Chapter 10 - The Intelligent Response of Aquaponics and Permaculture In Redressing Food Production

"All great changes are preceded by chaos" Deepak Chopra

The phenomenon of combining farming of edible plants and edible aquatic organisms is not a new idea. It is rumored to have started in 1000 AD when the Aztecs started to grow some of their crops on rafts on fish lakes. Then the Chinese combined rice paddies and fish farming. The contemporary concept of Aquaponics is about the same, but with more variety and complexity.

Aquaponics is a hydroponic growing method in that it requires no soil. In both methods, the plants' roots are constantly bathed in highly oxygenated, nutrient-rich water. Aquaponics is an improvement over hydroponics for the following reasons: 1. Expensive, non-renewable chemical nutrients are replaced by less expensive nutrients from fish water. Hydroponic nutrient solutions are expensive and are fast becoming more expensive. A gallon of hydroponic nutrient solution costs $30–60, and a few tomato plants will easily go through that during their productive lifetime. Meanwhile, a 50-pound (23-kg) bag of tilapia feed costs about the same amount, and at a 1.3 feed conversion ratio will give you 38 pounds (17 kg) of mature tilapia and simultaneously support about eight tomato plants. 2. You never dump out your nutrient solution. Water in hydroponic systems needs to be discharged periodically, as the salts and chemicals build up to levels that become toxic to the plants. This is both inconvenient and problematic, as the disposal location of this wastewater needs to be carefully considered. In an aquaponic system, rather than having these problems with chemical imbalance, you achieve a natural nitrogen balance that is the hallmark of an established ecosystem. The water in your system is a critical component that you nurture as part of that balance. In aquaponics, you never replace your water; you only top it up as it evaporates and transpires (evaporates from the leaves of the plants).

A well-balanced aquaculture system has to ensure that the waste from the fish is removed before it builds to toxic levels, or the fish will die. Hydroponics (predominantly used in the greenhouses of Canada and the world) requires a constant replenishment and manual balancing of the chemical nutrients, or the plants die. By combining the two systems, aquaponics transfers much of the responsibility for reaching equilibrium between the nonchemical biological filtration of the fish waste and the nutrient needs of the plants to Mother Nature.

Animal	Food conversion ratio, lb food / lb growth
Fish	1.5:1 (McGinty n.d.)
Poultry	2:1 (Hamre 2003)
Pigs	4:1 (Losinger 1995)
Cattle	7:1 (Cal Ag Ed 1990)
Sheep	8:1 (Cal Ag Ed 1990)

Fish are vastly more efficient sources of protein than other forms of animal protein. Currently 37 percent of the world grain harvest is being used to produce animal protein. (Brown, 2003) Why is this so? In his 2009 book Just Food, James McWilliams explains it eloquently: "The ability to float effortlessly negates the need to undertake such energy-hogging endeavors as standing, walking and running. All these forms of mobility are internal energy sinks for terrestrial creatures, but not for fish. A fish is ecologically honed to translate the majority of its caloric intake into ample flesh that's edible, usually tasty, rich in protein and flush with heart-healthy oil." (p. 155)

China produces 62 percent of the farm-raised fish in the world today. (Jolly, 2011)

Aquaponics can produce 50,000 pounds of tilapia and 100,000 pounds of vegetables per year in a single acre of space. By contrast, one grass-fed cow requires eight acres of grassland. Another way of looking at it is that over the course of a year, aquaponics will generate about 35,000 pounds of edible flesh per acre, while the grass-fed beef will generate about 75 pounds in the same space. (McWilliams, 2009). Farmed bugs for fish and pultry is a lot more appealing to me than me eating bugs and I like our traditional protein sources in addition. Just saying.

By seeking a solution through bio-mimicry techniques and observing nature, scientists found the solution in polyculture. By intertwining the fish culture and the plant culture through a man-made recreation of natural wetlands systems, aquaponics was born. In an aquaponics system, nature plays the lead role and the successful farmer conducts rather than dictates. A great deal of work in Aquaponics was inspired by Dr. John Todd, a Canadian biologist.

Where do I think aquaponics is headed?

The Urban Food Revolution: Changing the Way We Feed Cities (Peter Ladner)

A lot can be learned from the use of Victory Gardens during World War II. By 1945 in the UK, 1.5 million allotment plots were producing 10% of all the country's food, including half of all fruits and vegetables. In the United States, by the end of the war, over 20 million home gardens were supplying 40% of US domestically consumed produce.

In 2009, the number of Americans growing fruits and vegetables (41 million) grew by 13% over the year before.

Sales of canning supplies in Canada were up 11% in 2009. Mason jar sales were up even more — by 20%. Almost half the people who checked in at AllRecipes.com and who can their own food are under 40.

Urban and near-urban agriculture provide 45% of all vegetables consumed in Hong Kong, 80% of poultry in Singapore, 70% of the poultry and eggs in Dakar and Kampala, and in Shanghai, 60% of vegetables, all the milk, 90% of eggs and 50% of pork and poultry. Hanoi sources 80% of its daily fresh vegetables from within urban and near-urban areas, and cities like Beijing have built urban agriculture into their city plans. The town of Rodas, Cuba, population 33,600, was entirely self-sufficient in fruit and vegetable production in 2001 which makes them about 50% food self-sufficient overall. Will cities eventually grow all their own food? Not likely, but they don't necessarily have to. A substantial portion can be enough, as long as they also build strong ties to surrounding rural areas. Abbotsford, BC already has a lot of these characteristics. Google the EcoDairy in Abbotsford.

Some urban farmers and their farms are well disguised. Eli Zabar is a Manhattan baker, retailer and restaurateur. Up on the roof of a three-story brick complex on 91st St., under the eye of neighboring apartment buildings, his commercial rooftop greenhouses cover raised beds pumping out herbs, salad greens, radishes and tomatoes. A compost grinder helps convert bakery and deli waste into compost. Exhaust pipes from the ovens downstairs keep the greenhouses at the precise temperatures that work for growing tomatoes in the winter. The Fairmont Waterfront Hotel in Vancouver has put in place a similar operation.

Converting a roof to a garden isn't easy. The weight of the soil and the constant human traffic up to a rooftop requires extra structural support, which can be expensive. One of Uncommon Ground's owners estimates he spent $150,000 on construction. "We re-supported the entire building. We dug down five feet and put in all new posts and beams. That was all to support what we wanted to do on the roof....

