Sustainable food systems: how to SEE sustainability into the future

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From a practical point of view how can we effectively SEE (social, economic and environmental) sustainability of food systems into the future? To achieve this, supply chains must be modified through the development of new management strategies, and more efficient, flexible processing technologies. These types of modifications can potentially optimise food, energy and water resource usage to minimise food waste and also optimise population health. Ideally this occurs while maintaining economic health of the food systems and their surrounding environment.

There are several features of a possible sustainable food system, which include: implementing circular economy principles; sustainable agricultural practices; localised and seasonal distribution to reduce 'food miles'; production of healthy and sustainable foods; development of innovative increased shelf-life products to prevent food waste; and pathways for food excess and by-products (FE&Bs) to support a 'zero-waste' approach.

To approach a circular economy in food systems the goal is to design waste out of the value chain and move towards 'zero waste'. Sustainable agriculture practices which optimise resource usage of water, energy and crop nutrients and minimises greenhouse gas emissions, adverse biodiversity changes and eutrophication are advantageous. This could be managed by a combination of water-energy-food nexus analysis supported by digital agriculture strategies. In addition, localised food systems can not only reduce transport costs, but also emissions associated with longer logistical paths.

The prevention of waste can go a long way towards preventing not only food waste but also the waste of the resources used to produce that food. Strategies to combat this issue could include determining new supply chain pathways for any food excess and by-products which may be achieved through development of innovative increased shelf-life products. In the modern world, we already use food preservation technologies to extend shelf-life so foods can cover vast distances within global food supply chains. However, in a sustainable agri-food system the purpose of such technologies should also encompass preventing food loss and waste.

Our team's research proposes that the use of an integrated approach to valorise and use food components that might otherwise be disposed of can encompass some key approaches as outlined in Figure 1. Key to the success of such a strategy is identifying the pathways that have social, economic and environmental sustainability. This can be addressed through combined technoeconomic and life cycle analysis models.

Foundation components of an integrated food valorisation system could include capture and preservation of food excess and by-products, which then allows more time to extract and refine components from these materials. Other pathways could include the use of algae as a sink for some FE&Bs, while remaining biomass could be used to nourish animals and soil.

Capture and Preservation (CaP)

One of the core issues of food loss and waste generation is that there may be no processing or preservation infrastructure close to where it is generated (e.g. on-farm). To overcome this issue, a good approach is to localise capture and preservation of this food excess at the site of production to extend shelf life and prevent spoilage. This could be achieved using lower energy drying approaches, cold or frozen storage or the use of preservatives derived from the food excess and by-products themselves.

Extraction and Refining (EaR)

Once food has been captured and preserved, it is possible to build a stockpile of food material with an extended shelf life, and process it in

Organisation	Initiative
Sundrop Farms	Sundrop Farms produces tomatoes in a desert environment. This is achieved through a combination of hydroponic systems, desalinated seawater and a solar tower to produce evaporative cooling and steam to control the greenhouse climate. https://www.sundropfarms.com/ https://evokeag.com/evokeag/how-we-can-farm-australias-deserts/
Venus Shell Systems	Venus Shell Systems is an example of Integrated valorisation pathways as we depict in Figure 1. Wheat processing residue is used in tandem with kelp production with the kelp production component utilising this residue, CO2 and seawater. https://www.venusshellsystems.com.au/ https://www.abc.net.au/radionational/programs/scienceshow/new-seaweed-processing-plant-opens-in-southern-nsw/12512334
De Bortoli Wines	De Bortoli Wines has launched new wines in 2020 as part of its 17 Trees range which is underpinned by a range of sustainability initiatives throughout the supply chain including processing aid, water and energy recovery, composting and sustainable packaging and labelling. https://www.debortoli.com.au/17trees https://www.foodprocessing.com.au/content/sustainability/news/17-sustainability-intiative-stories-with-new-wine-range-749815082/
Knott Tara Farm, Barmedman, NSW	Growers of *Opuntia Ficus – Indica* (Sweet prickly pear). It is a very high yielding crop with every part of the plant providing a marketable product similarly to the approach outlined in Figure 1. Cactus products include food, fruit, juice, faux leather, pharmaceutical products and fodder for livestock. *Source: Personal communication with Benjamin Egge*

Table 1: *Examples of Australian food and beverage initiatives that incorporate integrated food systems and sustainable processing.*

a steadier fashion, as opposed to a period of high intensity processing matching the season of the food. For this to be sustainable, the value of any extracted or refined items must be greater than the economic activity that went into its production.

Symbiotic Algal/Fermentation for Energy and Residues (SAFER)

Algae is a sustainable 'crop' and a key reason why is that it is a photosynthetic organism, that is also highly productive in producing useful biomass. Algae may require less production resources than agricultural crops and can also be 'nourished' using food waste such as cheese whey wastewater, fermentation by-products including CO2 or spent coffee grounds amongst others. Algae also has the potential to clean wastewater, making it an ideal material to produce in symbiosis with processing of food excess and by-products.

Clean and Feed (CaFe)

While the CaP, EaR and SAFER approaches deal with many food excess and by-products, there may still be remaining biomass that has

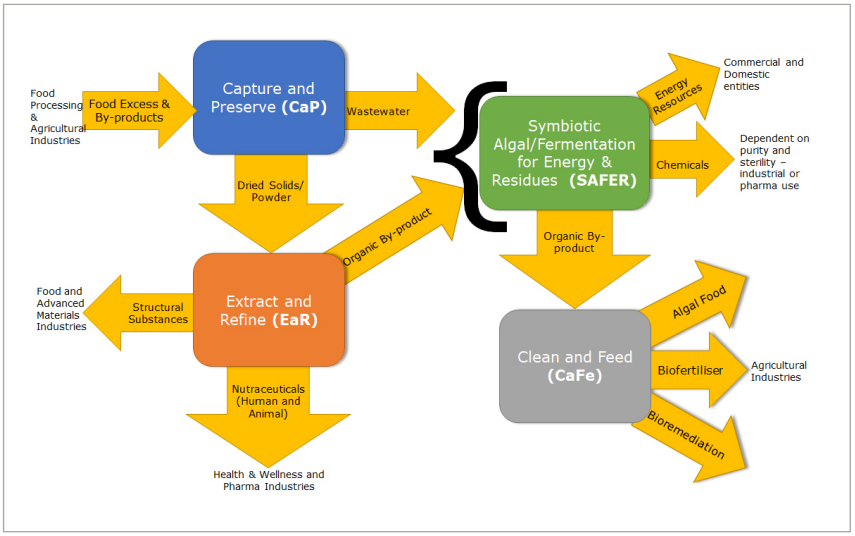

Figure 1: *Example of an integrated food system where food excess and by-products are diverted and valorised.*

further use. These materials could easily be used as standard compost, aid in bioremediation, or may be used as nutrient-rich biofertilisers. They can also be used to clean up land and water, and feed animals, soil, insects and plants. Potential applications to feed insects can be used for insect protein production.

In this way an integrated valorisation circular economy could be established for food and some current Australian examples are outlined in Table 1.

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