# Sacred Innovation in the Shadow Conservation Network

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## ABSTRACT

The global shadow conservation network is informally composed of all the sacred lands of the world. This essay explores the lands of the Kayapo of the Amazon Basin; the Maasai of Southern Kenya and Northern Tanzania; the Turkana of Northern Kenya; the Subak of Bali; the Khasis of Northern India and the Tofinu of Benin and the ancient infrastructures found there. From the material and construction modules, to the ecosystem as a whole, the sacredness imbued in the landscape works to maintain its ecological sustainability.

By combining eco-technology with sacred mythology, we find new and unique ways humans live symbiotically with nature. Three critical questions guided the beginning of this research: What ecologically sustainable knowledge do indigenous people know that we once knew? Is this knowledge lost or just forgotten? How can ecological designers use this knowledge today? The innovative landscapes these communities have evolved show us the potential environments mankind is capable of creating. Rather than primitive, as Corbusier would say, these relationships are primal, within us all.

***Keywords:*** *sacred, indigenous, ancient, innovation, environment*

## INTRODUCTION

Technology thrives on the sacred lands of indigenous peoples. Hidden in some of the most remote places on earth, innovations range in size from single river crossings to entire watershed reconstructions. (Figure 1) This essay explores the lands of the Kayapo of the Amazon Basin; the Chagga at the base of Mt. Kilimanjaro in Tanzania; the Masaai and Turkana of Kenya; the Uros of Bolivia; the Ma'dan of Southern Iraq; the Subak of Bali; the Ifugao of the Phillippines; the Khasis of Northern India; the Enawene Nawe of Brazil and the Tofinu of Benin (Figure 2) and the ancient systems founds there.

These ancient systems have survived for millennia due to sacred lores that conserve the land, and a combination of constructed systems and natural resources that benefit the entire indigenous community. There is an innate understanding within these groups that mutual co-existence relies on increasing biodiversity, resulting in more resilient ecosystems and more successful communities.

A key to success is sacred knowledge, passed down through generations since time immemorial. This sacred knowledge is called Traditional Ecological Knowledge (TEK)[1] and held in high regard by scientists but overlooked by designers. To learn

[1] Berkes, F. (2012).

*Figure 1:*
*The Living Root Bridges of the Khasis in Meghalaya, Northern India are the only living bridges on earth. The Subak rice terraces are constructions at the scale of watersheds that recontour the entire island of Bali. They are the oldest and most biodiverse agrarian systems known to man. Photo by Rio Helmi.*

from TEK, research investigations of indigenous innovations and sacred knowledge are exhibited through an architectural lens. By documenting the material, module and ecosystem scale of physically similar but geographically distant systems many unique ways of living symbiotically with nature are revealed. (Figure 3 & 4)

In a world facing rapid global extinction and extreme loss of biodiversity our burgeoning understanding of ecological design requires rapid advancement. The inspiration for this research began with three questions about the existence of contemporary indigenous communities: What ecologically sustainable knowledge do indigenous people know that we once knew? Is this knowledge lost or just forgotten? How can ecological designers use this knowledge today?

This research reveals that remote indigenous communities create symbiotic settlements in their ecosystems. By using a combination of spiritual, social, and environmental information in response to varied circumstances, these communities can provide guidance for the type of environments mankind is capable of creating. Rather than primitive, as Corbusier would say, these relationships are primal, within us all.[2]

## DISTURBANCE

All forms of life, whether animal or human, cause disturbance to an ecosystem. In the savannah, dawn reveals a trail of destruction left by the nighttime parade of hungry elephants. (Figure 5) Under the cover of dark, a herd will graze and bulldoze the largest of acacia trees in search of succulent leaves. In this landscape elephants are both deforesters and ecosystem managers. They allow the grasslands to thrive by halting the succession of primary forests.

