# State of the Art Report: Food Systems

## Final input and recommendations for Phase 1

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## Table of Contents



***Note about redacted sections: Any sections blacked out have been redacted to protect the intellectual property of Blue Frontiers' staff and volunteer team.**

# 1. Introduction

Blue Frontiers plans to bring innovative food production techniques to the Seastead, while utilizing local fruits & vegetables in order to reduce the reliance on foreign imports.

We will create new businesses to offer to the world a genuine range of flavorful local delicacies, grown with the utmost respect for nature and the environment.

**Short-term goals:**

- Create a restaurant and service area in the Anchor Zone with tables, bathrooms, drinking water, and food trucks that will come in for our first residents, so crews do not have to go off-site for food breaks.
- Start growing our own local foods as production supplies arrive, in one or two greenhouses where we can start growing aquaponic & hydroponic/aeroponic vegetables, and have honeybees.
- Create a chicken coop for local fowl, plus a vegetable processing area and a worm composting area. Surround these areas with various local fruit trees and fruiting vines to create a windbreak.
- Within one year, we hope to be supplying our workers/residents and restaurant in the Anchor Zone with a variety of organic foods that do not require extra processing.
- Additionally, we can establish a farmer's market that will provide local producers the opportunity to come and sell goods in the Anchor Zone and interact with our community.

**Long-term goals:**

- People will start moving out to the floating platforms and the equipment we used in our first stages will go out with them, so they can have snacks and small meals on the Float Zone without having to return ashore.
- Anchor Zone food production and farmer's market hosting can continue and expand, as desired.
- On the Float Zone, we will have a smaller kitchen and food stand featuring breakfast & lunch foods, smoothies, juice, coffee, and alcoholic beverages, supplied with as many locally grown & organic ingredients as possible.
- Modular commercial kitchen and food storage structure will be built to expand Anchor Zone food production, while introducing lower-level food production to the Float Zone.
- By the 5th year, we could have several lower-level food systems in addition to scattered platform-level vertical towers growing foods that will supply residents, juice bars, smoothie shops, and restaurants with organic produce & fish, all farmed on the Float Zone and/or Anchor Zone.

## 2. Food Production Background Information: French Polynesia Case Study

### 2.1. Fruit Trees Available

- Banana (apple banana[5]), mango, papaya, guava, passion fruit (lilikoi[6]), breadfruit, lychee[7], rambutan[8], pomelo[9], coconut, Meyer Lemon, Tahitian Lime, additional citrus[10], pineapple, starfruit[11], hall avocado[12], pomegranate, strawberries[13]
- Citrus for Tropical Yards and Gardens[14]
- We can use fruit trees to surround our aquaponics system, and more of our land zone, to create a wind barrier. They can be planted above ground if needed with geo-pots[15].
- An irrigation system will be plumbed into the aquaponics.
- Tree trimmings and waste harvest will be composted for landscaping & agriculture use.

### 2.2. Vegetables Grown in Tropical Climates

- Varieties of lettuce, leafy greens, and microgreens
    - Purple kale
    - Collard greens
    - Swiss chard
- Cucumbers
- Green beans, snap peas, edamame[16]
- Green onions, chives
- Sweet potatoes[17], carrots, taro, beets
- Basil varieties (including lemon basil[18])
- Rosemary, cilantro, mint
- Mushrooms

### 2.3. Animals in Polynesia

- Helpful/Edible Animals:
    - Chickens, pigs, goats, fish[19]
    - Pollinating insects
- Possibly harmful animals:
    - Cats, dogs, rats, birds
        - Island Myna Bird[20]

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[5] https://en.wikipedia.org/wiki/Latundan_banana
[6] https://en.wikipedia.org/wiki/Passion_fruit_(fruit)
[7] https://en.wikipedia.org/wiki/Lychee
[8] https://en.wikipedia.org/wiki/Rambutan
[9] https://en.wikipedia.org/wiki/Pomelo
[10] http://plantithawaii.com/sample-page/citrus/
[11] https://en.wikipedia.org/wiki/Carambola
[12] http://trec.ifas.ufl.edu/crane/avocado/hall.shtml
[13] http://www.tastinghawaii.com/2012/06/eating-local-hawaiian-strawberries.html
[14] https://www.ctahr.hawaii.edu/oc/freepubs/pdf/F_N-14.pdf
[15] https://www.geopot.com/products/black-self-supporting-geopot
[16] http://www.medicalnewstoday.com/articles/280285.php
[17] https://www.downtoearth.org/health/nutrition/okinawan-sweet-potato-purple-powerhouse-nutrition
[18] https://en.wikipedia.org/wiki/Lemon_basil
[19] http://fish.mongabay.com/data/Tahiti.htm
[20] https://en.wikipedia.org/wiki/Common_myna

        - Snails and slugs[21]
    - Pest insects, including ants and moths

### 2.4. Permaculture Design Factors

- Relevant permaculture information and resources[22]
    - A controlled ecosystem, using edible plants and animals to create nutrient cycles, and providing you the opportunity to harvest from multiple trophic levels.
    - Each component having multiple roles within the production system, as well as all roles being filled by multiple components
    - The ideal system has many such functional overlaps (functional redundancies), such that loss of any individual component does not significantly affect overall function
    - Simply taking inspiration from nature (Biomimicry[23])
- Green roofs & walls everywhere
    - Provides shade cooling and growing areas
- Vine plants growing on fruit trees
    - Additional food production from symbiotic relationship
- Gray water usage
    - Maximize use of scarce fresh water
    - Each home could have a food growing atrium by the window, fed by gray water
- How to arrange plants/trees: Permaculture Food Forest[24]
    - All Nations Food Forest[25]- Melbourne, Australia

## 3. Land Area: Anchor Zone

The goal is to be completely self-sustained, producing enough food for everyone living on the Seastead.

The plan is divided in terms of Day One, six months, one year and five years, with five years being the goal for the entire SeaZone to be completely self-sustaining.

Day One, we are hoping to have a deal with a local restaurant to feed our group. The first Blue Frontiers group will be a small crew who will supervise the set up on the Anchor Zone. Initially, there may be 10-20 people.

Within the first few months, we will build a parking lot area with tables, bathrooms, and drinking water for hosting food trucks. The point will be for our first residents and crews to not have to go off-site for food breaks. Additionally, we will start growing our food at this time as supplies arrive, maybe with one or two greenhouses where we can start growing fruits and vegetables, along with a chicken coop area. We can offer local producers the ability to come sell things at the Anchor Zone, as well.

The next step will be to establish our own small kitchen and stand that will have breakfast and lunch foods, smoothies, coffee, and alcoholic beverages, once we have about 50 people. At this point, people should not have to go off-site unless they are craving a dinner out.

Around 6 months, that first stand will grow to more individualized stands/containers/converted food trucks/etc to have one stand for selling groceries that will hopefully contain our first crops, one for juice/smoothies, one that's a bar, and so

[21] http://www.bogleech.com/bio-gastropoda.html
[22] https://permaculture.org/resources/
[23] https://biomimicry.org/what-is-biomimicry/
[24] http://charliedurrant.com/tropical-permaculture-food-forest/
[25] https://deepgreenpermaculture.com/2014/12/30/all-nations-food-forest-proposal-and-pre-design-considerations/

on. Additionally, we want to have our own honey.  Our kitchen should be large enough to prepare cafeteria-style meals for our residents and day-laborers. We are  hoping this will cover up to 100 people.

After one year, we hope to be supplying our produce to our restaurant on the Anchor Zone with foods that do not require much processing. We can assist the restaurants with Paleo-diet recipes and similar creative ideas.

Around the same time, people could start moving out to the floating platforms along with some equipment we used in our first stages. This will allow the residents to have snacks and small meals on the Float Zone without having to come in. Perhaps some people will still want to come to the Anchor Zone for dinners. Additionally, we can have smaller refrigerators on these first platforms so the residents can enjoy beverages and store some food.

By the 5th year, we will have several platforms with lower-level food systems, in addition to scattered vertical growing systems, which will supply residents, restaurants, smoothie/juice shops, and a farmer's market with produce and a fish all farm on the Sea Zone. Residents in the Float Zone will not have to come in often, or at all, as there should also be a small shop to sell eco-friendly hygiene and cleaning supplies in addition to the food production & storage.

In general, food production should be located close to utility connections to run water pumps and fish tank aerators. The food processing, kitchen-type, area should also be located near food production and utilities. We can keep harvested food in a large community fridge container and then use flying drone-cooler transport to Lagoon.

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### 3.3. Hydroponic/Aquaponic Vertical Growing

Vertical grow forms or towers are the most efficient, highest yielding per square meter food production system. They can be coupled with aquaponics or operate as a standalone decoupled system. A well designed system can maximize production within a given area; reduce labor costs; be easily scaled; maximize light exposure; improve air flow; reduce pest problems; and be automated.

It can also be integrated with soil culture using a method called “dual root zone” to further increase yields and balance nutrients.

Hydroponics[31] grows vegetables without using soil, allowing for precise control over nutrient levels.

