THE VERNACULAR AS EXAMPLE

HOW CAN TRADITIONAL VERNACULAR ARCHITECTURAL PRINCIPLES IMPROVE THE BUILDING CULTURE OF SINT MAARTEN?

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ABSTRACT

Sint Maarten's building culture is highly dependent on foreign expertise and imported building materials due to its colonial history, and is generally unsustainable, particularly in relation to the reoccurring hurricanes and earthquakes. In the quest for revitalizing Sint Maarten's building culture, the author is drawn towards traditional vernacular architecture. Four sustainable traditional vernacular principles are defined; material appropriateness, climate responsiveness, socio-economic advantages and adaptability. Of the first three aspects, case studies are conducted. The same three aspects of the current building culture of Sint Maarten are analyzed. They are compared and discussed. It was found that Sint Maarten's modern vernacular can be improved by incorporating traditional vernacular architectural principles. However, the current environmental, economic, political and social situation should not be disregarded. The ATUMICS model could be an adequate theoretical model for merging tradition with modernity.

KEYWORDS: *Vernacular architecture, building culture, climate responsiveness, material appropriateness, building knowledge and skill transmission.*

I. INTRODUCTION

Modernism and concurrent globalization have globally introduced alien and non-climate-specific architectural typologies that expel originality and the use of local, natural materials. Imagination, inventiveness, creativity and ornamentation are often replaced by concrete blocks and corrugated iron (Piesik, 2017). Sint Maarten has encountered a similar situation, and was introduced to foreign building methods and materials even before the advent of the Industrial Revolution. In search for overseas territories the Dutch occupied the island in 1631, bringing building materials and expertise with them. Initially, the Dutch brought bricks as building material. Later, local hewn stone was used to build, bonded by a lime mortar, in combination with imported North-American wood (Hartog, 1964, Andel, 1985). According to Fathy (1973), new materials and building methods also necessitate the intrusion of the professional architect, a specialist who has been taught the science of working in these materials.

This paper claims that due to Sint Maarten's historical context, the current building culture is highly dependent on foreign expertise and imported materials, and is generally confused and unsustainable. Particularly in relation to the climate with its reoccurring hurricanes and earthquakes, the current building customs seem to be in need of a sustainability and resilience-course, maybe best visible by the high percentage of destruction of the built environment of the latest hurricane (510, 2017), and the high CO2 per capita of Sint Maarten (Worldbank, 2014). The main problem stated in this paper is a lack of appropriate building knowledge, divided in three subjects; climate responsiveness, material appropriateness and transmission or dissemination of building knowledge and skills. The paper is part of a graduation project that aims to revitalize the current building culture of Sint Maarten, with an emphasis on finding solutions to the problems mentioned above.

In the quest for revitalizing Sint Maarten's building culture, the author is drawn towards vernacular architecture. Building traditions embody conclusions of many generations' experimentation with the same problem (Rudofsky, 1965, Fathy, 1973, Oliver, 1997), rendering vernacular architecture the practical embodiment of centuries of wisdom and experience (Piesik, 2017). The body of vernacular research defines four main sustainability principles of vernacular traditions; *climate responsiveness*, the idea that indigenous vernacular dwellings and settlements are, by virtue of their forms and materials, responsive to (changing) climate conditions, *material and site appropriateness*, the notion that materials are used in a way that secures their constant renewal and supply, while appropriately fitting in and relating to the surrounding environment;, *socio-economic advantages*, the notion that traditional community building processes foster social bonds and lower building costs; and *adaptability*, the idea that these dwellings are flexible, expandable or portable (Lee and AlSayyad, 2011).

The sustainable vernacular principles most closely related to the beforementioned problem statement are the basis for defining the main and sub questions of this paper: *How can traditional vernacular architectural principles improve the current building culture of Sint Maarten?* Of which sub-questions are; *1. How can vernacular architectural principles improve the climate responsiveness of the current building culture of Sint Maarten? 2. How can vernacular architectural principles improve the material appropriateness of the current building culture of Sint Maarten? 3. How can vernacular architectural principles improve the building knowledge and skill transferability of the current building culture of Sint Maarten?* To understand how findings could be applied to Sint Maarten, a fourth sub-question is added: *4. How can traditional architectural principles be applied to a modern building culture?*

1.2 A definition of Vernacular Architecture

A definition of vernacular architecture is a necessity in order to research it. Coming across several potential definitions of the vernacular (Rapoport, 1969, ICOMOS, 1999), Oliver (1997) notes that a number of attempts have been made to find an overall definition of vernacular architecture and that it is not surprising that attempts have been unsuccessful for the term is used to embrace an immense range of building types, forms, traditions, uses and contexts. He continues to give his own definition of the vernacular anyway; *'Vernacular architecture comprises the dwellings and all other buildings of the people. Related to their environmental contexts and available resources, they are customarily owner or community-built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of the cultures that produce them.'* Agreeing with this definition, but building up on it, it is considered here a definition of *traditional vernacular architecture*. During fieldwork, an architecture that can be described similarly was observed, though without using traditional technologies. When one leaves out the 'utilizing traditional technologies' of Oliver's definition, one has a definition of *modern vernacular architecture.*

II. METHODOLOGY

The methodology of this research is mainly qualitative and descriptive. The above mentioned concept of a traditional vernacular and a modern vernacular will be set forth throughout this paper. Traditional vernacular architectural research is conducted by literature research (case studies, chapter III). The modern vernacular architecture (i.e. the current building culture) is researched in-situ and conducted by (un)structured interviews, structured and recorded surveys, observation and fieldwork (chapter IV). The traditional vernacular and the modern vernacular are compared and discussed in the conclusion.

Considering the traditional vernacular, the case studies are selected according to the respective sub-topics mentioned in the introduction. Cases are also selected on geographic location, using a world map of natural hazards in combination with a Köppen-Geiger map (appendix A) (Munich, 2011, Piesik, 2017). If possible, a case is selected that is climatically similar to Sint Maarten, both in a (sub)tropical and a hurricane, cyclone or typhoon region. However, the available literature with an architectural emphasis on vernacular architecture is broad and mostly typological or aesthetical, but often not in depth in relation to the research focus of this paper. Therefore, cases are also selected on information quality and availability.

III. THE TRADITIONAL VERNACULAR; THREE CASES

3.1 Climate responsiveness: hurricane resilient measures of Ryukyu's vernacular

Edgar Hume, an American military engineer, documented the passing of typhoon Gloria over Okinawa, the largest of the Ryukyu islands, in July 1949. The typhoon reached wind speeds up to 270 kilometers per hour, nearly as intense as Sint Maarten's Irma in September 2017. He observed that the difference in the effect of the typhoon on the domestic huts of the Okinawans and on the military structures was remarkable (Hume, 1950). According to Hume (1950), the native houses certainly withstood the typhoon better than the military structures. In some cases, it could be explained by the location of the houses. Okinawans were already familiar with the reoccurring typhoons and situated their houses in tactical places, as sheltered nooks and the lee of the hills, where the wind would strike less severely. But even where Okinawan huts and American metal buildings stood side by side, it was usually the American buildings that suffered most damage. The local explanation was that the buildings of the Okinawans would let wind pass through. The tightly closed metal buildings were impervious. Wind could not enter their walls but did pass under the floors, pushing them up violently with an explosive effect, creating one of the largest hazards during Gloria; razor-sharp flying pieces of metal.

Not just the well thought geo-topographic relation and the permeability of the Ryukyu's vernacular results in its typhoon resiliency. On the Ryukyu Islands, local residents long followed a tradition of planting thick-leafed evergreen trees around their houses, known as Fukugi. Combined with a coral stone wall that is around 1.5 meters in height and 0.7 meter thick and carefully stacked, they create a streetscape unique to the Ryukyu islands. In addition to creating shade, the Fukugi and coral stone wall form a typhoon-barrier, protecting the houses from the horizontal gales, particularly protecting the roofs and eaves. Since the trees' trunks do not have thick foliage at their bases, the lower parts of the buildings are protected by the coral stone walls. The residents cannot completely surround their houses with walls; they need an opening to enter or leave their premises. To prevent winds from blowing in through this opening, a short additional wall, the Hinpun, is built behind it. A specific variation on Tonaki island shows ground levels of houses approximately 0.4 meters lower than street level. As many Ryukyu islands, Tonaki's subsoil is made up of coral reefs. Rainwater drains away quickly through the soil, making lowering the ground level of the house possible. The eaves of the roof are often made the same height or lower than the height of the surrounding stone and coral wall. With a height of the wall on Tonaki island being approximately 1,6 meters and the lowering of the ground level of 0.4 meters, the eaves are usually around 2,0 meters high (Park, 2012, Okubo, 2016).

Next to the barrier that should break the wind and redirect it over the eaves, other hurricane resilient measures are the distinctive red rooftiles that are bonded by a plaster, preventing separate roof tiles from blowing off. Furthermore, in the Ryukyu islands, large-scale houses are considered disadvantageous since they would catch more wind. Often the houses comprise of one or several small buildings. The form of the house is simple and close to square. Structurally, it has thick pillars, a low ridge, and a well-established frame (Park, 2012). Under the eaves, the open space characteristics of the house result in natural ventilation and allows wind to go through the house, making the uplift of the house due to strong winds virtually impossible (appendix B.1, B.2, B.3).

Image 1 (left): Streetscape of the Ryukyu islands; a typhoon barrier of coral stone walls and trees (Okubo, 2016). Image 2 (right): Visible are the coral stone walls, the Hinpun and the red rooftiles bonded with plaster (Okubo, 2016).

3.2. Material appropriateness: the renewable materials of Caribbean's pre-Columbian vernacular

The Caribbean islands were already colonized about 6000 years ago. When Europeans arrived, they found the Caribbean to be densely inhabited by diverse indigenous groups, and in their observation concluded the Caribbean of having two kinds of people, the Taino's (or Arawaks) and the Caribs, while in fact there were many different ethnic groups that all descended from the Saladoids that migrated around 500 – 0 B.C (Wilson, 1997). In the study of the vernacular architecture of the pre-Columbus Caribbean, similar domestic architectural typologies seem to have emerged (Samson et al., 2015). In the available literature, several types are defined, amongst them the maloca, the caney and the bohio. They differ in size and form, but are often constructional and materially alike, though the materials used for construction seems dependent on local availability.