Here the elephant is the 'Ecological Keystone Species', which like the keystone of an arch locks the ecosystem in place. Coined by zoology professor Robert Paine in 1969, a Keystone Species is defined as a plant or animal that plays a unique and crucial role in the way an ecosystem functions and is often found in the folklore of local, indigenous communities.[3] Still a relatively new concept, the ecosystem is defined as a biological community of interacting organisms and their physical environment.[4] While the lion or leopard are the apex predator and may appear to dominate the ecosystem, the elephant has the greatest impact. Elephants maintain an environment that allows other herbivore species, such as the zebra, gazelles and rhinoceros, to survive and thrive. Without these



2 Le Corbusier (2007).

3 Paine, R.T. (1995).

4 Foreman, R.T. (1979).


*Figure 2:*
*The Kayapo of the Amazon Basin; the Maasai of Southern Kenya and Northern Tanzania; the Turkana of Northern Kenya; the Subak of Bali; the Khasis of Northern India and the Tofinu of Benin.*

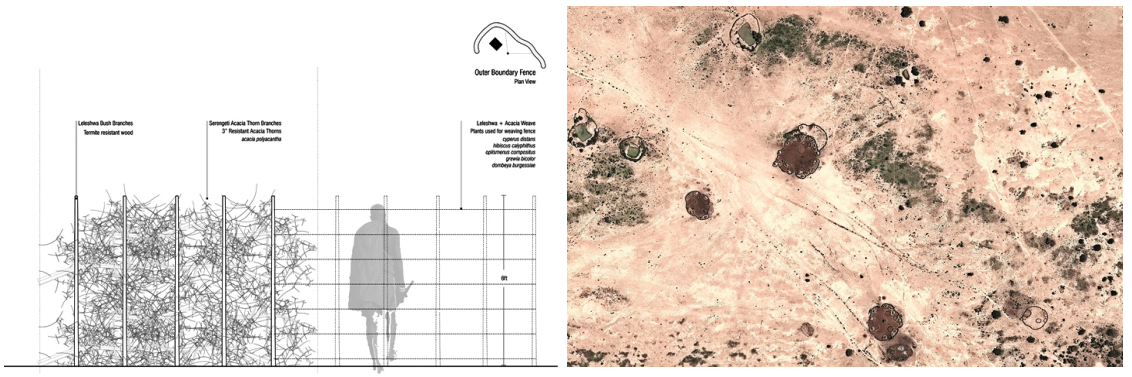


*Figure 3:*
*The material, module and ecosystem scale of Maasai Corral fencing. Graphics by Brittany Roy.*

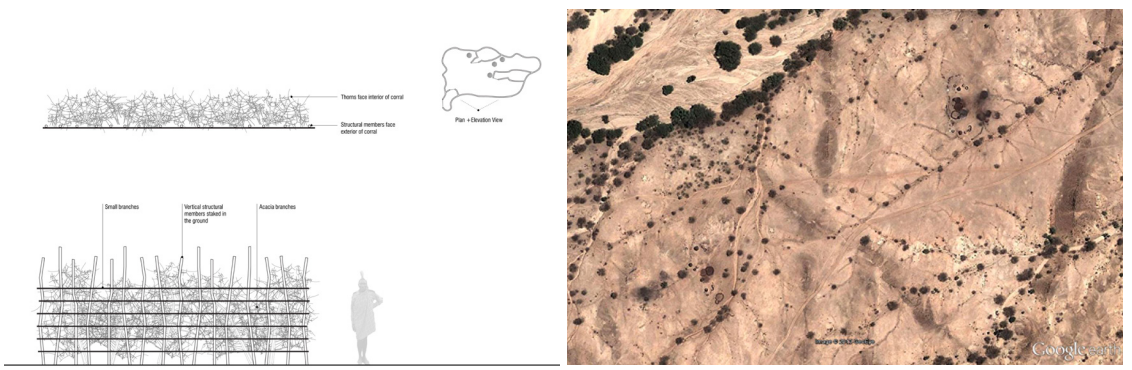


*Figure 4:*
*The material, module and ecosystem scale of Turkana Corral fencing. Graphics by Brittany Roy.*

*Figure 5:*
*The nighttime parade of a herd of elephants.*

*Figure 6:*
*Controlled burning or Pyrotechnology is used by the Mardu people of Western Australia. The process sustains grassland environs and reduces the incidence of devastating bushfires.*

Ecological Keystone Species, the forest would outgrow the grassland and the ecosystem would be dramatically different- or cease to exist altogether.

