REAMIT Networking Symposium

9th January 2020
Crowne Plaza Nottingham, UK

Nicholas M. Holden
Professor of Biosystems Engineering

Life Cycle Assessment and the Contribution of Valorization to the Sustainability of the Food System

Agricultural Systems Technology

Course Information

BAgrSc (Hons) (NFQ Level 8)

Full Time- Undergraduate Studies

CAO Code: DN250
CAO Points Range 2019: 423
Length of Course: 4 Years
Average Intake: 175

Leaving Certificate:
O6/H7 in English, Irish, Mathematics, a laboratory science subject and two other recognised subjects

Click below for equivalent entry requirements information for:

- A-Level/GCSE
- Other EU Applicants
- Non-EU Applicants
- QQI FET Entry Routes
- Level 6/7 Progression Routes
- Mature Entry Route

Why is this course for me?

This course is aimed at students who wish to build their knowledge and skills-base to address the complexities of developing, deploying and managing technology for the agriculture sector. With a focus on design, numeracy and technology, our students will be committed and engaged with farming and food production, and specifically with technology, to enhance efficiency, sustainability and reliability. Technologies of interest range from computer systems, networks, data management and sensors, through machinery systems to precision agriculture.

Career & Graduate Study Opportunities

Graduates will find rewarding and challenging employment in agri-food industries, including:

- Production agriculture
- Environmental protection
- Consulting
- Equipment manufacturing
- Agri-Tech

Typical roles include technical and managerial positions in:

- Production
- Service provision
- Environmental protection
- Information technology
- Manufacturing
- Process & product design

There are also excellent graduate study opportunities to specialise in Environmental Technology, Food Engineering and Sustainable Energy and Green Technology.

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Related Courses
- Agri-Environmental Sciences
- Agricultural Science
- Dairy Business
- Forestry

Contact Information

Agriculture, Food & Nutrition

Upcoming Events
- CAO & Mature Student Information Evening – 7th January
- UCD QQI-FET Open Day 2020 – 14th January

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Food
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Nearly half of all fresh potatoes thrown away daily by UK households

Figures show nearly 6 million potatoes a day are wasted, at a cost of £230m a year

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Food waste
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More than £1bn of food wasted bef… reaching supermarkets - study

Wrap report finds 3.6m tonnes of food is thrown away or fed t… animals each year in the UK

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Waste
This article is more than 2 years old

Britons to throw away £428m worth of barbecue food in August, study reveals

Exclusive: Nearly 12m barbecues in the UK likely to over-cater with food ranging from salads to burger rolls ending up in bins

Editorially independent, open to everyone
We chose a different approach – will you support it?
Find out more →

Why does this matter?

"If wasted food was a country, it would be the third largest producer of carbon dioxide in the world, after the United States and China"
foodtank.com (2015)

"Agriculture is the largest contributor to biodiversity loss with expanding impacts due to changing consumption patterns and growing populations. Agriculture destroys biodiversity by converting natural habitats to intensely managed systems and by releasing pollutants"
Dudley and Alexander (2017) *Biodiversity* 18, 45-49

THE IRISH TIMES Wed, Oct 9, 2019

NEWS | SPORT | BUSINESS | OPINION | LIFE & STYLE | CULTURE

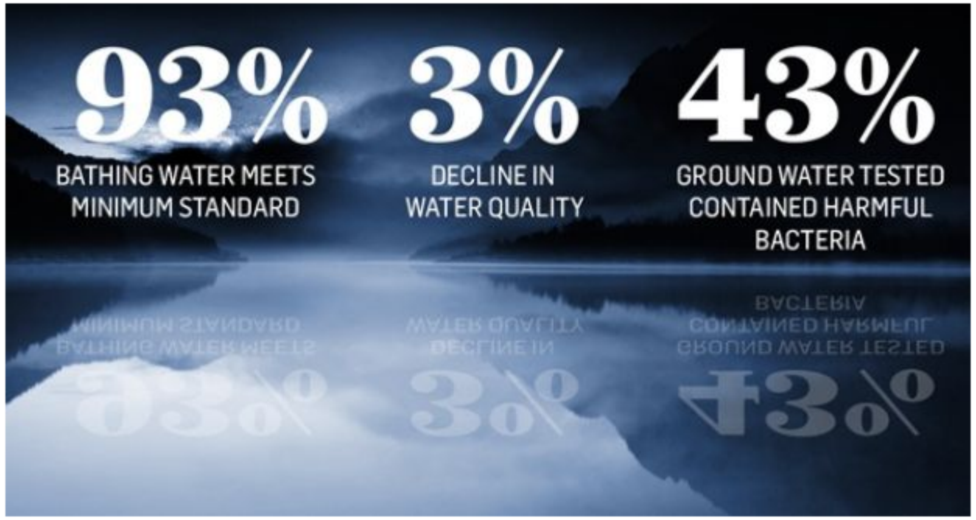
Ireland › Irish News

Farming pollution sees water quality in Ireland deteriorate

Environmental Protection Agency (EPA) says increased pollution is 'unacceptable'

Fri, Nov 30, 2018, 11:09 | Updated: Fri, Nov 30, 2018, 11:58

Ronan McGreevy



Some 269 waterways in Ireland, which include rivers, coastal areas, canals, estuaries and lakes, deteriorated in quality between 2015 and 2017, the EPA has found.

We waste huge amounts of food that was produced with high impact

There is a perception that ‘doing something’ with ‘food waste’ is a good idea


AGROCYCLE
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A BLUEPRINT AND EU POLICY-FORMING PROTOCOL FOR THE RECYCLING AND VALORISATION OF AGRI-FOOD WASTE


