Global Village Institute for Appropriate Technology

Non-Party Stakeholder Submission
to the Talanoa Dialogue of the UNFCCC

Albert Bates
April 2018

Summary of Input

We concur with the inputs to Talanoa from others summarizing the converging crises that are gaining in urgency, with dangerous runaway climate change as a real and present danger. Our input is to urge the Parties not to segment the problem or the arrayed solutions proposals but rather to create a holistic approach, combining the proposals where applicable, marrying decarbonization and drawdown targets to *all* the Sustainable Development Goals.

Our brief input will summarize a broader literature showing how this can be accomplished and moreover, *must* be approached in this way if the response is to have any chance in scaling to meet the challenge within the time allowed by climate processes already underway.

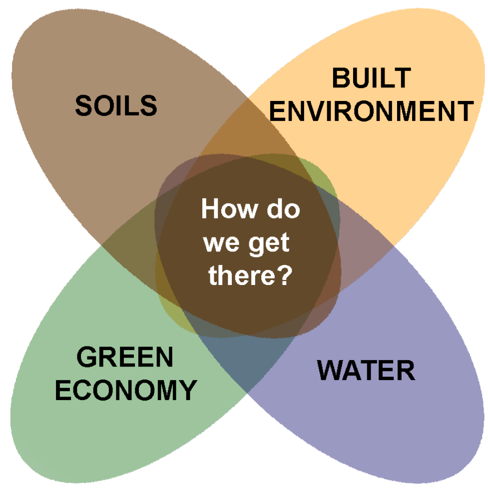
We propose a means by which to catalyze a global-local response to climate change by implementing large scale ecosystems regeneration in many locations, with highly replicable and economically viable methodologies. Where our input would differ from other proposals is that we propose models capable of rapid spreading (rather than concentrating) to achieve a culturally transformative response. We urge a systemic integration of local circular economies, bioregional production for bioregional consumption, regeneration of local photosynthetic productivity, and accelerated carbon retention in soils, infrastructure and the built environment. We also urge parties to address the needs of indigenous and traditional communities, including climate refugees, to preserve cultural heritage through this time of rapid transition.

Our tools include agroforestry, aquaculture, marine macro- and microalgae, (N'Yeurt 2012) holistic management, keyline design, renewable bioenergy, biochar and carbon farming. (Bates 2010) Rather than large, centralized, top-down (and fragile) industries, we propose local eco-social entrepreneurship in agricultural, fishing and production cooperatives and ecovillages, building upon trainings from ecosystem regeneration camps, green schools, permaculture and action learning workshops. Village-scale, adaptive, antifragile bio-refineries form the basis for creating a regenerative culture beyond fossil resource and energy use. The real power and speed of this model derives from local people generating innovative solutions elegantly adapted to the biological and cultural uniqueness of place. (Wahl 2016)

Reversing Climate Change by Regenerative Design

Global Village Institute (GVIx.org) was created in 1974 for the purpose of developing and disseminating promising new technologies that benefit humanity in socially and environmentally friendly ways. We participate in the United Nations conferences of parties through the auspices of the Global Ecovillage Network. We have been engaged with climate change since 1980, including research into food and energy applied sciences towards the end of improving economic security while reducing climate-altering dependence on fossil fuels.

Global Village Institute is pleased to submit this document as a civil society participant to the Talanoa Dialogue. We wish to make a case for an accelerated transition not merely to a low-carbon society, but to a human ecology redesigned to draw in carbon dioxide. We propose to run the carbon cycle in reverse, to unmine the coal and undrill the oil. We propose to do this in such a way as to achieve the aspirations of the Sustainable Development Goals, and to leave the Earth in far greater health than we find it at the start of the 21st century.



This paper addresses the Dialogue's third question — how do we get there? We propose four frameworks to resolve the present crisis. The first is a soils framework to restore balance to carbon, nitrogen and related cycles, enhancing nutrient density in food, rebuilding topsoil, and conditioning urban and agricultural lands to withstand flooding and drought. The second framework is to extend food and materials production to trophic cascades within the world's rivers, oceans and wetlands. The third is to shift urban and linking infrastructures — buildings, roads, bridges and ports — to incorporate drawdown materials and components. We propose replacement, where possible, of polymers and composites based upon fossil feedstocks or silicon with superior materials of pyrolyzed carbon that provide, through a blockchain accounting ledger, verifiable sequestration with every use. Our fourth framework is economic reorganization, using tools of the digital age, to restructure values assigned to currencies to incentivize carbon drawdown.

