Circular Economy applied to the Agri-Food Sector

Food is NOT just the product you eat (corn, meat, cereal)
- *the resources consumed to produce it (oil, water, soil, fertilisers, etc.) must be accounted for!*

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SERBIA
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Resources Used

Food Waste is a high energy & resource input product

10 MJ of fossil energy

1 MJ of food energy

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From a valorisation perspective ...

• Food waste is **NOT** a low resource value feedstock
• In effect, it’s a high fossil fuel (and other resources) based product
• Valorisation options are wide and varied - from combustion (for energy) to the extraction of high value bio-chemicals, etc.
• Some options better than others with regard to environmental impact
• ALL need a cascade type approach to determining the best environmentally compatible pathway
The primary role of Agriculture is to produce FOOD

Valorisation ONLY arises where there are UNAVOIDABLE waste streams (in effect byproducts)
Can ‘upgrade’ a waste stream for reuse within the agri-food system OR outside
Once the product goes outside the agri-food system it enters another domain (‘loop’)
Need to assess the impact of such ‘leakages’
Leakages ...

- But, as well as ‘leakages’ there are ‘inflows’ e.g. oil, P, agro-chemicals, etc. – and guano back in C19
- The agri-food system is OIL dependent!
- It’s a tapestry of interwoven pathways
  - Some ‘looped’
  - Others, linear (final destination)
Life Cycle Assessment (LCA)

• LCA tries to quantify these pathways
• Problem is, they are so varied and dispersed that it is NOT possible to account for all dimensions
• At best, hope to account for >50%
System Efficiency & Sustainability must take a full systems based approach (farm to table and beyond)

Valorisation Loops
- Some go back in
- Others go out ...
Inefficiencies and losses ...

• Unfortunately, the system is inefficient, with:
  • 30% losses and;
  • output foregone due to inefficient production operations
• So overall system losses > 50%
Let’s step back in time …
Sustainable agricultural production system

- 19th C - Norfolk four-course rotation
- World population: ca. 1.5 billion
- Locally based economy
- Soil quality retained

Global trade in guano

Norfolk C21 is needed to:
- Stabilise (reverse!) soil carbon losses;
- Ensure food production;
Within-Farm Loop
Valorisation Concepts and Systems

AgriLoop and Hercules
(developed by AUTH and DTU)

An attempt at a C21st Norfolk 4-Course Rotation

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Figure 2. The AGRILLOOP HOB-MOB Valorisation Process into a circular economy model: PGPB, bio stimulants, struvite, compost and SCP for enhanced crop and animal performance.
Oh, what a tangled web we weave
Sir Walter Scott

LCA
Local v. Global

• In 19th C, local could provide the needs of mankind
• Not so now – it’s GLOBAL!
• 1950 ca. 2.5 billion people
• Lifestyle was more frugal then!
• Both population & lifestyle have grown and continue to grow
• Unprecedented rate of growth in demand for food
• Ongoing changes in dietary preferences
Meet **LIFESTYLE**, the driver of **GLOBAL** demand...

**Expectations driven by:**
- Global communications: *Internet, Mobiles, TV, Films*
- Education
- Travel & immigration
- Rising standard of living (for most)
- Technical ability to deliver

**Awareness, expectations and an inner resolve to improve one’s options and lifestyle!**

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Environmental systems are global!!

Global Agri-Food Industry, The Atmosphere & Economics cannot be ‘ring-fenced’

Who pays?  Burden Shifting
If the world wants beef, is it the beef producing countries that take all the ‘environmental burden’ or is it the consumer?

Who pays the environmental cost?  Producer or consumer?
Who should pay?
Starting points ...

