What is A Sustainable Water Future?

Sustainability "...an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations"

- Paul Hawken

Triple Bottom Line Accounting



Systems Level Thinking integreated assessments, life cycle analysis

The Challenges (and the ubiquity of water)

Decrease reliance on fossil fuel

CO₂ emissions/greenhouse gas; geopolitical instability; diminishing supplies; need for new technology growth markets

Use water more efficiently

20% more water will be needed for agriculture by 2025
Drought may be a stress on civilizations in a warming future

: as during the last warming period of 800 -1200 A.D.)

1.4 billion people lack access to clean water

(waterborne disease kills a child every 8 seconds)

Develop sustainable agricultural systems

increasing production demands (population growth, biofuels) increasing energy costs (long distance networks, N fertilizer) shortages of water potential nutrient limitations (N and P)

Maintain (and define) necessary levels of natural ecosystems

Optimize ecosystem processes Preserve biodiversity



Year

Integrated Water Problem Map





DOES THE SOLUTION LIE BENEATH US?

As lakes and rivers run dry and Earth's surface water disappears. the solution might lie beneath us, in the vast (and largely untapped) network of underground aquifers. The United Nations cites over 23,400,000 km3 of water in aquifers, 547 times more than all of Earth's rivers combined. 98% of Earth's accessible water is thought to reside in aquifers, much of it 'fossil' water more than a million years old. Until recently deep aquifer pumping was out of the question (a cubic yard of water weighs one ton), but core-drilling technologies developed by the oil industry are changing the picture. Many of these aquifers span national borders, making access rights a huge matter of contention, and possibly a cause for future conflict.



NUBIAN SANDSTONE AQUIFER Volume is 500,000 times the annual flow of the Nile, but the desert climate above fails to replenish the aquifer below, making aquifer pumping an unsustainable solution.



WILL THERE BE WAR?

Of all the water on Earth, only 2.5% is fresh, and less than 0.007% is readily available to people through rivers, lakes, and streams. As worldwide populations surge, temperatures rise, climates change, and diseases spread, clean water will become ever more essential (and ever more rare). In 2000, United Nations Secretary-General Kofi Annan warned that national rivalries over water could harbor "the seeds of violent conflict' Opinions are split on the likelihood of "Water Wars". In the past 50 years, there have been 1,831 water-related interactions between countries. Of these, the vast majority (1,228) ended peacefully. Only 21 involved actual military violence (18 between Israel and its neighbors). Furthermore, there are few places in the world where a waterpoor country is in a military position to attack a water-rich neighbor. Still, many experts believe that as water shortages become increasingly urgent, countries (or at least local communities) will resort to violence to quench their thirsts.

LAMING TOAST PRODUCTION

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ALCOURT AND I	
BEST WATER	V
1) Finland	1
2) Canada	2)
3) New Zealand	3)
4) United Kingdom	4)
5) Japan	5)

lorocco

india

jordan

Sudan

Glass HALF EMPTY THE COMING WATER WARS



1970 WARNING SIGNS

In 1970, water consumption worldwide was half what is is today. With 80% of all sickness in the developing world linked to polluted water, and with populations sharply on the rise. the urgency of water management became apparent.

2003 DRY AND DIRTY

Over 1.3 billion people have no access to clean water. At least 2.2 million people die annually from diseases related to poor sanitation and contaminated drinking water - that's about 10,000 deaths from bad water (or no water) each day.

2025 PARCHED POPULACE

The United Nations estimates that the world's per capita water supply will drop by 1/3 in the next 20 years. The worst strain will be in Africa and the Middle East, where populations are growing fast and rivers are running dry.

WHO WILL HAVE THE WATER? PERCENTAGE OF WORLD WATER SUPPLY >20 10-20 5-10 2-5 1-2 BY NATURAL ECONOMIC REGION SOURCE - UNESCO

SOURCES - UNITED NATIONS - MONTREAL GAZETTE - UNESCO - NEW YORK TIMES - INTER PRESS SERVICE

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And the cost of upgrading our degrading water infrastructure will cost an Estimated 1 trillion dollars over the next 15 years.

U. of Illinois WaterCampws (The Center for Advanced Materials for the Purification of Water with Systems)

Human Civilization Has Been Down This Path Before



Jared Diamond "Collapse"

Past Centralized, 1-way flow

Present (emerging) Limit Waste, Eco-efficient

Future

Eliminate concept of waste Eco-effective, biophillic





Cradle to Cradle Design Principles

- The intelligence of natural systems should inform human design:
 - Waste Equals Food
 - Waste does not exist in nature. One organism's waste is food for another and nutrients flow indefinitely in cradle-to-cradle cycles of birth, decay and rebirth
 - Designers and engineers can use scientific assessments to select safe materials and optimize products and services, creating closed-loop material flows that are inherently benign and sustaining. Materials designed as:
 - as biological nutrients, such as textiles and packaging made from natural fibers, can biodegrade safely and restore soil after use., or
 - technical nutrients, such as carpet yarns made from synthetics that can be repeatedly depolymerized and repolymerized, are providing high quality, high-tech ingredients for generation after generation of synthetic products.

- Use Current Solar Income

- Living things thrive on the energy of the sun. Plants manufacture food from sunlight, an elegant, effective system that uses the earth's unrivalled and continuous source of energy income.
- Buildings and manufacturing processes should tap into current solar income using direct solar energy collection or passive solar processes, such as daylighting, and wind power (thermal flows fueled by sunlight)

- Celebrate Diversity

- Ecosystems are complex communities of living things, each of which has developed a unique response to its surroundings that works in concert with other organisms to sustain the system.
- Optimal sustainable design solutions draw information from and ultimately "fit" within local natural systems. Rather than offering the 1 size-fits-all solutions, designs that celebrate and support diversity and locality are more effective and sustaining as they engage natural systems.