Fully developed, our approach costs nothing — to the contrary, profits its users — and contains the seeds of a new, circular economy in which energy, natural resources, and human resources enter a virtuous cycle of improvement. It begins with food production, expands outward to farming, herding, and fishing communities, proceeds to the micro-economies of bioregions and cities, closing cycles between sources and sinks; raw materials and waste products; and the seasonality and rhythms of energy and nutrient flows. The tools to propagate this approach are immersive trainings, in part through UNITAR, in agroforestry, aquaculture, coral restoration, holistic management, keyline design, renewable energy systems, bioeconomics, networked B-corporations, action learning opportunities for all ages, production cooperatives, ecovillages, ecosystem regeneration camps, cryptocurrencies and new social media.

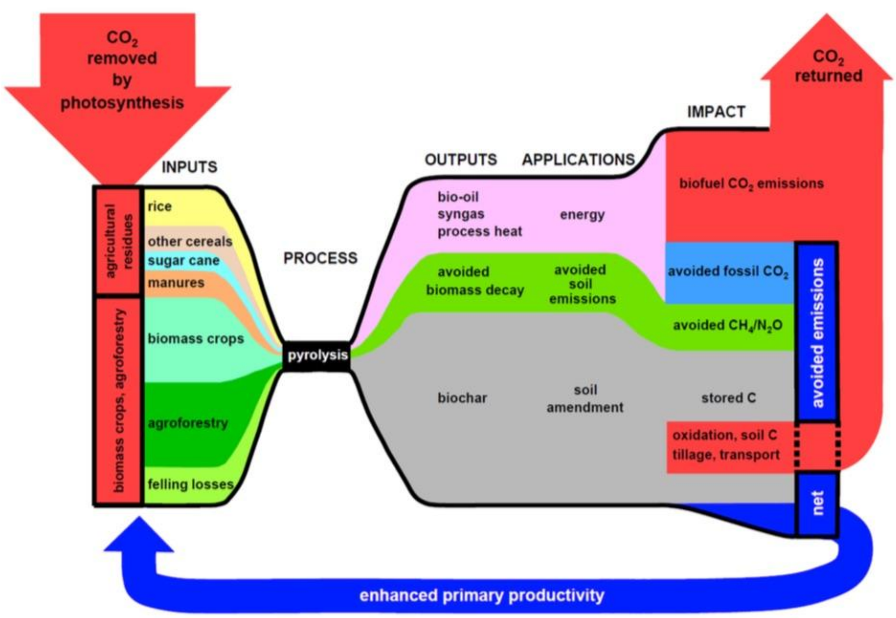
Natural Climate Solutions

For the reasons elaborated in the input of Cornell University to this dialogue, carbon dioxide removal technologies (CDR) offer a safer and more comprehensive solution to stabilize the Earth's climate system than solar radiation management or other geoengineering proposals. (Greene 2017, Williamson 2016, House 2011, APS 2011, Royal Society 2009) We have narrowed the focus of this submission to CDR but with an added restriction. We believe that Natural Climate Solutions (Griscom 2017) are adequate to supply the speed and scale required without untested or unproven CDR methods such as Direct Air Capture (artificial trees) or phytoplankton fertilization (artificial whales). Our solutions rely entirely on real trees and real whales.