- Hydroponic FAQs[32]

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[redacted]

27 https://www.wired.com/story/the-hydroponic-robotic-future-of-farming-in-greenhouses-at-iron-ox/
28 http://www.polysolar.co.uk/
29 https://news.ucsc.edu/2016/05/solar-greenhouse.html
30 https://www.habitat.org/stories/diy-worm-tower-great-for-garden-environment
31 http://www.simplyhydro.com/whatis.htm
32 https://hydroponics.com/knowledge-base/faq/hydroponic-basics-faq/

- Aeroponics FAQs[33]
- Types of vegetables grown[34]
- Required nutrients[35]
- [Food Production Methods Comparison]

### 3.4. Aquaponic Horizontal Growing

Aquaponics[36] uses far less land, doesn't require soil fertility or even soil, uses little water and far less energy than farming in the ground, is more productive for the same area, produces protein in addition to the vegetables, is certified organic, and is moveable if needed.

- Aquaponics FAQs[37]
- There is also substantially less labor required than farming in the ground with considerably less bending.
- Local ponds at hotels[38] and local aquaponics systems already have tilapia populations.

Minimum system design would be a 300 gallon fish tank with about a meter of water depth. From the fish tank, and after a swirl filter, any number of different closed loop systems can be incorporated into aquaponics. The types of loops under consideration include media beds, deep water culture[39] (DWC), nutrient film technique[40] (NFT), vertical growing, bato buckets[41], wicking beds[42].

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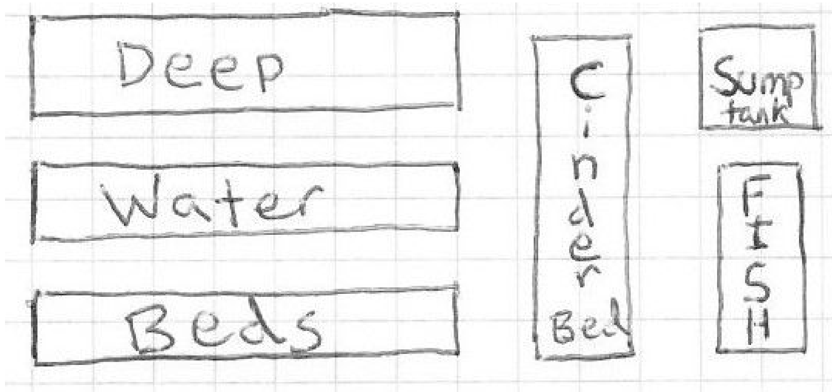
33 https://en.wikipedia.org/wiki/Aeroponics
34 https://blog.brightagrotech.com/best-crops-for-vertical-farming/
35 https://hydroponics.com/shop/product-category/growth-nutrients/
36 https://aquaponics.com/aquaponics-overview/
37 https://aquaponics.com/learn/aquaponics-journal/aquaponics-faq/
38
https://www.dreamstime.com/stock-photo-golden-tilapia-oreochromis-mossambicus-fish-living-pond-island-tahiti-french-polyensia-image43135730
39 http://practicalaquaponics.com/blog/category/floating-raft-system-dwc/
40 https://en.wikipedia.org/wiki/Nutrient_film_technique
41 https://www.hydroponics-simplified.com/bato-buckets.html
42 https://deepgreenpermaculture.com/diy-instructions/wicking-bed-construction/

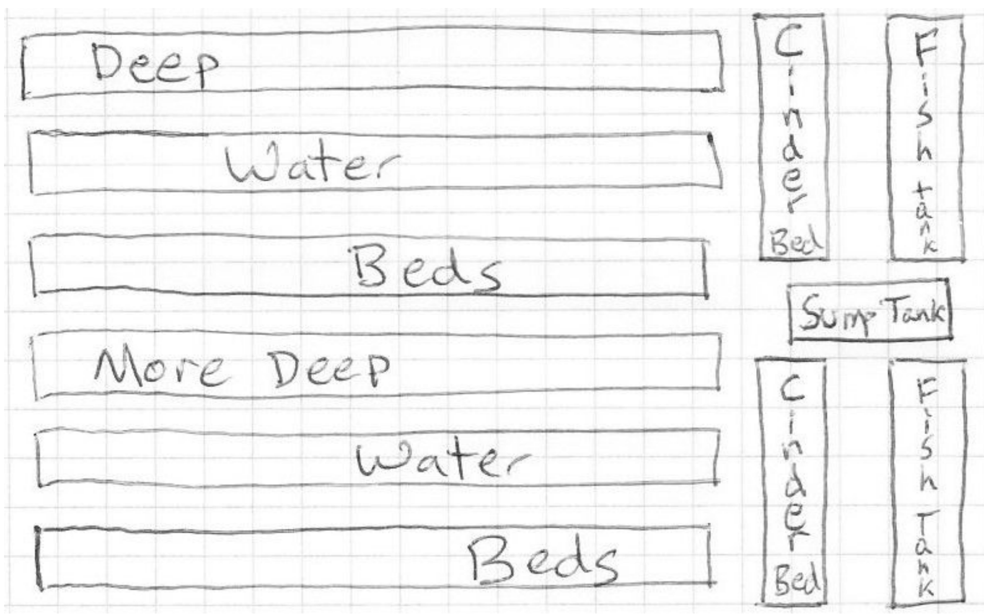
In tropical environments, the media used in the ‘media beds’ is often porous lava rock, sometimes called cinder rocks or pumice rocks.

An example of an aquaponics set-up, using a media (cinder) bed and deep water culture:




- Supports 24 square meters of grow-beds
  - Approximately nine 1.5m x 2m rafts with 1400 grow pods for plants
- Can hold 75 adult fish (tilapia[43])

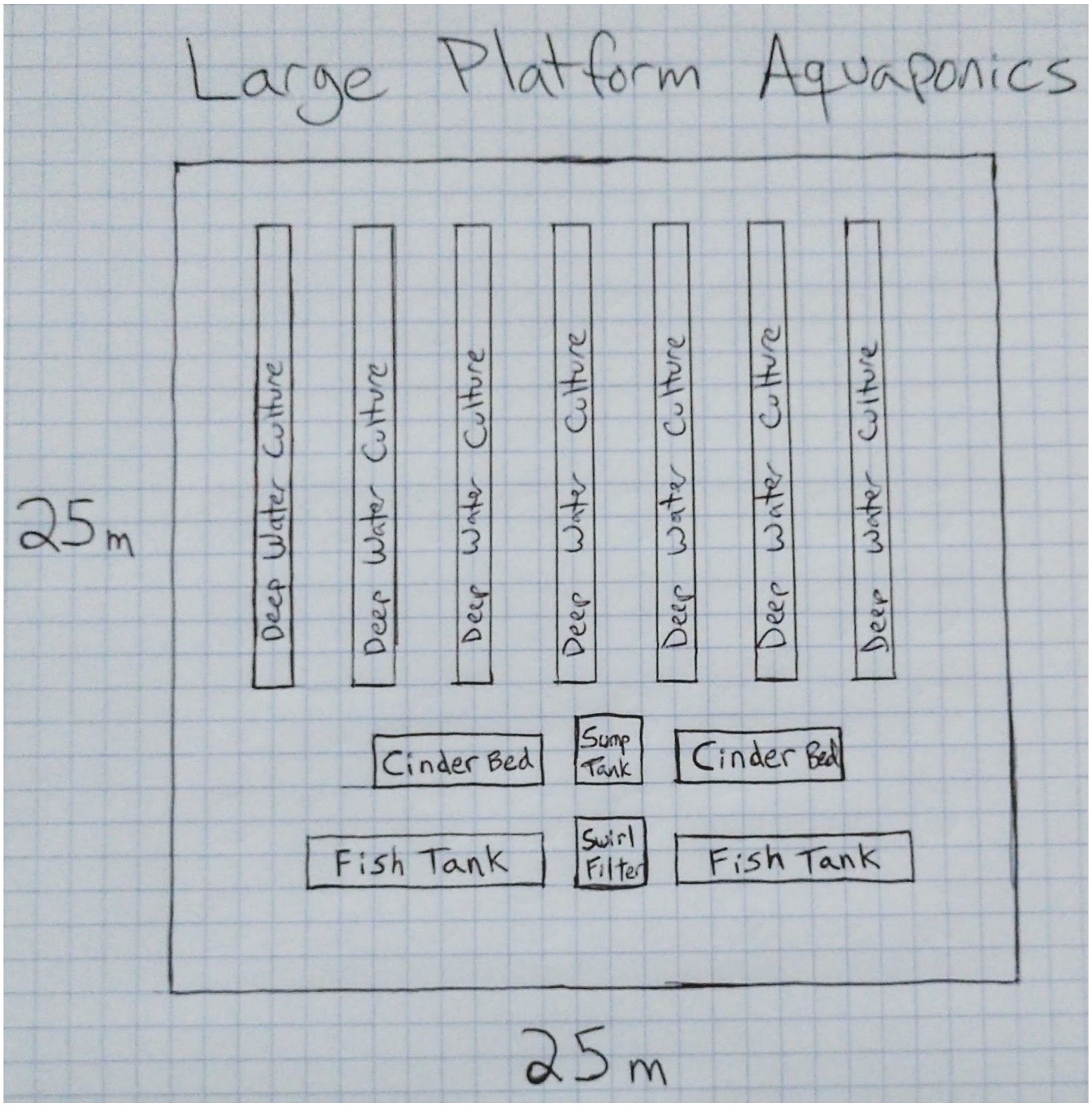
A larger system could use a two-tank design to maximize system output:




- A 1000 gallon tank can support 250 fish, which means 500 fish for a two-tank system
- Only uses one sump tank to minimize electricity usage
  - Supports 160 square meters of grow beds
    - Approximately fifty-three 1.5m x 2m rafts with 9300 pods for plants

[43] https://en.wikipedia.org/wiki/Mozambique_tilapia

Aquaponics systems can be sized for any available growing space. Greenhouse size can be made to mimic floating platform sizes, if desired.