The archeological study of Samson (2010) discusses Oviedo's encounter with the domestic architecture of the indigenes during the Spanish colonialization of the Caribbean and serves as a good material and construction description of the structures, of which a summary is provided here;

They come in two forms, both built according to the preferences of the builder. Many posts of good, round wood, each an appropriate thickness, four or five paces between each post, are set in a circle. On top of these, after being fixed in the ground at head height, a ring beam is placed. On top of these tie beams are placed, which take the tension of the roof. Radial rafters are placed with the thinnest parts uppermost around the ring beam, so that they come together in a point, like a military tent. Over the rafters crosswise canes are put, or laths, a palm's distance (21cm) from each other, single or two by two, and on top of this a covering of long thin straw. Others are covered with bihao leaves, bunches of cane or palm leaves, and others with other materials. Where the wall is, from the ring beam to the ground and between the posts, canes are put shallowly fixed into the ground between the posts, and as close together as fingers on a hand. Joined on to the other they make a wall. They are tied together very closely with bexucos, which are vines or round cords which grow around trees like bindweed. The bexucos are very good ties, because they are flexible and easy to cut, and they don't perish. They act to fix and bind instead of ropes and nails to attach one piece of wood to another, and to attach canes the same way. The house made in such a fashion is called a caney. In order that it is made strong and the structure and everything properly built, it has to have a center post or mast in the middle, which is fixed in the ground four or five palms deep and which reaches the highest point of the house, to which all the points of the roof rafters are attached.

The cross-disciplinary study of Samson et al. (2015) researches the resilience of pre-Columbian house building in relation to the climate and makes no typological subdivision, referring to pre-Columbian architecture as ‘the Caribbean architectural mode.’ In their discussion of the Caribbean architectural mode, they describe the larger poles of the structures to be of a tropical hardwood, such as mahogany or sapodilla. Samson (2010) and Ramcharan (2014) also name guayacan (lingum vitae) to be a wood used for the poles. Archeological remains show that posts were sometimes directly put into holes in the limestone bed rock. The postholes must have been made with great skill using shell picks or chisels. In El Cabo, where 30 circular house plans were archeologically analyzed, 90% of the postholes were less than 26cm across. Slender hardwood posts could support considerable loads (Samson et al., 2015). Furthermore, a remarkable feature of the indigenous vernacular of the Caribbean that Samson et al. (2015) describe is that many structures appeared to have endured a considerable length of time trough either rebuilding or the replacement of parts. Site occupation typically spanned several centuries. Foundations were secure in high winds and earth tremors, in part because long, dense hardwoods are heavy enough to resist uplift. Making postholes in the bedrock would have facilitated house dismantlement at the approach of extreme events, kept intact the most valuable and labor-intensive parts of the construction and allowed rapid repair and reuse after storm impact. Ease and speed of dismantlement could have played a role in favoring smaller over larger houses, and choice of smaller and thus more numerous dwellings may have increased building survivorship ratios. Houses thus incorporated and shared a sacrificial principle by virtue of their combination of robust and replaceable lightweight elements providing an effective recovery system.

Another interesting feature of the archeological research in El Cabo is that despite the fact that postholes in the bedrock offered the possibility of infinite re-use, inhabitants periodically built new foundations, possibly as part of coordinated periods of community renewal (Samson et al., 2015) (appendix C.1, C.2).

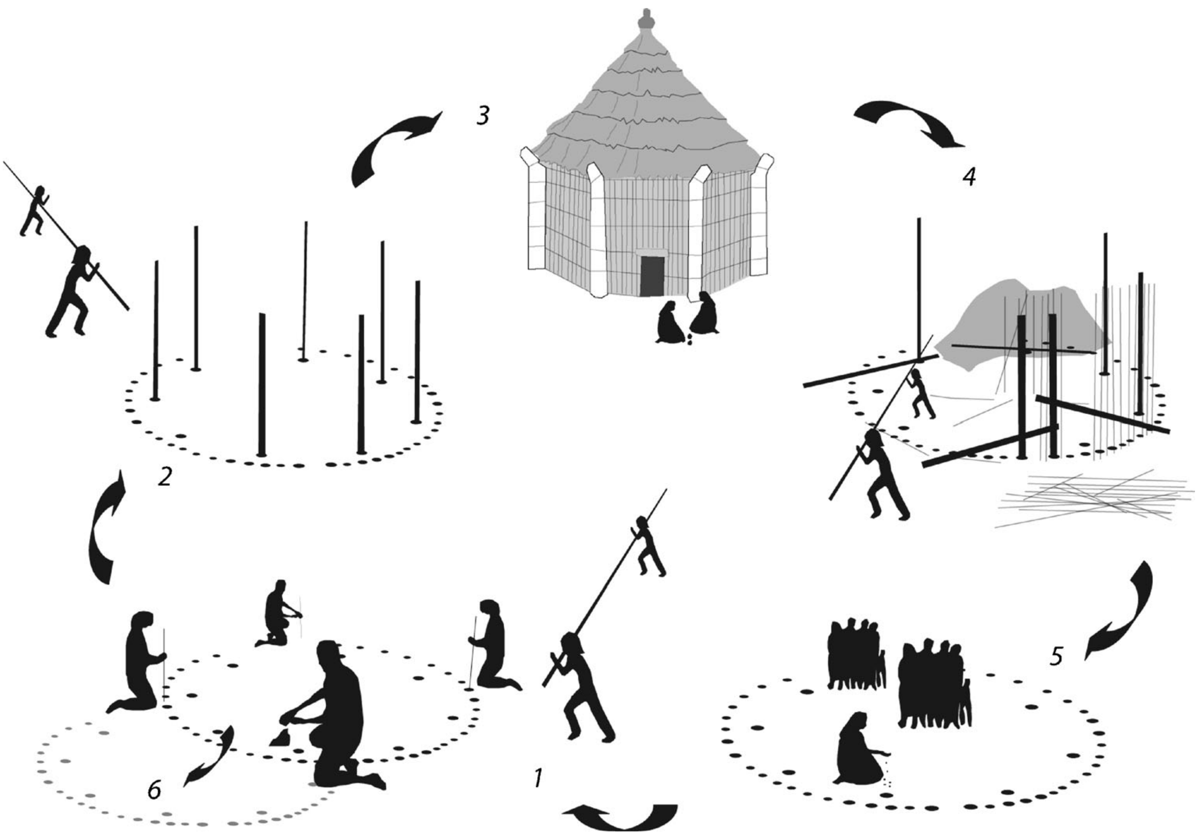


Image 3: Repair and rebuilding in the lifecycle of a Caney. 1: digging foundations, 2: construction, 3: habitation and cycles of repair, 4: abandonment and reuse of parts, 5: ritual closing, 6: starting anew. (Samson, 2010)

3.3. Socio-economic advantages: The Ise Shrine, transmitting traditional building knowledge and skills through rebuilding

Japan's Ise Shrine is famous for its thirteen-hundred-year-old reconstruction tradition, the *Shikinen Sengu.* In the shrine, two alternately used enclosures stand side by side. In an empty enclosure a new group of buildings is made in the image of the existing ones. This renewal process takes place every twenty years and is particularly remarkable for two reasons. First, it has preserved an ancient architectural style in a material that is susceptible to rot. Second, it has also preserved the ancient construction technologies needed to build it. The latter seems to be the most important aspect of the *Sengu*; the transmission of the tradition to the next generation, with an emphasis on preserving construction technologies (Tange et al., 1965, Adams, 1998).

In her research, Adams (1998) investigates the construction procedures used in the most recent reconstruction cycle and describes the procedures as subdivided in materials, labor, methods, management and rituals.

Considering the materials used, they are simple, traditional and locally available, similar to the materials that have been in use since ancient times. Amongst them are hinoki (Japanese cypress) for the buildings, kaya (a reed) for the roof thatch and white pebbles for the ground cover (Adams, 1998).

Ise's labor force is constructed similar to other construction projects; each worker is skilled in working with a specific material and works as part of a group of people having the skills needed to complete the task at hand. Craftsmen represented are sawyers, carpenters, laborers and thatchers. The main group consists of carpenters and are ranked according to experience level. The youngest and least experienced begin by working on the Uji Bridge, which is completed earlier than other construction work and functions to improve skills and experience. They work in small teams called *zoebu,* each headed by a more experienced carpenter. A group containing the most experienced people work on more complex aspects of the project and advises the lesser experienced groups. Architects are also involved in the reconstruction, but their work is more management than design related. Also, a traditional carpenter learns design skills in his training too, so a greater number of people are trained to participate in design decision making. A unique aspect of the construction is the participation of several hundred thousand unskilled worshipers to perform two ritualized construction tasks; the transport of logs from the forest to the work site and the placing of the pebbles on the ground around the completed buildings (ibid).

Planning of the construction procedures commence sixteen years in advance of the climactic *Sengyo* ceremony. Trees are harvested and processed into building elements. The selection of the trees is done by the head carpenter, who at this stage already knows which tree will be which building element. Logs are transported to work yards and laid to season, which can take several years. In the milling shed, sawyers cut them into rough planks. The wood rests until it is time for finishing. In a fabrication shed, carpenters plane the wood to final size and cut the joints. Simultaneously, another team is busy constructing a temporary shed over the building site. Electric tools and gas-powered engines are not allowed on the sacred building site, rendering all finishing tasks manual labor. The wooden structure is installed and the thatchers lay the roof. The temporary shed is disassembled and moved to the next building location, after which the pebbles are ceremonially placed on the ground around the new buildings. Six months after the *Sengyo* the old buildings are disassembled. The wood is saved for reuse (ibid).

