



## CASE 110

### Clustering Mangroves, Shrimps and Seaweed

#### Executive Summary:

Mangroves represent a unique ecosystem at the crossroads of four distinct forms of life: aerobic, anaerobic due to the tides causing changing water levels, exposure to air or submersion in water, and saline and fresh water, due to the arrival of fresh water from inland, and the bordering of the sea. Mangroves have been decimated like no other ecosystem to make space for coastal development. Often, mangroves ceded space to shrimp farming. However, after the white spot virus eradicated farming, it only left desolate flatlands behind. After a series of pioneering experiences in Namibia, Tanzania, and Eritrea, the Indonesian Ministry of Marine Affairs and Fisheries build up the experience and the proof that the regeneration of mangroves is the basis for a highly productive mariculture that includes the production and processing of fruits from mangroves, shrimps, fish and seaweed creating clusters of growth on land in despair. If one adds to these findings and experiences the arrival of sea rice, a natural biota discovered in China, then we can imagine how coastal of the world can resist climate change and rising seawater levels, and evolve into a new resilient economy.

*Keywords: mangroves, seaweed, salicornia, eucheuma, grouper, milk fish, climate change, rising sea levels, parasitic species, goats, sea rice, integrated mariculture, white spot virus,*

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### **Integrated Farming Systems: from Permaculture to Rock Gardens**

When I met Bill Mollison, the inspiration and the creator of Permaculture in Tokyo in 1994, I encountered a man with a great mission with a no-nonsense approach. He walked onto the stage of the United Nations University great conference hall in slippers and showed a series of pictures which demonstrated how to care for the land, and the production of food can be based on simple and ingenious cycles of minerals, water. He showed how exchanges between plants and animals and the flow of nutrients, energy and matter turned land considered infertile productive, and how increase output without reliance on costly inputs. He presented a built human and natural environment in balance, extending the design to a fresh look at science, maybe even a philosophy of art and life. Mr. Mollison had initiated Permaculture in 1978 in Australia in cooperation with David Holmgren<sup>1</sup> based on the original work of Joseph Russell Smith's book "Tree Crops" published in 1929. This work was preceded by Franklin King's book "Farmers for Forty Centuries: Permaculture of China, Korea and Japan. Mr. Mollison debated intensively his concepts with Professor George Chan, this sanitary engineer from Mauritius who served two years in the British Army during the second world war, got an engineering degree from Imperial College of London, worked for decades at the American Environmental Protection Agency in the South Pacific. Prof. Chan not only worked 20 years with ZERI, he had developed a knack for converting polluting sewage into biogas and convert the slurry into soil enrichment. These two masters went their own path, and I learned tremendously from each.



Bill Mollinson

Rock gardens remnants in New Mexico

Danny and Joey Sam at the Picuris Pueblo © 2003 SCI

Permaculture was my first exposure to integrated farming. Then, I learned through my work with the Picuris Pueblo outside Santa Fe, New Mexico (USA) about the rock gardens (also known as waffle gardens with ample rocks) another ingenious system that turns dry highlands into productive zones. The Native American tribe had

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<sup>1</sup> *Permaculture One: A Perennial Agriculture for Human Settlements* (with David Holmgren, Trasworld Publishers, 1978) [ISBN 978-0-938240-00-6](https://www.amazon.com/Permaculture-One-Perennial-Agriculture-Human/dp/0938240006)



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developed this farming system in the drylands of New Mexico that was able to feed fruit and vegetables to 140,000 members before the Spaniards arrived and colonized the region well before the Americans arrived, imposing their farming techniques, disregarding the ingenious spirals of rocks that has emerged after centuries of trial and error. As Mrs. Joey Sam and her husband Danny, the head of the bison herd and the tribal leadership explained when I was permitted to take a glimpse of their protected and holy grounds, the carefully selected rocks would be placed in a large virtuous conical shape fertilizing the land for the next 500 years. It was such a revelation and rather easy to comprehend that the sun, the heat in the summer, the snow and ice in the winter, the weathering winds and the lichens would slowly stimulate the release of trace minerals into the soil. It was so ingenious right before me. Then learned that this is one of the place where Bill Mollison had his inspiration to imagine Permaculture.

### **Starting from Rock Gardens and always Evolving to More**

The rocks not only released the minerals over time, these also absorbed the heat during the day, and released it at night, extending the farming in a zone prone to cold nights. And the water would flow from the top to the bottom carrying, releasing, absorbing minerals on the way. Then it depended solely on the different types of rocks where different types of vegetables would be farmed matching the mineral content to the mineral requirements of each plant species. I was stunned by the smart approach to farming and could very well imagine the high inspiration that Bill Mollison must have gotten when he observed three decades earlier what I had just learned. When I brought hundreds of people from out of state and out of the country to New Mexico thanks to Robert Haspel and Lynda Taylor, the founders of SCI/ZERI Foundation, who funded the reintroduction of the bison herd to the Picuris Pueblo, we observed that the Picuris had successfully integrated plants, animals and minerals. We started a dialogue to introduce bacteria and mushrooms and increase the cascading of nutrients, energy and matter through what we call "The Five Kingdoms of Nature" inspired by the work of Lynn Margulis.



