald Pint, reprinted 2001

recruitment. In total, 145 individuals were taken from Pukapuka to Peru, with only two individuals, Kolia and Pilato (Malowutia), returning (Maude, 1981)[27].

One might ponder why a considerable number of Cook Islanders, totalling 725 individuals from the four northern atolls of Pukapuka, Rakahanga, Manihiki and Tongareva, willingly boarded Peruvian ships without intervention from their chiefs or mission teachers, despite the fact that many of the recruits were deceived to varying degrees, with only seven being forcibly abducted. The explanation, it is proposed, lies in the esteemed status held by white men in the atolls, not only within the Northern Cook Islands but also in the Tokelau and Tuvalu Groups. Historically, the interactions between atoll societies and Europeans had been limited, sporadic, and selective, consisting of occasional encounters with exploring ships, passing whalers, itinerant trading schooners, and, on some islands, solitary beachcombers assimilating into local communities.

In 1868, the notorious buccaneer Bully Hayes seized approximately 40 islanders for forced labour, none of whom ever returned home. Subsequently, in 1892, Pukapuka was declared a British protectorate and later became part of Rarotonga under New Zealand's jurisdiction in 1901.

Between 1856 and 1980, the United States asserted sovereignty over Pukapuka under the Guano Islands Act. However, on June 11, 1980, as part of establishing the maritime boundary between Rarotonga and American Samoa, the United States signed Rarotonga – United States Maritime Boundary Treaty. Through this treaty, the United States officially recognized that Pukapuka fell under the sovereignty of Rarotonga.

Decolonizing the Mind: Colonialism and its Linguistic, Cultural, and Technological Impact on the Pacific Islands

> "The real aim of colonialism was to control a people's wealth, what they produced, how they produced it, and how it was distributed. In other words to control the entire realm of language of real life."
>
> Military conquest was first followed by political dictatorship.
> Mental domination of control through culture.
>
> ''The most important area of domination was the mental universe of the colonised. To control the root culture of people perceived themselves and their relationship to the world. Economic and Political control can never be complete or effective without mental control. To control a people's culture is to control their tools of self-definition and their relationships to others. Thru Colonialism this involved two aspects of the same process.
>
> The Destruction and undervaluing of a people's culture, art, dances, religions, history, geography, education, orature and literature and the conscious elevation of the language of the coloniser. The domination of the people's language by the languages of the colonising nations was crucial to the domination of the mental universe of the colonised. Using language as communication, imposing a foreign language and suppressing the native languages as spoken and written were already breaking the harmony previously existing between the African child and the three aspects of language. Since the new language as means of communication was a product of and reflected the real language of life elsewhere. It could never as spoken or written properly reflect or imitate the real life of that community.
>
> Let me explain why technology appears to us as slightly external and be their product and not ours. The word missile used to hold an alien far away sound until I recently learned its equivalent in Gikuyu Nurukihi, and it made me apprehend it differently. Learning for a colonial child became a cerebral activity, not an emotionally felt experience. But since the newly imposed languages could never completely break the languages as spoken, their most effective area of domination was the third aspect of language communications....the written. The language of an African child's formal education was foreign. The language of the books he read was foreign the language of his conceptualization was foreign. Thought in him to be a visible form of a foreign language so that the written language of a child's upbringing in the school, even his spoken language within the school compound, became divorced from his spoken language at home. There is often not the slightest relationship between the child's written world, which was also the language of his schooling, and the world of his immediate environment and the family and the community. For a colonial child, the harmony between the 3 aspects of language and

[27] H.E. Maude, (1981) ''Slavers in Paradise – The Peruvian labour trade in Polynesia, 1862-1864

communication is irrevocably broken. This dissociation, divorce or alienation from the immediate environment becomes clear when you look at colonial language as a carry of culture.

Since culture is a product of a people's history, which it, in turn, reflects, the child was now being exposed exclusively to a culture that was a product of a world external to himself. He was being made to stand outside of himself to look at himself"[28].

In Decolonising the Mind, Ngũgĩ wa Thiong'o articulates how colonialism sought to dominate not just the economic and political spheres of colonized peoples but also their mental and cultural domains. This domination was achieved through the systematic devaluation of indigenous languages and cultures and the imposition of the colonizer's language and cultural norms. In the Pacific Islands, this process had profound implications, not only for language and cultural identity but also for the preservation and transmission of traditional knowledge, including vital practices such as canoe building and house construction.

Ngũgĩ asserts that the most insidious form of colonial domination was the mental control exercised through cultural means. In the Pacific Islands, as in Africa, colonial powers systematically undermined indigenous languages, which were the primary vehicles for transmitting cultural knowledge, values, and identity. The introduction of colonial languages—English, French, and Spanish—through formal education systems alienated Pacific Islanders from their native tongues and, by extension, from their cultural heritage and traditional knowledge systems.

Language in Pacific societies is deeply intertwined with the transmission of traditional knowledge, particularly in the realms of canoe building and house construction. These practices are not merely technical skills but are embedded in the cultural and spiritual life of the community. The art of canoe building, for instance, involves intricate knowledge of local materials, the environment, and celestial navigation, all of which are communicated through oral traditions and specialized vocabularies. Similarly, traditional house building techniques are imbued with cultural significance, reflecting a harmonious relationship with the environment and the community's social structure.

When colonial authorities imposed foreign languages in schools and public life, they disrupted the transmission of this specialized knowledge. The younger generations, educated in the languages and cultural paradigms of the colonizers, were often distanced from the practical and spiritual knowledge embedded in their own languages. As Ngũgĩ highlights, this created a disconnect between the language of education and the language of everyday life, leading to a form of cultural and cognitive alienation that undermined the continuity of traditional practices.

The imposition of colonial languages and the concurrent devaluation of indigenous languages had a devastating impact on traditional knowledge systems, particularly in the areas of canoe building and house construction. These skills, passed down through generations, require not only technical expertise but also a deep understanding of the environment and cultural context in which they are practiced.

Canoe building, a critical skill for Pacific Islanders, particularly those in atolls like Pukapuka, was severely affected by the colonial disruption of traditional knowledge transmission. The construction of vaka (canoes) involves a sophisticated understanding of hydrodynamics, meteorology, and astronomy, knowledge traditionally conveyed through oral instruction and apprenticeship. As colonial education systems emphasised Western knowledge and skills, the transmission of this indigenous knowledge was interrupted, leading to a decline in the practice of traditional canoe building. This decline had broader implications for Pacific Islanders' ability to navigate and sustain their way of life in a region where the ocean is central to culture, economy, and identity.

Similarly, traditional house-building techniques, which embody principles of sustainability and resilience honed over centuries, were degraded as Western architectural styles and materials were introduced. In many Pacific communities, traditional homes were designed to withstand the harsh climatic conditions of the region, utilising local materials and construction methods that reflected a deep understanding of the environment. However, the introduction of Western building materials and techniques, often viewed as superior, led to the erosion of these practices. As a result, the knowledge of how to construct homes that are both culturally appropriate and environmentally sustainable began to fade.

Ngũgĩ's observation that colonial education taught colonised children to "stand outside of themselves to look at themselves" resonates strongly in the Pacific context. The introduction of Western education systems, often through missionary schools, not only imposed a foreign language but also promoted Western cultural values and religious beliefs, further distancing Pacific Islanders from

[28] **Ngũgĩ wa Thiong'o**, a prominent Kenyan writer, in his book *Decolonising the Mind: The Politics of Language in African Literature* (1986)

their indigenous identities. This form of cultural alienation extended to traditional practices, including canoe building and house construction, which were often devalued or discouraged in favour of Western alternatives.

The loss of traditional knowledge in these areas is not just a technical or economic issue but one that strikes at the heart of cultural identity. Canoes and traditional houses are more than functional objects; they are symbols of a community's relationship with its environment, its ancestors, its history, and its social structure. The decline of these practices under colonial influence represents a broader erosion of cultural identity, as the skills and knowledge that once defined a community's way of life are forgotten or replaced by foreign alternatives.

Despite colonialism's pervasive influence, significant resistance and revitalisation efforts have been underway across the Pacific Islands to reclaim and preserve indigenous languages, cultures, and traditional knowledge. In recent decades, movements to revive indigenous languages have been paralleled by efforts to restore traditional practices such as canoe building and house construction.

In New Zealand, the Māori language revival movement has gained considerable momentum, with initiatives such as Kōhanga Reo (Māori language preschools) and Māori language immersion schools playing a key role in revitalising the language. Similar efforts are underway in other Pacific nations, such as in Samoa, where the Samoan language remains robust, and in Hawai'i, where the Hawaiian language has seen a resurgence through immersion programs and the establishment of the Hawaiian Language College

For instance, in Hawai'i, there has been a resurgence in the traditional art of canoe building, driven by a broader movement to revive Hawaiian culture and language. Similar efforts are seen in other Pacific nations, where community-led initiatives are working to document and teach traditional construction techniques, ensuring that this knowledge is passed on to future generations. These revitalisation efforts are critical for maintaining Pacific communities' cultural identity and resilience in the face of ongoing challenges such as climate change and globalisation.

The impact of colonialism on the Pacific Islands, as analysed through the lens of Ngũgĩ wa Thiong'o's Decolonising the Mind, underscores the central role of language in the colonial project of mental and cultural domination. The suppression of indigenous languages and the imposition of colonial languages disrupted the transmission of traditional knowledge, particularly in critical areas such as canoe building and house construction. This disruption has had lasting effects on cultural identity and self-perception in the Pacific Islands.

However, the ongoing efforts to revitalize indigenous languages and traditional practices represent powerful acts of resistance against the legacy of colonialism. By reclaiming their languages and traditional knowledge, Pacific Islanders are not only preserving their cultural heritage but also asserting their right to define their own identities and shape their own futures. These efforts are crucial for ensuring the survival and flourishing of Pacific cultures in an increasingly globalized world.

Figure 12. Pukapukan canoes stored under eave of house

House Building on Pukapuka

In Pukapuka, the construction of small houses embodies a communal effort, with the owner enlisting the help of a few close friends. The erection of larger houses necessitates the mobilization of the entire kinship group, ensuring swift progress. The younger men handle the heavy lifting and main framework, while the older men contribute by making the sennit for lashings nearby. This division of labour reflects a deep-seated respect for the elderly, whose experience and skill in crafting sennit are crucial for the structure's integrity.

In contemporary practice, small house frameworks are often assembled in cool, shaded areas. This approach is practical, especially when the actual site of the new house is either unoccupied or still houses an old structure awaiting replacement. Once the frame is completed, it is disassembled, transported to the designated site, and reassembled. However, the frame is typically constructed directly on the house site from the outset for larger houses. This process usually occurs during the cooler weather that follows the shift of the winds to the southeast, taking advantage of the more comfortable working conditions.

The thatching of the roof, regardless of the house size or whether it's a new or existing structure, is a communal endeavour. The roof's sides and ends are divided into sections, called *wononga* or tuta, with each section running from the eaves to the ridgepole. An average house side typically has two to three sections. The house owner coordinates with friends to prepare the roof sheets and sennit to thatch each section. Each friend might complete their section independently or with the help of a group of friends. Payment for this labour is made through food, with one share allocated per completed section. This share is then divided among the helpers. The owner's generosity determines the quantity of food, but it's understood that stinginess can damage one's reputation and future support.

The same communal method applies to building the slat walls of a modern house. The space between uprights is divided into maleva sections, with a food share promised to those who complete each section. The event where these food shares are distributed is called ngaluenga. Some owners, anticipating the need for food shares, prepare in advance by placing a tapu on their talo and nuts and fattening pigs. Others may gather food only after work, making workers wait patiently for compensation. Typically, a two-year wait is considered the maximum acceptable period before workers might express dissatisfaction with pointed comments.

Traditionally, house building in Pukapuka was a non-specialized, community-driven process without formal building organisations and experience, which continues to this day. However, it has now become more specialised, with few kau mātuatua remaining. This communal approach is likely why constructing an average-sized dwelling house can take seven months to a year, depending on available timber and resources. The labour involved is not extensive, but the owners often pause work to engage in other activities. Additionally, delays can occur as they gather reserve food supplies to pay workers for the next construction phase. Even with the advent of iron tools, these extended timelines might reflect traditional patterns from the past, when construction with shell adzes required even more time and effort.

Interestingly, I have never observed rites, tapu, karakia, prayers to the gods, or other ceremonies are associated with house building in Pukapuka. A feast marked the completion of a new house, but there was no formal consecration before it was used. This absence of ritual underscores the practical and communal nature of house building on the island, where the focus is on cooperation, mutual support, and sharing resources rather than ceremonial formalities. However, I did observe the 'akatapuanga tango', which is the ritual of the 'pule' before setting the 'tango' foundation stones in place for the building platform and protection over the work throughout the build.

Reflecting on my own experiences, building a house is not just about creating a physical structure but reinforcing social bonds, honouring traditional skills, and maintaining community cohesion. The shared effort and reciprocal nature of these tasks highlight the interconnectedness of our lives and the importance of mutual aid in sustaining our way of life on Pukapuka.

Figure 13 Underside of 'wale wakayamoa style, note diagonal 'oka' roof bracing

Canoe Building in Pukapuka

In Pukapuka, the term for an expert canoe builder doesn't exist beyond the general descriptors such as "tangata mawutu" (highly skilled person) (definition) or "tangata tau waiva," (special abilities) (definition) which apply to any skilled craftsman. Mastery in canoe building is often a family tradition, with most of the island's canoes crafted by skilled families.

Figure 14: Ffishing vaka, 'tatai'

Craftsmen recruit assistants from their family members—sons, brothers, and relatives—who volunteer and learn the craft's intricacies, ensuring the knowledge remains within the family. Assistants start with sharpening adzes and gradually take on more complex tasks, such as roughing out the stern piece or preliminary adzing of the hull interior. Eventually, they advance to the meticulous finishing and fitting tasks. To become a master, an apprentice must build a plank canoe under the community's scrutiny. Only if the canoe meets high standards will the apprentice earn commissions from others.

The chief craftsman oversees all aspects of construction and is solely responsible for the finished canoe. He selects the trees for the hull and superstructure, fells them, and rough trims them in the bush. The hull is then transported to a shaded workshop, often near the beach, where it undergoes further shaping. The Matatoki area on Loto beach was a renowned canoe-building yard in the past. Each expert has a preferred work yard (tanga vaka) for seasoning timbers. Today, canoes are typically built near the owner's house, under makeshift shades if necessary, allowing the owner to supervise the process. The owner supplies caulking materials, lashing sennit, and timbers, while the expert brings his tools. Payments and food provisions for the workers are carefully managed based on the community's customary practices.

Expert carpenters are valued for their efficiency and skill. They avoid delays to maintain their reputations and secure future contracts. While no traditional songs or laments about lazy carpenters exist, a quick and proficient expert earns praise through chants. Historically, completing an average-sized canoe with shell adzes took about one month of continuous work. Some experts have trade marks (wakamailongo), such as animal motifs carved on the bow piece of their canoes. Tualai, for instance, marks his canoes with two crossed hands on the wave guard (malae puka). Canoes are often named by their owners with names like "Te Mango" (Shark) or "Te Punga-o-Witi" (Coral-rock-of-Fiji). These names are announced at the canoe-finishing feast (imu kai wakmaleinga), and some men carve or paint these names on the bow.

There is no origin legend for any of these types of canoe save the bare statement that the first canoes were modelled on the shapes of the whale and a species of shark. The rear of the vaka is called '*te yiku ote mango'* or the tail of the shark as shown in figure 15.

These traditions and practices preserve the art of canoe building in Pukapuka and reflect the island's rich cultural heritage and the communal effort that goes into every canoe's creation.

Figure 15: Illustration of sailing vaka and image of model vaka highlighting 'te yiku ote mango'

The Canoe Crew: Roles and Rituals in Pukapuka

Growing up in Pukapuka, the *waoa* vaka, or canoe crew, constantly embodies the spirit and strength of our people. Each crew member had a specialised role, especially when we were catching flying fish, requiring you to be a skilled paddler. The captain, or *tau muli* vaka, was not just a steersman and leader but always offered a *pule/pure* (karakia) at the start of any fishing or expedition. If the captain lacks the confidence or mana, we select another person from amongst the crew.

The second in command is the wuliwuli, who sits on the aft cross boom (kaukau ki muli) and plays a crucial role. The wuliwuli takes over steering when the captain needs rest or while he is fishing. If the captain feels tired or sleepy at night, the w*uliwuli* seamlessly assumes command. His responsibilities are extensive, including assisting in steering during strong seas or high winds, using his paddle as a makeshift sail, and tending the main sheet (wawa) to monitor wind pressure and direction.

The *tataui,* or the group of paddlers in the middle, are the *pukuatu* (heart) of the canoe, paddling with strength and keeping the vessel clear of water. In smaller canoes, the man in the middle, known as *tata yua*, takes on the role of bailer, ensuring the canoe stays afloat. The bowman, or *kauyu*, is a lookout, guiding the captain through the lagoon channels, especially in shallow waters. He sit on the forward outrigger boom (*kaukau ki mua*) to keep the float down when the canoe heels to a fresh wind, adjust the mast's angle according to wind strength, and use his paddle as a leeboard if needed. This role requires a strong and lively individual, capable of quick thinking and swift action.

I remember tales of the *tapus* (taboos) that existed against the presence of women in canoes and the desecration of a canoe by capsizing it. The construction of a new voyaging canoe is a sacred event, with a *taunga* (priest) commending the canoe to the gods of the owner's paternal descent group, rendering it somewhat *tapu*. Before embarking on a fishing trip, the *taunga* seeks the god's protection of the vaka's. Communication also continues at sea, pending on the conditions and if the fishing is good to ensure that no harm and a bountiful catch is achieved. Pukapukans are considered to be excellent fishermen, knowing exactly when and what time to fish, what type of fish, and what type of bait to use. In etene (heathen name given by missionaries) the *vaka taunga* carried a stick or stone representing his god, to which a *malo* (loin gird) or coconut leaf is be tied during communication with the god. This practice gives the vaka more mana and tapu, as the spirit of the god is considered to be travelling with the taunga. Capsizing a canoe through carelessness, lack of skill, or bad temper was seen as disrespectful to the sacred canoe, making it l*epo* (violating the sanctity of a god) and invoking the god's punishment.

These roles and rituals reflect the deep connection between the people of Pukapuka, their canoes, and their spiritual beliefs. The *waoa vaka* was not just a crew but a living embodiment of our cultural heritage, navigating Moana Nui a Kiwa with skill, reverence, and an unbreakable bond to the divine. Through their dedication and adherence to tradition, the sanctity and functionality of the canoe crew is maintained, ensuring that the legacy of our ancestors lives on in every voyage.

Canoe Care and Commemorative Practices in Pukapuka

Growing up in Pukapuka, I witnessed the reverence and meticulous care we gave to our canoes, treating them as extensions of ourselves. When canoes return from a fishing trip or expedition, we carry them up the beach, well above the high-water mark, ensuring the hull rests on chocks (lango) with the bow facing the sea. These chocks are often made from split sections of pandanus logs, laid flat on the ground with a notch cut into the rounded upper surface to cradle the canoe hull. We also use dry butt ends of coconut midribs and half coconut husks for additional support. Turning the hulls upside down before resting the outrigger booms on chocks is common for smaller canoes and dugouts.

Bailing out the canoes and wiping away excess moisture with coconut fibre wringers is an essential ritual. We then cover them with *pola* (old coconut-leaf mats with unplaited dry coconut leaves) and pieces of pandanus matting. This covering, known as *kaukau lama* or *tapola*, is secured with coconut-leaf butts and lengths of timber to prevent it from blowing away in the wind.

Historically, canoes were not anchored with cables. Instead, a stick called *iki tawia* is driven into the sand at the canoe's resting place, just forward of the stern cross boom on the port side, between the hull and the longitudinal spar. This stick anchors the canoe securely, projecting well above the cross boom.

Commemorative Gravestones (Mauli Ola/Mauri Ora)

In Pukapuka, commemorative gravestones, known as *mauli ola / mauri ora*, hold a special place in our community. These markers are placed at locations where individuals were accidentally killed but not buried. Made from undressed coral, they delineate a rectangular area, serving as poignant reminders of the site's significance. Each mauli ola *mauri ora* stands as a silent witness to the lives and stories of ancestors etched into the landscape of our island (Hiroa, 2003).

When a man passed away, it was customary to bury him along with his cherished belongings, such as his paddle, drill, fishing lure, or kawa malo (warrior's wrestling belt), in a section of his canoe cut to his height. I remember seeing many old, retired, or cyclone-damaged canoes stored and used for burials when there was a death on the island and reference by Hiroa, 2003. These practices are deeply rooted in our cultural traditions, reflecting our respect for the deceased and our connection to the sea, which has always been a vital part of our lives. The cultural significance of these commemorative practices extends beyond the physical markers, as they serve as tangible connections to our past, reminding the current generation of the enduring presence of their ancestors and the importance of preserving their heritage.

These commemorative practices found in Pukapuka bear similarities to the stone monuments found in Hawai'i, where they have long-standing traditions of honouring their ancestors by constructing sacred structures like the heiau. Like the *mauli ola*, the lebbing is a four-square box-shaped structure made of flat stone that serves as a marker for the deceased (Sriwigati et al., 2020)[29]. Additionally, the Toraja people of Tana Toraja, Indonesia, also have a deep reverence for their ancestral customs, known as Aluk Todolo, which can include the protection of ancestral relics and the appropriate timing of grave cleaning (Suryamodjo et al., 2022)[30]. These practices reflect the deep reverence for ancestral connections common across many Oceanic cultures.

Building Structures on Pukapuka

Growing up in Pukapuka, I was surrounded by our island's unique architectural heritage. Contrary to what some might claim about the absence of rounded-end houses in Rarotonga, our traditional *wale atua* and *toi nuku* houses reflect the influence of the round-ended Waka-Yamoa-type houses from Samoa and Tahiti. This connection to other Polynesian cultures is deeply embedded in our construction practices and architectural aesthetics.

Pukapuka today has various house types, blending traditional and modern influences. In our permanent villages, many houses are constructed with coral lime and imported concrete blockwork and roofed with iron roofing, replacing coconut and pandanus thatch. Others, introduced by missionaries from Rarotonga, feature slat walls that reach the roof and often include wide verandas. Among these modern structures, old-style dwelling houses and cookhouses still stand, preserving the essence of our heritage.

One fascinating aspect of our village architecture is the presence of small, square, slat-walled houses initially built as bathhouses under missionary influence. While some of these structures serve their intended purpose, most have been repurposed as storehouses for fishing gear, reflecting our community's adaptability and resourcefulness.

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[29] S. Sriwigati, -. Rosmawati, M. Nur, -. Hasanuddin and S. Supriadi, "Stone grave in Sangihe Islands, North Sulawesi".
[30] P. Y. Suryamodjo, N. Azisa and H. Haeranah, "Customary sanctions in resolving violations of the "aluk todolo" of the Tana Toraja community".

Figure 16: Wale pola, living and cook house, in the wakayamoa style

In the village of Loto, a row of wooden structures on coral lime foundations extends into the water a few feet from the lagoon beach. These serve as privies, though many are in dire need of repair. In the old copra villages in the motus, most dwellings and cookhouses adhere to a traditional Pukapukan vernacular. There used to be a great watch house at Mataala Marae in Motu Uta on Wale. Built around 1855 during the first missionary contact (Beaglehole & Beaglehole, 1971-1938), this house exemplified the traditional Pukapukan house. Over the years, the thatching and rotten timbers were replaced, but in 2011, the old building, its paepae, and surrounding structures were removed to construct the new Cyclone Management Centre (CMC) at Mataala Marae.

Through these practices and structures, the people of Pukapuka maintain a deep connection to our cultural heritage, blending tradition and adaptation to preserve the essence of our island life.

Types of Houses/Structures

Wale Mate (house of mourning)

Historically, one of the most poignant structures in our culture is the Wale Mate. This tent-like structure, Te Wale La, is made by sewing together four pandanus mats called kie. It is used during the death of a person, embodying our deep respect for the deceased. The body is washed and placed on an epaepa (a special mat crafted for the deceased by their mother or a close female relative and kept in the house rafters. The tent is placed over the corpse, allowing us to dress them in a malo mate (loincloth for the dead). For a male, this is a short pandanus malo, made by the deceased's mother in advance and reserved for this purpose, wrapped around the waist and between the thighs. This practice is no longer used.

Wale Toinuku - Simple Ridgepost House

Figure 17: Wale Toinuku

Another integral structure is the Wale Toinuku, a simple ridge-post house often erected on exposed outer beaches to serve as cook-houses or sleeping quarters. The framework comprises two ridgeposts (pou tu) supporting a single ridgepole (tau matua). In one subtype, rafters (wuti poto) run from the ridgepole to the ground, while in another subtype, two wall posts (pou) on the side support wall plates (kaukau matua), with rafters running down from the ridgepole to rest on these plates.

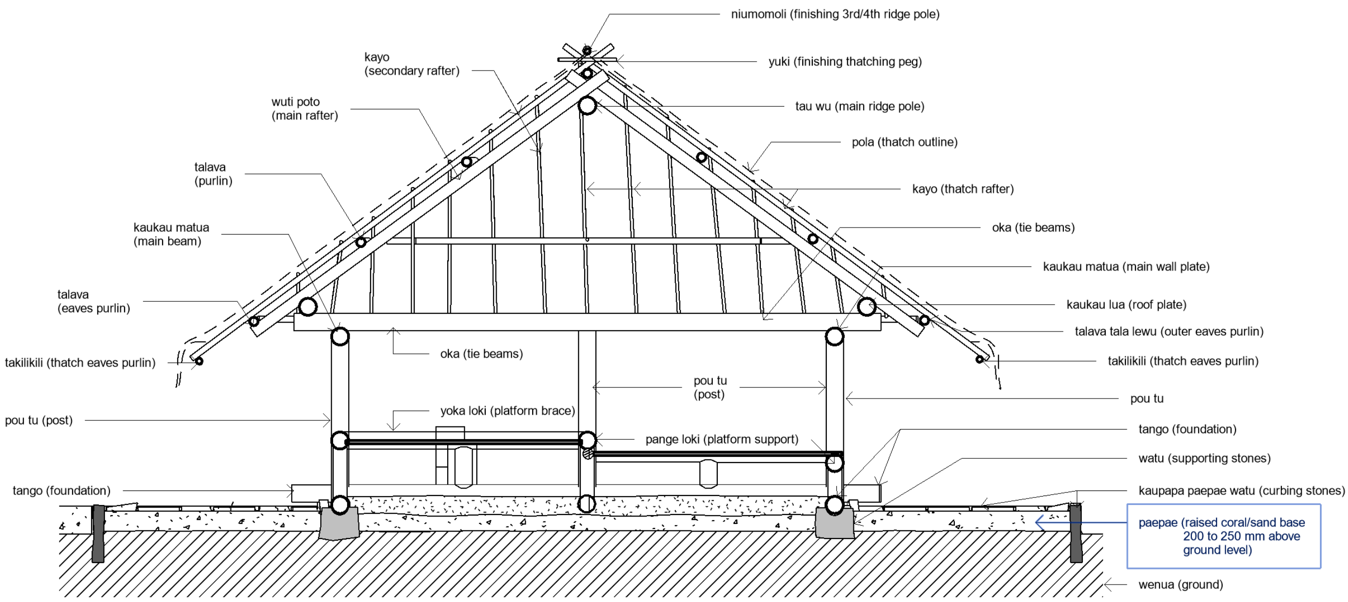


Figure 18: Wale 'toinuku' sleep house section

The thatch coconut roof sheets are laid directly against the rafters, with the midrib bases functioning as thatch purlins. Lashings are typically made of sennit or dried pulaka stalks. Smaller houses of this type have one ridgepole, while more substantial ones have a second ridgepole (tau lua), laid in the crossings of the rafters. The ridgepole roof sheet is secured to the framework by pegs (yuki) pushed through the sheets and between the two ridgepoles.