A 25 meter x 25 meter design features seven deep water culture beds, each supporting seven grow rafts, and two large cinder beds. The 1.5 meter x 2 meter grow raft supports 176 grow pods, allowing this system to yield 8,624 pods for plants.

Aquaponics doesn't use additional, often petroleum-based, fertilizers, but still needs to feed the fish.

- Is there a local feed store? Where do local aquaponics farmers get their feed?
  - Often tilapia feed at farm stores comes from Utah (Skretting trout[44]).
- We could make our own fish food or supplements
  - Black soldier fly larvae.
  - Algae and edible plants for fish.
  - (Making fish food requires labor and space, plus it could be inefficient on a small scale.)
  - Can partner with a local company to produce a feed supplement on a larger scale.
    - Example of a local Hawaii company, Aquafeed[45]
    - Also Oceanic Institute in Hawaii[46] (Should open soon[47])
    - We could try something similar with waste from our ocean-fish catch.

Building materials required:

- Frames of fish tanks and grow beds, green walls and roofs, etc.
  - Wood, plastic, metal, or fiberglass, etc.
    - Locally sourced materials preferred
    - Similar to Re-use Hawaii[48]
- Concrete blocks

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44 https://www.skrettingusa.com/products/classic-trout-floating-diet
45 http://www.aquafeed.com/about-us/who-we-are/
46 http://ulupono.com/portfolios/OI-HPU-feed-mill
47 http://www.bizjournals.com/pacific/news/2017/01/09/long-planned-hawaii-feed-mill-to-open-this-year.html
48 http://www.reusehawaii.org/about-us.php

- Fasteners (screws, etc.)
- Liners for fish tanks and grow beds
    - Food-grade plastic
- PVC pipes and connectors (food grade quality)
- Local lava rocks[49]
- Net pods/Grow pods[50]

### 3.5. Chicken Coop Area

Chickens are great for plant and soil health, recycling green waste, eating pests and spreading fertilizer, as well as being a source of eggs and meat.

- How many nests to make for egg-laying chickens?
    - Many simple designs house 4-6 chickens.[51] We could make a dozen or more.
        - Creative designs[52]
- Captive, well-managed, chickens should be able to live on a floating island too
- Chicken feed is even cheaper than fish feed (in Hawaii)
    - Feral chickens can be given scratch feed since they hunt bugs for additional nutrition[53]
    - Bugs can be provided from composting too and green roof areas

### 3.6. Contracting with a Restaurant

**Catering**

Contract food trucks and or local catering services[54]

**Kitchen/Store/Office**

Modular commercial kitchen and food storage structure.[55]

**Inventory**

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[49] http://www.hawaiiislandcinder.com/menu-aviator/
[50] https://www.htgsupply.com/products/3-inch-net-pots
[51] https://www.mypetchicken.com/catalog/Chicken-Coops/Red-Cedar-Backyard-Coop-4-6-chickens-p2216.aspx
[52] http://thepoultryguide.com/creative-chicken-coop/
[53] https://www.backyardchickens.com/threads/chicken-scratch-vs-chicken-feed.64616/
[54] https://roaminghunger.com/
[55] http://www.carlinmfg.com/

Wholesale deals with local produce and dry goods suppliers would be a great way to 'activate' the local economy. [56]

Bulk imports of speciality / luxury goods from various countries. Grocery/deli/pub/smoothie shop/supplies.[57]

### 3.7. Creating a Farmer's Market & CSA

**Anchor Zone Market**

**Structure/equipment**
Modular commercial kitchen and food storage structure.

**Inventory**
(expansion on Phase 1)

**Staff**

**Anchor Zone Farm**

**Structures**
2 hydro containers/1 work shed/2 screen houses $180k[58]

**Equipment**
Small combo-tractor (bobcat with attachments)

**Supplies**
Tools/trees/plants/seed/hive

### 3.8. Create a Smoothie & Juice Bar

Given the selection of greens, vegetables, and fruits we will produce, a smoothie & juice bar makes a lot of sense as an extra business we can run at our farmer's market on the Anchor Zone. A smaller bar subsidiary could be placed on the Seastead in the Float Zone.

Additional drink ideas: plant based milk[59]

- Coconut Milk[60]
- Pea Milk[61]
- Macadamia Milk[62] & additional information[63]

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56 http://www.fresha.co.nz/
57 https://www.bestfoodimporters.com/
[redacted]
59 https://www.ft.com/content/7df72c04-491a-11e6-8d68-72e9211e86ab
60 http://www.godairyfree.org/news/coconut-almond-soy-dairy-sustainable-milk
61 https://www.fastcompany.com/3058722/this-pea-based-milk-is-healthier-than-almond-milk-and-actually-tastes-almost-like-milk
62 https://www.macnuts.org/growpage.htm
63 https://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Archive/Macadamias/xmacf09.pdf

Having our own honey would work great with this type of bar as well. Furthermore, the bees will help pollinate the plants on the Anchor Zone.

### 3.9. Develop a Wellness Center

We have begun to formulate an idea for an alternative cancer treatment and wellness center. Food Systems would produce organic medicinal herbs, plants, and health foods tailored for the health-conscious tourist or patient. Produce and products would include ingredients for preparations like Essiac tea and Hoxsey tonic; wheatgrass for juices; sprouts; microgreens; heavy metal chelating chlorella and cilantro; fermented foods; and mushrooms used to fight cancer such as Shiitake, Maitake, and Reishi.

- Gerson Therapy[64]
- Riordan Clinic[65]
- Burzynski Clinic[66]

### 3.10. Hemp Crop

8,000 pounds of hemp seed per acre.[67] When cold-pressed, the 8,000 pounds of hemp seed yield over 300 gallons of hemp seed oil and a byproduct of 6,000 pounds of high protein hemp flour. Seed oils are both a food and a biodiesel fuel.[68]

Hemp production is already happening in France.[69] It's not a controversial crop anymore, it's a diverse and profitable one.

Hemp Crop References:

- CCR technology (processing equipment)[70]
- Hemp University[71]
- Start a hemp business[72]
- Hemp Facts[73]

### 3.11. Additional Technologies

- Agribots[74]
    - Solar powered robotic farming aids[75]
    - Future of farming in greenhouses[76]
- 3D Printed Foods
    - All natural ingredients
    - Kitchen appliance option[77]
    - BF farm can blend/mix and package fresh ingredients daily.

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[64] https://gerson.org/gerpress/
[65] https://riordanclinic.org/our-philosophy/
[66] http://www.burzynskiclinic.com/
[67] http://www.westword.com/restaurants/at-21-a-pound-roasted-hemp-seeds-look-like-a-cash-cow-6046115
[68] http://www.fibrealternatives.com/hemp%20is%20the%20ultimate%20cash%
[69] http://www.cannabusiness.com/news/products-innovation/from-clothing-to-construction-france-looks-to-hemp-for-environmentally-friendly-industrial-materials/
[70] http://www.purehemptech.com/technology/
[71] http://www.hempuniversity.com/hemp-university/growing-hemp/
[72] http://www.startahempbusiness.com/products/growing-hemp
[73] http://www.hempfarm.org/Papers/Hemp_Facts.html
[74] https://youtu.be/Li9eWpLGFiU
[75] http://confluence.acfr.usyd.edu.au/plugins/servlet/mobile?contentId=14451912#content/view/14451912
[76] https://www.wired.com/story/the-hydroponic-robotic-future-of-farming-in-greenhouses-at-iron-ox/
[77] https://www.naturalmachines.com/

- Lip balm made from fruit waste[78]

## 4. Lagoon Area: Float Zone

As previously stated, when people start moving out to the floating platforms we will also move some equipment used in our first stages. This will allow the residents to have snacks and small meals on the Float Zone even though some people will still come to the Anchor Zone for dinners. Additionally, we can have smaller refrigerators on the first platforms so the residents can enjoy beverages and store some food.

By the 5th year, we will have several platforms with lower-level food systems, in addition to scattered vertical growing systems, which will supply residents, restaurants, smoothie/juice shops, and a farmer's market with produce and a fish all farm on the Sea Zone. Residents in the Float Zone will not have to come in often, or at all, as there should also be a small shop to sell eco-friendly hygiene and cleaning supplies in addition to the food production & storage.

In general, food production on the Float Zone should be considered when planning our utility connections to run water pumps and fish tank aerators. If we have a floating food processing kitchen, that should be located near food production and utilities. We can keep harvested food in a large community fridge container if that uses less electricity than several small refrigerators.

