Interreg 2 Seas Mers Zeeën

BioBoost

Accelerating biobased horticulture

A Strategy for Accelerating Sustainable Valorisation of Unused Crops and Co-products

Working Document

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BioBoost – A Strategy for Accelerating Sustainable Valorisation of Unused Crops and Co-products

Authors
Lydia Smith and Denise Elliott (NIAB), Meredith Lloyd Evans (BioBridge Ltd), Veronique de Mey and Audrey Miserez (Inagro), Jeroen Straver (Municipality of Westland), 2020.
Case studies: Willem Kemmers (greenport West-Holland), Carl Coudron (Inagro), Thomas Spranghers (VIVES) and Bart van Droogenbroeck (ILVO).

Contact info
BioBoost coordinators: JCAJStraver@gemeentewestland.nl; gerrit.walstra@haute-equipe.nl
Project website: https://www.BioBoosteurope.com
Authors: lydia.smith@niab.com

Contents

1. The Status Quo in Fresh Produce Cultivation; what is happening now and context of business development

1.1. Background; Waste, Valorisation and the BioBoost Partnership

Fresh produce is one of the key sectors prioritised to deliver the 'Courtauld Commitment 2025'; a voluntary pledge initiated by WRAP (UK Government initiated Waste reduction action programme) and supported by 165 organisations (Spring 2020) to 'make food & drink production and consumption more sustainable' by developing solutions and implementing change; cutting waste by at least one fifth in 10 years. Whilst there are actions that individual businesses can take to reduce food surplus and waste and improve efficiency, collaboration along the whole supply chain will accelerate solutions and make a more significant impact. Whole supply chain actions involve businesses from field to retail, working together to reduce food waste and increase efficiency.

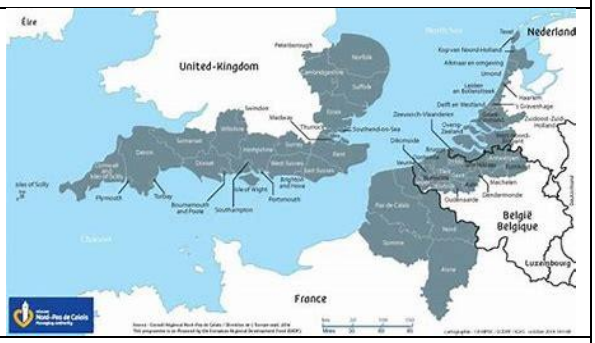
Once sources of by-products or food that has been rejected for sale or use have been identified, the next vital step is to identify alternative uses at a technological and organisational level. Solutions need to consider limiting factors. Impediments could include geographical limitations to use, economic constraints or legislative restrictions; or even customer rejection of new valorised products.

Identifying best practice from actions already being undertaken by businesses along the supply chain can help identify key points at which waste is being produced, and hence, where, why and how to start making improvements. In addition to lost revenue, there are actual costs relating to dealing with waste; not just storing, processing or its disposal. Depending on the position in a supply chain, additional costs can include the input costs associated with growing the crop, packaging, energy use, water use and treatment, labour, storage, transport and lost margins. Reducing waste therefore impacts on all these wasted resources. For the purposes of this document. UK WRAP identified five key species that account for the most waste and losses in north Europe: potatoes, bananas, onions, carrots and apples; all of these can be described as fresh produce The BioBoost partnership identified some key crops that account for significant waste and losses and are of particular relevance to business in the INTERREG 2Seas region: potatoes, onions (and other allium species) carrots, apples, salad crops and certain brassica field crops such as broccoli and cauliflower.

This document is intended to inform national governments and stakeholders in the 2 Seas Interreg regions towards optimal strategy to identify and reduce wasteful practices and to develop economically viable practices to valorise co-products and waste; producing new products that can be used by business and customers. Ultimately it is hoped that this will inform and impact on legislation at national and EU level.

1.2. Details of Participants and Definitions

Table 1: Definitions, partner participation and Interreg map of region

Name	Definition /detail	Example/page
Valorisation	Increase the value of a material	Bioconversion; see p14 *et sec*.
Fresh produce	Fruit, salad or vegetable crops sold in a largely unprocessed form other than simple cleaning or trimming	Lettuce, apple, plum, raspberry, sweet pepper, cucumber, cabbage, brussels sprouts, legumes/ leek onion, etc.
Interreg 2 Seas Region	EU region bordering the English Channel and North Sea; includes South & East UK counties, West Netherland Coast and west Belgium coast; shown in grey on map left	
NIAB	National Institute of Agricultural Botany, UK www.niab.com	UK research based independent company; application of genetics, physiology, soil science, precision agronomy and data science to improve the yield, efficiency and resilience of crop production across arable, forage and horticulture sectors
INAGRO	Belgium. www.inagro.be	INAGRO is a knowledge partner for agricultural and horticultural businesses in the areas of innovation and sustainability.
Municipality of Westland	Netherlands www.worldhorticenter.nl	Westland, a world horticulture centre and the most influential player in Greenport, characterised by innovation, sustainability and entrepreneurship. The latest innovations and developments in sustainable technology, and international trade

1.3. Best Practice to Prevent or Re-use Waste and Co-products

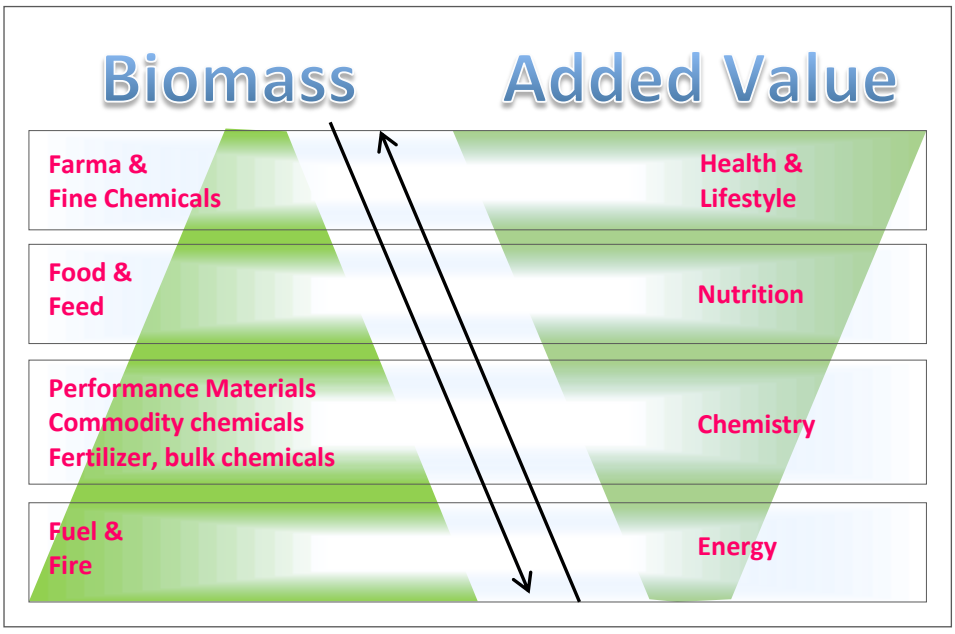
Discussions with fresh produce industries and producers; including key Courtauld signatory stakeholders, over 2018-19 have led to the identification of seven key activities that offer the best opportunities for impact on either directly reducing food surplus and waste or using those products differently. The first of these, the aim to achieve higher valorisation outcomes for selected feedstocks, was the main aim of the BioBoost project, but the additional six directly impact on the outcomes of valorisation and must be considered in tandem to ensure that future improved practices or changes in government /legislation will render feedstocks inaccessible for valorisation innovations. Each is listed here, then considered in more detail below:

1. Use of food/crop waste from the supply chain for higher valorisation
2. Redistribution along the supply chain for charity
3. Development of standard metrics and measurement (for targets, measurement and reporting)
4. Communication and information-sharing between producers/suppliers and retailers
5. Forecasting of yield and supply and demand
6. Maintaining product quality
7. Alternative food markets for surplus or out of specification food

1.3.1. Use of By-products & Residues from the Supply Chain for High Valorisation

Industry by-products, food surplus and waste can be used for higher valorisation purposes. The valorisation of biological by products, losses and food waste (biomass) is illustrated by the bio-cascading principle, also known as the 'value pyramid' (Figure 2. below). Pharmaceutical products & Fine Chemicals add considerable value/unit of product but at small volumes, whereas energy carriers (Fuel & Fire) add low value/unit of product but in large quantities. Agriculture, horticulture and livestock farming produce feedstock and products at all levels across the value pyramid. Each layer in the pyramid hosts its own number of bio-based innovations.

Figure 1: Value pyramid of Bio-renewable Feedstock (redrawn from: Biobasedpress.eu)



By-products are often described as 'waste'; but this can negatively affect expectations and consumer acceptance. Renaming waste as 'biomass residual streams', 'by-products' or 'co-products' will aid a change in producer mind-set and consumer choices. Examples of valorisation that involve collaboration along the supply chain are shown below.

Figure 2: Examples of valorisation that use collaboration along the supply chain

Cardboard made from tomato plants; which won a European Sustainability prize

This unique solid cardboard, enriched with tomato plant fibres, produced by Solidus Solutions, was the winner of the Packaging Europe Sustainability Awards 2016. Packaging Europe, (International Journal of Packaging, organised the contest. The cardboard enriched with fibres from tomato plants, won in the category 'bio based packaging'. *(Source: Hortidayli)*

Celbius Ltd (based at Eastern Agri-Tech Innovation Hub) produce natural slug repellent, 'Zlug', based on the dried olive stone by-product after crushing for olive oil production. http://www.celbius.com/

AgriGrub Ltd, based at the Eastern Agri-Tech Innovation Hub, produce high value outputs such as fish food, bio-oils and soil conditioner. These have been produced by breeding Black Soldier Flies; feeding the larvae on food waste, collected from local growers. (https://www.agrigrub.co.uk/)

Camgoed Green Residuals

Black Soldier Fly Frass from AgriGrub Ltd

Comgoed (http://comgoed.nl/en/#redirect) a BioBoost partner from the Netherlands, collect and process green residuals to produce wood pellets and chips; which are used for large industrial biomass power plants and semi-industrial plants for farmers, gardeners, swimming pools, saunas, schools and SME's. They also produce compost and soil improvers and are currently running a small-scale pilot to test the chipboard production.

1.3.2. Redistribution along the Supply Chain for Charity

Many businesses in the supply chain donate food to charity, either directly from the pack-house or from the storage facility to maximise shelf life, or from retail stores. Surplus food could be supplied directly from the field. The earlier in the supply chain that surplus/out-of-spec food is sourced, the less likely that the produce is rejected or discarded due to spoilage or having passed its 'Sell By' date. The ideal scenario is to retain food in its original form before valorisation. The following are examples of some **best practices**:

- Identify and quantify what surplus could be available for charity redistribution
- Identify key contacts for redistribution and contacts at charities
- Identify charities especially local ones (reducing spoilage, transport time and costs). Supply directly from pack houses and depots, to reduce transit time, packaging and extra transport.
- Enable and encourage partnerships; define what is required and develop procedures to identify surplus for possible redistribution quickly – culminating in a 'Procedure Document' for each charity
- Make agreements between third party customers (including discussions about branded produce)
- Consider drawing up charity redistribution policy and procedure documents for each customer
- Ensure recipient charities officially sign-up to collection policy to prevent the initiative foundering due to infrequent/delayed collections; improve communication to prevent such problems
- Ensure producers understand which are the 'right types of food' (which are acceptable or usable by recipients) that can be used by a given charity; improving communication

Some examples of redistribution charities and other sources of support include: FareShare, The Gleaning Network, The Trussell Trust, Company Shop, Food Cloud, The Real Junk Food Project, Neighbourly, OLIO, and Plan Z heroes.