Lynda Taylor



Ivanka Milenkovic



George Chan



Lynn Margulis



Robert Haspel



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Ivanka Milenkovic joined the Picuris from Serbia, George Chan joined from Mauritius, and Antonio Giraldo joined from Colombia with the purpose of generating more value from the existing systemic approach. Ivanka shared how to farm mushrooms on the fibers from the rock garden farming, George introduced the digester and Antonio helped convert invasive species into charcoal and cured wood for home furniture and fittings. It was one of the first experiences that permitted me to see how we can build on culture and tradition, how wisdom of the Native Tribes has the capacity to respond to basic needs and how a few fresh insights in science could boost the productivity of the system beyond what even was already a remarkable achievement.



Joannie Klar Bruce



Jerome Ostenskowski



Paolo Lugari



Amory Lovins

I was invited by Anthony Rodale to visit the Rodale Institute's farm in Kutztown, Pennsylvania (USA) back in 1996 to discuss the findings on integrated farming which we were developing in at the Montfort Boys Town, in Fiji, and how we planned to publish this to make it widely available. The Rodale Institute has been committed to promote organic farming since 1947, and my position was that organic farming only tells you what is not in the food. We need to know what is in there, and we need to know how ecosystems based on biodiversity could produce more than monocultures with GMO could ever imagine. It seems that our concepts on integrated farming with the Five Kingdoms of Nature and this commitment to zero waste and zero emissions was a step too far for these pioneers in organics. However, these contacts were not in vain, thanks to an introduction of Rodale and the work of Joannie Klar Bruce, who is a founding member of the International Bamboo Foundation in Ubud, Bali (Indonesia), I got acquainted with Jerome Ostenskowski, one of the founders of Permaculture in the US who has been teaching Permaculture since 1987 in the Central Rocky Mountains.

We shared the logic of the stone gardens and our new findings. Jerome lived at 2,300 meters altitude and his land was characterized by basalt rock, that named the town. It is one of the richest sources of magnesium. While attempting to farm on rocks at that altitude would be considered mad from the traditional agricultural point of view dominated by scientists who live in parts of the world where there are four seasons, and



are used to an abundance of rich top soil, it was a challenge that Jerome gladly accepted. Thirty years after starting his venture in the Rocky Mountains, and inspired by Bill Mollison, Jerome integrated our proposals micro-algae and lichens into his equation, and even started farming mushrooms ensuring that he could have self-sufficiency in food and nutrition where the world thinks that there is no way to survive. The greenhouse of Jerome would even produce bananas which was later emulated by the Mr. Amory Lovins, co-founder of the Rocky Mountain Institute further North in the valley.

### **There are no Poor Soils and there is no Bad Water**

Paolo Lugari, who created Las Gaviotas and regenerated the rainforest in the savannah once remarked that there are no poor or rich soils, there is only poor minds, people who cannot see the opportunities because their training and experience has forced them to look at reality with very specific mindset. Whatever does not fit their existing knowledge or experience is considered poor, and is subject to attempts to be converted to what is the standard on the market. Jerome is another point in case that demonstrates this logic. We need to observe the reality as it is, take stock of the local resources and imagine how to create a cascading of nutrients, matter and energy that makes this work.

To demonstrate my point I took students to a field trip in the Namib Desert, and we traveled in 1998 to Swakopmund and Heintiesbay. Standing on the beach with the sandy hills and the vast desert behind and the cold seawater before us, we asked the challenging question to the students: could you farm fruits and vegetables here? Most of the students would feel frustrated since even in their wildest fantasy could they imagine farming anything in the desert. Even though we had all been exposed to Permaculture and the Rock Gardens, most of the team members were pressed to explain to me why it would not be possible.

The most important shift in our approach to challenges in this world is not to discard opportunities because we think it is not possible. The mere fact that we think it is not possible, is the reason why it is not possible. That is why the Blue Economy is close to the logic of the Positive Economy proposed by Jacques Attali, the French policy maker and author. Instead of making efforts to explain why it is not possible, why not focus on this extraordinary effort to explain - first and foremost to ourselves - that there are ways to make it possible. The sandy beaches of Heinties Bay now benefit from a dedicated research center that was created by Prof. Dr. Osmund Mwandemele, today the Pro-Vice Chancellor of the University of Namibia and at the time the Dean of the Faculty of Agriculture and Natural Resources. We demonstrated that the farming of asparagus in the sand is not only viable, but even competitive with imported food that dominates the Namibian market convinced that there is no chance to farm.

### **Studying the Interface between Sea and Land**

The experience in Namibia was the first one to study the interface between the sea and land. Thanks to the excellent academic support from the University of Namibia, an



academic institution that had to reinvent itself after the country gained independence and had to transform a white dominated learning system into one that reflects the realities of society. Prof. Dr. Peter Katjavivi, the Vice Chancellor played a critical role in securing that this fresh approach did not only have the backing of the academia but also of HE Sam Nujoma, the Founding President of Namibia and the Chancellor of the University. Our numerous meetings and trips - the President participated in the 3rd World Congress on Zero Emissions in Indonesia as state guest of the President of Indonesia- and hosted the 4th World Congress in Windhoek, Namibia which culminated with the inauguration of the Tunweni Breweries where we drank our first pot of coffee with water boiled by the biogas from the digester fed with brewery waste.