When preparing our experiments for a Seastead to eventually be in open ocean, food sustainability will become a paramount importance. The need to resupply from shore should be minimized wherever possible in order to demonstrate independence and maintain integrity.

### 4.1. Marine Culture & Polyculture

- Saltwater tolerant plants[79]
- Potential farming projects in the Float Zone: engage with local fish farmers
    - Seaweed
        - Varieties eaten in many cultures
            - Nori, Seagrape, Kombu, Hizikia
        - Seaweed farming example video[80]
        - Farming can simply be done using ropes
    - Algae & Macro-algae
        - Can be used to feed black soldier fly larvae
        - Some types are used in pharmaceuticals: Astaxanthin
    - Giant Clams
        - Base abductor muscle sells for $20-$22 a kilogram.
        - One pair can produce 300,000 offspring.
            - 72% survival rate.
        - Two ways to grow them:
            - Rope polystyrene floats
                - 50,000 clams per hectare
                - Drone cleaned
                - 7 years till yield
        - Ranching
            - 300,000 starter clam sown on 6 hectares

78 https://www.springwise.com/award-winning-startup-turns-fruit-waste-natural-cosmetics/
79 http://www.biosalinity.org/salt-tolerant_plants.htm
80 https://youtu.be/lFWiHt0tkng

        - by airplane or drone
        - in an anti-predator environment
      - 9 years till yield
  - Oyster farms (for pearls too?)
    - Non-invasive methods for either lagoon-based cage culture and/or refugium (tank) polyculture

### 4.2. Scattered Platform-Level Vertical Towers

Having lots of plants around has been shown to have significant positive effects on people
- Cover the seastead with edible plants
  - Geo-Potted fruit trees
  - Worm Towers
- Plants also help to soften edges in the landscape, ameliorate wind/sea spray, and help to moderate temperature.

Establish a variety of independent production systems on the floating islands
- Isolated issues with productivity do not immediately lead to shortages
- Small gardens on individual pods/houses/boats/balconies
- Larger community gardens in central locations (or rooftops)
- Different production systems have different benefits and can be integrated with other systems to cycle resources

### 4.3. Lower-Level Platform Growing

It's likely the first large scale growing system, after the grow towers scattered about, will be underneath a platform in the "basement". This could require extra electricity to power LED lights and climate control systems, such as fans and/or air conditioning. The use of light tubes could help as well.

### 4.4. Expanded Food Production

Continue to expand Anchor Zone food production (profits from market/food production).

Introduce Food Underneath Platform(s) to Float Zone.

**Food Platform**
purchase/build barge/platform

**Structures**
2 hydro container/work shed/2 screen houses,

**Material/Equipment**
Soil imports, equipment; small combo-tractor, supplies; tools/trees/plants/seed/hive

**Staff**

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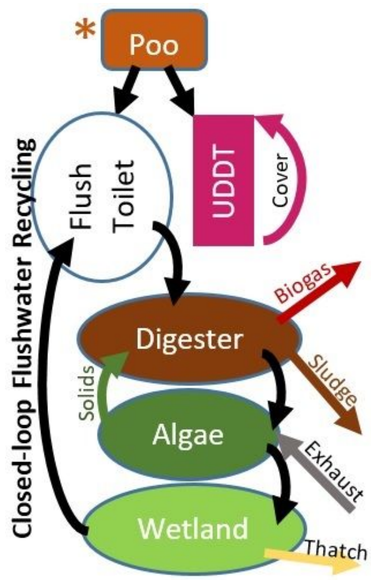
## 5. Waste Management/ Nutrient Cycling

Conventional, land-based "Waste Management" will have to be forgotten in Seasteading. No longer can anything be wasted or thought of as waste, but must be thought of as a resource that can be reused. Human excrement, urine, food scraps, green plant trimmings and paper scraps are organic materials that all have energy and nutrient values, and can be recycled to provide other services. Glass and the right types of plastic can be reused many times. Hazardous waste, such as batteries, electronics and drugs, are something that will require considerable creativity to be eliminated completely.

### 5.1. Human Manure and Urine

## Sanitation in both zones

In order to achieve the goal of not contaminating the environment, Seasteads should emit zero effluent into the ocean, while applying sanitation that is as foolproof, low-tech, economical, and nature-based as possible. The key reason for not releasing even treated wastewater is that no treatment is 100% effective, especially in terms of pharmaceuticals and other chemicals. Safe, hygienic sanitation that allows for efficient nutrient recycling will be implemented via Urine-diverting Dry Toilets, Waterless Urinals, and Flush Toilets with Closed-loop Flushwater Recycling.




Seasteading is also a grand opportunity to showcase simple, practical techniques of Sustainable Sanitation, in an aspirational setting, such that others in the world may choose to replicate them to protect ecosystems and public health. If these techniques are inexpensive and robust, they can be replicated on a massive scale.

## Urine-diverting Dry Toilets

Urine-diverting Dry Toilets[81] (UDDTs) do not need or contaminate water and are based on the following principles:

· Urine and feces are entirely different materials, with distinct potentials, risks, and treatment requirements.

· Urine is an excellent fertilizer for plants, holding 90% of the plant nutrients that are found in human excrement.

· Feces contain nearly all of the pathogens and the few exotic ones found in urine are destroyed quickly by soil microbes when dispersed in the soil.

· The bad smells associated with pit latrines, sewer lines, etc., are due to the mix of urine and feces, together with the lack of oxygen.

[81] http://www.ecosanres.org/pdf_files/Ecological_Sanitation_2004.pdf

· By keeping the feces as dry as possible, less odor is produced, more oxygen can enter the pile, the material dries out faster, and pathogens die off more quickly.

· It is infinitely simpler and more efficient to keep excrement out of water from the start, instead of mixing these and later trying to separate them.

These toilets do not require radical changes in the users' behavior. If the toilet is for sitting, one only needs to sit normally and let things go. If it is for squatting, the same applies when squatting in the right place. One only needs to demonstrate that humans can be just as intelligent as cats and add dry soil, instead of clean water. The main behavior change is that men should not pee standing, nor women hovering, and there will be Waterless Urinals for that.

Urine is captured in a funnel toward the front, while feces fall farther back into a chamber or container. At the end of urination, women may drip a little bit farther back, but this is not a problem, since the vast majority goes into the funnel.

Urine may be dispersed in the soil as quickly as possible. One way to achieve this is for it to flow directly into perforated hoses that are buried some 10 cm below the surface of the soil, among fruit trees or crops (especially if the part that is consumed is aboveground, to not disturb the hose). Urine can also be stored in jugs, barrels, or tanks and later be taken to where it is needed. Some recommend storing urine for months, in order for any pathogens to die[82], but these pathogens would mainly be from cross contamination from the feces through improper use, and no one would have contact with these if the urine is dispersed inside the topsoil.

Immediately after each use, the feces are covered with a cup of dry material to get them out of sight and control smell and flies. Optimally, this cover material should also inoculate the feces with microbes that will break them down and kill any pathogens that may be present. For this reason, the best cover material consists in the decomposed feces from a previous cycle, with all the winning microbes from then, ready to keep winning. This is also very practical on Seasteads, since new cover material does not have to be constantly accessed and transported, plus there is roughly the same amount year after year, given that feces are mostly water that evaporates off and bacteria that finish eating each other.

Others often use sawdust or wood ash in UDDTs, but these do not control flies or smell as well as this "recycled soil", nor do they supply any beneficial microbes to the process. In addition, there would almost certainly not be enough wood fires or carpenters on Seasteads to produce these materials.

Toilet paper and other materials for wiping, such as leaves, are deposited with the feces and decompose with them. It is feasible to wash with water, via a bidet or via pouring as done in India, only this water must be kept separate and be treated via artificial wetlands, wastewater gardens, or be soaked into the ground (if on land).

Once enclosed in the soil, the feces should be left to dry and decompose for at least 6 months in the Tropics (or 1 year in the Temperate Zone) for all pathogens to die. If that is too long to wait, bags of fresh feces could be put in a solar oven, where they are heated to over 75°C for more than half an hour, and the pathogens would also be eliminated[83], only that would be much more complicated, someone would have to manipulate fresh feces, and the whole process would have to be closely monitored.

In Chris Canaday's new concept for UDDTs in multi-story buildings, fecal ducts reach down about 2 floors and the material takes over 6 months to get to the bottom, where it is gradually taken out, having received its treatment along the way and having moved down by gravity without anyone dealing with it. This is now taken back upstairs and is used as

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[82] http://www.ecosanres.org/pdf_files/ESR2010-1-PracticalGuidanceOnTheUseOfUrineInCropProduction.pdf

[83] https://www.omicsonline.org/open-access/timetemperature-model-for-bacterial-and-parasitic-annihilation-from-cowdung-and-human-faecal-sludge-a-forthcoming-biofertilizer-2155-9597-1000284.php?aid=78532

cover material once again. Testing could be done at this point and, if need be or just for extra measure, the material could be spread thinly in the sun for a few days. Some of this finished compost could be used to improve the soil of the gardens, only, as mentioned above, there is roughly the same volume year after year, so the amount taken to the garden could be replaced with bulky organic materials that do not break down quickly, like biochar[84], egg shells, and rice hulls, which will help to maintain adequate air flow through the pile. The duct would also preferably be made from material that allows for gas exchange, thus permitting water vapor to get out and oxygen to filter in. It is also feasible for the duct to be on the outside of the building.

