Game Changer in Addressing the Scarcity of the Two Main Drivers of Agriculture and Food Systems

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Discussed during The SEARCA Agriculture and Development Seminar Series (ADSS) held on June 20, 2019, 3 to 5 pm; at Drillon Hall, SEARCA, UPLB, College, Laguna
Flow of Discussion

→ Water and energy >>>> the 2 main drivers for agriculture and food systems

→ Game Changer to hurdle their scarcity
Why water and energy were considered as the 2 main drivers for agriculture and food systems & not .. POP’N

The main driver?

Population $\leftarrow$ food

Population $\rightarrow$ food

$\downarrow$

water + energy

Stop population growth? Stabilize at 8B & not 9.8 B $\rightarrow$ Is it feasible??

Population the main driver
2017 world’s population numbered nearly 7.6 billion
→ (mid-2017..added 1 billion inhabitants over the last twelve years).

- 60% - Asia (4.5 billion)
- SEA--- 0.640 billion(10 countries)-8.4%
  - 17% Africa (1.3 billion),
  - 10% Europe (742 million),
  - 9% Latin America and the Caribbean (646 million),
  - 6% Northern America (361 million) and Oceania (41 million).
- 19% China (1.4 billion)
- 18% India (1.3 billion)

1st Driver

Energy
Why Energy ......

Producing and distributing food is energy-intensive

1 cal of food (organic) = 3-4 cal energy to produce + 3-4 cal to distribute

= 6-8 cal of energy

1 cal of food (conventional) = 8-10 cal to produce + 3-4 cal to distribute

= 11-14 cal/cal of food
Food is Energy…….

*Producing food uses a lot of energy ➔ fossil fuel oil*

➔ Fossil fuel oil supply has reached its GLOBAL peak or half of it had been used.

➔ Consuming oil had liberated 70% to 80% of Carbon causing global warming (about 1 deg. C rise in temperature)

➔ Burning all the oil will liberate \(17\) Tgt \(\text{CO}_2\text{e eq.}\) the calculated limit was only \(1\) Tgt so temperature rise will not exceed \(2\) deg C. (Baake, 2014)

.....sequester \(1.2\) Tgt \(\text{CO}_2\text{e eq.}\).

Oil discovery (Edwin Drake, 1859) made our food production & distribution so oil-dependent
Oil–based Food systems

→ high carbon emission in the food systems (44-57% CO$_2$e).

... the main driver of Global warming .. *Climate Change*!
Global oil consumption was 93 million barrels per day (bbl/day) = 34 billion BBL/YR on average in 2015.

By 2017, 99.5 million bbl/day 36.3 billion BBL/YR

(International Energy Agency (IEA)
https://www.google.com/search?rls=aso&client=gmail&q=global%20oil%20consumption%20per%20year &authuser=0

1 barrel oil= 158.987 → 1590 l i .... *Burning 1 li oil = 3.15 kg CO₂

Burning all known reserves of oil, gas, and coal would inject about 5 trillion tons of heat-trapping carbon into the atmosphere, mainly in the form of carbon dioxide, ...10 times the 540 billion tons of carbon emitted since the start of industrialization ... temperature shall increase up to 9.5 deg Centigrade.

The emission limit is 1.0 trillion tons to keep temp. below 2.0 deg C

*https://www.google.com/search?client=gmail&rls=aso&authuser=0&q=carbon+dioxide+emission+in+burning+1+li+of+oil&nirf=carbon+dioxide+emission+in+burning+1+li+of+oil&sa=X&ved=0ahUKEwj6nZ6jlfPiAhWMH3AKHWE8C2UQ8BYILigB&biw=1366&bih=657
Food logistics are so oil-dependent — power, transport, storage, processing, food factories, mills, equipment, tools

- oil provides more than 92 percent of the energy for all transportation, ½ of petroleum use (International Energy Agency, 2004).

- generates electricity, power industry and agriculture, and heat homes.

- asphalt for making road for transportation
Oil-based agriculture paved the way for sufficient food averting Malthusian prognosis. But....

- enhanced soil erosion,
- pollution of ground- and surface water.

- declining crop yields, and decrease in fertilizer use efficiency

...the response is to increase the use of fertilizers and pesticides derived from petroleum.