On-site construction work is overseen by the *zoecho,* consisting of about forty carpenters managed by a team of five men, all of whom are overseen by a general construction manager. A number of subgroups are responsible for various parts of construction, including the beforementioned *zoebu.* As stated before, the most important aspect of the entire management process is the transmission of skills and technologies to the next generation. The carpenters at Ise do not make elaborate drawings of their work, most of their knowledge is passed on orally. Records consist of written descriptions of overall building dimensions, lists of wood members and their sizes, a rough site plan and a few detailed drawings of decorations. Besides de *zoecho,* the construction of Ise includes another management group; the *zojingu*. This organization oversees and regulates the ritual conditions within which the construction takes place (ibid).

What differentiates Ise of other traditional building practices are the rituals that mark more than thirty steps in the construction process. The rituals can be divided in roughly four groups; rituals that marks activities that disturb the natural environment such as harvesting trees, rituals that mark completion of particular phases of work, rituals held when particularly sacred building elements are installed and rituals in which the construction activity has become sacralized, for instance the collective white pebble placement (ibid) (appendix D.1, D.2).

Image 1 (left): using a hand-operated winch for lifting heavy wooden members into place (Adams, 1998). Image 2 (right): trolley for moving materials from the work yard to the sacred building site (Adams, 1998).

IV. THE MODERN VERNACULAR OF SINT MAARTEN

From observation during fieldwork, wherein 22 houses were visited, it was concluded that generally there are three domestic modern vernacular types. These are; buildings with a concrete foundation, a wooden structure and a wooden roof; buildings with a concrete foundation, concrete walls and a wooden roof and buildings with a concrete foundation, concrete walls and a concrete flat roof (appendix E.1, E.2, E.3). In this chapter, the climate responsiveness, material appropriateness and building knowledge and skill transfer in relation to these types are briefly discussed.

4.1. Climate responsiveness: Sint Maarten

The domestic modern vernacular of Sint Maarten embeds some hurricane proof elements. The more aerodynamic hipped roof with short to no overhang is a characteristic of the modern vernacular dating back to the limestone wood houses described by van Andel (1985). Also, the proper bracing of wooden walls and roof are hurricane proof elements that are observable. Some houses have a verandah, which are meant to not be attached to the main roof structure since the overhang could ‘catch wind’ and rip of the complete roof. Windows are of a special type, that allow for cross ventilation and can be closed in the advent of a hurricane. Furthermore, especially the buildings that have concrete walls seem to be rather impervious to the characteristic eastern breeze present on the island. From conversation and observation, it became clear that building practices focus on the resistance towards hurricanes (and not to earthquakes), resulting in a preference of the concrete foundation, concrete walls and concrete roof-type over the other types.

4.2. Material appropriateness: Sint Maarten

Considering material appropriateness, the use of renewable materials is marginal. Also, all building materials are imported, providing serious logistic issues after hurricane impact. As described above, there seems to be an increasing preference over the full concrete type house due to its seemingly hurricane-resistant capacity, though hurricane-resistance highly depends on the quality of building (specifically of the anchoring, bracings and connections) and not on the material (Vaes, 2019). The Red Cross does not help with constructing concrete roofs for a clear reason; though it is not the most present threat, Sint Maarten is also prone to earthquakes. However infrequent, having a concrete roof could be disastrous in the advent of one.

4.3. Building knowledge and skill transfer in Sint Maarten

Self-building practices are not possible without having certain building skills and knowledge. It is likely that the knowledge and skill is also transferred within Sint Maarten's communities, though conversations with builders showed that often experience was developed during a job in construction on another Caribbean island. There is some skill to build, however, the knowledge on how to build hurricane and earthquake proof or resilient seems to be little and divergent. The lack of appropriate building knowledge is also observable by the low quality of the self-built buildings. Sint Maarten has a vocational school (NIPA), but schooled builders usually find their way to repairing hotels or other buildings for financial reasons (Vaes, 2019). The Red Cross teaches residents of Sint Maarten in need of a job to repair roofs with the Red Cross construction team (Gatóo, 2019) (appendix F). In doing so, the Red Cross is the only party on the island working on getting adequate building knowledge back into the communities and decreasing their dependency on expertise.

V. TRADITION AND MODERNITY

In architectural literature, traditional vernacular architecture is easily adopted as sustainable by definition. In response, Lee and AlSayyad (2011) suggest that it is important to think of the concept of a traditional vernacular in relation to the notion of time, resulting in the question; *when* is traditional vernacular architecture sustainable? The sustainability principles of the traditional vernacular are often inapplicable in today's context. A deeper reflection is needed about present-day environmental, economic, political and social issues in relation to sustainability and the traditional vernacular. Furthermore, in trying to recover the sustainable aspects of the vernacular, one should be careful not to adopt a copy-paste attitude. Solutions from the past often no longer meet current social aspirations, and put out of context could be alienating and even ignorant of local climatic characteristics (Piesik, 2017). Piesik (2017) also advocates that countries need to establish a new paradigm for the expansion of their built environment; one that is based on the adaption of their past and the sensitive use of local resources, as well as meeting modern needs and aspirations.

5.1. ATUMICS, connecting tradition with modernity

Similarly, according to Walker et al. (2017) traditions have to change and adapt in order to stay relevant. Transforming tradition means connecting it with modernity. They propose a theoretical model with a product design emphasis, which has potential for architectural projects (appendix G.1). Practically, one can use the model as a guide in the process of designing a new object (or architecture). When designing something based on tradition, the method can be used to inform the designer which factors should be considered, which aspects of tradition or contemporaneousness could be used, and how to combine traditional with contemporary elements. Artifacts (or architectures) are classified according to six fundamental elements; the technique, utility, material, icon, concept and shape. *Technique* suggests a production process. *Utility* refers to the functionality and usability of a product or building. *Material* refers to the physical matter from which the artefact or architecture can be made. *Icon* suggests any form of local imagery that emerges from nature, color, myth, people or artifacts. *Concept* refers to hidden factors that exist beyond objects and forms and s*hape* suggests the form or the visual and physical properties of an object. Furthermore, the method helps to clarify the designers motivation, and whether his design would aim at being a one-off project, or a mass produced project (Walker et al., 2017).

To understand this method better it will be used to analyze the work of Hiroto Kobayashi, who borrows knowledge from vernacular solutions in the region and combines this with an efficient modern structural system (Piesik, 2017). Particularly here, a project in Myanmar will be analyzed, the Manawhari learning center, which was constructed in the aftermath of a typhoon and a concurrent flood. The motivation for his work is both social and ecological. Kobayashi aims at restoring the connection between people and the built environment, and believes that people should become involved in the process of construction (Kobayashi, 2019). He uses this method for just several of his works across the world, making his work a craft rather than mass-produced. The project in Myanmar combines a self-built veneer construction with an infill of local woven bamboo mats. Thus, the *technique* in this project is both modern and traditional. Considering the *utility*, the function of the building inspired on the vernacular typology of the region is not domestic but public. The utility is thus modern. The *material* is again a combination of traditional and modern elements. The stilts are now concrete, the structure is veneer, but the infills are the locally traditional woven mats. Considering the *icon* and *concept,* they are hard to read from this project. The *icon* could be the local pattern of bamboo weave for example. The *shape*, is inspired on tradition, since it follows the typology of the regions domestic vernacular (appendix G.2).

VI. CONCLUSIONS

Ryukyu's traditional vernacular takes into account the geo-topographic relation before choosing a site to build upon, and lets wind pass through, therefore making uplift due to wind virtually impossible. Other elements are the use of a coral stone and tree windbreak around the perimeter, a qualitative construction, and a heavy solid roof. Also, houses often consist of one or several smaller buildings, large structures are considered to be less advantageous since they would catch more wind. Sint Maarten's modern vernacular could adopt site strategies, however there is generally a lack of space to build upon, and site motivation is often financial. Accepting wind to pass through a structure could be an interesting design implementation, as well as adding vegetation and other windbreaks along the perimeters of the plots to reduce hurricane impact. Since Sint Maarten's subsoil is not similar to the Ryukyu islands, lowering the foundation level of the building could be problematic in relation to the hurricane's concurrent rainfall. Creating several smaller structures rather than one large structure is advisable (appendix H.1).

The pre-Columbian architectural mode consisted fully of locally available materials. Structural elements were made out of hardwoods, the walls and roof structure of canes, and the roof material was often thatched with palm, bijao leaves or other materials at hand. As connecting element, vines were used. Postholes were sometimes carved into the limestone bedrock. This mode incorporated a material disaster resiliency; robust materials would survive and could be reused, lightweight elements were allowed to be destroyed for they could be replaced easily. During colonization, this simple technology was misinterpreted as expedient and insubstantial. Sint Maarten's modern vernacular uses natural materials marginally, and is fully dependent on import, but has a rich colonial cultivation history (plantations). Reintroducing means of cultivation (of building materials), this time for local use, could be an interesting design implementation. Also, the sacrificial principle of light weight biodegradable elements could be incorporated in the design of the modern vernacular, as well as more durable and reusable structural members (appendix H.2).

The Ise Shrine in Japan is unique for its continuous cycle of rebuilding. This is done primarily for the preservation of traditional building knowledge and skills and shows that, above all, vernacular architecture exists in the minds and skills of the people who create it. Considering the organization of the labor force, the *zoucho* work on highly skilled projects under supervision of the *master carpenter*. The younger and less experienced *zoubu* work under supervision of the *zoucho* and start with easier projects in order to gain experience. Unskilled, heavy work is done collectively by worshippers. Sint Maarten's modern vernacular building knowledge and skills are considered limited and generally inadequate in relation to the reoccurring hurricanes and earthquakes. Also, if there is expertise, it tends to dissolve into financially attractive projects. The general public could do well with a model for disseminating building knowledge and skills based on practice. In the educational structure of community building, the idea of building renewal in order to learn could be implemented. This could go hand in hand with the relatively high maintenance needs due to the island's harsh environmental conditions. The organizational structure of the labor force could be similar to Ise, divided in unskilled, skilled and highly skilled work, with the appropriate supervision (appendix H.3).