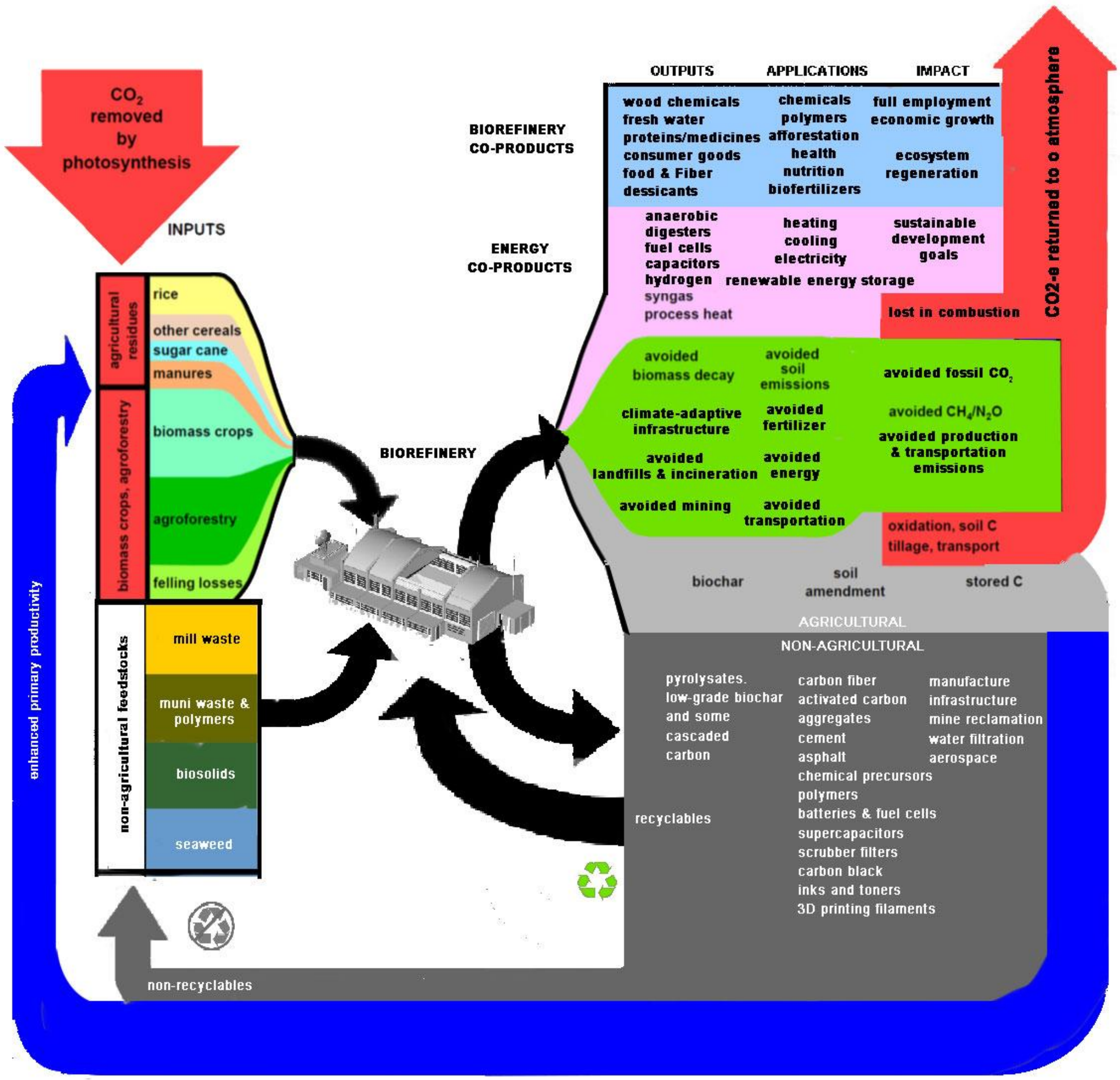
To address global problems like human population, food, water, energy and climate change — and the inertia of human behavior — traditional, specialized, categorical problem-solving approaches are limited and have not proven effective in the past. Dilemmas at planetary scale must be approached as multidisciplinary, interconnected wholes within larger wholes. We need to "walk through walls" with a new genre of quantum solutioneering.

We recommend neither strictly top-down government approaches nor bottom-up nonprofit approaches, but rather rely upon microenterprise networks as our primary delivery vehicle. Public sector finance can provide design, engineering, education, demonstrations, and marketing to accelerate the process and encourage private investment. (IGES 2018) We applaud the new level of collaboration between the Technology Mechanism and the Financial Mechanism to deliver projects that incubate and accelerate new ideas — "innovation labs" — to support local startups and entrepreneurs.

What will be required for any solution is both technical — climate smart farming, biorefineries, climate ecoforestry, educational products and business structures — and a high degree of community cohesion, conscientiously constructed.



Biomass Energy with Biochar Storage
Model proposed by Woolf & Amonette, 2010
Limited to biomass crops and residues; soil applications
Potential for sequestration is 1.8 GtC-e/y



Biorefinery with Biochar Storage
Model proposed by Bates & Draper, 2018
Includes pyrolysates unsuited as soil amendments; non-soil applications
Potential sequestration yield is > 100 GtC-e/y

We propose a global shift in the atmospheric impact of human ecosystems, essentially redesigning in nearly every aspect to be net carbon sequestering rather than net emitting. The strategy involves pyrolysis of orphaned resources — municipal wastes, sewage biosolids, crop residues, mill wastes and more — and substitution of mineralized carbon products for common consumer, industrial and infrastructure feedstocks (Schmidt 2014, DeVallance 2015, Karp 2017, Bates 2018) — sand, asphalt, concrete aggregates, polymers, plastic microbeads and steel — to move beyond carbon neutrality to annual net sequestration. This tactic is neither impracticable nor unprecedented but to reach scale it must spread — which we propose be done through devices like microenterprise hubs, blockchain carbon ledgers and community-based, networked B-corporations.