As the elephant stops the forest outgrowing the grassland, human beings cause similar disturbances to ecosystems (Figure 6) through the use of pyro-technology. For millennia, humans have lit seasonal fires to maintain grasslands at the transitional edges of ecosystems. In landscape ecology, popularized by Richard T. Foremann,[5] edge conditions amplify biodiversity, creating a lucrative interface between adjacent ecosystems. Indigenous communities are attracted to this interface because the diversity of plants and animals offer an abundance of natural resources, which are beneficial to their livelihood. This co-existence of cultural diversity and biological diversity between ecosystems has been documented in global mappings from the Millennium Ecosystem Assessment.[6]

The use of pyro-technology is a global phenomenon. Like the Mardu people of Western Australia, the Milpa of Mesoamerica, the Chagga of East Africa or the Kayapo of the Amazon Basin, so to the Anishinaabe of Northern Canada use pyro-technology to burn off spring grasslands.[7] In the sacred mythology of the Anishinaabe people, a mythological creature called the Thunderbird shoots lightning or puhkeenun by the blinking of its eye to begin the seasonal spring fires that renew the vestiges of the winter. While appearing to destroy the land, these fires or Beenesay Eshkotay begin the process of ecosystem rejuvenation by allowing underground roots to survive, while also stimulating new growth. The purposefully lit 'Pishashkooseewuhseekaag' pyro-technology, which translates to "spring burning of the marshes", imitates the actions of the mythological Thunderbird. (Figure 7) Ancient folklore explains that when the ice on a lake turns from cloudy to clear and begins to break, it's time to light the seasonal spring fires.[8] The Anishinaabe have learned to control the spread and heat of fire to diffuse potential destruction. Fire allows the new passage of wind to reduce mosquito infestation and stimulate new growth for habitat, insulation, housing and bedding. With a deep understanding of the life cycle of successional growth that occurs after fire, new productive forest ecosystems are possible. For example: blueberry patches spontaneously grow and attract larger animals to hunt.[9]

Similarly in Mesoamerica, the *Milpa* is an ancient intercropping system planted within the forest, which takes advantage of the same system of pyro-technology, biodiversity and succession. It is composed of 'The Three Sisters'; maize (corn), beans and squash, which have been the principal diet for the Mayan civilization for millennia. This system of planting is found in several different indigenous nations (Mayan, Aztec, Pueblo, Anasazi, Tewa, Cherokee and Iroquois), which is testament to the efficacy of grounding this framework of understanding in a familial mythology.

The Iroquois story is a simple one about three "sisters" that learn to work together to survive. The first and strongest of the sisters is Corn Girl. The corn stalk offers the vertical support needed for her sisters to grow. The bean plant is another sister, weaker and in need of support- who offers nutrients and nitrogen to the soil for her sisters the corn and squash. The protective sister of the squash plant has broad leaves that shade the delicate soil underneath to retain moisture and act as climate control. The shared legend of the Three Sisters helps to explain the ecological relationship behind this universal companion planting scheme.

From origin stories to everyday life, maize and humans have formed a deep spiritual connection over thousands of years. In Mayan mythology, the first mothers and fathers of the Maya were formed from maize[10], so the practice of *Milpa* is a responsibility given by the gods. Legend posits that the white corn formed their bones, yellow corn their flesh, black corn for their hair and eyes, and red corn for their blood. *Milpa* plantations are thus believed to be places of spiritual significance, and the cultivation of maize is considered a spiritual

5 Foreman, R.T. (1986).

6 Sachs, J. (2006).

7 Berkes, F. (2005).

8 Hunt-Miller, D. (2010).

9 Miller, A. (2010).

10 Tedlock, D. (1996).

*Figure 7:*
*The Anishinaabe people believe a mythological creature called the Thunderbird shoots lightning or puhkeenun by the blinking of its eye to begin the sacred spring burning of the marshes. The Pishashkooseewuhseekaag pyrotechnology, which translates to the spring burning of the marshes, imitates the actions of this mythological Thunderbird.*

act.[11] Many ceremonies are still carried out as part of the annual agricultural cycle of *Milpa,* from soil preparation to harvest.

## ANCIENT INNOVATION

Ancient ecological knowledge is not forgotten, it's just hidden in some of the most remote places on earth. Coupled Human and Nature Systems, or CHANS, are unique ecosystems that have been adapted for co-existence by the people who construct them.[12] The study of Complex Socio-Ecological Systems such as CHANS is an interdisciplinary science in the field of Complexity theory that grew out of systems theory popularized in the 1960's.[13] A complex socio-ecological system consists of a bio-geo-physical unit and its associated social actors and institutions.[14] Contemporary cities are CHANS that demand designers to resolve sustainability issues arising from this disconnect with their natural environment.