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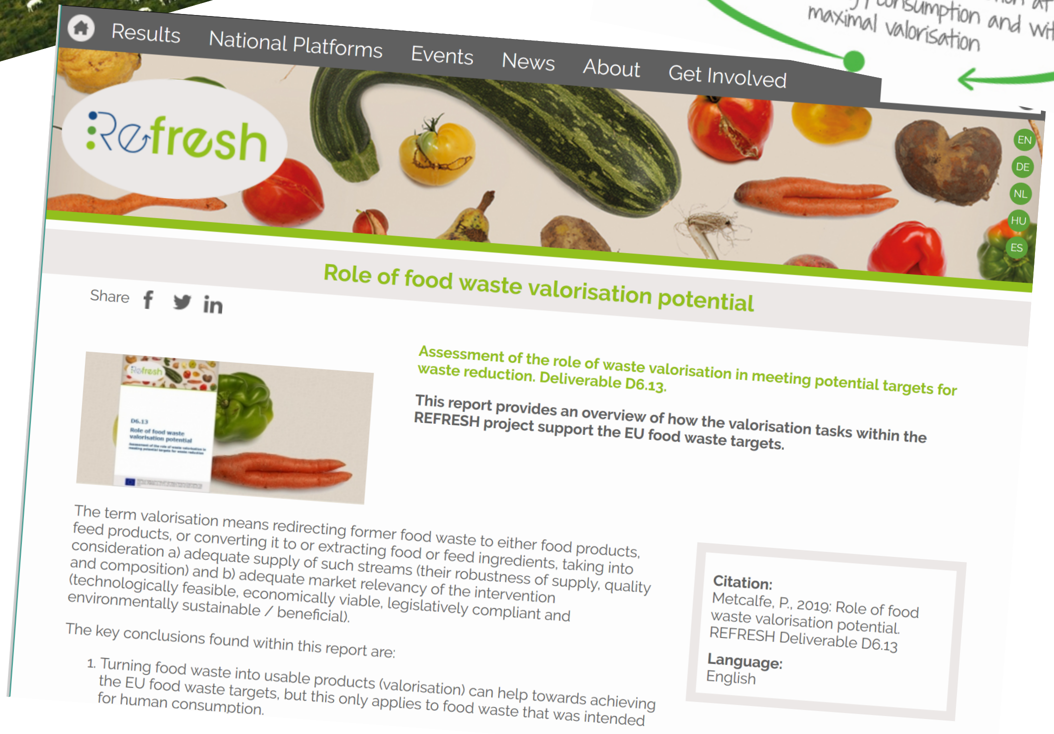
FOOD WASTE DATABASE
WELCOME TO NOSHAN
NOSHAN will investigate the process and technologies needed to use food waste for feed production at low cost, low energy consumption and with maximal valorisation of starting wastes. Nutritional value and functionality according to animal needs as well as safety and quality issues will be investigated and addressed as main leading factors for the feed production using food derived (fruit/vegetable/plant and dairy).
The achievement of the project objectives and results would bring companies a competitive advantage in the feed producing sector using wastes as co-streams. NOSHAN results should bring a reduction in cost of the final feed as well as production cost. Indeed it could also reduce the cost of feed additive and exert a positive impact on final feed product.
NOSHAN consortium will enforce the cooperation among SMEs, large industrial partners and research institutions.
NOSHAN started in August 2012 and it is financed under the Knowledge Based Bio-Economy (KBBE) theme, part of the EU Seventh-Framework Programme, in a total of about 3 million Euro.
The main focus:
use food waste for feed production at low cost, low energy consumption and with maximal valorisation
LATEST NEWS
A free food waste database is available thanks to NOSHAN project!
A huge amount of data has been produced within NOSHAN project when performing the molecular characterization of 42 waste streams. This information has been organized and it's available for free in NOSHAN's website. Just check the "Food waste database" in this web.
Refractance Window Drying has completed the ETV
One of NOSHAN technologies, the Refractance Window Drying, has completed the Environmental Technology Verification (ETV). Check it out here. Want to know what ETV is? Click here.
Video: "General overview about NOSHAN EU project"
Want to know more about the NOSHAN Project? Here is a presentation video. Watch it here: https://www.youtube.com/watch?v=xlIZR08a_cc&feature=youtu.be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Role of food waste valorisation potential
Share
Assessment of the role of waste valorisation in meeting potential targets for waste reduction. Deliverable D6.13.
This report provides an overview of how the valorisation tasks within the REFRESH project support the EU food waste targets.
The term valorisation means redirecting former food waste to either food products, feed products, or converting it to or extracting food or feed ingredients, taking into consideration a) adequate supply of such streams (their robustness of supply, quality and composition) and b) adequate market relevancy of the intervention (technologically feasible, economically viable, legislatively compliant and environmentally sustainable / beneficial).
The key conclusions found within this report are:
1. Turning food waste into usable products (valorisation) can help towards achieving the EU food waste targets, but this only applies to food waste that was intended for human consumption.
Citation:
Metcalfe, P., 2019: Role of food waste valorisation potential. REFRESH Deliverable D6.13
Language:
English

UCD DUBLIN

The question we asked…

Does it really make sense to make things from wasted food?

Why did we ask this question?


npj | Science of Food www.nature.com/npjscifood

REVIEW ARTICLE OPEN

Review of the sustainability of food systems and transition using the Internet of Food

Nicholas M. Holden[1], Eoin P. White[2], Matthew. C. Lange[3] and Thomas L. Oldfield[1]

Many current food systems are unsustainable because they cause significant resource depletion and unacceptable environmental impacts. This problem is so severe, it can be argued that the food eaten today is equivalent to a fossil resource. The transition to sustainable food systems will require many changes but of particular importance will be the harnessing of internet technology, in the form of an 'Internet of Food', which offers the chance to use global resources more efficiently, to stimulate rural livelihoods, to develop systems for resilience and to facilitate responsible governance by means of computation, communication, education and trade without limits of knowledge and access. A brief analysis of the evidence of resource depletion and environmental impact associated with food production and an outline of the limitations of tools like life cycle assessment, which are used to quantify the impact of food products, indicates that the ability to combine data across the whole system from farm to human will be required in order to design sustainable food systems. Developing an Internet of Food, as a precompetitive platform on which business models can be built, much like the internet as we currently know it, will require agreed vocabularies and ontologies to be able to reason and compute across the vast amounts of data that are becoming available. The ability to compute over large amounts of data will change the way the food system is analysed and understood and will permit a transition to sustainable food systems.

npj Science of Food (2018)2:18 ; doi:10.1038/s41538-018-0027-3

INTRODUCTION

The food we eat today is unsustainable for two reasons: the food system causes unacceptable environmental impacts and it is depleting non-renewable resources. Our food can be regarded as 'fossil food' because its production relies on fossil fuel, non-renewable mineral resources, depletion of groundwater reserves and excessive soil loss. The idea of sustainable food systems is at the heart of global efforts to manage and regulate human food supply.[1] The sustainable development goals focus on a number of critical global issues, but Goal 2 ('end hunger, achieve food security and improved nutrition and promote sustainable agriculture'), Goal 12 ('ensure sustainable consumption and production patterns') and Goal 13 ('take urgent action to combat climate change and its impacts') are intimately related to the need to transition global food systems from fossil to sustainable. To understand how to meet the challenge presented by these goals, it is necessary to consider what is meant by 'sustainable' in the context of a food system. In 1989, the Food and Agriculture Organisation (FAO) council defined sustainable development as 'the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable'.[2] The important ideas in this definition are working within the planetary boundary ('the natural resource base'), having a future-proof system ('continued satisfaction', 'present and future generations'), limiting impacts to those manageable by the buffering capacity of the planet ('environmentally non-degrading'), considering the financial needs of business stakeholders ('economically viable') and compatible with local needs and customs ('socially acceptable').