The soils framework not only *permanently* sequesters carbon, but also restores the nitrogen, phosphorus and potassium cycles, enhances nutrient density, builds topsoil, conditions agricultural lands to withstand flooding and drought, and costs nothing — to the contrary, profits its adopters. It contains the seeds of a new, circular economy in which energy, natural resources, and human resources enter a virtuous cycle of improvement. It is robust, resilient and antifragile.

The greatest challenge when devising climate solutions is social cohesion and training. Our input is directed at encouraging attractive demonstrations and then recruiting communities, especially near current and future refugee sites, in a manner consistent with preserving and enhancing indigenous culture and biodiversity, to supply the unique needs of each community from the 100 or more carbon drawdown methods. (Hawken 2017) The green economies framework links every application of drawdown to the Sustainable Development Goals by achieving those goals more from business profits than from public finance.

An Early Prototype

Following four decades of development, in 2015 our solutions team began to demonstrate our open source model. Leading figures in key fields arrived at our pilot site of El Valle in the Dominican Republic to train, advise and participate. Surveys and public meetings preceded site work. Once the social fabric was strong and the community was eager to proceed, cooperative design processes began and the groundwork was laid.

In that rural setting, the design process produced a 3000 hectare development plan that is illustrative. Working with indigenous farmers and fishing families, we developed a Code of Covenants and Restrictions. Within the district, apart from a limited number of service vehicles, transportation is to be restricted to slow micro-vehicles including personal transport that can be recharged by renewable energy and operate within the pedestrian-optimized landscape. By community consensus, the principal industries will be food, nutrition, health products, and low impact “ecotourism” or “agrotourism.”

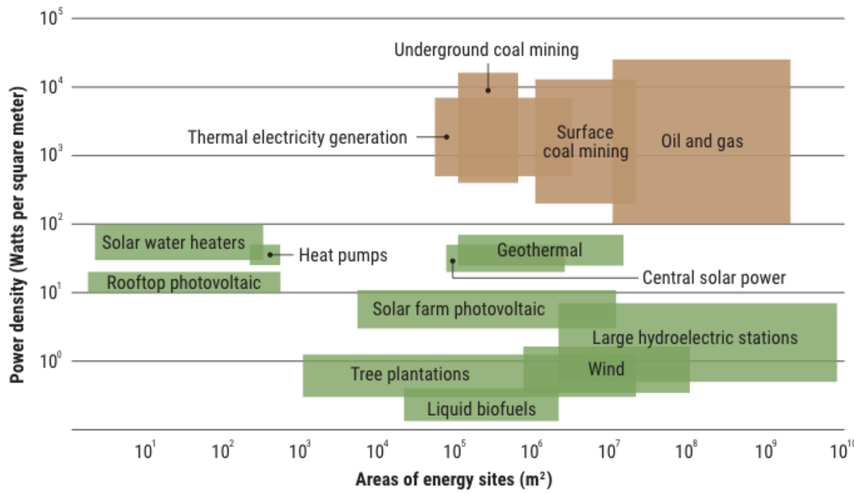
Landscaping must comply with NOFA Standards for Organic Land Care and the native plant species list. Development is held to a 90/10 offset density ratio, meaning that only 10 percent of the land area of the valley will be permitted to be developed. The remaining 90 percent will be kept wilderness or mixed age, mixed species ecoforestry. The most degraded portions are zoned for regeneration. Biodiversity and soil carbon will become metrics of quality assurance.

Crop residues and biowastes are gasified to produce power, chemical feedstocks and biochar. Biomass energy crops of supergrasses are shredded and pelletized for neighboring industries, replacing fuel oil at 1/5th the present cost. The entire energy cycle is carbon sequestering. (Lee 2010) After only 2 years, we have shown we can produce 10 times more carbon drawdown than solar or wind energy, with a $500,000 investment soon to be generating annual profit returns above 20%.

A future product line will cascade co-products from the biomass-to-biochar energy biorefinery such as protein supplements, animal and aqua-feeds and biochar fertilizers. We expect this phase to cost initially US$2 to 5 million dollars and get underway in 2019. While macro-and microalgae farming have not yet been incorporated into the business plan, the warm Caribbean bay in El Valle, frequented by humpback whales, invites that possibility at a future date.