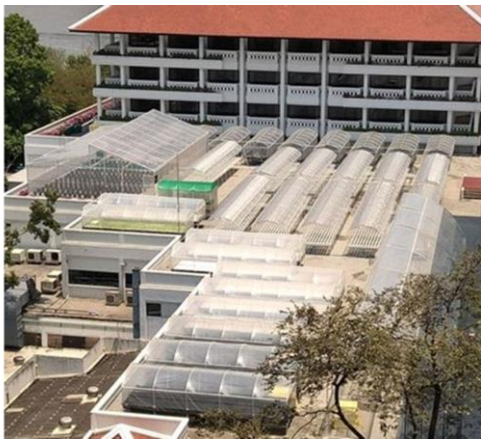
Uncommon Ground's roof also features a pair of beehives that produce 40–50 pounds of honey for the restaurant.

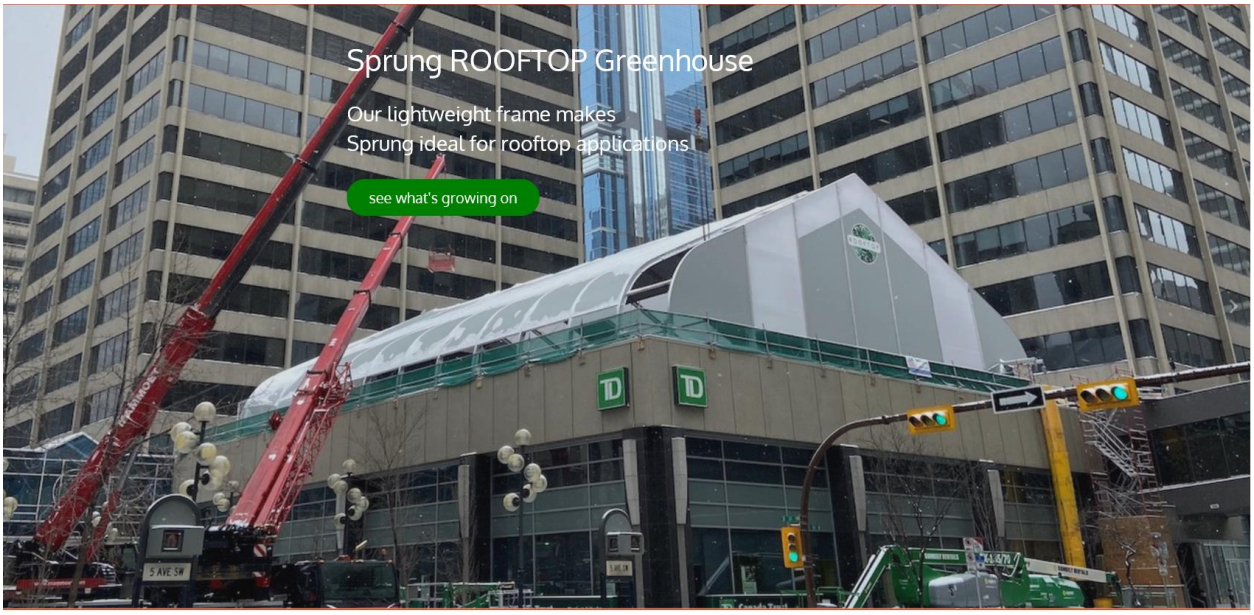
Mori Building, developer of Rop-pongi Hills in Tokyo, is using rooftop gardens to create "vertical garden cities" to add green space to a depressed area and dampen its intense urban heat island. The company's Keyakizaka complex rooftop boasts a seventh-floor rice paddy — yes, rice paddy — and vegetable plot. The paddy is small (155 square feet) and largely symbolic, but

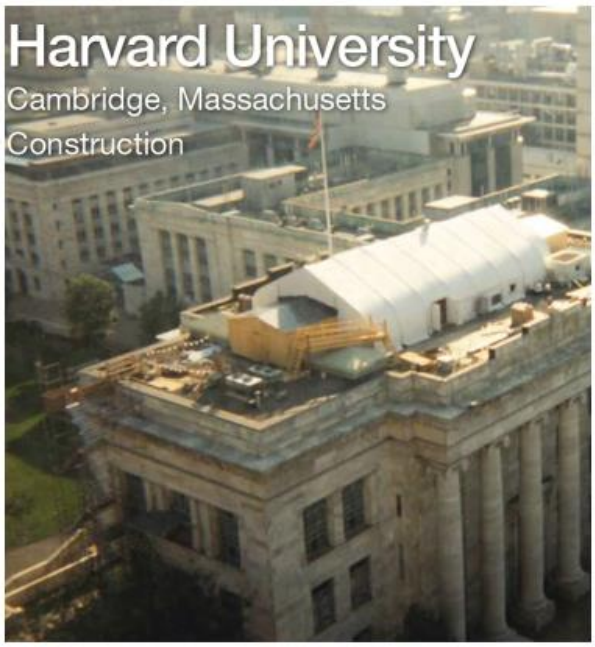
still capable of producing 135 pounds of rice, with elementary school students doing the planting and harvesting under the instruction of rice farmers.

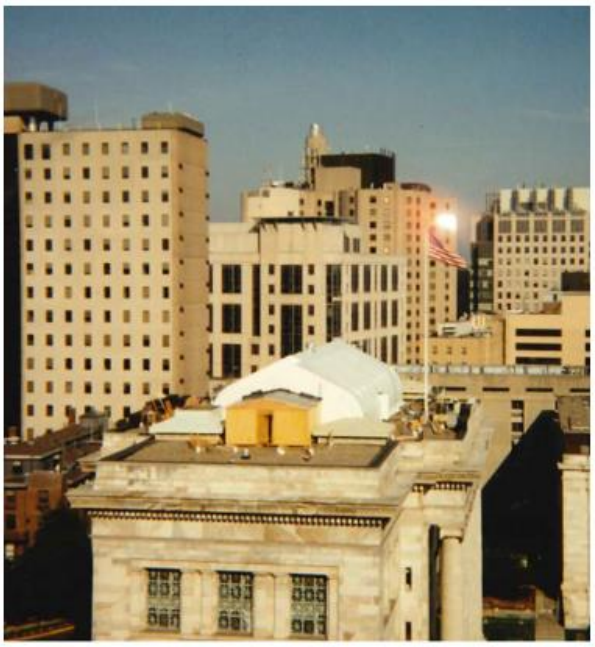
Thai hotel grows rooftop vegetables in Bangkok's scorching heat