Sint Maarten has deviated from the Caribbean architectural mode due to external reasons. Other mode's have emerged and disappeared. Certain elements seem to have survived since colonialism, as the wooden hipped roof and the verandah. The current architectural mode seems to develop in a way loose of any tradition. In attempting to incorporate traditional vernacular elements in Sint Maarten's current building culture, one has to be thoughtful and rethink the principles in relation to the current environmental, economic, political and social situation. Also, traditional vernacular principles have to change and adapt in order to stay relevant. Transforming tradition means connecting it with modernity, for which the ATUMICS model could be a theoretical framework.

REFERENCES

510. 2017. *Damage Percentage per Sub-Area of St. Maarten* [Online]. Red Cross St. Maarten, 510. Available: https://www.510.global/st-maarten/ [Accessed].

ADAMS, C. 1998. Japan's Ise Shrine and Its Thirteen-Hundred-Year-Old Reconstruction Tradition. *Journal of Architectural Education (1984-),* 52**,** 49-60.

ANDEL, J. 1985. *Caribbean traditional architecture : the traditional architecture of Philipsburg, St. Martin (N.A.),* Leiden, Caraïbische Afdeling, Koninklijk Instituut voor Taal-, Land- en Volkenkunde.

FATHY, H. 1973. *Architecture for the poor : an experiment in rural Egypt,* Chicago, University of Chicago Press.

FERNANDEZ DE OVIEDO Y VALDES, G. 1851. Historia general y natural de las Indias.

GATÓO, A. 2019. Red Cross building education in Sint Maarten. *In:* GROENENDIJK, R. (ed.).

HARTOG, J. 1964. *De Bovenwindse eilanden : Sint Maarten - Saba - Sint Eustatius : eens gouden rots, nu zilveren dollars,* Aruba, De Wit.

HUME, E. 1950. Gloria on Okinawa. *The Military Engineer,* 42**,** 167-171.

ICOMOS 1999. Charter on the Built Vernacular Heritage. International Council on Monuments and Sites.

ITOH, T. & FUTAGAWA, Y. 1984. *Alte Häuser in Japan,* Stuttgart, Deutsche Verlags-Anstalt.

KOBAYASHI, H. 2019. *Veneer House* [Online]. Japan. Available: https://www.veneerhouse.com/projects-en [Accessed].

LEE, S. & ALSAYYAD, N. 2011. *Aesthetics of sustainable architecture,* Rotterdam, 010 Publishers.

MUNICH, R. 2011. Nathan; World Map of Natural Hazards. Munich: Munich RE.

OKUBO, T. 2016. Traditional wisdom for disaster mitigation in history of Japanese Architectures and historic cities. *Journal of Cultural Heritage,* 20**,** 715-724.

OLIVER, P. 1997. *Encyclopedia of vernacular architecture of the world / Vol. 1, Theories and principles,* Cambridge, Cambridge University Press.

PARK, S. 2012. Research on the Traditional Collective Space Configuration in Okinawa. Kansai: Kansai University East-West Research Institute.

PIESIK, S. 2017. *Habitat : vernacular architecture for a changing planet,* London, Thames & Hudson.

RAMCHARAN, S. 2014. Caribbean Domestic Prehistoric Architecture Study Of Spatio-temporal Dynamics And Acculturation. Saarbrücken: LAP LAMBERT Academic Publishing.

RAPOPORT, A. 1969. *House form and culture,* Englewood Cliffs, NJ, Prentice-Hall.

RUDOFSKY, B. 1965. *Architecture without architects : a short introduction to non-pedigreed architecture,* New York, Museum of Modern Art.

SAMSON, A. V. M. 2010. Renewing the House : Trajectories of Social Life in the Yucayeque (community) of El Cabo, Higueey, Dominican Republic, AD 800 to 1504. Havertown: Sidestone Press.

SAMSON, A. V. M., CRAWFORD, C. A., HOOGLAND, M. L. P. & HOFMAN, C. L. 2015. Resilience in Pre-Columbian Caribbean House-Building: Dialogue Between Archaeology and Humanitarian Shelter. *Human Ecology : An Interdisciplinary Journal,* 43**,** 323-337.

TANGE, K., KAWAZOE, N. & WATANABE, Y. F. 1965. *Ise : prototype of Japanese architecture,* Cambridge, Mass., MIT press.

VAES, B. 2019. *RE: Red Cross Sint Maarten presentation for MSc1, 3.*

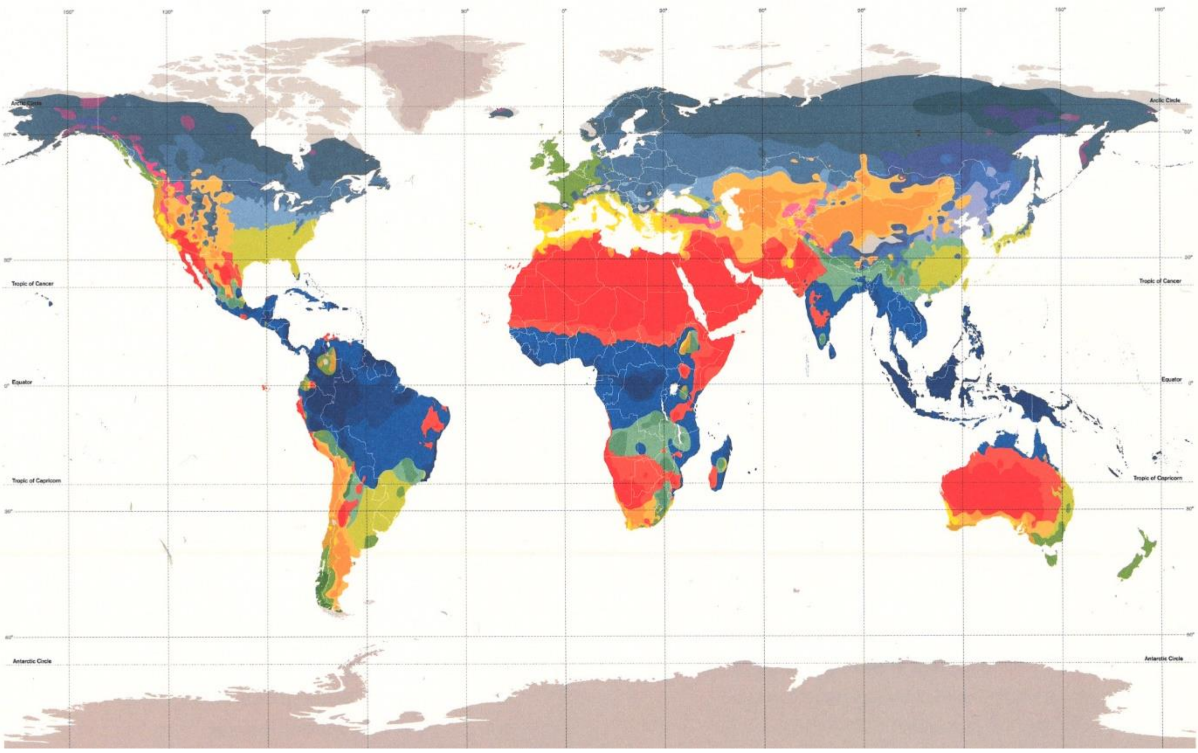
WALKER, S., EVANS, M., CASSIDY, T., JUNG, J. & TWIGGER HOLROYD, A. 2017. *Design roots : culturally significant designs, products, and practices,* London, Bloomsbury.

WILSON, S. 1997. The indigenous people of the Caribbean. Gainesville, Fla.: University Press of Florida.

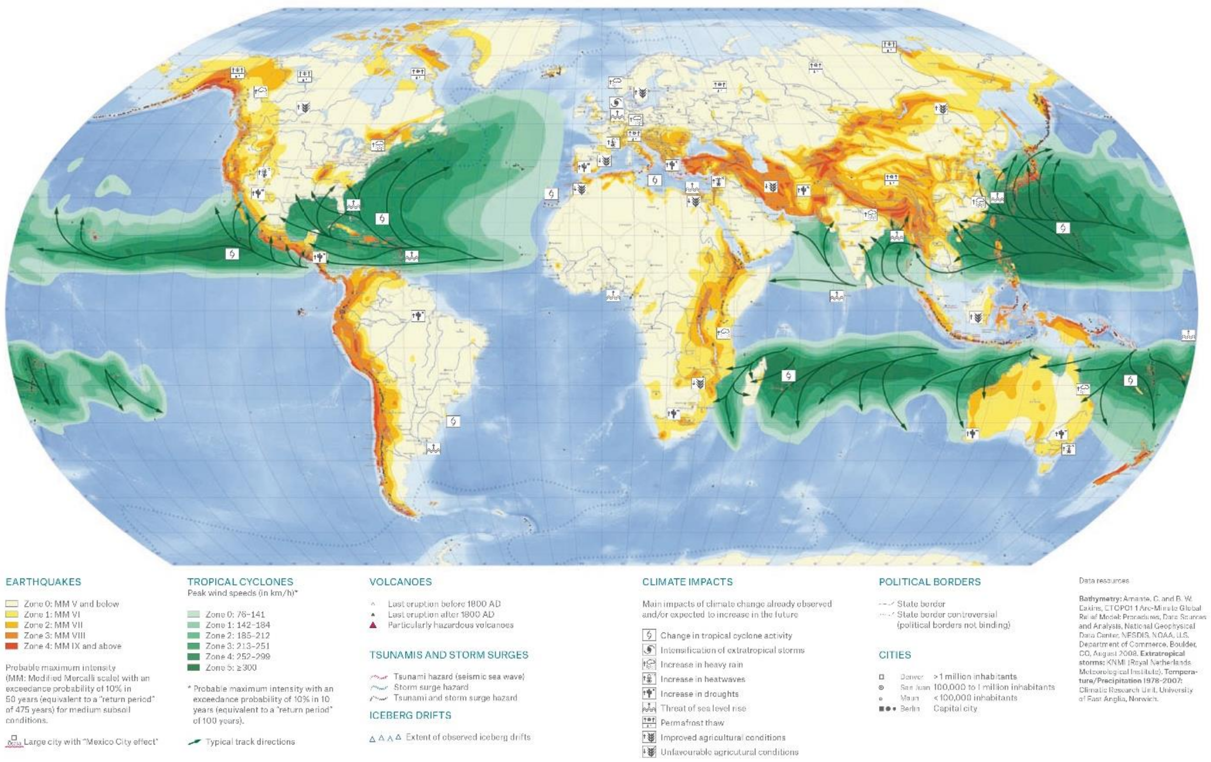
WORLDBANK. 2014. *CO2 emissions (metric tons per capita)* [Online]. Available: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?locations=SX [Accessed].