An indigenous CHANS exists by cultivating the symbiotic ecological relationships memorialized in sacred folklore, engaging the human, natural and spiritual world. The relationships that have evolved between man and nature in this scenario are symbiotic. The natural world is sacred and mythological stories hold ancient wisdom. Study of this wisdom reveals how humans can cultivate and prosper in harmony with the natural world, and thus ensures the survival of all species.

Myths are a form of Traditional Ecological Knowledge (TEK) that play an important role in understanding the opportunistic ways that humans use ecological relationships for innovation.[15] Within this mythology lies an intrinsic understanding of designed ecosystems and innovations that have survived for millennia. This knowledge is the collective consciousness of the community, and is passed down through ceremony in hopes of sustaining local resources.

Indigenous folklore reveals the most important



11 Frece, A. & Poole, N. (2008).
12 Carter, N. (2014).
13 Grobman, G. (2005).
14 Shugart, H. & O' Neill, R. (1979).
15 Berkes, F. (2005).

relationships between humans and nature. Just as certain species of plants or animals appear to exhibit a particularly large influence on the ecosystem they inhabit and are known as the Ecological Keystone Species, the same is true in socio-cultural systems.[16] The 'Cultural Keystone Species' is a culturally salient species that in a major way shapes the cultural identity of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices.[17]

In the Amazon rainforest, the Kayapo have been cultivating forest islands for thousands of years. They create 10,000m$^2$ concentric circles known as Apete, which are burnt using pyro-technology through the forest canopy to begin the process of village building and agricultural production. (Figure 8) The Kayapo have also developed an intimate, symbiotic relationship with the insects of the rainforest. Domesticated bees are the Cultural Keystone Species of the Kayapo.[18] They live with, garden with, and worship bees and other insects during ceremonies by wearing elaborate body paint reminiscent of insect markings. (Figure 9) They believe their ancestors learned social skills from these creatures. In an era of global colony collapse, what can be learned from CHANS of the Kayapo whose daily existence depends on a sacred communion with bees?

## INNOVATING AQUACULTURE:

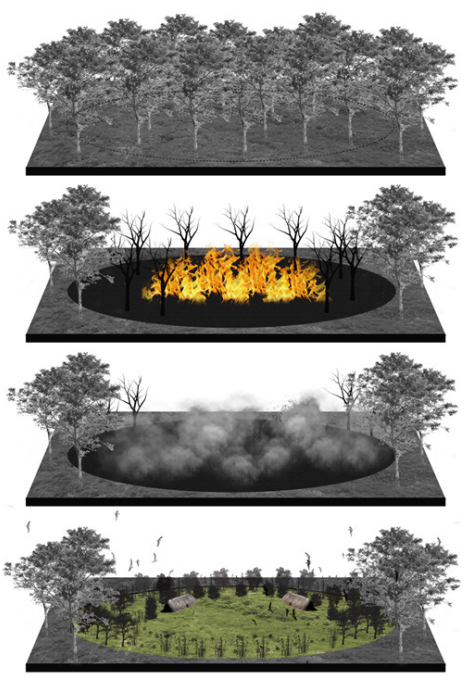

*Figure 8:*
*A Kayapo village called an Apete. The aftermath of a controlled burn, which is the first stage of constructing the Kayapo village. A time lapse axon showing the stages involved in the creation of an Apete forest island. Illustration by Despina Linaraki.*



16 Paine, R.T. (1968).

17 Garibaldi, A. & Turner, N. (2004).

18 Posey, D. & Plenderleith, K. (2002).


*Figure 9:*
*The Kayapo have developed an intimate relationship with the insects of the rainforest. Bees are worshipped during ceremonies by wearing elaborate body paint reminiscent of insect markings.*

## THE ACADJA ARTIFICIAL REEFS OF THE TOFINU TRIBE

A powerful example of human disturbance and innovation working together can be seen in the city of Ganvie built by the Tofinu tribe. They've evolved an indigenous CHANS in the form of a lake settlement surrounded by an artificial aquaculture system at a scale and level of productivity that rivals the most advanced commercial scale and high-tech systems.

Flying over Lake Nokoué in Southern Benin of West Africa, reveals a shoreline of floating forests and frenetic cities. Four hundred years ago the king of the Tofinu people or 'men of water', took the form of a great egret to soar the same path over the lake's sacred waters searching to resettle his kingdom. At the Sô River inlet several miles from any shoreline, King Abodohoue created Ganvie. Today, the city has been christened the 'Venice of Africa' and is one of the most unique urban lacustrine environments on earth.