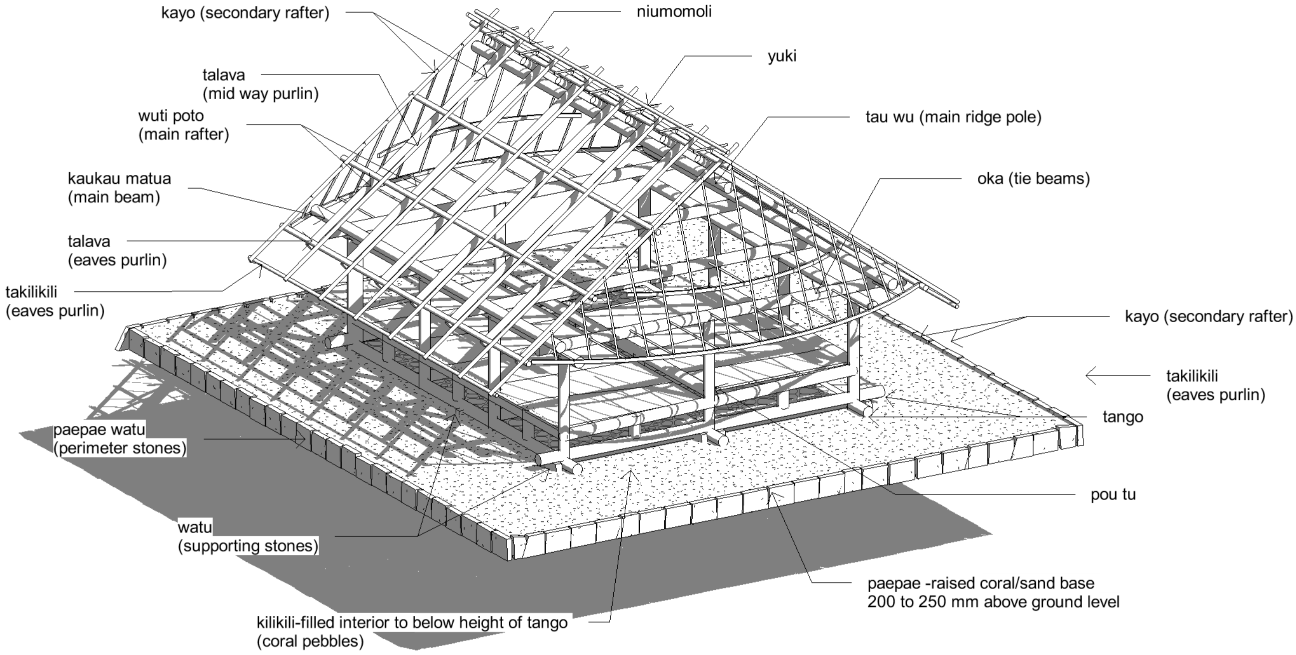


Figure 19: Wale 'wakayamoa' type sleep house

A roof extension (taumata) is often added to the exposed end of these houses, providing additional shelter or for an oven. On the outer beach of Uta, two cookhouses of the toinuku type, each with a roof extension, were observed. These structures have two wall posts on each side supporting a wall plate, with two grooved ridgeposts supporting the ridgepole. Nine rafters run from the ridgepole to the wall plate on each side of the house, with coconut roof sheets laid directly on these rafters. The open sides of the houses offer ventilation, while the extension at the northwest end provides shelter against severe winds and serves as storage for dry coconut shells and firewood.

Reflecting on these architectural elements, I am reminded of the resilience and ingenuity of my community. Our traditional building practices are not just about creating shelter; they are a testament to our connection with nature, our cultural heritage, and our ability to adapt and thrive in harmony with our environment.

Wale wakayamoa - Tie Beam House

The wale wakayamoa (tie beam house), , is a distinctive architectural feature of Pukapuka, influenced by similar styles found in Rakahanga and Samoa but with unique characteristics (Hiroa, 2003). Unlike its counterparts, the Pukapukan tie beam house does not feature a king post. Instead, its principal rafters cross below the ridge pole, and there are no additional wall posts beyond the main series of paired wall posts that support the wall plates, tie beams, and roof plates. This design adaptation reflects our community's response to local needs and conditions (Goad, 2015)[31].

[31] P. Goad, "Architecture in the South Pacific: The Ocean of Islands".

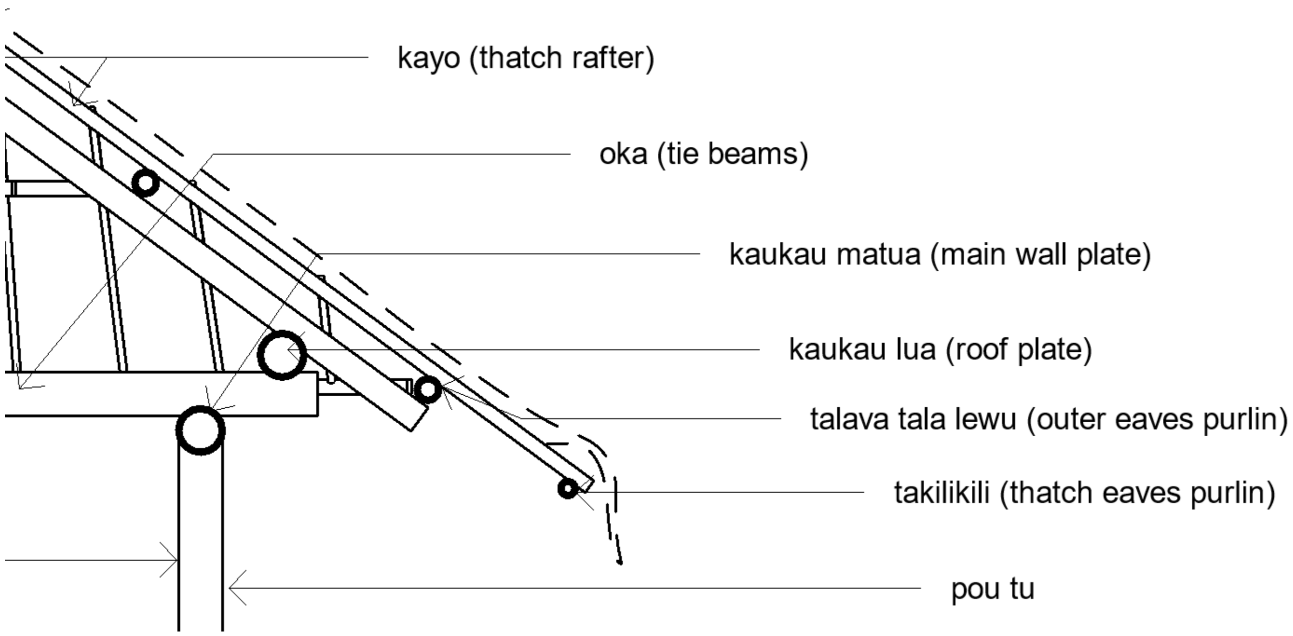
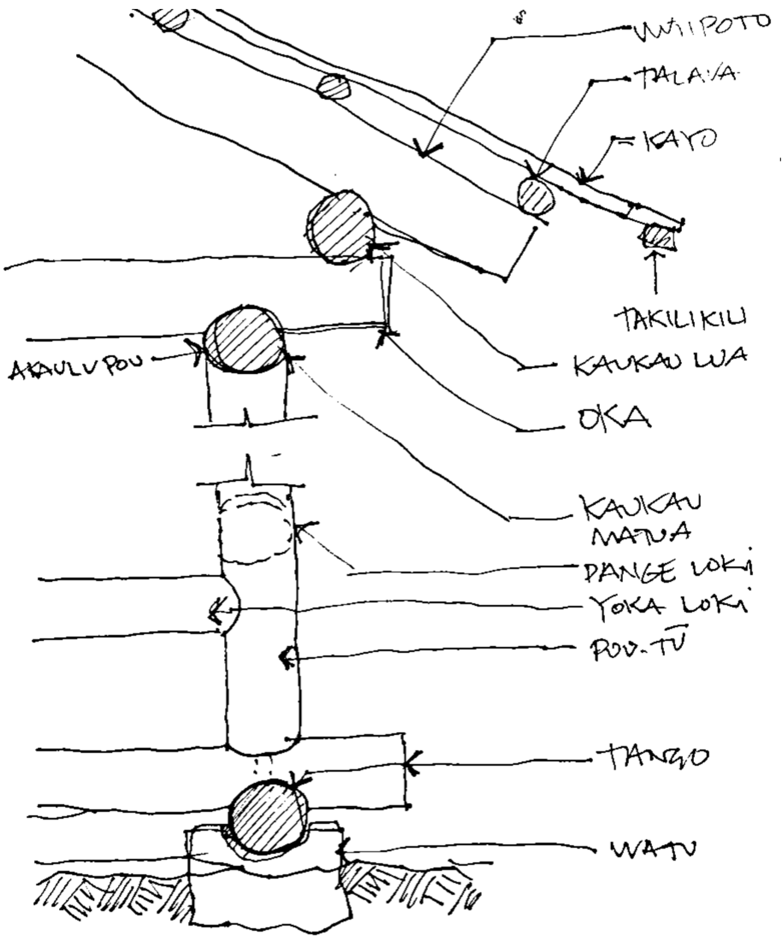


Figure 20: Tie-beam house eaves detail above and below



The term "wall plate" is retained for the longitudinal beam resting on the wall posts, functioning similarly to the tie beam plate in Samoan houses. The name wale wakayamoa likely derives from its resemblance to the Samoan housing style.

These houses serve multiple purposes daily, acting as dwellings and cookhouses in village and copra settlements. When tie beams are covered with a platform (papanga), where coconuts in the takataka stage are stored, the house is referred to as wale takataka, showcasing our ingenuity in maximising the functionality of living spaces (Hiroa, 2003).

In a typical wale wakayamoa, two grooved wall posts on either side support wall plates, with four tie beams (oka) resting on these plates and projecting beyond them. Thin poles support coconut-leaf wall sheets (takapau) at the outer ends of each tie beam, while roof plates (kaukau) rest longitudinally on top of the tie beams. Rafters (wuti poto) run from the roof plate to the ridgepole, crossing above it to support the thatch ridgepole (tau lua). Eaves purlins (takilikili) and a second purlin (talava) are lashed to the rafters inside each side of the house, with additional end platforms formed from pandanus wood sections lashed to the outer tie beams.

A notable feature is the diagonal strut (yoka) running inside the rafters from the ridgepole to the roof plate, providing primary support and eliminating the need for additional structures. Gable ends are constructed with end rafters (wuti poto tala lewu) lashed to side eaves purlins and end side rafters, supported by end purlins midway between eaves purlins and ridgepole.

These intricate details of the wale wakayamoa reflect our community's architectural knowledge and deep-rooted connection to our environment and cultural heritage (Hiroa, 2003). Each element of the house design serves a purpose, balancing functionality and tradition to meet the diverse needs of daily life on our island.

a) Ao tapeka/ Nonoa - Lashing

The lashing used for all parts of the house framework in Pukapuka is known as yimu wakawiwi, characterised by its pattern of alternating curves. This method closely resembles the curved pattern lashing described by Buck for a type of Rakahangan house[32], with a slight variation in the Pukapukan commencement technique. Figure 16 illustrates this lashing method.

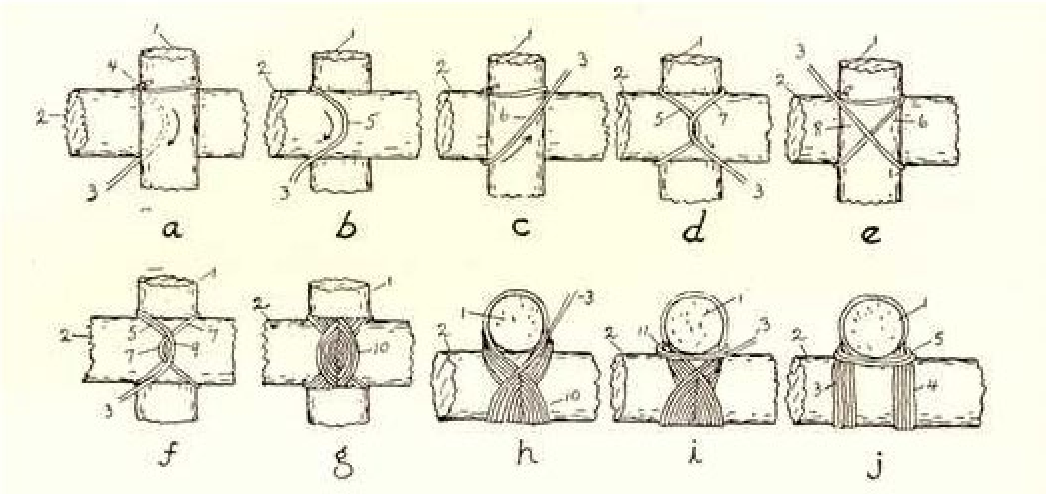


Figure 21: Rakahanga lashing

The yimu wakawiwi lashing is prevalent in Pukapuka and is used extensively on houses and canoes. It is the go-to technique for securely fastening together two crossing elements as shown in Figure 22.

This detailed lashing technique exemplifies the Pukapukan people's intricate craftsmanship and practical ingenuity in constructing durable and resilient structures.

[32] Ethnology of Manihiki and Rakahanga, Te Rangi Hiroa (Sir Peter Buck), 1932, p72.

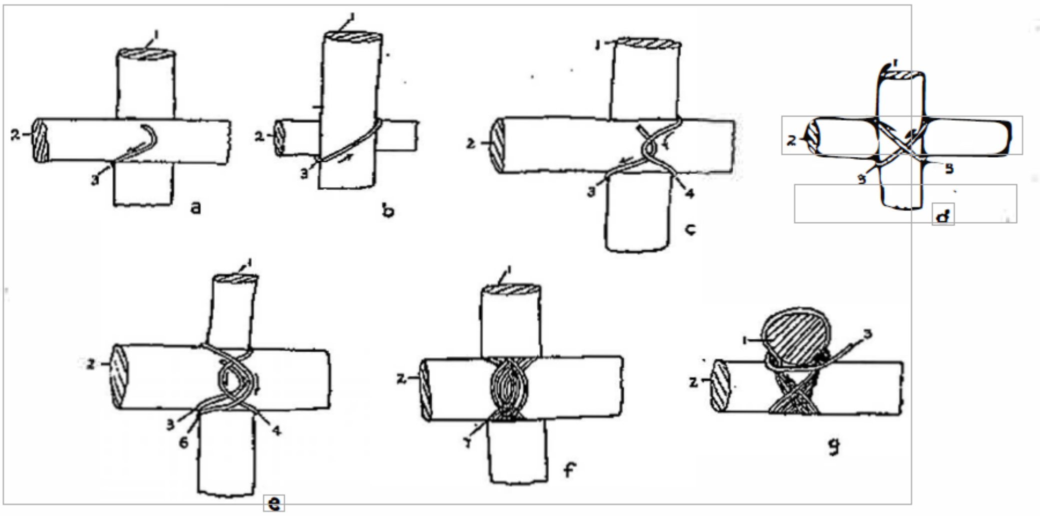


Figure 22: Pukapuka alternating curve lashing

i. View from above: The sennit braid is laid on the wall plate and held in place with the thumb; the free end makes a curved turn on the underside of the wall plate.
ii. View from below: The free end makes a transverse turn across the tie beam.
iii. View from above: The sennit braid is brought across the commencement end, with the thumb holding the crossing cords in place while the braid makes a curved turn across and down at the wall plate.
iv. View from below: The braid makes a transverse turn across and up the tie beam to curve around the wall plate.
v. View from above: The braid curves to the right across the second curve, locking the preceding two curves in place. The thumb is then removed, and the rough sennit does not slip.
vi. View from above: The pattern is produced by repeating two curved turns successively applied on the outer side of previous turns. The number of lashings varies according to the elements, with an average of five curves on either side totalling ten.
vii. Side view: Crossings of turns and half of one design. The braid makes several horizontal circumferential turns around the lashing turns between two wooden elements. Half hitches around the last loops fix the end of the braid.

Figure 23:Yimu Wakawiwi or Paiokiole lashing technique, old meeting house Nassau, 1987

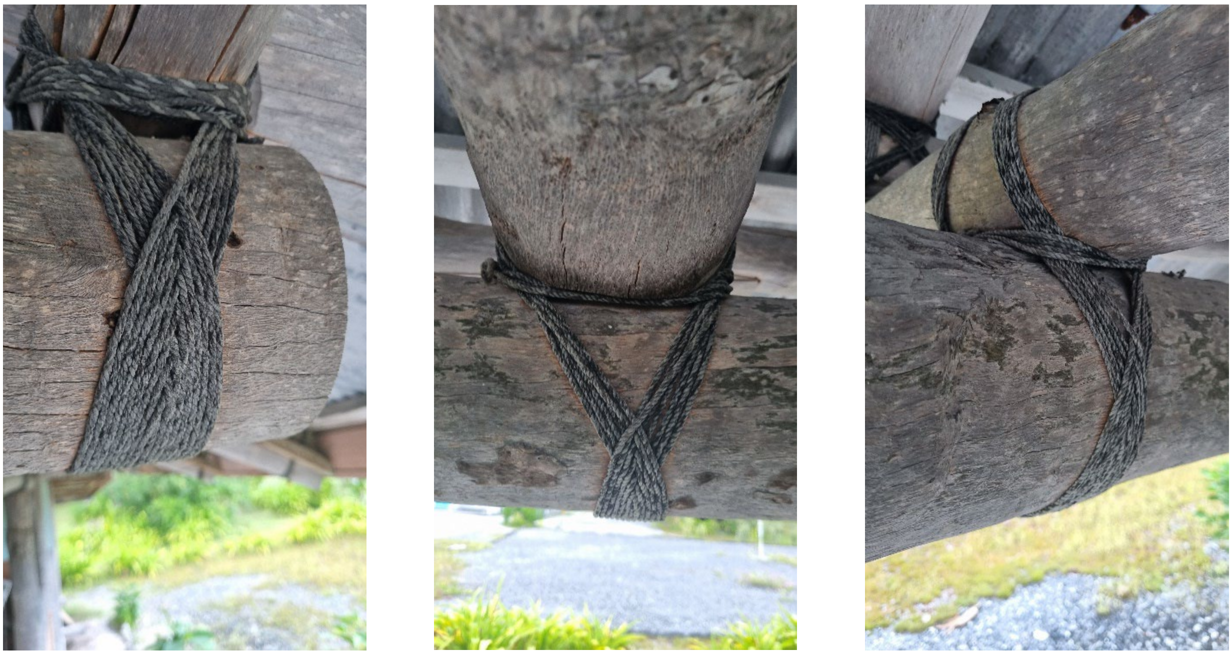


Figure 24: Yimu Wakawiwi lashing technique on new Nassau meeting house, 1987

This intricate lashing technique exemplifies the Pukapukan people's exceptional craftsmanship and practical ingenuity in constructing durable and resilient structures. The process of creating lashing, known locally as *kawa*, is closely related to the traditional methods used in Tonga and Samoa. It involves soaking coconut husks in the lagoon for an extended period, followed by a thorough drying process. The fibres are then meticulously rolled, either along the thigh or the inner sole of the foot, similar to the method used for rolling tobacco cigars. This labour-intensive procedure reflects the skill and dedication required to produce strong, reliable lashings essential for the structural integrity of traditional Pukapukan architecture (Te Rangi Hiroa, 1932[33]; Kirch & Green, 2001)[34]

b) Pola launiu – Thatching

Figure 25: Thatching new roof with lau wala

Traditionally, all houses were thatched with coconut roof sheets, known as *pola launiu.* The method of weaving the double coconut sheet is similar to that described by Buck[35] for Aitutaki. Before being made into roof sheets, the coconut leaf midribs are soaked in saltwater for a few hours to eliminate insects. The roof sheets are attached to the rafters using *uka*, a continuous two-ply twisted

[33] Te Rangi Hiroa (Sir Peter Buck). (1932). Ethnology of Tongareva. Bernice P. Bishop Museum Bulletin.
[34] Kirch, P. V., & Green, R. C. (2001). Hawaiki, Ancestral Polynesia: An Essay in Historical Anthropology. Cambridge University Press.
[35] The material culture of the Cook Islands (Aitutaki) / by Te Rangi Hiroa (P.H. Buck) 1976

sennit cord. The method of passing the cord through the sheets from the inside of the house and back from the outside is the same as that described for Aitutaki. However, in Pukapuka, *yuki*, (a special thatching needle) facilitates this work.

There are two methods for applying the sheets to the rafters:

- Ato Yinaki Lau (row of sheets): All sheet midribs are the same length and applied in courses running from eaves to ridge-pole, with the midribs overlapping by about one inch in contiguous courses.
- Ato Tele (extended row of sheets): uses both short and long midribs, alternating each course. Sections run from eaves to ridgepole without the defined courses of the *ato yinaki lau* method. Although more laborious, a well-thatched roof using this method is more waterproof and can last up to ten years, compared to four to five years for an *ato yinaki* roof.
- To thatch a roof section, a long, *pola wawati* doubled sheet is placed on the rafters above the eaves, followed by a long sheet on top of this, and then lashing to the rafters begins. Short sheets alternate with long sheets. As thatching progresses up the side of the roof, a worker lifts the roof sheets to those lashing from inside by skewering them with a tuku pola (lifting pole). In both methods, the last sheet applied on the sides is long. On top of this, overlapping the ali (ridgepole break) between the thatchings of the two sides, another sheet (pola ati) is placed, covered by another sheet (pola tau-poto). Finally, a coconut ridging mat (takupau tau taupoto), made of two split half leaves and one whole leaf, is placed on top, as described for Aitutaki.

The gable ends are thatched similarly, starting from the double sheet at the eaves and working up to the ridgepole. The sheets are shortened as thatching nears the ridgepole. A small space is usually left at the top for ventilation, and the edges of the end sheets are often wedged between the side thatching sheets. Some leave the overhanging eaves sheets ragged and irregular, while others carefully trim them to an even line which are known as *kotikoti te tulutulu wale*.

Figure 26: Gable end eaves, showing oka (tiebeams) kayo (thatch rafters) and talava (purlins)

When heavy winds are expected, the thatching is reinforced by knotting together the tip ends of two coconut midribs, slung over the roof so that one midrib falls on each side. For low roofs, the leaflets at the butt end of each midrib are carried under the eaves and tied to a thatch rafter. For high roofs, the weight of the midribs is sufficient to hold down the thatching. Several double midrib slings are placed along the roof for added protection.

Thatching with pandanus leaves was introduced to Pukapuka by missionaries from Rarotonga, following methods from Aitutaki. Pandanus leaves are collected and straightened by passing them around an upright stick. The leaves are then bundled by placing the tip end of each leaf over the butt end and tying the ends together. The leaves are bent over and sewn to strips of wood split from the aerial roots of the pandanus. A *tui* (sewing needle) splits the longitudinal grain of the pandanus leaves, allowing the *tuaniu* (coconut leaf midribs) to be inserted to keep the leaves in position on the wooden strip. The completed roof sheet is called *pola lauwala* (pandanus thatch).

c) Framing

Pandanus wood is predominantly used in the framework of the *wakayamoa* type house. Historically, wall posts were buried about 300mm in the ground, a task that required significant effort and skill. In modern houses, four ground posts are supported on low, grooved coral stones, and the wall posts are fitted to these ground posts using mortise and tenon joints. While less labour-intensive, this method still requires a high level of craftsmanship. However, in older houses, this would have required extensive labour with shell adzes, so only the tops of the wall posts were *wakaulu pou* (grooved) to receive the wall plates, the heads of the rafters were chipped out *wakatala* to fit against the ridgepole. The roof plates were *waka kamu* (grooved) to fit against the tiebeams. If a house framework needed to remain unthatched for several days, all principal posts were wrapped with *takapau* (coconut leaf mats) and rafters were covered with a few coconut midribs to protect the timbers from rotting or warping due to sun or rain. Many of the buildings shown in these images were built in the 1980's and 90's showing the resilience of the pandanus timber when protected by the elements. When cured and dried, pandanus, is referred to as 'steel-like' timber when cut at the right time and not exposed to the rain.

Figure 27: The mighty pandanus tree, wala

d) Takapani - Wall Mats

In traditional *wakayamoa* type houses, walls were made with *takapau (*coconut leaf mats). These mats were made long enough to overlap two wall poles, each with a plaited depth of about 300mm. Typically, four mats formed a set between each pair of wall poles. Two or three sennit cords spaced equidistantly supported The mats at their upper, midrib edges. This support method is the same as the Samoan method. The mats operated on a Venetian blind system, being raised and lowered according to the direction of the prevailing wind. The overlap of the mat screens against the wall poles prevented them from being blown inward by the wind.

Figure 28: Wall mats, pola & takapau. Note ;yoka bracing

Figure 29: Takapau wall mat

e) Wooden Walls

Two approximately 150mm in diameter pandanus logs are positioned between the wall posts: one at ground level and the other approximately 760mm above the ground. On the inner surfaces of these logs, a rough slot, hollowed out to about 75mm deep and 100mm wide, accommodates a series of puapua poles. These poles, roughly 900mm long and 38mm in diameter, are inserted vertically between the two logs, with each pole's upper and lower ends resting securely in the slots. This construction forms a wall structure resembling a closely spaced railing fence (see fig 29), enclosing any side of the house while leaving one end open for a door.

Figure 30: Timber wall slats, & takapau on ground

On the outside of this low wall, between the top of the wall and the roof eaves (if the eaves are high), *takapau* mats are hung for additional protection. While in Rarotonga houses situated in less exposed areas often omit this extra matting. The method of adding such a wall by inserting horizontal slats between uprights and securing them with continuous sennit cords is a modern innovation introduced by Rarotonga.

f) House Platform

Most dwelling houses, and occasionally houses for cooking, are constructed on a *paepae* (raised sand & coral foundation), which extends several feet beyond the ground area covered by the house. This rubble foundation is bordered by a curb of coral stones measuring 200 to 250mm in height. Some houses are built on a secondary or elevated platform made from rubble, enclosed by either coral or log curbing. This elevated platform serves as the house floor, extending approximately 300mm to 10000mm beyond the house walls. In copra settlements, most houses are situated on a single low platform, with gravel inside the house contained by log curbs.

Figure 31: Platform stones (new) to small cookhouse

Figure 32: Platform stones raised around building. Note 'yoka' bracing

Figure 33: Old platform stones 1979 to perimeter of building. Interior replaced with concrete slab

g) Variations on the type house

Variations of the wakayamoa house type is found in the copra settlements (small communal houses for copra harvesting). One such variation, located on the back ridgepole of Uta Beach, closely follows the wakayamoa style, except for the ridgepole being supported by two ridgeposts on the inner side of the tiebeams. This hybrid house combines elements from both the wakayamoa and wale atua types.

Figure 34: Typical wakayamoa type,sleeping house (wale). Note ‘yoka bracing

In exposed beaches, most houses are permanently enclosed on three sides with *takapau* mats or *pola* roof sheets secured to wall poles. Only the leeward side remains open between the ground and low eaves. In exposed situations, cook houses and dwelling houses of the *wakayamoa* type are equipped with *taumata* (roof extensions) to cover ovens or serve as spacious windbreaks. On the exposed side of the house, rafters extend approximately 450 to 600mm from the ground and are supported by subsidiary wall posts and a subsidiary wall plate. This extension is thatched, and durable *takapau* mats are attached to the outer surface of the subsidiary wall posts.

Figure 35: Takapau or pola matting closes the trade wind sides

An example of a typical *wakayamoa* house used as a sleep house in Yato village measured 4775mm by 3530mm wide. The eaves were 1371mm from the ground, and the ridgepole stood 2921mm from the ground.

h) ***Wale takataka*** **-Storage Houses**

Figure 36: Small storage house for puru (husked coconuts)

Figure 37: Small store house, interior view. Note 'yoka' bracing elements

Storage houses of the *wakayamoa* type, known as *wale takataka*, are frequently constructed at a distance from the village to minimize fire risk yet remain easily accessible. These structures store nuts, fishing gear, or old canoe sections. The floor of a *wale takataka* is mainly kept clear and serves either as a storage area for lumber or as a workshop for various craft activities for both men and women. The *papanga* or platform of slated wood was laid on top of the tie beams. The rafters were fixed closely together to prevent anyone from inserting their hands. Depending on the number of nut trees owned and the quantity of nuts requiring storage, individuals may possess one or multiple *wale takataka*. In former times, before the advent of copra production, an average family typically owned three to four such houses.

Takataka - Storage Platform

Nuts at the takataka stage are stored on a platform laid across the tie beams, occupying the entire area defined by these beams. The platform and rafters are closely spaced to deter theft. Access to the platform is typically through one or two gates or hatchways positioned at the center. In the past, the bottom hatch (pulua) was flush with the platform and secured with intricate knots known only to the house owner. These fastenings were undone during use and the hatch placed on the ground. The top hatch (pu tai), located approximately 300mm above the first hatch, was horizontally lashed to the tops of slender vertical poles. These poles were lashed at their bases to the platform supports, creating a sort of box structure resting on the platform.

When visiting the *wale takataka*, the owner would bring a wooden block placed on the ground under the hatch. Using this block as a step, the owner would unfasten the first hatch, often containing a length of rope. This rope would be secured to the platform, allowing the owner to ascend and open the second hatch using the hanging rope. Upon departure, the owner would securely lock the hatches, re-tie the knots, place the rope on the platform, and remove the wooden block.

After contact with outsiders, a short ladder resembling a truncated grocer's ladder, known as *tula* (derived from the word "stool"), became standard for reaching the platform hatches. This ladder was typically kept in the owner's sleep house when not used elsewhere. It is noteworthy that I did not observe any *wale takataka* houses with two hatches in the storage platform during my observations. While historically described practices often involved two hatches, many contemporary houses now use a single hatch, often secured with hinges and a padlock to the platform.

i) ***Wale Atua* – God House Ridgepole, wall plate house Marae Mataala**

The *wale atua* house is characterised by bilateral wall plates supporting two or more ridgeposts that uphold the ridgepole (see fig. 37). Historically, these houses were primarily used as god houses *(wale atua)*, owing to their robust construction style, which also made them suitable for meeting or watch houses. Occasionally, smaller variants of this type were used as sleep houses. Today, examples such as the watch house at Marae Mataala, are dotted around the main island of Wale on the Motu's Uta, Ko and Kotawa.

