Sustainable Agriculture-Problem/Opportunity

Problem: There are over 7.2 billion people in the world today which is expected to grow to over 9 billion by 2050 (US Census Bureau 12-31-15).

Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007)

Today, over 80% of the land suitable for raising crops is used. This equates to a landmass approximately the size of South America (≈6 million square miles/15.5 million square km).

The world's largest cities include the following: Tokyo in Japan supports 38 million people, Delhi in India with 25 million, Shanghai in China with 23 million, and Mexico City, Mumbai, India, and Sao Paulo in Brazil, each with a population of around 21 million inhabitants. "By 2030, the world is projected to have 41 megacities with more than 10 million inhabitants each" (UN-WUP2014). The majority of the population growth will reside in cities, increasing the percentage to 70%, up from 54% in urban environments by 2050 (2011 GAP). The primary "Green Revolution" or modern farming in developed countries is almost peaked. Using existing technology (engineered crops, new automated planting and harvesting techniques, irrigation automation technologies, sUAS [small unmanned aerial vehicles] scouting methods, new fertigation, and chemigation chemicals and methods) to improve Total Factor Productivity (TFP) designed to double or quadruple production per acre.

"With 54% of the world population currently living in cities with 82% of North Americans living in urban areas." (UN WUP2014).

The plan as of now is to apply these modern farming techniques and technologies in developing countries to meet current and future demand where the majority of the growth will be. However, the educational and environmental infrastructure doesn't exist. The unpredictability of the world's weather patterns has made it so the growers can no longer rely on a consistent growing season. These are fundamental reasons why irrigation control and management are the keys to expanding modern farming worldwide.

One of the critical questions becomes, is the freshwater (surface and ground) available? The sizeable harmful byproduct of irrigation is decreased water quality due to improper irrigation control and the associated run-off carrying unabsorbed nutrients into the waterways. In developed countries, all farmers must learn to adapt accordingly, creating the need to embrace modern farming techniques and technology.

The following key question is as scary as not having enough fresh water for potable use and irrigation; what is the cause of species (plant and animal) extinction? It is reported and backed up with current data the leading cause of habitat degradation worldwide is agriculture, with urban sprawl, logging, mining, and some fishing practices close behind. Habitat degradation manifests itself through contamination (chemical pollution) of the living environment and the physical destruction of niche habitats. The widespread destruction of tropical rainforests in developing countries and replacing it with farmland eliminates many species' infrastructure to survive.

> "Global warming has allowed some species to expand their range, bringing unwelcome competition to other species that previously occupied that area. Sometimes these new competitors are predators and directly affect prey species, while at other times they may merely outcompete vulnerable species for limited resources. Vital resources including water and food can also be limited during habitat degradation, leading to extinction."

Do we really want to expand traditional farming anywhere?

The G8 and G20 group of countries have recognized the problem and have prioritized how to feed the world during the financial crisis and are thus trying to define the new vision of agriculture. The era of cheap food has come to an end. The higher cost of food is due to a combination of factors—rising demand in India and China, a dietary shift away from cereals towards meat and vegetables (Economist). Data shows that we produce enough calories/person for the population now, but the food is not where it needs to be. Improving distribution is not cost-effective or sustainable due to logistics, operation, and maintenance of conditioned transport and spoilage. The unpredictable effects of climate change have altered the ability of farmers to manage their farms and environmental resources easily.

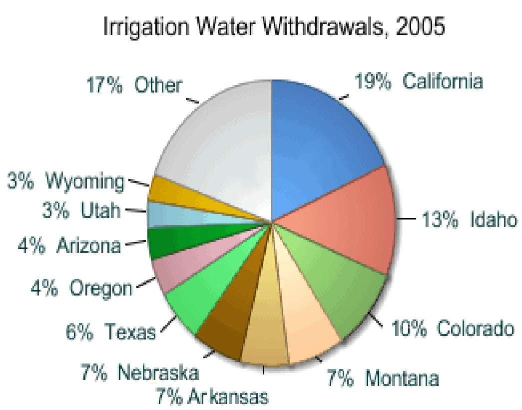
The G20 has not appropriately defined the financial support to implement this world-scale project to expand modern farming. A new tractor costs half a million dollars (USD) each, without accessories, and an automated diesel-driven irrigation pump costs 85,000 dollars (USD), not including installation. The picture is clear; the model to expand traditional farms to feed 9 billion people by 2050 is not economically or environmentally sustainable.