Going to Scale

We know that at a global scale, rapid atmospheric changes have been induced by changes in land use — up to 37 gigatons of carbon drawdown in the historical example of the Columbian Encounter (Dull 2010) or 700 megatons in the example of the Mongol invasion of Europe in the 13th century. (Pongranz 2011) Sequestration is a two-step process involving photosynthesis — recovering atmospheric carbon into biomass — and then sequestering some of that carbon more permanently before it returns to the atmosphere.



(GRAPHIC) J. YOU/*SCIENCE*; (DATA) V. SMIL, ENERGY TRANSITIONS, PRAEGER, 2017; V. SMIL, POWER DENSITY, MIT PRESS, 2015

Human civilization stands at the cusp of an historic shift in how it obtains its energy. In every prior energy revolution we moved to energy sources that provided more joules per gram and required less land to produce. Renewables, which have been a declining share of our energy mix since 1820, are lower in density than fossil fuels. This means that to hold to the 2-degree target, society may have to devote 100 times more land area to energy production than today. That shift will have enormous impacts on agriculture, biodiversity, and quality of life. (Voosen 2018) With dispersed, diverse, community-led design and implementation, that unavoidable change to a much more vegetated planet can be positive.

The type of energy, fertilizer and food production system we've outlined just for one prototype project, taken to the 20 Gha of low-productivity land available globally (Smith 2012) could sequester carbon from the atmosphere at the average rate of 13.6 GtC/yr by 24 years. (Michael 2018) It would achieve cumulative storage of the 600-700 GtC required to bring atmospheric carbon back to pre-industrial levels within about 50 years, taking into account the oceans' CO2 outgassing feedback and other black swans. Were nations to collectively phase out fossil fuel emissions, the reduction would be achieved sooner. Carbon would be stored in urban hardscape, tidal barriers, dams, highways and living biomass and provide numerous additional benefits beyond sequestration.

Built Environment

The Dominican Republic prototype would not apply to an urban setting. Let us consider a slightly different example there. Testing carbon concretes at 5, 10, 15, and 20 percent biochar content (by weight) we find:

- All biochar admixtures had less weight loss due to moisture evaporation. Mortar mixes with biochar have better water retention and this may lead to improved strength. (Choi 2012)
- 5 to 10 percent biochar performs similarly to 20 percent replacement with fly ash (the toxic residue of cement making and other industries). (Justo-Reinoso 2018)

- Blending biochar with cement provides thermal insulation in hot climates. (Al-Jabry 2005)
- Adding up to 5 percent biochar shows an increase in compression strength. Beyond that — to 15 percent or more by volume — the strength would need to be compensated by additional materials, such as charoset. (Ahktar 2018)
- Carbon cement outperforms silica-based controls in bending strength, compression & fracture energy. (Restuccia 2016)
- Biochar from coffee bean discards does better on compression tests. (Restuccia 2016)
- Biochar from hazelnut shells does better on flexural (MOR) and fracture energy tests. (Khushnood 2016)
- Hazelnut shells' irregular morphology, transferred to biochar, creates "perfect bond with surrounding matrix." (Khushnood 2016)
- Coffee powder-based biochar has higher silicates which could work as an accelerator helping speed up the hydration process. It stabilized at 7 days. (Restuccia 2016)

Concrete engineers have found in repeated tests worldwide that using similar amounts and types of biochar and pre-saturating biochar six hours prior to mixing, adds higher compressive, flexural and split-tensile strength. (Choi 2012) Concretes made this way actively draw carbon from the atmosphere for many years and self-heal cracks through the activity of bacteria. (Gupta 2018)

The world produces 4.1 billion tons of cement annually at a life-cycle cost of 3.3 gigatonnes of CO2-equivalent, making cement one of the largest anthropogenic sources of climate change. If 50 percent were replaced with charoset, a stronger, more durable cement incorporating biochar, (Shi 2018) the avoided CO2-e would be 800 million tonnes per year and the permanent sequestration of recalcitrant carbon would be 600 million tonnes per year. One might well inquire, is there enough biomass feedstock to allow such production? Prior estimates of available feedstocks (Griscom 2017, Hawken 2017, Smith 2016, Wolff 2010, Royal Society 2009) have said there is not, but regrettably their research ended at biomass wastes and did not examine other easily carbonized sources, such as municipal wastes, tires and biosolids.