At the beginning of the first cycle, the fecal ducts can be nearly filled with a mix of 50% forest soil, decomposed farmyard manure and/or compost, including any fecal compost that is available, with 50% bulky organic materials that do not break down easily (e.g., biochar, egg shells, rice hulls, seashells, etc.) that have been dried, crushed and sieved through a screen with holes that are 1 cm in size. The first group provides the beneficial bacteria, archaea, funguses, and viruses that will break down the feces, while the second group maintains air flow and helps to prevent clumping. Biochar can be produced from woody organic waste that could not go into biodigesters or easily be composted (e.g., pruned branches, wood scraps, certain squash shells, etc.) by cooking with them in Top-lit Up-draft Stoves[85], thus also contributing to our energy budget.

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84 https://en.wikipedia.org/wiki/Biochar
85 https://en.wikipedia.org/wiki/Top-lit_updraft_gasifier

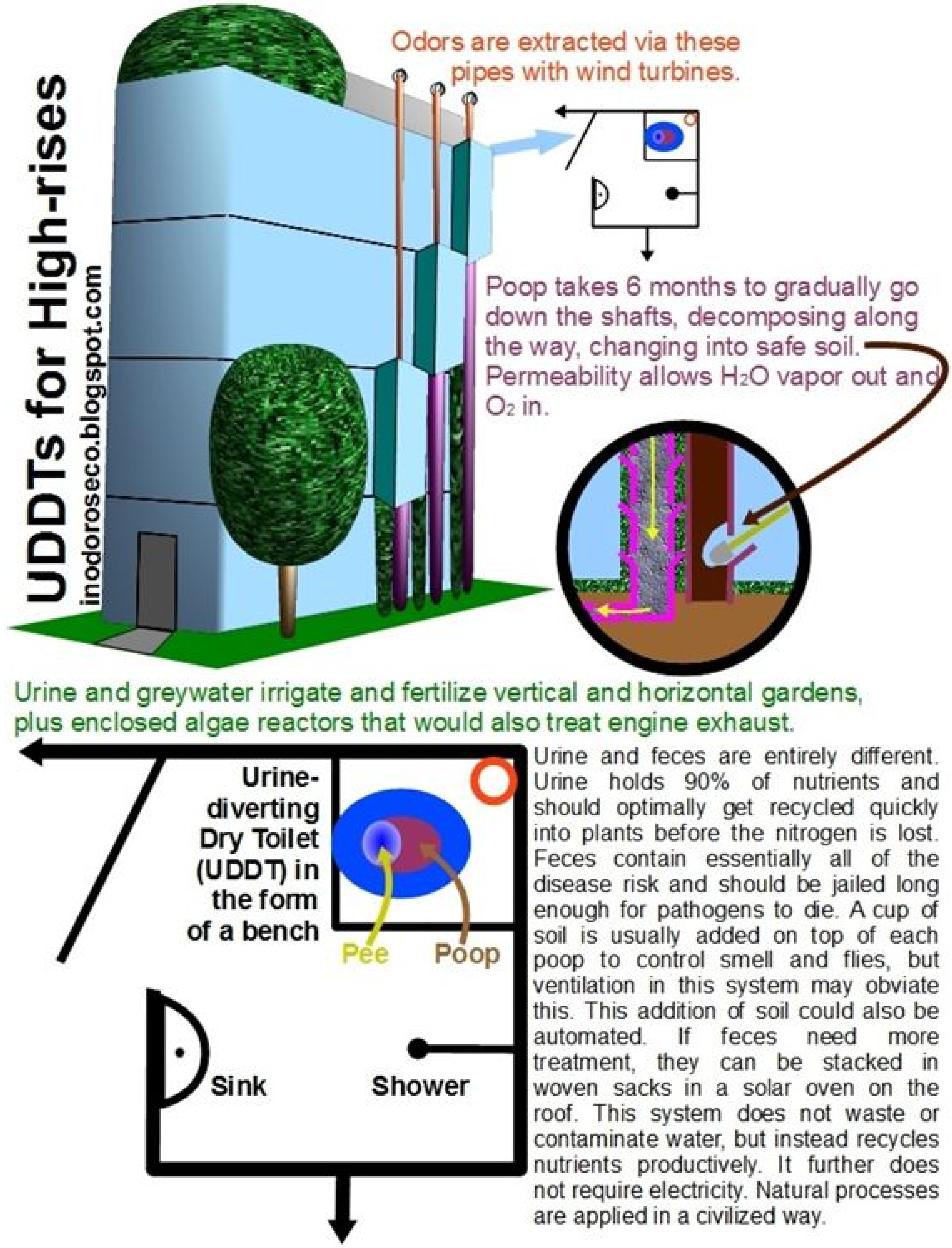



Figure X. Canaday's concept for Urine-diverting Dry Toilets in multi-story and high-rise buildings. In Seasteading, urine and greywater could be piped directly to gardens to be used as fertilizer or crops could be planted as shown here. (Creative Commons BY NC SA licensing applies; commercial use can be arranged with Chris Canaday, canaday2@gmail.com.)

One aspect of dry toilets that some people do not like is the need to scoop and throw cover material. It actually is not so bothersome, but some do not aim very well and spill material in the urine funnel, the floor, and the bench. Also, if the user gets some soil on her hands, this will remind her to wash those same hands, which many tend to forget to do. Nonetheless, Chris Canaday and Charles Horvath have designed an automatic mechanism (without electricity, computers, or sensors) that takes advantage of the user's weight to add a cup of soil when he leaves.

Lighting in the bathroom and the frequency of removal of soil from below can be arranged such that the pile is essentially always out of sight. Toys, coins, and wedding rings can be retrieved half a year later, when the soil is sieved before reuse.

Built and managed correctly, UDDTs emit very little smell, and this can easily be whisked away with passive or active ventilation. One option is to install a little electric fan that pulls air into the toilet and pumps it into garden soil, in what @MichaelCollins seems to call an "EarthLung". (This is the tiny dotted arrow on the chart running from $H_2O/CO_2$ to Plants, but could also include small amounts of ammonia.) Flush toilets, in contrast, have no ventilation and, when someone has digestive trouble, no one else wants to go into the bathroom for an hour, until it ventilates.

Canaday builds UDDTs with normal materials from the hardware store, with urine funnels cut from ubiquitous plastic bottles (inodoroseco.blogspot.com).

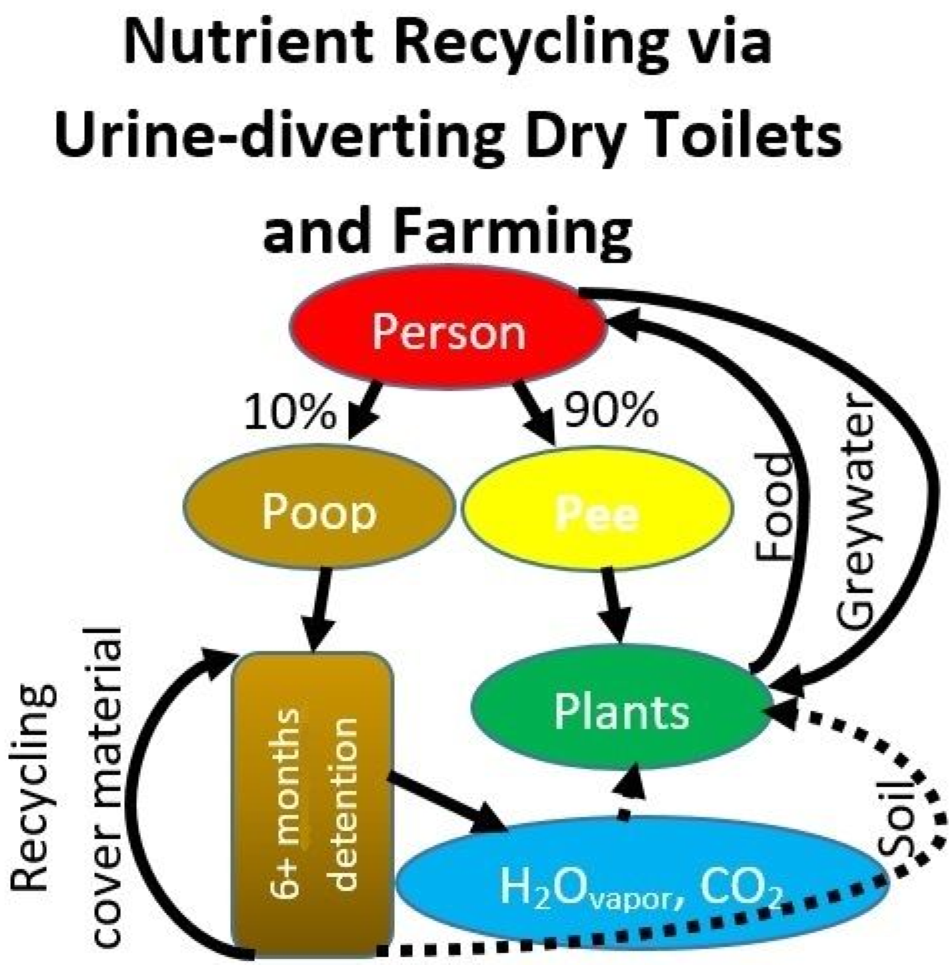
UDDTs can also be done with a higher level of finish, with factory-made inserts that form the funnel (but with the seat all the way to the edge). This one (below) costs US$ 30 from Arrebol Perú (www.facebook.com/arrebolperu/).