- A Bangkok chef is now able to serve his customers the freshest fruits and vegetables that are available in Thailand's national capital. They come from the 2,800 square meter hydroponic rooftop farm that recently opened on the third floor of the Anantara Riverside Bangkok Resort.
- http://www.hortidaily.com/article/29041/Thai-hotel-grows-rooftop-vegetables-in-Bangkoks-scorching-heat









A more current example agro-urbia is Village Homes, a 70-acre upscale residential development in Davis, California that boasts community gardens, orchards, and edible landscaping. It provides 24% of its residents' food needs. Knowing what is possible, some cities are aiming for getting targeted percentages of their food needs from within their own boundaries. A study by Michigan State University estimated that with the use of greenhouses, trained farmers, proper storage, and bio-intensive techniques, just 570 of Detroit's vacant 5,000 acres of city land could produce 70% of the city's vegetables and 40% of its fruit.

A study in Toronto concluded that the city of Toronto has enough available land and rooftop space within its own boundaries to produce 10% of the fresh vegetables currently consumed. A "Forbes 2020" team of experts and authors predicted that within a decade or so, 20% of all food consumed in cities will come from rooftop and parking lot farms.

Think how much the food industry has changed in the last 50 years in North America, from when the interstate highway system, supermarkets and franchise restaurants were just starting to catch on. Why could it not change equally as profoundly in the next 50 years, this time driven by ecological, social, and economic sustainability, and concerns about food security? See also in Brooklyn the Eagle Street Rooftop Farm.

Model Developments

Developers with projects in Vancouver's Southeast False Creek downtown housing development are required to include edible landscaping and food-producing garden plots for rooftops and courtyards. Rooftops feature espaliered fruit trees and raised vegetable beds, and courtyards are framed with blueberry and raspberry bushes and trellises supporting fruit-bearing vines.

Situated at the juncture of two railway lines about an hour's ride north of Chicago, **Prairie Crossing** is a 677-acre development in the 5,000-acre Liberty Prairie Reserve. In some ways it is like a thousand other bedroom suburbs — it is a bunch of detached homes on former farmlands a long way from jobs and commercial centers. But one big difference is that the farm hasn't gone away. The mostly low-density, detached housing occupies only 20% of the developed land; 145 acres are devoted to an organic farm, and the rest is reserved for wild habitat preservation. Ten miles of trails wind through a landscape of farm fields, pastures, newly created lakes and ponds, restored native prairies and wetlands, and acres of historic hedgerows — all set on top of formerly depleted corn and soybean fields. The 20-year-old development is grounded in the vision of its founders, George and Vicky Ranney. In the words of Vicky Ranney: "On the assumption that the ground under our economy may be shifting... the future of development lies with community designs that take into account climate change, public health concerns and new forms of agriculture." What really makes Prairie Crossing different is its complete integration of residential housing and farming. Agriculture is an integral part of the community. A salaried manager looks after the on-site organic farm, and 15 acres are available for community farming. Most of the residents rent community garden plots and grow food for themselves. And some of the food comes from edible landscaping that residents have planted around their own properties. A quarter of residents have volunteered on the farm. It is just part of a sense of community engagement built around growing their own food.

Prairie Crossing has been visited by hundreds of planners, developers and agriculture advocates, and spawned a rash of similar developments across the United States. They are all part of the movement variously known as New Urbanism, agro-urbia, agricultural urbanism, conservation developments or, more glibly, “farming as the new golf.” Source: Building Communities with Farms, Insights from Developers, Architects and Farmers on Integrating Agriculture and Development by Vicky Ranney, Keith Kirley and Michael Sands, Sept. 2010, Liberty Prairie Foundation.

One of New Urbanism’s most prominent proponents is evangelist Andrés Duany, of Duany Plater-Zyberk & Company (DPZ), architects and town planners. In developments like Farmview in Makefield, Pennsylvania; Serenbe in Chattahoochee Hills, Georgia; South Village in Vermont; and Qroe Farm Preservation Development projects in Massachusetts and Virginia, as much as 80% of the farmland and natural habitat is preserved as part of a housing development. In some cases, an existing farmer can stay on the land, compensated by new owners who cover taxes, lost development potential and farm costs. Homeowners pre-purchase crops through a Community Supported Agriculture (CSA) food box program. Other projects have been retrofitted to include agricultural urbanism, including the New Town at St. Charles in Missouri, and Sky in Florida, where land is preserved, and sustainable building is encouraged in a predominantly rural (and formerly agricultural) community. There’s Troy Gardens in Madison, Wisconsin, which is a community-owned 31 acre urban agro-ecology project. It has 30 co-housing units integrated with a large community garden, an urban CSA farm, a prairie restoration and edible landscaping that includes fruit and nut trees and herbs.

When they work, these “conservation developments” free a new generation of farmers from the cost-price squeeze that’s driving so many aging farmers out of business.

In Serenbe, about 30 minutes from Atlanta’s airport, a working farm backed by a CSA is at the heart of a new community of 1,000 planned homes where 80% of the farmland is permanently preserved. The surrounding 35,000 acres are almost totally undeveloped,

In the Netherlands, a new town development proposes to take this to the next level. In cooperation with a network of stakeholders, the Dutch University in Wageningen designed a virtual rural-urban city district called “Agromere” that has agriculture and urban living tightly enmeshed.

According to Ed McMahon, Senior Fellow with the Urban Land Institute, these projects in North America are still mostly “boutique” developments, but many developers are waking up to the attraction of providing an open space amenity that generates a cashflow even before any lots are sold.

Greenhouse & Vertical Farming

The pressure to produce more food in smaller and unconventional spaces has led to vertical farming — adding height to the traditional one-story greenhouse. Will Allen at Growing Power in Milwaukee is using part of his 2008 $500,000 “genius grant” from the John D. and Catherine T. MacArthur Foundation to build “a five-story vertical building totally off the grid with renewable energy, where people can come and learn, so they can go back to their communities around the world and grow healthy food.”