Just world wastewater production is 450 km2 per year. At 720.8 kg/cubic meter, that sludge weighs 324 gigatonnes. Dewatered to 30% biosolids and carbonized with a yield of 25% biochar by weight it would more than supply the demand for charoset offered in our example. If 20 percent of the world's sludge (much of it too contaminated with heavy metals, pharmaceuticals, fertility hormones and other pollutants to be suitable for soil) were carbonized this way, 17.9 gigatonnes per year of CO2-e could be withdrawn from the carbon cycle and entombed in hardscape — buildings, roads, airports and dams. It has been shown to improve asphalt. (Jeffry 2018, Zhao 2014, Schmidt 2014) Nearly two billion tonnes of asphalt is poured every year. (EAPA 2011, Asphalt Institute 2015) These substitutions are the essence of our third framework.

The new paradigm of net sequestering human activity must also build social capital. The problem is no longer a technical one — we know how to turn the carbon cycle in reverse by entirely natural means. (Griscom 2017) The principal obstacle is cultural inertia and the psychology of stranded investments. (Diaz-Rainey 2017, Patenaude 2011) Moreover, complexity itself is a challenge, requiring broad, interdisciplinary competence. (Clarke 2014, Wahl 2016)

Cross-cutting obstacles will be encountered — conflict zones, population, religious intolerance, natural disasters and more. Any approach must build antifragility as it develops, with training centers that prepare adopters for everything. Failures are fast learning opportunities. Here is a simple example.

Between January 1981 and July 1982, the world price of sugar collapsed for the second time in ten years. The effect of this collapse was devastating to many sugar-producing countries. Cuba took it especially hard, closing many refineries that had been supporting entire communities for centuries. Leaving fertile fields out of cultivation, tropical invasives exploited the opportunity and thrived.

Years later, with the price of sugar up and sugar farmers, now all-organic, wishing to recover these fields, Cubans found they were up against a formidable adversary — *Dychrostachys cinerea.* Marabú, also called sickle bush, is a woody weed — really a small tree — with long needle-like thorns. It has jumped from the sugar fields to the surrounding areas and today covers 18 percent of Cuba — 20,000 square miles. Because it spreads by rhizome, the more the farmers cut it out, wading in with machetes and chainsaws, the faster it grows back. By the late 1990s, the weed had become a thorn in the entire nation's side.

It was then Cuba switched from viewing the weed as a problem to seeing it as a resource. Slowly at first, but then with greater momentum, they began converting it into money. Farmers in the provinces of Cienfuegos, Camaguey and Granma cut the trees down and carbonized them by slow burning. The charcoal was shipped to Spain, Greece, France, and Germany where it is used for cooking.

By 2011, marabú charcoal exports brought Cuba 4.9 million euros (USD$6 million) in needed exchange. It is estimated that if all 900,000 tons of marabú available in Cuba each year were carbonized it could generate one billion dollars in foreign trade and domestic products. (Inspire-Cuba 2018)

But Cuba has another idea. Rather than export it, it wants to use its marabú to replace expensive oil imports. It is machine-harvesting marabú and making electricity. Juventud Rebelde, a researcher of the University of Camaguey said, "With each hectare generating 35 tons of marabú biomass, we can produce up to 13 megawatts from the harvest of 10 hectares daily."

Cuba's invasive marabú "crops" have incredible potential to generate electricity as biomass, with a value greater than 3000 kilocalories per kilogram. Three tons of marabú are roughly the equivalent to one ton of crude oil. Each biomass facility will save Cuba over 300,000 barrels of oil annually. All that remains is to merge its marabú charcoal and electricity with more products and services into a carbon cascade. The char could be activated to remove impurities in the distilling of Cuban rum, or since it can store electricity as cathodes in fuel cells, to make batteries for a fleet of electric jitneys. For that matter, it could build the jitneys (or 1950s replicars) from marabú carbon fiber weaves. (Karp 2017, Thomas 2017) Why choose one product over another when you can have them all?

By training the army of machete-wielding volunteers fighting the war on invasives to become charistas, pestilence has become enterprise.

Such enterprises already exist in many places, from agroforestry, aquaculture, and production of biochar products and biofertilizers in rural areas to microenterprise hubs generating power, chemical feedstocks, building materials and consumer products in urban neighborhoods. The power and ambition of youth is captured in ecosystem regeneration camps, reforesting damaged lands and restoring infertile soils. The culture of indigenous peoples is honored and preserved by drawing upon their lessons of wildlife husbandry, chinampas, conucos and milpa. The more than 20,000 examples provided by the Global Ecovillage Network and the Transition Network prove it can be done. It *is* being done.