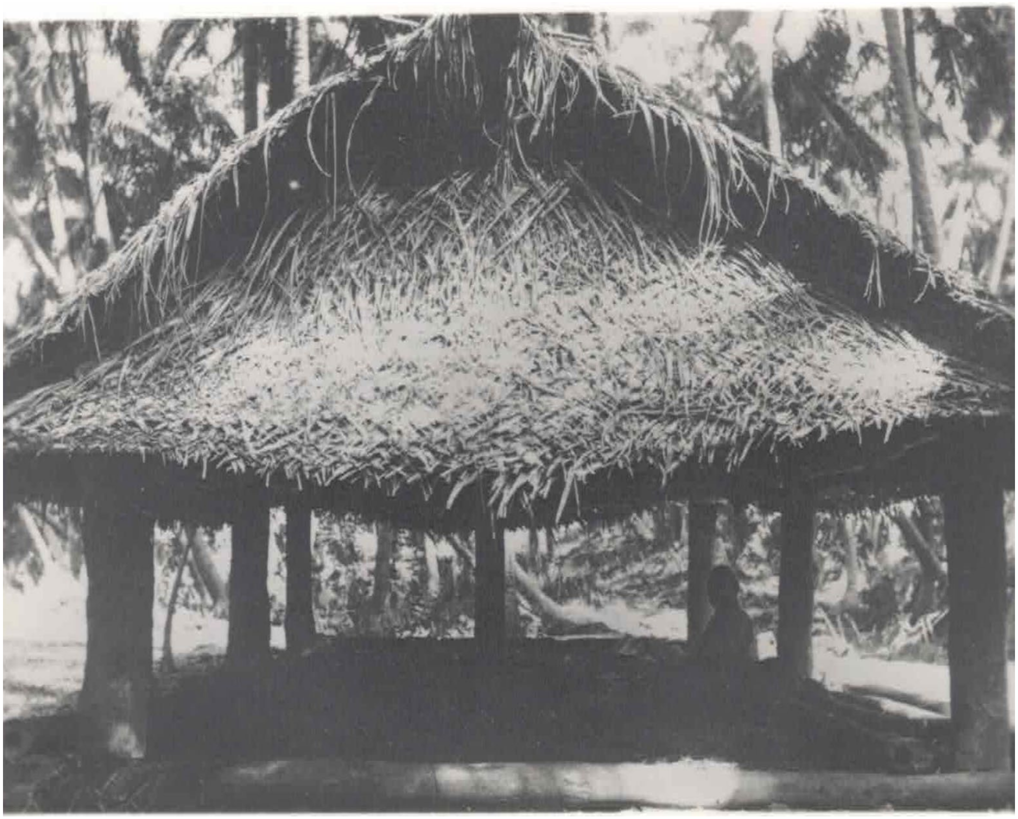


Figure 3738: Marae Mataala wale

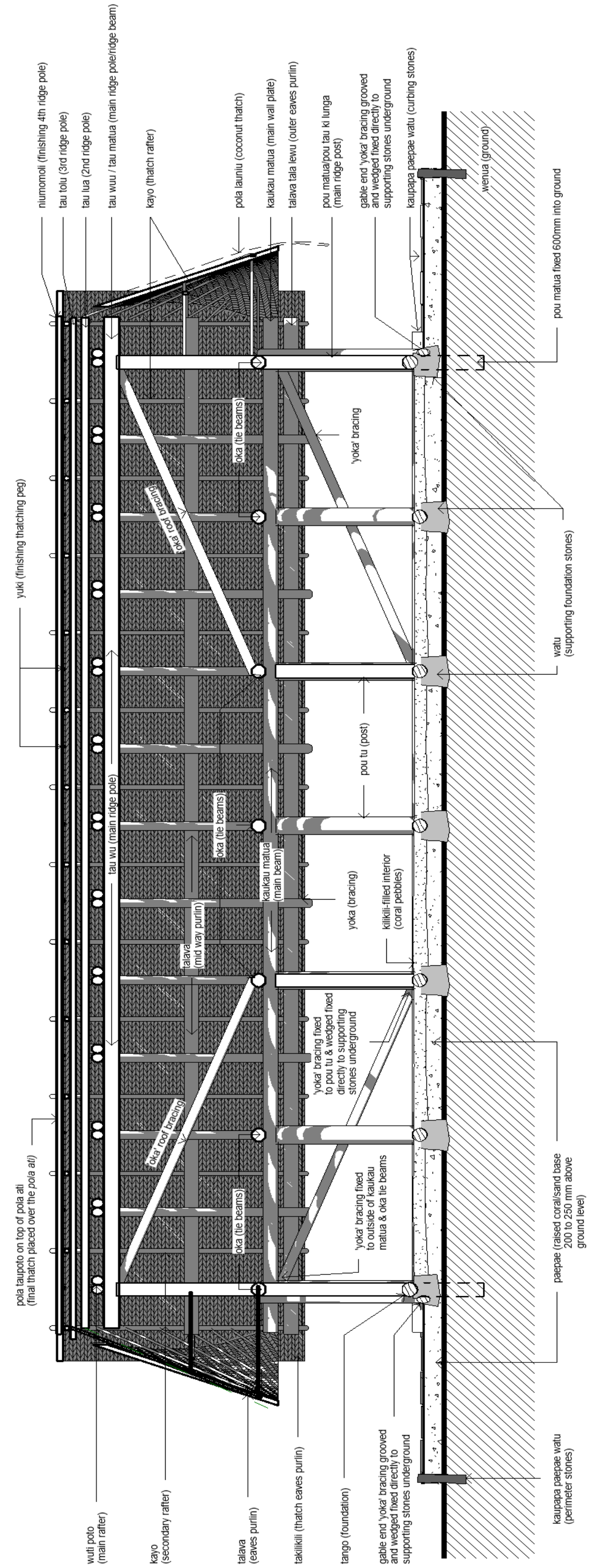


Figure 38: Wale Atua cross section

The *wale atua* house is characterised by bilateral wall plates supporting two or more ridgeposts that uphold the ridgepole (see fig. 38). Historically, these houses were primarily used as god houses *(wale atua)*, owing to their robust construction style, which also made them suitable for meeting or watch houses. Occasionally, smaller variants of this type were used as sleep houses. Today, examples such as the watch house at Marae Mataala, are dotted around the main island of Wale on the Motu's Uta, Ko and Kotawa.

The watch house was originally built with six wall posts, later reinforced with a seventh post for additional strength. These *puapua* ([*Guettarda speciosa, Beach Gardenia*]) wood wall posts are buried about an arm's length into the ground and are round in cross-section, except at the top, where they are roughly adzed into a rectangular shape. Each post's top is grooved to accommodate the unlashed wall plates made from pandanus wood, which rest securely within these grooves (see fig 42).

Figure 39: Wale atua style house style, Nassau

Figure 40: Wale house under construction

Five tie-beams span across the wall plates—one at each end and the remaining three equidistant along the length of the house. The end of each tie-beam is grooved to fit snugly over the corresponding wall plate to which it is lashed. These tie-beams are flush with the wall plates once installed. Two ridgeposts of *puapua* wood are positioned at one end, buried in the ground, and grooved at the other to support the main ridgepole made from pandanus wood. The ridgepole rests in these grooves without lashings. Each ridge-post rises from the ground on the inner side of the second tie-beam from each end, approximately 100mm in round cross-section, grooved at each end to fit against the ridgepole and wall plate, where they are securely lashed.

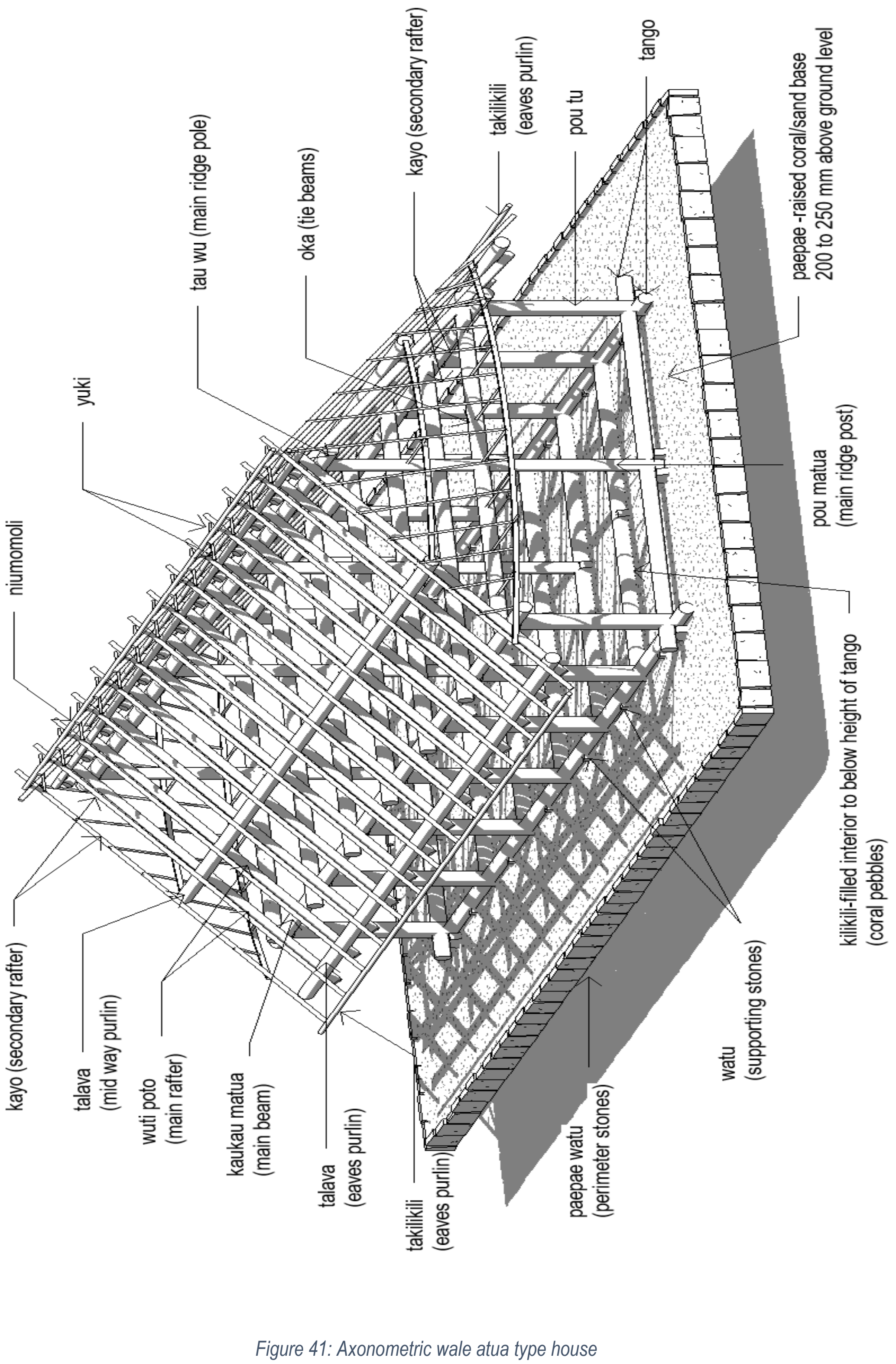


Figure 41: Axonometric wale atua type house

Figure 41: Wale atua house with tie beams notched into top wall plates

Each rafter extends approximately 225mm beyond the wall plate at its lower end. Before lashing, the underside of the rafter end is flattened to ensure a tight fit with the square face of the eaves purlin (see fig 42).

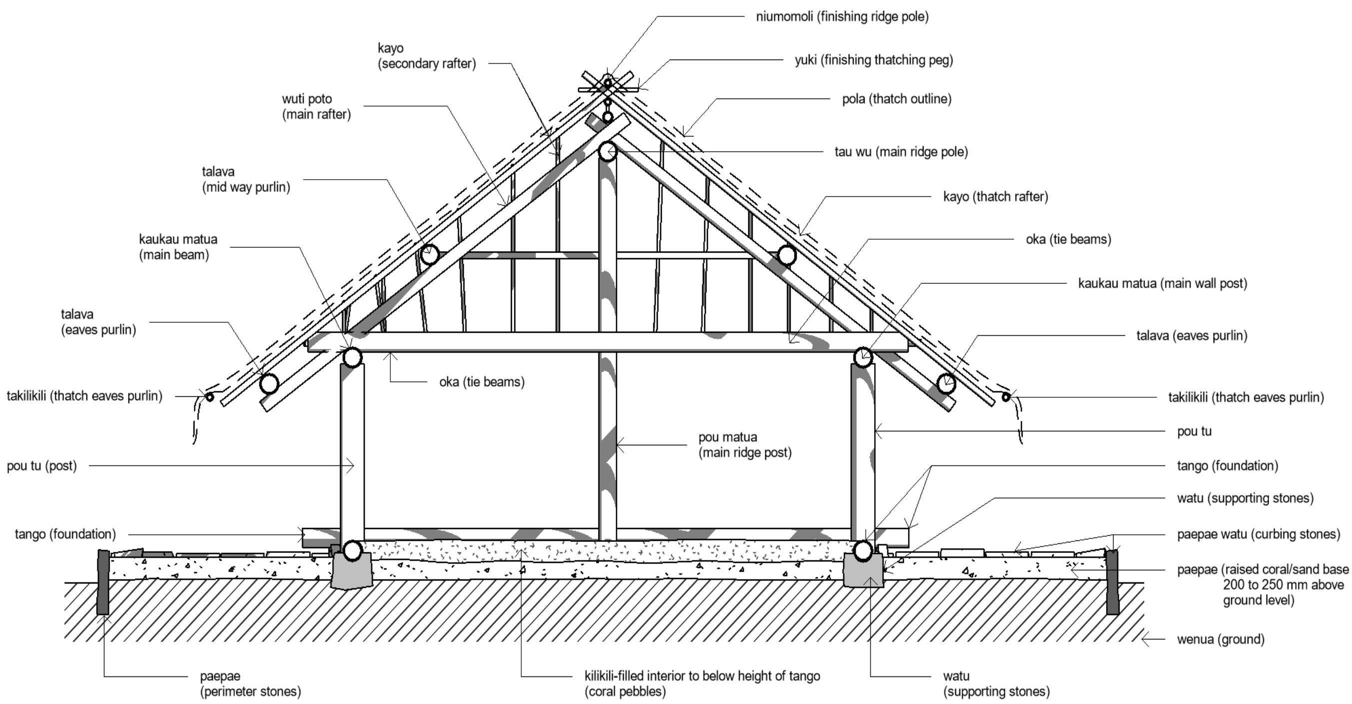


Figure 42: Section through wale atua, wale tulu

25 thatch rafters (*kayo*) made from *puapua* wood are lashed to the eave and midway purlins on each side of the house. Near the top, each pair of thatch rafters crosses over the ridgepole to support a thatch ridgepole, to which each rafter is securely lashed. At the bottom, the thatch rafters are lashed to a longitudinal thatch purlin resting atop the series of rafters.

Each gable end begins with three main rafters crafted from *wakanava* wood, lashed to the end tiebeam. The two outermost end rafters extend between the end tiebeam and the outermost side rafters, where they are lashed about two-thirds of the way up from the lower ends of the side rafters. The middle end rafter runs from the end tiebeam to the main ridgepole, where it is lashed approximately 0.9 meters (3 feet) from the end of the ridgepole and on the inner side of the first two main end rafters. An end eaves purlin is lashed to the bottom ends of these end rafters. Nine end thatch rafters are lashed at their lower ends to an end eaves purlin and at their upper ends to the adjacent side thatch rafters. This arrangement causes the gable ends of the house to slope inward, projecting the main roof beyond the gable end by about 0.76 meters (2.5 feet).

The house employs two types of lashings. Thatch rafters are secured to eave, midway purlins, and to the thatch ridgepole with a continuous cord of three-ply braided sennit, 6 mm thick. This lashing method involves two transverse turns around the intersecting elements, followed by a single circumferential turn between the turns, then onto the next intersection. All other lashings utilize the typical Pukapukan alternating curves pattern with three-ply braided sennit, ranging from 3 to 6 mm thick.

Figure 43: Paiokiore lashing

The roof is thatched with coconut roof sheets, following the method used for the *wale wakayamoa* house. The floor is covered with coral gravel, retained by lengths of timber laid on the ground inside the wall posts.

Key measurements of this wale atua type watch house are as follows: length, 10.4 meters; width, 4.3 meters; height of wall posts from the ground, 1.5 meters; height of eaves from the ground, 1.2 meters; height of ridgepost, 3.1 meters; diameter of ridgepost, 12.7 to 15.2 cm; diameter of wall posts, 22.9 cm; diameter of tiebeams, 15.2 cm; diameter of principal rafters, 10.2 cm.

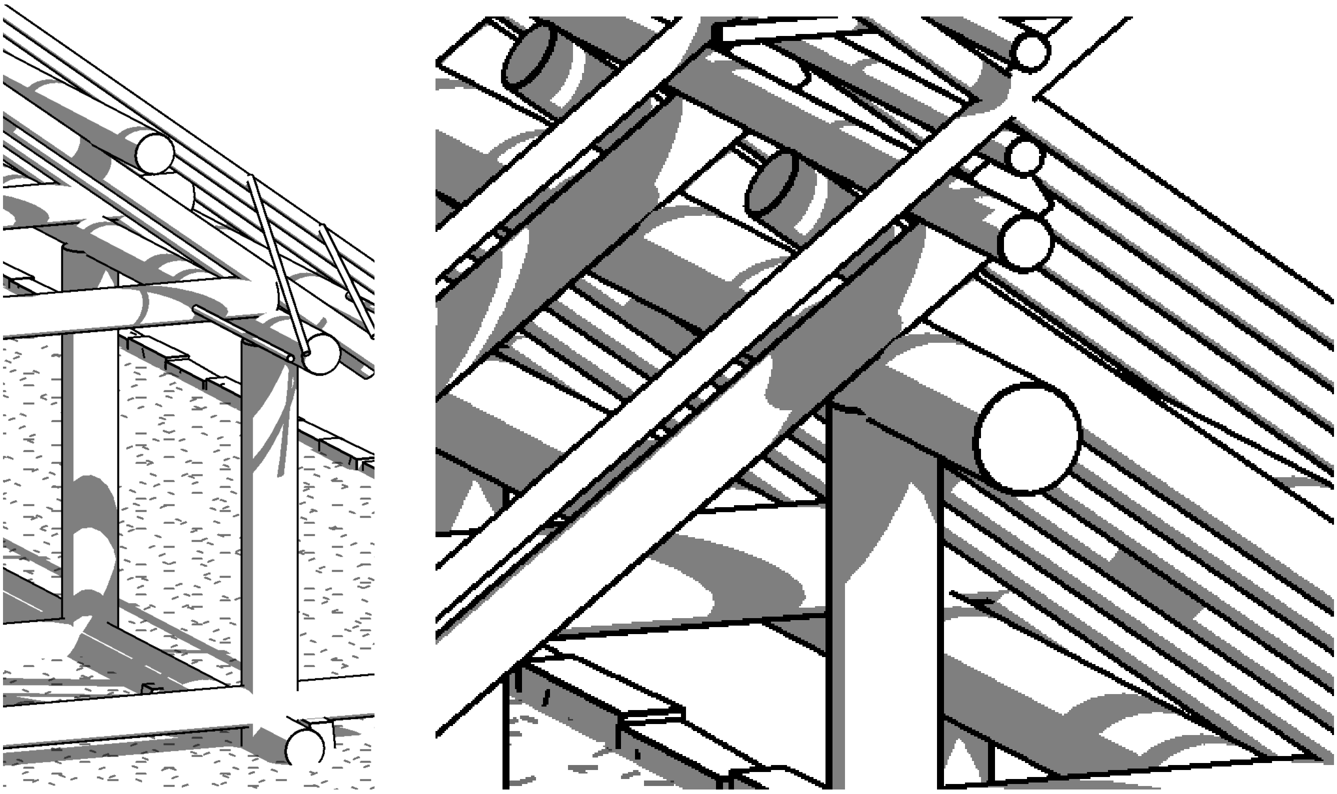


Figure 45: Left - detail view of post-to-beam connection & right - niu momoli (4th ridge pole) at roof apex

Figure 46: Underside view of post beam, rafter eaves connection. Note recycled notched wall plate

Variations
The construction of the sleep house on the outer beach of Uta are identical with the basic structure of the watch house from Marae Mataala, except for the following variations:

Wale moe - Sleep house
This house features a basic structure similar to the watch house described earlier but with several notable variations. It includes four ridgeposts grooved to support the ridgepole. Each side of the house has four wall posts grooved to hold the wall plate, supporting four tiebeams positioned flush with the wall plates. Thatch rafters cross above the ridgepole to support a thatch ridgepole, with their lower ends flush against the wall plates. There are no purlins or thatch rafters; coconut roof sheets are directly fastened to the rafters.

Subsidiary wall posts are placed every 60 cm (2 feet) along the windward side and west end, lashed at their upper ends to the wall plate or end plate. Thatching from the roof or end extends to the ground on these sides, with coconut roof sheets applied directly to the subsidiary wall posts, forming a permanent wall. At the east end, the end rafters extend at a 60-degree angle from the side rafters and are supported at their lower ends by six low end posts, each 50.8 cm (20 inches) high, and an end wall plate. Thatching at the east end continues to the ground, tied directly to the end wall posts. The entire south (leeward) side of the house remains permanently open. Refer to Fig 47 below.

Figure 44: Wale pola house at motu Uta, south side of house remains open. Note the pandanus tree to the right

This house measures 7.3 meters long and 3 meters wide, with a ridgepost height of 1.8 meters and eaves at 0.9 meters from the ground. It is designed to be low, strong, and compact, well-suited to withstand strong northwest gales prevalent on the exposed beach.

Modern House Combining Features of Wale Wakayamoa and Wale Atua Types:

This house incorporates elements from both the wale wakayamoa and wale atua types. It includes five wall posts on each side, two wall plates, and six tiebeams that extend beyond the wall plates to support two roof plates. Four ridgeposts are positioned—one on the inner side of each end tiebeam and two on the outer sides of the third and fourth tiebeams. Eight principal rafters on each side run from the roof plates, crossing above the main ridgepole to support a rafter ridgepole (tau lua).

On each side are two purlins—an eaves purlin and a narrower midway purlin, which is widened with chocks (*neinei)* to maintain equidistance of thatch rafters from principal rafters. Thatch rafters run outside these purlins and support a third ridgepole (thatch rafter ridgepole or t*autolu*), separated from the rafter ridgepole by chocks (*neinei)* but lashed to the thatch rafters. At the top of the crossed thatch rafters is laid a fourth ridgepole (thatch ridgepole or *niu momoli*). Fig 45. At the bottom, the thatch rafters support a thatch eaves purlin *takilikili*.

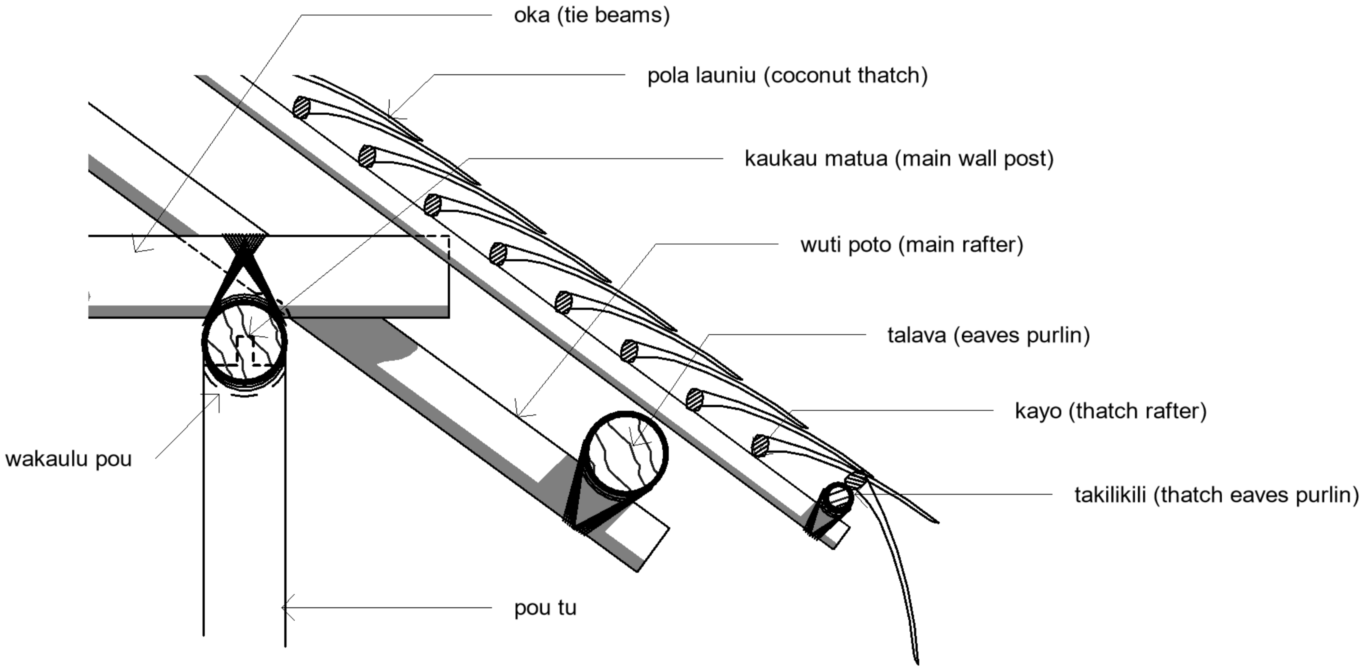


Figure 4845: Typical post, beam, rafter eaves section

At each gable end, end wall plates (or additional tiebeams) are lashed at each end to the ends of the side wall plates. Principal end rafters are fastened at the top to the second side rafters, except for the center end rafter, secured to the main ridgepole between the second and third side rafters. At their lower ends, the end rafters are lashed to the end wall plate but extend downward to support an end eaves purlin, which is fastened at each end to the side eaves purlins. End wall plates are braced by two struts *(yoka)* lashed to the outer tiebeams and projecting far enough to be secured to the end wall plates. End thatch rafters run outside the end eaves purlins to the first rafter on each side, with a thatch rafter eaves purlin lashed to their bottom outside, joined at each end to the side thatch rafter eaves purlins.

The ridgepole is further reinforced by *yoka* (two diagonal braces), each running from the middle of the third tiebeam to the main ridgepole and lashed to both the tiebeam and the ridgepole (Fig 33, 38).. The lashings throughout the house follow the Pukapukan pattern. The central principal rafters and diagonal braces, lying obliquely against the main ridgepole, are lashed with four transverse turns tightened by *yimu u'akapeka* (three circumferential turns). The first and second ridgepoles, and again the third and fourth ridgepoles, are braced against each other by five transverse turns of sennit, tautened by three or four circumferential turns, forming a yimu wakamau (suspended loop lashing

These variations in the model wale atua type house align it closely with the wakayamoa house type, with the key distinction being the use of ridgeposts and a sturdier roof framework. Informants suggest projecting the tiebeams beyond the wall plates, then adding roof plates to support principal rafters, protects pandanus wall posts from weather exposure. This design, with eaves providing ample protection to wall posts, allows for easy replacement of supporting poles if they rot, compared to rebuilding the roof framework to replace main wall posts.

House Furnishings

Furnishings in Pukapukan houses are typically simple. People sleep on coconut leaves and pandanus sleeping mats placed on the coral pebble floor or wooden platforms. When not in use, mats are tapulu (rolled) and stored on rough platforms made by laying longitudinal members across the house's tiebeams.

Tuluma (plaited pandanus satchels) are used to store valuable fishhooks, and larger satchels for *malos* (loin cloth) and other clothing items are also kept on the tiebeam platforms.

Ulunga laukawa (pandanus pillows) and *ulunga lakau* (wooden headrests) are occasionally used. Many people, however, use any suitable wood block for sleeping purposes. In the past, a common headrest is a block of wood inserted into a European pillowcase and filled tightly with a thin layer of kapok, combining desired hardness with the prestige of using a European object.

Teke (wooden backrests) made from wakanava (*Pacific Rosewood, Cordia subcordata)* wood was occasionally used for reclining inside or outside the house.

Ueue (insect switches) are in demand during *namu* (mosquito) season. These switches are quickly made by binding three sections from the tip end of coconut leaf midribs together with fibre or knotting two leaflets around several midribs in opposite directions. The switch is discarded when the leaflets dry out.