The Namibian experience got institutionalized within the academic community. The academic content was so rich and innovative that Federico Mayor Zaragoza, the Director General of UNESCO and a member of the Club of Rome, offered to finance the first and only UNESCO Chair on Zero Emissions at the University of Namibia. The Japanese Government immediately offered to fund this professorship which was taken on by Prof. Keto Mshigeni, then the vice-chair of the ZERI Scientific Advisory Board.. This UN institution provided funds to teach zero emissions and funded a research team to document and publish the findings catapulting this reconverted university to the top of original articles in Africa that have been peer group reviewed. Since the ranking of universities is highly dependent on its publications, we succeeded that the work we undertook around the world benefited the young graduates who did not study agriculture and ecosystems as seen by those who live in a world characterized by four seasons, rather by the understanding of the opportunities that each ecosystem offers. The University of Namibia was quickly elevated into the top league of publishers of original academic content.

### **How a Seal Colony feeds Itself?**

One of these explorations covered the integrated biosystem of seal colonies. On the outskirts of Heintiesbay is a 70,000 rich colony of seals. The locals avoid the area at all cost since it exhumes a repulsive smell. However, the smell does not only keep the humans at bay, it offers a uniquely productive ecosystem where the excrements of the baby seals, fed by the high quality seal milk, stimulate a prolific growth of micro-algae which double in volume every 24 hours ensuring that both mother and baby can have access to an abundant supply of nutrients rich in trace minerals much needed in this phase of life. As the babies grow in size, and their excrements increase as well, more micro-algae are produced thriving on the rich flow of nutrients. It was a first hand lesson in integrated maritime farming involving animals, algae and seaweeds.

Seaweed has been collected in Namibia since the 1950s but it was in 1975 that it got organized as a business and only in 1981 did local entrepreneurs start farming seaweed. I learned to know Klauss Rottman, the founder of Taurus Chemicals who had established an integrated farming system of seaweed in Luderitz, on the South Western



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coastal tip of Namibia. There his company farmed, harvested and processed *Gracilaria verrucosa* into raw material for agar and garnish for sushi, *Ecklonia maxima* (the giant brown kelp) for the production of alginates, and an excellent moisture retainer in agriculture, as abalone feed and raw material for fertilizer; *Gelidium pristoides* for the production of bacteriological agar; and, *Laminaria pallida* kelp for the extraction of medical products. It was this small biochemical company in Namibia, with its farming and harvesting in along the coast influenced by the cold Benguela Current with business units from Namibia to Saldannah Bay in the Western Cape of South Africa that introduced me to the rich portfolio of chemicals that could be derived from seaweeds.



Oyster farming and seaweed harvesting in Lüderitz (Namibia) © 2013, City of Ludertiz

#### **Farming Seaweed in Zanzibar: a First Component**

Prof. Dr. Keto Mshigeni, then the Pro-Vice-Chancellor of the University of Namibia, a Tanzanian national who obtained his doctorate in marine biology at the University of Hawai'i, and turned an expert in seaweeds with a post-doctoral degree from the University of the Philippines introduced me to seaweed (*Euceuma sp.*) farming and took me to his large scale project on the islands of Zanzibar, Mafia and Pemba. I traveled with him to the Indian Ocean side of Zanzibar in 1995 and visited half a dozen villages. It was remarkable to see how the women withstood wading up to their harvest in the sea, or bending over to knot small seaweeds on strings that would absorb the nutrients from the sea. However, this process would only work if the coastal zone is protected from the onslaught of the tides by the coral reefs. It was again a unique opportunity to see how an integrated approach permitted not only the regeneration of the coral reefs, protected from dynamite fishing which are the precondition of the income generation which at its peak secured revenues for 23,000 women.

The seaweed farming in Zanzibar grew thanks to the pioneering work into the third most important supplier of the world, after the Philippines and Indonesia. The farmers were only farming, drying and baling the harvest and I engaged in exchanges with Dr. Yadon



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Kohi, the Director General of COSTECH, the Tanzania Commission for Science and Technology to identify opportunities for more value and jobs along the lines of the work of Taurus in Namibia which operated on a much smaller scale. Then climate change started to take its toll. The increase of the seawater temperature cut the output of seaweed on Zanzibar in 2014 into to half from its peak, causing a major social challenge. The farmers on the neighboring island Pemba quickly looked for deeper flats which are supplied with cooler water upwellings. This requires the women to make an occasional swim. The good news is that Pemba has been able to maintain its output through this shift in farming and now represents 80% of the output of the region. Since the women on Zanzibar were never taught to swim, they now have the difficult choice: or lose their business or learn how to swim.



Osmund Mwandemele

Yadon Kohi

Keto Mshigeni

Lourdes Luque de Jaramillo

### **Shrimp Crisis in Ecuador: the Second Component**

Mrs. Lourdes Luque de Jaramillo, the Ecuadorian Minister of Environment invited me to Quito for the Ministerial Meeting of the ten nations with Mega-Biodiversity to debate the opportunities related to the natural resources available. Her interest was based on my book published in Colombia in 1998 "*Estrategias para la Diversificación en base de la Biodiversidad*" - "Strategies for Diversification based on Biodiversity" published in cooperation with the Colombian Agency for Training and Employment (SENA). In the margin of this ministerial meeting, she organized a series of discussions with industry. The shrimp sector had been battered by an onslaught of the white spot syndrome virus (WSSV), an epizootic disease. A US\$ 750 million export industry evaporated in a few months time. The extensive use of disinfectants and a considerable application of antibiotics proved incapable of controlling the virus. Worse its use was prohibited by the European Union.