Active listening, integration of the sustainable development goals, cultural preservation and visible improvements to the lives of the adopters sustain the pace of change. Simple improvements in quality of life reverse refugee flows.

As a function of determining success, including the well-being of the populations served, research must be conducted that monitors and measures various attributes of the human communities affected. This may involve behavioral research of populations. All research should be structured to ensure protection of privacy rights and to be without discrimination. Consent to participate must be free and fully informed.

Blockchain

Just based upon numbers of Initial Coin Offerings (ICO), 2018 is likely to be “the year of the cryptocurrencies.” Until 2019 exceeds that. But what does this mean for a more sustainable, steady state, circular economy — one that achieves the sustainable development goals? Aren’t blockchain based tokens just a way to dupe gullible speculators into investing millions into nothing more than a white paper, a website and an algorithm?

Equally troubling is the insane energy consumption of Bitcoin, now using power equal to Greece and on track to use more power by 2020 than the entire world does today. (BECI 2018) That won’t happen simply because of the laws of physics, but it is still an outsize climate footprint.

> Just a few years into the cryptocurrency revolution, bitcoin mining is already eating up an estimated 20,000 gigawatt hours of electricity per year. That’s roughly 0.1% of global generation, on par with the power demand of Ireland. The primary culprits are bitcoin mining appliances like the Antminer S9, a computer processor that does nothing but endlessly crunch algorithms to lengthen the blockchain. An Antminer draws a load of 1.5 kilowatts — enough to power two refrigerators and a flat-screen TV. If you run an Antminer 24/7 for a year it will produce about 0.85 bitcoins, at a cost of about 15,000 kilowatt hours. Depending on your power prices it will cost anywhere from $600 (at 3 cents per kWh) to $1,800 (at 9 cents per kWh) to mine one coin. Even with bitcoin having plunged to $11,600 this morning, there’s still money to be made, assuming you can get your machines cheap enough. Walmart sells the Antminer S9 for $8,200.
>
> — Christopher Helman, *Forbes*, January 16, 2018

Current estimated annual electricity consumption for Bitcoin mining is 56.71 TWh. Twenty-eight U.S. households could be powered for 1 day by the electricity consumed for a single transaction. Bitcoin's carbon footprint per transaction is 408.42 kg of CO_2-e.

Analysts at Credit Suisse examined Bitcoin’s potential to consume all the world’s energy and concluded for that to happen the price of a coin would have to rise to $1.1 million. Credit Suisse is not worried because they think coin miners will improve efficiency to reduce their demand for power. Since 2010, power demand by the internet’s server farms has stayed level for this reason, despite exponential growth in consumer demand. (Helman 2018)

Credit Suisse concedes blockchain-based payment systems will eventually replace our hack-prone credit cards, but warns a breakthrough far more threatening to energy security is the electric vehicle. By 2040, if not sooner, EVs could require more than 280 gigawatts of additional power generation capacity. Translating into solar panels, that would cover an area of 55 to 148 square miles (142-383 km^2).

Alternatively, it would require 28,000 to 56,000 of the largest offshore wind generators being manufactured today.

Number 7 of the UN's Sustainable Development Goals is affordable and clean energy. Putting the internet in everyone's pocket means more than the demand for recharging power will be rising — aspirations will. The more power people have, the more they will demand.

Fossil fuel electric generators must be retired, as quickly as they can be replaced. At the moment, even though new solar power has dropped to less than fossil operating cost, and far less than nuclear energy, with greater advantages for grid reliability, baseload, and national security, it is still costly to build, and with a larger embodied fossil energy footprint than biomass energy with co-product cascades. (DOE 2016)

What if that could be flipped, and instead of exponentially increasing power demand, and atmospheric carbon, the next world monetary system exponentially decreased it? How about if, at the same time, it went for achievement of all the sustainable development goals and brought population and sprawl under control so that once achieved, that better world could actually be sustained? This is the domain of our four frameworks, working together to redesign the human ecology of the 21st century.

Right now, carbon removal, like renewable energy, has different costs, degrees of maturity, permanence, and uncertainties. The blockchain — really just a verification and tracking ledger — will allow us to establish, harmonize and stabilize a market approach to these innovations. Algorithms must embed social and ecological goals.

One such coin was already launched in 2017, the Nori, worth 1 ton of CO2 removal.