An arctic greenhouse feeds on round-the-clock sun one hundred and twenty-five miles north of the Arctic Circle, behind Igloo Church, at the corner of Gwich'in Road and Breynat Street, called the Inuvik Community Greenhouse. It is the northernmost commercial hothouse on the continent, and it may be the only community greenhouse of its kind in the world. Since November 1998, the former hockey arena has been home to a variety of crops and flowers. There are two growing areas: a 12,000-square foot community garden, where residents and local groups can rent 40 square foot plots for $100/year; and a 4,000-square foot commercial greenhouse that pays for itself. Despite a relatively short season-mid-May to late September – eight weeks of non-stop sun intensifies the growth. Now, residents of Inuvik (which has a mean temperature of 15 degrees Fahrenheit) have access to fresh local produce for as many months of the year as most of the rest of Canada.

A big advance in vertical growing in a greenhouse or a closed building like a vacant warehouse is coming from Valcent Products Inc., developers of Europe’s first vertical farm at the Paignton Zoo in Devon, UK. On 1,075 square feet, the zoo is growing $160,000 worth of crops, using only 5% of the water that would be required to grow them outdoors — and even that 5% can be recycled.

Investors from the green tech world are just waking up to the financial opportunities. “Sustainable agriculture is a space [for investment] that looks as big or bigger than clean tech,” says Paul Matteucci, a venture capitalist with US Venture Partners in Menlo Park, Calif. “Historically, we have not seen a ton of entrepreneurial activity in agriculture, but we are beginning to see it now, and the opportunities are huge.” Investors are increasingly aware of its dependence on huge amounts of water and fossil fuels that are becoming more expensive and less available.

The Nuskin Grov Story

Grov is an 18,000 ft2 (1,672m2) vertical farming operation. Organic micro-greens/fodder grown in multiple towers represent about 500 acres of conventional crop farming to feed 17,000 dairy cows. This 100% black out greenhouse allows complete environmental control that is unaffected by climate and minimizes the use of water and fertilizers.

Two layers of architectural membrane envelope a 9" (228mm) thick plant-based insulation blanket that results in thermal efficiency (R-30) complete with an air tight (2% air exchange) envelope.

Groviv History

- In 2014, two of our founders of Groviv were serving on the board of directors for a non-profit that was working with an orphanage and developed a prototype of an indoor growing system that not only fed the children of the orphanage but provided an opportunity for a micro-business to sell the excess fresh greens outside of the orphanage. But why stop there with just a salad?

https://finance.yahoo.com/news/nu-skin-enterprises-promote-technology-184100520.html

We will always need farmland. Indoor growing must be seen as a supplement to outdoor growing, not a replacement for it. Fields will likely always be more suitable for growing crops like grains, rice and corn (about 50 percent of calorie intake). Aquaponics and urban and near-urban plots will increasingly supply other crops.

Following The Money

I AM AN OKANAGAN [B.C.] orchardist," writes an anonymous farmer (signed in as "nlo") in the comment section of an online news service. "We need about 35 cents a pound for apples to make a living. When we get 35 cents, the price in the stores is about $1.50. Last year we (our industry) averaged 12 cents and lost a lot of money. The average retail price was still about $1.50. "Retail concentration has happened so there will be very little [retail] competition; the big 3 (Overwaitea, Sobey's, Loblaws) don't like competition. They hire ruthless people with MBAs who shop the world for the best deal; often the deal is due to the generosity of another nations' taxpayers; but it's very wrong to believe they 'pass on the savings.'

A study in Seattle (one of many similar studies) found that shifting just 20% of the food dollars spent into "locally directed spending" would inject nearly $1 billion into the region's economy each year.

The economic impact of local procurement was measured in Portland in a study that gave school districts a bit of extra money to buy local food for school lunches. So instead of paying 30 cents for a serving of chili from a national distributor, they could afford to pay 34 cents to a local supplier. The local lunches cost 13% more, but for every dollar spent locally by two school districts, another 87 cents was spent in Oregon, adding up to a 1.87 multiplier. The extra $66,000 invested in more expensive local foods inspired an additional $225,000 in spending — a 241% return on the investment.

Even when local food is being exported, Iowa, a top agricultural export state, imports about 90% of its food. At least 60% of the fresh produce consumed in Toronto is imported from the United States, and a third of this arrives during Ontario's own growing season, competing with local produce. This amounts to $172 million spent annually in Greater Toronto to import fresh vegetables, many of which can be grown locally. Despite having more than half of Canada's most productive agricultural land, Ontario has a food deficit of approximately $3 billion.

QUOTE from https://archive.ph/qBv2S#selection-1287.0-1287.45 : "First, to the Netherlands, where farmers have been protesting, blockading roads with their tractors and staging enormous rallies. ... the Netherlands is an ag success story. The bite-sized Western European nation is the second-largest food exporter on earth, after only the United States, which is 237 times larger."

QUOTE: "**And all the more so since, as Michael Shellenberger points out, Dutch farms aren't using any more nitrogen-emitting fertilizer than they were back in the 1960s.**"

Betcha they are growing more food than in the 1960s, though, which means whatever "emissions" they have from fertilizer are actually going down, on a ton-per-ton basis. Globalist will never mention that, though.

But this article's point is twofold: (1) that all the "experts" who are bringing on this net-zero nonsense are PROFOUNDLY IGNORANT about the things they are trying to regulate, and (2) they assume the "working class" is behind all this leftist nonsense--but they're not.

Local economic development thrives on the multiplier effect: money spent on a local business circulates through other local businesses, multiplying its benefits to the community. The economic multiplier from spending a dollar at a locally owned business, like a local farm, is estimated to be 2–4 times the impact of a dollar spent at a business owned outside the community.

Michigan State University did a study in 2006 that predicted that doubling or tripling the amount of fruits and vegetables sold by Michigan farmers to local outlets could generate up to 1,889 new jobs across the state and $187 million in new personal income.

Adding value to unprocessed food is big business. The food and beverage processing sector is Ontario and Canada's third largest manufacturing sector, led by bakeries, meat processing and beverages. Two-thirds of the companies in the business are owner-operated, producing "fresh product" or serving specialty markets in the city.

It's breaking out all over North America. The Illinois Local Food, Farms, and Jobs Act of 2009 established a goal for state institutions (hospitals, schools, prisons) to procure 20% of all food and food products from local farms or manufacturers by 2020, even if they have to pay a premium for it. Oregon allows its public agencies to pay up to a 10% premium for locally sourced foods. The University of Toronto was the first institution to commit to buying a percentage of its food from sources ratified by Local Food Plus, a Toronto-based organization that has developed criteria for awarding a "Certified Local Sustainable" label.