• Feeding the world is a challenge but perfectly feasible
• Population has tripled since WWII (2.5 billion to 7.5 billion)
• Dietary requirements and expectations changing rapidly towards a ‘cosmopolitan’ diet
• **Cannot feed the world without global food trade**
• Food should be grown as **efficiently** and **sustainably** as possible
• Must support the most efficient and sustainable producers – e.g. match zone (country/region) to the efficiency and sustainability of food production
• Policy and economics must support (NOT penalise) efficiency & sustainability
• Use global trade to bring efficiently produced food to markets
• C emissions (CO\(_2\) and CH\(_4\)) are, primarily, a GLOBAL issue, NOT Regional/Local
Efficiency means less environmental impact ...

- Environmental impact increases as food production efficiency decreases!
- Environmental impact (particularly atmospheric) knows no boundaries!
- Implementing ‘circular systems’ within a STATE boundary invariably leads to HIGHER GLOBAL environmental impacts!
- Example:
  - Meat and milk production in Ireland ranks in the top efficiency tier globally;
  - Yet EU and National policies and other ‘pressures’ want to cull bovine numbers in Ireland BECAUSE Ireland has a CH₄ emissions reduction target to reach!
  - A classic case of ‘the right hand not knowing what the left hand is doing’!

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Circular Economy

• The ‘circular economy’ is primarily about resource use efficiency
• It is NOT just about cycling resources - the starting point is to use FEWER resources in the 1\textsuperscript{st} instance!
• System efficiency is fundamental – cannot assume that if a waste is ‘used’ then the system is in some way more sustainable
• Must avoid The Jevons Paradox – creating a ‘market’ for waste may generate more waste!
• Global trade in both food (feed) and back-trade in input resources required to achieve a reasonable level of ‘sustainability’

• On the risk side regarding global trade: supply chain integrity; food safety; ‘politicking’ food; etc.

• Regulation is a powerful and necessary tool to support sustainable systems

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Market for Waste

In implementing a bioeconomy approach, there is a real danger of generating a market for waste streams thereby reducing the pressure on primary producers to be efficient and on consumers to reduce food waste.
3. Low Mass and High Value

Secondary demand exists because output is valuable. As the value increases, there is a risk that demand will generate greater mass forcing

4. High Mass and High Value

Should not be considered as waste. As clear market value and driver to support generation of mass. If part of a waste stream then there is significant upstream inefficiency to create the valuable substance. Indicative of sub-system optimisation. The incentive to reduce is low.

Enhance return by producing more waste

Tail wagging the dog!!

Enhance value

Jevon’s Paradox

1. Low Mass and Low Value

Arises because there is either little waste produced or system has been modified to reduce waste. Low value either because resource has little inherent value or there is too little available to make utilisation worthwhile. If use found, could be forced to class 3. The incentive to reduce is high.

2. High Mass and Low Value

Arises because system inherently produces too much waste. No real post-process market for outputs. If use found, could be forced to class 4 rather than reduced to class 1.

Improve efficiency

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Agri-Food based Bioeconomy

• Treat with caution!
• It has a valuable role BUT only ‘after the fact’
• A bioeconomy should only be built on ‘unavoidable’ agri-food wastes *(i.e. byproducts of efficient agri-food chain)*
• A bioeconomy creates a market for wastes
• The citizen assumes ‘problem solved’
• Ultimately the feedstock supply dwindles and system fails!
Corporate Social Responsibility (CSR)

• Very much in vogue
• Potentially a very powerful pathway to achieving impact
• Citizens demand it BUT citizens tend to follow media hype!
• Pressure on businesses relentless
• CSR initiatives are being scrutinised, more so now than ever
• Companies have a lot to lose if they get it wrong, but there is an element of ‘running with the hare and hunting with the hound’!
  • They want to meet the expectations of their clients (and wider society) while also satisfying regulations and the science
Key points ...

• Global trade in food is essential to ensure the scale and variety necessary to meet the exponential rise in global demand for food
• Local food production cannot meet this demand
• Global trade is a key enabler of efficient food production and ‘circularity’
• There is a limited land base and input resources (e.g. P) for food production
• Future is a hybrid local-GLOBAL food market, with GLOBAL the dominant (> 90%) and both local and GLOBAL resource recycling loops
• Market and regulatory systems should incentivise GLOBAL trade in produce from countries that are the most efficient (and sustainable) producers (i.e. those in the upper echelons of production efficiency, sustainability, quality and safety)
Efficiency from farm to table, and beyond ...