Worldwide, in 2012, over 324 million hectares are equipped for irrigation, of which about 85 percent or 275 million ha are actually irrigated.
### Increasing rice yields is through the use of agrochemical inputs

<table>
<thead>
<tr>
<th>Rice</th>
<th>Grain yield/ha</th>
<th>Total energy bill</th>
<th>Energy use/kg</th>
<th>Relative incr.of Energy (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low yield group*</td>
<td>3410.0</td>
<td>9871.0</td>
<td>2.96</td>
<td>206.59</td>
</tr>
<tr>
<td>Average yield group*</td>
<td>4931.0</td>
<td>13940</td>
<td>2.86</td>
<td>291.75</td>
</tr>
<tr>
<td>High yield group*</td>
<td>6196.0</td>
<td>17627</td>
<td>2.85</td>
<td>368.92</td>
</tr>
<tr>
<td>SL 8** (Hybrid)</td>
<td>8,350</td>
<td>35,971</td>
<td>4.31</td>
<td>752.85</td>
</tr>
</tbody>
</table>

* Shine et al 2016

** May soe & Mendoza (2017)

 Increasing yield from 6 ton/ha to 8.3 tons/ha increased the energy bill by 50%
Oil-based agriculture paved the way for sufficient food averting Malthusian prognosis.

Furthermore....

→ Soil organic matter decline → decreased water holding/retention capacity

....more oil energy is also used to pump irrigation water and to process polluted water (Pfeiffer, 2003)

Irrigation contributes to 40 percent of crop production worldwide - grown on 20 % of the world's cultivated area.

Worldwide, in 2012 over 324 million hectares are equipped for irrigation, of which about 85 percent or 275 million ha are actually irrigated.
...Water

2nd Driver
Why Water ......

Producing food is water-intensive

1 kg dry biomass = 3,000 kg water
1 kg rice = 5,000 kg water
1 kg beef = 19,000 kg water

Food is water
<table>
<thead>
<tr>
<th>FOODSTUFF</th>
<th>QUANTITY</th>
<th>Water consumption, li</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate</td>
<td>1 kg</td>
<td>17,196</td>
</tr>
<tr>
<td>Beef</td>
<td>1 kg</td>
<td>17,900 - 22,000</td>
</tr>
<tr>
<td>Sheep Meat</td>
<td>1 kg</td>
<td>10,412</td>
</tr>
<tr>
<td>Pork</td>
<td>1 kg</td>
<td>5,988</td>
</tr>
<tr>
<td>Butter</td>
<td>1 kg</td>
<td>5,553</td>
</tr>
<tr>
<td>Chicken meat</td>
<td>1 kg</td>
<td>4,325</td>
</tr>
<tr>
<td>Cheese</td>
<td>1 kg</td>
<td>3,178</td>
</tr>
<tr>
<td>Milk</td>
<td>1 kg</td>
<td>1,020</td>
</tr>
<tr>
<td>Rice</td>
<td>1 kg</td>
<td>2,497-5,000*</td>
</tr>
<tr>
<td>Cotton</td>
<td>1 @ 250g</td>
<td>2,495</td>
</tr>
<tr>
<td>Pasta (dry)</td>
<td>1 kg</td>
<td>1,849</td>
</tr>
<tr>
<td>Bread</td>
<td>1 kg</td>
<td>1,608</td>
</tr>
<tr>
<td>Pizza</td>
<td>1 unit</td>
<td>1,239</td>
</tr>
<tr>
<td>Apple</td>
<td>1 kg</td>
<td>822</td>
</tr>
<tr>
<td>Banana</td>
<td>1 kg</td>
<td>790</td>
</tr>
<tr>
<td>Potatoes</td>
<td>1 kg</td>
<td>287</td>
</tr>
<tr>
<td>Milk</td>
<td>1 x 250ml glass</td>
<td>255</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1 kg</td>
<td>237</td>
</tr>
<tr>
<td>Tomato</td>
<td>1 kg</td>
<td>214</td>
</tr>
<tr>
<td>Egg</td>
<td>1</td>
<td>196</td>
</tr>
<tr>
<td>Wine</td>
<td>1 x 250ml glass</td>
<td>109</td>
</tr>
<tr>
<td>Beer</td>
<td>1 x 250ml glass</td>
<td>74</td>
</tr>
<tr>
<td>Tea</td>
<td>1 x 250 ml cup</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: IME

https://docs.google.com/spreadsheets/d/1nzLd1LbiwVe2TL4y4kiejuUQKplx4Z3R5GHOguwvmo/edit#gid=0
WATER