Five principles have been identified to support a common vision for sustainable agriculture and food.[3] These are: (1) resource efficiency; (2) action to conserve, protect and enhance natural resources; (3) rural livelihood protection and social well-being; (4) enhanced resilience of people, communities and ecosystems; and (5) responsible governance. The aim of this paper is to outline the case for why food systems are not sustainable and to define the case for using technology, specifically internet technologies (hardware and software combined to make the 'Internet of Food') to enable the transition of the food system from fossil to sustainable. Increasing population, increasing consumption, a billion malnourished people and agriculture that is concurrently degrading land, water, biodiversity and climate on a global scale[4] combine to indicate that the fossil food systems we currently rely on are not fit-for-purpose. It is suggested that halting agricultural expansion, closing yield gaps, increasing efficiency, changing diets and reducing waste could lead to a doubling of food production with reduced environmental impacts of agriculture.[4] To achieve these changes, it is going to be necessary to harness internet technology, in the form of an 'Internet of Food', which offers the chance to use global resources more efficiently, to stimulate rural livelihoods, to develop systems for resilience and to facilitate responsible governance by means of computation, communication, education and trade without limits of knowledge and access.

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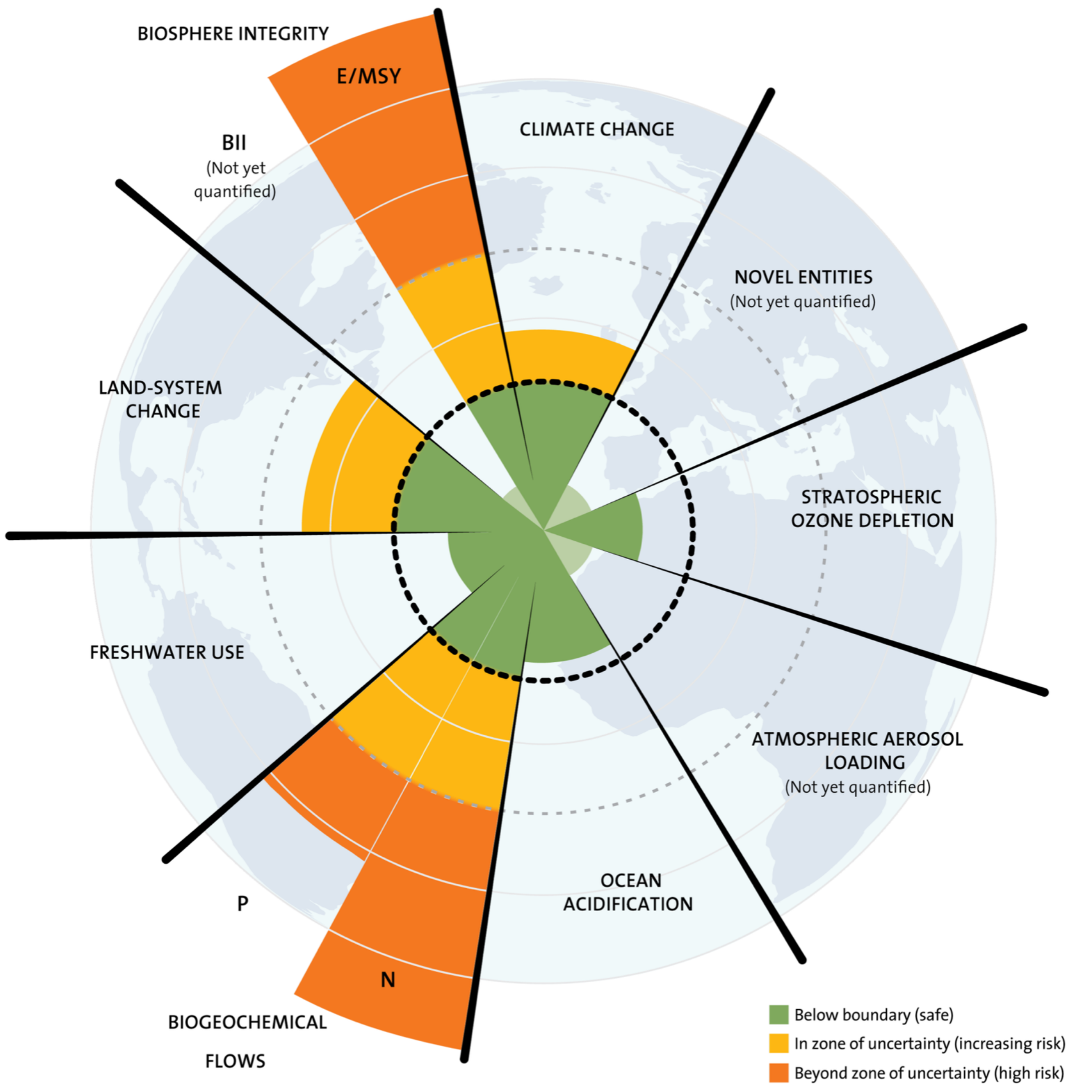
This paper lays out the case for the concept of 'fossil food'

We are not the first to do this, but we spell out the case clearly

Our food requires

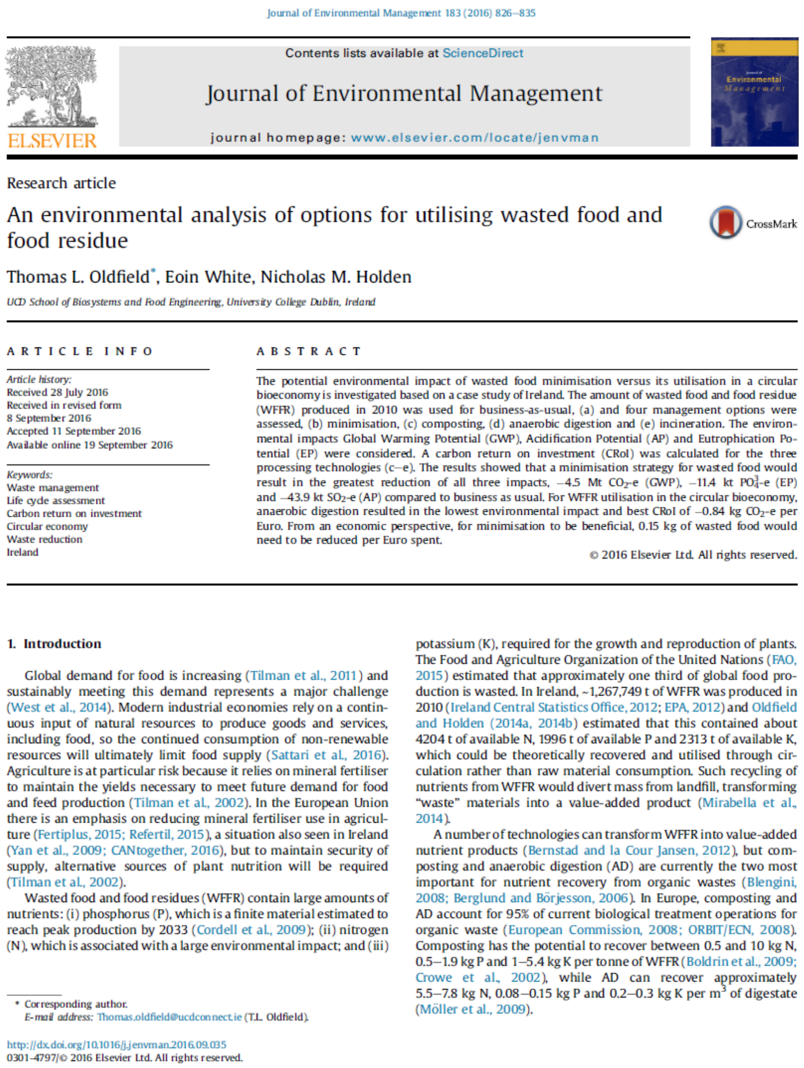
- fossil fuel (for mechanisation and N from atmosphere)
- non-renewable P and K
- non-renewable water
- soil erosion