Local Food Plus is partnering with the University of Toronto to bring local sustainable food to its 70,000 students. Food service contractors agreed to spend 10% of the annual dollar value of food purchased on local sustainable food, with a 5% increase each year. By the end of the 2010–2011 school year, this reached 25%.

Woody Tasch, a Massachusetts-based investor-philanthropist-activist says never mind waiting for economic development policies to stimulate a saner approach to growing good food. Tasch wants to harness the private market with a different set of reins. City and near-urban farmers would be at the front of the line for investments under Woody Tasch's Slow Money model (sympathetic with the Slow Food movement, but organized separately). His bold goal is to have "millions of Americans contributing tens of millions of dollars a year to be invested in local production (www.slowmoneyalliance.org and www.slowfood.com

When the Waterloo region of Ontario studied how much food consumed in the region was locally grown in 2005, it found that only a tiny fraction of the food processed in the big local processing plants was locally sourced. Only 3% of the apples that were juiced, dried or canned at Golden Town Apple Products came from the region. "There's lots of buzz about a lack of processing facilities and a need to build new infrastructure," Peter Katona, the executive director of FoodLink Waterloo, told TheTyee.ca. "Nobody's still really looked at the root cause of why we lost our processing infrastructure, which is price. Farm labor wages in Ontario, not to mention high health and safety costs, are 25% higher than US wages, and 25 times higher than Mexican wages." Transportation costs are likely to be the great equalizer in this as of 2022.

"Grocery is more than half of Walmart's [$405-billion-a-year] business." One of Walmart's goals is to save money by reducing waste and shortening supply chains — which should mean less spoiled food, longer shelf lives and more profit for everyone. Walmart, too, is getting ready for higher fossil fuel prices.

Well-established, existing infrastructure can adapt to the drive for more local food. Sysco, North America's largest food service distributor (it has $40 billion in annual revenues) is realizing that buying local is a trend that's not going away. It has been running pilot projects to figure out how to overcome the complexities of buying from smaller local suppliers.

Working with local farmers in a 2008 pilot project, Sysco's Grand Rapids operating subsidiary found that by adding new local products, they boosted sales by 10%. They offered local alfalfa sprouts, pesticide-free hydroponic leafy greens, and twice as many varieties of Michigan apples as before — in all, there were 18 new products from 20 producers. Six of the farm suppliers were new Sysco clients, and all the farms involved were family owned and committed to environmentally sensitive practices. Sysco was able to ramp up local sales by adding "Michigan-produced" to their order sheets and restricting sales of a particular item to local products when they were in season.

As a result of this pilot, Sysco got 100% of Michigan State University's food services contract. A similar Sysco project in Kansas City added 76 new local family farm suppliers. A similar initiative to Sysco's is fellow-behemoth Walmart's October 2010 decision to double the percentage of locally grown produce it sells in the United States to 9%. In Canada, where Walmart is just getting into grocery sales, it will buy 30% of its produce locally by 2013 — or 100% if it's available. (In the United States, "local" means from within the same state.) And then along came the lockdowns of the pandemic and all this has been reversed with a tremendous number of small business bankruptcies!

The Atwater Market in Montreal, Detroit's Eastern Central Market, Granville Island Market in Vancouver and Toronto's Ontario Food Terminal wholesale market are just a few examples of the huge popularity of farmers markets. Farmers are willing to get up at 4 am to haul their products to these places because they can keep up to 90 cents for every dollar of sales — a lot more than the 18 cents they typically get when their food is sold through a traditional grocery store.

Spending at farmers markets in Canada was estimated at $1.08 billion-plus in 2008. Farmers markets are growing fast. Direct sales in the United States jumped 55% between 2002 and 2007. As of mid-2010, there were 6,132 farmers markets operating in the United States — a 16% increase from 2009, and more than a doubling over the past decade.

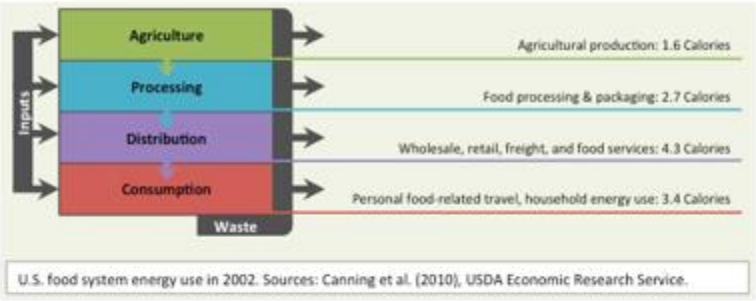
Economy, fresher food, unique local flavors, neighbourhood festivities, better health, and the opportunity to make a personal link with the farmers who grow the food you put into your body.

The allure of farmers markets makes them the #2 source of groceries for 62% of Canadian shoppers (after big grocery stores). Canadian farmers markets generate $2 billion in economic spinoff, though it's hard to say how that compares with jobs created by mainstream grocery sales.

Waste Not

THINK OF THAT BIT OF CHEESE that went moldy in the fridge before you could eat it. It either hardened up into a dry lump, or it grew a blue-gray coat of fuzz that screamed: "throw me out, now!" Not being a recommended addition to a rodent-free compost pile, it went into the garbage. Now, think of the embodied energy — all the handling, transportation and resources — that went into getting that piece of cheese into the drawer in your refrigerator. A cow somewhere had to be raised, fed, housed

and milked to start that little lump on its journey. Its milk had to be pasteurized then cooled and shipped in a refrigerated truck or train to a cheese processor. There, it demanded more roofs, heating, cooling and handling; then it had to be packed and shipped to a central warehouse; then it went into another truck to the retail store; then you took it home in a car, or perhaps a bus. Then it had to be stored in your refrigerator that worked for days to convert electricity to cool air to shepherd that lump of energized milk into the state where it qualified as garbage. Even after all that, your cheese still requires more energy. It will be dumped into the back of another truck and rumbled off to a big compost pile or maybe an incinerator. Or, it may end up in a landfill where it will rot and vaporize into methane, a greenhouse gas. That bit of cheese was only one tiny piece of a massive food-wasting frenzy that's embodied in rich-world food habits.



U.S. food system energy use in 2002. Sources: Canning et al. (2010), USDA Economic Research Service.