Of the 1.4 billion km\(^3\) of water: 97.4% is salt water, 2.0% is locked in ice-caps and glaciers. Only 0.6% or 8.4 million km\(^3\) is fresh water. → About 8.0 million km\(^3\) of this, however, is trapped underground.

Available fresh water is only 0.4 million km\(^3\) (Pedrick, 1996) .... 0.03% of the total water

Available fresh water = \(\frac{0.4}{1400} \times 100\) = 0.03% of the total water

or

Available fresh water = \(\frac{0.04}{8.4} \times 100\) = 4.8% of the total fresh water
Water use by purpose

70% of fresh water for agriculture
20% for industry
10% for residential purposes

Fresh water consumption is almost 2x that of its replenishment

4.0 li/day ---- water for drinking
Economic Growth/development and its influence on how we produce our food

→ GDP-------= $ 2.0 trillion to 77.99trillion (38.5X)

→ 11 more energy

1960s (50 years ago), -11 million barrels of oil/day.
2017, 75 million barrels per day

→ 8 times material resources

50% ecological overshoot

→ CO2 level (pre-industrial)—280ppm

2013 → 400ppm
2017 → 430ppm?

Source: How Our Growth-Hungry Economy Has Devastated the Planet -- And How We Can Change Course, Berrett-Koehler Publishers / By Rob Dietz, Dan O'Neill
...how do we produce our food??????

→ more GHGe (46-54%, Grain International) leading to global warming/climate change

→ High GhGe is the Combined effects of .....  
  ..Deforestation, oil based-agric./food systems 
  ...Globalized instead of localized food(food miles effect, logistics intensive 
  ...Economic Growth/development
how do we produce our food?????

more GHGe (46-54%, Grain International) leading to global warming /Climate change
how do we produce our food??????

Limiting global warming to 1.5 deg. Celsius ...

Requires

→ €2.1 trillion of investments in the global energy system every year between 2016 and 2035, or about 2.5% of world GDP

→ Sequestering back 1.2 TGt of CO2e

How do we sequester back 1.2 TGt CO2e ?????
Feeding the Billions ....

Resource Scarcity -- the mother of inventions .. innovations

Technological innovations should be decoupled with energy and carbon emission and be water use-efficient.

Plus, it must be inclusive.

...by 2030 the world will need around 50% more food and energy, ...
30% more fresh water..... Mitigate and adapt to climate change....
There are over **0.5 million plant species** on the planet,

- 4 crops (wheat, rice, maize and soybean) supplies >3/4 direct food needs & as raw materials for livestock, aquaculture feeds and bioenergy systems.

→ `grown in a limited number of exporting countries... as industrialized monocultures.`

fossil fuel based inputs such as fertilizers, pesticides and irrigation, machines, globalized food→food miles

4 crops alone cannot feed a hotter world.

As the global temperatures increase by +2°C, the productivity of these 4 major crops will be much affected.

→ We need agricultural diversification to include a wider range of crops and cropping systems and localized


What are the Game Changers to hurdle the scarcity of the 2 main drivers of Agriculture and Food Systems... ????
In agriculture and food systems, the Game changer is Organic Agriculture..

→ The 2\textsuperscript{nd} Green Revolution

or

the 4\textsuperscript{th} Wave Agriculture (Agric.4.0)
Organic agriculture... the game changer

Decrease oil usage

The 2\textsuperscript{nd} Green Revolution

Increase water retention in the soil

Increase water use efficiency

Effective Carbon sinks

Safe, nutritious & healthy, medicinal food

Organic Agriculture

Decrease costs of production

No synthetic fertilizer & pesticides, growth hormone

Localized food / decrease food miles

Decrease costs of production

Organic Agriculture is growing healthy soil

Therapeutic activity

Achieve agriculture multifunctions
reduce the energy use .. Decouple high oil-based energy use in agric.? 