"To produce 60% more food by 2050 to feed the expected nine billion people, it can't be business as usual. We simply don't have the energy or water to sustain such an increase."

Gerda Verburg – Chair of the UN Committee on World Food Security (02-27-15)

The vision is clear: expand indoor/vertical farming solutions for leafy greens and vegetables – an economically viable plan because it is environmentally sustainable. The farmer controls the environment managing the plant's photosynthesis cycle, increasing yield by at least ten times per given area by maximizing plant density and increasing the number of "growing seasons."

The US is blessed with more arable land than any other nation, with 408 million acres (including harvested, failed, and fallowed land) used for crop production. Approximately 80% of the Nation's consumptive water use is used for Agriculture (USDA-NASS-ERS 2008). Only 18% of the total farmland in this country is within a metropolitan area (USDA NRCS). A USDA study conducted in 2008 evaluating only 17 western states confirmed that 39 million acres utilize controlled irrigation out of 160 million farmed acres. Based on this report, a total of 23.4 trillion gallons of water was used to irrigate the crops in these 17 states. The survey showed that the energy cost required to apply the 23.4 trillion gallons of water (all fuels: gas, diesel, LP, electricity) was 2.4 billion dollars, with an average cost of $89/acre for (CA, ID, KS & TX). This cost per acre does not include the labor or transportation costs of managing the irrigation process. The irrigation implementation, control, and management process have been proven worldwide to improve yields across a broad range of lands. We haven't even employed new irrigation automation systems throughout drought-stricken CA over the last three years. Do we think it is realistic to expect third-world countries to fund and install these solutions?



Most water withdrawals (85 percent) and irrigated acres (74 percent) were in the 17 conterminous Western States. The 17 Western States are in areas where average annual precipitation typically is less than 20 inches and is insufficient to support crops without supplemental water. Surface water was the primary water source in the arid West and the Mountain States. California, Idaho, Colorado, and Montana combined accounted for 49 percent of the total irrigation withdrawals and 64 percent surface-water irrigation withdrawals. Nearly 90 percent of the groundwater used for irrigation was withdrawn in 13 States, and each of these States consumed more than 1,000 Mgal/d (1,120 thousand acre-feet per year) of groundwater for irrigation in 2005. Among these 13 States, groundwater was the primary source for irrigation in Nebraska, Arkansas, Texas, Kansas, Mississippi, and Missouri.

Five States—California, Nebraska, Texas, Arkansas, and Idaho—accounted for 52 percent of total irrigated acreage. Nebraska, Texas, and California accounted for 41 percent of the irrigated acreage using sprinkler and micro-irrigation systems. California alone accounted for 65 percent of the irrigated acreage with micro-irrigation systems. Sprinkler and micro-irrigation systems combined were associated with more than 56 percent of total irrigated acreage. But of the water used for irrigation, only about one-half is reusable. For example, the rest of the water is lost to evaporation, evapotranspiration from plants, or lost in transit by a leaking pipe.

The 41 separate assessments prove that the long-term (1900-2008) cumulative depletion of groundwater in the US is about 1,000 cubic kilometers (264 trillion gallons)-nearly twice the volume contained in Lake Erie. This large volume of depletion represents a severe problem in the US because much of this storage loss cannot be easily or quickly recovered and affects the sustainability of some critical water supplies and baseflow to streams, among other effects.

The three individual systems that represent the most significant contributors to groundwater depletion in the US are the principal aquifer systems: High Plains aquifer includes the Ogallala aquifer and underlies about 175,000 sq miles (Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming), the Mississippi embayment aquifer system Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee) and the Central Valley aquifer system (supplying over 20,000 sq miles) in CA. In addition to the adverse environmental effects of groundwater depletion, the depletion also impacts communities dependent on groundwater resources. The continuation of withdrawal at observed rates makes the water supply unsustainable. The observed rates of depletion must eventually decrease as economic and physical constraints lead to reduced extraction levels. (USGS – Groundwater Depletion in the US (1900-2008)).