1.3.3. Development of Standard Metrics and Measurements

Clearly, defining all components of crop products is vital; this will vary between products, businesses and supply chains. Not all parts of a given crop can be harvested, for example, and some parts may be inedible or even toxic to humans/livestock. Mapping at each point along the supply chain is vital to enable decisions for valorisation options. This will minimise material designated as 'waste'; facilitate accurate measurement and why. Once established, this can help to identify where improvement can be made, and to target areas of significant co-product/ waste generation that could lead to targeting for innovations.

Accurate measurement of co-products and waste thus allows stakeholders to see where improvements can be made. Having clear waste reduction targets, key performance indicators (KPIs) and measurable goals also allow observation of the progress being made, and areas for further improvement. These targets can be shared between businesses along a supply chain to establish common goals, and results can be published to demonstrate progress. Benchmarking performance will further improve outcomes; this requires consistent terminology and recording of metrics to allow comparisons of like with like in terms of given by-product or waste produced and its performance.

1.3.4. Communication and Information-Sharing Between Stakeholders

All stakeholders have stressed the importance of communication along the supply chain as one of the most fundamental actions that can help to prevent food surplus and waste. In particular, conversations over the telephone were highlighted as a key practice to gain mutual understanding and sharing of information. It will vary between supply chains how communications and decision-making can be improved.

Effective communication can now be facilitated by range of information technology. Many businesses in the supply chain are now sharing information using a range of software and web support applications. Uptake and utilisation of such software could be expanded to use along the whole supply chain, particularly between growers and producer organisations.

1.3.5. Yield, Supply and Demand Forecasting

Regular crop monitoring in the field and in storage facilities can provide predictions for yield and quality, and timely communication of this information along the supply chain can be used to inform storage and orders. Changes in volume or quality due to field conditions, or storage conditions/availability, can require specification negotiations, design of new lines / classes or promotions to respond to gluts, or alterations to 'use by' date labels.

1.3.6. Maintaining Product Quality

There are various strategies and steps to help maintain product quality. Good communication and infrastructure, for example; to reduce transit time and improve secondary storage during transit and use of refrigerated displays in retail stores. Other strategies could include; improving storage conditions along the whole supply chain, reducing handling damage and maintaining optimum temperature from field to store.

Some are working in collaboration with researchers to develop and explore a broad range of technologies that which can increase the percentage of saleable food and help to reduce waste. This includes predicting alterations in expected supply (for example due to changes in quality or quantity of produce) and reducing unexpected surpluses or shortages. These might include monitoring produce while it is in storage.

1.3.7. Alternative Markets for Surplus or Out-of-Specification Fresh Produce

Once produce has been identified as either surplus to retail contract or need, or below minimum specification by retail customers, the quest for alternative markets for sale could be optimised, especially in terms of speed. Users could be wholesalers or alternative retail (such as smaller supermarkets, other shops and market sellers).

Surplus and out of specification food is often also suitable for alternative higher value products following some processing; such as ready meals, juices, smoothies etc., as well as in innovative outlets such as ingredients for health and beauty products.

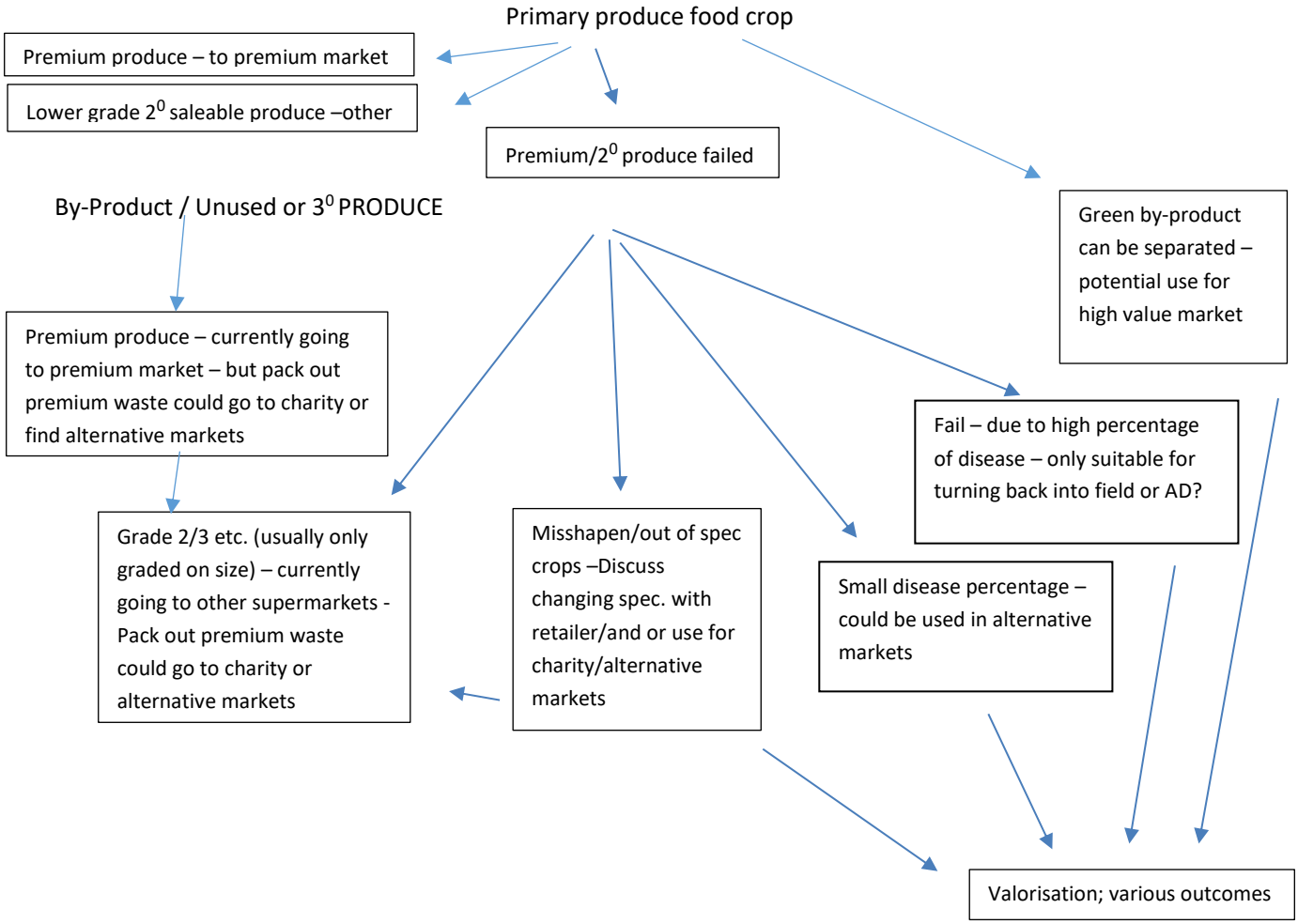
Optimisation of this alternative would benefit from links to waste mapping activities (part of the first principle) in order to plan these outlets immediately a surplus/out of specification event occurs. Fast communication is also vital, whereby a list of potential contacts is maintained and can be contacted, perhaps using an automated system, for ease of access and speed to prevent fresh produce-based food degrading and becoming reclassified as 'waste'.

1.4. Decision Support; Potential Need and Use

To ensure that decision makers take clear, effective actions when food is at risk of becoming loss or waste, a decision support framework may be considered. The following diagram is an example of the type of decision support, which the supply chain could be using, in order to determine optimal destinations for food that is surplus or out of specification.

This could be at any stage for all the processes used in the supply chain, from selling to alternative markets, through to charity redistribution and higher valorisation. With decision support in place it would allow the supplier, make fast decisions and accurate communication with the desired markets.

Figure 3: Illustration of a Simple Potential Decision Support System



2. Selected Outputs from BioBoost; Three Case Study Exemplars of Improved Valorisation

Chapter 1 described the need and potential for valorisation or reduced wastage that can be achieved in an improved circular bioeconomy. In this chapter, three case studies are described in more detail to show how some well-developed strategies with defined feedstocks and user markets can enable effective and economically viable valorisation of waste and co-products.

Brief Description of the Case Studies:

1). The first example considers how insect cultivation can be used to convert very low value material into much higher value products; using in this case a living bio-refinery. It provides new sources of higher value end-products and can remove the need for paying to dispose of waste into landfill.

2). A second study looks at the use of Brussels sprouts and pea waste. These crops are produced in very high quantities in a very small geographic area. INAGRO Belgium has trialled better utilisation of these local crop/food waste-specific products.

3). Crop co-products are often of lower value initially and have often been incinerated or ploughed into the soil or used in low grade packaging. But it is now known this can provide feedstocks for much higher value compounds, such as textile, soft pharma, or industrial ingredients. Effective industry interactions are often vital in such outcomes. This example describes how textiles could be manufactured using tomato stems.

2.1. Case Study 1; Using Insects to Valorise Waste and Co-products

Soldier Flies, Mealworms, Crickets

Interreg2Seas; BIOBOOST

Executive Summary

A decade ago, the knowledge and the enthusiasm to use insects as a method for processing waste was virtually non-existent in Europe. This waste processing solution is now gathering momentum. Thanks to EU funding from Interreg2Seas R&D funds, the BioBoost Partnership has set up and tested pilot sites in the UK (NIAB) and in Belgium (INAGRO & VIVES).

Working co-operatively, the teams have been optimising hatcheries and growth of selected insect species using various waste feedstocks. Black Soldier Fly and mealworm have emerged as potential winners. Other teams and companies are beginning to benefit from this activity too.

Challenges

There was existing knowledge about the biology of some potential insect species that could be used to valorise waste, but this mainly related to their life cycles, food preferences and their preferred environmental conditions in wild, free living situations. Considerable work was needed to convert this knowledge to a farmed /controlled growth situation. Three species were initially selected for trials; Black soldier Fly (Hermetia illucens) BSF, Mealworm (Tenebrio molitor) MW and Crickets (Gryllus bimaculatus) Cr. Initial choice was based on their breadth of food choice, the need for a vegetarian diet and acceptability of products to customers.

The first step was to determine mating and breeding requirements; translation of the behavioural expectations of these species was used to inform design of a pilot set-up that was economically viable, controllable and manageable in the different situations being investigated. The next step was to understand environmental and food requirements of these species for optimal growth.

Food and Environment choices

Several factors and options were analysed by the two teams, taking into account cost, availability and type of waste locally:

Temperature, light, oxygen, type and quantity of waste products from the insects themselves, type and supply of feed (waste/co-products), optimal growth rate, potential for disease breakout in the hatchery or growth chambers and insect genetic resources selected.

Another factor that emerged was adverse impact on the insect farmers. Two of the species (crickets and, to a lesser extent, mealworms) were found to stimulate allergic reactions in staff involved. Although it is possible to design production processes to protect staff and ensure health and safety, such as masks, gloves and filters, this was potentially a significant problem for farmers to set up and maintain insect farms.

The need for waste to be available within a given range of water content was another limiting factor. Waste and co-products are supplied in a form that is not under the control of the insect farmers. In particular, the need to reduce water-content could have profound limitations on the economic sustainability of an operation due to the cost of de-watering.