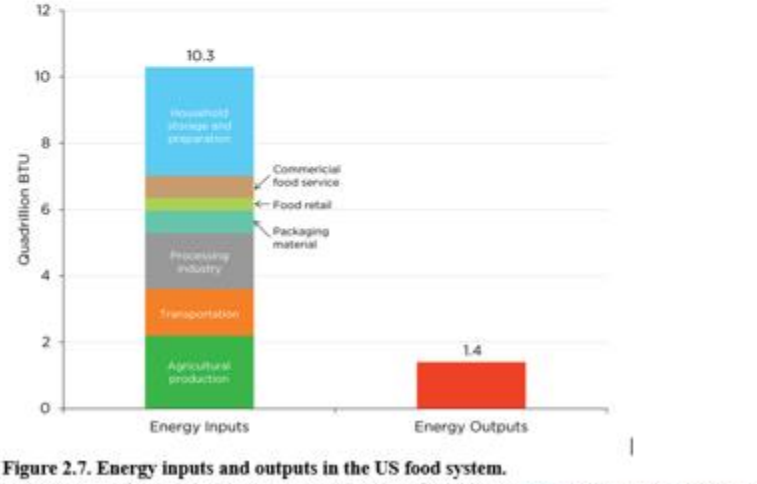


Figure 2.7. Energy inputs and outputs in the US food system.
Source: Center for Sustainable Systems, University of Michigan, "U.S. Food System Factsheet." CSS01-06 (2015).

One US study from the EPA says that between 4–10% of food purchased becomes waste before ever reaching a plate. Another says Americans throw away more than 25% of the unprepared food they buy, which comes to about 48 million tons of food waste each year.

As a result of Walmart's new sustainability and buy-local initiatives, Walmart has stated that by the end of 2015 it will reduce food waste in emerging-market stores by 15%, and in other stores by 10%. www.lovefoodhatewaste.com Likely they have not reached the stated goal.

The British food retailer Sainsbury's has started sending all its food waste from its Scottish stores to a biofuel refinery plant in Motherwell where it is converted into fuel for generating electricity. They've worked out that each ton of food waste diverted from landfill by Sainsbury's will generate enough power for 500 homes.

Production of fish and, to a lesser extent, water vegetables (macro-phytes) in ponds fertilized by human waste has long been, and continues to be, practiced in many countries in Asia (India, Thailand, Indonesia, Vietnam, Taiwan, China), Israel and Africa. Some of these ponds can produce up to six tons of fish per hectare per year. The East Calcutta Wetlands, consisting of 30 square kilometers of fishponds, raises tilapia and carp in the world's largest sewage-fed fish production site. The Wetlands reportedly produce 22 tons of fish per day, treat 150 million gallons of Calcutta's wastewater and supply 10–15% of the fish consumed in Calcutta. I'm not saying we should do this in North America…

Sending sewage into waste stabilization ponds, where it is filtered from pond to pond over a few weeks, can produce safe irrigation water 1,000 times cleaner than what comes out of a conventional treatment plant. The downside is that these ponds

require a lot more space than conventional sewage treatment, even though they cost about a quarter as much to construct. Some industries are mimicking, at a smaller scale, the large and successful waste stabilization wetland in Calcutta that raises fish, processes waste and provides nutrient-rich irrigation water for farmers.

All living things need phosphates. Humans get theirs from mostly mined phosphate that goes into fertilizers. Most of the world's phosphate, of which 90% is used for food production, is in China and the Western Sahara. Just five nations control over 90% of the world's high-grade phosphorus, including China, the United States and Morocco. China's phosphate is protected behind a 135% export tariff. Currently, it is estimated that there is only enough phosphate left to be mined for a 50–100-year supply. The United States, the world's fourth largest repository, only has a 25-year supply. Europe and India import all their phosphate. Production of phosphorus is expected to peak in 2034 and, unlike oil, there is no known substitute other than re-harvesting what we have diluted dramatically in the worlds oceans… a slow and expensive process.

Phosphate is a critical ingredient of fertilizer, and there is no substitute for it (because plants are partially made from it). This photo shows the difference between corn fertilized with phosphorus (background) and corn without.

United Nations Environment Program

In the past ~120 years, we have become completely dependent on phosphate rock for phosphorus used in commercial fertilizer. Before that, our phosphate came from manure.

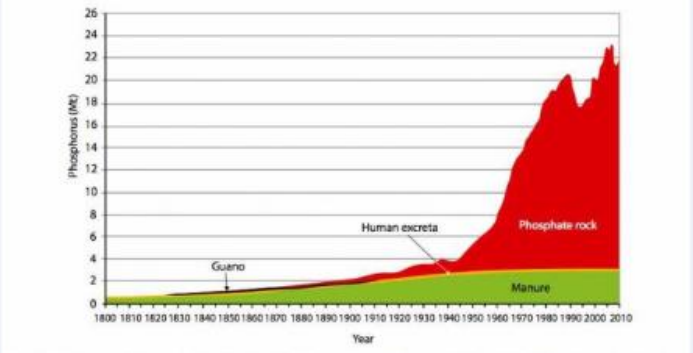


Figure 2: Global sources of phosphorus fertilizer. Since the mid-1940s, population growth accompanied by greater food demand and urbanization have led to a dramatic increase in the use of mined phosphate rock compared with other sources of phosphorus. *Source: Cordell et al. (2009)*

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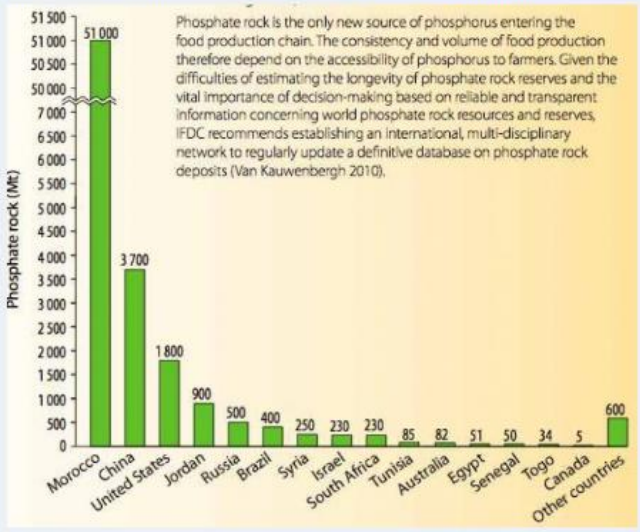
The trouble is that there isn't an infinite amount of phosphate rock. Estimates differ on the amount of reserves available in the world, but they're not unlimited. Some scientists think we have enough to last hundreds of years. Others, however, are far less optimistic.