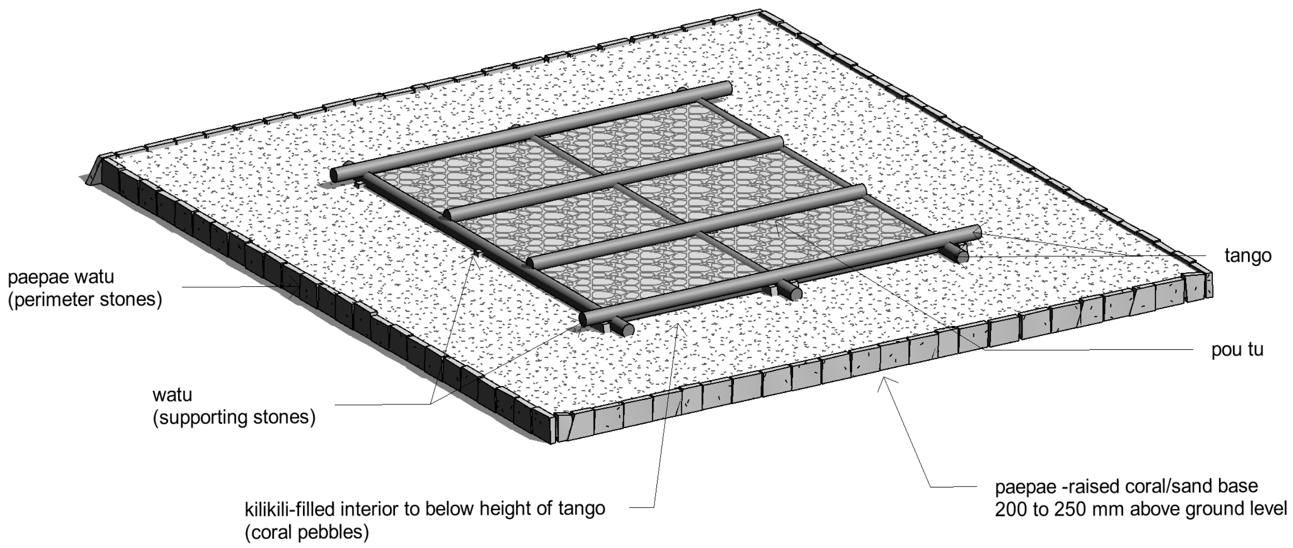
velevele (brooms) made from coconut leaflet midribs are commonly used to clean dwellings or cook houses. A short broom (*velevele tua niu*) is made by braiding midribs stripped from coconut leaflets and dried in the sun. About 170 midribs, braided with pandanus material (lito), form a bundle with approximately 60 cm long bristles.

A large broom (velevele wolo) for sweeping outside houses is made from hard, dried coconut midribs gathered around a long handle, typically ngangie wood about 1.2 meters long. The midribs are fastened to the handle with transverse turns of sennit.

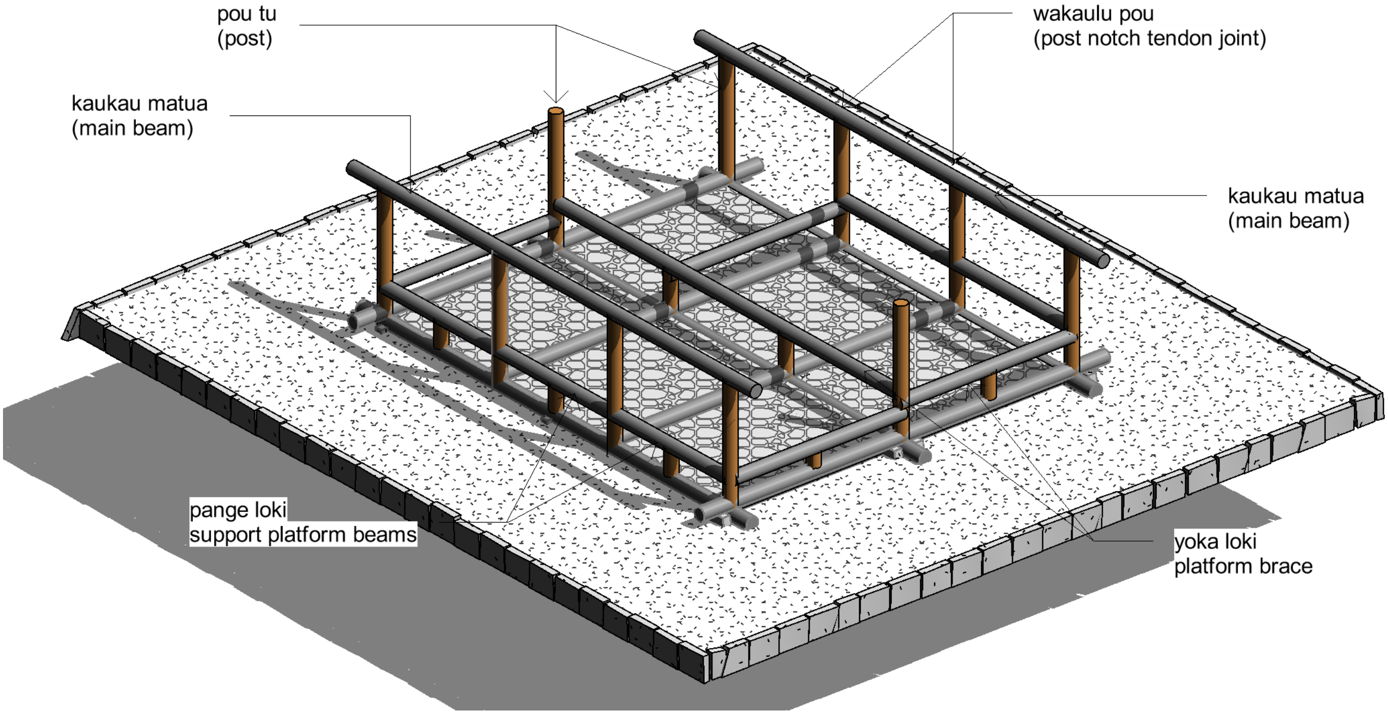
Interior lighting in dwelling houses is traditionally provided by burning dry coconut shells on the floor. Growing up, kerosene lanterns are common, especially for evening prayers and all-night vigils over a corpse. Outdoors on dark moonlit nights, small coconut shell fires provide light. These fires are made by stringing half shells together on pandanus strips, lighting them with a taume torch for a fierce flame, termed *lama ngaipu*. Today, LED and fluorescent light fittings are widely used throughout, now with a more reliable solar RE power stations on the island.

Diagrammatic sequence

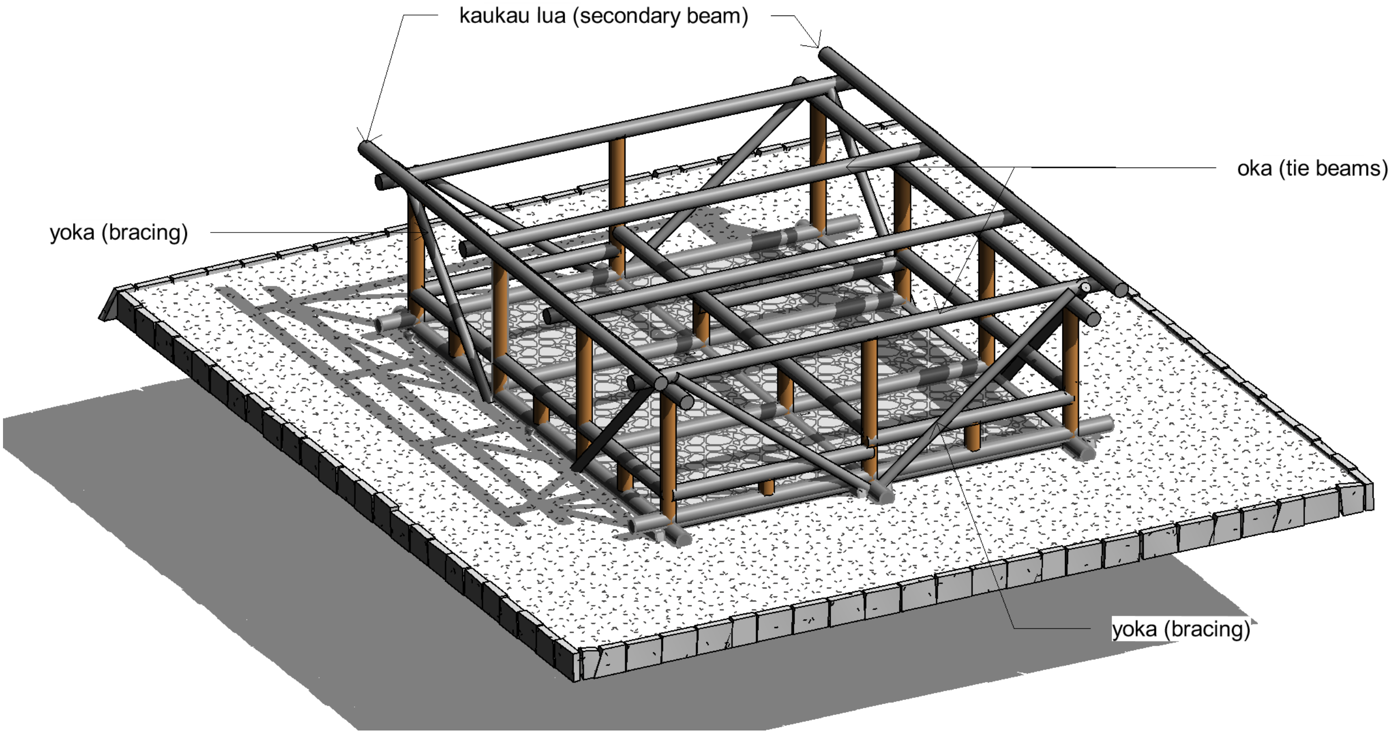
Step 1: The site is selected based on land stability, exposure to wind, and proximity to communal areas.
The outline of the house is marked using wooden stakes, ensuring proper alignment and spacing for structural elements.
The ground is levelled and cleared of vegetation and debris.
The raised platform is created for elevation and drainage.
Foundation stones are set and the tango (foundation plates) of wala (pandanus) is set on top



Step 2: Installation of pou (upright wooden posts)
Main support posts (poutu) are cut from hardwood such as pou wala (pandanus) and firmly embedded into the ground for 'toi nuku' house or onto stone supports for a' wale tulu' house
The number of posts depends on the house size, variation with usually four or five wall support posts.
The main wall plates (kaukau matua) and space dividers, including sleeping platforms (pange loki and yoka loki) are installed

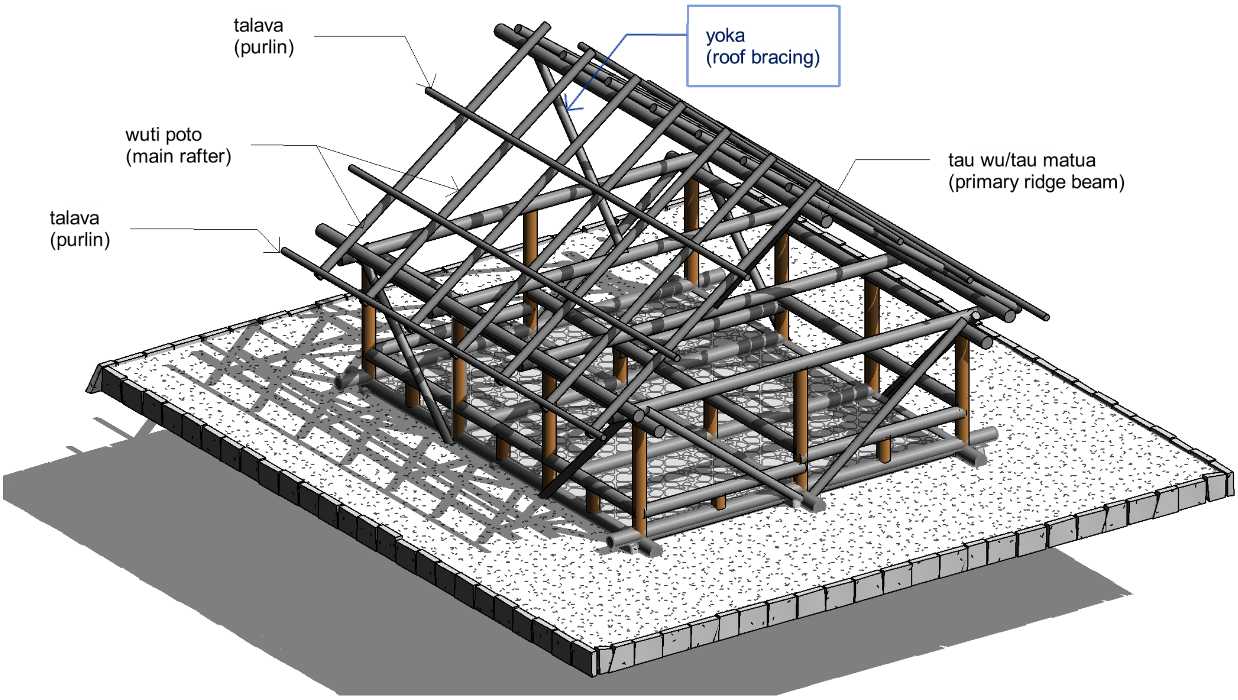


Step 3: Install of main bracing elements, placement of 'yoka' and 'oka' tie beams
Secondary beams (kaukau lua) are notched and fixed and lashed to the 'oka' tie beams which set directly onto the kaukau matua with kawa (coconut sennit fibre). .
These beams serve as the primary load-bearing elements of the roof structure. To form the roof skeleton, running perpendicular to the main beams.
The yoka bracing (cross-bracing system) are fixed directly to the wall plates/tie beams and roof enhance structural integrity at corners.
The framework is carefully lashed using binding techniques, which allow for slight movement in high winds without breaking.

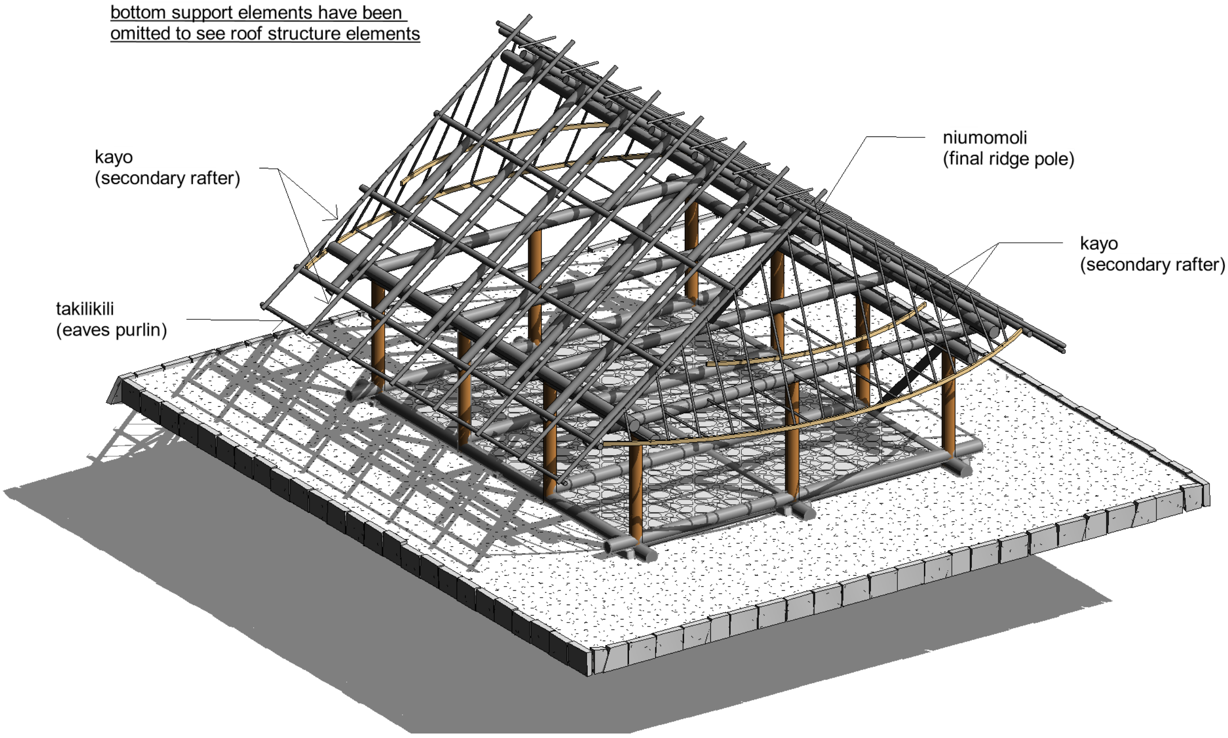


Step 4: Placement of roof framework

Main rafters (wuti poto) are notched and lashed to the kaukau lua (secondary beams) and fixed to the tau wuu / tau matua (primary ridge beam)
Talava (purlins) are fixed directly to the wuti poto
'Yoka' diagonal roof bracing is set into position lashed to the tau wuu (ridge beam/pole) to the oka tie beams below



Step 5: Roof construction 1 – final framework
The secondary rafters (kayo) are fixed lashed to the purlins (talava). (secondary beams) and fixed to the tau wuu / tau matua (primary ridge beam)
Talava (purlins) are lashed directly to the wuti poto
'Yoka' diagonal roof bracing is set into position lashed to the tau wuu (ridge beam/pole) to the oka tie beams below

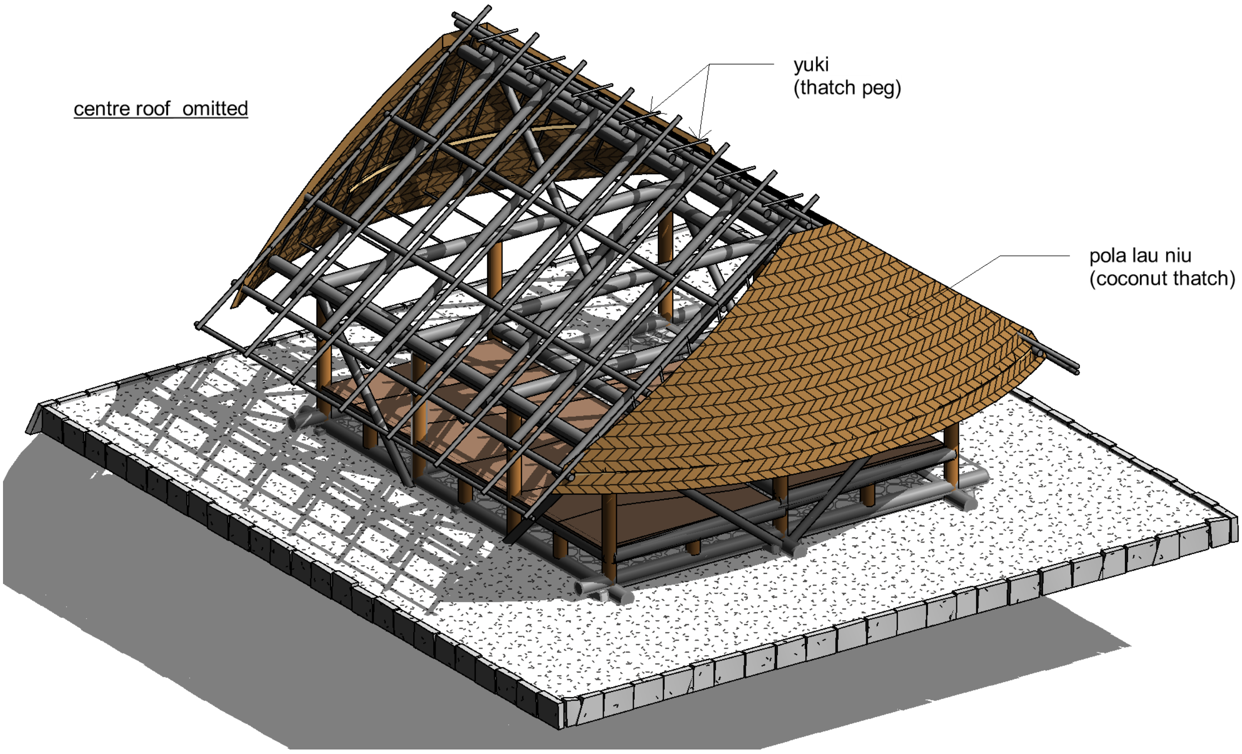


Step 6: Roof construction 2 – thatch roofing

The roof structure is covered with pola launiu (coconut thatch) directly to the kayo (secondary rafters) every mid-rib (75mm). Harvested pola (coconut thatch) is soaked in seawater overnight to rid of any bugs and easy plaiting, dried, stored and layered from the bottom up, ensuring proper runoff. Refer to Fig 22.

Each layer is overlapped and bound tightly to create a waterproof and insulated roof. The thatching is secured with cross-lashing techniques, reinforcing the layers against strong winds.

Final step is fixing the pola taupoto on top of pola ati (final double sided thatch placed over the *pola ati)* and secured with a yuki (peg)



Awanga Marae - Religious Enclosures

Ngungulu mai tai o Awanga,	Your Marae rumbles from the sea,
Yali ngongo mai tāua ma tōna kaupapa,	Let us scoop and hurl its block of coral,
Ni muyumuyu matangi wua, ni talatalanga wua,	These are just wind whispers, just talk,
Nā mea a te wui lōpā,	These things of all the young men,
Ko langakina mai tō ingoa.	Who mentions your name.

Religious enclosures (maraes) on Pukapuka were distinct from the more well-known Eastern Polynesian maraes in their form and construction. Unlike the rectangular or square-shaped maraes commonly found in French Polynesia, Hawaii, the Cook Islands and Aotearoa (Emory, 1933; Kahn & Kirch, 2013)[36], Pukapukan maraes were typically round or oval, marked by a circle of stones placed on edge. Two gaps were entrances into these sacred spaces, where priests communicated with the gods. A sacred stone (unu) representing the deity was at the centre of each enclosure. The interior ground was covered with fine white coral gravel, a feature not commonly found in Eastern Polynesian maraes (Fisher, 2017)[37].

The form of Pukapukan maraes more closely resembled those found in Western Polynesia, including Tonga, Fiji, and Samoa, where circular and oval sacred enclosures were commonly used for religious and social gatherings (Davidson, 1987)[38]. These enclosures often featured a central deity stone or platform, similar to the sacred stones (unu) found in Pukapuka. The presence of upright coral stones marking sacred spaces also aligns with practices in Tonga and Samoa, where stone markers were used to delineate areas of ritual significance (Kirch, 1984)[39].

Today, only remnants of these structures remain. No complete stone representations of gods are preserved, but large blocks of unshaped punga coral are believed to have served this purpose. For instance, a section of stone believed to represent the goddess Taua now acts as a foundation stone for an old copra shed on Loto beach (Best, 1924)[40].

Several sites of old religious structures were located at Utupoa on Wale, once the site of Ngake village. Two sites have been partially cleared for examination. Nine undressed coral stones remain at the religious structure of the god Te Alongaoa. Each stone measures approximately 81 cm wide, 41 cm high, and 10 cm thick. These stones form an outline suggesting a structure about 12 paces in diameter, with stones around its perimeter. The former religious structure of the god Tulikalo revealed five stones of similar size, indicating an enclosure about 10 paces in diameter (Fisher, 2017)[41].

61 cm long, 20 cm above ground, and 15 cm in diameter, remains at Te Matakiate. Informants described Te Matakiate's structure as oval, approximately 15 paces by 13 paces (Firth, 1967)[42].

Historically, other sites lacked stones due to removal during early missionary times and repurposed for building a causeway across the talo swamp, stone houses, and burning for lime mortar for church buildings (Gill, 1876)[43]. he design of these low-walled, circular or oval enclosures with a central deity stone is unique in Polynesia but bears resemblance to structures documented by Rev. William Gill during his 1872 visit to Niutao in the Ellice Islands (Gill, 1876). Gill observed similar low enclosures with upright stone representations of gods, often adjacent to burial grounds.

Commemorative stones marking ancestor shrines (yionga) on Pukapuka typically consisted of single upright stones or multiple stones set on edge, forming a rectangular structure filled with coral gravel. These shrines bore a striking resemblance to priests' seats (poutu) in god houses (wale atua) and the low seats placed before stone representations of gods in religious enclosures (Kirk, 1959)[44]. Similarly, in Western Polynesia, stone platforms and shrines were often dedicated to ancestral deities, reinforcing the broader cultural connections between Pukapuka and the western Pacific (Kirch, 1984)[45].

[36] Emory, K.P. (1933). *Stone Remains in the Society Islands*. Bernice P. Bishop Museum Bulletin.
Kahn, J., & Kirch, P. (2013). *Monumentality and Ritual Landscapes in Polynesia*. University of Hawaii Press.
[37] Fisher, R. (2017). *Archaeological Studies of Polynesian Ritual Spaces*. University of Hawaii Press.
[38] Davidson, J. (1987). *The Prehistory of New Zealand*. Longman Paul.
[39] Kirch, P. (1984). *The Evolution of the Polynesian Chiefdoms*. Cambridge University Press.
[40] Best, E. (1924). *The Maori as He Was: A Brief Account of Maori Life as it was in Pre-European Days*. Dominion Museum.
[41] Fisher, R. (2017). *Archaeological Studies of Polynesian Ritual Spaces*. University of Hawaii Press.
[42] Firth, R. (1967). *Tikopia Ritual and Belief*. Allen & Unwin.
[43]Gill, W. (1876). *Life in the Southern Isles*. Religious Tract Society.
[44] Kirk, M. (1959). *Religious Structures and Practices in Polynesia*. Polynesian Society.
[45] Kirch, P. (1984). *The Evolution of the Polynesian Chiefdoms*. Cambridge University Press.

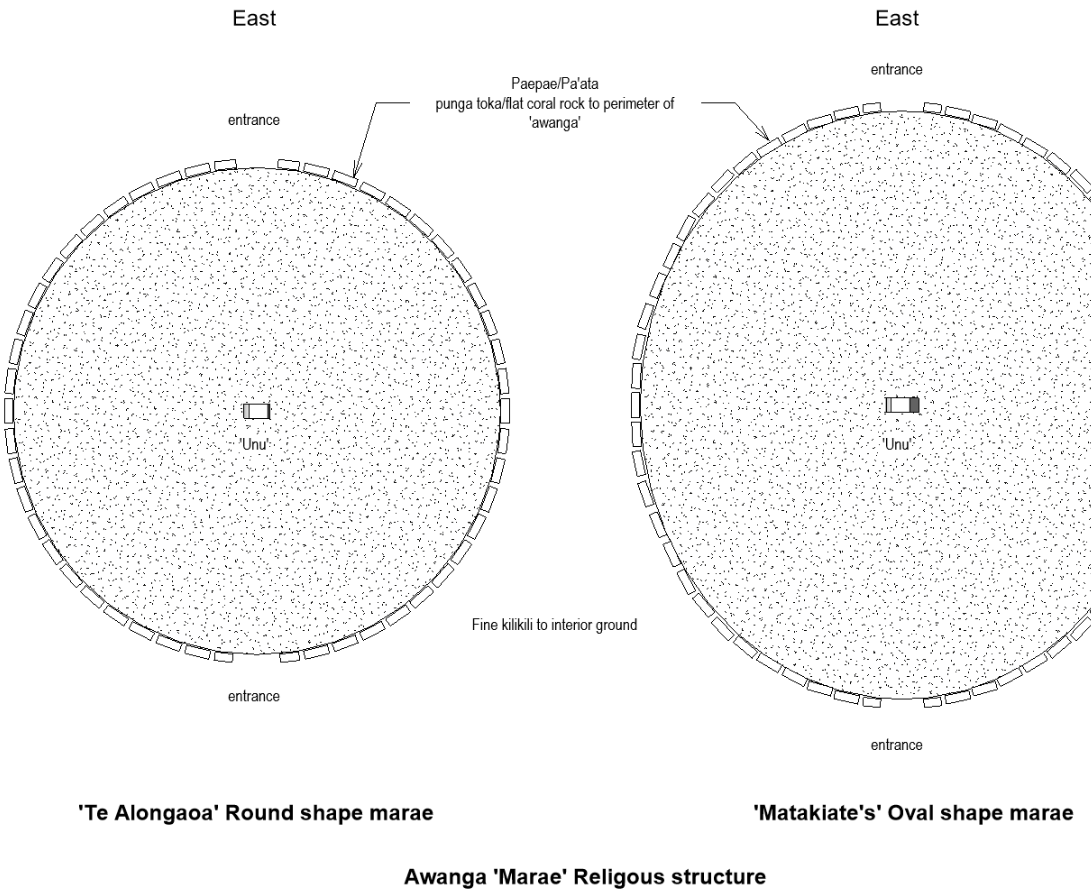


Figure 49: 'Awanga' marae religous enclosures

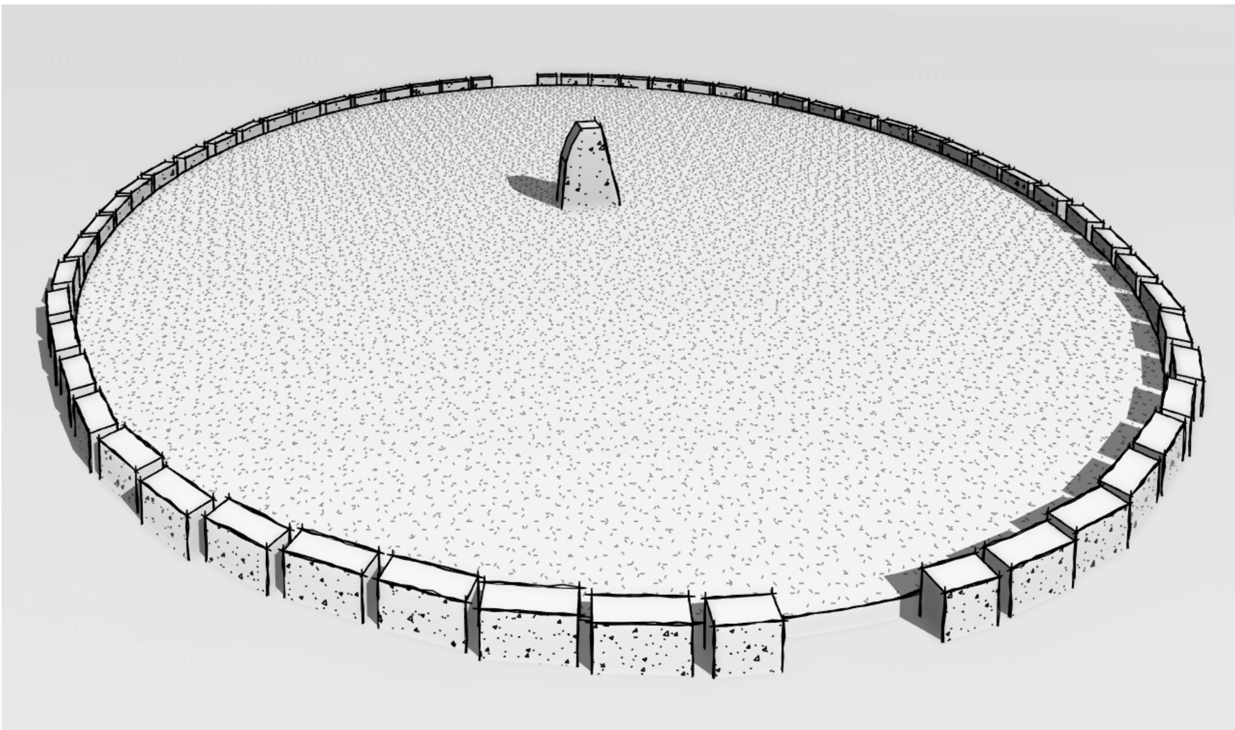


Figure 46: 'Awanga' view from west entrance

Nearby, other sacred site, such as those dedicated to the gods Tumulivaka and Te Matakiate are heavily overgrown, making clearing impossible. Ground examination revealed no remaining stones at Tumulivaka, while one stone of undressed punga coral, measuring

While no intact enclosures remain today, the sites of several are well-known, preserving cultural and historical significance on Pukapuka. One notable burial site is the grave of the Tongan warrior Taupeloa, situated between Yato and Loto villages. This grave, separate from the nearest lineage cemetery, originally consisted of 11 undressed coral stones arranged in a rectangular pattern measuring 1.8 meters by 1.5 meters. Today, only 10 stones remain, varying in size from 18 to 76 cm in length, 20 to 76 cm in height, and 2.5 to 10 cm in thickness.