APPENDIX A.

Köppen-Geiger map, (sub)tropical regions in (dark)blue between tropic of Cancer and tropic of Capricorn (Piesik, 2017):



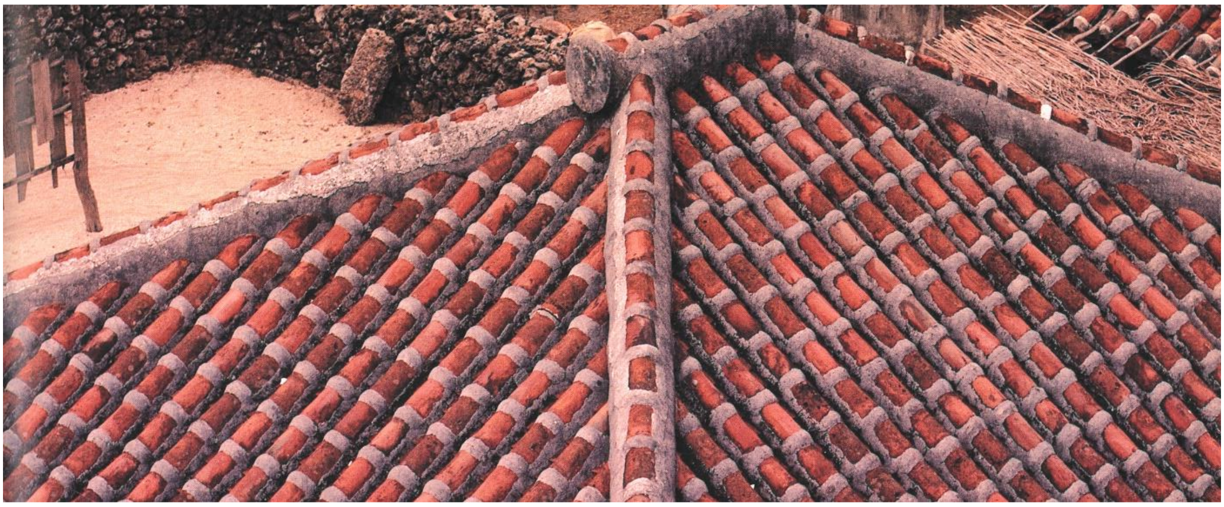
NATHAN world map of natural hazards (green: hurricane regions) (Munich, 2011):



APPENDIX B.1.

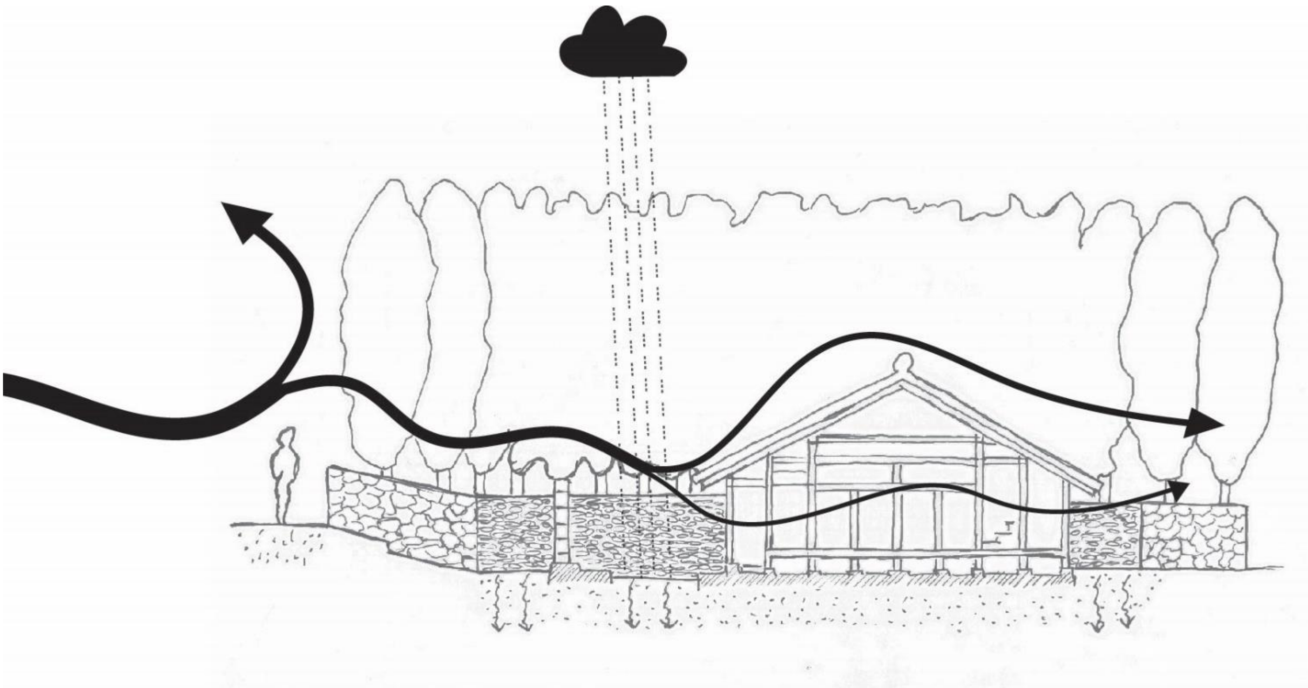
Ryukyu's vernacular; Okinawa. This image does not show a lot of Fukugi trees, potentially they are planted only at the side where hurricane winds strike severest (Itoh and Futagawa, 1984)**:**

Ryukyu's vernacular; Okinawa. The clay rooftiles bonded with plaster from up close (Itoh and Futagawa, 1984)**:**



APPENDIX B.2.

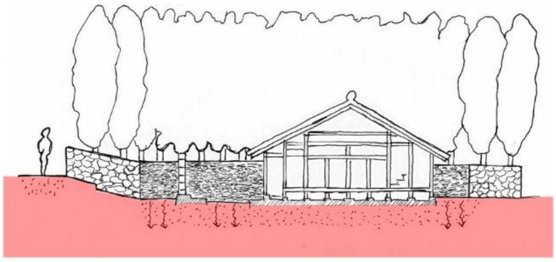
Section sketch of the behavior of one of Ryukyu's islands (Tonaki) vernacular in a typhoon (with concurrent rainfall). Park (2012) describes that using the Fukugi-coral-stone wind break can reduce the typhoon force on the structure up to 50%. Own illustration after Okubo (2016).



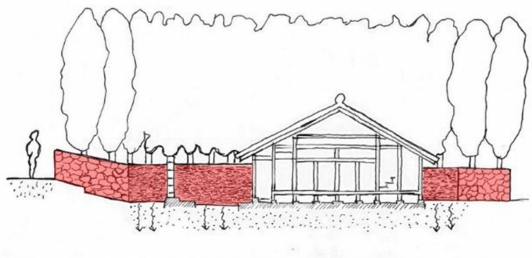
APPENDIX B.3.

Hurricane proof elements of Tonaki's vernacular, own illustrations after Okubo (2016).

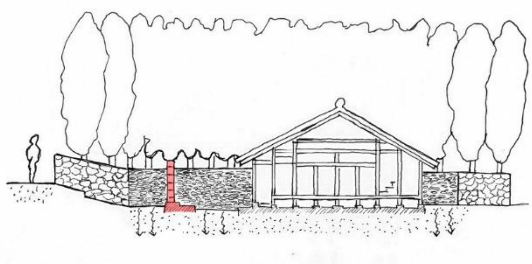
1. Subsoil of coral allows for adequate drainage during (excessive) rainfall. Therefore, ground level can be lower than street level, reducing typhoon impact on the building.



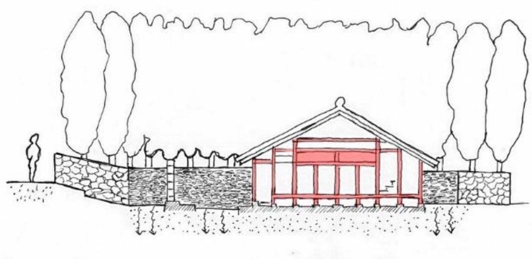
2. Coral stone walls are built along the perimeter of the plot, usually 1,5 meters high and 0,7 meters thick, functioning as a windbreak.



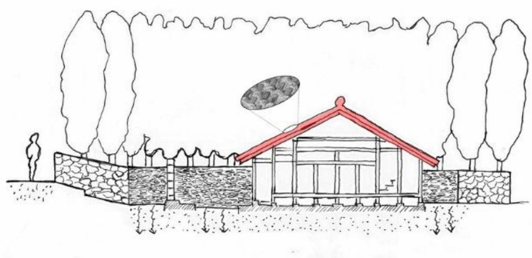
3. The coral stone windbreak cannot be continuous since one has to be able to enter the house. Therefore, the Hinpun is added (also for spiritual reasons).



4. The structure is made of local wood. It has thick pillars, a low ridge, and a well-established frame. Wind is allowed to go trough the structure.



5. Most roofs consist of clay tiles, some are thatched. In order for the tiles not to blow off in the advent of a typhoon, they are bonded with a plaster.