Each species has a relatively narrow flexibility in terms of maximum protein consumption as a proportion of total feed. Beyond the maximum, excess protein is degraded, leading to ammonia production. Not only is this wasteful, it can lead to negative environmental impact experienced by neighbours of growing facilities, including smell and formation of toxic particulates that would be unacceptable.

Potential benefits from the system

Conversion of mixed, sometimes hazardous food waste was the goal of this activity - this is a good example of waste or co-product valorisation to a higher value alternative product that can be used by either the producer or the alternative customers.

In the worst-case scenario, the waste would need to be disposed safely, which will often incur a cost. Alternatively, mixed food waste could be used in low-grade applications such as a feedstock for AD (anaerobic digestion) for biogas generation, or as a soil amendment.

There is potential for production of highly focused feed or food production from the insect rearing process. In some cases, this could replace feed that is currently either expensive or becoming difficult to source; perhaps through over-exploitation of natural resources or changes in local production

Results, Return on Investment and Future Plans

The duplication of this activity at sites in the UK and in Belgium was vital to consider the potential for identifying different waste or co-product utilisation under the environmental and legislative background in different states within the EU Interreg2Seas region.

The NIAB site chose the option of working directly with new start-up companies that were keen to try this system of waste valorisation. Funds from the BioBoost programme enabled NIAB to Set up and manage a pilot facility in the East of England to trial this innovation. Initially, Entomics Ltd was working closely with NIAB to design and build a working facility. NIAB and Entomics worked together to identify waste feedstocks. An early decision was to source a range of waste fresh produce from the local supermarket Sainsbury. This enabled the group to trial a very broad range of feedstocks and the material was provided free (which was otherwise mainly landfilled).

It is necessary to balance the various components of the feed to ensure a balance of nutrients; fat, carbohydrate and protein alongside water and various vitamins/nutrients. Poultry feed was initially used as an amendment to less nutritionally rich waste.

By 2018, Entomics Ltd had grown, matured and split into two companies; Entomics concentrates on high-end products, using more specific insect genetic resources and feed fermentation. A new company was born; AgriGrub, that focused on the original plan to use waste food and co-products.

AgriGrub was connected to companies and farmers until a good fit was found in terms of waste material direct from producers (rather than retail). This includes the use of brewers waste (not poultry feed) to ensure balanced nutrition.

Four products are now close-to, or actually being marketed from this pilot activity:

1) Live grubs sold into pet-food markets
2) Dead grubs or pupae for bird food
3) Semi processed for fish food
4) Frass; insect excrement + indigestible components of feed; can be used soil amendment and crop feed

At INAGRO/VIVES, four insect species were considered. BSF and MW were considered in depth; CR & Cr were given lower priority due to issues with health & safety.

The team considered feed /environment optimisation, initially using poultry feed to understand nutritional needs and balance. Subsequent work, in collaboration with the auction system in Belgium, identified suitable unsaleable produce. Avocado in particular proved to be a good feed, though issues were encountered with excess protein and ammonia emissions. 6 climate-controlled rooms were used and the integration of insect production in different agricultural sectors such as biogas and aquaponics has been considered.

Potential for use of robots in optimisation of the system is looking very promising. Such is the success of this innovative idea that BSF now has its own Wiki site relating to use in waste-valorisation:

https://en.wikipedia.org/wiki/Hermetia illucens

Figure 1 from top left: mealworms, robot trials, BSF hatchery, final saleable products

2.2. Case Study 2; Valorisation of By-Products from Brussels Sprouts

Brussels sprouts (*Brassica oleracea* L. *gemminifera*)

Interreg2Seas; BIOBOOST

Executive Summary

A growing demand for new and sustainable resources useful for future bio- and circular economies, in combination with stricter regulations, provides an incentive to valorise by-products and waste fractions from the agri-food sector. Thanks to R&D funding from the EU Interreg2Seas fund, the BioBoost Partnership has searched for appropriate harvesting techniques and potential for valorisation of different waste and crop co-products in Belgium, The Netherlands and UK. Brussels sprouts are presented in this case study. Food and farming companies are keen to see improved valorisation of under-utilised biomass fractions and will therefore benefit from these research activities.

Situation

Europe has a total area of approximately 12,250 ha (1) of Brussels sprouts production, with main production (~95%) in the European countries covered by the EU interreg2Seas BioBoost project partners (UK, The Netherlands and Belgium).

The edible part of the Brussels sprout plants (the sprouts themselves) only account for 25-40% weight of the total above-ground biomass, with typical yields of 12 to 18 ton/ha. The following 'inedible' parts are described as a by-product, which is often wasted:

- **Leaves,** left on the main stem
- **Stems,** with a production of approximately 15 ton/ha/year, with 20% DM. On average, 230,000 tons of stems are produced per annum in the EU
- **Under and oversized sprouts,** which are not acceptable to retail outlets (fresh or frozen)

In horticultural value chains, there are often several steps from cultivation to consumption. Agrifood by-products and waste fractions are usually produced throughout the value chain, from cultivation through to harvesting, processing, retail (food loss) and finally consumption (food waste). Improved valorisation of these by-products requires engagement from different actors in the value chain.

Challenges and opportunities

One important challenge early in the Brussels sprout value chain relates to harvesting of residual biomass. Waste leaves are difficult to collect because most will have detached from the plant before the Brussels sprout harvesting period. Furthermore, their dry matter content is low and degrades quickly. Currently, these are usually stripped and left on the field by a defoliator.

Conversely, the stems are produced in large quantities and have greater potential for use in different valorisation paths. Some harvesters have already been adapted, so that this by-product can be collected by growers at the same time as the main crop.

Figure 1 (A) and (B) shows adapted harvesters augmented with an additional collection belt for the stems. When sprouts are harvested, stems are cut and collected separately from the Brussel sprout plants.

These modifications to the harvest regime result in additional harvesting costs of circa €23-34 /ton or €520-740 /ha, accounting for an increase in labour costs (+ 1 h work/ha), fuel costs (+ 1.5 L/ha) and investment costs (~ €30 000, depreciated over 5 years).

Figure 1. Adapted harvester

(A) Adapted harvester for small scale cultivation (1 row)

(B) Adapted harvester for bigger production areas (4 rows)

Stems and sprouts are separated after harvest, by using different collection belts.

The development of a novel value chain forms a second challenge. Brussels sprouts are only harvested between September and March, which means that the co-product biomass is not available throughout the year, unless economically viable storage solutions are found. Ensiling has already been considered, but further experiments are needed to confirm its utility (2).

Currently, the collection of stems as by-product is limited to a few farms; upscaling to more farms is vital to ensure feedstock availability can be ensured, so that supply will be able to fulfil demand. Further efforts from the stakeholders interested in valorisation of Brussels sprout stems into valuable products is therefore needed.

Potential valorisation applications

Paper and cardboard - The stems have a good high fibre content, and they therefore have potential for use as an alternative feedstock in the paper industry. Initial lab tests and pilot production tests were promising and resulted in good quality paper with an aesthetically pleasing range of natural off-white colours (Figure 2).

The next step that is now required is a breakdown of costs to determine whether the price asked by growers for these residues will make their use economically feasible. The logistics required form an important component of this and must be addressed.

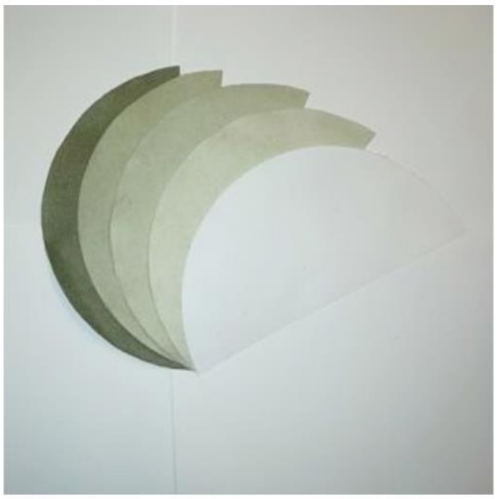


Figure 2 – First experimental results of Brussels sprout paper obtained by Millvision in the Interreg project 'Growing a Green Future'

Additional Valorisation options for Brussels Sprout waste and residual biomass

Animal feed – There are currently seven Brussels sprout farmers in NL and BE using the stems as a component of cattle-feed. It provides their livestock with fresh feed during the winter months, (September to March). Feed values provide between 124.1 kVEM/ton or 10 kg DVE / ton, giving the stems a value of between €25 and €30 per ton. VEM and DVE are standard Dutch feed measurements; VME is a defined as the net energy content of a product for milking cows and is related to the energy content of 1 kg standardised barley (= 1000 VEM); DVE is defined as unit for the amount of proteins available and digestible in the small intestine.

Before using as a feed, the stems were mixed with pressed pulp and then ensiled. This strategy was developed recently in the VEGCAT project; scientists discovered that cattle do not like the hard outer tissues of the stems. Some chopping of the stems is therefore required. This provides good mixed silage feed for all but high output dairy cattle.

Figure 3 – (A) Ensiled Brussels sprouts stems and (B) parts of Brussel sprouts stems that are not eaten by the cattle

Soil improver - Valorisation of the residuals can also be achieved within the farm. Many growers have highlighted the importance of these residuals as soil improvers. They have found that crop productivity increases if residues are returned to the field (3). Although this also depends on climatic factors and soil characterisation, Brussels sprouts residues are characterised by a high N-content and are become available in wet and cold periods of the year (autumn / winter).

Research has shown that the soil mineral N-contents were not significantly improved in fields in which resides from cauliflower, celery, leek or white cabbage were left, compared to fields were residues were removed (4). Gaseous loss of nitrogen by volatilisation and leaching of soluble NO_3 may explain why only a small fraction of the N is available for following crops. For Brussels sprouts residues, total N_2O emissions ranged between 0.13 and 14.6% of the amount of N added as residue (4).

Leaving the residues on the field can therefore be considered as a potential thread to the Nitrates Directive. Another potential use for these co-products could be in production of compost, although their low dry matter content necessitates the addition of other residues to optimise composting efficiency.

Insect feed - The stems and out-of-spec sprouts also have potential as insect feed (see Bioboost Case Study 1 on Black Soldier Flies and Mealworms). Research in the Bioboost project indicates that if up to 80% of insect feed is replaced by Brussel sprouts residuals, a food conversion ratio (FCR) of 1.7 could be obtained. The FCR indicates the required amount of feed to increase animal weight by one kg. The FCR obtained is approximately the same as the control insect feed (chicken meal, with FCR = 1.6).

This is promising information, because the use of waste/residuals as feed is more sustainable compared to the use of chicken meal that is produced using combinations of wheat and other high value food products. Finally, using these residues as a feedstock valorisation through insect production could be an additional source of income from these products.

Energy - Tests to determine Potential for use in an Anaerobic Digester (AD plant). Digestibility tests were performed on Brussels sprout residues (stems, leaves and remaining sprouts). They were found to have a biogas potential of 104 Nm^3/ton, comparable to the potential of leek (5). However, non-continuous feeding of the digester, and higher (mineral) soil contents, hamper this processing method. The digestate resulting from the digestion can be reapplied to the field and is considered to be a useful soil improver.

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2.3. Case Study 3; Using Tomato Stems to Produce 'T' Shirts

The Tomato T-shirt

Interreg2Seas; BIOBOOST

Executive Summary

Learning from a mature project, in which cardboard tomato boxes were made some material derived from waste remnants of tomato plants, we were inspired to consider further ideas. Our team have investigated utilisation of tomato stems to manufacture textiles. The stems are currently collected and composted, then used as soil amendments in public gardens.