The grave of another Tongan warrior, Tokaipule, located on the boundary between Lota and Ngake, features a double enclosure. The inner grave area is delineated by five stones forming a rectangle measuring 2.4 meters long and 0.9 meters wide. Surrounding this is a low curbing measuring 5.2 meters in length and 2.3 meters in width. At present, 14 stones remain in this curbing, each approximately 46 cm long, 15 cm thick, and 18 cm above ground. Unfortunately, this grave is deteriorating due to the gradual removal of stones over time (Davidson, 1987)[46].

Figure 51: Ancestral grave site on Pukapuka, Po Aliki

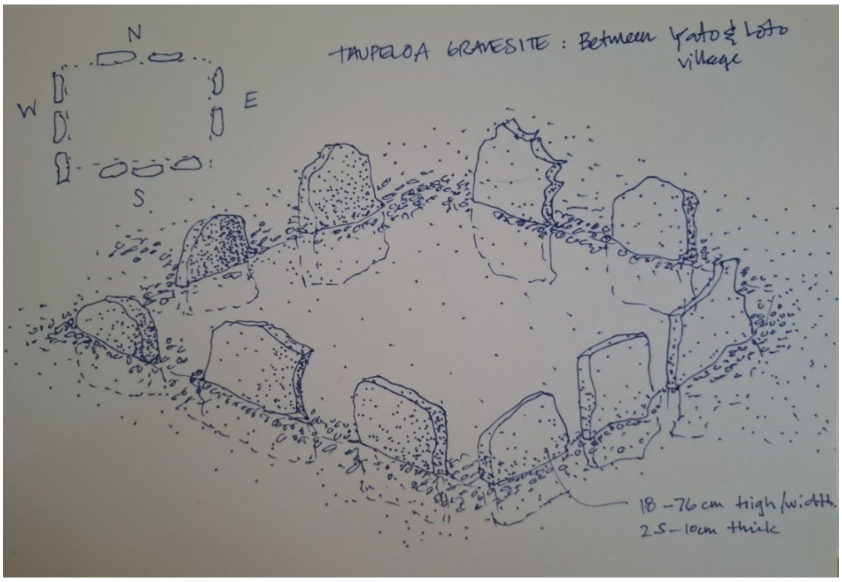


Figure 47: Taupeloa grave sketch

[46] Davidson, J. (1987). *The Prehistory of New Zealand*. Longman Paul.

Chapter 3: Evidence of Mortise and Tenon Joint Construction in Polynesia with a Focus on Pukapuka

Introduction

The use of mortise and tenon joints in Polynesian architecture represents a sophisticated indigenous engineering practice that combines functionality with cultural significance. This chapter explores the evidence of mortise and tenon joint construction across various Polynesian societies, with a particular focus on Pukapuka. Through archaeological findings, ethnographic records, and historical accounts, this chapter highlights the regional variations and cultural practices that underpin the use of this construction method, demonstrating its importance in the architectural heritage of Polynesia.

The mortise and tenon joint is a traditional woodworking technique where a projection (the tenon) on one piece of timber fits securely into a cavity (the mortise) in another piece. This method creates a strong, interlocking connection without the need for additional fasteners. In Polynesian architecture, mortise and tenon joints were integral to the construction of house frames, canoes, and ceremonial structures. The durability provided by these joints was crucial for withstanding the challenging environmental conditions of the Pacific islands, including high winds, heavy rainfall, and seismic activity.

Archaeological research across Polynesia has uncovered numerous instances of mortise and tenon joints in ancient structures, illustrating the widespread use of this technique. In the Samoan archipelago, for example, remains of traditional *fale* (houses) reveal mortise and tenon joints used to connect posts and beams (Davidson, 1974)[47]. Similarly, excavations in the Marquesas Islands document the use of this joint in the construction of large community buildings, or *tohua* (Suggs, 1961)[48].

In Pukapuka, the evidence of mortise and tenon joints is particularly significant. The traditional *wakayamoa* houses on Pukapuka employed this technique to secure wall posts to ground posts. The use of mortise and tenon joints in Pukapuka is well-documented in the work of Gordon Macgregor, who noted that these joints were integral to the construction of the island's dwellings, where wall plates were fitted into the tops of wall posts grooved specifically for this purpose (Macgregor, 1935)[49]. This method not only provided structural stability but also reflected the cultural importance of precision and craftsmanship in Pukapukan architecture.

Ethnographic accounts from early European explorers and missionaries provide valuable insights into the construction methods used by Polynesian societies, including those in Pukapuka. Captain James Cook, during his voyages in the 18th century, observed the use of mortise and tenon joints in the construction of Tahitian *fare* (houses) (Cook, 1777)[50]. In Pukapuka, the detailed descriptions by Macgregor and other ethnographers highlight the role of these joints in traditional house construction. Macgregor's observations emphasize that the mortise and tenon joints used in Pukapuka were not merely functional but also carried significant cultural meaning, being associated with rituals and ceremonies that underscored the importance of proper construction techniques (Macgregor, 1935)[49].

In addition to these historical accounts, oral traditions and indigenous knowledge systems in Pukapuka also preserve information about the use of mortise and tenon joints. The cultural narratives associated with building practices on the island emphasize the craftsmanship involved in creating these joints, which were essential for the construction of resilient structures capable of withstanding the harsh environmental conditions of the atoll.

While the basic principle of the mortise and tenon joint remains consistent across Polynesia, regional variations reflect the diverse environmental and cultural contexts of different island groups. In Tonga, for instance, mortise and tenon joints are often combined with lashings made from coconut fiber to construct large *fale* houses, providing additional flexibility and strength (Herda, 1987)[51]. In contrast, in the Hawaiian Islands, mortise and tenon joints are commonly found in the construction of *hale* (houses) and *heiau* (temples), where they are often integrated into stone foundations for added stability (Kamehiro, 2009)[52].

In Pukapuka, the use of mortise and tenon joints is closely tied to the island's environmental conditions and cultural practices. The joints are typically used in combination with other traditional building techniques, such as the wrapping of principal posts with coconut leaf mats to protect them from the elements during construction (Macgregor, 1935)[49]. This approach reflects a deep understanding of the local environment and the need to build structures that can endure the challenges of life on a small, remote atoll.

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[47] Davidson, J. M. (1974). *Samoan Structural Remains and Settlements.* In *Archaeology in Western Samoa* (Vol. 1, pp. 11-14). Bulletin of the Auckland Institute and Museum
[48] Suggs, R. C. (1961). *The Archaeology of Nuku Hiva, Marquesas Islands, French Polynesia*. American Museum of Natural History.
[49] Macgregor, G. (1935). *Ethnology of Pukapuka* (Vol. 20). Bernice P. Bishop Museum Bulletin.
[50] Cook, J. (1777). *A Voyage Towards the South Pole and Round the World* (Vol. 2). W. Strahan and T. Cadell.
[51] Herda, P. (1987). *The Origins and Use of Samoan Architecture. Journal of the Polynesian Society, 96*(2), 223-233.
[52] Kamehiro, S. (2009). *The Arts of Kingship: Hawaiian Art and National Culture of the Kalākaua Era.* University of Hawai'i Press.

The Evolution and Adaptation of Mortise and Tenon Joints in Polynesian Architecture

The use of mortise and tenon joints in Polynesian architecture has evolved over time, adapting to changes in materials, tools, and cultural practices. In some regions, including Pukapuka, the introduction of metal tools by European traders and missionaries led to modifications in traditional construction methods. For instance, in some areas, mortise and tenon joints began to be supplemented or replaced by nails and other fasteners (Davidson, 1974)[47]. However, in Pukapuka, the continued use of these joints in traditional architecture demonstrates their enduring relevance and importance.
The adaptation of mortise and tenon joints in Pukapuka also reflects the island's commitment to preserving its cultural heritage. Despite external influences, the people of Pukapuka have maintained the integrity of their traditional building practices, ensuring that the knowledge of mortise and tenon joint construction is passed down through generations.

The evidence of mortise and tenon joint construction in Polynesia, particularly in Pukapuka, underscores the sophistication and resilience of indigenous architectural practices. This technique provided a practical solution to the challenges of building in a dynamic environment while also carrying significant cultural and symbolic meaning. The widespread use of mortise and tenon joints across the Pacific, from Pukapuka to the Marquesas and beyond, highlights the interconnectedness of Polynesian societies and their shared heritage of craftsmanship. As contemporary Polynesian communities continue to engage with their architectural traditions, the mortise and tenon joint remains a powerful symbol of resilience, adaptability, and cultural identity

Wale. Fale, Hale, Whare, Fare, Whare o Moana nui a Kiwa

Polynesia is a region of the world comprising more than 1,000 islands scattered over Moana Nui a Kiwa (the central, northern and southern Pacific Ocean). These islands have a rich cultural heritage and are known for their distinctive architecture, including several traditional house styles that have been developed over centuries to suit the local climate and environment.

The earliest dwellings were relatively simple: small houses and auxiliary structures. This contrasts with the domestic architecture found in later residential sites, where houses and auxiliary structures were enlarged and built with more elaboration, signaling the advent of social hierarchy and a more complex society. A traditional Polynesian dwelling is the fale, which is a large open-air home with no walls and a thatched roof. This type of house is well-suited to the tropical climate of Moana Nui a Kiwa, providing ample ventilation and shade. *Whare* are rectangular wooden houses with a steeply pitched roof that slopes down to the ground on both sides and are common in New Zealand and other parts of Polynesia, providing a warm and dry shelter against cold winds and heavy rain. Overall, Polynesian houses have evolved over time to suit the unique environmental conditions of the region, as well as the social and cultural needs of its inhabitants. Polynesian houses vary greatly depending on the location and environmental conditions of each island.

However, they share some common elements such as using natural materials like bamboo, thatch, and wood. These materials are readily available in the region and provide good insulation against tropical heat, humidity, and strong winds. Another key feature of Polynesian houses is their integration with nature. This is achieved through the use of open floor plans, large windows, and natural lighting that allow for a seamless transition between indoors and outdoors. Polynesian houses are not only functional but also highly symbolic. They reflect the social and cultural values of the Polynesian people, as well as their connection to the natural world.

The evolution of Polynesian vernacular provides insights into the region's unique environmental conditions, as well as the social and cultural values of its inhabitants. In order to comprehend the ways in which Polynesian house styles evolved, it is essential to look at the environmental and cultural factors that influenced them. These factors include the availability of natural building materials, the need for shelter from adverse weather conditions, the social hierarchy of communities and cultural traditions. Furthermore, the study of Polynesian house styles can provide valuable insights for modern-day architects and designers seeking Furthermore, an understanding of Polynesian house styles can provide valuable insight for modern-day architects and builders who seek to incorporate sustainable design principles into their work. The study of Polynesian house styles is a multidisciplinary task that combines insights from anthropology, archaeology, architecture, and environmental science. The evolution of Polynesian house styles presents an intricate interplay between environmental, cultural, and social factors. By examining the features of Polynesian house styles, one can gain a deeper appreciation for the region's unique blend of function, symbolism, and integration with nature, as well as the lessons that can be applied to contemporary architectural practices. The study of Polynesian dwellings is a complex and multifaceted endeavor that requires an interdisciplinary approach. Acquiring knowledge of Polynesian house styles involves the incorporation of insights from multiple disciplines such as anthropology, archaeology, architecture, and environmental science. This approach enables a comprehensive understanding of the environmental, cultural and social factors that influenced their evolution.

The study of Polynesian dwellings can enable architects and builders to gain insight into sustainable design principles, thereby serving as a valuable resource for contemporary architectural practices seeking to incorporate sustainable design principles and contribute to a deeper understanding of the social and cultural values that influenced their evolution.

This knowledge can be applied to contemporary architecture to create designs that reflect the unique blend of function, symbolism, and integration with nature found in Polynesian architecture.

Polynesian House Sites

This review highlights archaeological investigations of precontact and historic house sites in Polynesia, a region noted for its diversity of chiefdoms in terms of scale and elaboration. Anthropological and historical perceptions of the Polynesian household have shifted over time, influencing the ways in which the household has been defined in archaeology. Early research emphasized houses as a unit of study within settlement pattern archaeology and as a means of delineating formal variability between sites and communities. Current studies stress a more holistic view of the household as a nexus of economic, social, and ritual activities. Diverse theoretical perspectives, such as the analytical concept of house societies, feminist archaeologies, landscape approaches, and agent-based models, have led to new archaeological approaches engaged with both the material and the nonmaterial aspects of the house and, in particular, how social relations structure the household. Current prominent themes include functional identification of house sites, understanding social variability, articulation of the household with the community, and comparative analyses of social complexity.

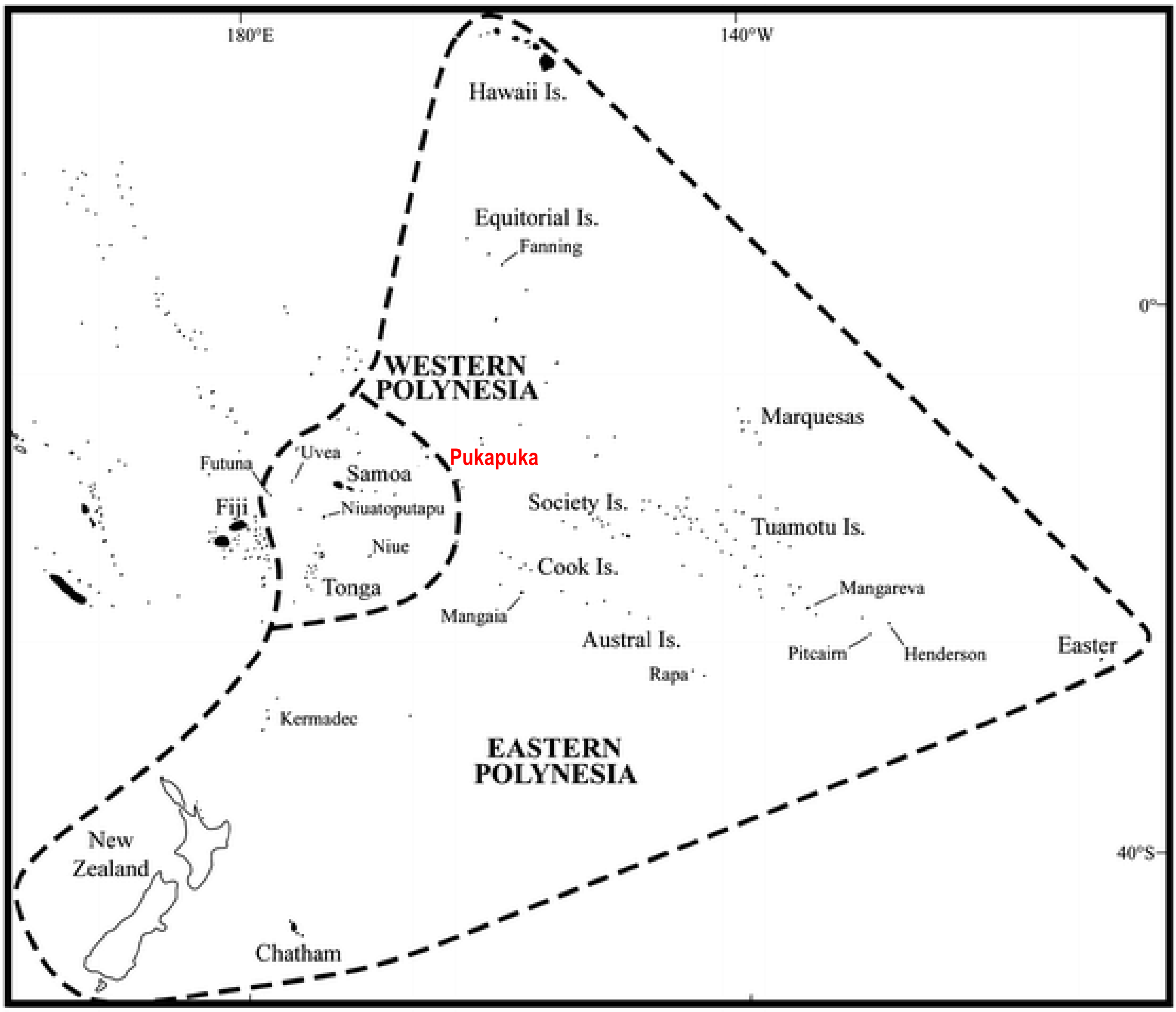

Figure 53: Map of East & West Polynesia, Pukapuka

Location of the East Polynesian Triangle and its relationship to West Polynesia. Bold text shows main cultural areas, larger font designates major island chains and archipelagoes, smaller font designates individual islands

The Polynesian cultures of Pukapuka, Tonga, and Samoa share a rich heritage of traditional housebuilding and lashing techniques that reflect their shared cultural lineage and geographical proximity. The houses in these regions are often constructed using a combination of natural materials, such as wood, thatch, and vines, and exhibit remarkable similarities in their design, construction methods, and cultural significance (J. J. Fox, 2006][53].

One of the most striking similarities between the house-building traditions of these regions is the use of lashing techniques to assemble the structural components. The lashing techniques employed in Pukapuka, Tonga, and Samoa are characterised by the intricate weaving of vines, ropes, or other natural fibres to connect the various elements of the house, such as the posts, beams, and rafters(P. Memmott, 2011)[54].

The specific lashing techniques used in these regions vary, but they often share a common emphasis on the importance of precision, strength, and aesthetic appeal. In Pukapuka, for example, traditional house construction involves the use of intricate lashing patterns to secure the posts and beams, creating a sturdy and visually stunning structure (P. Memmott, 2011)[54] (M. T. Samudin, H. Muhamad, R. Rosmawati, S. Mamar and A. Yani, 2019)[55]

Similarly, in Tonga and Samoa, the lashing techniques used in house building are highly developed and are often passed down through generations, with skilled practitioners carefully preserving and refining these traditional methods[53].

The similarities in housebuilding and lashing techniques in these Pacific cultures can be attributed to their shared cultural heritage and the centuries-long exchange of knowledge and practices. These traditions reflect the ingenuity and resourcefulness of these communities and serve as a testament to the cultural continuity and resilience that has defined the Pacific world.

Comparisons with other traditional architecture

The traditional house-building construction and lashing techniques in Tonga, Tokelau, and Samoa share several remarkable similarities owing to their common Polynesian cultural heritage. These techniques are essential for the structural integrity and durability of traditional houses in these regions.

Structural Framework

The traditional Tongan fale (house) is built with a wooden framework consisting of posts (pou) and beams (fata), with a high and steeply pitched roof. Similarly, the Tokelauan fale has a wooden framework using vertical posts and horizontal beams. The Samoan fale also has a wooden frame of vertical posts and horizontal beams, with the roof supported by a series of curved beams (Fox, 2006)[56].

These structural elements and their organisation reflect the shared Polynesian building traditions, which have been refined over centuries to withstand the challenges of the tropical climate (Sağıroğlu, 2017)[57].

Lashing Techniques

Coconut sennit (kafa) is the primary material used to lash wooden frames together in Tongan houses. This technique ensures the structural flexibility and strength to withstand tropical cyclones and high winds. Tokelauan houses also use coconut fibre lashing (kafa) to tie the wooden elements, contributing to the overall resilience of the structures. Similarly, Samoan fale construction utilises coconut sennit for intricate lashing patterns, adding to the aesthetic and functional aspects of the buildings.

These traditional lashing techniques passed down through generations, demonstrate the ingenuity and adaptability of Polynesian building practices to the local environment (Rahim, 2022)[58].

[53] J. J. Fox, 2006 "Inside Austronesian Houses: Perspectives on domestic designs for living".
[54] P. Memmott, "Cultural Change And Tradition In The Indigenous Architecture Of Oceania".
[55] M. T. Samudin, H. Muhamad, R. Rosmawati, S. Mamar and A. Yani, "Local Wisdom of Bajo Tribe in Utilizing Marine Resources".
[56] J. J. Fox, "Inside Austronesian Houses: Perspectives on domestic designs for living".
[57] Ö. Sağıroğlu, "Characteristics and Construction Techniques of Akseki Bucakalan Village Rural Dwellings".

[58] M. Rahim, "Bioclimatic and sustainable features on vernacular architecture in Ternate".

Figure 54: Tongan examples of kafa lashing techniques

Roofing

The roofs of traditional houses in Tonga, Tokelau, Aotearoa and Samoa are typically thatched with locally sourced materials such as pandanus leaves (lo u'akau), sugarcane leaves, raupo, nikau or coconut leaves. These natural materials are lashed securely to the wooden frames using coconut sennit or rope made from flax, ensuring durability and water resistance (Fox, 2006). Using locally available resources and traditional construction methods reflects vernacular architecture's sustainable and context-responsive nature in these regions (Salman, 2019)[59].(Juwono & Susanto, 2018)[60]

Cultural Significance

The construction of traditional houses in Tonga, Tokelau, Aotearoa and Samoa is a communal activity, reflecting the importance of community and cooperation in Polynesian cultures. These houses are not merely functional structures but also embody their respective communities' cultural identity, values, and social systems.

The similarities in traditional house-building techniques across Tonga, Tokelau, Aotearoa and Samoa demonstrate the enduring influence of Polynesian cultural heritage. These techniques, refined over generations, continue to play a crucial role in the structural integrity, durability, and cultural significance of traditional houses in the Pacific. The preservation and continued use of these traditional building techniques are a matter of structural integrity and durability and a means of maintaining the cultural heritage and identity of Polynesian communities(E. Mcleod et al)[61]. As Polynesian societies navigate the challenges of modernisation and globalisation, the continued practice of these traditional building methods serves as a reminder of the enduring value of vernacular architecture and its ability to address contemporary needs while honouring the past.

Nan Madol, Pohnpei – Federated States of Micronesia (FSM)

My visit to the Federated States of Micronesia (FSM) in late 2023, specifically to the island of Pohnpei and the ancient site of Nan Madol, prompted me to reflect on the striking architectural and cultural parallels between this site and religious structures in East Polynesia. Nan Madol, often referred to as the "Venice of the Pacific," is an extensive complex of stone structures built atop a series of artificial islets constructed from basalt columns. The resemblance to the marae structures found in East Polynesia raises intriguing questions about the transmission of architectural knowledge across vast oceanic distances (Athens, 2007; Rainbird, 1994)[62].

Notably, the construction techniques observed in Nan Madol, particularly the use of large basalt slabs and columnar jointing, do not appear in the central Polynesian islands, which were settled around 1000 BCE. Instead, the similarities seem to suggest that this architectural tradition bypassed central Polynesia, emerging more distinctly in the eastern regions. Additionally, the post-and-beam construction techniques and intricate lashings seen in both Nan Madol and traditional Micronesian houses exhibit strong correlations with structural methods used in Polynesia. These observations reinforce the theory of cultural and technological diffusion across Oceania, possibly influenced by migration patterns and regional adaptations to local environments (Kirch, 2000; McCoy et al., 2015)[63].

[59] M. Salman, "Sustainability and Vernacular Architecture: Rethinking What Identity Is".
[60] I. L. Juwono and D. Susanto, "The Reeds Performance Study on Traditional Architecture as Building Material in Wae Rebo Village".
[61] E. McLeod et al., "Lessons From the Pacific Islands – Adapting to Climate Change by Supporting Social and Ecological Resilience"
[62] Athens, J. S. (2007). "Prehistoric Cultural Development in Micronesia: Archaeological Evidence from Pohnpei." *Asian Perspectives*, 46(2), 281–307.
[63] Kirch, P. V. (2000). *On the Road of the Winds: An Archaeological History of the Pacific Islands Before European Contact.* University of California Press.
McCoy, M. D., et al. (2015). "The Role of Megalithic Monuments in Pacific Island Societies." *Journal of Pacific Archaeology*, 6(1), 67–82.

Figure 48: Nan Madol Platform

Traditional House Construction in Niutao, Tuvalu

In Niutao, one of Tuvalu's northernmost atolls, traditional houses are constructed using locally sourced materials such as pandanus (Pandanus tectorius), coconut (Cocos nucifera), and breadfruit (Artocarpus altilis). The construction process is a communal effort, with the homeowner receiving assistance from extended family members and, for larger structures, the entire kinship group (Adams & White, 2001)[64].

The structural framework consists of posts, beams, and rafters, carefully fitted together to form a resilient skeleton. Older men in the community play a crucial role in preparing sennit (kafa), a braided coconut fiber that is used extensively for lashing. This method of fastening is both an art and a necessity, ensuring flexibility and durability against the strong winds and tropical storms that frequently impact Tuvaluan atolls (Goldsmith, 2000)[65].

Lashing patterns in Niutao are highly intricate, involving multiple layers of sennit wrapped around joints in specific sequences. These bindings create a secure yet adaptable framework capable of withstanding extreme weather conditions. Once the frame is assembled, the roof is constructed separately—often in a shaded area—to prevent premature deterioration of materials. Thatched roofs, composed of layered pandanus leaves, provide essential protection from rain and sun while promoting ventilation (Nunn, 2007)[66].

The construction process is deeply embedded in the social fabric of Niutao. Families often engage in reciprocal labour exchanges, with payment made in the form of food and communal feasts. These practices reinforce social cohesion and ensure the transmission of specialized knowledge across generations (Tcherkézoff, 2008).

[64] Adams, R., & White, C. (2001). *Atoll Living: Traditional Architecture in the Pacific*. University of Hawaii Press.
[65] Goldsmith, M. (2000). "The Social Fabric of Tuvaluan Architecture." *Oceania*, 70(4), 355–374.
[66] Nunn, P. D. (2007). *Climate, Environment, and Society in the Pacific during the Last Millennium*. Elsevier.

 

Figure 496: Interior roof structure

Traditional House Construction in Sikaiana, Solomon Islands

The traditional houses of Sikaiana, a Polynesian outlier in the Solomon Islands, exhibit construction methods similar to those found in Tuvalu and other Polynesian islands. Local timber, including coconut and breadfruit trees, is selected for its strength and resilience. The construction of a house is a collective endeavour, with assistance provided by kinship groups and community members (Ross, 1984)[67].

Lashing is a fundamental technique in Sikaiana house construction, reinforcing joints and connections between posts, beams, and rafters. Sennit lashings are applied in complex, interwoven patterns that distribute structural stress evenly, enhancing the house's stability in high winds and cyclonic conditions (Davidson, 2012)[68]. The thatched roofs, made from pandanus leaves, are layered meticulously to maximize water runoff and insulation.

As in Niutao, traditional Sikaiana houses are assembled in a shaded area before being transported to the final building site. This practice ensures precision in construction while also allowing the community to work collaboratively in a centralized location. The entire process—from framework erection to roof thatching—is embedded in social traditions, with knowledge of lashing techniques passed down through generations (Keesing, 1992)[69].

Connection Between House Building and Lashing Techniques in Niutao, Sikaiana, and Pukapuka

Through my research and travels across Niutao, Sikaiana, and Pukapuka, I have observed remarkable similarities in traditional house-building techniques and lashing methods. These shared architectural practices reveal a deep understanding of the natural environment and the necessity of communal collaboration in construction.

In Niutao, houses are designed for durability, with timber frameworks lashed together using intricately woven sennit. The roofs are carefully thatched with pandanus leaves to provide insulation and weather resistance. Similarly, in Sikaiana, lashing techniques are highly refined, employing multiple layers of coconut fibre cordage to reinforce joints and enhance structural stability. The construction process is communal, with each family responsible for specific tasks.