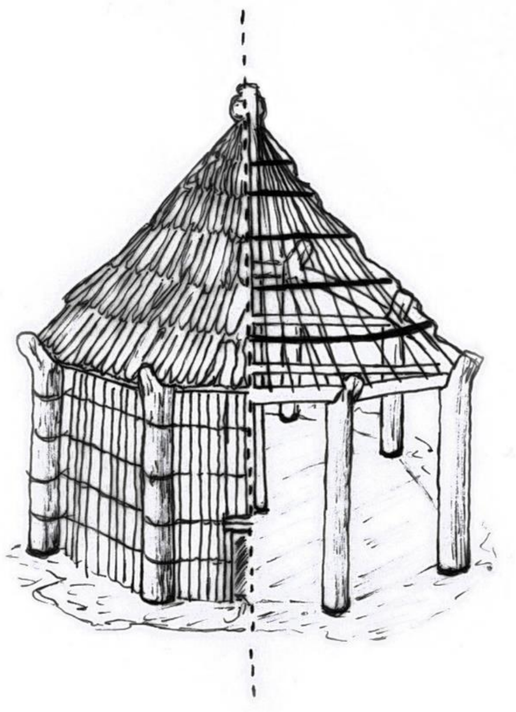


6. Fukugi trees are planted around the perimeter and form the windbreak together with the coral stone wall.

APPENDIX C.1.

The Caney after original drawings of Fernandez de Oviedo y Valdes (1851)

The Caney, own illustration after Fernandez de Oviedo y Valdes (1851) and Samson (2010).

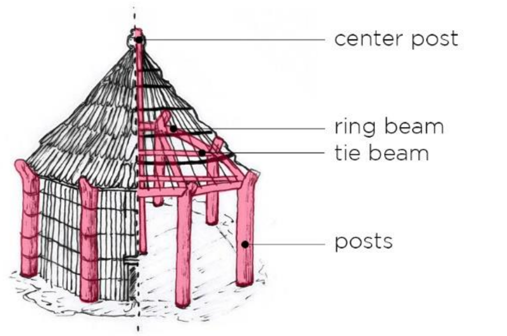


Appendix C.2.

The Caney’s elements and materials, own illustration.

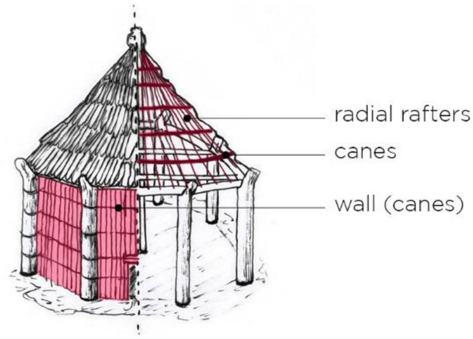
Materials of center post, ring beam, tie beam, posts;

- Locally available hardwood (sapadilla, mahogany, guayacan).
- These durable elements can be disassembled in the advent of a hurricane and can be easily reused in other structures.



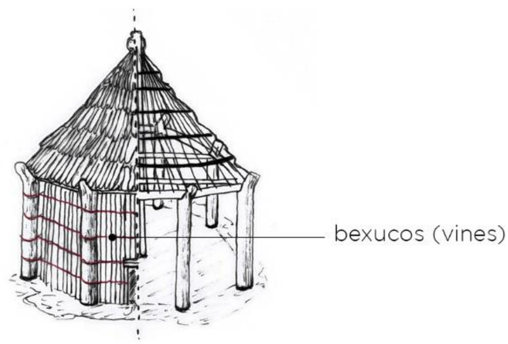
Materials of walls, radial rafters, laths;

- Locally available canes
- These elements were potentially less durable, but their availability was abundant and renewable.



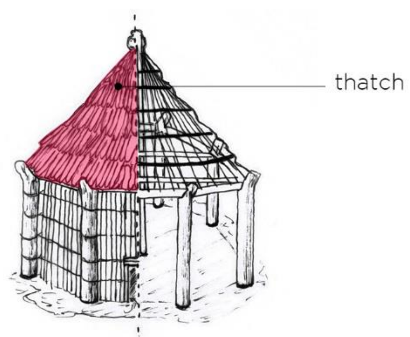
Connection material;

- Locally available ‘bexucos;’ vines. Similar to lianas. Flexible and easy to cut, does not perish. Acts to fix and bind instead of rope or nails.
- The avialability of these bexucos was abundant and renewable.



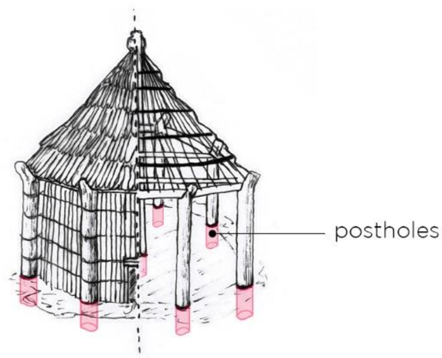
Roofing material;

- Thatch could be different kinds of materials; straw, canes, bijao leaves, palm leaves, other materials.
- Material used for the roof was dependent on the preferences of the builder and on local availability.



Postholes in limestone;

- Often the hardwood posts were connected to the ground by excavating a hole in the limestone bedrock. This way, posts could be removed after the lifecycle of the caney and reused in other structures.



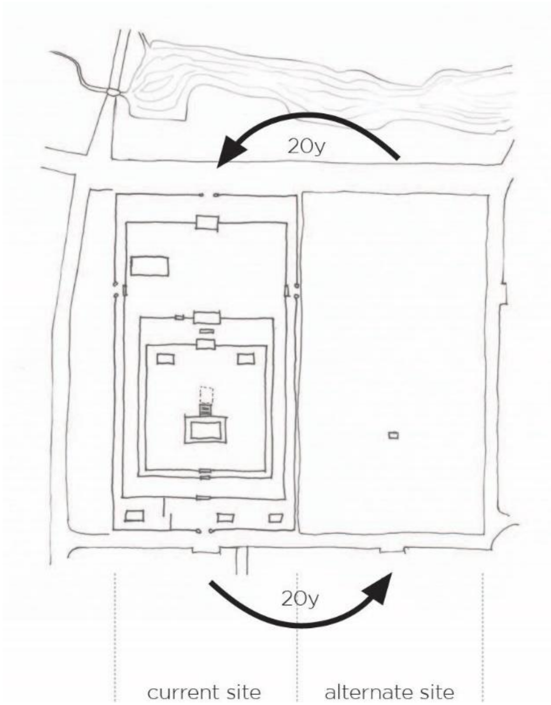
APPENDIX D.1.

An aerial photo of the inner precinct of the Ise Shrine, showing two locations, one built, one unbuilt (Tange et al., 1965).

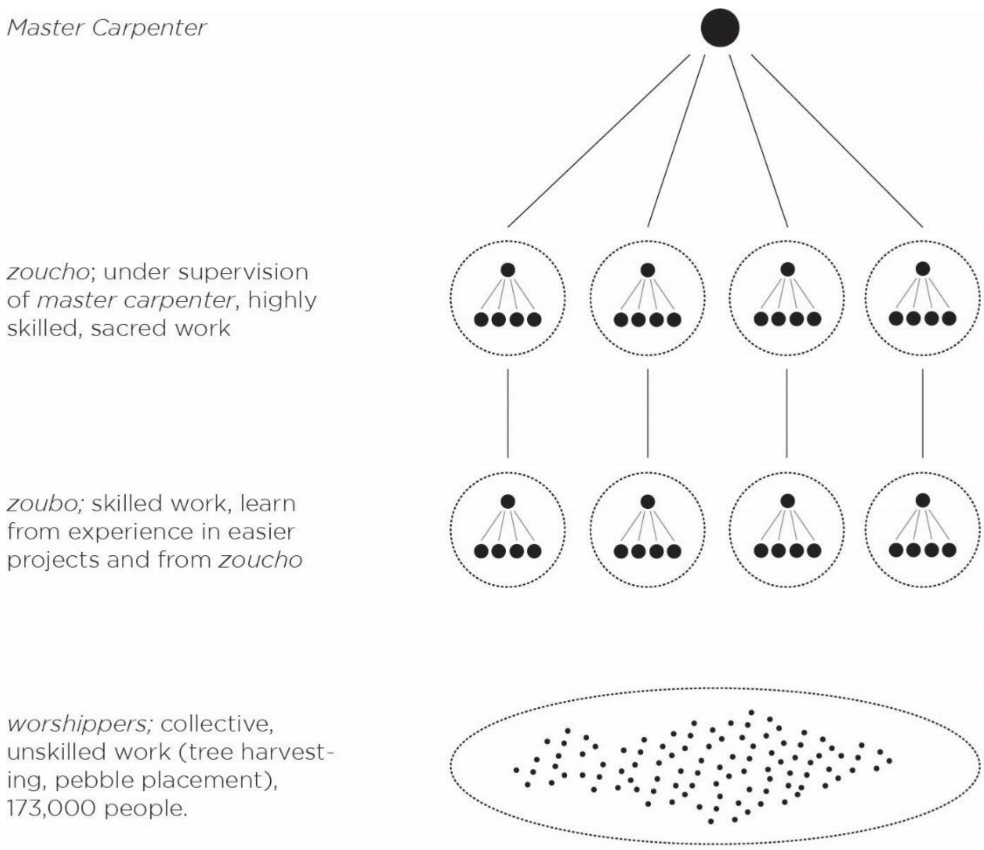
Looking at the inner precinct from the alternate site (Tange et al., 1965).

APPENDIX D.2.

Socio-economic advantage of the Ise Shrine rebuilding tradition; transferring building tradition and techniques every twenty years. Own illustration after (Tange et al., 1965).



Labor force setup in the Ise shrine rebuilding, own illustration.