After studying the case visiting the sites, I concluded that the real cause of the proliferation of this epidemic was the destruction of the mangrove ecosystem combined with the degeneration of the immune system of the shrimps due to an erroneous search for productivity and efficiency that shrimps are forced to feed on animal protein, soy and



corn. Up to 40% of the shrimp body mass processed locally ends up as feed for the same shrimps. Shrimps are at best an omnivore, and rarely a carnivore and a cannibal. When shrimps are forced to eat their own waste and are fed soy which is totally inappropriate for their digestive system, then it is no surprise that they degenerate.

The industry consulted scientists who proposed to cross-breed, even genetically modify shrimps to make these resistant to MSSV. Others proposed to widely apply ultraviolet radiation to sterilize the environment. Back in 2002 I proposed that the farming of shrimps cannot continue in the waste land left behind after the removal of the mangroves, rather it must be planned in harmony with the planting of the mangroves. The move towards monocultures and industrialization has not only cut down the amount of tree cover on land, and the destructive fishing techniques based on dynamite and acids have decimated corals. While these two destructions are well documented, the elimination of mangroves had hardly gotten attention in the beginning of the 21st century. However, the pressure to destroy this unique interface between salt and sweet water, aerobic and anaerobic environment has led to the elimination of millions of kilometers of mangrove forests along the coasts of Africa, Middle East, Asia, and Latin America. The combined disintegration of the sea (corals) and the interface of land (the mangroves) needs to be reversed in order to recover shrimp farming.

The role of mangroves were debated when the tsunami on December 26, 2004 devastated the Indian Ocean rim. Experts agreed that the removal of the mangroves to make place for luxury hotels along the beach and shrimp farms eliminated the natural buffer that had always protected the inland from the onslaught of this massive wall of water which leaves nothing standing with its tremendous weight of one ton per cubic meter of water. Mangroves were finally recognized for the ecosystem services. And while the role of the mangrove was recognized, in the aftermath of the disaster, mangrove reconstruction never became part of the reconstruction plan and had not been debated as a means to design sustainable shrimp farming. Sometimes it is surprising how slow humanity learns its lessons.

The integrated farming of shrimps and mangroves was a visionary statement in 2002 and was summarized in my article entitled "The Shrimp Cluster" placed on the ZERI website. The focus was on how to generate multiple benefits and how to ensure that the ecosystem creates the conditions that are ideal for shrimp farming. When we recognize that the largest cost of shrimp farming (and most types of animal husbandry) is the feed, which is usually imported into the region of consumption, the observation that shrimp larvae depend on plankton, micro-algae, and soft seaweeds which thrives in mangrove forests was not a difficult one to arrive at. Adult shrimps are bottom feeders and love worms, mud shrimp which again are abundant in and around mangroves.



### The Pioneering Experience of Eritrea

It was the pioneering work of Professor Carl Hodges, the founder of the Seawater Foundation in the USA triggered a further research into the opportunities to regenerate mangroves. While Carl Hodges and his wife Elizabeth imagined the grand design to channel seawater into the desert to create salicornia farms and mangroves to regenerate the ecosystem, it was the practical approach to generating income and jobs that caught my attention. I was introduced to the work of Mr. Hodges by Prof. Dr. Carl-Göran Hedén, of the Swedish Royal Academy of Sciences. I also appreciated the leadership of Professor Eduardo Blumwald of the University of Toronto who had developed tomatoes and canola plants that grow in brackish water (one third of the salinity of seawater) with normal fruit and seed yields. When I learned that this



Carl Hodges

Carl-Göran Hedén

Eduardo Blumwald

Christer Salén

James O'Leary

Tekie Anday

technology portfolio was licensed by the University of Toronto Innovations Foundation to Seaphire International, a partner of Carl Hodges in Eritrea I decided to study this case in more detail.

It was a surprise to find out that Seaphire International was controlled by Exeter Life Sciences, a specialist in animal cloning technologies which was later merged with other experts in genetic modification. However, with a firm belief in the integrity of Carl Hodges and his team, including his Swedish financier Christer Salén, the founder of the Seawater Forests Initiative in the Netherlands, I gave this project the benefit of the doubt. The project implemented in Massawa, Eritrea set for me a new standard for mariculture farming. A channel created a salt water river connecting the inner land for the farming of shrimps, nurturing thousand of mangroves, irrigating field crops like salicornia. The water percolates through the sand back to the sea. The coastal desert turned green thanks to a new mangrove forest which absorbs over time millions of tons of CO<sub>2</sub> in its roots. The broad belt of green reduces the temperature and increases the likelihood of rain, increasing the comfort of living, while mitigating the impact of climate change.

This joint venture with the Government of Eritrea was an important learning platform and represented the first integrated mariculture farming exercise with remarkable



results. The trimming of the mangroves stimulated the roots to grow faster fixing more carbon, and to create more resilient plants, while the leaves were used as fodder for goats and camels known to eat any shrub and contribute to desertification. Thanks to the research of **Dr. James O'Leary** and his team at the University of Arizona at Tuscon, salicornia caught the attention of innovators like Carl Hodges. The salicornia seeds from these salt resistant plant that originates from Mexico contains 30% oil by far exceeding the 20% produced by soybeans, while it contains +70% linoleic acids used in paints, surfactants and cosmetics. Since salicornia accumulates salt in its tissue, it can be used to remediate soils affected by high salinity, salt intrusion, or rising seawater levels while it is an excellent feed - after extraction of the oil - for shrimps and goats, and leaving behind pure salt.