BIOSPHERE INTEGRITY
E/MSY
BII
(Not yet quantified)
CLIMATE CHANGE
NOVEL ENTITIES
(Not yet quantified)
LAND-SYSTEM CHANGE
STRATOSPHERIC OZONE DEPLETION
FRESHWATER USE
ATMOSPHERIC AEROSOL LOADING
(Not yet quantified)
OCEAN ACIDIFICATION
P
N
BIOGEOCHEMICAL FLOWS
Below boundary (safe)
In zone of uncertainty (increasing risk)
Beyond zone of uncertainty (high risk)

By the time we ‘waste’ food we have already ‘spent’ non-renewable resources and caused impact by making it

3

We can demonstrate that treating wasted food as a ‘valuable substance’ is not a good idea



Journal of Environmental Management 183 (2016) 826–835

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Research article

An environmental analysis of options for utilising wasted food and food residue

Thomas L. Oldfield*, Eoin White, Nicholas M. Holden

UCD School of Biosystems and Food Engineering, University College Dublin, Ireland

ARTICLE INFO

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Carbon return on investment
Circular economy
Waste reduction
Ireland

ABSTRACT

The potential environmental impact of wasted food minimisation versus its utilisation in a circular bioeconomy is investigated based on a case study of Ireland. The amount of wasted food and food residue (WFFR) produced in 2010 was used for business-as-usual, (a) and four management options were assessed, (b) minimisation, (c) composting, (d) anaerobic digestion and (e) incineration. The environmental impacts Global Warming Potential (GWP), Acidification Potential (AP) and Eutrophication Potential (EP) were considered. A carbon return on investment (CRoI) was calculated for the three processing technologies (c–e). The results showed that a minimisation strategy for wasted food would result in the greatest reduction of all three impacts, –4.5 Mt CO_2-e (GWP), –11.4 kt PO_4^{3}-e (EP) and –43.9 kt SO_2-e (AP) compared to business as usual. For WFFR utilisation in the circular bioeconomy, anaerobic digestion resulted in the lowest environmental impact and best CRoI of –0.84 kg CO_2-e per Euro. From an economic perspective, for minimisation to be beneficial, 0.15 kg of wasted food would need to be reduced per Euro spent.

1. Introduction

Global demand for food is increasing (Tilman et al., 2011) and sustainably meeting this demand represents a major challenge (West et al., 2014). Modern industrial economies rely on a continuous input of natural resources to produce goods and services, including food, so the continued consumption of non-renewable resources will ultimately limit food supply (Sattari et al., 2016). Agriculture is at particular risk because it relies on mineral fertiliser to maintain the yields necessary to meet future demand for food and feed production (Tilman et al., 2002). In the European Union there is an emphasis on reducing mineral fertiliser use in agriculture (Fertiplus, 2015; Refertil, 2015), a situation also seen in Ireland (Yan et al., 2009; CANtogether, 2016), but to maintain security of supply, alternative sources of plant nutrition will be required (Tilman et al., 2002).

Wasted food and food residues (WFFR) contain large amounts of nutrients: (i) phosphorus (P), which is a finite material estimated to reach peak production by 2033 (Cordell et al., 2009); (ii) nitrogen (N), which is associated with a large environmental impact; and (iii) potassium (K), required for the growth and reproduction of plants. The Food and Agriculture Organization of the United Nations (FAO, 2015) estimated that approximately one third of global food production is wasted. In Ireland, ~1,267,749 t of WFFR was produced in 2010 (Ireland Central Statistics Office, 2012; EPA, 2012) and Oldfield and Holden (2014a, 2014b) estimated that this contained about 4204 t of available N, 1996 t of available P and 2313 t of available K, which could be theoretically recovered and utilised through circulation rather than raw material consumption. Such recycling of nutrients from WFFR would divert mass from landfill, transforming "waste" materials into a value-added product (Mirabella et al., 2014).

A number of technologies can transform WFFR into value-added nutrient products (Bernstad and la Cour Jansen, 2012), but composting and anaerobic digestion (AD) are currently the two most important for nutrient recovery from organic wastes (Blengini, 2008; Berglund and Börjesson, 2006). In Europe, composting and AD account for 95% of current biological treatment operations for organic waste (European Commission, 2008; ORBIT/ECN, 2008). Composting has the potential to recover between 0.5 and 10 kg N, 0.5–1.9 kg P and 1–5.4 kg K per tonne of WFFR (Boldrin et al., 2009; Crowe et al., 2002), while AD can recover approximately 5.5–7.8 kg N, 0.08–0.15 kg P and 0.2–0.3 kg K per m^3 of digestate (Möller et al., 2009).

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E-mail address: Thomas.oldfield@ucdconnect.ie (T.L. Oldfield).

http://dx.doi.org/10.1016/j.jenvman.2016.09.035

This paper used life cycle assessment to model wasted food valorised by various methods