Ganvie meaning 'we survived', is a lake city made of bamboo and teak stilted houses occupied by Tofinu fishing families. (Figure 10) The city is a collection of eleven villages organized by canals and navigated by dugout canoes, which is entirely surrounded by an artificial reef of 12,000 enclosed fish paddocks that sustain waters teeming with fish and wildlife. A healthy relationship between a growing city and lake is rare. This extraordinary civilization has evolved an aquaculture that embodies the most advanced ecological design thinking of today - the use of symbiotic species relationships - to feed an entire city while making a healthier ecosystem for its native flora and fauna. This reef is an indigenous aquaculture system using mangroves called an '*acadja* brush park' and the technology has spread from the waters of Lake Nokoue to populate the water's of other aquatic Beninese communities.[19]

Fed by ocean tides and freshwater rivers, almost half of the 150 square kilometer surface of the brackish lagoon is covered by the brush park. This self-sustaining, locally grown aquaculture system attracts fish species normally found living amongst the natural vegetation of the shoreline and the large woody debris found in rivers, floodplain lakes and lagoons. As an individually farmed paddock the impact of a single *acadja* fish pen is insignificant. However, the aggregated impact of the Tofinu system that has spontaneously multiplied into a large-scale, co-managed organic fish farm has environmental benefits rarely seen in modern aquaculture. (Figure 11)

The *acadja* system increases aquatic biodiversity without the negative drawbacks of other techniques. Using symbiosis and mimicry, the Tofinu fishermen have successfully constructed an ideal fish rearing habitat free from the pollution of antibiotics and pesticides, non-endemic escapees, accidental entanglements and nutrient loading of fish waste or uneaten food, as the system provides its own food source. Using locally grown materials from nearby mangrove forests, the Tofinu fishermen have constructed a sophisticated and sustainable form of indigenous aquaculture by proliferating the *acadja* or mangrove as a Keystone Species.

Indigenous societies have often used aquaculture to adapt to unforeseen changes such as growing populations, climatic shifts and cultural diffusion. Archeological remnants of ancient techniques from China, Thailand, Egypt and Hawaii that supported the growth of huge civilizations still exist. For the Tofinu, mythological stories tell of a time when assisted by crocodiles and pursued by the neighboring slave trading Fon tribe, whose cultural taboos prevented them from fighting on the sacred waters, the Tofinu people fled to settle the lucastrine village of Ganvie.



[19] Niyonkuru, C., Laleye, P.A. & Moreau, J. (2010).

*Figure 10:*
*The Tofinu floating village of Ganvie in Benin, West Africa.*

*Figure 11:*
*A Tofinu fisherman maintaining an Acadja Fish Paddock in Lake Nokoue, Benin.*

The former grazing community took their terrestrial knowledge coupled with ancient pastoral practices to this new aquatic environment and adapted the ecosystem of the lake into the self-sustaining *acadja* fish paddocks seen today. Instead of livestock and chickens, the *acadja* method rears indigenous aquatic life in the small-scale, organic fish paddocks where fish are penned using local materials such as reeds, mangrove branches and palm fronds. Similar cost-effective structures can be found in Sri Lanka and Bangladesh, but despite high yields and widespread use in the developing world, the social, environmental and economic conditions that support the growth of the *acadja* has been minimally studied.

Ganvie is the largest lake city in the world, and has residential, commercial and productive activities spreading and submerging below the lake's surface. The city is a collection of 3000 buildings including a post office, bank, hospital, school, church, mosque, floating market, royal square and a few hotels, bars and restaurants, that are all surrounded by a highly-controlled radiating reef system. Two innovative fishing techniques have evolved from this unique environment; the *acadja* and the lesser used mesh net *Medokpokonou* fishing. The *acadja* is a typical Beninese form of traditional fish breeding which creates a favorable ecosystem for the production of big fish. The mesh net *Medokpokonou* is a funnel-shaped form utilized in circulating water. From a bird's eye view these spiral and square shaped systems can be seen working with the high and low tidal flux of their differing environs. In combination they help to reconfigure our understanding of successful urban eco-morphology.