### **Lessons Learned from the Mangrove - Shrimp Cluster**

Unfortunately the pioneering work in Eritrea did not expand beyond the initial project that was well documented. I was saddened to see this effort disintegrate due to internal government politics in 2003. On the other hand was grateful to have witnessed that the regeneration of mangroves was viable and turned out to be a pre-condition for (re)creating a shrimp farming industry. In addition, the logic of the mangrove-shrimp cluster was strengthened by a clear focus on generating local feed for shrimps and the local animal husbandry of goats and camels. This exercise created at its peak in Eritrea 800 jobs, a local economic development and livelihood while demonstrating the capacity to reverse the desertification along the Northern African coast. Carl Hodges was very disappointed, but a man of his stature never despaired and is working today under the mantle of Global Seawater Foundation to revive his concept in Bahia Kino, Sonora (Mexico). His team includes **Tekie Teclemariam Anday**, the Eritrean marine biologist who worked with him in Africa.



Sarwono Kusumaatmadja

Sharif Sutardjo

Suseno Sukoyano

Endang Suhaedi

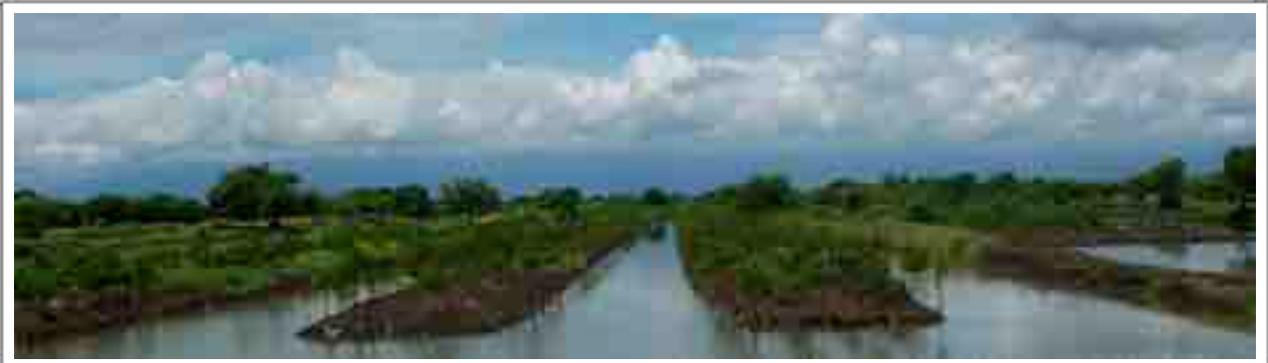
Bambang Suprakto

H. Soekarwo

While Carl Hodges and his team continue to make strides forward to implement the Mexican project, on the other side of the globe in Java, Indonesia, the Ministry of Marine Affairs and Fisheries took the decision in 2007 to undertake a broad initiative to provide a livelihood to the people living along the coast line on the 17,000 populated islands of this 250 million strong nation rethinking how to replant mangroves and how to relaunch shrimp farming that had suffered the same WSSV as Ecuador and Thailand. Mr.



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Mangrove restoration with planting of one year old, growing to 6 year old and shrimp farming in the channels © 2007-2014 MMF

**Sarwono Kusumaadmadja**, was the first Minister of this Ministry, that was created to serve the large marine resources of Indonesia. Mr. Sarwono served previously as Minister of the Environment and hosted the 3rd World Congress on Zero Emissions in Jakarta in 1997. It was during this conference that we discussed the need to regenerate forests, including mangroves and bamboo, and that we pointed to the opportunities to convert coastal zones into centers of local economic development. Paolo Lugari came



to this event and offered a testimonial of the importance of local economic growth based on regeneration of forests.

### **Indonesia sets the Stage for Integrated Mariculture**

The Ministry of Marine Affairs and Fisheries dedicated 47 hectares of land to trials to study in 24 different settings the opportunities to implement integrated mariculture combining mangroves, fish, crabs and seaweeds. The responsibility was in the hands of Dr. **Suseno Sukoyono**, the Director of the Agency of Marine Affairs and Fisheries Human Resources Development which oversees more than twenty academic institutions. Mr. Sharif Sutardjo, the Minister of Marine Affairs and Fisheries decided to further support this pioneering work. The implementation of the study was entrusted to the Polytechnic Sidoarjo in Surabaya, in the Province of East Java. This led to the creation in 2007 of the Mangrove Study Center of the Sidoarjo Marine and Fisheries Politechnique in Pulokerto village, Pasuruan regency, in the same province. **Dr. Bambang Suprakto** and **Dr. Endang Suhaedy**, an engineer by training, took on the responsibility to design a program that converts the defunct shrimp pond culture into a mangrove based integrated farming system. This is another example how innovative business models based on fresh scientific insights can convert stranded assets into generators of value and jobs. **Dr. H. Soekarwo**, Governor of East Java is in full support of this initiative and declared his province as the home of the seaweed economy while the recently elected president recognizes for the first time that Indonesia is a Maritime Nation with a Maritime Economy.