- Composting
- Anaerobic digestion
- Incineration

Versus

- Landfill (BaU)
- Avoidance

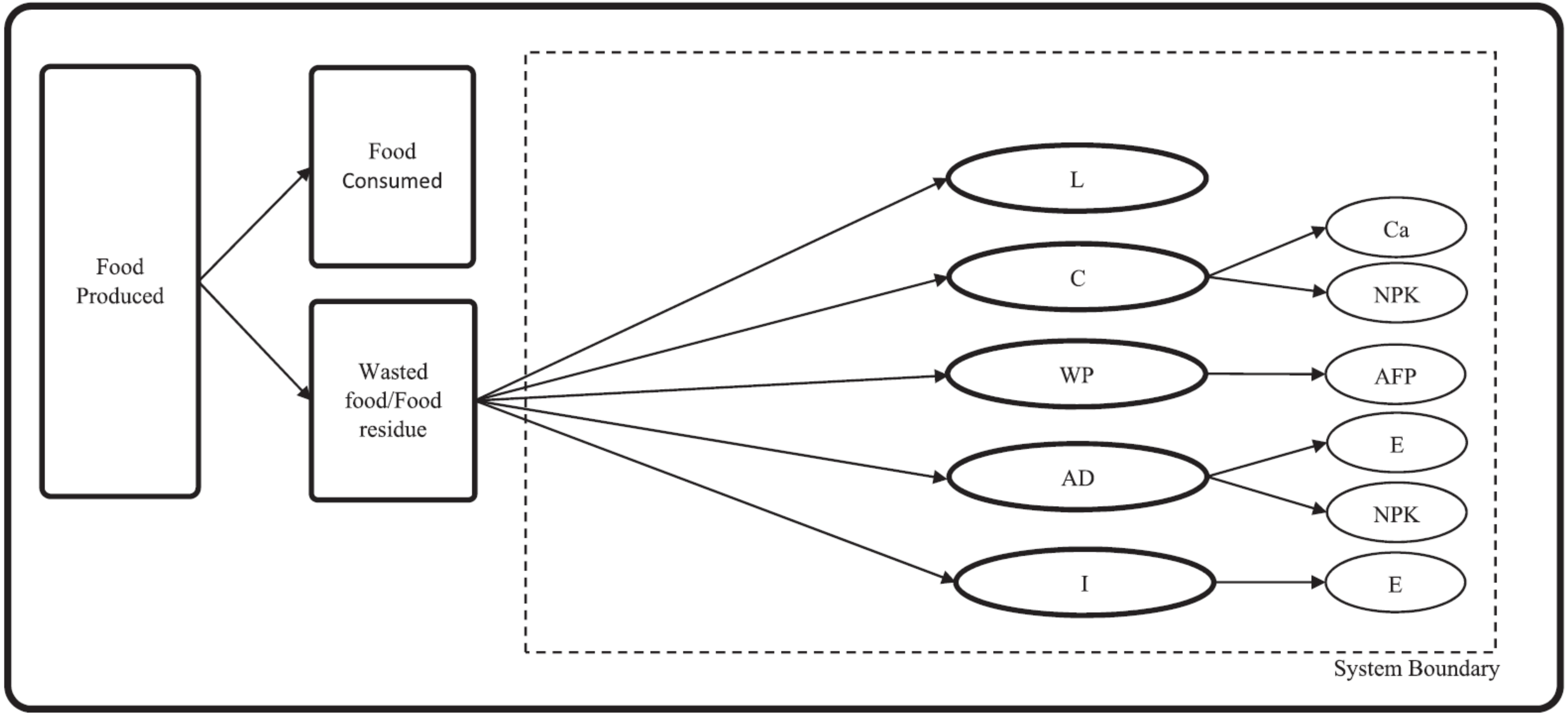


Fig. 1. System diagram: L = Landfill, C = Composting, WP = Waste prevention, AD = Anaerobic digestion, I = Incineration, Ca = Carbon sequestration, NPK = Fertiliser avoidance, AFP = Avoided food production, E = Electricity generated.

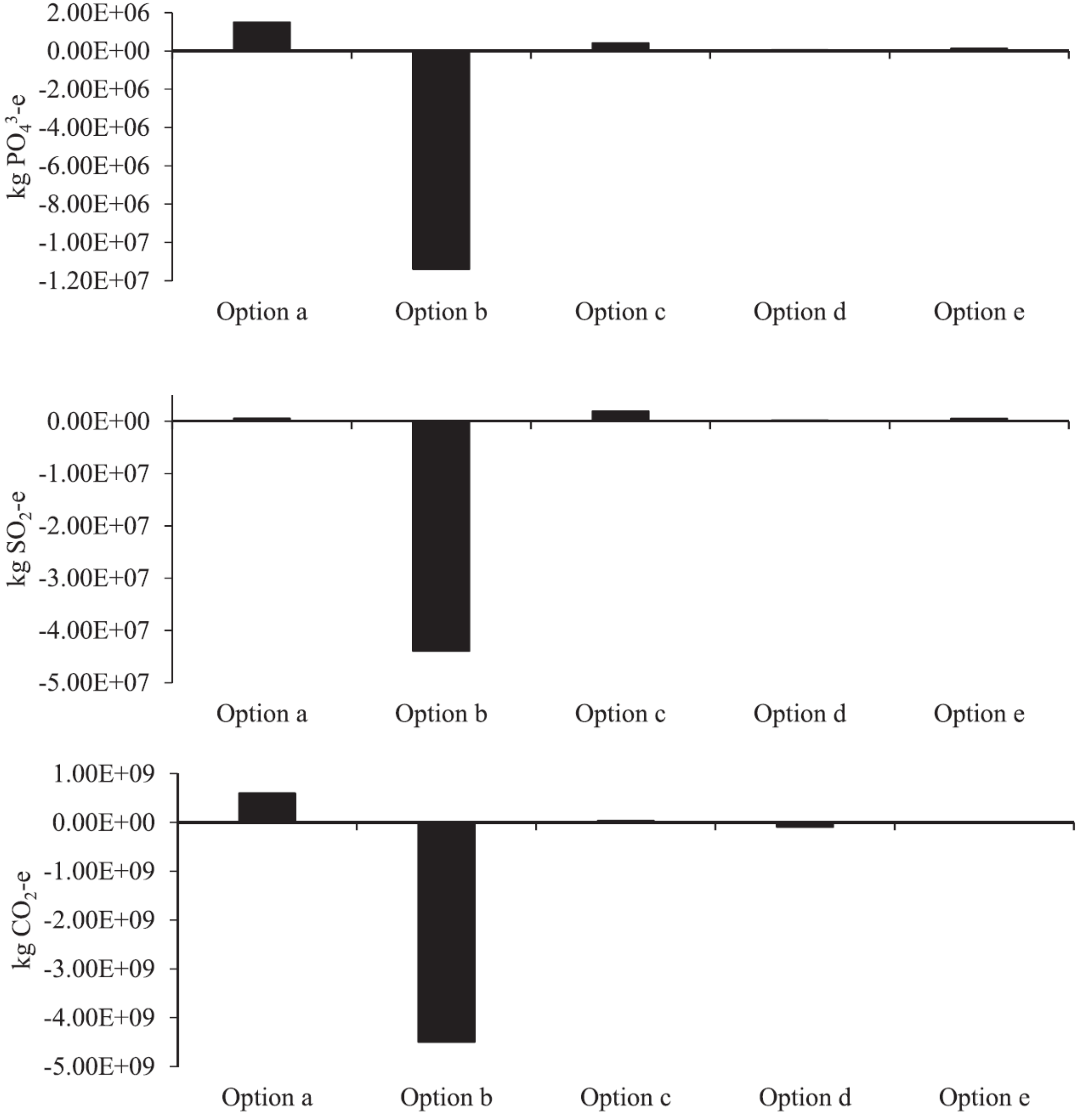


Fig. 2. Global warming potential, acidification potential and eutrophication potential and per functional unit of BaU and four management options.