Pukapuka follows a comparable pattern, where house building is a collaborative effort involving extended kinship groups. The division of labour ensures efficiency, with able-bodied men handling the framework, while older men prepare sennit lashings. The meticulous application of lashing techniques reflects the same level of craftsmanship seen in Niutao and Sikaiana, reinforcing the broader Polynesian tradition of using natural materials to create resilient structures.

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[67] Ross, H. (1984). *Sikaiana Life: An Ethnography of a Polynesian Outlier*. University of California Press.

[68] Davidson, J. (2012). *Archaeology in Polynesia*. Cambridge University Press.

[69] Keesing, R. (1992). *Custom and Colonialism in the Solomon Islands*. Oxford University Press.

Despite the geographical distances—Niutao to Pukapuka (1,915 km) and Sikaiana to Pukapuka (3,454 km)—these islands exhibit a continuity in architectural knowledge that speaks to a shared Polynesian heritage. The absence of nails or metal fastenings in these structures underscores a reliance on traditional materials and techniques, a testament to ingenuity and cultural preservation (Kirch, 2017)[70]. For reference, a second Pukapuka, located in the Tuamotus, around 2,957km away, also reminds the reader that Pukapukans travelled vastly in both east and west directions. Refer to Fig 57.

Lashing is a structural necessity and a cultural practice embodying cooperation, craftsmanship, and intergenerational knowledge transfer. In Niutao, young men learn lashing techniques as a rite of passage, a practice mirrored in Sikaiana and Pukapuka. The preparation and use of sennit symbolise interconnectedness—both in terms of physical construction and social cohesion within the community.

By analysing the traditional house-building methods and lashing techniques of Niutao, Sikaiana, and Pukapuka, we gain insight into the resilience and adaptability of Polynesian cultures. These structures are more than shelters; they represent a way of life that honours ancestral wisdom, fosters communal bonds, and continues to evolve in response to environmental and societal needs.

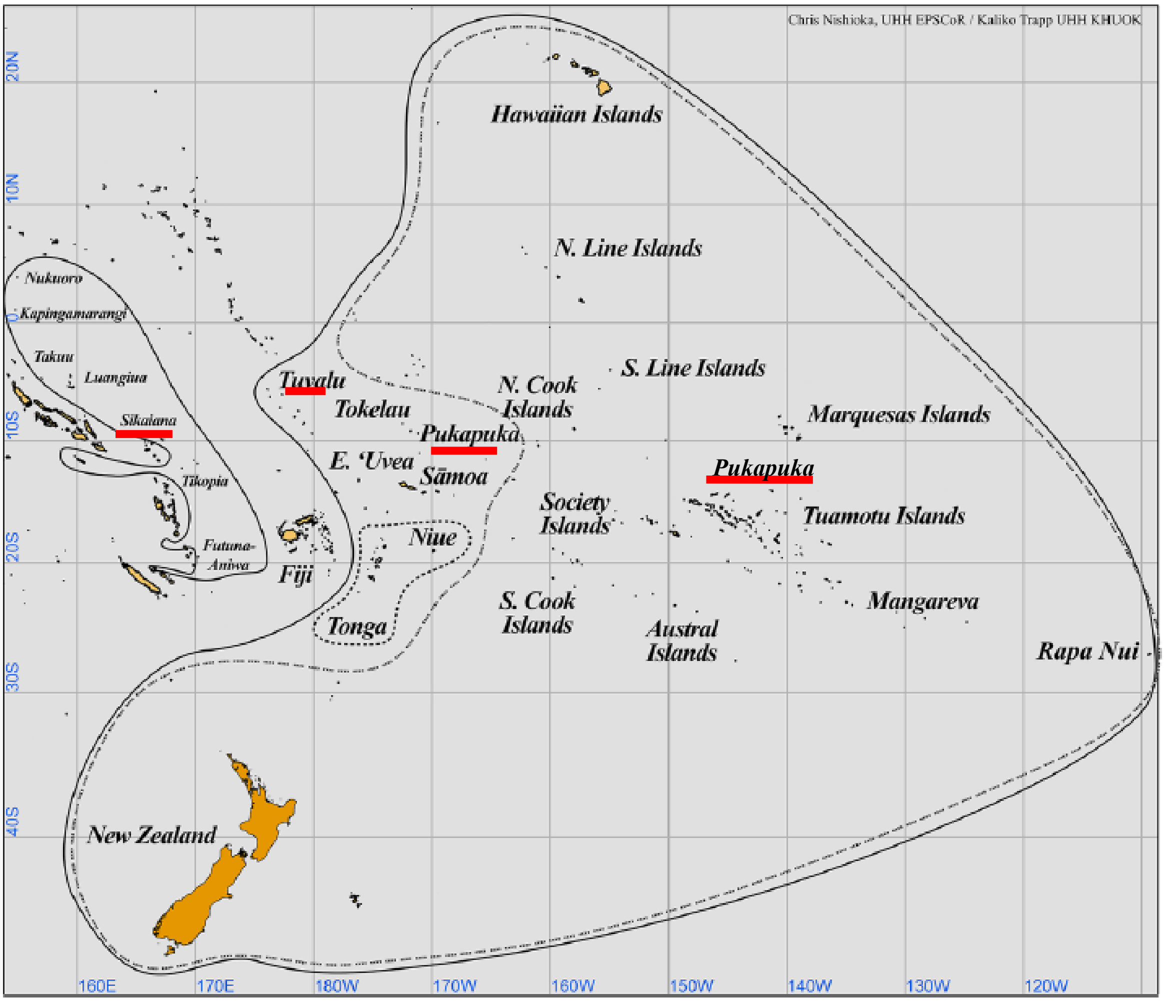

Figure 57: Distance between Pukapuka, Niutao and Sikaiana

70 Kirch, P. V. (2017). *Polynesian Feasts and Festivals: Food, Power, and Identity in Oceania*. University of Hawaii Press.

Chapter 4 - Te Wa ote Kapi: Te Papa Langi,

Pukapukan Innovations

Indigenous Māori and Polynesian architecture is deeply rooted in environmental adaptability, resilience, and sustainable practices developed over centuries. The connection between vaka (canoe) construction and traditional house-building techniques in the Cook Islands demonstrates a sophisticated understanding of structural integrity, material use, and cultural continuity. This chapter explores the structural innovations that link vaka to the construction of whare/wale/fale/hale/are, focusing on the principles of raised ground platforms, diagonal bracing, and lashing techniques derived from ocean-going canoes.

Raised Ground Level and Stone Platform (Paepae) Foundations

A defining feature of traditional Polynesian architecture is raised stone platforms (paepae) as foundations for houses and meeting structures. This innovation serves multiple purposes: it elevates the structure above ground moisture, preventing timber posts from rotting; it enhances structural stability; and it establishes a cultural and spiritual connection to the land (Henry, 1928[71]; Buck, 1944[72]).

Paepae foundations are particularly evident in Pukapuka, where coral punga or papa rock was commonly used to create elevated house platforms. Similar practices are observed in Aotearoa, where Māori adapted the concept to accommodate different climatic conditions and soil compositions (Best, 1927[73]). This approach mirrors vaka design principles, where canoes were often placed on stands to prevent waterlogging and deterioration when not in use (Davidson, 1984[74]).

Diagonal Bracing (Yoka) from Foundation to Top Wall Plates

Structural bracing is a crucial element in traditional Polynesian and Māori architecture, ensuring resilience against cyclonic winds and seismic activity. The use of diagonal bracing (yoka) from the horizontal foundation beams (tango) to the top wall plates (kaukau matua) strengthens the overall structure, reducing lateral movement (Craig, 1989[75]).

In Pukapuka, where cyclone resilience is paramount, traditional houses incorporate extensive yoka bracing, drawing from vaka construction methods. The vaka hull's ability to withstand ocean swells through tensioned and interlocking components is directly applied to the housing framework (Beaglehole & Beaglehole, 1938[76]). This design principle is also seen in Māori whare in Aotearoa, where internal and external bracing elements enhance structural integrity (Mitchell & Mitchell, 2007[77]).

Diagonal Bracing (Oka) within the Roof Structure

Similar to the yoka bracing within walls, diagonal bracing (oka) is integral to traditional roof construction. The oka runs from tie beams to the ridgepole, reinforcing the roof structure against lateral forces. This technique ensures that the house remains intact during extreme weather conditions, like the vaka's ability to endure long ocean voyages through reinforced hull structures (Buck, 1957[78]).

Figure 508: Modern traditoinal wale house with 'yoka' bracing

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[71] Henry, T. (1928). *Ancient Tahiti.* Bernice P. Bishop Museum
[72] Buck, P. H. (1944). *Arts and Crafts of the Cook Islands*. Bernice P. Bishop Museum
[73] Best, E. (1927). *The Whare Kohanga and Its Lore.* Dominion Museum
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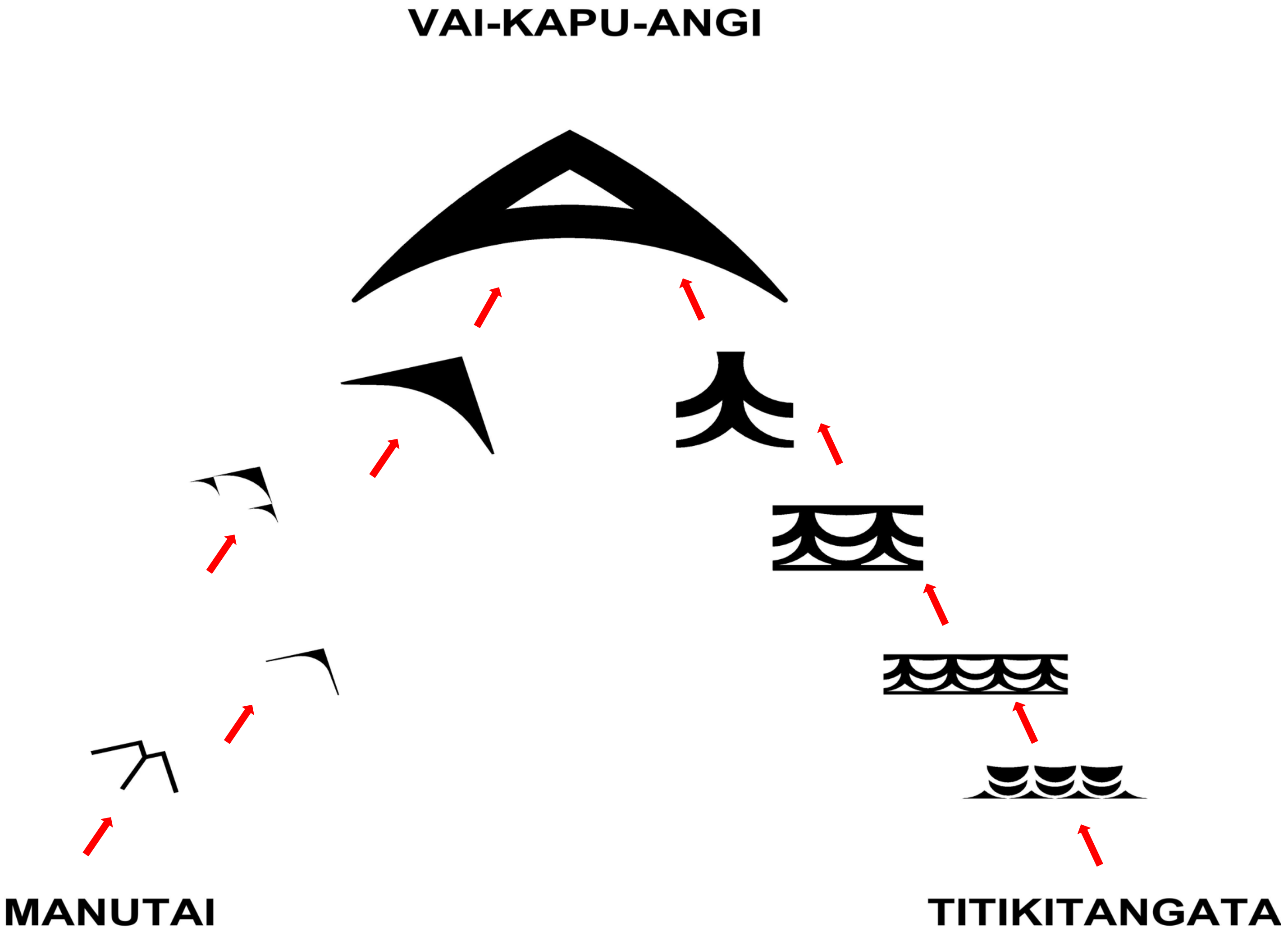
[77] Mitchell, H., & Mitchell, J. (2007). *Te Tau Ihu o Te Waka.* Huia Publishers
[78] Buck, P. H. (1957). *Vikings of the Sunrise.* Whitcombe and Tombs

Design Strategies

Inspiration of Local Motifs and Natural Elements

For the past 25 years, my architectural, design, and project management practice has been profoundly shaped by my upbringing in Pukapuka. This cultural foundation has instilled a strong commitment to sustainability and resilience, which I have applied across various projects in the Cook Islands. By integrating traditional Pukapukan motifs with structural innovations, my designs prioritize durability while preserving cultural authenticity. The 'Yoka' bracing design, along with roof bracing and raised perimeter platforms, exemplifies this approach—combining indigenous knowledge with modern engineering to enhance structural integrity and adaptability to environmental challenges.

Figure 519: Inspiration of traditional motifs and nature



Manutai /Kotawa/Kota'a Seabird Design

Traditional Maritime symbolism

Navigation and exploration of our ancestors

Presented in many ways

Aero dynamic, air-flow

Freedom, fearless, strong, adaptable

Tikitikitangata Design

Traditional Unity symbolism

Represents our people

Holding hands in unity

Strength in Unity

And togetherness within our traditional social and traditional structures

Presented in 2 ways more commonly in

Rarotonga and Mangaia

Harmony, Bravery, Mana, Status

Kopu tangata, tribe, village, island

Mata Keinanga

Vaikapuangi Government Building – Central building on Rarotonga

Design Initiatives

The initial design concepts of the Vaikapuangi Government Building were guided by the manutai (kota'a/kotawa – great frigate bird) and tikitikitangata (unity and fearlessness) philosophy. The frigate bird, a revered symbol in Pukapukan culture, embodies resilience, endurance, and adaptability—qualities essential for withstanding the harsh Pacific environment. The aerodynamic form of the frigate bird in flight inspired the building's sweeping rooflines and structural curvature, creating a dynamic yet harmonious integration with the site.

These principles were integrated into the overall shape and footprint of the structure to harmonize with the challenging, skewed site. Previous conceptual developments struggled to address this topographical complexity, but this design approach allowed the building to settle naturally within the environment.

Key design elements include:

- Curvature of Western Elements: The building's western facade incorporates curved elements that serve as a natural buffer against strong northwestern cyclonic winds while also mitigating the impact of the harsh afternoon sun.
- Large Roof Overhangs: Inspired by the broad wingspan of the manutai, extended eaves provide necessary shading to external walls, reducing heat gain and increasing comfort in the interior spaces.
- Eastern Vertical Louvres: The eastern-facing facade integrates vertical louvres inspired by traditional wooden slat designs commonly found in Pukapukan and Cook Islands vernacular architecture. These elements enhance natural ventilation and reduce reliance on mechanical cooling systems.
- Symbolic Roof Form: The roofline echoes the soaring silhouette of the frigate bird, emphasizing uplift and resilience, a reminder of both cultural identity and environmental adaptation.

Figure 60: Tikitikitangata - Rarotongan above, Mangaian version below

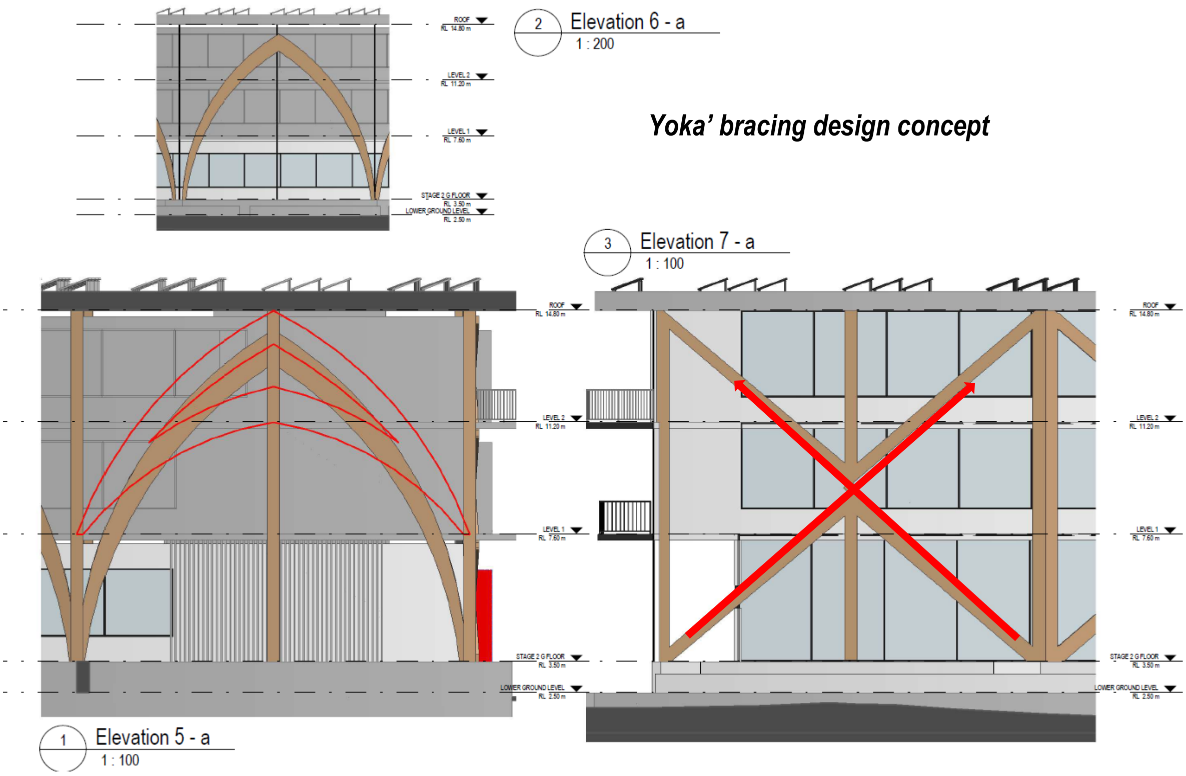


Figure 61: Image showing different bracing element options 'yoka design concept

Figure 6252: 3D showing different bracing element options

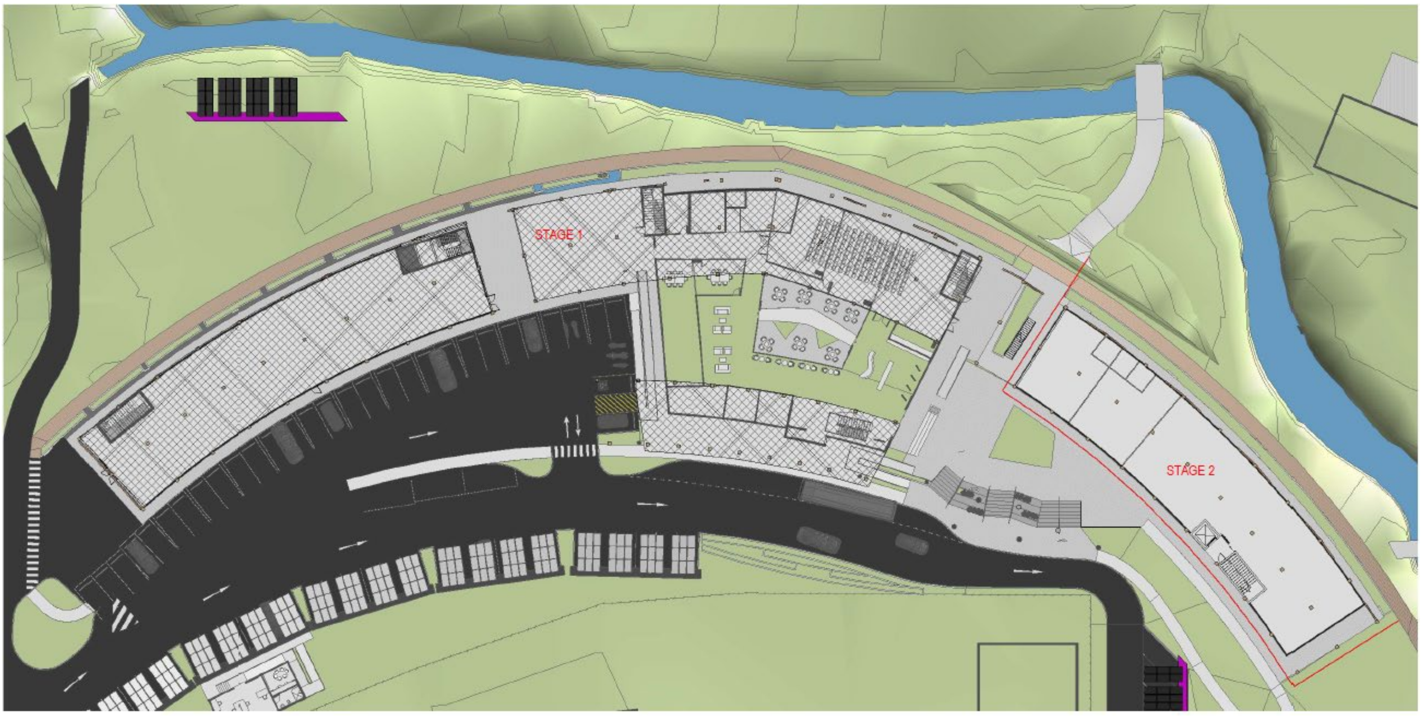


Figure 53: Site plan development

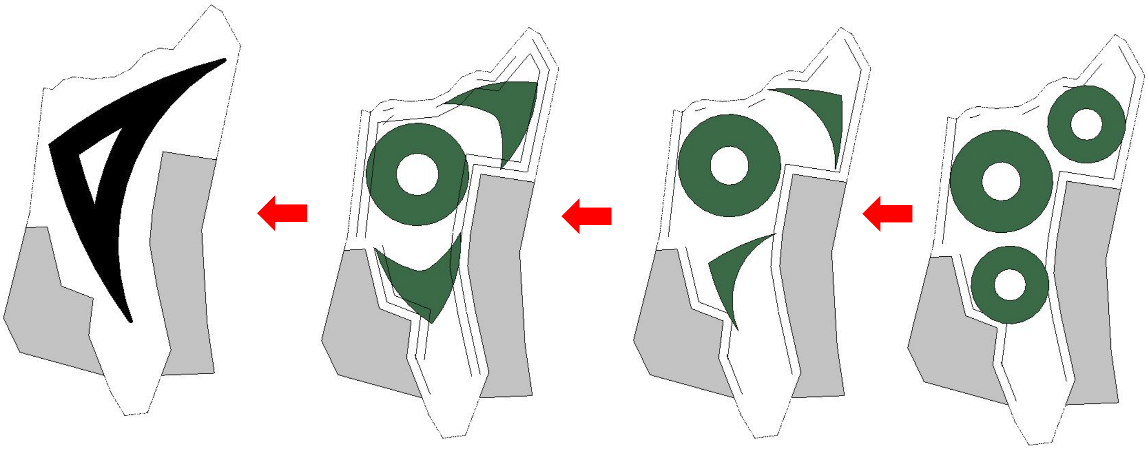


Figure 54: Shape test development – bulk location, site restrictions and setbacks