> Blockchain technologies allow us to issue a token, Nori, which sets one uniform price on removing carbon dioxide. Because a carbon removal credit can only be used once, and is immediately retired, our blockchain system avoids double counting, which occurs in the design of all other traditional carbon offset schemes. Furthermore, using a blockchain solution allows for complete transparency to the new type of carbon removal asset. Blockchain allows for substantially lower verification costs through automation and removing the many middle men involved in traditional carbon removal transactions. Lastly, through using a blockchain token as a medium of exchange, this solution removes the requirement for project sellers and buyers to find a counterparty, allowing all parties to participate in a fungible market.
>
> Whenever a seller performs a carbon removal action, we first verify the carbon dioxide has actually been removed from the atmosphere and stored. The seller either uploads data manually, or the removal data is automatically reported into the Nori platform. This generates the creation of a new Carbon Removal Credit smart contract now available for purchase by a buyer.
>
> We only accept carbon removal projects. Reductions in emissions are not good enough. (Nori 2018)

Creating new cryptocurrencies is not a heavy lift. The hard part seems to be incentivizing the type of economic activity that leads to the kind of world we want to live in. Art Brock, one of the founders of the Holo project, says,

> “Cryptocurrencies do not have to be gambling tokens created from nothing. They can be responsibly connected to assets, promises, or real-world value. They don’t have to re-create all the speculative money problems that they were supposed to be solving.” (Brock 2017)

Climatecoin’s Brad Jones adds:

> “Blockchain is currently the most promising ledger technology available, so using it to track carbon credits/offsets could solve some of these problems. With the planet’s carbon dioxide levels higher now than they’ve been in millions of years, any action that addresses the emissions problem is worth considering.” (Jones 2018)

Going back to our earlier examples of asphalt highways, suppose a highway that was constructed with biochar substituting for aggregate was backed by a blockchain carbon credit. Decades later, that highway needs to be torn up and the question is whether to recycle the recovered aggregate or burn it to produce power. Burning it would transform it from credit to debit against the value of the country and/or the ownership entity. Recycling the asphalt would leave it on the ledger as an asset.

One proposal, from Hélène Nivoix in France to the UN Environmental Programme, is to set up a division called the Organic Monetary Fund. OMF would peg currency values to the growth of healthy living biomass and soil carbon. (Nivoix 2016)

All IMF member countries can volunteer to be part of the OMF scheme provided that their country agrees to certified management cooperatives. These would be groups of small, multi-purpose agricultural and forestry units applying the principles of agroecology and permaculture.

The global scientific community provides annual figures on the growth of healthy living biomass produced by participating countries. The OMF then grants each member country a draw from the IMF in the relevant national currency.

Under OMF rules, a nation’s currency grows or shrinks in proportion its role in the carbon cycle. Money is created by making its land increasingly fertile. A nation’s ability to borrow and lend diminishes if soil fertility is depleted and carbon is lost to the atmosphere or ocean. Every national economy becomes determined by how well each nation harnesses photosynthesis. Growth of soils, biomass and biodiversity means true wealth and abundance for local communities.

Conclusion

Small-scale, decentralized, viral adoption of incubators, accelerators and microenterprise hubs based upon the marriage of drawdown techniques and sustainable development goals offer realistic hope of moving into atmospheric carbon reduction territory, year on year, well before mid-century, and returning Earth to the comfortable Holocene — from which mammalian higher life forms such as ourselves evolved — by the end of the century. While large-scale industrial production of renewable energy and other products (marine microalgae for instance) can play a role in the transition, they lack the breadth and depth to engage the world population (particularly the youth) and supply the truly transformative shift to the circular economy that is required. Investments in further research, project development, on-the-ground proofs of concept, LCA and social impact monitoring will be helpful during the next decade, but what we have described is already profitable and entrepreneurial opportunities beckon right now.

Respectfully Submitted,

Albert Bates

Albert Bates
Global Village Institute

184 Schoolhouse Rd
Summertown TN 38483-0090 USA
www.gvix.org
ecovillage@thefarm.org

Global Village Institute for Appropriate Technology

Author's Note:
The topics covered above are described in previous works by the author of this submission, *The Biochar Solution: Carbon Farming and Climate Change* (2010) and *The Paris Agreement: The Best Chance We Have to Save the One Planet We've Got* (2015). They will be elaborated further in a forthcoming co-authored book, *Carbon Casades, Designing Human Ecologies to Reverse Climate Change* (Chelsea Green Publishers, 2018 in press).

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