Our aim was a more valuable outcome; use of tomato fibres in manufactured textiles, for t-shirts or other clothing . Thanks to R&D funding from the EU Interreg2Seas fund, the Bioboost partnership has set up a project together with Blue CityLab 010 to investigate this innovation.

The idea

The idea builds on several trends; fruit and vegetables are becoming much more attractive in diets, with growing vegan trend. Some millennials increasingly want to be more aware of food and clothing; asking questions about source and production.

In addition, the clothing industry - especially the cotton industry - has a poor reputation in terms of environmental damage and resource use, which has been highlighted in the media. [1] In a recent broadcast, a group of people from the fashion industry visited Myanmar and were appalled to observe the reality of cotton production; involving copious use of pesticides and water. Furthermore, workers dyed the clothing under harsh difficult conditions by western standards. This study seeks to use a waste product to reduce this reliance on such unacceptable production systems. We sought to pilot use of alternative basic raw materials, and/or return (a small part of) production to This would result in textile-production; potentially sold under a sustainable label. The greater goal is to achieve a cross-over between the horticulture and textile industry and to enable these two large industries work

[1] NPO Genaaid.

together using circular bioeconomy principles. That is the dot on the far horizon, but this project is an initial exploration.

The approach

The assignment for this project was given to BlueCityLab in Rotterdam. The project leader designated by BlueCityLab is Tiemen Visser. From BlueCityLab. Our project is divided into three main phases:

1) Conversion of tomato fibres to textile fibre.
2) Attempt to turn this textile fibre into a fabric
3) Pilot production of a t-shirt or blouse from the fabric

In all these phases there is a lot of research and testing. These were recorded on film and - where possible - shared via Instagram @tomatentextiel. Contact is also being sought with other textile researchers in order to reach the goal faster together.

Plant -> Pulp -> Polymer -> Filament -> Yarn -> Textile.

Challenges

In December 2018 the route to making a natural synthetic fibre was assessed, which could also be processed into a portable textile product.

1. Local pulp production is an important condition for the development of the tomato textile. Facilities are not currently available; the challenge was to find partners who could offer a constant, pure and clean amount of stems.

2. The method that will be used to produce synthetic fibre from the tomato pulp also depends on scalability of the production process, the demand for the degree of circularity and what quality requirements are required for the product.

The breakdown of the tomato plant into cellulose as a basis for lyocell can be achieved via three basic routes;

- Biological; Bio-enzymes
- Mechanical; assisted by Caustic soda
- Chemical; without biological/chemical input

The initial preference was the mechanical / caustic soda route. This could be achieved efficiently in-house and did not depend on other institutes/ institutions with inherent delay. A major challenge was the bleaching and separation of the cellulose. Additional support was found by collaborating with Rotterdam University of Applied Sciences; affiliated with the tomato textile project. A pulp was developed using the lyocell process with the help of enzymes. Investigation was carried out for obtaining pure cellulose from the pulp.

For making the polymer, the challenge is to find out which sustainable technology is best suited to produce "large" amounts of cellulose. Finding knowledge partners was also a challenge.

Production of a good filament necessitated finding the right nozzle for the extruder. The need to test for viscosity was also an important requisite. The costs for production and testing were found to be very high (€ 70.000). This need is now supplied by Rotterdam University of applied Sciences.

Finding a spinning mill for production of prototype T shirts from the manufactured 'lyocell' was the final challenge; and is ongoing.

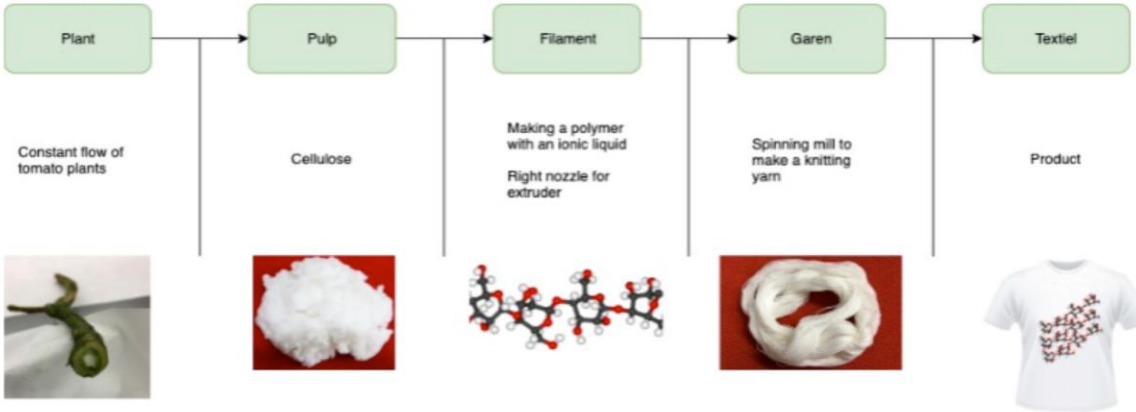
Potential benefits from the system

Conversion of horticultural biomass into wearable clothing was the final goal of this activity. This is a good example of waste or co-product valorisation to a higher value alternative product that can be used by either the producer or the alternative customers. Offering an alternative for the textile industry that is more sustainable (reducing pesticides and water use, more humane labour, and sustainable dying of clothing was the aim. Reducing the costs; or even returning extra income to the horticultural companies supplying the original biomass is another aim. Currently, the waste is used for a very low value outcome.

Results, Return on Investment and Future Plans

The project is still in the development phase. After making a polymer from the pulp, using chemical processing, the production method is being investigated. We were keen to design a production process can be replaced by less environmentally harmful steps; such as the use of enzymes. A production batch was made from the pulp and later also from the polymer. External parties tendered for production of a filament, based on the polymer production. This is being undertaken via Rotterdam University of Applied Sciences.

We are still looking for a small-scale producer for the next step; production of the yarn. For the time being, the European Spinning Group in Belgium is helping with pilot production. A small spinning machine for cotton and lyocell is also being considered. The company, called 'Saints Basics', in The Hague has its own spinning mill in Portugal, which will be trialled soon.



2.4. Higher Valorisation Options in the Fresh Produce Supply-Chain - Discovery and Utilisation

The examples shown in these case studies are just a few of the many potential new business opportunities that could be set up, helping to reduce and make better use of food waste and by-products, adding value to the economy and helping to reduce climate change by using the abundant variety of waste stream sources. In the UK and Netherlands, there is increasing activity beginning to gain traction and economically viable outcomes; building on discovery and utilisation.

One important challenge is to identify and organise new business models for extraction of various ingredients for new end users from simple sugars, proteins and fibres through to complex secondary metabolites. Transport to a processing facility is key and this could be achieved, for example, by using mobile installations or by transport to regionally central locations. A future bio-based economy aims to optimise the value of biomass. Prior to extraction of such ingredients, high-quality bio refineries (converting biomass to energy and other beneficial by-products) may be employed to produce new ingredients for food or non-food applications. At bio refineries, all parts (including non-edible parts) could be optimally utilised.

It is necessary to demonstrate to producers and industry that there are many possible higher value uses for surplus and previously wasted material. Knowledge exchange (KE) workshops, seminars, events and collaborations can maximise links and communication between stakeholders. Encouraging and growing partnerships at different points in the value chain helps to produce new products for end users.

2.5. Regional Hubs

The development of partnerships requires regional bio-based organisations where partners in the value chain can meet and develop new business cases and a place where new companies can develop valorisation pilot projects. An example of this is the UK is the Eastern Agri-Tech Innovation Hub set up and managed by NIAB in the East of England (www.innovationhubuk.co.uk).

The Innovation Hub is a purpose-built facility in the heart of Cambridgeshire, facilitated by funding from the Eastern Agri-tech Growth Initiative and run by NIAB (www.niab.com). This unique centre has a particular focus on reducing waste during the whole production process; concentrating especially on fresh produce and field vegetables. It welcomes farmers and growers, food businesses, and other users wishing to engage in a new business, applied research or pilot studies to reduce waste or re-use various types of waste and by-products in the food supply chain and improve resource use efficiency in its production, often in collaboration with other innovators. The Innovation Hub was set up to support and integrate SME's, large industry and researchers to find innovative ways of reducing food waste. The Hub is a centre for two of the pilots undertaken in BioBoost (www.bioboosteu.com).

Realisation of value from biomass can be assisted by building infrastructure for clusters (platforms) where companies work together with governance and knowledge centres to value substances from the biomass, which could be termed 'valorisation regions'. It has been estimated that the demand for (sustainable) biomass in Europe will be much greater than supply by 2050 (source - the Netherlands PBL, 2013). This will increase the price for biomass and reduce the threshold for transport over longer distances. There is a risk that growers will subsequently find it more profitable to sell this biomass elsewhere; therefore, businesses should, where possible, enter into equitable partnerships. If each region wishes to retain the benefit of

'added value' within their regional boundaries, it will be necessary to act now to implement the plans. Waste streams are currently often used for compost or left on the field, although this can be an important contributor to soil health, there are often higher value potential uses too and the two should be balanced.

In the Interreg2Seas region, a start has been made, but the potential for higher valorisation using innovative processes requires more awareness and better dissemination of knowledge and methodologies. Some new exemplar case studies are illustrated at the beginning of Chapter 2, but many other options can be considered. Governments and advocates for a bio-based economy need to invest in infrastructure and communication to drive this process. Growers are increasingly passionate about waste reduction and keen to embrace the concept of a circular economy and bioeconomy, but require help, guidance and infrastructure to realise this aim.

2.6. Use of by-products and residues along the Supply Chain for Higher Valorisation

- The BioBoost inventory highlighted that the most significant 'waste' products were green waste and crop co-products in the UK, Belgium and the Netherlands
- These should therefore be the focus of new ideas and innovations along the whole supply chain
- Realisation of value from biomass can be assisted by building infrastructure for clusters (platforms)
- The Greenery in the Netherlands and the Greenport area of Zuid-Holland are examples of the whole supply chain working in collaboration
- The Eastern Agri-Tech Innovation Hub is a good example of knowledge exchange between industry, academia and local government etc
- The Hub model could be replicated in other areas, facilitating localised knowledge exchange and support for SME's and research producing innovative ideas for higher valorisation of surplus food

3. Realising the Outcomes of BioBoost

This chapter details ways in which the Interreg 2Seas region can further realise the products of this BioBoost project and beyond in terms of business activity opportunities. A report of the activities related to insect cultivation; the potential for use of field derived pea and sprout material; and T-Shirt manufacture using tomato stems are already detailed in case studies 1-3 in Chapter 2.

The impact of BioBoost is already being realised in the East of England and wider UK. The project inspired the delivery of an event organised by NIAB and supported by Agri-Tech East, (the UK's Agri-Tech cluster organisation) around concepts of a "Circular Economy", to bring together growers and farmers with researchers and commercial technology developers innovating in this innovative subject-area. This event, held in May 2019, was a direct result of discussions underway centred at NIAB and driven by the EA Innovation Hub team. Two of the licensees of the Hub spoke at the event (Agri-Grub and Celbius Ltd). The event also showcased examples of innovations where valorisation is being undertaken using material currently discarded, but from which additional value can be derived (such as anthocyanin pigment components from berries, and use of spent coffee grounds for electricity generation). Delegates also heard from the Senior Business Interaction Manager of the BBSRC; the Biotechnology and Biological Sciences Research Council, which is the UK's research council providing funding for research into non-medical biosciences. We also considered the need for future policy and funding for this area.