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Not necessarily. It turns out that our urine and feces contain a lot of phosphorus--which is why they make good fertilizer. If we got serious about recycling our bio-waste, we could reduce our need for phosphate rock.

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Source: http://www.businessinsider.com/peak-phosphorus-and-food-production-2012-12?op=1

As cheap fertilizer increasingly becomes a thing of the past, attention is turning to urine, which can be combined with organic sources like manure, feces and food waste to essentially replace the need for mined phosphate rock. All human settlements in all countries of the world have a urine surplus. Urine is sterile (it's even safe to drink – BUT!), and it contains the key nutrients plants need — phosphorus, nitrogen and potassium — in the correct ratio.

By using "urine diversion" to get the heavy, sterile, productive urine away from pathogen-rich feces, it can be used as a fertilizer. In Sweden, more than 135,000 urine-diverting toilets have been installed since 1990 — mostly in remote vacation homes. But experiments are ongoing in urban locations. Urine collected at the Cantonal Library in Liestal, Switzerland, using Swiss-designed NoMix toilets, has been used to produce 20–30 liters a week of a pollutant-free liquid fertilizer ("Urevit") licensed by the Federal Office for Agriculture.

Although farmers are often very concerned about the micropollutants in urine (hormones and pharmaceuticals), there are some indications that this obstacle can be overcome. In the Netherlands, engineers are precipitating ammonium magnesium phosphate fertilizer out of stored urine at a treatment plant. Denmark has a urine separation project that works well enough

that an organic vegetable farming collective called the Svanholm Gods is using it as fertilizer. A Vancouver-based company, Ostara Nutrient Recovery Technologies, Inc., has plants running in Edmonton, Portland, Philadelphia and London that extract phosphorus from wastewater and turn it into dry pellets that are used as fertilizer (see www.ostara.com).

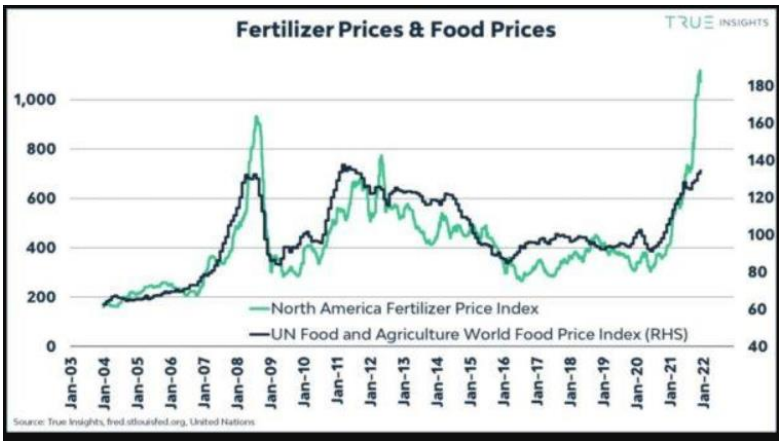
Having worms in your compost bin speeds up the creation of beautiful rich, black compost. Compared to "normal" soil, worm castings have five times the available nitrogen, 7 times the phosphorus, 3 times the magnesium, 11 times the potassium, and 1½ times the calcium. (That's twice the amount of nitrogen needed for optimal growth; 7 times the phosphorus and potassium.)

Worms eat half their weight in food each day, so one pound of worms will eat half a pound of food scraps daily. The Kingdome Stadium in Seattle, Washington, feed a third of the stadium's food waste to 18,000 worms in 12 containers. They have had no problems with odors or pests, and use the worm castings on the King-dome's flower beds. In Eugene, the University of Oregon organic gardening program teamed up with the university's grounds crew in 1994 on a vermicomposting experiment that turned yard waste and 2,000 pounds of daily food waste into a nutrient-rich soil-enhancing material that replaced the fertilizers the university used to buy. They did this without bins or special worm purchases. All they did was spread organic wastes on a half-acre site between rows of fruit trees and blueberry bushes; they relied on the worms that naturally occur in the soil. Every few days they would spread a thin layer of about 250 pounds of unused food from a local restaurant on the ground between the fruit trees. They would rotate the drops around the trees, each area getting a new load every 14 days. They'd sprinkle a thin layer of rock dust from a local quarry on top, along with grass, leaves and shredded branches delivered by campus ground crews, the city and private landscapers. The fruit trees and vegetables planted on the site thrive.

Taken together, farm runoff in all its forms is by far the world's most damaging source of pollution, creating dead zones wherever major rivers empty into the ocean…

Every bit of today's farming in the developed world is driven by technology. New kinds of farm equipment, new planting strategies, global-positioning systems for precision farming, and other high-tech approaches have extended the life of most soils far beyond their natural carrying capacity for producing, regardless of the crop in question…

Graduate schools of agriculture throughout the world have led the way in changing what once was a hit-or-miss situation regarding what and where we can farm into a predictable science of crop production. The agrochemical industries have been quick to adopt these new findings and have commercialized them to not only help the farmer but also to bolster their own profit margins. The Ag business is booming; fertilizer, herbicide and pesticide product lines have become their bread and butter. No one denies the fact that these products have helped greatly in ushering in the second green revolution. That is not to say that there are no problems looming on the near horizon, even for those fortunate countries with minimal environmental impact on their agricultural industries. But fossil fuels also figure into the equation. Higher yields are linked to increased fossil-fuel use by new farming machines. In the United States, more than 30 percent of all burned fuels go to agriculture. The price of food is also linked to fossil-fuel use, and in 2008, the cost of food worldwide nearly doubled compared to the year 2000.