(http://www.flickriver.com/photos/gtzecosan/sets/72157626092736007/)

These 2-hole (pink, below) and 3-hole (blue) urine-diverting ceramic squat pans where made by an Indian NGO named Energy, Environment and Development Society (EEDS, eedsngo@gmail.com). The third hole in the blue one is for washing with water, after having moved back about 15 cm after defecation. (Wikipedia) Since Seasteaders will be invited from all over the world, it is important to offer them toilets they would be comfortable with.


Other UDDTs are available on the market with more bells and whistles (e.g., Separett) and can cost thousands of dollars, but are no more effective than the simpler ones shown above. One reason some of these cost so much is that they have mechanisms to deal with the feces right there, without extending below the floor, but this is something we can clearly do in

Seasteading. One feature that may be worth including is a panel that opens only when the user is sitting on the toilet seat, so that no one ever sees down the drop hole (below), although, when soil is added, one only sees soil. In any case, the more complicated the system is, the more likely that things will break and need to be fixed.




### What is the tech readiness level of UDDTs? Is it proven tech?

UDDTs have been successfully used since the 1950s, when they were designed in Vietnam. It has been estimated that there are over a million currently functioning in China. There are also thousands of up-scale units in Scandinavian homes and cabins. This is almost biomimicry, except that the same natural processes are being applied directly, without any mimicry.

Why has no one done UDDTs as proposed here before? No one had this clear concept before, together with the firm decision to not contaminate the environment. In general, no one wants to really even think about sanitation, people are mostly stuck with the same flush toilets as Queen Victoria had, and the erroneous operative paradigm is that Nature can take whatever we throw at it. (One could also ask, “Why has no one done Seasteading before?”)

Is it something we can make money from or have usable surplus from?

By returning nutrients in a safe and orderly way back to the soil, UDDTs will make the agriculture in Seasteading more productive and sustainable. Some of the agricultural products can be sold and the buyers may ask, “Has this been fertilized or sprayed with chemicals?”, and the response will be, “No, it’s all organic.”

## Waterless Urinals

Urination is the most frequent reason to visit a bathroom, and the conventional response in Western Society is to chase the few hundred milliliters of this basic bodily function with gallons and gallons of clean drinking water, just to make it disappear and to prevent any bad odors, without taking into account its value as a resource … then, in each city, spend millions of dollars to try to get it back out of the water in wastewater treatment plants, and never really achieve this completely. It is much more logical to treat it as the valuable fertilizer that it is and apply simple techniques to control its odor.


Every year the average person urinates 4 kg of nitrogen in the form urea, which is roughly the amount that plants need to make food for that person again. It is also balanced with all of the other nutrients that plants need, because they originally came from these same plants.

A couple of years ago, Chris Canaday developed the following simple, inexpensive Waterless Urinal, which is made from mostly recycled materials. Only the funnel is purchased in a store, where it costs less than US$2, and even it could be made with recycled materials if one chooses.

It does not stink because a hose reaches from the funnel to the bottom of the jug, thus the stench inside cannot exit via the funnel, and the displaced air has to filter through fertile soil in the bottle, eliminating any odor. The soil does not simply absorb the odors, but, instead, it houses microbes that consume them. Instructions on how to make one are found here (in English and Spanish): (http://inodoroseco.blogspot.com/2015/12/un-nuevo-modelo-de-urinario-sin-agua.html)

This design is extremely practical for men, with none of the splash-back that occurs in conventional urinals. Some women say that they could easily urinate in this urinal, but most would prefer to squat all the way down and would be worried about germs, so each could have her own empty yogurt or ice cream container to pee in, empty it into the urinal, rinse it with water, throw that water in the soil of gardens or flower pots, put the lid back on the container, and save it until the next urge to give back to Nature, thus this is much more hygienic and ecological than what Society currently offers women.

When it starts to fill, or there are plants that need to be fertilized, the urinal is unplugged from the jug and the jug is capped and taken to the garden. Urine can sit in this urinal for a month, with no smell issues, and then be given back to plants. Remember to dilute the urine with 3 or more times as much water (which can be greywater from the kitchen or shower), and to spread it on the soil (not the leaves), especially if the plants are delicate and are just getting established. If the field has not been planted yet, it can receive nearly all the pure urine you like to give it, over a week before planting, to let the soil bacteria assimilate the nitrogen and avoid overdosing your crops.

The urine could also go into aquaponics systems, except that the pharmaceuticals people consume could make their way into food and affect the fish, so it is preferable for urine to go into soil. It could, nonetheless, go into aquatic systems that are not part of our food chain, like algal reactors that also clean up motor exhaust and wastewater, while producing biodiesel or some other useful product.

In the internet, there are Waterless Urinals from Germany that cost US$400. This high price is due to the complicated mechanisms for preventing the stench of the sewer from coming up toward the user (and there is an insert that has to be replaced every 6 months, so this is a very good business for those companies). In the case of the simple urinal presented here, there is no connection to the sewer and odors are controlled much more simply.

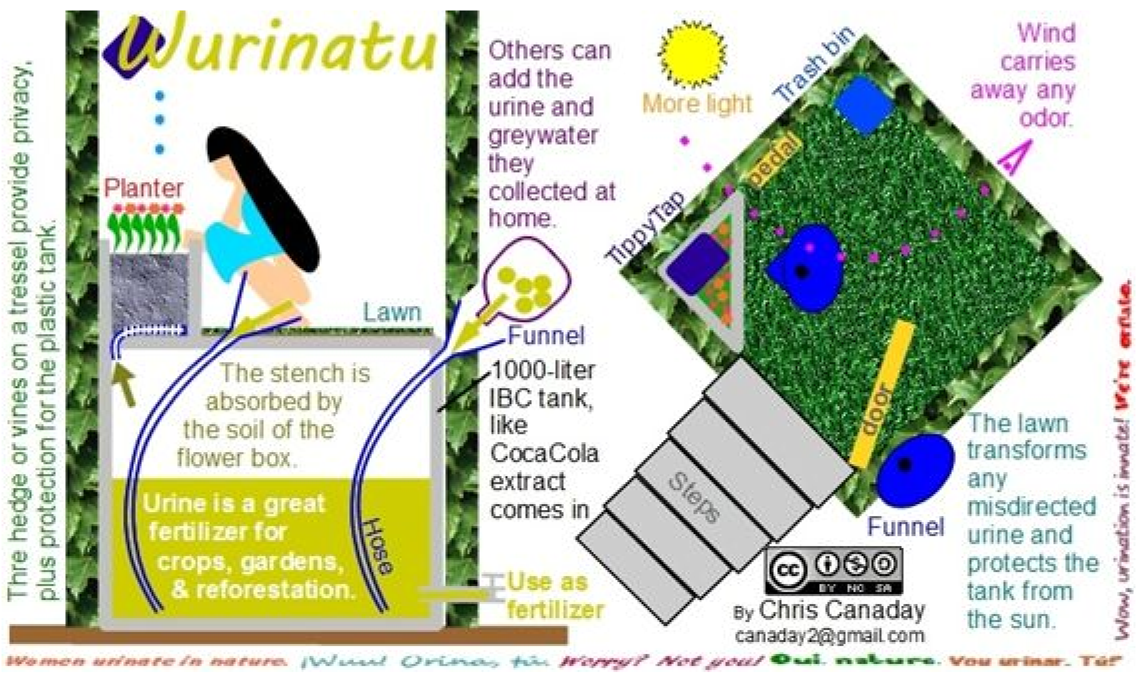
This simple, Waterless Urinal should be used everywhere that water is scarce, algae blooms in the river are not desired, the people downstream do not want to randomly drink our pharmaceuticals, or we want our agriculture to be more productive (in other words, everywhere). (In a permanent location, this urinal could also feed into a perforated hose buried 10 cm under the surface of the soil, among banana plants or fruit trees, if one prefers.)

What is the tech readiness level of Waterless Urinals? Is it proven tech?

Totally ready and proven. Nothing iffy or questionable.

**Wurinatu: a Women's URInal in NATUre**

This is a special type of waterless urinal that is specifically for women. A major concern for women is privacy when urinating. Another is the risk of infections, if the bathroom is not clean. Even worse, if you have to go when you are out in a public toilet, where who knows who has been there with who knows what disease ... and there are only sit-down toilets ... which most women do not want to even touch, for fear of germs. In addition, it hurts their thigh muscles to "hover" over those toilets and they cannot empty their bladders completely in that position. For this, Chris Canaday proposes a special design of Waterless Urinal.