In 2018, the UK Government issued a call for major project proposals to encourage a place-based approach to research and innovation funding to support significant local economic growth. This flagship national initiative resulted in the submission of over 80 Expressions of Interest. The Eastern Agri-Tech Innovation Hub and Agri-Tech East led the scoping of a proposal, collaborating with a number of business and academic partners, including the Universities of East Anglia, Lincoln and Essex, and businesses, including G's Growers, Abbey View Produce, Frederick Hiam, the National Physical Laboratory, BT and agricultural consultancy businesses such as Brown & Co. The scope of the project is to help increase efficiency and add additional value to by-products and has a major strand looking at waste valorisation in recognition of the traction in this area partly facilitated by BioBoost. The project was one of 24 to be invited to submit a full proposal by September 2019; this is currently awaiting an outcome.

The impact of BioBoost has also been demonstrated in the collaboration between Microbiotech and AgriGrub and their work together looking at biocontrol trials for Green Pesticide WP5. They have obtained some very promising results and would like to carry out further trials, so NIAB have supported these SME's with a large funding application to IUK and to WRAP.

Significant activities are also underway or in development in the Netherlands; the world Horti-centre opened which provides both physical and virtual demonstration facilities. There are spaces for businesses to demonstrate their innovations and talk to industry stakeholders. It provides a hub for researchers and technical experts and assist with research proposals. Hardware, such as state-of the art glasshouse and horticultural supplies are also demonstrated here.

In Belgium, our partners in INAGRO and ILVO and VIVES have developed, in addition to pilot black soldier fly and mealworm rearing pilots, with online resources to explain this to possible users. On the VIVES Web Pages, there are descriptions of valorisation details such as the process of 'Entomatisation'; the process of conversion of waste into insects.

In the Netherlands, Westland has set up and is now running a web-based platform (https://www.bioboost-platform.com/).This platform connects all biobased horticultural initiatives; providing details of innovation, contact and a means to connect with like minded individuals or businesses to upload bio based initiatives and reuse of green residual streams in the horticultural sector. As a 'free' member of the site you can request the contact details and more information about each initiative. By Summer 2020, there were 60 initiatives detailed there; including for example ways to valorise sugar beet pulp; bringing waste "back to pigs"; rearing chickens on bakery waste; and beer from surplus potatoes.

The "save Our Planet" Game Learning /teaching module was also available from November 2019; developed by BioBoost partner Hogeschool, Vives, which consists of a ready-to-use board game for schools; targeting pre university students. This resource enables students to learn about the concept of a bio-based economy in horticulture in a pleasurable and interactive discursive way. There are 500 games available for schools supplied free and these have already been distributed in Belgium and the UK. VIVES have now made this game available on line using a specialised dashboard interface via the following link (https://canvas.instructure.com/).

3.1. International perspective

There is considerable potential for additional impact from the activities of this project some of which have potential for activities in developing countries, especially in parts of Sub-Saharan Africa and parts of rural India. Some of the circular Economy principles are now being integrated into ongoing projects funded by GCRF (projects led by the University of Cambridge; TIGR2ESS https://tigr2ess.globalfood.cam.ac.uk/ and MillNETi https://www.globalfood.cam.ac.uk/keyprogs/millneti). Use of valorisation for novel food has been considered. Over the past year, the BSFL component of valorisation activities has been discussed with considerable interest by colleagues in Africa with a view to exporting the innovation; we are looking at the conversion of waste to fly larvae in a Ghana waste collection depot outside the capital Accra.

This provides further value-added outcomes from the activities and knowledge delivered by BioBoost. NIAB VIVES and INAGRO have worked closely on the optimisation of BSFL pilots; exchanging information with three SMEs based at the UK EAIH. Impact has including discussion of new ideas between the three businesses; exchange visits have resulted in ongoing collaboration that will continue after completion of BioBoost. Inagro has also produced a video about BSF production on YouTube which has already had 1,190 views: (https://www.youtube.com/watch?v=I5frGGtQD8s&list=PLDsHWM8dws3i4ocjI3N6o3TFycjgSNtDn&index=9&t=1s).

In addition to the activities listed above, BioBoost has contributed many international value-added outcomes from partner research projects investigating higher valorisation and biobased solutions such as

- Processing residual streams fruits and vegetables - Tomabel
- Chipboard production from green residuals – Comgoed
- Green pesticides – NIAB
- Natural plant materials for cosmetic, beauty and health industry – NIAB
- Finding the optimal logistic solutions for harvesting and collecting of vegetable residues – INAGRO
- Stabilisation of horticultural waste, value adding techniques and recipe development – VIVES
- Regional cooperation - Regional platforms have been established in the three regions to stimulate the bioeconomy – Municipality of Westland
- The production of an Inventory that describes the present state of horticultural bioeconomy which is the input for the development of the strategy/approach to stimulate the transition of the horticulture to a bioeconomy

4. Impediments and Structural Needs

Analysis of the current situation in each of the three regions suggests that there are fundamental impediments preventing realisation of waste reduction and valorisation options. Specifically, important physical or structural requirements allied to knowledge should be considered encourage the transition from research or innovation through to practical application in this context:

- Knowledge centres – we need leaders and teachers in this area that can then prime the users. This would benefit from infrastructure in terms of places to learn and inclusion of waste/valorisation principles into national curricula.
- Pre-planning is needed in advance of future development; infrastructure to enable waste valorisation should be built into planning permission requirements.

A major discussion is underway within the UK around a potential "Sector Deal" for the food, drink and agriculture sector, which has the skills and learning agenda as one of its major themes. It is an ongoing challenge to incorporate these types of learning outcomes into the curriculum and to engage teachers and students from primary, secondary and further education.

It is imperative to capitalise on the energy generated by the current zeitgeist around use of single-use plastics and the activities of Extinction Rebellion which have raised the wider issue of climate change and environmental issues higher in the public and political conscience. Changes to the UK's national curriculum, however, take time to embed and often depend on individual teachers to convey key messages to their students. There is local will and political ambition; the President of the UK's National Farmers' Union has stated she aims to make the UK agriculture industry net carbon zero by 2040. But connecting these components in a structured way to deliver national, or even global impact, requires resource and coordination. Discussions are underway to embed this agenda with LEAF (Linking Environment and Farming - https://leafuk.org/) who recently took over the Farming and Countryside Education activities from the National Farmers' Union to create LEAF Education (https://education.leafuk.org/).

If introducing new concepts into the primary and secondary national curricula is a challenge, the UK faces an even bigger issue when considering further and higher education. Easton and Otley College; the Eastern UK regional land-based skills College has been forced to split and merge with other Colleges as it has struggled with finance in recent years; other land-based FE Colleges face similar financial pressures and dwindling students, hence removing another conduit for training about the potential opportunities and pushing it further into the HE sector. Agriculture and food-based degrees have traditionally struggled to fill courses, however with the rise in interest and potential of Agri-robotics (for example a recent major investment into training students in agricultural robotics in the fresh produce sector at the worlds' first Centre for Doctoral Training at the University of Lincoln, with Cambridge and the University of East Anglia) will provide the context for a wider conversation about waste valorisation and circular economy that is central to the BioBoost agenda.

4.1. An example of a regional 'horticultural cluster' in the Netherlands

In contrast to the 'Hub' approach, described above for the UK, there is an example in the Netherlands, of another approach where different sectors in the horticultural supply chain are working and collaborating in one area, in a 'cluster'. In the Netherlands, large horticultural clusters where plants, trees, flowers, flower bulbs and vegetables are cultivated are called 'Greenports'. The initial concept came from national

spatial planning (2004) for spatial concentrations of horticultural industry, the concept developed to a cluster cooperation involving stakeholders from the whole chain; including regional and local authorities (who often took the initiative). In some 'Greenports' there are (sub) collaborations of the commercial sector and authorities as well. There are five 'Greenports' in the Netherlands, which cooperate under an over-arching organisation structure called Greenport Holland. These are:

- West-Holland (Westland region) (glasshouse industry)
- Bollenstreek (bulb growing industry)
- Boskoop (pot plants, shrubs- open field/ glasshouses)
- Aalsmeer and surroundings (glasshouse industry)
- Venlo (glasshouse industry) Noord-Holland-Noord (glasshouse industry, arable crops)

One key asset of the Greenport is the strong synergy with the maritime and transport sectors, ensuring that fresh produce is efficiently transported quickly to destinations across the globe. The Greenport is also forging ever-closer links with the bio & life sciences sector, as the 'greenhouse' is considered the pharmacy of the future: an incubator of new medicines. The Greenports also provide fertile ground for new solutions to global food and energy issues in metropolitan areas. Therefore, the Greenport knowledge institutes have collaborated with major companies, such as Siemens, to develop a new energy system for the Agri & food sector. Many of the sustainability objectives have a cross-sector dimension: the logistics sector is working on food transportation by water, the energy sector is mobilising thermal and residual heat for food production, and food and biomass waste is being harnessed as a new energy source.

4.2. Strategies to produce partnerships in Greenport for a regional horticultural cluster

Greenport West-Holland is a partnership between entrepreneurs, governments, education and knowledge institutions; the so-called 'triple helix'. These parties work together on a healthy, vital and sustainable future for the regional horticulture cluster. Information and resources are available online via the following link, which gives an outline of the cluster and positioning: https://greenportwestholland.nl/wp-content/uploads/2015/05/PositionPaperGPWO.pdf. The cluster includes all companies and organisations that are active in the field of food and floriculture: from trade to production and from breeders to logistic companies. The Greenport examines which actions are necessary to realise this healthy, vital and sustainable future. In this matter, regional entrepreneurs are in charge; governments facilitate, and, when it comes to the knowledge of the future, education and knowledge institutions create the basis for the entrepreneurs to be successful. This Greenport operates as a leader in terms of stimulating sustainable regional cooperation both nationally and internationally.

The regional models of Greenport with their commercial collaboration and partnerships between entrepreneurs, governments, and education and knowledge institutions could be replicated in agricultural/horticultures parts of the UK as could the model of the Eastern Agri-Tech Innovation Hub in order to facilitate the reduction of food waste throughout the supply chain. One strategy could include restricting a move into the new enterprise zone to only those companies that are sustainable and have a rational business case.

4.3. Impediments to Realisation of Circular Economy Principles

The Dutch publication; '***A Circular Economy in the Netherlands by 2050'*** recognises several powerful impediments; it will require concerted effort by the horticulture industry to overcome these:

- Current regulations focus too much on containing the potentially damaging effects of waste and emissions and not enough on allowing realisation of as much value as possible from raw materials;
- Regulations have often been designed to focus on specific sectors and not on cross-sector facilitation;
- The narrow constrictive definitions of waste are not realistic for sustainable, circular activity;
- The true environmental costs of established, damaging and non-sustainable products are hidden, so that sustainable products are more expensive and fail to gain market traction.

BioBoost's **Inventory of BBE barriers** in the Netherlands identifies 69 barriers to the Bio-Based Economy[1]. 23 of these are operational and expected to be resolved during implementation by discussion with the appropriate local authorities and policy organisations. These are items such as granting of permits, provision of subsidies, requirements for monitoring etc. 14 are structural obstacles where Government departments are already working to remove them via new regulations or policy interpretation. An example of this is the Energy Transition interdepartmental activity. 23 are fundamental obstacles under study by the Interdepartmental Bio-economy programme, which fall into 5 areas: innovations needed for the Bio-based economy that are too expensive for the industry to adopt; lack of value-added certification and similar systems that could justify fully-priced products; bans on the use of biotechnology for output-engineering; excessive duties on imports and exports; lack of harmonisation or equivalence of regulation of products and processes between industry sectors that could use bio-based products, and between countries that could import the products. Finally, there are 9 obstacles that conflict with other fundamental aspects of government such as social obligations. These will require closer analysis to see if any compromise can be made that would allow bio-based industry development and policy changes.