> 'If current irrigation trends continue, 69 percent of the groundwater stored in the High Plains Aquifer of Kansas will be depleted in 50 years.' (David Steward-KS State 08/2013)

> 'Between 2011 and 2013 the High Plains aquifer the largest in the US dropped 2.1' or a 12% volume decline showing we are removing more than Mother Nature can make up.' (USGS 2014)

'Over pumping in the Central Valley has depleted groundwater reserves by nearly 20 million acre-feet (6.5 trillion gallons) of water between 2002 and 2012. Areas of the valley are sinking as growers pull more and more water from the ground, which has been on a negative decline since 1962.' (CA Dept of Water Resources, USGS)

> 'The inability to reach water is expected to cause 428,000 acres or 5% of irrigated CA crop land to go out of production with the direct costs to CA agriculture totaling $1.5 billion dollars (USD) in 2014. (UC Davis-07-2014). With the CA April snow survey revealing the lowest snowpack measurement ever recorded, the state will experience its fourth year of severe drought conditions, creating even more competition for water resources (04-01-15).'

It's not simple math, calculating how much-added production will be needed to feed 9 billion people in 2050. Many have estimated that we will need to increase food production by 70%, with output in developing countries doubling as improved economic conditions occur. It has been shown that as inhabitants become more affluent, their tastes change from grains to more vegetables and meat. Their new preferences would require us to create an unsustainable increase in growing area by 270,000 to 463,000 sq miles (700,000 – 1.2 mil km2) with irrigated land growing by 11%, which puts additional pressure on renewable water resources already stressed (FAO-2009). This new area would be the size of California and Texas combined! Is this possible? Can the earth's ecosystem afford to support the destruction of rain forests to create this new farmland (see species extinction above)?

Multiple studies have shown that both rich (waste it) and poor (lose it) countries don't utilize a staggering 30-50% of all food produced; it rots away uneaten! Dairy products and fresh vegetables are wasted primarily due to conditioned transit-related issues, while grains are lost post-harvest by primarily unsecure storage methods in developing countries.

Significantly less waste will be created by only harvesting what is needed for the meal from the indoor farm. No waste is produced from conditioned vegetable transportation needs, leading to food spoilage before reaching the shelves or table. US production of fresh vegetables totaled 42.6 billion pounds in 2014 (USDA-ERS), with over 15 billion pounds of fresh vegetables imported. Can you imagine avoiding the waste and handling cost of up to 28 billion pounds of fresh vegetables?

> *"Food loss is the blind spot in our fight against hunger 64% of food is lost before it gets to market despite the fact that technological solutions are available. This is both tragic and unnecessary."*
> Salif Romano Niang – Aspen Institute Food Security Strategy Group

Opportunity:

Indoor/Vertical Farming is a closed-loop agricultural process, conserving water (up to 22 gallons/head of lettuce savings) by circulating it and only making up the water used by the plant, resulting in very little evaporation. The potential to eliminate the need for pesticides, minimize nutrient addition by only providing what the plant needs, producing no run-off, eliminating the adverse water quality issues experienced in almost all agricultural areas across the world. According to the USDA NAAS, there were 4.8 billion heads of Iceberg and Romaine lettuce produced in the US in 2013, if 20 percent were made indoors, we would save 21 billion gallons of water, avoid the fuel used to pump the water, and the GHG created by burning the fuel. Based on losses due to transportation and handling, we would be potentially saving up to 384 million heads of lettuce if we produced 20% of them locally, saving an additional 8.4 billion gallons of water!

The US produces 70% of lettuce in CA, and transportation costs the consumer between 19 – 34% to deliver it to the east coast. The USDA ERS study in 2013 confirmed the cost of production is subject to the volatility of worldwide oil prices, and as more local produce is available, this will become a non-issue. The lettuce waste caused by physical damage (vibration, compression, and impact) caused by transportation will also be eliminated if local indoor farms are created. The cost of packaging, the energy, and materials used for packaging and handling will dramatically decrease the delivered price.

Indoor farming would allow the farmer to fine-tune the needs to maximize photosynthesis, resulting in improved yields and plant health, leading to multiple harvests per year, all year round, regardless of changing weather patterns. Drastically minimizing the carbon footprint of farming further decreases our dependence on fossil fuel and the contribution to air pollution that the transportation of food currently causes.

The Indoor Ag Business is experiencing rapid growth with a potential annual market size now reaching $9 billion (USD) due to:

- *Food supply chain challenges*
- *California's drought*
- *Desire and need not to destroy forests to create a sustainable planet*
- *Transportation/handling costs*
- *Scarcity of new farmland*
- *The push against genetically modified plants (GMO)*
- *Consumers desire to have fresh locally produced food production*

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