Option:

a: landfill

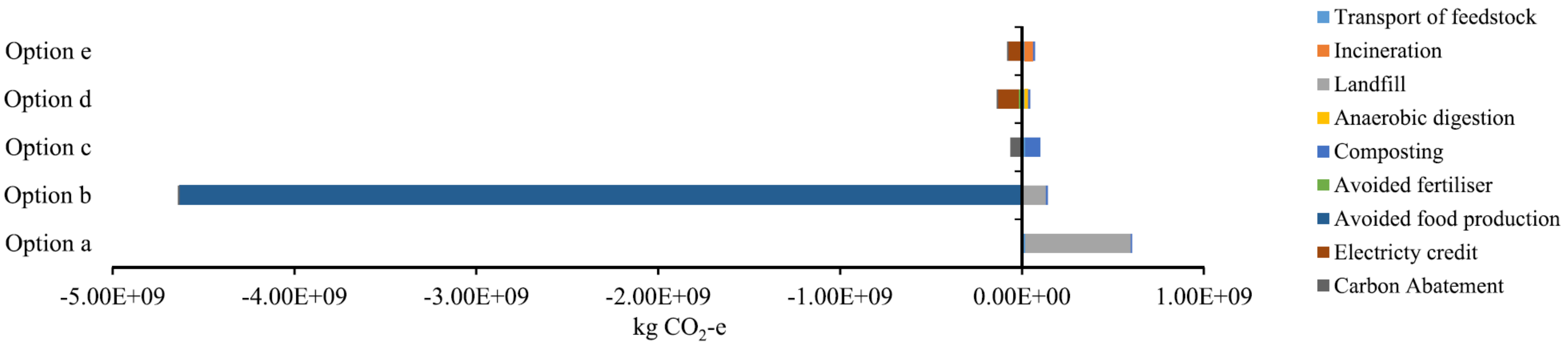
b: food waste prevention

c: composting

d: anaerobic digestion

e: incineration + energy

What was the cause of this result?



Once we have ‘spent’ resources on making food, we cannot offset that spend by valorisation

What is the relative value of avoiding wasted food?

Carbon return on investment

(reduction in kg CO2-e per €1 spent on the technology)

T.L. Oldfield et al. / Journal of Environmental Management 183 (2016) 826–835 833

Table 2
Carbon return on investment.

	AD	Composting	Incineration	Landfill	Minimisation
Investment Cost (€/t)	136[a]	125[b]	600[c]	10[d]	Variable
Technology Impact (kg CO_2-e/t)	−114	13	−27	530	Variable
CRoI (kgCO_2-e/€)	−0.84	0.1	−0.05	53	Variable

[a] SEAI (2010).
[b] Inter-Trade Ireland (2011).
[c] TCD (2011).
[d] Cointreau (2008).

- Landfill causes GHG emissions per €1 spent
- Composting is likely to cause emissions or be close to neutral
- Incineration reduces emissions, but will decrease as grid becomes renewable
- Anaerobic digestion has a positive benefit for the spend

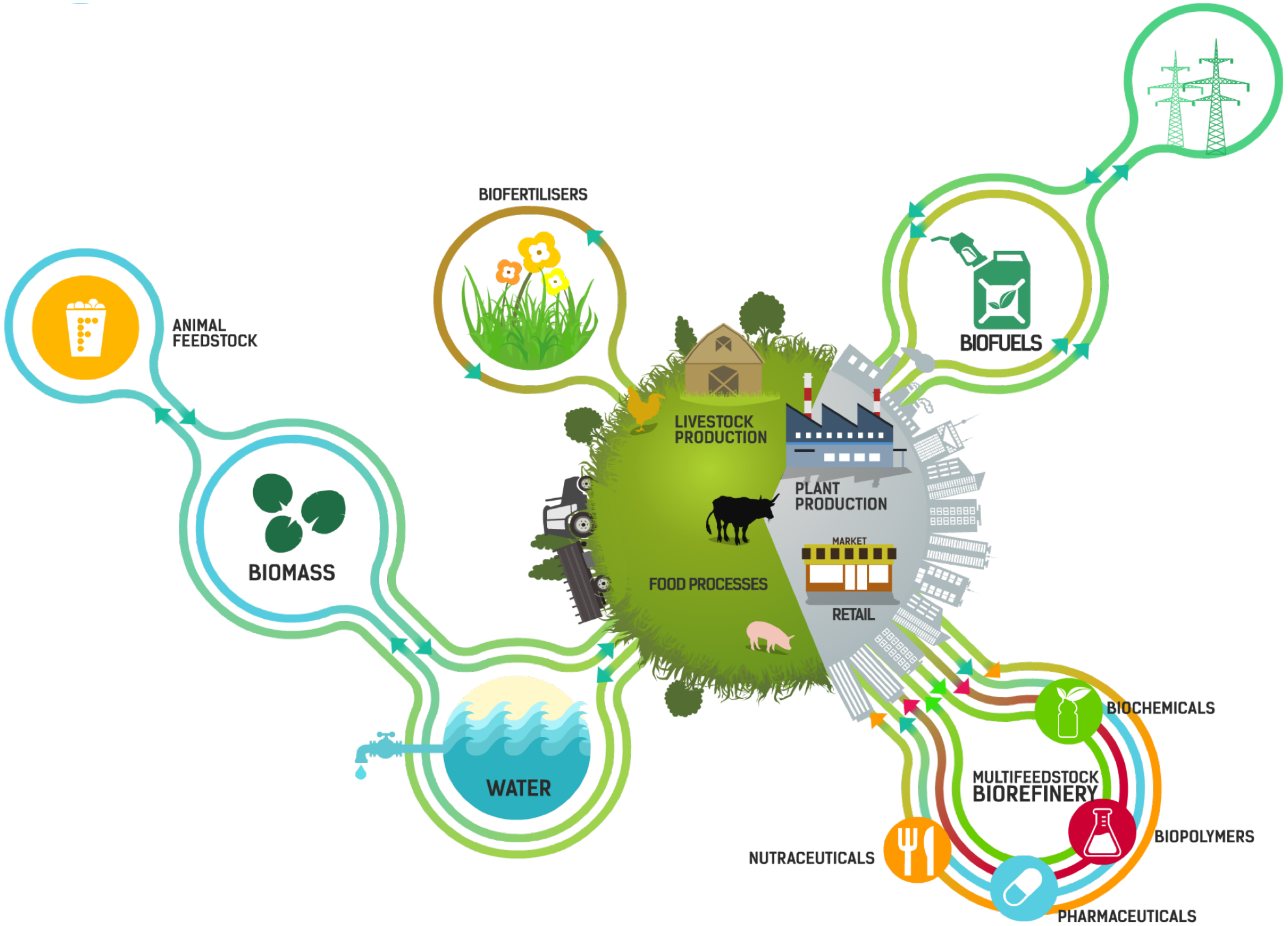
Preventing 150 g wasted food per €1 spent on a minimization programme would have the same benefit as the best valorisation option