The Wurinatu solves all these problems and lets women pee in privacy, with fewer odors and germs, and even in a natural,

flowery place. It is published under a "Creative Commons license" (https://en.wikipedia.org/wiki/Creative_Commons_license). There is more information on how to make one at (http://inodoroseco.blogspot.com/2017/05/wurinatu-un-urinario-publico-florido.html)
Advantages include:

- Women can squat all the way down, which is more comfortable and, since this is the most natural position, it allows the complete drainage of the bladder. (There is also something to hold on to for equilibrium).
- More air and less smell, as there is no roof.
- More light (during the day) and the sun helps to kill microbes.
- Rain cleans it (and people can continue to use their umbrellas and jackets ... plus they only need to be there for a moment.)
- Any misdirected urine gets absorbed and transformed by the lawn.
- Less concern about fecal pathogens, since this is a place only for urination.
- The woman can watch butterflies drink one nectar while she emits another.
- No need for piped water or sewer lines.
- People walking outside can hear if anything bad is happening inside.
- The stored urine can be used as fertilizer in agriculture or gardens. (It can even be fermented right here with other ingredients to make an even better fertilizer, like Nadia Andreev does in Moldova.)
- The odor of the air that comes out is eliminated by filtering through soil.

Menstruation is not a problem. Any blood on the funnel or the lawn can be washed away using a spray bottle tied to the structure with a string. Menstrual cups can be emptied and rinsed into the funnel, and women can bring bottles of clean water from home for this or the same spray bottle could be used. If there is piped water, a spray hose can also be installed for this. Disposable pads and tampons can be thrown in the trash bin. A little bit of blood in the urine does not impede its use as fertilizer:
http://forum.susana.org/172-urinals/11084-details-on-waterless-urinals-for-women-and-for-female-pupils-in-schools-in-africa#16140

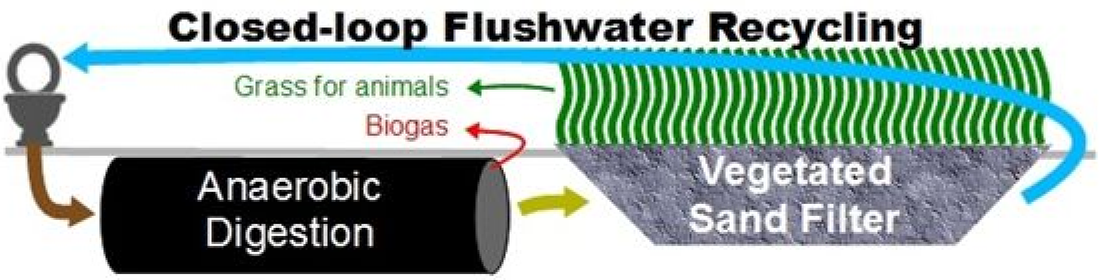
Variations on this theme:

- If there is enough space, this could be done without the tank and steps, by simply distributing the urine in the soil via a perforated hose buried 10 cm below the surface, among fruit trees, banana plants, reforestation, etc. This can be right next to the house, for more ease and security, even in the city, if there is a big enough garden to fertilize.
- In subways and other places without enough light for the plants, the privacy walls could be made with translucent plastic that is just as high as necessary, with mesh reaching all the way to the ceiling. The translucency would allow passersby and police to see if anything bad is happening inside, plus they can easily hear over the walls. The mesh would protect the user from things being thrown over the wall. It could be kept open all night, since it would not lend itself to crime.

## Flush Toilets with Closed-loop Flushwater Recycling

UDDTs are very logical, but we must remember that humans are creatures of habit and old habits are hard to change, especially those that have to do with toilets. Some seasteaders may never be able to imagine not using a flush toilet, plus there will certainly be brief visitors who would not be ready to see anything novel in the toilet, especially among the tourists who will stay at the 5-star hotel.

For these people, Canaday suggests a system in which wastewater from toilets is kept separate, cleansed, and put back into the same toilets. Remember that no one touches or drinks the water in the toilet ... and one of the main contaminants that would be left would be people's pharmaceuticals, which cannot be eliminated in any conventional methods of wastewater treatment and which certainly should be kept out of the ocean. If there is no odor, color, or disease risk, what is the difference and who would care, since a toilet bowl is never 100% clean anyway?




The treatment would consist of first removing the solids and greases via an Anaerobic Baffled Reactor, which would also produce biogas and very little sludge (since the organics would mostly be converted into biogas). This would take approximately 24 hours. Second, the water, which would still have odor, color, and disease risk, would be treated via constructed wetlands (= root zone treatment, phytoremediation; https://en.wikipedia.org/wiki/Constructed_wetland) to remove them, especially through the action of bacteria that live around the roots in the presence of oxygen provided by the plants. On land, one could use Vegetated Sand Filters, but the sand may likely be too heavy for use on a Seastead, so similar treatment could be achieved with Rafted Wetlands (with plants provided with flotation) in tanks of water tied alongside the platforms. Another potential option is to replace the sand with particles of plastic that is only slightly denser than water, so that the flotation of the unit would not be so problematic. Such particles of plastic trash may be available to be mined from the bottom of the ocean or at the mouths of rivers. The water should spend about 3 days passing through the wetland and then come out indistinguishable from tap water, unless it is analyzed in a laboratory. It can now be returned to the same toilets to continue to perform this same task indefinitely, serving as a permanent conveyor belt, instead of something cheap and disposable. This will certainly work, only the details need to be ironed out.

The water that is lost via the evapotranspiration of the plants can be compensated by adding greywater (wastewater that does not contain feces) as needed. This system requires more hoses and pumping, but the benefits outweigh those investments ... and we can install pumps that serve as exercise equipment (https://www.youtube.com/watch?v=gkcnSki9unk ). Similar wetlands can also be implemented to treat other wastewater streams.

Low-flow toilets should be used in this system, and the users should still be encouraged to use Waterless Urinals, given that, if less water flows through the system, it will receive better treatment. Optimally, urine should be kept separate, in order to use it as fertilizer and to improve the efficiency of blackwater treatment. Urine-diverting Flush Toilets do exist (http://www.wostman.se/ecoflush-1/, US$800, below left), but are expensive, difficult to obtain, and sometimes have technical problems. A simple, more practical solution is to sit on the edge of the flush toilet, lean the 20-liter Waterless Urinal toward oneself, and pee into it, while pooping into the toilet. Another option is to have a Pour-flush Urine-diverting Squat Toilet (below right; this one could be done better), in which the user pours recycled water manually from a pitcher filled at a faucet that is only for this. (Squatting is the most hygienic and ergonomic position, with less incidence of hemorrhoids and constipation, plus people from all cultures will be invited to seastead.) Bidets and Indian-style anal washing may also be applied with this system.

Despite this being so logical, no one has done it yet, we can be the first. The closest current example of this seems to be in the San Francisco Public Utilities Commission Building in California, although they mix all their wastewater and still dump into the sewer from time to time (https://sfwater.org/index.aspx?page=1156). The Solaire Building in New York City treats a percentage of its sewage for flushing toilets (http://www.waterworld.com/articles/wwi/print/volume-21/issue-1/features/nyc-high-rise-reuse-proves-decentralized-system-works.html), but not in a closed loop, as proposed here, and they keep contaminating the river with chemicals that no wastewater treatment plant can reliably eliminate.

This system would be entirely presentable to even the most conventional and demanding of users, but would cost more to build and maintain than UDDTs (see above) and would lend itself to more doubts about each phase of treatment.

It would also be great to demonstrate these systems on land with interested seasteaders, especially in water-stressed places like California.

This system has the following advantages:

- Water consumption would be greatly reduced;
- The ocean would not be polluted with excrement, pharmaceuticals, or drugs; and
- Grass for animals and biogas for cooking would be produced.

What is the tech readiness level? Is it proven tech?

This is entirely ready to apply. Check out this project that BORDA from Germany did in India: [https://www.youtube.com/watch?v=zTqE-8j9Unw](https://www.youtube.com/watch?v=zTqE-8j9Unw) The only part lacking is that blackwater is not kept in a separate loop.

## Greywater

This is the wastewater that does not contain feces and is very variable, depending on what it was used for.