'Breaking the barriers to the Circular Economy', was the title of a 2017 report on a substantial survey and interview programme of European corporates and Governments, validates many of the points in strategy documents and concludes that the main barriers to uptake of a circular economy culture are poor awareness of the concept as well as its value amongst consumers. There are examples of regulations actively preventing circularity; such as a road-making company that could not use recycled materials in the top asphalt layers and a plastics company that could not transport its waste Bakelite across the border to a Belgian company, which could then use it in legitimate recycled products. Given support by allied industry associations and selected politicians, legislative change is needed and would be most effective if it could be implemented at a national or supranational EU level in addition to local government.

4.4. Problems Associated with Waste being Invisible to Public and Policy-makers

- Waste produced pre farmgate in the agricultural and horticultural industries is often not highlighted compared with processing and consumer food wastes: in the UK, in the context of minimisation of food waste, agriculture is mentioned in the context of food production, alongside manufacturing, but it is noticeable that it gets little specific attention[2].
- Despite the differences between horticulture and open field agriculture, it is difficult if not impossible to find tailored or specific strategies and policies. Too often, horticulture disappears within agriculture, which means it is not visible as a valid target with its own rationales for policy changes.
- Horticultural waste is less visible than purpose-grown and commodity crops and forestry, as a source of biomass: waste output in the EU in primary production has been estimated at $9.1 \pm 1.5 \times 10^6$ tonnes, but this cannot be broken down further[3].
- The different sub-sectors within horticulture (e.g. fruit, vegetables, ornamentals, amenity plants; glasshouses versus arable crops) are likely to have different problems and solutions for circular bioeconomy actions - these are difficult to tackle when the umbrella term 'horticulture' is used.
- Appropriate data for total biomass production in horticulture is lacking or inadequate, mainly because there are no statutory requirements in many countries (only 6 out of 15 member states) for data-

collection or obvious purpose yet for the data to be collected and to be made useful. The EU funded FUSIONS project found that data for primary production across the value-chain, is of insufficient quality[4].

4.5. Problems of Inappropriateness

- Policies for inducing circular bioeconomy include providing subsidies for carbon-mitigating actions such as land adaptation as carbon sinks or replacement of high-footprint crops by lower-footprint crops. Horticulture will find itself at a disadvantage because there is less scope and scale for such action than in commodity-crop agriculture. In the Netherlands, policy is more supportive than the UK.
- Policies increasingly focused on environmental action, such as promoting development of biopolymers in place of petroleum-origin plastics, may narrow the potential for innovation in other types of biomass-derived products.
- Programmes of technology and innovation support may focus on advanced precision farming, i.e. such as the use of data, IT, satellite-scanning, novel engineering and other tools, to increase yields using more precise application of resources such as water, fertiliser, disease control agents and more efficient timing of planting, growing and harvesting. But this risks reducing the funding for new and better use of residual, by-product and waste biomass and investment in the scale-up and demonstration needed for processing and end-product generation.

4.6. Problems Associated with Lack of Co-ordination

- The responsibility for Food and Agriculture biomass management strategies in Environment departments is often in the context of reducing greenhouse gases (GHG) and carbon impacts, meaning that many useful initiatives focus too much on surplus, secondary or waste biomass from processing, storage, transportation, retailing and consumption[5] – the policy and strategy for production stages is housed in Agriculture commissions or ministries, and bioeconomy actions are only recently taking more precedence compared with yield enhancement and disease management.

4.7. Problems due to Bureaucracy and Regulations

- Planning practices and regulations may restrict valid uses of biomass: e.g. in the Netherlands, other enterprises cannot be set up in areas near to horticultural glasshouses, which is a current impediment to on-site use of Black Soldier Fly larvae; a good valorisation use for unsaleable produce[6].
- Generally, existing financial support regimes or subsidy programmes exclude greenhouse production and horticulture in the UK; as above, schemes are better aligned in the Netherlands and Belgium.
- Detailed data for horticultural and agricultural waste is urgently needed; and made available by government agencies, so that that its availability is known for other uses.
- The use of horticultural biomass and different types of residues is hampered by legal definitions of waste and the restrictions on its use allied to bureaucracy related to obtaining permits. Regulations may also hamper recycling or repurposing of non-crop cultivation materials such as composts, plastics and water effluents (such as washings).
- Existing products occupy the market but often benefit from combinations of favourable subsidies and support regimes and lower costs due to economies of scale and duration in the market.

5. Governments; National Regional and Local Activity to Facilitate Positive Change

5.1. Transition to a Circular Bioeconomy in Horticulture

Based on the existing actions and strategy and policy positions, ten key elements have been identified that are needed to implement a practical plan enabling transition to a Circular Bioeconomy in Horticulture:

1. Establish effective lobbying government and legislators for horticulture at national and supranational levels;
2. Ensure that new value chains are built simultaneously with new initiatives, so that new products have a ready market;
3. Promote short supply-chain initiatives in the circular bioeconomy, where possible; such as through creation of inter-industry clusters;
4. Establish certification systems that clearly mark new products, which fulfil horticultural circular bioeconomy principles, and therefore contribute to sustainability;
5. Increase public perception of the quantities and types of non-saleable biomass and other materials in horticulture, where they occur in the production process, and the kinds of actions that maximise the potential for reuse, recycling and to extract maximum value;
6. Reduce waste generated through production of sub-specification crops, by improving management, logistics and negotiation of more realistic specifications with suppliers and customers;
7. Increase the utilisation of products that meet specification, to extract more value and reduce discards, by innovating new end uses and developing new products, through e.g. pre-processing;
8. Reduce grower costs by improving production efficiencies and maximise recycling of spent growing medium/resources, and crop co-products (including biomass, water, energy, fertilisers, soil improvers and processing materials (e.g. packaging & plastics);
9. Increase the appropriate use of precision horticulture and automated technologies to maximise yields and improve timeliness and efficiency of harvesting;
10. Tackle practical issues faced within the horticulture industry sub-sectors, including:
    a. Differences in costs and technical maturity between countries, regions and types of horticultural production that can hamper uptake of innovations (e.g. precision farming or high-intensity water efficiency;
    b. Technical/economic difficulties associated with separating waste-streams to gain value;
    c. Manage disease implications of recycling plant materials, water, soil substrates or replacements, plastics etc. and develop effective decontamination techniques;
    d. Optimise/rationalise legislative standards for suitability of waste and its utilisation;
    e. Encourage/enable provision of skilled/semi-skilled labour to deliver bio-circular activities, through e.g. training and incentives.

In the Interreg 2Seas regions covered by BioBoost, the Netherlands is particularly active in recognising the importance of the horticulture sector as a contributor to the national economy (>€7B vegetable exports in 2014, for example[7]) and for its role in sustainability and a circular bioeconomy. Horticulture and growers are specifically mentioned in the 2018 NL Vision document, '**Agriculture, nature and food: valuable and connected'**[8]. Approaches described in this can be used as models for elsewhere; in particular, the development of criteria for assessing whether policies and regulations are adequate to favour development of circular bioeconomy. This document recognises that horticulture, particularly closed-system or intensive glasshouse, is already on course for sustainable crop production and pinpoints water efficiencies and energy reclamation as two targets. So called 'Greenports' are identified as a positive way forward, building clusters of interlinked activities; promotion of short-chain linkages to consumers is also identified as a positive. One strategic target is clearly the positioning of advanced horticulture within cities, including sustainable provision of food and other products, based firmly on circularity.

The Dutch criteria question how well policies and regulations robustly support the circular economy in agriculture and horticulture, in addition to maintenance of food safety and product quality. In tackling unhelpful regulation, BioBoost can apply these more widely, in lobbying for change; and whether they facilitate the following **key outcomes**:

1. Helping to close cycles, to reduce emissions and to reduce biomass wastage throughout the food system
2. Strengthening the socio-economic position of the farmer in the supply chain
3. Contribute to the climate task for agriculture and land use
4. Benefit ecosystems, biodiversity and the natural value of the landscape
5. Contribute to the recognition of the value of food and to strengthening the relationship between farmers and citizens.
6. Share initiatives from each partner region and propose changes at national and local government level.

On a European scale, the key actors in establishing the Bioeconomy are the public-private Joint Undertaking, the Bio-Based Industry Forum[9] and its effector arm, the Bio-Based Industry Consortium BIC[10]. Streaming biomass through to bio-products using biotechnology is the underpinning aim, which aligns with but is not identical to the target of a Circular Bioeconomy in Horticulture. Internationally, the FAO's International Sustainable Bioeconomy Working Group is tasked with putting guidelines together for a global sustainable development strategy. The Horticulture sector in general need to engage with these supranational initiatives to ensure that the sector's needs for funding for demonstration, pilot-stage and commercial validation of new systems can be considered, that recommended policies are appropriate for horticulture and that the outputs of the BioBoost regions' horticultural circular bioeconomy activities are compatible with developing international standards in eco-awareness and 'green' credentials.

5.2. Policy Recommendations and Actions

The major conclusions from those strategies within agriculture, horticulture and the food value chain that have been used for this analysis are:

- Horticulture does not have enough visibility within the whole crop production industry; the rolling-in of field and glasshouse horticulture activities with agriculture in general has an adverse effect when considering impacts of policies and strategies or development of new ones, and leads to lack of consideration of the need for changes that are tailored to conditions in the sector[11];
    - The voice of Horticulture needs to be more prominent at European and national level, both supporting agricultural bioeconomy policies, and ensuring that this results in positive action specific to horticulture;
    - The Circular Bioeconomy strategy for horticulture should be included in the agenda of every meeting of European fruit-and-vegetable producer associations;
    - Conference opportunities should be identified and secured at all major relevant Circular Bioeconomy meetings and horticultural events;
    - Horticulture interests should be well-represented in transnational platforms such as EIP-AGRI and in the relevant committees of the European Parliament;
- The horticulture industry should apply sustained pressure to take advantage of existing inter-ministerial initiatives, such as already happens to some extent in the Netherlands, and promote them as best practice when better integrated action is needed.

- To help at political level and at practical level with producers, an inventory of case studies, where possible supported by economic analyses, would be a very useful resource and would best be established as a separate EU- or internationally-funded project, housed in a top-level organism such as a Platform or cross-industry grouping.
- There is a need to ensure that the Circular Bioeconomy and additional co-product uses of agricultural and horticultural outputs are given the same emphasis as measures to increase production and uptake of crops and to link together the concepts of Industrial Biotechnology, the Circular Economy, and sustainable crop-based bioeconomy in horticulture;
- There is still too much focus on consumer-level food waste and not enough on producer-level circular bioeconomy potential including valorisation;
- The lack of formal systems for measuring biomass output and waste production, by total amount and types, means there are no mass-balance tools to determine production efficiencies and impacts of actions – this is particularly obvious in the UK but much better developed in Belgium;
- Strategic, top-level intentions need to be translated decisively into ground-level supportive policies, including mirroring visions produced by inter-ministerial groups into local government actions:
    - the tendency for support-mechanisms to be divided between Research & Innovation, Investment, Social, Political and Regulatory compartments should be redressed;
    - local and national planning and resource-management requirements must not restrict or limit the establishment of 'virtuous circles' e.g. water recycling systems or processing-plant co-siting;
- There's a strong need to institute mechanisms for revision of legal categorisations of wastes and enforcement of waste management rules that limit the potential for re-use of biomass and used materials; also, mechanisms for rapid review of these as innovations arise;
- There is a need to build a widely accepted [and enforceable] programme that applies 'public green procurement' principles to horticulture and its outputs, including adoption of Circular Bioeconomy production criteria by food processors and suppliers who interface with public procurement;
- Establish a credible 'eco-plus' label for the primary and secondary outputs of horticulture and energise momentum to overcome the difficulties in achieving its establishment – experiences and achievements of other eco-labels could be used to help this.