In Ireland there is 31.7 kg of wasted food generated every second (assuming 1 M t per year)

4

€1M investment would only have to avoid 150 t wasted food to have the same benefit as investing in AD

In Ireland we would only have to avoid wasted food for 17 mins to achieve this (assuming 1 M t per year)



AgroCycle

What we learned

①

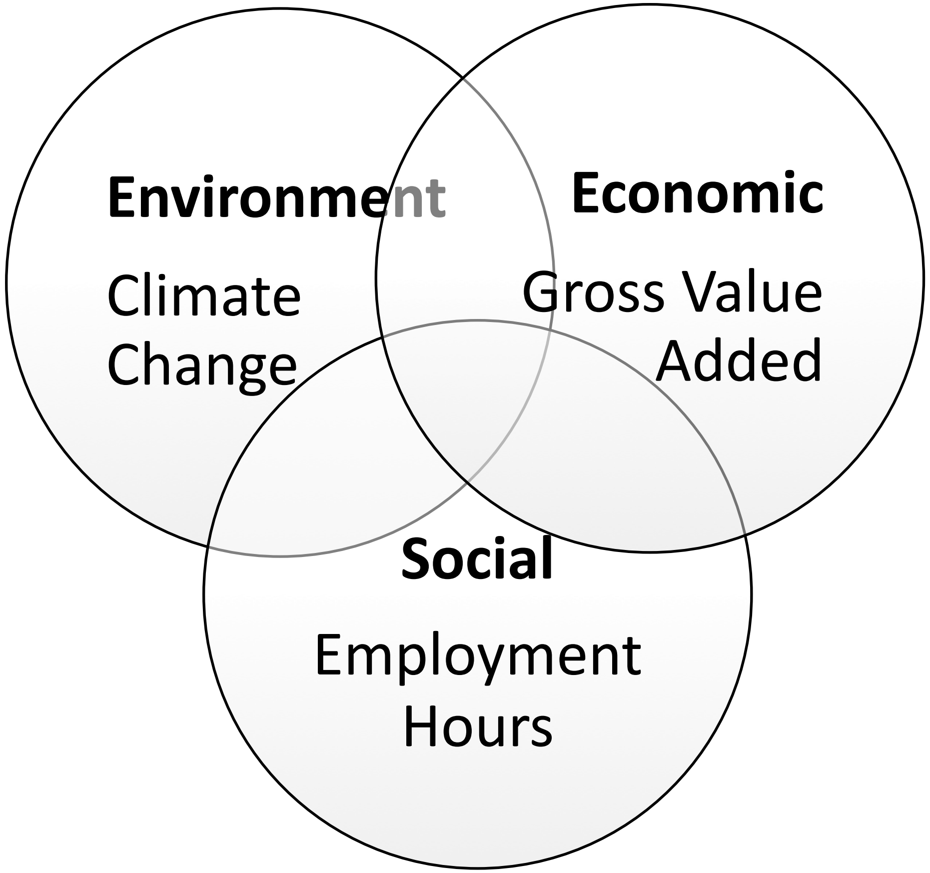
We need tools to
allow technologies to
'Fail Early'

Focus on the most important impacts first…

Environmental issue	Indicator	Unit	Social issue	Indicator	Unit	Economic issue	Indicator	Unit
Global warming	Global warming potential	kg CO_2-eq	**Fair wage**	Cumulative risk of fair wage in supply chain	Euro	**Production Cost**	Labour cost	€
Acidification	Acidification potential	Kg SO_2-eq	**Health and safety**	Cumulative fatality rate (injury rate) in supply chain	Number of cases	**Production Cost**	Transportation cost	€
Eutrophication	Aquatic eutrophication potential	kg PO_4^{3-}-eq or kg NO_3-eq	**Working time**	Cumulative working time in supply chain	Second	**Production Cost**	Equipment cost	€
	Terrestrial eutrophication potential	m^2 UES	**Public living condition**	Avoided environmental cost on human health in supply chain	Euro	**Production Cost**	Electricity and fuel cost	€
Water use	Blue water consumption	m^3	**Provision of employment**	Created employment opportunity	Number of jobs	**Production Cost**	waste collection and material cost	€
Land use	Land occupation	m^2-years	**Child labour**	Cumulative child labour in supply chain	Labour unit	**Production Cost**	Maintenance cost	€
Mineral resource depletion	Mineral extraction	MJ extra	**Forced labour**	Cumulative forced labour in supply chain	Labour unit	**Production Cost**	Soft cost (design fee, permit fee…)	€
Human toxicity	Human toxicity, non-carcinogens	kg C_2H_3Cl-eq	**Contribution to economy**	Total added value to economy in macro scale	Euro	**Profitability**	Net income per function unit	€
	Human toxicity, carcinogens	kg C_2H_3Cl-eq	**Technology development**	Change of production efficiency	%	**Efficiency of value creation**	Net value added per kg waste	€/kg
Ozone layer depletion	Ozone layer depletion potential	kg CFC-11-eq	**Promoting social responsibility**	Waste reused or recycled	Kg waste			
Eco-toxicity	Fresh (Marine) water eco-toxicity potential	kg TEG-eq	**Resource and energy security**	Avoided resource and energy	kg resource or MJ energy			
	Terrestrial eco-toxicity potential	kg TEG-eq						
Photochemical smog	Photochemical oxidation potential	m2*ppm*hours or kgC_2H_4-eq						