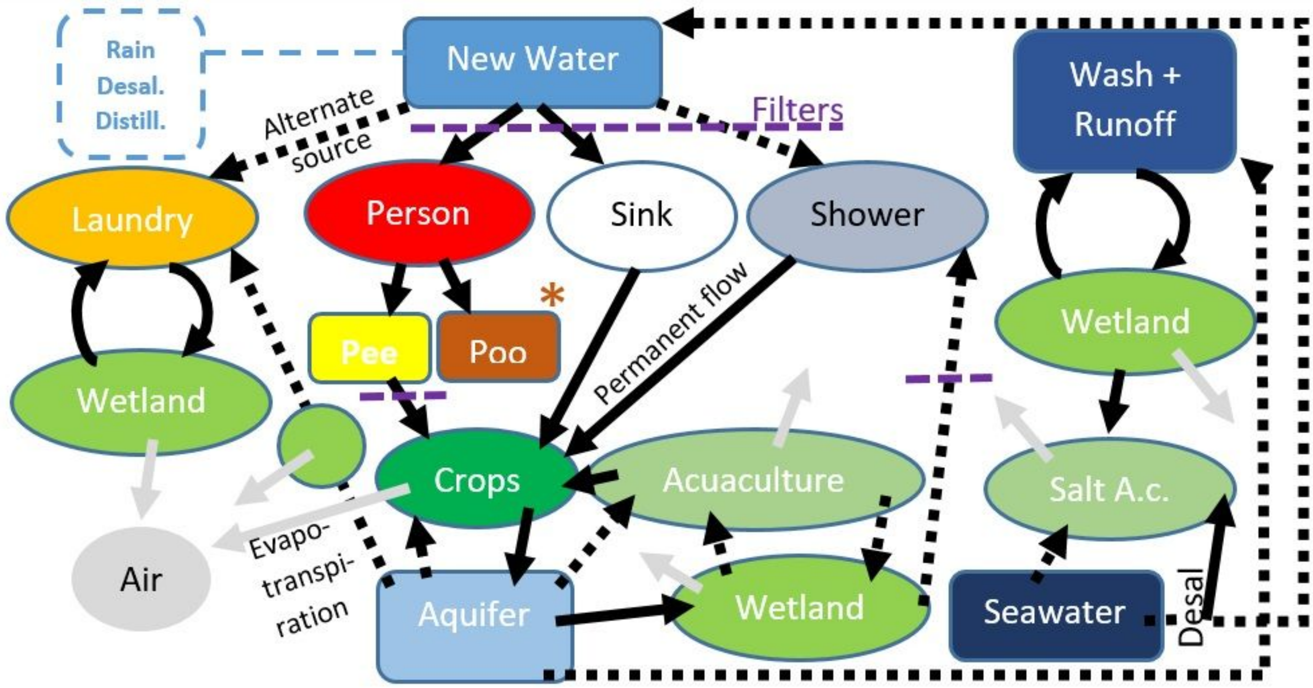
One of our overarching goals is to not discharge any wastewater, treated or not, into the ocean, so it should all be purified as needed and put back to use productively. By maintaining different types of greywater separate, each may receive proper treatment and productive reuse. In many cases, this is very simple. For example, greywater from kitchens can go straight to our gardens, where the particles of food will fertilize the soil, especially if toxic chemicals are not used. Each liter of water that we recycle is a liter less that we need to take from nature and one liter less that is given back to nature with some degree of contamination.

In many cases, the same exact water can fulfill a function, receive proper treatment, and then go back to doing the same task, without needing to constantly use new water. For example, in laundries, it is feasible to install grease traps and artificial wetlands (as described in the section on Closed-loop Flushwater Recycling, in the Food Systems Report) to clean the water and then use it again various times or indefinitely, taking into account that it is not necessary to use potable water. Even the same non-biodegradable detergents could continue to do their same task time and time again. The rinse cycle could be done with 'new water', which may compensate for the water lost via the evapotranspiration of the plants, especially if rainwater is kept out by putting the artificial wetlands in greenhouses. This would have the added advantage that clean rainwater could be collected from the top of the roof and distilled water evapotranspired by the plants from the bottom of it.

The OMEGA system, with cultivation of algae in floating plastic containers, has great potential for treating greywater that includes chemical contamination that we want to keep away from our food chain (e.g., industrial wastewater), together with motor exhaust (as a source of $CO_2$), to form biodiesel and/or other products. The treated water could return to the same uses and the remaining algal solids could be placed in a dedicated biodigester (possibly an Anaerobic Baffled Reactor with recycling water) for biogas production, and the small amount of resulting sludge could be composted for agricultural use, buried in the forest reserve, or land-filled, depending on the final degree of contamination. This may shade the underlying coral reef excessively, although in the middle of the ocean this should not be a problem. Another disadvantage would be the risk of the plastic containers breaking opening in the ocean (and, to reduce this risk, the containers could consist of rugged post-consumer beverage bottles … and Canaday figured out how to do this). It may be more prudent to install vertical algal reactors on the sides of buildings on the platforms, especially if the volumes to be treated are not too great.

This can be done with open-source technology, managed by seasteaders themselves, without dependence on secret, patented intellectual property. Further concepts on sanitation and water recycling are discussed here: https://issuu.com/chriscana/docs/suggestions_for_sustainable_sanitat

Water will come from various sources, including rain, desalination, and distillation, and then it is used and reused, with the necessary treatment in each cycle (see the following initial scheme by Canaday). Distillation will even include having saltwater fish ponds inside greenhouses and collecting the condensation. Note that the only water that leaves the system is that of evapotranspiration and no arrows lead to the ocean, since the goal is to not contaminate the sea at all. The term, "aquifer", refers to an artificial structure in the basement of each platform, where water will accumulate after filtering through the soil of gardens. "Wash + Runoff" refers to water used to clean the Seasteads, together with stormwater. Crops receive nutrients from diverse sources and constructed wetlands strategically clean the water sufficiently. Dotted arrows indicate alternate sources of water for those uses. (Urine-diverting Dry Toilets do not use water, and the Toilets with Closed-loop Flushwater Recycling will continually reuse the same water, so these are omitted from this graph.)




5.2. **Food scraps**

**Biogas/ Anaerobic Digestion**

Anaerobic digestion provides an efficient, proven way to convert almost any kind of biomass into energy and organic fertilizer. Soft, wet biomass is the most digestible, and will on average require 30 days of retention time, although that time can vary widely based on the specific parameters of the digester, and desired goals of the operators. Wastewater and manure, as well as food and even green and some types of paper waste will digest readily, while hard, woody biomass will take longer and may not ever fully digest. **Feedstocks like food waste are ideal, because they are very high in embodied energy and will produce the most gas. Manure/ wastewater by contrast, is very low in energy and will not produce much gas.**[86]

The most important parameters for a digester are temperature and pH. The optimal digester temperature is usually either 35 or 55 degrees C, depending on whether the digester is classified as mesophilic or thermophilic. A higher temperature digester will digest faster, but the reaction is more unstable and susceptible to upset from small changes in temperature or pH. Keeping the right Carbon: Nitrogen ratio will also help the digester work more efficiently and allow it to produce more gas.[87]

The biogas produced by an anaerobic digester is about 60-70% methane (chemically identical to natural gas) and 30-40% Carbon Dioxide. Biogas is considered "carbon neutral" because the carbon dioxide that is emitted is part of the natural carbon cycle, and is not a fossil fuel that is extracted from the Earth (added to the carbon cycle). The fact that biogas is largely similar to natural gas makes it a diverse fuel that can be used in almost any appliance that runs on natural gas. At 600-700 BTUs per cubic foot (methane has roughly 1,000 BTUs per cubic foot), it is far more energy dense than syngas -

[86] David House, The Complete Biogas Handbook.
[87] David House, The Complete Biogas Handbook.

the byproduct of waste gasification - which only contains 67-131 BTUs per cubic foot,[88] and is made of 30-60% carbon monoxide, 5-15% carbon dioxide, 25-30% hydrogen, and only 0-5% methane.[89]

While not very energy dense compared to liquid fuels, methane can be easily stored in large PVC-reinforced inflatable bags - a common practice all over the world. Such a bag could be floated off the side of the FIP platform, where it could safely store energy for electricity production when needed.

There are dozens of turn-key anaerobic digester systems on the market all over the world, but only a few that are small enough for the purposes of the first FIP. If the digester is used just to process food waste, in order to maximize energy yield per volume of digester space, and each adult human produces about 1 pound per day of food waste, then we can expect about 200 pounds per day, or 0.75 tons per week.

The HORSE (High-solids Organic-waste Recycling System with Energy output)[90], made by Impact Bioenergy and distributed by Everflux Technologies (in California) is the only commercial biogas unit that is designed for a weekly input this small, with systems ranging from 0.5 tons per week to 16 tons per week. This system provides on-site generation of energy from food waste and similar organic materials, avoiding expensive offsite trucking and turning waste into value.[91]


An alternative model for the first FIP might be to have an individual food waste anaerobic digester for every household. In this case, it would be technically and logistically challenging to collect all that biogas to produce electricity, however individual households could use it for cooking gas. An option for this application is HomeBiogas, made in Israel.

### 5.3. Recyclables

There will be an active program of recycling and reuse of “waste materials”.

### 5.4. Hazardous waste

Entry of hazardous materials will be strictly controlled. Any that do enter, or are somehow generated, should be carefully landfilled in the Anchor Zone, as far as possible from the ocean, or be given to the local authorities for disposal.

### 5.5. Eliminating non-compostable, non-recyclable waste

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88 http://www.cleangreenengines.com/banners-view/renewableenerg/
89 https://www.netl.doe.gov/research/coal/energy-systems/gasification/gasifipedia/syngas-composition
90 http://www.everfluxtechnologies.com/uploads/7/6/7/4/76741299/horse-ad-25-series-fact-sheet-2017.pdf
91 http://www.everfluxtechnologies.com/commercial-kitchens.html

Relatively inert items, like unclassified bits of plastic or metal, can be compacted into disposable beverage bottles. When no more can fit, the bottle is capped and used an Eco-brick[92] for use in construction. These are more seismic-resistant and have better thermal insulation properties, compared to earthen bricks.

[92] http://www.ecobricks.org/