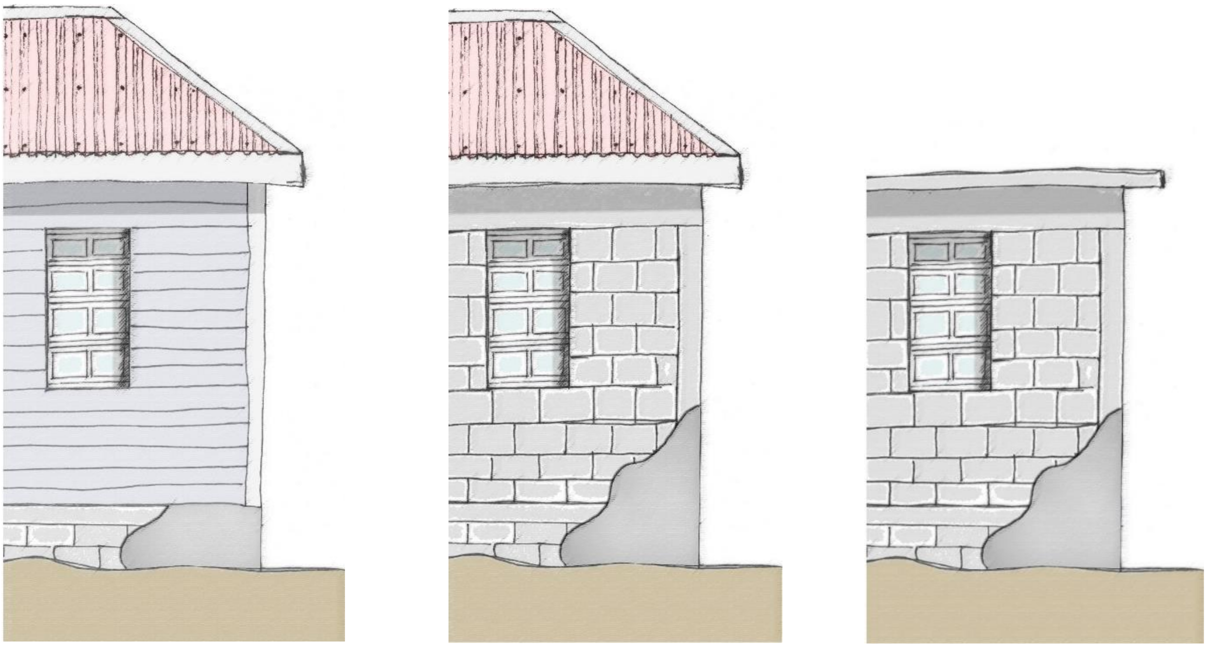
APPENDIX E.1.

Modern domestic vernacular observed during fieldwork: Basic information of observed domestic vernacular during Red Cross fieldwork (own illustrations).

House	Area	Family structure	Building skills	Desire to learn?	Type	Surveyed?
1	1	Man and wife, doughter and son, douchter has three kids.	none.	yes, doughter and son.	concrete foundation and walls, wood roof.	yes.
2	1	Man and wife.	yes, workes in construction.	yes.	concrete foundation and walls, wood roof.	no.
3	1	Women, old, pensioned	none.	no.	concrete foundation and walls, wood roof.	no.
4	1	Man, old pensioned	yes, worked in construction	not anymore.	concrete foundation and walls, wood roof.	yes.
5	1	Man and woman, kids.	yes.	yes.	concrete foundation and walls, concrete roof.	no.
6	1	Woman, old, pensioned.	none.	no.	concrete foundation and walls, wood roof.	no.
7	1	Woman and son.	none.	don't know.	concrete foundation and walls, concrete roof.	no.
8	1	Woman.	don't know.	don't know.	in construction; concrete walls.	no.
9	1	Man with baby.	don’t know.	don't know.	two storeys, concrete foundation and walls, wood roof	no.
10	1	Woman with three kids.	don't know.	don't know.	concrete foundation, wood walls and roof.	no.
11	1	Man (pensioned) with wife.	yes, worked in construction.	yes.	no foundation, concrete walls, concrete roof.	no.
12	1	Woman, old, pensioned. Lived together with son (50).	none.	no.	concrete foundation, wood walls and roof.	no.
13	1	Man (pensioned) with kid.	don't know.	don't know.	full wood house incrementally changed to full concrete.	no.
14	1	Woman with man.	yes, (man).	yes.	concrete foundation and walls, conrete roof.	no.
15	1	Don't know, nobody was home.	don't know.	don’t know.	full wood house incrementally changed to full concrete.	no.
16	1	Man and wife.	yes.	yes.	concrete foundation, wood walls (being replaced by c.).	yes.
17	1	Woman, old, pensioned.	none.	no.	concrete foundation and walls, concrete roof.	no.
18	1	Man and wife.	yes (carpenter).	yes.	concrete foundation, wood walls and roof.	no.
19	1	Man.	yes.	yes.	concrete foundation, part concrete and wooden frame (no roof)	no.
20	2	Man and wife.	yes.	yes.	concrete foundation, wood wall and roof.	no.
21	2	Man.	yes.	yes.	conrete foundation, wooden shack.	no.
22	2	Man, renter of part of house 20.	none.	don’t know.	concrete foundation, wood wall and roof (8 sq m.)	no.

APPENDIX E.2.

Sketch of the three domestic vernacular types, from left to right; 1. concrete foundation, wood walls, wood roof; 2. concrete foundation, concrete walls, wood roof; 3. concrete foundation, concrete walls, concrete flat roof (own illustrations).



APPENDIX E.3.

Images of the three domestic vernacular types; 1, 2 and 3 from top to bottom (own images):

APPENDIX F.

Interview with Ana Gatóo; the construction coordinator in the Home Repair Program of the Red Cross Sint Maarten:

1) Can you give an introduction of yourself?

My name is Ana Gatóo. I studied Building Engineering in Spain, then I did a Master in Architecture focused on tropical and post-disaster architecture in Indonesia. While being there I worked for the NGO Humanitarian Bamboo developing and editing Bamboo Guidelines for the humanitarian context. I then spent three years in the University of Cambridge at the Centre for Natural Material Innovation, as the EcoHouse Initiative project manager, an initiative working with NGOs to improve their house designs. I supervised one hundred students of engineering and architecture to develop better housing for the developing world. After the earthquakes in Nepal in 2015, I was hired as a consultant by Catholic Relief Services to study the feasibility of using bamboo in the reconstruction. I also worked there as the Senior Technical Manager for Habitat for Humanity both on reconstruction after the earthquakes and on development on non-affected communities. I there led a team of local architects and engineers who I transferred my knowledge. I then spent some time in Australia giving workshops on humanitarian construction in collaboration with Red Cross Australia. I have been recently in Rwanda where I worked as the Project lead and architectural engineer of the Rwanda Cricket Stadium, funded by a British NGO with the purpose of using sports as a mean of healing from the genocide. I have been working for Red Cross SXM since February 2019.

2) Can you describe your function within the Red Cross SXM?

I work as the construction coordinator in the Home Repair Program. The Home Repair Program is planning to repair 200 houses with builders trained by the Red Cross. I train the builders and I coordinate the construction. I provide materials when needed, supervise the construction, coordinate the teams and the houses where they have to go next, speak to beneficiaries and check the houses beforehand and check on the supervisors too.

3) Who are the people that want to learn how to build via the Red Cross program? Why do they want to learn how to build?

It is mostly vulnerable people in need of a job and of learning new skills or improving the ones they have. But all of them are in real need of getting a job.

4) How do you teach them how to build? With a workshop? What is the duration of this? Also field training?

We first give them a 5-day training in the office. The first two days are mostly theory. We start with an introduction of the work we do, we explain how to build a roof, talk about the tools, they make some practical exercises with wood, we analyze many photos and examples and we talk about health and safety. The next three days are practical. They have to build a roof model under our supervision. The second week they go to the field and we repair a home.

5) Do they have any building skills prior to joining the program?

The first group didn't but we learnt it was too hard to just have people with no experience. From the second group onwards we have tried to balance that by having both people with no experience and people with experience. We make groups of 3 or 4 where there is one builder and 2-3 apprentices.

6) Is there any skill they adopt better than others? For example carpentry versus casting concrete? Is there any skill that they seem to have trouble with learning?

We just train them on carpentry. Our program is mainly focused on building timber roofs. However, they sometimes have to do some concrete works as for example repairing or rebuilding ring beams or repairing concrete block walls. The builder or person in charge has normally notions on how to work with concrete. If they don't we will train them on site previous to do the work and be with them till we are certain they can do it by themselves. What they have more trouble leaning about is the planning of the construction, checking the materials for example. They never manage to do that ahead of time. They will always call us to tell us they run out of screws for example but they never manage to realize with time. We are still working on that.

7) What can be problematic in teaching these people how to build? For example not being able to read or write.
Some of them can barely read or write and that is indeed a challenge. As an example, we recommend to build the roofs at an angle of 30º. For people who had no education explaining what an angle of 30º is, can become a challenge. We work with feet and inches too and as you know those are divided by fractions. Measuring for some of them is very hard also. But as they are in groups of 3 or 4 we try to balance that too so there is always someone in the team capable of measuring and drawing the right angles.

8) If they cannot read or write, then how do you teach them how to build?
We try to do it as practical as possible. They won't be reading drawings and therefore they don't actually need to read or write. The theory is given to them through a huge amount of pictures so they can assess what do they see in those. And what is not photographs it´s mainly simple drawings. We try to avoid text as much as possible.

9) If you bring people into the field that are new to building, then what is the ratio of skilled builders to starting builders?
Normally we find around one person every 3 or 4 that have some experience, although not necessarily a lot. If they don't we will provide more attention and supervision to that group.

10) In your opinion, how can you best teach unskilled people how to build?
It has to be very practical, make it very engaging and try to make it simple, step by step. You have to involve them a lot and make it very easy. Then we try to start with houses that are easier and scale up to more difficult ones.