Lake Nokoue is the ideal shallow environment for *acadja* development of this kind, which spurned the enormous growth of the system. King Abodohoue was wise to build here. With lake depths ranging between 0.4 to 3.4 meters, the reef functions by artificially replicating habitats favored by certain fish species. This type of Indigenous CHANS helps to ensure the success of the reefs, which are constructed through a process of planting dense masses of branches and saplings cut from the shoreline forests into the muddy floor of the shallow lagoon, at a depth of one meter. Before planting, branches are soaked and dried for two weeks to reduce buoyancy. A large net cloaks the frame a perimeter around the artificial reef habitat creating a substitute mangrove forest, providing habitat and feeding grounds to attract wildlife.

At the end of the installation, the parks are enclosed with tall branches of bamboo spaced every 50cm around the net to protect against wind, except for a small section left open. This section gives the owner access to the pen for the net fishing. The average paddocks size is 10 x 15 meters and a 1500 square meter enclosure may be stocked with 15 000 fry (10 fry per square meter). (Figure 12) Fishing is the main source of income and activity on the lake with the *acadjas* contributing to about 40% of the island water catches from Ganvie.[20]

The system enhances fish production by providing

[20] Welcomme, R.L. (1972).

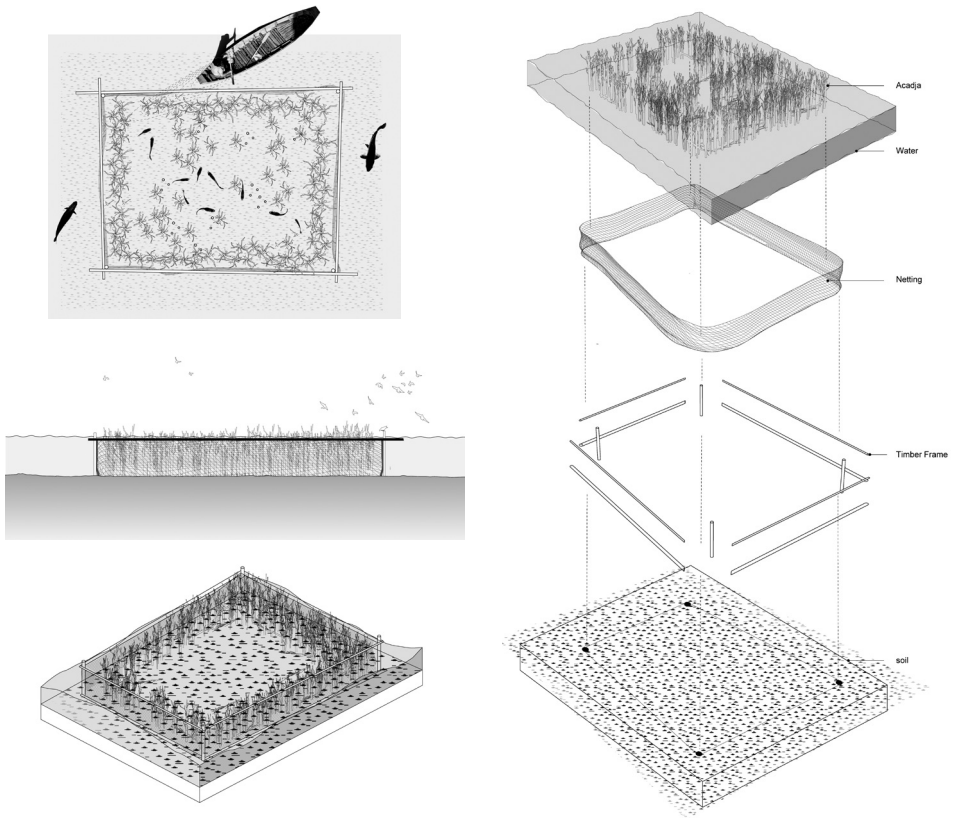


*Figure 12:*
*Plan, section and exploded axonometric showing the construction of an Acadja Fish Paddock.*

healthy substrata for the development of plants and animals on which the fish will feed. Rotting wood acts as a catalyst for algae growth, insect aggregation, avian feeding, and fish breeding, by attracting mangrove ecology to the highly controlled island condition. Many different fish species are found in Lake Nokoue and in the *acadja,* however the artificial ecosystem is particularly attractive to Sarotherodon melanotheron (blackchin tilapia), a prized species for its edible flesh. While S. melanotheron only accounts for 8.6% of the lake's overall fish biomass they make up 87% of acadja production and are present year round.