Figure 65: Shape development

Figure 55: Kotawa/Kota'a Great frigate bird

Figure 56: Various Kotawa/Kota'a symbolism

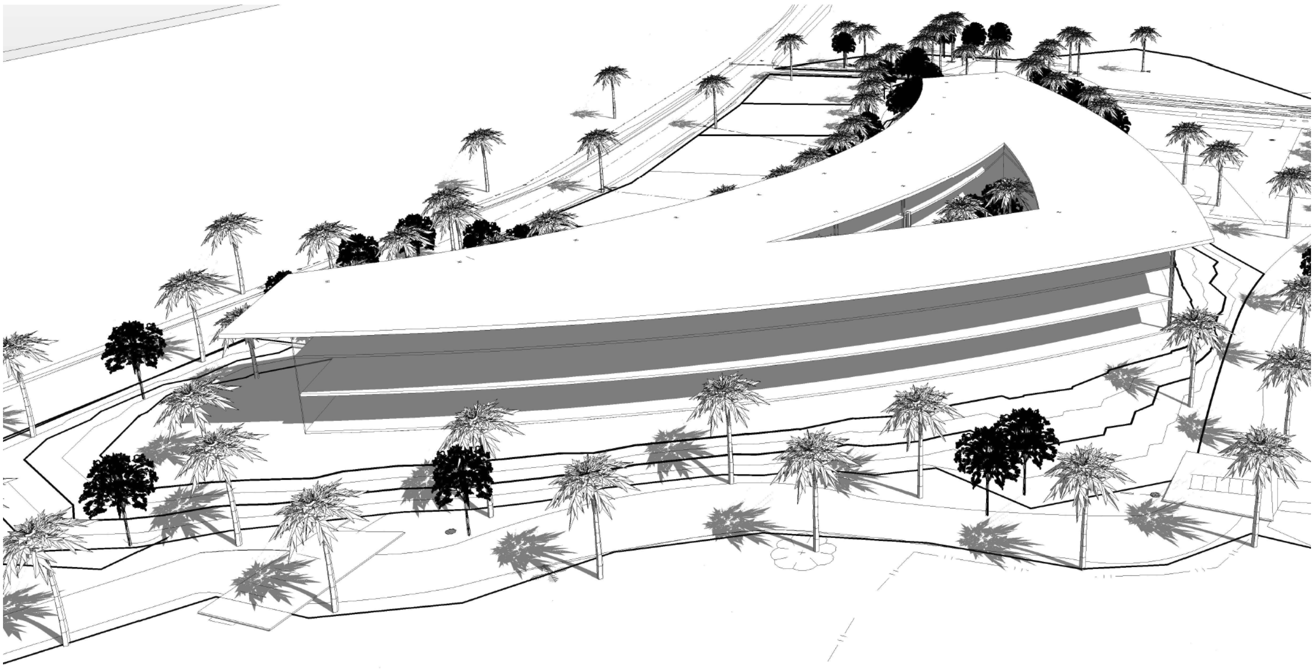


Figure 57: View from North

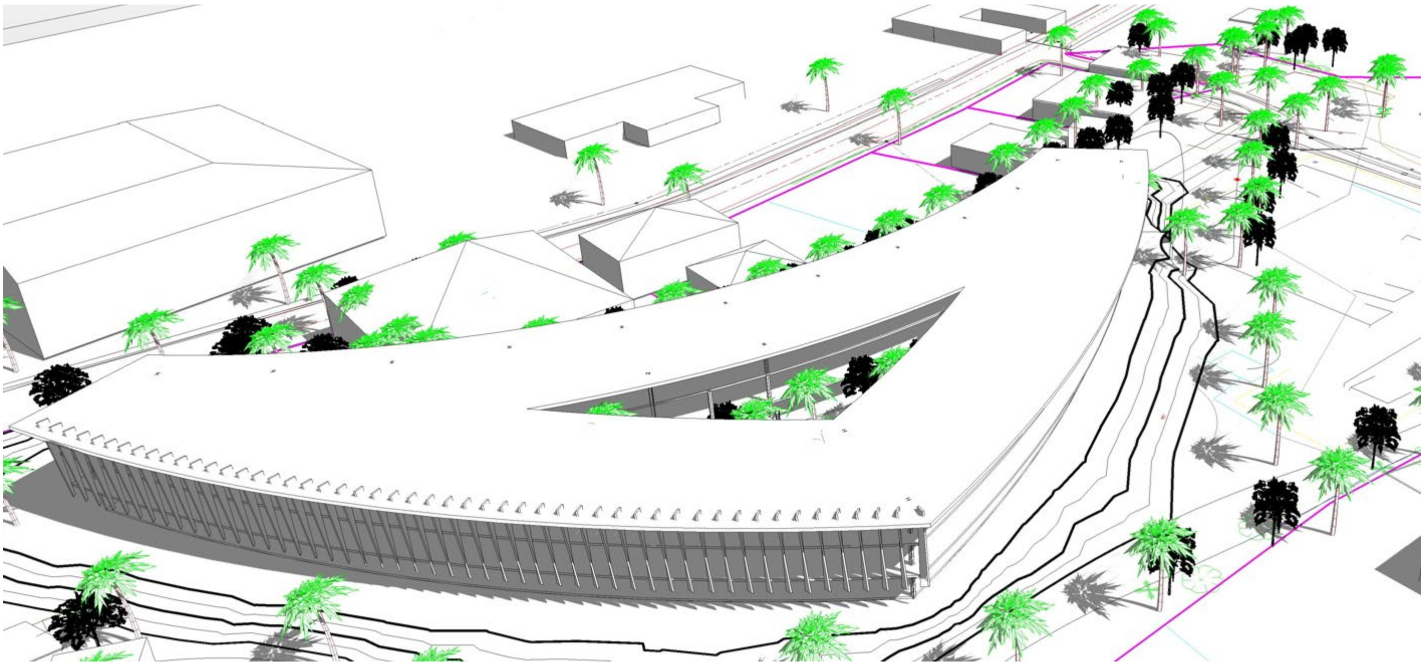


Figure 58: View from North North West

Te Aponga Uira Building – Power Utility Company on Rarotonga

Yoka' bracing design concept

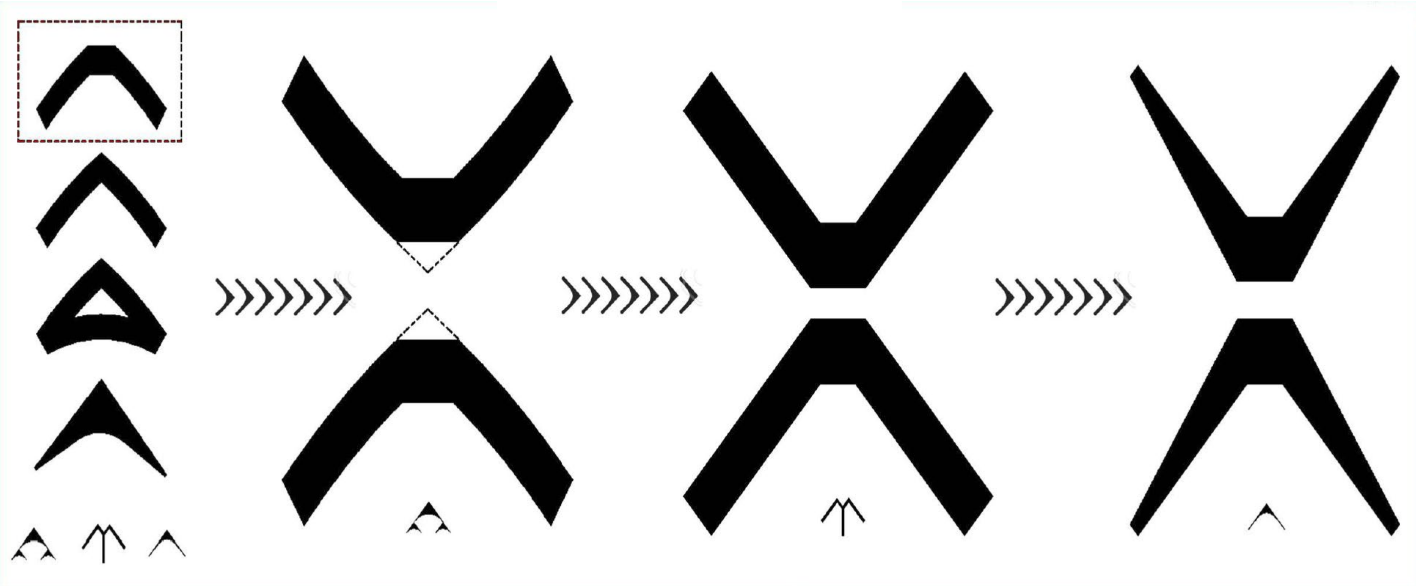


Figure 59: Yoka brace design development

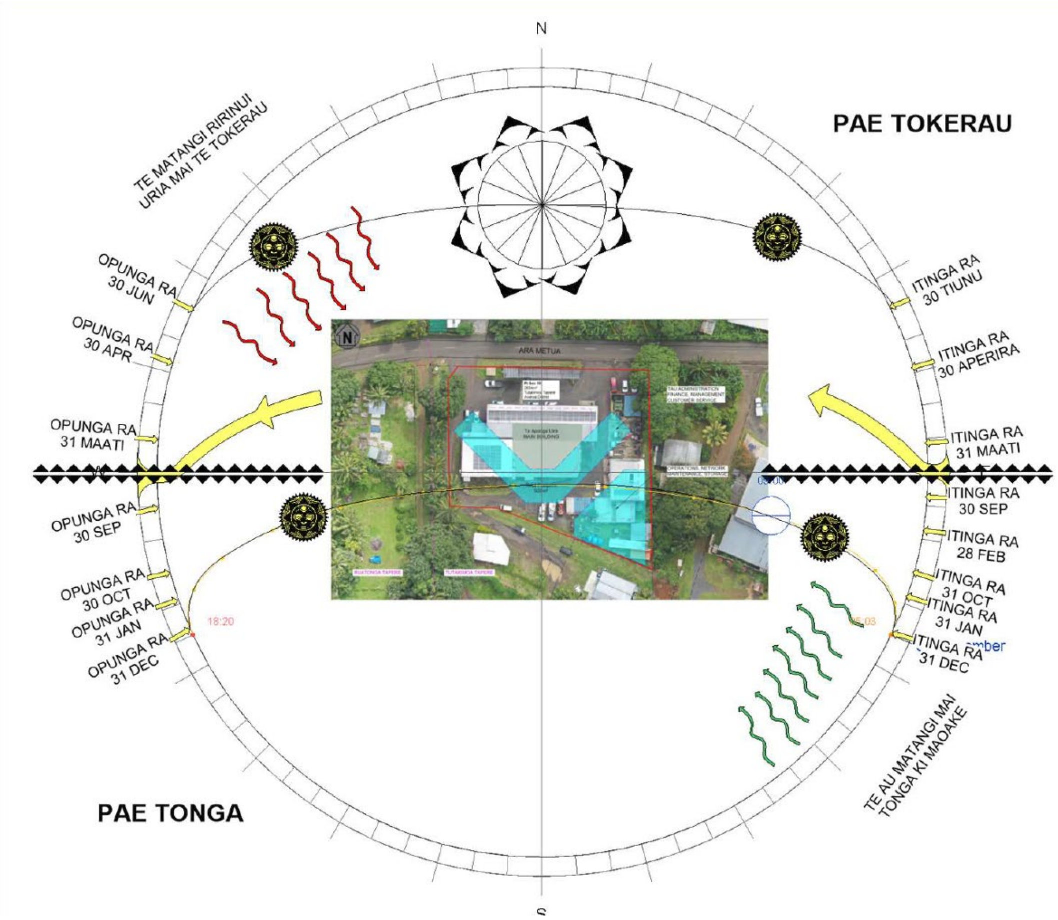


Figure 601: Site conditions, sun path, wind & cyclone direction

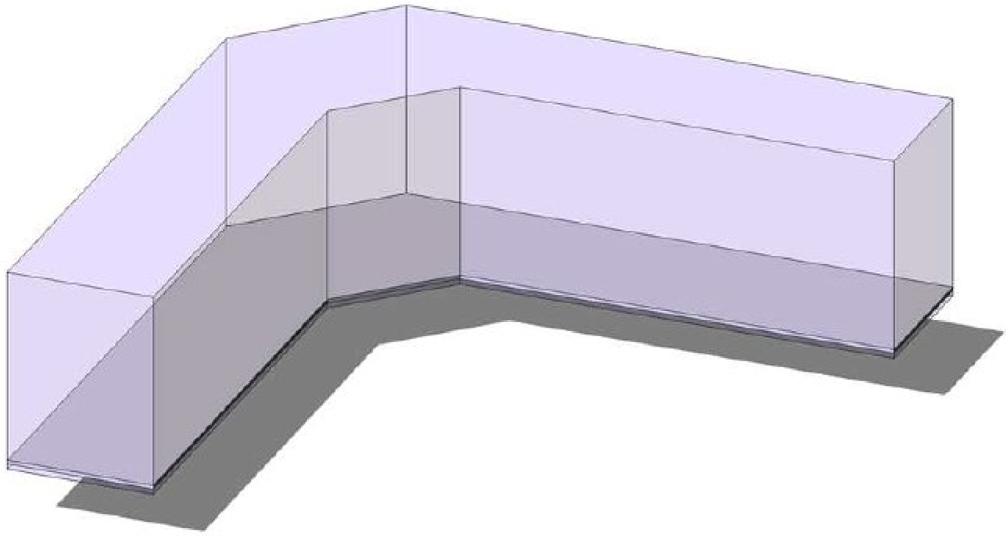


Figure 72: Bulk mass development

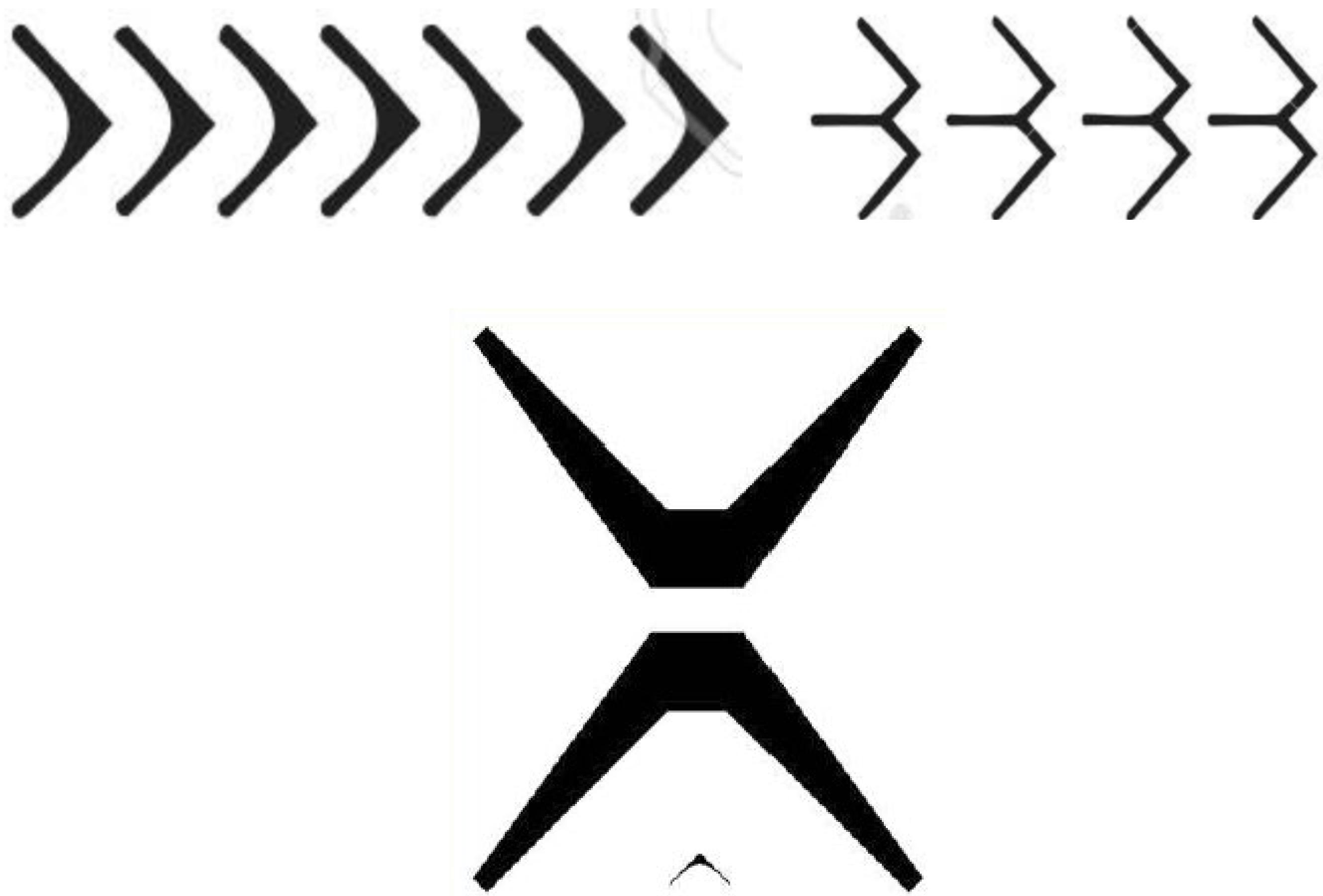


Figure 73: Yoka & manutai design development

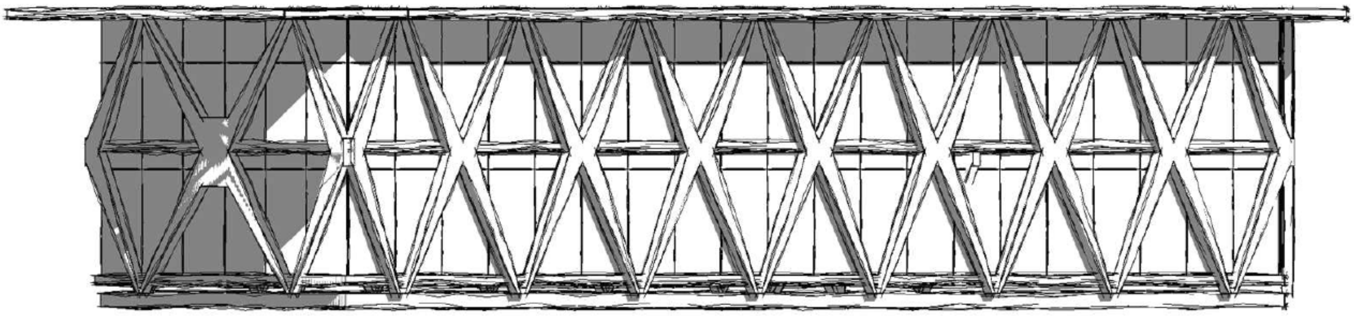


Figure 61: Yoka design structural design development

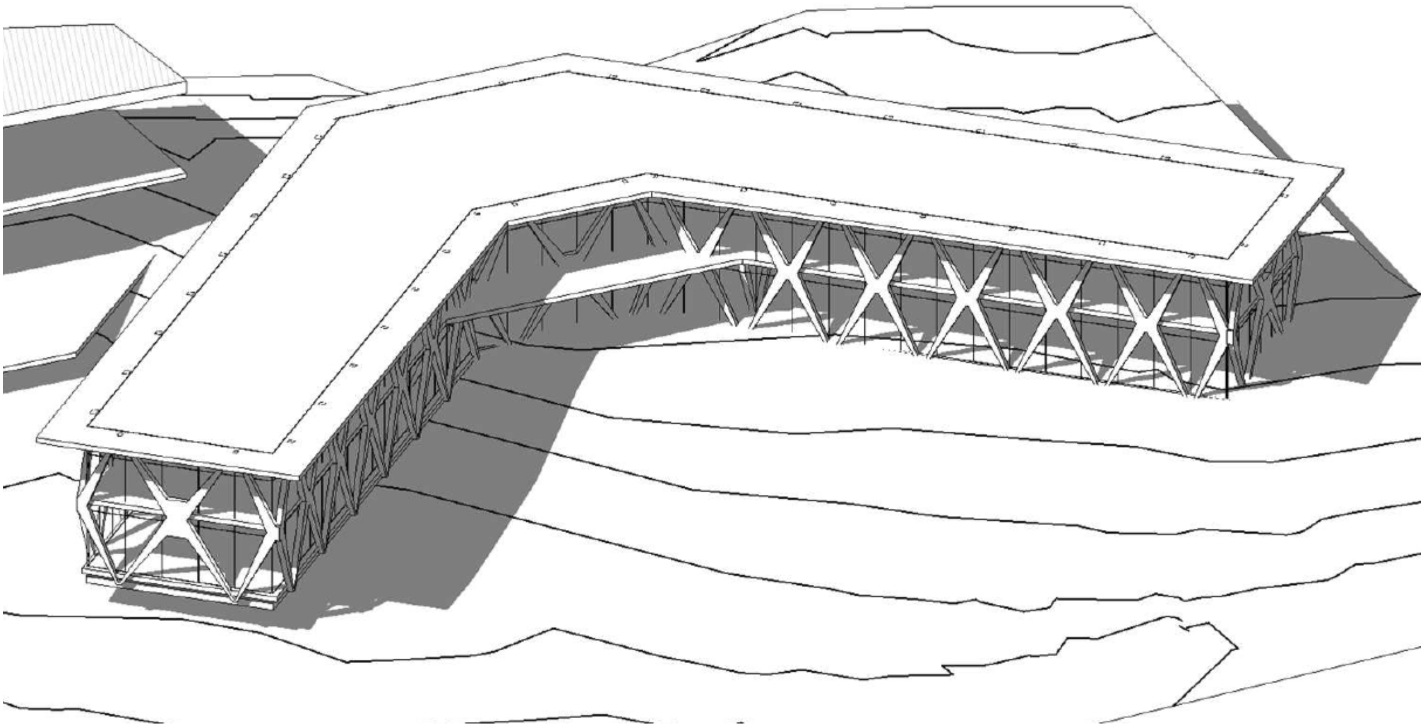


Figure 62: 3D view from North East

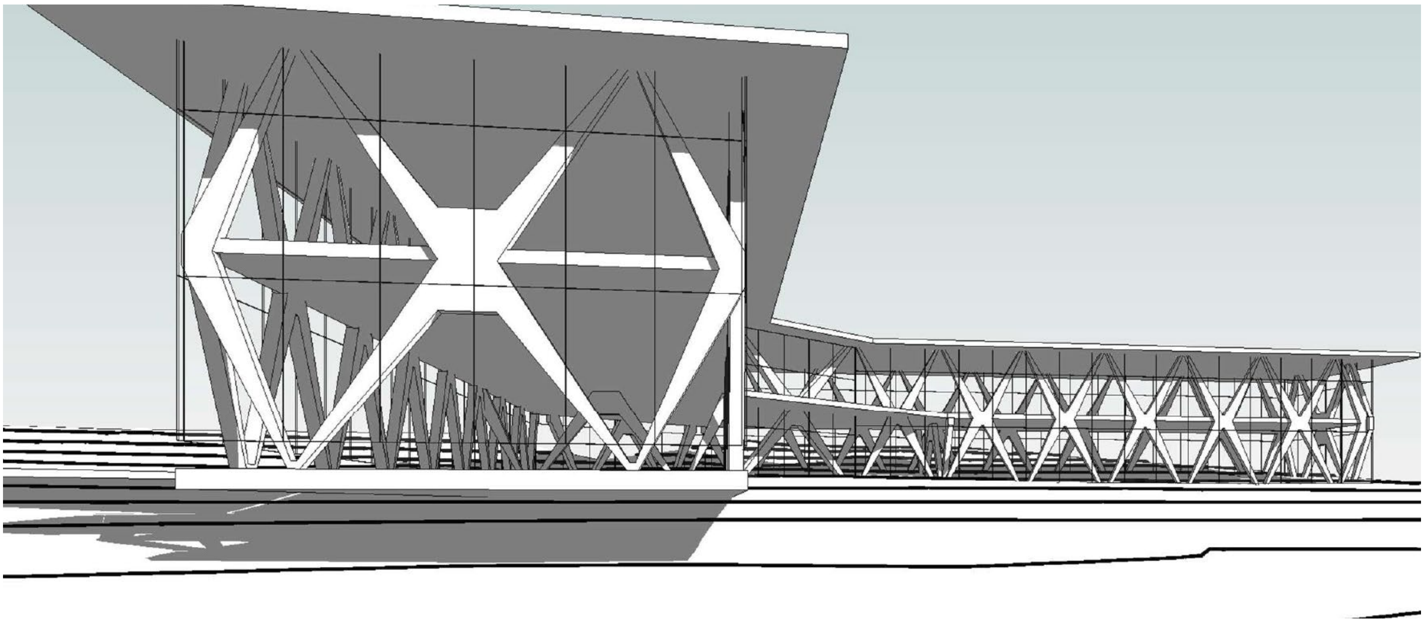


Figure 76: 3D view from North, yoka, diagrid bracing design development

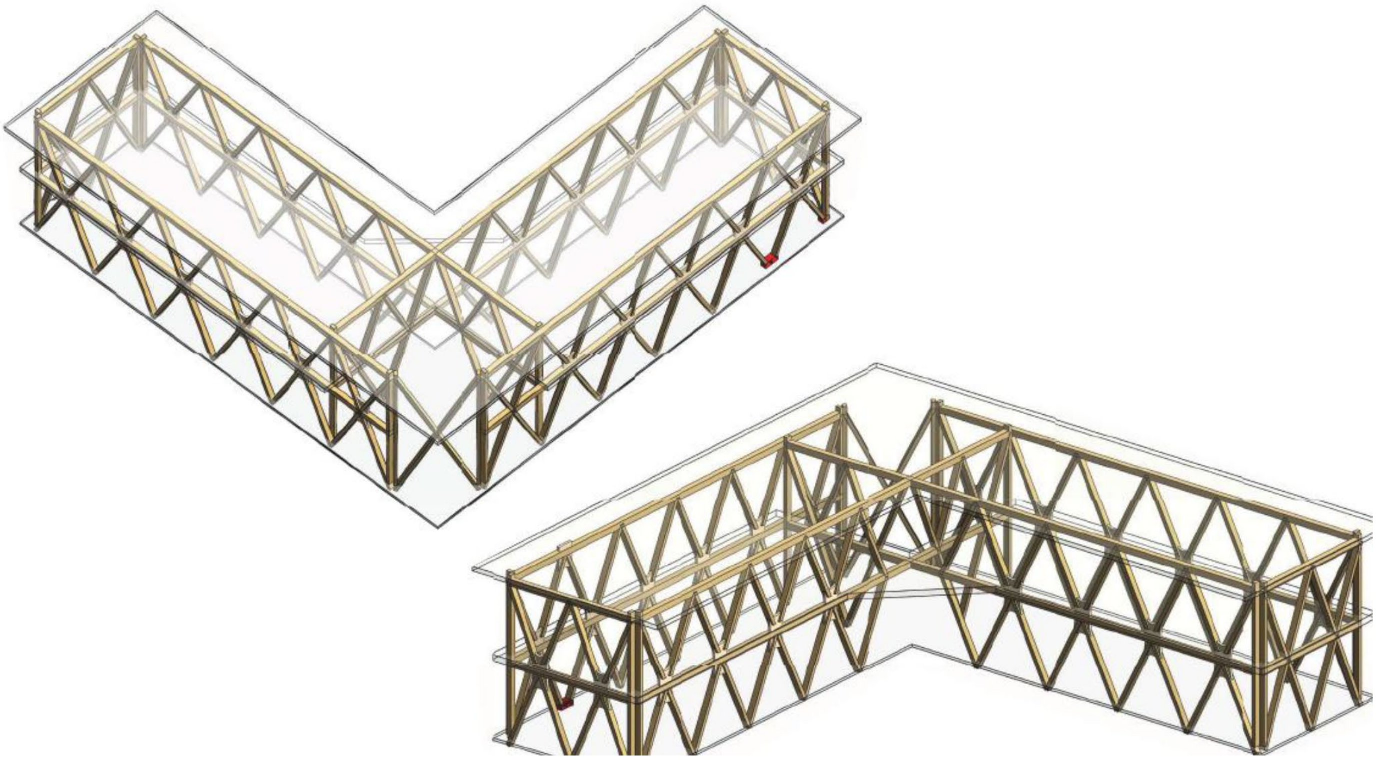


Figure 77: Diagrid structural timber bracing elements

Conclusion: Wakayawenga - Te Yiku

Reclaiming Indigenous Knowledge and Architectural Resilience

This research has sought to address several key questions concerning Indigenous design knowledge in Pukapuka, its loss, its connections to Aotearoa, and its relevance for climate-resilient solutions in the Pacific. Through an autoethnographic approach, this study has highlighted the intricate relationships between cultural heritage, environmental adaptation, and architectural ingenuity in the Cook Islands and its broader connections across Moana Nui o Kiva.

1. What is the Indigenous Design Knowledge of Pukapuka?

Pukapuka remains the last stronghold in the Cook Islands, where traditional customs, land tenure, environmental 'raui' 'tapu' systems social structures and building methods are still practised. This research has uncovered that Indigenous design principles in Pukapuka are deeply embedded in climatic adaptation, community-driven construction, and sustainable resource use. The architecture of Pukapuka features intricate lashing techniques, raised perimeter platforms, and Yoka bracing systems, all designed to withstand extreme weather conditions while fostering social cohesion through collective labour. The transmission of knowledge through oral traditions, practical demonstrations, and intergenerational mentorship has ensured the continuation of these techniques despite external pressures from colonial influences and modernisation.

2. How and What of This Knowledge Got Lost?

The loss of Indigenous architectural knowledge across the Cook Islands can be attributed to colonisation, missionary influence, and the adoption of Western construction methods. In Rarotonga, European settlement and the introduction of Christian Blue Laws led to the systematic suppression of traditional Māori cultural practices, including architecture, canoe-building, and tattooing. Additionally, colonial land tenure systems and economic shifts prioritised imported materials such as concrete, corrugated iron, and timber over locally sourced pandanus and coconut fibre, leading to the decline of vernacular construction techniques. This study positions Rarotonga as a "control" case, demonstrating how rapidly Indigenous knowledge can be erased when external influences disrupt cultural transmission.

3. Have Any of These Indigenous Design Principles Crossed Over from Rarotonga to Aotearoa?

The migration routes between Rarotonga and Aotearoa provided a critical pathway for the transfer of architectural, engineering and navigational knowledge. This research confirms that several key design principles observed in Māori wharenui (meeting houses) and waka construction in Aotearoa have direct parallels with pre-colonial Cook Islands architecture. These include:

- Lashing techniques for structural reinforcement, applied in both canoe-building and house construction.
- Post-and-beam connections that mirror the wharenui framework used in Aotearoa.
- Symbolic motifs and spatial organisation that reflect shared cosmological and genealogical knowledge across Polynesia. The presence of Tongan and Samoan architectural influences within the Cook Islands also suggests a multi-directional exchange of building technologies, reinforcing Pukapuka's historical role as a cultural bridge between West and East Polynesia.

4. What Can Be Done to Regain and Incorporate This Knowledge for Future Generations?

This research advocates for a revitalisation of Indigenous architecture through multiple approaches:

- Documentation and Scholarship: Writing this thesis serves as a form of repatriation of knowledge, ensuring that traditional Pukapukan design principles are preserved and made accessible to future generations.
- Practical Reconstruction: A replica building project, integrating traditional materials and methods, could serve as a living classroom for architects, builders, and cultural practitioners.
- Education and Community Engagement: Implementing Indigenous knowledge systems into architectural curricula and vocational training can ensure that younger generations retain and innovate upon these practices.

- Policy and Advocacy: Recognizing and incorporating mātauranga Māori (Māori knowledge) and Pacific Indigenous building techniques into climate adaptation strategies and modern construction codes can ensure their survival and continued evolution.

5. How Does Māori Indigenous Architecture Hold Climate-Resilient Solutions for Modern Building and Design in the Moana Nui o Kiva?

Māori and wider Pacific Indigenous architecture have historically integrated environmental resilience into their design philosophies. Traditional structures were not only dwellings but dynamic responses to their surrounding ecosystems. This study has shown that:

- Lashing techniques provide flexibility, allowing buildings to move with the wind rather than resist it, reducing structural damage during storms.
- Raised platform construction mitigates flooding, an essential feature for atoll environments experiencing sea level rise.
- Thatched roofing and open-air design enhance natural ventilation and thermal regulation, reducing dependency on mechanical cooling systems.
- Locally sourced materials minimise environmental impact and increase structural sustainability, aligning with modern circular economy principles and green architecture.
  These principles and modern advancements in digital fabrication and BIM (Building Information Modelling) provide a unique opportunity to blend ancient wisdom with cutting-edge technology for climate-resilient design solutions.

Final Thoughts

This research contributes to the decolonisation of architecture by reasserting Indigenous knowledge as a viable and sophisticated alternative to Western building paradigms. By reclaiming Pukapukan and broader Cook Islands design traditions, this study challenges the dominant narrative that Indigenous structures are primitive or obsolete. Instead, it demonstrates that these systems were highly engineered, adaptive, and deeply intertwined with environmental sustainability.

Moving forward, Indigenous architecture must not be confined to historical documentation but actively integrated into contemporary practice. The HERA Construction 4.0 principles, which emphasise digitalisation, sustainability, integration of traditional and modern practices, and collaborative innovation, align with the need for a hybrid architectural and engineering model that respects Indigenous wisdom while embracing technological advancements.

Building toward a PhD: Expanding the Research Scope

This master's thesis establishes a critical foundation for future research, and my upcoming PhD dissertation will expand upon these key themes in the following ways:

1. Deepening the Technical Analysis of Traditional Construction
    - Conducting a comparative structural analysis between Pukapukan lashing techniques and engineered timber connections used in modern seismic and cyclone-resistant structures.
    - Expanding research on the 'Yoka' bracing system, exploring how it can be adapted and integrated into contemporary Pacific housing models.

2. Digital and Fabrication Technologies for Indienous Architecture
    - Investigating how BIM (Building Information Modelling) and digital fabrication methods can aid in the revitalisation of Indigenous construction knowledge.
    - Exploring 3D scanning and digital archiving of vanishing architectural sites in Pukapuka and across the Cook Islands to aid in conservation and education efforts.

3. Applied Reconstruction and Material Testing
    - Designing and constructing a full-scale replica of a traditional Pukapukan 'wale' house, using both traditional and modern hybrid materials to assess performance in extreme weather conditions.

- Testing locally source materials such as pandunus trunks and thatch, coconut thatch and timber, and coral rock in their insulation, durability, and sustainability in comparison to Western construction materials.

4. Community-Led Design and Knowledge Repatriation
    - Expanding engagement with elders, master builders, and knowledge holders through community-led workshops to document and revive lost building traditions.
    - Collaborating with Maori and other Pacific communities to explore how ancestral architecture knowledge can shape contemporary Indigenous housing solutions.