The team of the Politechnique planted +100,000 mangroves as a pilot project on the old ponds that were left behind after the WSSV attacked and left the farmers without recourse. Based on the commitment to start with the regeneration of a local mangrove forest the team designed ponds where 40 to 50% of the space is reserved for *Rhizophora sp.* and *Avicennia sp.* mangroves, and the remaining 50 to 60% is used for shrimp farming like the *Penaeus monodon* also known as the tiger prawn. The ponds benefit from tidal flows of water. The Penang river which suffers from major pollution, is buffered by a dense and newly created mangrove forest. The efficiency of mangrove integrated shrimp farming with *Rhizophora* reached the highest levels, outpacing in investment cost, operational expenses and profit margins the non-mangrove ponds. The predominant feed for shrimps is free, supplied by the ecosystem, and only a minor portion is added for fish and crabs. The mangrove serves as a biofilter as well as a rich supply of antioxidants. This ecosystem enjoys a low risk of disease, while its size makes it ideal for small scale coastal farmers. Seaweeds reduce inorganic waste, and fish control micro and macro algae, while bottom feeders like seacucumbers reduce organic waste and reduce eutrophication, cutting down the need for oxygenation of the ponds.

The research noted that the management of this mangrove dominated ecosystem quickly brings additional benefits beyond mangroves and shrimps. Soft shell crabs easily populate the area, while seaweed (*Gracilaria sp.*) takes up its role in managing



the pond. Fishes, especially the much sought after milkfish high Omega 3 content, can be farmed within the same system, as well as sea cucumbers which are in special demand in China. The mangrove fruits are popular amongst the local population and provide another components for a new local economy to emerge. What the Indonesian team has achieved in 6 years deserves not just our appreciation but our admiration. There is no other center that has designed and implemented such a diverse mariculture built around the regeneration of mangroves.

### **From Integrated Mariculture to Seaweed-driven Biorefineries**

It is also clear to all that this is only the beginning of an enriching scientific experiment, that leads to a transformation of the local economy with a proven track record how to involve the local population that had lost all confidence in shrimp farming and may not even remember the mangroves. The interesting development is that while the government pursues integrated mariculture at a scale and diverse content that is unique in the world, the seaweed industry is emerging in parallel pursuing the philosophy of the biorefinery. Java Biocolloids processes seaweed (*Gracilaria sp.*) located in Pandaan, Pasuruan just a 30 minutes drive from the mangrove research center. Mr. Lino Paravano, a biochemist who started his career in Venice trying to control the micro-algae in the laguna is turning this profitable business into an engine for local economic growth, undertaking a special effort to ensure that farmers and their children see a future in land and sea. The extraction of agar agar from seaweed is an energy and water intensive process but with seaweed output reaching 6 million tons in Indonesia, and local production falling short of demand there is room for further industrialization.



Lino Paravano

Li Kangmin

Jorge Alberto Vieira Costa

Dewi Smaragdina and Sriworo Harijoro

Java Biocolloid processes at present 20 tons of seaweed per day and is poised to increase its production to 80 tons. While the commercial product agar agar represents only 7-8% of the raw material, the rest is an ideal blend to be converted into multiple valuable products. The biomass represents one opportunity, the water is a second opportunity. One kilogram of agar agar requires 600 liters of water implying an urgent need to design a cascading of nutrients and water to generate more value. At first the



company imagined the production of compost, now it is evolving towards the production of feed. Indonesia is a large importer of feed in spite that it has food processing industries and a rich biodiversity in a nation that benefits from abundant sun. The nation has all the ingredients required to become and maintain self-sufficiency in its feed business. It is actually surprising how soybeans and corn have crowded other nutrition out of the market. As Prof. Dr. Jorge Vieira Costa pointed out on the occasion of his visit to Java Biocolloids the processing of seaweeds offers a unique opportunity to create numerous additional value chains that will take the local economy to another level.

### **A New Generation of Mariculture: More Products and More Jobs**

What we witness is the unfolding of a new generation of mariculture which takes the pioneering experiences of Carl Hodges to a next level, with a wide variety of applications, and a flexible portfolio of outputs which respond to the critical needs of maritime countries like Indonesia. First, there is the need to create resilience against the harsh weather conditions of the Pacific which include tsunamis. Man-made climate change also requires coastal villages to adapt to rising sea levels and increased salinity. This makes mangrove based integrated mariculture most relevant, and even necessary to ensure food security. However, many economies have become highly dependent on the importation of frozen fish and chicken to respond to the basic needs of people at a perceived low cost, forgetting that the import of feed drains cash out of the local economy and creates the poverty trap. The strategy to produce local food, importing feed has not made much of a difference since the economies of scale and the cost of feed renders the cost of local production often too high. Those who make money are the suppliers of the feed and the sales representatives of the hardware. It seems that nothing has changed since the gold rush.

The mangrove-driven mariculture produces multiple of cash flows starting with the mangroves themselves, producing fruits which are locally processed. Then the mangroves produce an amazing range of color pigments which are even transformed into one of the most appraised batik clothes that take two years to produce, but which are a great reminiscence of the extraordinary textile industry that once reigned in this region. The coloring technique requires 20 washes combined with a natural fixing of the colors that demonstrates that mangrove-based dyes are not only surviving, thanks to this integrated approach these coloring agents are making a comeback.

As has been demonstrated elsewhere, mangroves are the most productive ecosystem for honey once the parasite plants can complement the mangroves with long blossoming flowers that turn the beehives in this environment the most productive in the world. However the production of fish is a remarkable sub-system of efficiency and value generation. The choice of the milk fish (*Chanos chanos*), the national fish of the Philippines (under the name bangús) which feeds on algae and invertebrates was a fine choice to combine with mangrove shrimp farming. The *ikan bandeng*, as milk fish is popularly called in Indonesia is a very bony fish which was already farmed 800 years



ago. However its popularity is dependent on the removal of its 214 bones. Unless the bones are removed the fish ends up as cat food.