The tilapia eat detritus and algae from the rotting wood, while the limbs provide protection from predators and the necessary breeding environment to reproduce and maintain the population within the *acadjas.* Most importantly is this high abundance of food: as periphyton which is a complex mixture of algae, cyanobacteria, heterotrophic microbes and detritus that grow on the surface of the branches and as a bottom fauna enriched by decaying wood. Artificial food is therefore unnecessary, which is one of the primary constraints of aquaculture in rural areas. (Figure 13) The perimeter net is constructed at a large enough gauge that small, unsellable fish can pass through, while larger, more valuable, fish are retained and predators are relegated to the exterior. Once inside the fence, small fish will remain and grow until they're too large to swim back out. *Acadjas* also spread fish larvae and fry around the entire ecosystem resulting in better yields for nearby fisherman using other fishing techniques.

Typically, new brush is added to existing *acadjas* prior to the rainy season, offering fish extra protection during high water levels of the rainy season, and food during the high production dry season. The enclosure can be artificially stocked or left in a natural state to self-populate. Fish are harvested in one of two ways: a single harvest after 12 months,

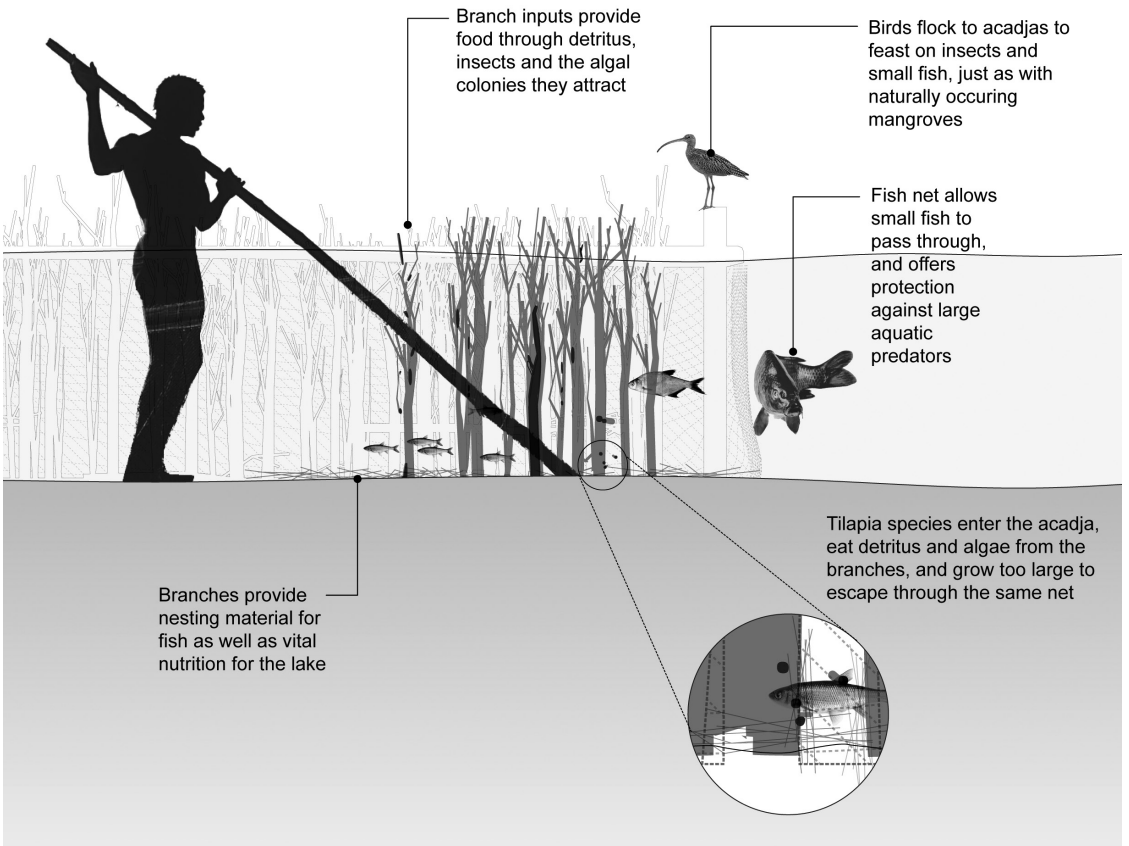


*Figure 13:*
*Detail showing the ecological relationships of an Acadja on Mangrove Fish Paddock.*

or selective fishing throughout the year using nets with holes large enough to allow small fish to escape. Due to this natural cycle, the only necessary input into the system is the annual restoration of the reefs with fresh wood. However there is one critical drawback noticed over recent years resulting from the combined population of over a million people in the three surrounding lakeside cities. Ganvie's artificial reefs are now attracting flora and fauna displaced from the shrinking mangrove forests that surround the lake. This shrinking is caused in part by the overwhelming success of the *acadja* system and its increasing use. The effect of the system and city growth on Lake Nokué's ecosystem cannot be underestimated.