As of 2009 there were forty-nine LDCs, most of which were in tropical regions of Africa and Central America. LDCs cannot afford commercially available fertilizers and are forced to use human and animal feces. This turns out to be the best way of spreading intestinal parasites from person to person. Worldwide, there are some 3 billion human infections with geohelminths (worm parasites of the gut tract transmitted through fecal contamination of the soil) that severely limit the health of an entire generation of children. Those LDCs that are located in tropical zones have poor soils to work with, save for those few countries in East Africa that are blessed with volcanically generated soils. It is well established that the vast majority of tropical soils are shallow at best and cannot store significant amounts of carbon below ground. In addition, since it rains for a good portion of the year, valuable nutrients in the form of fallen leaves have to be recycled in days, as opposed to temperate-zone forests that

may take an entire year to recycle their leaf litter into reusable nutrients. Tropical soils are poor in essential stored micronutrients because of leaching caused by the abundant rainfall. Growing significant amounts of food in these situations is impossible without nutrient supplementation, if not from feces then from the ashes of burned trees and shrubs that were cleared to make room for the crops ("slash and burn" agriculture). In this scenario, only three years' worth of crops can be harvested before the itinerate farmer has to move his family to yet another pristine forest site, where he then repeats the process. It is the single most common cause of deforestation in the tropics, with gold mining coming in a distant second. It is also the reason why in the tropics malnutrition is commonplace and starvation is routine, especially when a crop fails.

Perhaps the most life-altering result of organic (permaculture) farming has been the liberation from debt. Even with government subsidies, it costs 500,000 Tanzanian shillings, more than $300, to buy fertilizer and pesticide (also derived from fossil fuels) to treat a single acre – a crippling expense in a country where the annual per capita income is less than $1,600. "Before, when we had to buy fertilizer, we had no money left over to send our children to school,' says Kibwana. Her oldest daughter has now finished high school. And the farms are more productive too. 'Most of the food in our markets is from small farmers,' says Maro. 'They feed our nation.'

Conflict has already occurred over the scarcity of water in many places. For example, in 2008, during the height of the twenty-five-year drought plaguing the Southeastern region of the United States, the states of Florida and Alabama sued the state of Georgia for withholding water releases from Lake Lanier. Atlanta gets its drinking water from that lake, but the Chattahoochee River below the hydroelectric dam eventually courses through parts of Florida and Alabama on its way to the ocean. The argument over the amount of released water considered minimally essential to satisfy the needs of those living downstream is, as of this writing, still in court and unresolved. Ironically, the following year, Georgia experienced massive flooding in September, in which an enormous quantity of topsoil was lost.

Cereal crops have the virtues of being fast growing, high in carbohydrates, and yielding up to a ton of edible food per hectare cultivated. As a result, cereals today account for over half of all calories consumed by humans and include five of the modern world's 12 leading crops (wheat, corn, rice, barley, and sorghum).

Of the 200,000 wild plant species, only a few thousand are eaten by humans, and just a few hundred of these have been more or less domesticated. Even of these several hundred crops, most provide minor supplements to our diet and would not by themselves have sufficed to support the rise of civilizations. A mere dozen species account for over 80 percent of the modern world's annual tonnage of all crops. Those dozen blockbusters are the cereals wheat, corn, rice, barley, and sorghum; the pulse soybean; the roots or tubers potato, manioc, and sweet potato; the sugar sources sugarcane and sugar beet; and the fruit banana.

Our failure to domesticate even a single major new food plant in modern times suggests that ancient peoples really may have explored virtually all useful wild plants and domesticated much of those "worth domesticating".

It is obvious, therefore, that the traits we value as consumers of plants have little or nothing to do with the ones that enabled their ancestors to withstand severe environmental changes associated with droughts, floods, plant diseases, insect pests and wide fluctuations in temperature. In short, we have bred the "wildness" out of them in favor of things that favor their growth as irrigated, pampered, well-fed monocultures, or "cultivars." If an environmental change should occur that exceeds the narrow tolerance limits for a given cultivar, then that crop will surely fail in that environment. It would be like turning our pet lap dogs loose in the woods and expecting them to survive on their own. Today in the United States, more than 90 percent of all seeds used in large-scale agriculture, regardless of the crop, are produced by just three companies. They are all highly domesticated strains with very narrow tolerance limits for temperature and precipitation. More than half the world's farmland is suboptimal with respect to most commercial crops and will only get worse over time. This is especially true throughout the tropics, in which the soils are mere inches thick and do not have much in the way of stored nutrients. The tropics are also the region of our planet experiencing the highest rates of population growth.

Throughout the ages, most of our crops (with the possible exception of wheat) have been carefully selected for growth in a series of narrow climate regimes. For this reason, regions of the world have become known for producing certain crops, but not all of them. It's worth emphasizing again that the conditions that plants depend on most relate to annual patterns of temperature and precipitation.

Like it or not, we cannot live out our lives apart from nature. Scientists from all of the sub disciplines of ecology have independently come to the same conclusion; namely, that all of life on earth is linked either directly or indirectly to each other in mutually dependent life-renewing cycles. It is the foundation upon which that science is built. That is the nexus of economy and the environment.

Without our interference, life would go on in an equitable manner, with all the life forms living within a given eco-zone sharing their part of the energy budget provided to them each day by the sun. We have always been part and parcel of that scheme, but only recently in our history, just over the last fifty years or so, have we come to appreciate these intimate connections from a formal, scientific perspective.

All of the available scientific evidence points to the fact that the most destructive force on earth is our penchant for encroaching into natural systems, mostly for the purpose of producing more food. But, locked into our present mode of food procurement, what choice do we have? We have indeed become trapped, held prisoner by our own device (shades of “Hotel California”), locked into an outdated system of food production that requires us to use more and more land to address the demands of a rising human population. If we continue down this dead-end road, then Malthus will indeed have been correct, if a tad premature in his predictions. Unless, of course, another set of technological breakthroughs once again comes to the rescue and pulls us off the tracks of potentially impending doom. However, what is most required at this point in our history is not yet another quick techno-fix, but rather a permanent overhaul in the way we behave as a species. I believe there must be ways to satisfy both our needs and natures. I think that creating sustainable food-generating systems within the urban landscape would be an excellent first step and would solve several problems associated with environmental destruction. A city-based agricultural system would allow us to carry out our lives without further damaging the environment. In fact, by relieving a sizable portion of the land of its food-production obligations, we would become two-time winners; we’d still get our food, and we would begin to regenerate the ecological services we unwittingly forfeited when we encroached.

‘You see the egrets flying out there?’ Outside a rice farmer office, a flock is descending on the green paddies, the mountains beyond glow with evening light. ‘In the early 90s you didn’t see birds here. The pesticides used to kill the birds and snails and everything else. Then we invested a lot to understand the ecological structures of rice paddies. You have these complex webs (nexus), and if you disrupt them, you have pest outbreaks. We learned that in the vast cases, you do not need pesticides. Rice is a tough plant. You can build resistance into it. We now have a rich ecology here, and our yields haven’t dropped.’