- On-farm efficiency ... technology + market ‘pressures’
  - Supply contracts to processors or retailers impact on efficiency and losses

- Retail operations ...
  - Some marketing initiatives may generate waste (e.g. 3 for price of 2) – moves the waste elsewhere (i.e. to the home) – the “cleaner fish’ scenario!!
  - Packaging - positive (hygiene, shelf-life, marketing) and negative (waste)
  - Supply contracts (farmer discard ‘unacceptable’ produce)

- Bio-economy ... Uses agri-food waste as feedstock
  - Danger of the Jevons effect!
  - Longer-term sustainability – if the availability of feedstock decreases due to enhanced upstream efficiency ...
Waste across the complete agri-food chain

• On-farm due to:
  • operational inefficiencies
  • contractual issue with off-farm customer (processing plant, retailer)

• Retail business
  • The Citizen (Consumer) – key driver!!
  • Beware of a bio-economy built on waste as feedstock!
‘consumer pays principle’

Assign the true burden to the end-user (i.e. consumer), not the producer
- i.e. in effect, a ‘consumer pays principle’ which is analogous to the long established ‘polluter pays principle’
Produce more using LESS

The overall objective must be to produce more food using fewer input resources (i.e. the ‘more from less’ paradigm)

This is particularly important in the livestock sector, where the overall resources inputs per unit output are significantly higher than plant-based food systems
Global trade in food and agri-resources (e.g. fertilisers) is truly extensive.
Use these networks to implement globally efficient food chains.
No extra environmental or economic burden involved.
GLOBAL Circular Economy

Achieve reduced global impact through the growing of food (using best practice) in the most efficient zones for each food (or feed) product, with global trade enabling the distribution of these foods (feeds)

AND

Back-trade in resources (e.g. bio-fertilisers)
Life cycle assessment (LCA)

In order to understand which technology pathway should be prioritised for a given agricultural waste or for a specific scenario, life cycle assessment (LCA) tools have been used extensively for assessing waste management and are being used now to evaluate the implications of waste valorisation within a ‘circular economy’.
I bring you back to where we started ... LIFESTYLE, the driver of GLOBAL demand...

Expectations driven by:
- Global communications: Internet, Mobiles, TV, Films
- Education
- Travel & immigration
- Rising standard of living (for most)
- Technical ability to deliver

Awareness, expectations and an inner resolve to improve one’s options and lifestyle!
Critical Levers for Circular Economy

- Efficiency
- Consumer education & incentives
- Societal responses (avoid ‘herd instincts’) 
- Must avoid The Jevons Paradox
- Corporate Social Responsibility
- Valorisation options need careful evaluation 
- Policy *(Pen mightier than the sword!)*
- Regulation

Policy MUST be well informed!
The ultimate solution is Societal, underpinned by Technical ...

- **BALANCED** and well-informed Education and Awareness
- Too many vested interest causing DAMAGE
- My Grandmother’s sayings:
  - he who shouts loudest ...
  - Empty vessels make most sound!!

- And there is a lot of NOISE out there – and Governments are deafened by its sheer volume and ‘simple solutions’ proffered by vested interests!
- Policy MUST be very well informed, adaptable and impacts monitored
- Plenty of mistake will be made
- It’s a MAJOR policy challenge requiring GLOBAL impact!
- There is no easy solution nor is there a PERFECT solution!
Socio-Economic 
consumer behaviour – education & lifestyle

• AgroCycle Kids (http://agrocycle-platform.com/)
• Start young
• Embed in the primary education system
• Long term impact
• Far greater than any technological solution!
• BioBeo – led by UCD with MU as the education specialist

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The impact of Education >> Technological …

• Far greater impact (medium to long term) than any technological solution!
• This is an open invitation to participate in BioBeo education programme

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