As seen in the *acadja* system, mangrove forests are the nurseries of our global waters, teeming with aquatic life. In the past 30 years, 50% of our global coastal mangrove forests have been destroyed by the construction of unsustainable coastal aquaculture farms in the developing world. While seemingly simple the Tofinu '*acadja*' system is a sophisticated example of a complex socio-ecological system and the city of Ganvie an example of an indigenous CHANS. The survival of the Tofinu people depends on maintaining local natural resources and mangrove communities. The *Acadja* innovation has the potential to migrate to many expansive coastal lagoons and to restore existing aquaculture systems causing habitat destruction or experiencing the impact of typical pollutants. In the middle of the lake village is a furnished royal square where stands the statue of the first king and founder of Ganvie. It's hard to imagine that King Abodohoue could have ever envisioned the city that exists on Lake Nokoue today, one of the most unique on our planet.

## CONCLUSION

In the remotest places on earth, indigenous people maintain a unique existence with nature. (Figure 14) They are acknowledged as the primary protector's of the world's biodiversity in global mappings like the Millennium Ecosystem Assessment, which prove the co-existence of the world's biological and cultural diversity. Seemingly 'untouched' Indigenous lands are actually highly and intelligently adapted complex socio-ecological systems geared to increase local resources and biodiversity, which will be one of the major challenges for humankind in the years to come. Ancient innovations are living examples of how humans can construct healthy, thriving and CHANS.

Shrouded in mystery and mythology, information we're searching for to advance our civilizations is in the ancient innovations of the world's indigenous peoples. The exploration of their vernacular technology is ongoing, as Bernard Rudofsky's 1964 'Architecture without Architects' MoMA New York Exhibition first revealed. Rudofsky's manifesto that documented a handful of ancient innovations changed the ideology of an entire generation of designers. (Figure 15) The exhibition was reviewed as a groundbreaking visual manifesto on the "human spirit beyond style and fashion, and, more importantly, beyond the narrows of Roman-Greek tradition."[21] Over fifty years, later landscape architecture and urban design has yet to follow the example set by architects. This is a critical oversight as ancient innovations offer incredible, living examples of ecological design. To fill the void, the many ways that indigenous and traditional people adapt their ecosystems, must be explored to inform new innovations in contemporary design.

While Darwin was the forefather of modern ecological thinking and we use his 'theory of the ecological division of labor' as a fundamental principle of ecological design, he also said 'Extinction happens slowly'.[22] In the past 40 years, we've lost 52% of the world's biodiversity.[23] We're entering a period of mass extinction that threatens humanity's very existence.[24] Etymologist and Harvard professor

*Figure 14:*
*An uncontacted tribe photographed in the Amazon.*

*Figure 15:*
*The 'Architecture without Architects' exhibition by Bernard Rudofsky at MoMA New York in 1964.*



21 Rudofsky, B. (1964).

22 Darwin, C. (1859).

23 WWF, (2014).

Edward O. Wilson states that the next hundred years will be a period where humankind will struggle to find balance by slowing population growth, land transformation, resource extraction and extinction. In this bottleneck, our most important objective is to bring through as much biodiversity as possible.[25] Unlike the elephant, our urban CHANS are inhospitable environments sustaining little diversity. While not only protecting global biodiversity, indigenous people use advanced eco-technology and sacred ecosystem knowledge to co-exist in healthy, highly adapted ecosystems.

The rituals and ceremonies, the sacred knowledge or TEK taught by previous generations who learned how to protect the natural world in symbiosis with their own survival are forgotten. The sacred knowledge and ancient innovations of the world's indigenous peoples are living examples of ancient innovation. How can this knowledge be used today? This knowledge will be used to design an alternative and sustainable future for human kind.

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