*Organic rice reduce energy input \( \rightarrow 69-76.5\% \).

*May Soe oo & Mendoza, 2018
Healthy plants grow in *healthy soil*

Human health starts from our soil.

Poisoning our soil (use of herbicides, pesticides) is poisoning ourselves.
Organic agriculture is biodiverse agriculture

Therapeutic human activity

Biodiversity......3 levels-----genetic, species, ecosystems

Achieving farm multifunctionality

Biodiverse, Integrated
Organic (ORGANIC) farming ---
growing diverse crops
on a 0.2 ha (2,000 m²)
---root crops, vegetables,
---herbs, spices,
---medicinal plants
---and fruits
(juara, citrus, banana)
Crop establishment
Timing, spacing sequence

Seeds/seed production
Storage multi-species planting

Irrigation, Drainage, Conservation
Re-landscape

Nutrient management
Production, cycling
On environment

Season/environment
Linked.. Crop seasonality

Organic agriculture is making Agroecology at work

Food logistics

Biodiverse agroecosystems/components Interactions: crops, soil, water, pest.
Organic farms are productive...

Nutrient cycling, N-fixing, P-solubilizing bacteria nourishing the plants and plant growth-promoting bacteria enhancing crop growth & yields,

- Planted into biodiverse crops → multi-trophic level interaction of pests, predator, parasites, parasitoids
- Healthy soil → healthy crop - microbes (nano-eliciting) confers resistance/immunity to pathogens and other pests, or systemic acquired resistance (SAR) makes crop resists pests.
- Pollinators - bees, butterflies, -- seeds spreaders
- High soil organic matter (SOM)

Soil – the bases of healthy food → heathy people

→ Carbon sequestration
Soil Organic Matter....... Living Carbon

- Holds up to 30X its weight in water
- Cements soil particles, humus ..glue-like substances ... better soil aggregation
  >> improves soil structure
- >> reduces soil erosion
- Humus can last 2000 years in the soil.

**Volume of Water Retained /ha (to 30 cm vs.soil organic matter (OM))**
- 0.5% OM = 80,000 litres (common level)
- 1% OM = 160,000 litres (common level)
- 2% OM = 320,000 litres
- 3% OM = 480,000 litres
- 4% OM = 640,000 litres (levels pre farming)
2nd Game Changer

Addresses simultaneously water and energy.....
→ Food sufficiency
Adopting Organic Agriculture is not enough. Need efficient, less energy & water-using consumption pattern.

Off season → more pesticides.

500km distance increases the energy bill 22x. What more if imported from Thailand or Vietnam?

- Less...less meat...
- Plant-based diet
- No cooking

Accept crop seasonality

Consume food Low in the food chain

Eat locally Grown diverse food

Eat fresh/ Raw food
Eating locally grown food .. Better grow your own food

Minimize food miles

>>> Reduce the use of fossil fuel energy for transport, process, package, store in cold storage

Mae Soe oo & Mendoza, 2017
Adopt Plant-based diet -- Reduce meat consumption

1. 70-80% of all our agricultural lands are used to produce feed, forage, pasture (30% of terrestrial lands)

2. More than half of all cereals (56%) are fed to animals grown using oil-based inputs (fertilizers, pesticides)

3. Excessive thermodynamic loss of food protein
   →6 to 7 kg plant protein = 1kg protein from meat

1 + 2 + 3 = clearing lands = deforestation

Meat consumption = deforestation
The African Swine Fever outbreak, has now spread to China, could result in the slaughter of 200 million hogs this year, in an effort to get the disease under control. China grows half of World’s pig ...more than 400 million pigs a year.*

7 kg of plant protein is needed to produce 1 kg beef. This ramifies into excessive water use. 1 kg of beef consumes 15,000 to 19,000 liters of water;

4 kg of plant protein is needed to produce 1 kg pork. 1 kg pork at 8,000 to 12,000 liters of water and

2.5 kg of plant protein is needed to produce 1 kg broiler. 1 kg broiler at 6,000 to 8,000 liters of water

<2.0 kg of plant protein is needed to produce 1 kg fish.
Land requirement to achieve food sufficiency

Meat based ‘Atkinson” diet – 1.4 ha

Typical American diet requires 1.35 ha

→ If we all eat like the Americans, we will need 4 more earths

Vegetarian → 0.06 ha

→ 10B/16.6) = 600Mha (world)

or 40% of total agricultural land =1.5 Bha

→ 180/16.6) = 10.8M ha (Phil.)