Additional cash flows generated from the processing of Gracilaria: compost, animal feed, and shells to be converted to  $\text{CaCO}_3$

The Indonesian Ministry of Marine Affairs and Fisheries set out to train workers to remove all bones, increasing the value of this Omega 3 rich fish by factor three. The bones are not lost, this calcium rich concentrate is converted to Halal-certified food that adheres to the Islamic standard. Based on the original work of **Visayas Institute of Fish Processing Technology** at the College of Fisheries and Ocean Studies of the University of the Philippines in Miag-ao, in Oloilo City in cooperation with the **Philippine Council for Industry and Energy Research and Development** at the time headed by Mr. Graciano Yumul Jr. its executive director, the Mangrove initiative in Java unfolded and created products as diverse as calcium rich spaghetti, fish skin crispies and ingredients for shrimp feed. The factor three in value thanks to the deboning is now factor five thanks to the value added generated from the bones and the skins, providing quality local food.

While the soft crabs are successfully farmed and sold fresh on the local market, where these are considered a delicacy amongst the Chinese population, the seaweeds are become another sub-cluster of growth. The power of the initiative of the Java Biocolloid, which states on its website that "Blue is the New Green" is that it actively searches for cooperation with other producers of waste streams that are in search for value. First Java Biocolloids focusses on ensuring that its massive consumption of water is not exploiting, but cascading. The extraction of agar agar leaves a rich mix of N, P and K in the waste water which is channelled to local rice farmers who can now reduce their fertilizers by 60%, thus not only cutting the cost of pumping water, but also reducing the chemical input, while this reduces the load on the industrial waste water treatment plant.

### **A Never Ending Value Chain**

The seaweed farmers who established themselves as reliable suppliers receive a cleansing tunnel from Java Biocolloids. Since *Gracilaria* is farmed in shallow coastal zones, it brings with it sand, benthos and shells. Through the investment in salt water washing units at the seaweed harvesting site, the amount of sand is cut in half, reducing the cost of transport and increasing the value generated by the seaweed. Still the factory separates small gastropod seashells at a rate of two tons per day. Seashells



have been collected and valued as currencies, but these are produced of pure calcium carbonate (calcite, aragonite and vaterite), and its varieties like nacre (mother of pearl) which are made of a mix of aragonite and some elastic biopolymers such as chitin is easily converted to an extra value chain.

Since Java Biocolloids uses natural processes only, the  $\text{CaCO}_3$  can be transformed on site into pharmaceutical quality calcium concentrates (with 40% pure calcium) to produce tablets and chewing gum. Since this source is produced by a natural cycle and not mined, or produced synthetically, it is highly valued for the production of toothpaste, body lotion, soap bars and color cosmetics. These shells are excellent raw materials for calcium addition, and white pigments which are in great demand (known as E170) at a premium price. As a Blue Economy company, Java Biocolloids is prepared to invest in the exploitation of these additional value chains that are (again) mostly imported, but could be competitively produced since its arrival in the factory ... is for free. It is easy to compete on the local market, substituting imports with a raw material that cost nothing to obtain. Hence, we find another opportunity to relaunch local industries in connection with mariculture.

The waste streams of Gracilaria are laced with a mineral iodine that the body needs to make thyroid hormones which control the body's metabolism. The introduction of more processed food, and the reduction of maritime based nutrition deprives many communities of the required daily allowance of iodine. Iodine deficiency is known as a disorder since it affects the health of the child, and its brain development in particular. The world has taken notice and the World Health Organization promotes the intake of iodized salt. Already in 1997 I wrote an article indicating that the export of subsidized iodized salt from Europe to Africa and Asia is an anachronism. Iodine-laced food must be produced locally in connection with the processing of seaweed. I had proposed this in vain to the seaweed farmers in Zanzibar who preferred to accept iodized salt sold at low price thanks to European Union's subsidies. I wondered what is it about development cooperation when instead of paying Europeans to add synthetic iodine to salt, the European aid agencies could not invest in facilities that process food and feed in an integrated way so that iodine is part of the cycle. I must admit that the European lobby groups that are addicted to these annual cash injections have prevailed until today.

Java Biocolloids's solid waste stream, which represents 92-93% of the production contains 15 to 25 ppm of iodine, equalling the concentration of iodine in iodized salt. This means that if the focus of the waste streams is to enter the food and feed cycle, then the spin-off industries will make a direct contribution to the improvement of health, especially in the Indonesian highlands which often lack iodine in the daily food intake. Now the first and obvious use of the waste is to turn it into compost. While this is done successfully, it makes more social and economic sense to secure the upcycling of the fibers, amino acids, fatty acids, lipids and a rich variety of elements including calcium



(Ca), potassium (K), sodium (Na), iron (Fe), nickel (Ni), copper (Cu) and manganese (Mn). While some argue that there is a potential to generate biofuels from the fatty acids, we consider this the least interesting. After all, we do not wish to burn what could be turned into nutrition! However residual wastes can always be digested anaerobically creating biogas in the process.