5.3. Strategies and their evolution

Strategies relevant to horticulture include global, regional and national commitments to safe and nutritious food produced without environmental harm and in a sustainable way[12]. Apart from the Nationale Tuinbouwagenda produced by Greenports and the Welsh Horticulture Strategy in UK, none has a focus on horticulture or been produced by the horticulture sector. Current strategies include:

- The UN and FAO have provided the umbrella positions within which action for a Circular Bioeconomy can be established
    - *Sustainable Development Goals* & *2030 Agenda for Sustainable Development* 2015
    - *Sustainable Bioeconomy Guidelines* of the UN Food and Agriculture Organization 2017
- The EU has strongly supported transition to a Circular Economy and to a Bioeconomy, via Directives, Framework Programmes, Platforms and funding instruments:
    - *The Waste Framework Directive* 2009
    - *McIntyre Report: Future of Europe's Horticulture Industry* 2014
    - *Circular Economy Action Plan: Closing the Loop* 2015
    - *Food 2030* 2015
    - *A Clean Planet for All* 2018

    - The BIC *Vision: The Circular bio-society in 2050* 2018
    - *European Cluster Policy* and use of non-food biomass
- Belgium – specific activities include the following:
    - *Flanders' Materials Programme* 2011
    - *Bioeconomy in Flanders* 2013
    - *Visie 2050: a long-term strategy for Flanders* 2016
    - W. Belgian Federal Proposals for a Circular Economy 2016
    - Brussels Capital Region *Regional Programmer for Circular Economy* 2016
- The Netherlands – specific activities include the following:
    - *The Coordinating programme on Circular Economy* 2009
    - *Waste Management Plan* 2009
    - *Raw Materials Memorandum* 2011
    - *The programme on Bio-based Economy* 2012
    - *Memorandum (Hoofdlijnennotitie) Biobased Economy* 2012
    - *Policy for Green Growth* 2013
    - *The initiative From Waste to Resource* 2014/2015
    - *Biomassa 2030: Strategische visie voor de inzet van biomassa op weg naar 2030* 2015
    - *Onderzoeksagenda Biobased Economy 2015-2027 B4B: biobased voor bedrijven, burgers en beleid* 2015
    - *A Circular Economy in the Netherlands by 2050* 2016
    - *Nationale Tuinbouwagenda 2019-2030* Greenports Nederland 2019
- The UK – specific activities include the following:
    - *The WRAP Courtauld Commitment 2025* 2005
    - *Industrial Strategy: Building a Britain fit for the future* 2017
    - *A Green Future: Our 25-year plan to improve the environment* 2018
    - *Growing the Bioeconomy: Improving lives and strengthening our economy: a national bioeconomy strategy to 2030* 2018
    - *Health & Harmony: The future for food, farming and environment in a Green Brexit* 2018
    - *The Resources and Waste Strategy* 2018
    - Scotland: *A Biorefinery Roadmap for Scotland* 2015
    - Scotland: *Making Things Last: A circular economy strategy for Scotland* 2016
    - Scotland: *Biorefining Potential for Scotland* 2017
    - Wales: *Strategic Action Plan for the Welsh Horticultural Industry*

Their evolution means that waste reduction, GHG minimisation, climate change mitigation and avoidance of microplastics are now the drivers for policy changes, including regulation and controls. Stimulation of supply-side and demand-side by innovation funding, subsidies for transition and levies will increasingly be focused on carbon-sink and climate change actions. In agriculture, the immediate opportunities are still seen as using surplus, unharvested and waste biomass in AD, generating biogas for energy use and digestate for organic fertiliser, replacing fossil-fuel-origin or high-carbon-footprint conventional 'chemical' fertilisers[13,14], and encouraging uptake of edible but unsaleable produce through re-distribution schemes. As food waste is such a big contributor to climate change, this could be used as the focus to promote the biobased economy.

The FAO states that it considers production and use of biomass and bioproducts are 'in scope' for the Sustainable Development Guidelines, which are intended to be in place by 2021[15]. Much of the SDG's aspirational principles and criteria are directly relevant to BioBoost partners and their work:

- Principle 1: Sustainable bioeconomy development should support food security and nutrition at all levels; Criterion 1.2: Sustainable intensification of biomass production is promoted;

- Principle 3: Sustainable bioeconomy should support competitive and inclusive economic growth; Criteria 3.1-3.3: Economic development is fostered, Inclusive economic growth is strengthened, and Resilience of the rural and urban economy is enhanced, resp.;
- Principle 5: Sustainable bioeconomy should rely on improved efficiency in the use of resources and biomass; Criteria 5.1-5.2: Resource efficiency, waste prevention and waste re-use along the whole bioeconomy value chain are improved, and Food loss and waste is minimised and, when unavoidable, its biomass is reused or recycled, resp.;
- Principle 6: responsible and effective governance mechanisms should underpin sustainable bioeconomy; Criterion 6.1: Policies, regulations and institutional set-ups relevant to bioeconomy sectors are adequately harmonized;
- Principle 7: Sustainable bioeconomy should make good use of existing relevant knowledge and proven sound technologies and good practices, and, where appropriate, promote research and innovation; Criteria 7.1-7.2 Existing knowledge is adequately valued and proven sound technologies are fostered, and Knowledge generation and innovation are promoted, resp.;
- Principle 8: Sustainable bioeconomy should use and promote sustainable trade and market practices; Criterion 8.1: Local economies are not hampered but rather harnessed by the trade of raw and processed biomass, and related technologies;
- Principle 9. Sustainable bioeconomy should address societal needs and encourage sustainable consumption: Criteria 9.1-9.2: Consumption patterns of bioeconomy goods match sustainable supply levels of biomass, and Demand- and supply-side market mechanisms and policy coherence between supply and demand of food and non-food goods are enhanced.

The FAO is also working on criteria and measurements for assessing biomass, actions within the sustainable bioeconomy and impacts[16] .Earlier in 2019, the OECD reported on bioeconomy and sustainability in the agriculture and food system[17]. Key findings include that national strategies should highlight food security and environmental protection, rather than bio-based opportunities; and that development of the bio-economy is not intrinsically sustainable. Policy-making is therefore highly challenging in the light of these disagreements. Empirical evidence of bioeconomy benefits is lacking. Better monitoring and assessment of economic, environmental and social impacts is therefore needed. Consumer awareness of bioeconomy products is needed in order to push it up to the top of national agendas. Current concepts of coherence across sectors are too vague and ineffective, and too few countries are tackling inhibitory regulation. These are all concerns that must be addressed in a coherent Horticulture Bioeconomy Strategy.

The EU could benefit from the US National Bioeconomy Blueprint[18]. Although it is not specific about the Circular Bioeconomy, some of its intentions (e.g. to strengthen Small Business Innovation research; fund and organise more translational work; encourage review of regulations to ensure they are appropriate) are applicable.

5.4. Policies Promoting a Circular Bioeconomy; Current Situation in The Netherlands, UK and Belgium

The Table in Appendix 2 summarises the policy documents in the 3 BioBoost partner countries. The EU-funded Interreg NWE project BIOBASE4SME has also produced very useful Bioeconomy Factsheets for Belgium, the Netherlands and the UK, amongst other European countries[19]. These give an overview of the national bioeconomy innovation technology systems, key government interventions, research institutes, networks, finance instruments and examples of industry action.

Belgium (Flanders)

The ***Materials Programme*** was founded in 2011, by OVAM, the Agency for Public Waste, Materials and Soil; case studies have been published[20]. The ***Flemish Bioeconomy Strategy***[21] mentions the importance of Flanders in intensive horticultural production, but has no specific strategy. However, Flanders has a stronger economy in bio-based products than in bioenergy, and the report establishes the hierarchy of Food first, Products second and Energy third, as ways of using biomass, residuals and wastes from primary production (like that seen in UK WRAP publications). ***Visie 2050*** (2016) includes the circular economy as a transition priority and states that "Green Deal Circular Purchasing" is part of the work programme, which gives opportunities for horticultural circular bioeconomy products[22]. A Circular Economy Policy Research Centre has been established. The activities of ***Flanders Food***[23] and ***ILVO*** (The Research Institute for Agriculture, Fisheries and Food[24]) have the potential to be strong drivers for bioeconomy through their links with the horticulture industry. The national ***Proposal for a Circular Economy***[25] acknowledges value-added [bio]chemicals, biogas, composting and improvement of the biosphere as relevant contributions of agriculture. Brussels Capital Region has a ***Programme for the Circular Economy*** that focuses mainly on dealing with urban materials but does mention recycling agricultural materials and food waste; the latest report does not discuss the potential of bio-based products[26]. The main driving force in Flanders is the government interdepartmental working group Bioeconomy ***IWG BE***, set up in 2012 by EWI (Research & Innovation), Agriculture & Fisheries and Environment; EWI concluded in 2017 that, though biomass valorisation for wood and paper streams was well-established, progress was needed in using other biomass resources[27].

The Netherlands

The strategy ***Circular Economy in the Netherlands by 2050*** recognises the role of biomass and food as a resource for bioplastics, as well as the drive to minimise wastefulness and make maximum use of biomass in food production and processing[28]. Nine Top Sectors are included in a Bioeconomy Agenda, with the Sectors of Horticulture and Starting Materials[29], Biobased Economy and Agri & Food being highly relevant[30]. A major strategic imperative for enhancing circularity in food production is seen as "the removal of statutory obstacles", including redefinition of some materials e.g. unsaleable vegetable biomass, as residues and not waste, so they can be valorised, at least for use in animal feed. The ***Industrial Biotechnology Strategy to 2030*** for the Netherlands only mentions biofuels from non-food crops or wastes. In practice, biomass, animal manures and residual flows from food production are recognised as foundations for the NL agriculture-based bioeconomy[31].

UK; with a focus on England

Health and Harmony pinpoints the UK AHDB (Agriculture and Horticulture Development Board) as the agency that will be responsible for stronger resource efficiency and sustainable growth, and signposts precision farming as an enabler for innovation in horticulture[32]. ***A Green Future*** lacks any vision for horticulture's role in improving the environment through targeted circular bioeconomy actions but mentions the development of bioplastics as part of a strategy for the bioeconomy[33]. ***Growing the Bioeconomy*** establishes several 'Actions for Change' in UK including a market intelligence tool to support decisions on resource allocations of food wastes and other biomass and acceleration of progress in minimising waste creation and maximising value extraction. The ***Bioeconomy Strategy Consortium*** set up as part of this does not include any member with direct focus on horticulture. In ***Courtauld 2025***, WRAP, the main UK agency charged with waste minimisation and valorisation in UK, has produced a Food Waste Reduction Roadmap to support its 'Target, Measure, Act' programme. The ***Industrial Strategy*** of 2017 identifies the East of England as an exemplar of the sustainable Agri-Tech of the future, and the North of England for Agri-Tech bioeconomy[34]. Biomass valorisation is mentioned in the context of the North of England's Science and Innovation Audit, with examples of new proteins from feed wheat and energy from pea-plant wastes helping power the pea processing plant[35]. ***Horticulture Wales***, the project resulting from the Welsh Strategy for Horticulture, has published a Practical Guide on ***Reducing Waste in Horticulture***, which embodies WRAP's Courtauld 2025 and other European approaches in terms of identifying types of waste and where it arises, measuring wastes and putting targeted actions in place[36]. Water conservation and reuse will also be addressed.