Estimated agric. land area per cap (Phil.)= 0.41 ha (CIA, 2004)

By 2050, the Philippines shall have 180 million population.

→ need 74 Mha of AGRIC LAND. BSWM 2017 estimates of agric.land = 7.78Mha ...

→ need 9.95 x more lands
• **Plant-based diet**.... **Source of protein**

  - Protein sources - mungbean, pigeon pea, batao, sitao (pole, bush sitao), **moringa (contains all amino acids)**, + fish + native chicken

• Vegetarian - Pesco vegetarian, - lacto vegetarian, - Ovo vegetarian, - Lacto ovo pesco vegetarian
  Vegan (pure plant-based diet)

→ Flexitarian during the transition stage

**Beyond Meat soars 163%.. in biggest-popping U.S. IPO since 2000**
Beyond Meat CEO Ethan Brown thinks his meatless product is ready to take the global stage
Meat+ milk-based diet

Animals ⇒ major cause of deforestation, biodiversity decline, Green house gases emission & health crisis

Increasing meat consumption due to increased income + human population
Animal agric. & meat diet --- the major cause

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The costs of beef

Steak is expensive, its true cost is even higher than you may think.
(Adam Nierenberg August 04, 2014
https://www.ep.org/topics/2013-08-04/steak-expensive.html?fbclid=IwAR3q-Fby24ijT34AWQbttQPElYityznyxYU1STxjxyu7z_0W6hjzIqL2PA

1. mega-calorie of beef — or 1,000 calories — requires about 100 square meters of land. By comparison, eggs or poultry require about 6 square meters.

2. The beef uses 1.8 cubic meters of water compared to about .1 cubic meters of water for eggs or poultry.

3. Beef contributes to water pollution eight times more than eggs or poultry.

“A factor of eight is staggering.”
Logging – legal/illegal, slash & burn farming, charcoal making

..... to reforest 10 Mha = PhP 1 trillion..... 10 year @ 1Mha/yr
= PhP 100 billion/year

South Korea forests
Animals → major contributor of Green house gas emission

30-36% of all GHG emissions → contribution of Animals

All the 850M vehicles contribute only 18% of GHG.

>>70% of all the agricultural lands are devoted for pasture and forage production
.....15-18 % of GHG is attributed to land use change/deforestation.
= 13% of all GHG due to land use change/deforestation to raise animals

>>>50-60% of all grains are fed to animals in CAFO (Confined Animal Farming Operations). Thus, accounting for 50-60% of all oil-based manufactured inputs (fertilizer pesticides) emitting CO₂, CH₄. Animals produce manure that liberate CH₄ and NOₓ during decomposition. Enteric fermentation in ruminants emits huge methane.

Processing and distribution of animal products contribute much CO₂ emission.
As a whole, about 60% of all emission in the food system (about 57%) is due to animal production and meat/ milk processing.
### Carbonfootprint by food type (protein) *

<table>
<thead>
<tr>
<th>Food Source</th>
<th>gCO2 e</th>
<th>X more</th>
<th>Relative to Beef (%)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef / mutton</td>
<td>221.63</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pork</td>
<td>36.33</td>
<td>6</td>
<td>16.4</td>
<td>83.61</td>
</tr>
<tr>
<td>Dairy</td>
<td>35.07</td>
<td>6</td>
<td>15.8</td>
<td>84.18</td>
</tr>
<tr>
<td>Poultry</td>
<td>31.75</td>
<td>7</td>
<td>14.3</td>
<td>85.67</td>
</tr>
<tr>
<td>Eggs</td>
<td>24.37</td>
<td>9</td>
<td>11.0</td>
<td>89.00</td>
</tr>
<tr>
<td>Rice</td>
<td>21.16</td>
<td>10</td>
<td>9.5</td>
<td>90.45</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.62</td>
<td>48</td>
<td>2.1</td>
<td>97.92</td>
</tr>
<tr>
<td>Maize</td>
<td>4.42</td>
<td>50</td>
<td>2.0</td>
<td>98.01</td>
</tr>
<tr>
<td>Pulses</td>
<td>0.58</td>
<td>382</td>
<td>0.3</td>
<td>99.74</td>
</tr>
</tbody>
</table>

*Clark & Tilman, 2017*
Meat consumption is on the rise..