The combination of the mangrove cluster with the seaweed cluster provides a solid backbone for local economic development. Now if this can be strengthened by additional flows of readily available biomass available in the region, then we can further enhance the nutrient cycle. Right behind the mangroves are rice fields. Rice has several waste streams, but rice bran in particular is rich in anti-oxidants. A survey undertaken by Java Biocolloids unveiled also the local availability of yeast. As highlighted in the previous case 109, yeast contains a wealth of proteins that are very similar to animal protein while adding Vitamin B, Thiamin, Riboflavin and Niacin. The opportunity to create a feed stream that is based on seaweed, rice and yeast, all three in abundance in the region can quickly generate a 100 tons per day feed business, that produces +36,000 tons per year substituting imported soy and corn which can never compete with the wealth of nutrition that can be generated through this mix.

### **The Next Frontier: Battling Climate Change**

The initiatives unfolding by the Government and the private sector in Indonesia now have a third component: how to deal with rising sea levels and the 1.2 million hectares of flatland along the coasts that are likely to succumb to the salinity and alkalinity of the shores. When I traveled the coast line of Java (Indonesia) on the occasion of the 9th World Congress on Zero Emissions and the Blue Economy, organized by the Indonesian Blue Economy Foundation created by Ibu Dewi Smaragdina and chaired by Ibu Sriworo Harijono in Jakarta, it became clear that Indonesia needs to embrace the farming of sea rice, or face the hardship of climate change like the women in Zanzibar.

Prof. Li Kangmin, a member of the ZERI network of scientists since the beginning in 1994 and "a student" of Prof. George Chan, has written extensively on integrated aquaculture. His articles "Extending Integrated Aquaculture to Mariculture in China - New Trends in Fish Farming"<sup>2</sup> and "New Ideas and Approaches to Sustainable Seafood Products"<sup>3</sup> summarize both his experience and his vision. Prof. Li Kangmin informed us about a major breakthrough in China. Mr. Chen Risheng, a graduate from Zhanjiang Agricultural College (Guangdong) studied with his teacher Prof. Luo Wenlie discovered nearly thirty years ago a wild flowering plant with resemblance to rice. In 1987 Chen Risheng started testing this sea rice and 28 years later his areal had grown to 133 HA.

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<sup>2</sup> This article was published in the Encyclopedia of Life Support Systems (EOLSS) by UNESCO in 2008 and is available on <[www.eolss.net](http://www.eolss.net)>.

<sup>3</sup> This article is included in the proceedings of the ACOFB 2013 Congress held in Bali, Indonesia in 2013. Additional articles by Prof. Li Kangmin are included in the annex of this Case.



#### Another Case of The Blue Economy by Gunter Pauli

He created the International Sea-Rice Biotechnology Company Ltd with a research staff of 80 in Beijing. The Chinese Ministry of Agriculture extended trials on alkaline-saline soils in Lingshui, Hainan; Zhanjiang, Guangdong; and, Panjin, Liaoning. These test demonstrated that the rice can grow in a soil with a pH 9.3, where no trees can grow. The sea rice can withstand water logging and has no problems being submerged for three to four hours during high tide in plain seawater. Since sea rice does not need fresh water it saves in the order of 1,000 m<sup>3</sup> of fresh water per ton of rice without any need of fertilizers.



Mr. Chen Risheng with a crop of sea rice © 2013, International Sea Rice Biotechnology Company

China has an estimated 100 million hectares of saline-alkaline soil. Indonesia has an estimated 150 million hectares along its coastal zones which is the longest in the world. If both nations were able to grow rice on saline land with a yield of 2,250 kg/ha then one can expect an additional production of 225 million tons in China and 337 million tons in Indonesia. The conclusions of this breakthrough level of productivity is that both China and Indonesia can feed themselves. However if we add the clusters described here and add the mushroom farming on rice straw, and the conversion of the substrate into animal feed after harvesting the fungi, then we realize that this world is set to create abundance where the majority sees scarcity. We see millions of new jobs, where others worry about terrorism and extremism as the result of high youth unemployment rates for which the traditional economic model of globalization does not see any outcome on the basis of all statistical analysis. That is why we refuse to look at the statistics and take it as a reality. We know we have to create a new reality.



### **Investments and Jobs**

The investments in research, education and the new industrial facilities over these years have accumulated into a capital lay-out in the order of US\$220 million. The facilities have benefited from in-kind contributions from Governments, as well as research and education budgets that go unaccounted for like the one guaranteed by the Indonesian Ministry of Marine Affairs and Fisheries. The investment in seaweed farming, mangrove restoration, and shrimp farming that we have participated and witnessed over nearly 2 decades including Tanzania, Ethiopia, China and Indonesia by other partners is only a fraction of total investments in the world. Still, what our network and local organizations have been associated with still represents a considerable budget. The number of jobs created in farming is high, at its peak 23,000 in Zanzibar alone. The employment in one seaweed processing factory reaches 800 when operating only at one quarter of its capacity. We therefore put the number of direct jobs to 42,000.

This new cluster of mariculture has the potential to generate millions of jobs, and secure future economic activities beyond the rising sea levels and the increasing overall productivity of land and sea securing that we do not have to expect the earth to produce more, we can do more with the production capacity of the earth, as the original statement on the occasion of the creation of the Zero Emissions Research Initiative proposed.

### **Translation into Gunter's Fables**

The farming of rice and algae has inspired me from early on to write fable 24 "Red Rice" dedicated to Jorge Alberto Vieira Costa. The opportunity to farm anywhere has been share in fable 13 "Cold Feet" which was inspired by John P. Craven. For more information please visit <[www.GuntersFables.org](http://www.GuntersFables.org)> or <[www.ZERILearning.org](http://www.ZERILearning.org)>.

### **For more information**

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