Is this "Pie in the Sky"?

The real problem is that there are too many people.

There is more biomass of ants or microbes on the planet, yet their activities (which should have a larger impact given their higher turnover rates) have positive effects on the biosphere

The real problem is how we live, not how many of us there are.

It's not economically feasible.

This is not the old ecology versus industry argument. This is ecology as industry.

Waste into food violates the laws of thermodynamics.

"Waste" as energy and nutrients is an inherent component of natural systems.





Haber Bosch Process

The most influential invention of the 20st century? Certainly enabled World War II And dramatically increased world population



Supporting 40% of the worlds's population (M. D. Fryzuk, Nature 427, p 498, 5 Feb 2004).

So what's bad about the Haber Bosch process?

nitrogen cascade" – cumulative impact of human-generated reactive nitrogen in the environment.



What about the energy costs?

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Human

And greenhouse gas production (3.7 lbs of CO_2 produced per lb of ammonia fertilizer?)

Why is Wastewater Not A Waste?

- Water (typical wastewater is 95% water)
- Energy (from the Water Environment Research Foundation)
 - US spends 5-7% of its total energy on wastewater and water treatment
 - Energy content of the waste water represents up to 12% of our total energy use
- Nutrients
 - 24 Tg of N, ~1 T g of P
- Source separate the flows to maximize recovery
 - Domestic from industrial from stormwater
 - Emphasizes decentralization, point of use treatment (saves energy and water)
 - Hygiene water; mostly water, can be readily treated and recycled
 - Also concentrates the other streams , facilitates resource recovery
 - Urine: most of the nutrients
 - Urinals, urine separating toilet
 - Feces: most of the organic matter, i.e., energy
 - Vaccum assisted collection (low water content)

Options for households



15 Ashbolt *et al.* (2006) In: 2nd IWA Leading-Edge on Sustainability in Water-Limited Environments. WEMS vol

Why Divert the Urine?



- Use as a plant fertilizer
 - Normal nitrogen application (80-100 kg/ha)
 - \equiv 10-40 tonnes of urine/ha is needed

Urine as a Nutrient Source







Struvite: MgNH₄PO₄.6H20



Crystal formed under alkaline conditions in urine

Microbial action increases potential for precipitation Due to urea hydrolysis to ammonia (consumes H+)

> Can be a problem kidney stones scaling of wastewater systems

But is a "spontaneous" way to produce a purified (i.e, crystal) slow release fertilizer



Fecal matter as energy

- Energy content in wastewater influent was 9.3 times greater than energy used at the wastewater plant (Bagley, University of Toronto)
 - Potential for positive net energy is much greater for decentralized systems
- How do you recover the energy?

Microbial Fuel Cells



Biogas (The Cinderella of Biofuels"



Integration Not a New Concept in Agriculture

Terra Preta do Indio or Black Indian Earth



Associated with Human Settlements



Charcoal, human waste, bones Unintentional? Kitchen Midden?

High Organic Content, high cation exchange, & high fertility - in contract to normal soils

Terra Preta sanitation of human waste: low energy procedure for sanitizing and recycling human waste Factura et al. Water Science Technology 2010

Growing Power, Inc.

Inspiring communities to build sustainable food systems

- that are equitable and ecologically sound Integrated Aquaponics with a heavy dose of composting
- Six greenhouses growing over 12,000 pots of herbs, salad mix, beet greens, arugula, mustards, seedlings, sunflower and radish sprouts. These greenhouses also host production of six hydroponic systems growing Tilapia, Perch, and a variety of herb and salad greens, and over 50 bins of red wriggler worms;
- **a aquaponics hoop house** with two independent fish runs and growing beds for additional salad mix and seedlings;
- three hoop houses growing a mixture of salad greens;
- **a worm depository** hoop house;
- **an apiary** with 5 beehives;

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- **three poultry hoop houses** with laying hens and ducks;
- outdoor pens for livestock including goats, rabbits, and turkeys;
- a large plot of land on which the first stage of the organization's sophisticated **composting operation** is located including 30 pallet compost systems;
- an **anerobic digester** to produce energy from the farm's food waste; and
- **a small retail store** to sell produce, meat, worm castings, and compost to the community





"While many of my acquaintances tend to point the finger at the big agro-chemical conglomerates as villains, the fault really is with all of us who casually, willingly, even happily surrendered our rights to safe, wholesome, affordable and plentiful food in exchange for over-processed and pre-packaged convenience.

To many people, this might sound a bit hysterical. There is still food in the suburban supermarket aisles, yes. The shelves are not empty; there are no bread lines. We haven't read of any number of Americans actually starving to death. No, we are not suddenly starving to death; we are slowly but surely malnourishing ourselves to death. And this fate is falling ever more heavily on those who were already stressed: the poor. "

Organic "Waste" 100,000 lbs per week (food, brewery, coffee grounds)

Compost





Grow Beds



Bioreactor



Ammonium



Diffusion of Technology (Everett Rodgers)



Innovators (2.5%) - venturesome, educated, multiple info sources, greater propensity to take risk Early adopters (13.5%) - social leaders, popular, educated Early majority (34%) - deliberate, many informal social contacts Late majority (34%) - skeptical, traditional, lower socio-economic status Laggards (16%) - neighbours and friends are main info sources, fear of debt

U.S. diffusion of major inventions





Relevance to Sprout Industry?



Internal controllability

An ecosystem accumulates biomass and nutrients, and those resources are controlled by the existing interconnected system. But the system becomes overconnected, overly rigid (an accident waiting to happen). Resources are suddenly released, and reorganized . "Creative destruction". Two opposites: growth and stability vs. change and variety)