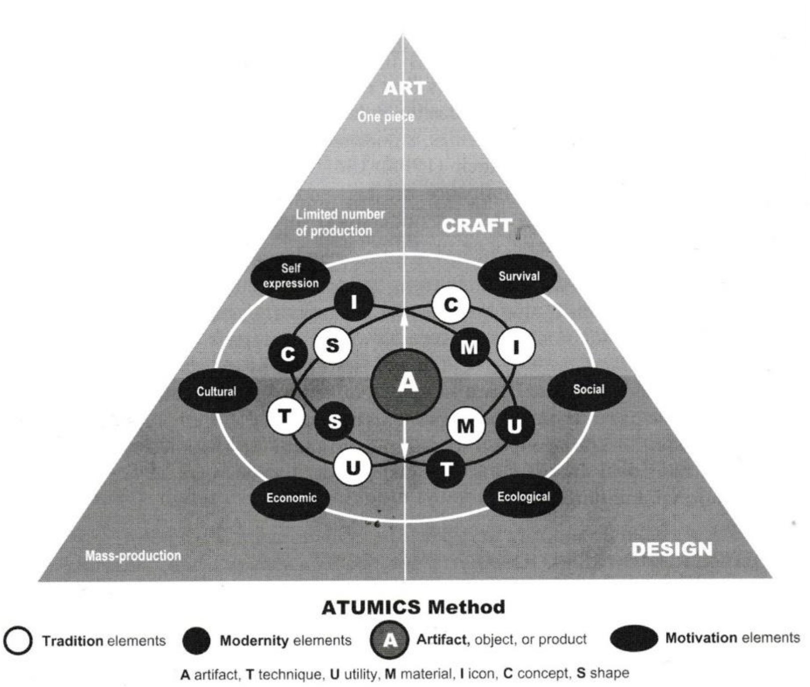
11) If any, what are other parties on the island that provide building knowledge or education?
I don't know.

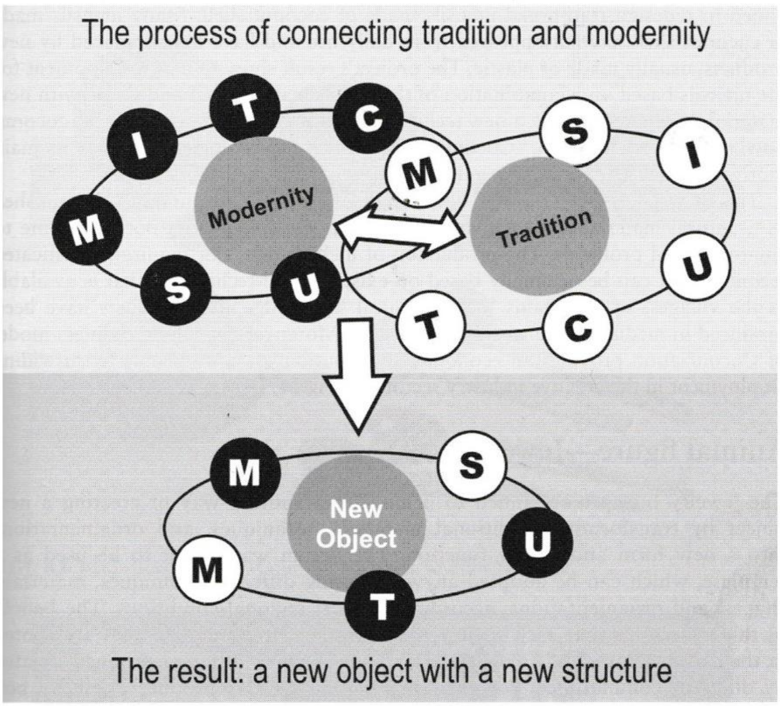
12) I understand that in the home repair program there is a social team, a technical team and a construction team. Can you shortly describe what they do?
The social team is the one that finds the beneficiaries. They go through the selected neighborhoods and they try to find anyone who needs repairs in their houses. They then make a social assessment. If they find them vulnerable, they will get them registered. Once registered, the technical team visits them and makes a technical assessment. If they think they can become part of our program i.e. we can technically assist them, they will measure their houses and prepare a BoQ (Bill of Quantity) of the materials needed for the repairs. They will decide also if they are eligible for a Red Cross construction team or not. The program aims to assist 1200 beneficiaries of which 200 (the most vulnerable) will get an RC construction team. Once the BoQ is prepared, we invite them to a Saturday workshop in which we explain how they should repair their roof to be safer and we give them their BoQ. With the BoQ they will go to one of the two main hardware stores in the island, specified by us and will get their materials. Through the building process the technical team visits the beneficiaries several times to monitor and provide technical assistance when needed. For those who are eligible for an RC team (Red Cross construction team) we provide materials but as well a team of builders trained by us. We plan to have 13 teams (45 workers) working plus 4 construction supervisors. We supervise their works on a daily basis and keep on training them throughout the whole program.

13) How many Red Cross builders are currently working in the construction team? (the ones that were educated via the Red Cross)
As of today 33 workers in 10 teams and 3 construction supervisors. This week we are training the last group of 12 workers which we will incorporate to the field next week.

APPENDIX G.1.

ATUMICS, a theoretical model for merging tradition with modernity (Walker et al., 2017).



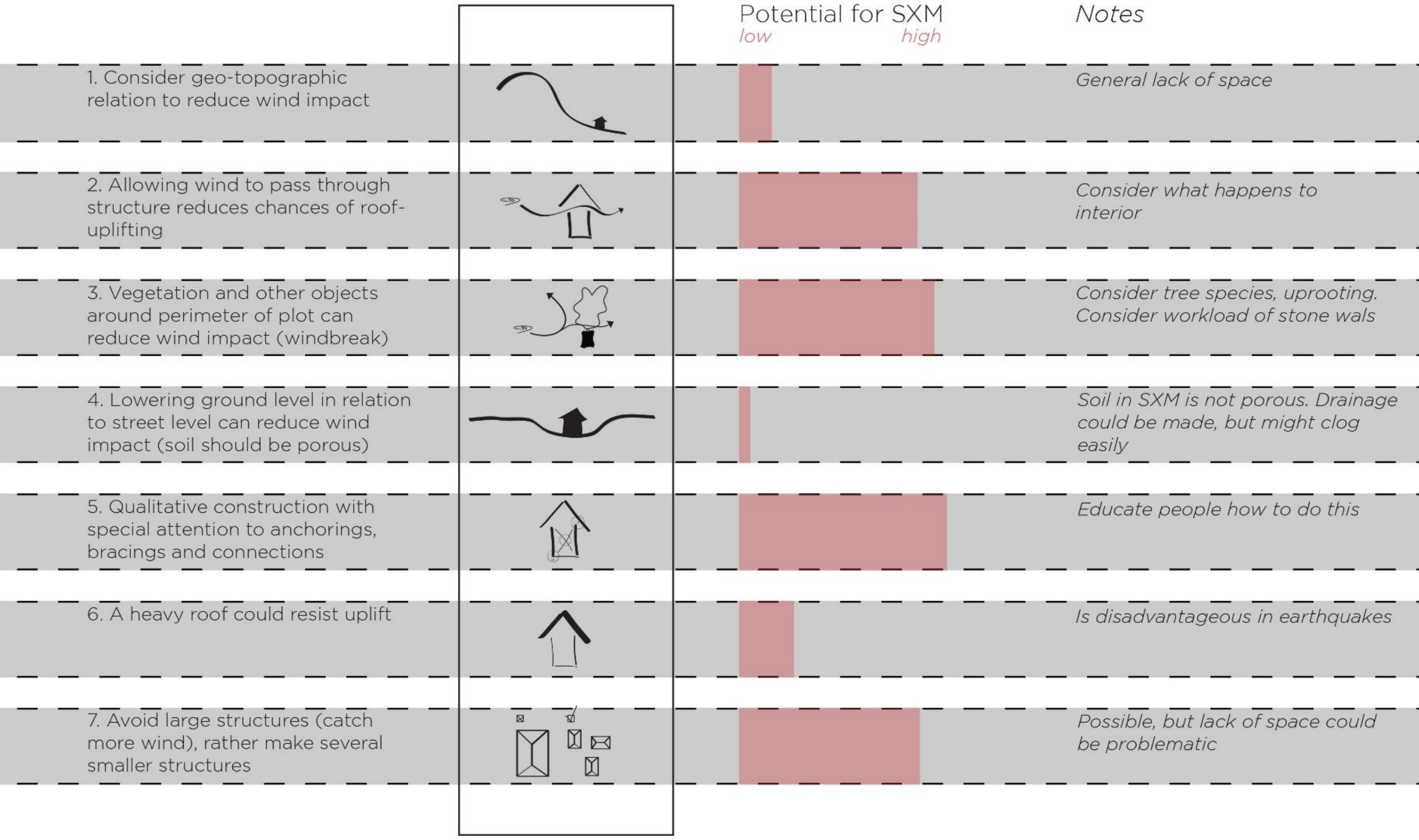


APPENDIX G.2.

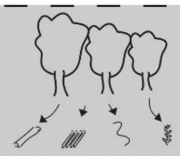
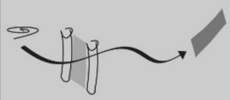
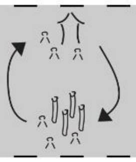
ATUMICS, applied to the work of Hiroto Kobayashi, who's motivation for merging tradition with modernity is socio-ecological, and his work is not a one-off but also not mass produced, hence a craft. He merges modern and traditional techniques and materials, therewith creating a new architecture, embodying traditional and modern elements (Kobayashi, 2019).

APPENDIX H.1.

Conclusions; climate responsiveness

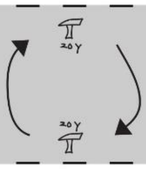
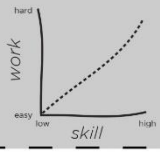
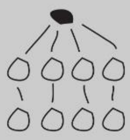


APPENDIX H.2.
Conclusions; material appropriateness

		Potential for SXM *low* — *high*	*Notes*
1. Material availability; try to use local (regional) renewable building materials			*Consider cultivation potentials, consider regional renewable materials, consider durability / preservation*
2. Consider sacraficial, easily replacable elements. Consider more durable, reusable structural members.			*Consider what happens to interior if elements are sacrificial. Consider what happens to these sacrificial elements*
3. Consider a process of communal rebuilding (or repairing).			*Could go hand in hand with maintanance needs*

APPENDIX H.3.

Conclusions; socio-economic advantages (knowledge and skill transmittance)

		Potential for SXM (low – high)	*Notes*
1. Consider the perpertual rebuilding of structures			*Could be way of disseminating knowledge and skills*
2. Consider a division in work related to task-importance and difficulty			*Could be communal strategy*
3. Create a stategic setup to advice less experienced how to build (mostly based on practice, not theory).			*Consider who would be specialists, and how they would relate to other builders*