Tier 1	Tier 2	Tier 3

… LCSA Preemptive Indicators – Tier 1 / TRL 4



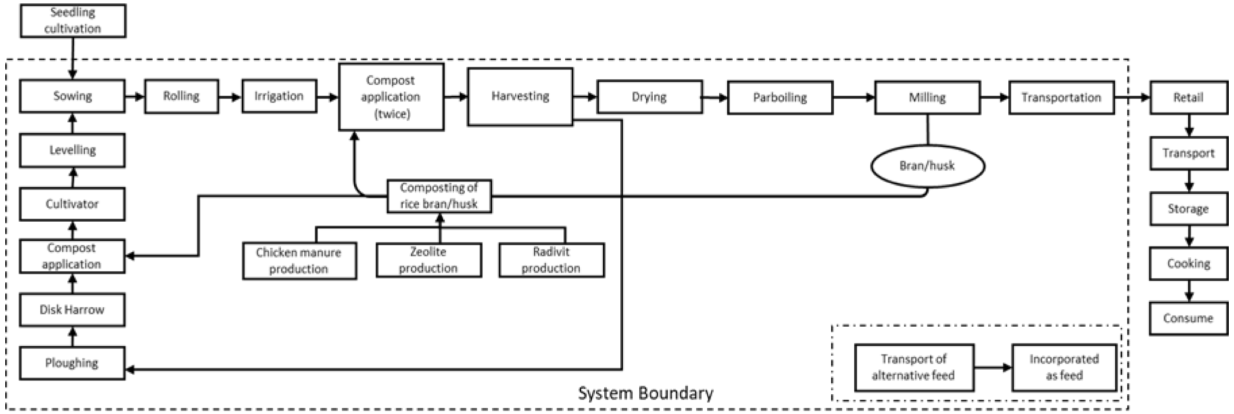
②

‘Waste’ comes from somewhere…

…the impact of how it was created matters

We must include upstream impact…

We are **not** working with end-of-pipe solutions…

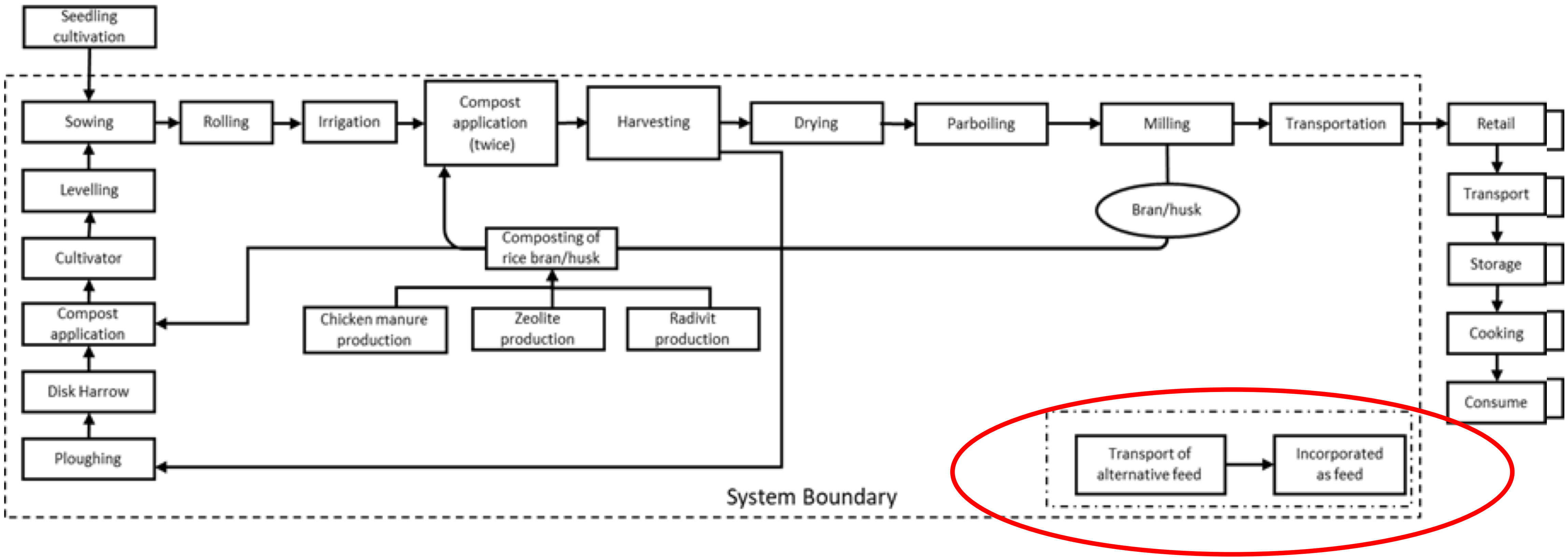


These are valorization technologies…

③

When calculating impacts…
…all functions matter

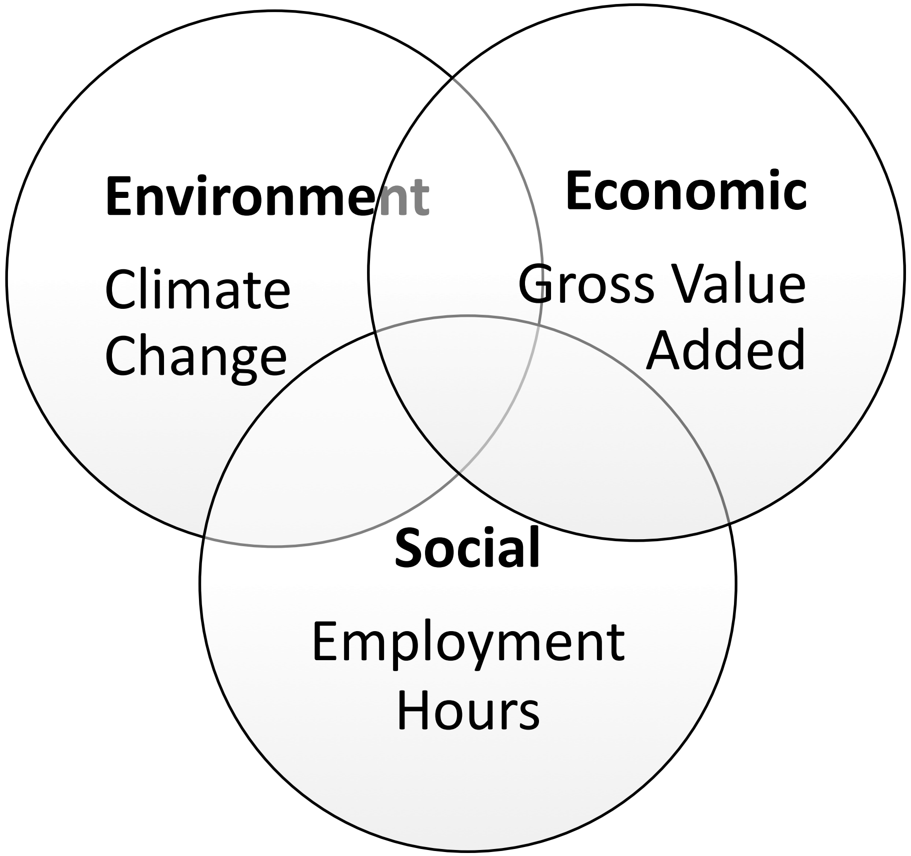
We cannot ignore the bits we aren't interested in…



④

All AgroCycle technologies gave mixed results (all were using residues, not ‘wasted food’)

Can we hit the triple bottom line?



⑤

Doing ‘something’ with residues is not always best

If we ‘fail early’ we can design issues out of the system…

…otherwise we do not solve real problems

Conclusions

Why are UCD involved in REAMIT?

We must distinguish between ‘wasted food’ and unavoidable residues and co-products

Avoid wasted food

Correctly valorize residues

UCD will be an active partner in REAMIT because it offers the change to understand how IoT technology can help us make real reductions in ‘wasted food’

This is a key early step in food system transformation

You are all welcome to join us ¦ Please submit an abstract