- World meat consumption: 47 million tons in 1950, 260 million tons in 2005, more than doubling consumption per person from 17 kilograms to 40 kilograms.

- Consumption of milk and eggs has also risen. Where incomes have risen, meat consumption too.

- About 730 million tons of the world grain harvest are used to produce animal protein.

Plan B 2.0: Rescuing a Planet Under Stress and a Civilization in Trouble Lester R. Brown
Chapter 9. Feeding Seven Billion Well: Producing Protein More Efficiently
GLOBAL animal population

- 1.7 billion sheep and goats
- **1.3 billion cows**
- 0.85 billion pigs
  - 0.12 billion horses
  - 0.16 billion camels and water buffalo
- **10-11 billion fowl, chickens**

Source: [Livestock - Cows, Sheep And Goats, Pigs, Horse And Donkey, Camels And Llamas, Buffalo - Rabbits](http://science.jrank.org/pages/3980/Livestock.html)

- **600 million plus CATS** [https://animals.howstuffworks.com/pets/just-how-many-house-cats-are-there-the-world.htm](https://animals.howstuffworks.com/pets/just-how-many-house-cats-are-there-the-world.htm)
Meat consumption, Philippines (2014)

<table>
<thead>
<tr>
<th>Commodity/Meat Type</th>
<th>kg/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork</td>
<td>14.87</td>
</tr>
<tr>
<td>Dressed Chicken</td>
<td>10.97</td>
</tr>
<tr>
<td>Beef</td>
<td>2.01</td>
</tr>
<tr>
<td>Carabeef</td>
<td>1.25</td>
</tr>
<tr>
<td>Chevon</td>
<td>0.42</td>
</tr>
<tr>
<td>Duck</td>
<td>0.16</td>
</tr>
</tbody>
</table>

29.68 KG
If we eat less and less meat

→ great reduction in the fossil energy bill, water of our food which is centered on grains.

→ Grain production is fertilized heavily of Haber-Bosch nitrogen fertilizer (that emits 12.18 kg CO₂eq per Kg N ) to produce 2.4 billion tons of grain.

→ less pressure to produce feed grains providing ample time to convert farms into organic (no chemical N-fertilizer and pesticides ).

→ Reducing meat consumption by ½ shall free 0.7 billion ha of lands that can be reverted back into forests lands.
In summary ..the Game Changers to hurdle the scarcity of water & energy in agriculture and Food Systems are:

1. Adopt a localized, biodiverse Organic Agriculture —
   - Less energy, water-efficient, cost-saving, safe & healthy foods
   - Sequester CO$_2$e in the landscape

2. Shift to Plant-based diet— less and less meat
   - Free more lands to plant trees
   - Less grains be fed to animals
   - In combination with organic agriculture, use less energy and water + sequester CO$_2$e in the landscape
Thanks for your attention...

Thanks to those who have already reduced their meat intake and for all those who are about to start reducing their love for meat.

.. Carry on !!!

Q.E.D

ted c. mendoza
I acknowledge with thanks the Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) for the travel grant and UPLB for the permit to travel officially and be able to present the gist of this game changing advocacy on overcoming the 2 drivers of food scarcity in Bali, Indonesia during the 7th International Conference on Integrating Science and Technology for Sustainable Development held at Patra Bali Resort and Villas, Bali, Indonesia, November 26-29, 2018. In turn, it gave me this opportunity to present this to Agriculture and Development Seminar Series (ADSS). And also to the many farmers I have interacted with during these years whose names I could not recall at all.....

I thank them for cheerfully sharing on a give-all–atmosphere their organic farming experiences, systems, and innovations unique to their farms.