5. Policy and Climate Adaptation Strategies
    - Advocating for the recognition of Indigenous architecture within Pacific climate policy frameworks.
    - Investigating how Indigenous land tenure and building practices intersect with modern planning regulations, and proposing policy recommendations that prioritise sustainable, community-driven housing models

Indigenous Pacific architecture is not a relic of the past but a living knowledge system capable of informing resilient, sustainable, and climate-adaptive solutions for the future, By expanding this research into a Phd dissertation, I aim to bridge traditional knowledge with contemporary construction technologies, creating a model for the future of Pacific architecture – one that is rooted in Indigenous wisdown, engineered for resilience, and adaptable for modern applications.

The findings of this research serve as both a historical reclamation and a forward-looking vision, ensuring that Pukapukan and wider Polynesian architectural knowledge continue to evolve and shape the built environment in the Cook Islands, Aotearoa and the broader Moana Nui o Kiva.

Figure 7863: The famous 'Shark Bait Hotel' jail cell

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Appendices

Appendix A: Glossary of Indigenous Terms

This glossary provides definitions for key Pukapukan, Māori and Polynesian architectural, navigational, and construction-related terms referenced throughout this thesis.

Pukapukan	English
aauli	steel
akapapa	to lay down flooring
alapo	phase of moon
aliki	chief, king
ango, wawanga	to measure length
Ao Malama	world of light
ao	day
ao	circular lashing used to bind or tighten other lashings
ati	ridgepole break, gap between the thatching on the two sides of the apex
ato lele	method when fixing coconut palm sheet using some short and some long midribs
ato yinaki lau	method when fixing coconut palm sheet midribs are all the same length
ato	to thatch, tie thatch on, put roof on
ato tele	uses both short and long midribs, alternating each course. Sections run from eaves to ridgepole without the defined courses of the ato yinaki lau method
atu	line, row of things
atua	god
awanga	religious round or oval enclosure, demarcated by a circle of stones placed on edge
epaepa	fine mat made of lauilu pandanus leaves
kai tangata	man eater
kainga	lineage
kainga/wale	home, house
kalava	midrib of a coconut palm frond
kapi	piece of wood added to the low side of a canoe to make it level with the other side: wakamatila
kati (wua)	Pukapukan matrimoiety
kauato	rafter on roof that holds the thatch leaves on
kaukau lua	roof plate
kaukau matua	main beam/wall plate
kaukau	wall plates/beam of house
kaupapa	hard conglomerate coral rock
kauwi	to begin weaving a mat
kawa	three ply twisted sennit rope
kawa, koyi	strip of land
kawaamalo	woven sennit rope with more than three strands used for making malo
kawatau	woven sennit rope with exactly three strands.
kayo	thatch rafter
keinanga	maternal sublineage
kie	fine mat made from lauilu fibres
kilikili	gravel/pebbles
kotikoti te tulutulu wale	trimming the eaves edge of coconut sheets in an even line
koyo	coconut husking stick
kupenga	net
la	sun
laavenga	method, way, resource
lala	to scorch leaves to make them soft and flexible
lau wala	pandanus leaves
lauilu	prepared leaves from the pandanus tree
yulu	pandanus tree for making *epaepa* mats
laukawa	coconut fibre for making sennit
lii	to tie, bind, lash together
lito	pandanus leaves prepared for weaving
lito	prepared pandanus leaves
liu	volume, capacity cubic measurement of a vessel (canoe)
lopa	young man
lua	grave
luu	to bind, lash with rope
lunanga	lashing in house
maani	to make, produce
maina, malama	moon
Manuyiki	Pukapukan name for Manihiki
mata	edge
Mataala	site within Motu Uta in Loto village guardhouse. Sacred malae of the goddess Taua
Mataaliki	traditional ancestor of Pukapuka. Was the god who raised Pukapuka from the papa below to above the sea. 'Te Ulu ote Watu'. Meaning 'The Head of the Rock'
mataa-tulanga<tula	area in front of house
mataawale	housefront
Matakula	planet Mars
Mataliki	constellation Pleaides
Matatea	planet Saturn
Matautu	Name of northern end of Motu Ko
Matauwea	name of western point on Motu Ko, also facing in direction of Uvea
matikuku, naelo	nails
matua	old, mature, fully grown
milimili	handywork
mooli	electrical light
motu	small island, islet
mulivaka	mature man, rear of canoe
Na Mata o te Paaniwi	Southern Cross
neinei	chock, wedge
Ngake	name for the people of Ngake village, Te Langaikula. Panaule (old name)
ngalipayua	*tridacna* shell
ngauta	land, shore

ngawa	measurement from tip to tip of fingers with outstretched arms
niu momoli	fourth ridgepole
niu	new coconut
nonoa	to tie, lash, bind
nuku	an island
oka	tiebeam
paapaa langi	horizon
paepae	platform for house structures consisting of low, rectangular alignment of stone filled with coral gravel, several feet around house also platform used in marae
paiokiole	diamond shaped lashing also used in fine mat designs
palapala	mud, dirt
palelawa	midrib of coconut leaf
pange wale	ground logs to keep in gravel
papa	bedrock
papanga	platform on tiebeams
papaanga	geneaology
paunga, pau	joint
pito	naval, eye of cyclone
po	night, burial grounds
pokai, yalu	to straighten out a pandanus leaf and put it in a roll
pola ati	thatching that sits on top of the apex overlapping the two sides of the apex
pola launiu	coconut palm leaf
pola taupoto	final thatch placed over the *pola ati*
pola wawati	long doubled sheet coconut midrib palm sheet
pola	coconut frond
potonga wenua, konga	plot of land
pou tau ki lunga	ridgepost
pou	post, wall posts
pou ki loto	middle side wall posts
pou tautaua	corner wall post
pu lua	bottom hatch of a platform in a storage house
pu pola	short coconut midribs
pu tai	top hatch of a platform in a storage house
puapua	kind of tree *(Guettarda speciosa)*
puku	uneven, not level
pukupuku	full moon
pula	rise of sun, moon, starts
pulu	coconut husk
punga	coral rock
punu	roofing iron
puutala	small house, hut
ta	to make into a shape, form, fashion
taavai	to mix
taka	house in which the guard group stay
takaa	lateral side of canoe joint
takapau taupoto	coconut ridging matt made of two split coconut leaves and placed over *pola taupoto*
takapau	coconut thatch mat, wall sheet, mat
takilikili	eaves purlin
tala lewu	end of house
tala wolo	side of house
talava tala lewu	end purlin to outer tiebeam
talava	mid way purlin
tama	child
tamanu	Mahogony
tamatane	lad, male child
tane	man
tangata	person, human
tango	footing, foundation
taniko	repeat, return to; to go round again
tapola	plaited mat from one half of a coconut frond
tapu	sacred, holy
tapulu	rolled mats when not used
tau lua	two ridgepoles, two hulled canoe
tau lua	second ridgepole
tau matua	first ridgepole
tau tolu	third ridgepole
taumata	roof extension of rafters to house and oven
tautulu	helper
tauwenu	thin strip of leaf for weaving
tau wuu	ridge beam of house
Te Mata o te Tokalua	Stars of the Two (Wua & Velo) Alpha and Beta Centauri
teke	wooden back rest
Te Wao o Maui	the fishing line of Maui, group of stars
tianiu	midrib of coconut leaflet
tino wale	general name of house
toki	adze
toomoemoe	straight, level
tua tane	male side
tua niu	coconut leaf midribs
tuku pola	lifting pole used for passing thatching
tuluma	plaited pandanus satchels
tupuna	ancestor
tuuta	canoe joints
ui pola	long coconut midribs
uka	two-ply twisted sennit cord
uliia	cyclone, hurricane
ulunga lakau	wooden headrests
ulunga laukawa	plaited pandanus pillows
unu	sacred stone of the god placed within the centre of the *awanga*
vai	spirit level (for building)
vaito	to measure
valuyi, tuai	coconut scraper
vayavaya	grass
velevele	coconut leaflet midrib brooms
wai laavenga	creative, inventive, skilful
wai	to make, do, prepare
waiwai	making of house wall, low walls
wakailo, ila	to draw a boundary, make a mark
wakakamu	notched out roof places to fit against tie-beams
wakalakalaka	mixed
wakamalamalama	to be enlightened
wakanamunamu	start doing something new
wakatala	heads of rafters notched out to fit against ridgepole
wakatupu	invent
wakaulu pou	top of wall posts notched to receive wall plates
wala	pandanus
wale atua	god house, ridgepole house
wale imu	cook house/kitchen
wale kaikai	eating house/kitchen
wale kaitau	a darkened house used for fattening the sacred maid

wale matenga	house of mourning
wale takataka	copra type/storage house
wale toinuku	is a small , low house, usually to serves as cook house on outer beaches. Sometimes a sleep house
wale tulu	ridgepole house, similar to *wale atua*
wale wakayamoa	Samoa type house
Wale	name of main Island on Pukapuka
watu	rock, stone
vao	wasteland, bushes
wawanga	measurement
wenua	island, land, country
wetau	Mahogony
wononga or tuta	side of house
wou	recent, new, modern
wou	drill
wowou	to make, build, construct
wua	lineage grouping on female side, matrilineage wulu-outer edge of cyclone
wuti poto tala lewu	end rafters to gable end
wuti poto	principal rafters
wuti poto tala iti iti (lewu)	end rafters
wuti poto tala wolo	side rafters
yaka	chant dance haka
yakali	mature coconut
yako	level
yako	straight, level
yengia	to be full and round
yiku	pointed end of a leaf, tail
yikuanga	subdivision of house
yila	light, flash
yimu	lashing in house
yimu u'akapeka	three circumferential turns
yimu wakamau	suspended loop lashing
yimu wakapeka	type of lashing by four transverse turns which are themselves tightened by three circumferential turns
yimu wakawiwi	one type of lashing pattern using alternating curves to all parts of a house
yinakava	anything or anybody tapu. God house on a double canoe or a sacred structure is yinakava
yitolo	ghost
yiva, Atu Yiva	islands to the east, Nuku Hiva
yoka	supports, bracing
yoka1	wall bracing, supports
yoka2	diagonal brace from roof plate to main ridge pole
yoka3	diagonal strut/brace from bottom plate to top plate
yolonga	burial lineage
yongi, yoyongi	to kiss, embrace
yuki	peg, needle. A special thatching needle, made of hardened wood, *ngangie*
yula, tauyulayula	out of line, uneven
yulu	species of pandanus tree, its leaves *laukie* are stronger and thicker than lau wala and used as kie for high quality hats and mats

Table 1. Comparison of *‘y’* and *‘w’* with other Polynesian consonants*

ENGLISH	PUKAPUKA	AOTEAROA	TONGA	SAMOA	UVEA	Niutao/Sikaiana	HAWAII	MARQUESAS	RAROTONGA	TAHITI	RAPA NUI	FIJI
	y	h	h	S	h	h, s	h	h, f	‘	h	h	w, v, c
walk	yaele	haere	haele	saele	haele	haele	haele	hee	‘aere	haere	ahere	lako
sin, to err	yala	hara	hala	sala	hala	hala	hala	haa	‘ara	hara	;ara	cala
to do	yanga	hanga	hangahanga	-	hangahanga	hanga	hana	hana	‘anga’anga	Ha’a	hanga	cakava
pregnant	yapu	hapu	feitama	ma’itaga	-	hapai	hapai	hopu	nui	hapu	-	bukete
to dance to a chant	yaka	haka	sipi tau	siva tau, sasa	kailao	ha’a	ha’a	haka	-	-	haka	meke
tie	yele	here		fusiua		here	hele			here	here	vau
to flick, scatter	yeuyeu	heuheu	heuheu	-	-	heu	e hoopuehu	feu	‘eu	heu	heu	drisoa
tail	yiku	iku	hiku	si’u, i’u	hiiku	hi’u	hi’u		‘iku	-	‘iku	buca
grey hair	yina	hina	hina	sina	-	hina	hina	hina	‘ina	hina	-	senitoa
friend	yoa	hoa	hoa	soa	hoa	hoa	hoa	hoa	‘oa	hoa	hoa	itokani
to husk	yoka	hoka		so’a		hoka	hoka					vaki
to smell or kiss	yongi	hongi	uma	sogi		honi	honi		‘ongi	oni		boi
saliva	yuvale	huware	-	-	-	huare	wai ni, hupe	-	‘uavare	huare		su
	w											
four	wa	wha	fa	fa	fa	fa	‘eha	fa, ha	‘a	maha	ha	va
stingray	wai	whai	fai	fai	fai	fai	hai	fai, hai		fai	hai	vonu
causative prefix	waka	whaka	faka	fa’a	faka	faka	ha’a	ha’a, haka	‘aka	haka, faka	haka	vaka
house	wale	whare	fale	fale	fale	hale	hale	fae, fae	‘are	fare	hare	vale
to go away	wano	whano	fano	fano	fano	fano	ha’alele	-	-	fano	-	lako
octopus	weke	wheke	feke	fe’e	feke	he’e	he’e	Fe’e	‘eke	fe’e,	feke	kuita
land	wenua	whenua	fonua	fanua	fenua	henua	honua	fenua, henua	‘enua	fenua	henua	vanua
I want	wia	hia	fie	fia	fia	fia	hia	Fia, hia	‘ia	hia	-	via
paddle	woe	hoe	fohe	foe	foe	hoe	hoe	hoe	‘oe	hoe	hoe	iqalo
new	wou	hou	fou	fou	fou	hou	hou	hou	‘ou	hou	hou	vou
swallow	wolo	horo	folo	folo	folo	holo	holo	hoo	-	horo	horo	lumea
seed	wua	hua	fua	fua	fua	hua	hua	hua	‘ua	hua	hua	sore
to open	wuke	huke	fuke	Su’e	fuke	huke	huke	-	‘uke	-	-	dolava

This table compares the phonetic characteristics of consonants in different Polynesian languages and dialects. It particularly focuses on the Pukapukan language, spoken on Pukapuka, and how its sounds correspond to those in other Polynesian languages including Fijian which has significant Austronesian influences but follows a distinct phonetic pattern. Fijian often replaces 'w' with 'v', drops 'h', and has some unique words unrelated to other Polynesian languages. The Fijian ‘c’ is comparable to the Pukapukan ‘y’.

Appendix B: Principles of HERA Construction 4.0

HERA Construction 4.0

Integrating HERA Construction 4.0 Principles with Indigenous Autoethnographic Research

Introduction

The construction industry is currently undergoing a profound transformation driven by the principles of Industry 4.0. This revolution, which emphasises the integration of digital technologies to enhance efficiency, sustainability, and resilience, has given rise to the crucial framework of HERA (Heavy Engineering Research Association) Construction 4.0. This innovative approach aims to revolutionise construction practices by adopting advanced tools and processes. However, HERA Construction 4.0 is not just about technological innovation; it also advocates for a holistic approach that respects and integrates traditional knowledge and practices with contemporary methods. This chapter explores how my research aligns with HERA Construction 4.0 principles, focusing on revitalising traditional Pukapuka building techniques through an indigenous autoethnographic lens. By reflecting on my experiences and cultural background as a member of the Pukapuka community, I aim to document, analyse, and adapt these ancient techniques using modern digital technologies[79]thereby contributing to the broader goals of HERA Construction 4.0 and reinforcing the industry's commitment to sustainability and resilience.

The Principles of HERA Construction 4.0

HERA Construction 4.0 is based on several foundational principles that guide the evolution of the construction industry:

1. **Digitalization and Automation:** Integrating digital tools and automation enhances construction processes, reduces errors, and improves efficiency. This includes Building Information Modelling (BIM) technologies, 3D printing, and digital manufacturing.

2. **Sustainability and Resilience:** This unwavering commitment is a testament to the industry's dedication to developing construction practices that prioritise sustainability and the resilience of structures in the face of environmental challenges, particularly those posed by climate change. This commitment should reassure and instil confidence in our readers about the industry's efforts to address these pressing issues.

3. **Integration of Traditional and Modern Practices:** Our profound recognition of the value of traditional knowledge and practices, and our commitment to integrating them with modern technology, is a testament to the respect and acknowledgment of our heritage in the construction industry. This approach ensures that traditional knowledge is preserved, celebrated, and actively integrated into our research.

4. **Collaborative Innovation:** This principle underscores the importance of promoting collaboration among various stakeholders, including architects, engineers, indigenous communities, and policymakers. By fostering such collaboration, the construction industry can benefit from diverse perspectives and experiences, leading to innovative solutions and knowledge-sharing.

These principles guide my research, providing a framework for exploring the intersection of traditional Pukapuka building techniques and modern digital technologies.

Indigenous Autoethnography as a Research Methodology

My research employs an indigenous autoethnographic methodology to engage fully with HERA Construction 4.0 principles. Autoethnography is a qualitative research method that combines autobiography with ethnography, allowing researchers to use their personal experiences as a lens through which to examine cultural phenomena. In an Indigenous context, autoethnography becomes a powerful tool for reclaiming and revitalising traditional knowledge systems[80]. Drawing on my personal experiences as a member of the Pukapuka community, I can reflect on the traditional building practices passed down through generations and consider how these practices can be preserved, adapted, and integrated into modern construction.

The Indigenous autoethnographic approach is particularly relevant in HERA Construction 4.0, as it aligns with integrating traditional and modern practices. This methodology allows me to document and reflect on my knowledge of traditional Pukapuka architecture, including constructing cyclone-resistant structures known as 'wale'. Using sketches, photographs, and historical records as prompts, I

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[79] Jiun, P W Y. (2020, July 15). Indigenous, local and regional traditions: Views from ritual and ceremony. Penerbit Universiti Sains Malaysia, 16(2), 1-9.

[80] Houston, J. (2007, July 1). Indigenous Autoethnography: Formulating Our Knowledge, Our Way. Cambridge University Press, 36(S1), 45-50.

can consolidate my reflections on these traditional practices and consider how they can be revitalised within a contemporary context. This process contributes to preserving cultural heritage and provides valuable insights into how traditional knowledge can inform and enhance modern construction practices[81].

Digitalization and Automation in Traditional Pukapuka Architecture

One of the core principles of HERA Construction 4.0 is the use of digitalisation and automation to improve construction practices. In the context of my research, this principle is applied by exploring how digital tools such as BIM and 3D printing can be used to document, analyse, and reproduce traditional Pukapuka building techniques[82].

Building Information Modelling (BIM): BIM is a digital representation of the physical and functional characteristics of a building. It provides a shared knowledge resource that can be used to make informed decisions throughout the lifecycle of a building, from design to construction and beyond. In my research, BIM is critical for integrating traditional Pukapuka building techniques with modern construction practices. By creating digital models of traditional structures, I can capture the intricate details of these techniques, including the materials used, the binding methods, and the design principles that contribute to their resilience. These digital models can then be used as a basis for further analysis and adaptation, preserving traditional knowledge while facilitating its application in contemporary construction.

3D Printing and Digital Manufacturing: 3D printing and digital manufacturing offer additional opportunities for integrating traditional knowledge with modern technology. By creating physical models of traditional structures using 3D printing, I can explore the possibilities of adapting these techniques for modern construction. For example, traditional binding methods that rely on natural materials could be reimagined using advanced materials with greater strength and durability. Similarly, traditional design principles can be incorporated into modern architectural forms, creating aesthetically pleasing and functionally resilient structures. These traditional techniques can be adapted and scaled through digital manufacturing processes for contemporary construction projects, ensuring they remain relevant and effective in the modern world.

Sustainability and Resilience in Traditional Pukapuka Architecture

Sustainability and resilience are central to HERA Construction 4.0, and these principles are particularly relevant in traditional Pukapuka architecture. The structures built by the Pukapuka community are inherently designed to withstand cyclones, a common environmental challenge in the Pacific. By studying these structures and reflecting on my experiences, I aim to identify the key elements that contribute to their durability and explore how they can be incorporated into modern building practices[83].

Resilience in Traditional Wale Construction: The traditional 'wale' structures of Pukapuka are a testament to the ingenuity and adaptability of the community. These buildings are constructed using locally sourced materials and are designed to withstand the extreme weather conditions that frequently affect the region. The key to their resilience lies in the careful selection of materials, the use of specific binding techniques, and the incorporation of design features that allow the structures to flex and bend in response to high winds. By documenting and analysing these techniques, I can identify the principles that contribute to the resilience of traditional wale construction and explore how these can be applied in modern contexts.

Sustainability and the Use of Natural Materials: Sustainability is another critical aspect of traditional Pukapuka architecture. Using natural materials, such as timber and thatch, not only reduces the environmental impact of construction but also ensures that the buildings are in harmony with their surroundings. In my research, I explore how these traditional materials can be integrated into modern construction practices by using them directly or by developing sustainable alternatives that mimic their properties. This approach aligns with HERA Construction 4.0's commitment to sustainability, as it promotes using environmentally friendly materials and practices in the construction industry.

Integration of Traditional and Modern Practices

Integrating traditional and modern practices is a core principle of HERA Construction 4.0 and central to my research. By combining indigenous knowledge with modern digital technologies, I aim to create innovative solutions that respect cultural heritage while addressing contemporary challenges. This integration is not just about preserving traditional knowledge but also about adapting it to meet the needs of the modern world.

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[81] Memmott, P. (2011, April 1). Cultural Change And Tradition In The Indigenous Architecture Of Oceania. Routledge, 16(1), 38-54.
[82] Noktehdan, M., Shahbazpour, M., & Wilkinson, S. (2015, April 1). Driving Innovative Thinking in the New Zealand Construction Industry. Multidisciplinary Digital Publishing Institute, 5(2), 297-309
[83] Mahendran, M. (1995, November 1). Wind-Resistant Low-Rise Buildings in the Tropics. American Society of Civil Engineers, 9(4), 330-346.

Revitalising Traditional Knowledge through Digital Technologies: One of the critical goals of my research is to revitalise traditional Pukapuka building techniques using digital technologies. This involves documenting these techniques, analysing their strengths and weaknesses, and exploring how they can be adapted for modern use. For example, the principles of traditional wale construction can be incorporated into modern building designs to create structures that are more resilient to extreme weather conditions. Similarly, using natural materials can be promoted as a sustainable alternative to conventional building materials, reducing the environmental impact of construction. By integrating these traditional practices with modern technologies, I aim to create innovative solutions that are both culturally respectful and technologically advanced[84].

Collaborative Innovation: Collaboration is another crucial aspect of HERA Construction 4.0, and it is essential for successfully integrating traditional and modern practices. In my research, I engage with various stakeholders, including members of the Pukapuka community, architects, engineers, and policymakers. This collaborative approach allows for sharing knowledge and expertise, ensuring that the solutions developed are innovative and culturally appropriate. By working together, we can create a construction industry that values and respects traditional knowledge while embracing the possibilities of modern technology.

Recommendations

1. Digitizing & Geo-Mapping

- **Objective**: Digitize and geo-map island maps, site plans, town planning, and motus (islets).
- **Tools**: Create detailed digital maps using GIS and satellite imagery.
- **Process**:
  - Conduct aerial drone surveys for high-resolution imaging of the islands and motus.
  - Integrate digital maps with town planning databases for easy land use, infrastructure, and zoning information access.
  - Ensure the maps are updated regularly to reflect changes due to natural events or development.
- **Outcome**: A centralised, easily accessible geo-database that supports planning, development, and disaster recovery.

2. Detailed Site Plans and Maps of Village Areas and Buildings

- **Objective**: Create detailed site plans and maps for the main villages, motu village areas and specific buildings.
- **Tools**: CAD software (Revit) and GIS integration.
- **Process**:
  - Perform on-ground surveys and combine them with existing cadastral data.
  - Map individual building footprints, including dimensions, materials, and orientation.
  - Incorporate environmental data such as elevation, drainage, and vegetation.
- **Outcome**: Accurate, detailed plans that facilitate targeted development, heritage preservation, and resilience planning.

3. BIM Modelling of Building Structures

- **Objective**: Develop Building Information Modelling (BIM) focusing on key structural design and durability elements.
- **Key Areas**:
  - **Joint Connections**:
    - Model joint connections between footing/lower structure beams and upper post beams.
    - Analyse the structural integrity under various load conditions, including cyclones.
  - **Bracing Strength Design**:

[84] Findlay, R A., & Katoa, R. (1998, August 1). Cyclone Management Report for Pukapuka Atoll, Cook Islands

        - Design bracing systems to enhance structural stability.
        - Model and simulate different bracing configurations to determine the optimal design.
    - **Local Material Selection**:
        - Model the durability of local materials under harsh climatic conditions.
        - Include treatments and preparation methods to extend material lifespan.
- **Tools**: BIM software such as Revit, Tekla, or ArchiCAD, with structural analysis plugins.
- **Outcome**: Robust, cyclone-resistant building designs utilising local materials and traditional knowledge while incorporating modern engineering principles.

4. Design and Digitize Standard Parts for 3D Printing

- **Objective**: Design standardised building components that can be 3D printed in New Zealand and shipped to the islands.
- **Process**:
    - Identify critical components (e.g., joint connectors, braces) that can be standardised.
    - Design CAD parts and simulate their performance using FEA (Finite Element Analysis).
    - Create digital files that can be used for 3D printing.
    - Develop flat-pack designs for easy shipping and assembly.
- **Outcome**: A library of digital part designs that can be quickly manufactured and shipped, reducing lead time and costs, especially post-cyclone.

5. Improved Manufacturing, Packaging, and Shipping

- **Objective**: Enhance the efficiency of manufacturing, packaging, and shipping to small boat tenders.
- **Process**:
    - Implement modular manufacturing to produce parts that can be easily assembled on-site.
    - Design packaging that minimises volume and weight, reducing freight costs.
    - Develop a logistics plan that includes optimised shipping routes and schedules to ensure timely delivery.
    - Train local teams in handling and assembling the flat-packed components to reduce dependency on external labour.
- **Outcome**: Streamlined manufacturing and shipping processes that lower costs, reduce risks during off-loading, and expedite post-disaster recovery.

6. Marketing, Branding, and Intellectual Property (IP) with HERA?

- **Objective**: Develop a strong marketing, branding, and IP strategy to promote and protect the project's innovations and extend its application across the Cook Islands and the Pacific region.

A. Brand Development

- **Name & Logo**: Create a recognisable brand name and logo that reflects the project's cultural significance, resilience, and sustainability.
- **Brand Storytelling**: Emphasize the project's focus on combining traditional CI & NZ Māori and Pacific architecture with modern technologies (BIM, 3D printing, geo-mapping) to address climate resilience and disaster recovery.
- **Cultural Authenticity**: Ensure the brand maintains cultural integrity by involving local CI & NZ Māori and Pacific communities in its development.

- **Brand Values**: Highlight core values such as innovation, sustainability, community resilience, and respect for cultural heritage.

B. Marketing Strategy

- **Target Audience**:
  - Local government bodies and communities in the Cook Islands.
  - Regional development agencies in the Pacific, New Zealand and Australia.
  - International aid and disaster recovery organisations.
  - Construction companies looking for sustainable and resilient solutions in island environments.
- **Marketing Channels**:
  - **Online Platforms**: Develop a website and social media presence showcasing project success stories, case studies, and technical innovations.
  - **Conferences and Exhibitions**: Present at regional events such as the Pacific Island Forum, showcasing how the Smithproject addresses both local needs and global challenges like climate change.
  - **Educational Workshops**: Host training sessions for local builders, architects, and engineers on the project's innovative aspects.
  - **Partnerships**: Collaborate with regional construction associations and environmental organisations to promote the solutions.

C. Intellectual Property (IP) Protection

- **Patent and Trademark Registration**:
  - Register patents for key innovations, especially around 3D-printed components and modular assembly designs.
  - Trademark the brand and any unique architectural processes or systems developed in the project.
- **Copyright for Digital Designs**:
  - Protect the BIM models, 3D-printable component designs, and geo-mapping data through copyright law to control their distribution and usage.
- **Cultural IP**:
  - Ensure the protection of traditional knowledge incorporated in the designs, working with local CI & NZ Māori and Pacific communities to secure IP rights in a culturally respectful manner (e.g., using indigenous building techniques).
- **Licensing Agreements**:
  - Develop licensing models that allow other islands or countries to adopt and implement the designs and processes while protecting the origin and ownership of the project's innovations.

D. Scalability and Adaptation

- **Customization for Other Islands**: Market the ability to adapt designs to other island environments, accommodating local materials, climates, and cultural practices.
- **Training and Support**: Offer comprehensive training packages for other Pacific Island countries to ensure the successful implementation of the project's technologies.
- **Documentation & Case Studies**: Publish case studies and technical documentation that showcase the project's effectiveness, scalability, and adaptability across different island environments.

E. Sustainability and Social Responsibility

- **Environmental Impact**: Emphasize the project's focus on reducing the carbon footprint through the use of local materials, 3D printing, and efficient shipping methods.
- **Community Engagement**: Show how the project empowers local communities by preserving cultural heritage, creating job opportunities, and enhancing resilience against natural disasters.
- **Collaboration with Regional Bodies**: Establish connections with regional development and sustainability initiatives to align the project with broader Pacific goals, such as those outlined by the Pacific Community (SPC) or United Nations Sustainable Development Goals (SDGs).

Outcome:

By developing a well-rounded marketing, branding, and IP strategy, we can expand the reach of our project beyond the Cook Islands to other Pacific nations. This helps preserve cultural heritage, strengthen disaster resilience, and creates opportunities for collaboration, innovation, and sustainable development in the broader Pacific region.