6. Communication and Public Interaction

6.1. Clever communication and cooperation

The concepts of bioeconomy cannot be embraced and applied by suppliers into society unless society knows what constitutes a bioeconomy. Society needs to both understand its role and welcome its products and services. Furthermore, suppliers within the value chain need to see the advantages and the perspectives. You could say a push and pull approach is necessary: push from supplier side, pull from consumer side.

Significant change can only made through the participation of all players in the production and value chain and by creating the right conditions for involvement of all stakeholders, including public authorities and consumers. Added value should be equally divided along value chain so that economic feasibility is assured for all actors involved.

6.2. Key messages per target group

Depending on the target group, basic messages need to be developed suitable for specific situations. In our campaign we worked with the following basic message:

'*Horticultural waste streams can be used for new purposes; which contribute to the development of a bioeconomy. Such a development leads to a win-win situation for the environment and the economy.*'

The dissemination and communication of BioBoost work, mission and aims is of vital importance in order to achieve its project goals. This chapter describes the background and approach of the 'Bioeconomy awareness and activation campaign'. This was a major activity in the BioBoost project, which was funded by the Interreg 2 Seas Programme.

BioBoost started at the beginning of 2017. The aim of the project is the high-quality use of plant waste streams and plant compounds for food & feed, pharma & cosmetics and as a raw material for the construction and paper & cardboard industry, among other things. To this end, activities are carried out in the project that test possible applications. In the project, various partners from the United Kingdom, Belgium and the Netherlands have worked together to achieve its deliverables. The prime objective is to influence waste reduction in the horticulture production chain, strengthen the economic base of that chain and promote policy change to achieve these goals.

The key BioBoost message is to "Reuse Horticultural Waste Streams"

'Horticultural waste streams can be used for new purposes that contributes to the development of a bioeconomy. Such a development will benefit the environment and the economy. Horticultural waste streams will be reduced and mainly be (re) used as base material for new applications, products or raw material. This is positive for the environment and for combating climate change. In addition, high-quality use of these waste streams can lead to additional income for the horticultural sector and can strengthen its economic position'.

6.3. Target group and goals

BioBoost focused primarily on early parts of the fresh-food chain, where in horticulture the vegetables and fruit are grown and supplied to the market. Therefore, the primary target group are growers, farmers and grower groups in horticulture, fruit, ornamental and the food industry. The secondary target group are the general public. The goals for the campaign are summarised as follows:

1. SMEs:

a. inform about the concept of a bioeconomy and the use of residual flows
b. provide with background information
c. advocate the added value of this
d. inspire to action

2. General public:

a. to raise awareness about developments in this area and benefits
b. to provide them with background information
c. a positive attitude towards the use of residual flows

6.4. Intended impact on SMEs (Small and Medium sized Enterprises)

a. 50%[1] are positive about the idea of bioeconomy and the use of residual flows
b. 50% is interested in exploring its possibilities

Knowledge: Greenhouse horticulture entrepreneurs are aware of the new revenue models and no longer see plant and fruit residues as waste, but as raw materials for new products.

Attitude: Greenhouse horticulture businesses see the added value of bio-based products and are positive about it.

Behaviour: Greenhouse horticulture entrepreneurs are prepared to invest in order to make new products from vegetable waste.

6.5. Impact on the General public

a. consumers are positive about the benefits of bio economy products for the environment, for the society and for the businesses
b. prefer these products over other products (long term effect)

6.6. Outreach and good examples delivered as part of BioBoost

Publicity, communication and the dissemination of the BioBoost findings, concepts and results has been a major and important part of BioBoost. A summary of what has been delivered is as follows:

- BioBoost project billboards, posters, signage, plaques, brochure, website, e- newsletter and twitter feed
- Promotion and description of BioBoost on partner websites and other platforms
- Learning module (the bio-based game as mentioned in Chapter 4)

[11] In application: '50*% of the SMEs reached in the three regions are positive to green innovations and the bioeconomy and interested t explore their possibilities'*

- Events with a stand promoting BioBoost – including posters, fliers, brochures, and WP examples
- Seminar presentations from the three regions; introducing opportunities that co-products and by-products in horticulture offer for new products and business have reached many stakeholders
- End of project conference in the Netherlands, promoting the BioBoost outcomes and messages to stakeholders; the results of the project is postponed due to Covid19 with a new date to be confirmed.
- NIAB has had over 80 SME interactions and further interactions with government officials, NGO's, students and academics for the promotion of BioBoost. Some of these were delegates from India and Africa.
- NIAB promotion of BioBoost at events and outreach include: three annual events as part of Agri-Tech Week, NIAB open days, Royal Norfolk Show, Festival of Plants at the Cambridge Botanic Gardens, Science Week, Annual Cereals events.
- Belgium has hosted farmer facing events with delegates able to try new products produced at pilots and discuss production requirement. Partners have interacted with >50 SMEs during the project.
- Netherlands has set up a new Web-Based Platform where SMEs and large businesses can give details of valorisation and novel co-product utilisation initiatives.

7. Summary of dialogue - outputs of BioBoost and projected Strategy Drivers in the Future

7.1. Structural needs and Political Drivers – A Strategy for the Future

Before national or regional action can gain significant traction, policymakers and politicians need a vision that shows how Horticulture can benefit the economy and environment by embedding circular bioeconomy principles in stakeholder activities. The horticulture sector needs to create, discuss and agree then act; including lobbying for necessary funding and regulatory change. Ideally, government and politicians should be actors in the process of moving the vision forward and, local government encouraged to provide resources for implementation e.g. a Green Bioeconomy Unit/Centre or similar. These are the practical experiences of Greenport Westland in the Netherlands[37].

7.2. Clusters, networks and platforms

Networks, clusters, hubs (such as the Eastern Agri-Tech Innovation Hub) and platforms (such as BioBoost and the BioBoost Platform, set up by Westland in NL) are essential. They promote and accelerate development of actions, transfer knowledge and best practice, enhance potential for investment and can lobby for changes in strategy and policy. The EAIH link and liaise government, by collaborating with SME's, growers, industry and research. The Hub and the BioBoost platform will promote these models for others to use. They should engage in discussions with appropriate governments, so that the vision for the bioeconomy can be further reinforced. These already exist for industrial biotechnology and Bio-based Industry and, to a lesser extent, for general agriculture. They have the potential to generate case studies that will encourage investment and uptake of circular bioeconomy opportunities more widely.

Clusters for the future should not be restricted to same-sector enterprises but should include mixtures of activity, to create opportunities from innovation and new value chains from usable residues and co-products, maximising the chances for **locally produced,** short supply-chains, and enhancing viability of new biomass-based CBE webs. Such mixed-sector clusters should also be catalysts for more appropriate and realistic local regulations and controls, including those for management and re-use of wastes and zoning rules for buildings and industrial activities. There is also a need for establishment of a cross-regional organisation for horticulture. It should build on existing hubs, clusters or networks in horticulture, foster establishment of new ones and capture and integrate momentum within the sector. It needs to make horticulture visible by working with umbrella organisations to ensure that special needs of horticulture are considered when support and funding programmes are put in place for agriculture, or strategy or policy for agriculture or bioeconomy is being developed or reviewed. There is an ever-present challenge to maintain influence at all levels, local and national in the production country and umbrella-level within Europe or indeed internationally.

Demonstration and process development and validation centres are also essential to establishing circular bioeconomy actions, and the Horticulture sector should be making full use of those such as the EUY's Pilots4U network of open access bioeconomy pilot and demonstration facilities, 2017-2019[38]; Belgium's Bio Base Europe Pilot Plant Ghent[39] and ILVO in Ostende[40]; the Netherlands' Greenports[41], (BioBoost partner Westland is a member of Greenport West Holland. There are also the Dutch Biorefinery Clusters[42], The Bioprocess Pilot Facility Delft[43], and innovation centres; such as Green PAC in Emmen and Zwolle[44];

and the UK's Biorenewables Centre York[45], the Agri-Tech Centres of Agricultural Innovation – the Agri-EPI Centre (https://agri-epicentre.com/about-us/agri-tech-centres-of-agricultural-innovation/) and the Eastern Agri-Tech Innovation Hub[46].

Underpinning and energising the clusters are knowledge networks and platforms. The ***European Innovation Partnership for agricultural productivity and sustainability*** EIP-AGRI includes horticulture in its remit. It was founded in 2012 as part of the Europe 2020 Strategy and brings together funding opportunities and networks of the Rural Development programmes and H2020[47]. It held a workshop on opportunities for circular economy in agriculture in 2015[48] that used TomatoMasters and Aqua4C (an integrated tomato horticulture-fish farm circular initiative in Flanders[49]) as a case study for discussion. The EIP-AGRI also established Focus Groups FG 27 on Circular Horticulture 2017-2019, whose publications include a Starting Paper, which sees a large potential in protected cultivation using precision systems and many underexploited opportunities for circularity[50] a short paper on clusters to enhance circular horticulture[51] and their Final Report, covering circularity in glasshouse systems[52]. The short paper provides a blueprint for establishing effective clusters and gives examples, one of which, Flanders' Food, is in the BioBoost regions. Their Operational Groups, supported by the EU's Rural Development Programme, are clusters of companies and establishments looking at specific problems that require innovation to overcome them; their project portfolio from 2016 to 2019[53] includes case studies, assessing costs and generating potential best practice in animal and crop production, horticulture, food and wine production and resource efficiencies.

Industry groupings are also important, ranging from the national biotechnology organisations committed to bio-based economy through to local groupings focused on bio-based value flows, such as Biobased Delta in the Netherlands, which promotes the use of biomass from sugar-beet and sweet corn, amongst other sources, for bio-based products[54].

7.3. Market drivers and linkages

Overall market forecasts are strong drivers for investment. In the bioeconomy, **Table 2** summarises some market data that underpin ideas of growth and opportunity. Clearly, innovation in horticultural circular bioeconomy could aim at the largest sectors. On the other hand, relatively niche products, such as fibre-based products from tomato wastes[55], are just as feasible as marketable valorisations of biomass.

Table 2: Estimates of some markets for biomass-derived products

Market sector	Size	By or in Year	scope
Cellulosic bioethanol	€14.4B	2030	Global
Bio-based chemicals and plastics	€5.2B	2030	EU
Bio-based jet fuels	€1.4B	2030	Global
Functional foods & nutraceuticals, % of	€52B*	2010	Global
Alternative proteins, % of	€33.4B	2013	Europe
Plant-derived drugs, % of	€20.9B*	2010	Global
Biosurfactants, % of	$2.4B	2025	Global
Crop-origin Oils and fats, % of	€0.58B-€1.16B*	2010	Global

*Source: Eaves, McQuilkin et al. (2017) and Global Market Insights 2019 (Biosurfactants data); * = GBP data converted to € at average rate for 2010; "% of" means quoted market size is for all products*

There is a good example of successful political impact on the horticulture industry in the Netherlands, following production of a proposed 'government – wide programme' written by two Dutch ministers for the Environment and Economic Affairs; the so called 'Dijksma-Kamp letter, 2016. This cross-ministerial policy document sought to implement a 'Smart Regulation Programme' to support entrepreneurs by removing real-life obstacles and tracking down and addressing structural barriers to recovering value from wastes[56]. If the outcomes and case studies are positive, it becomes an example of best practice, and so needs continuous watching by the Horticultural industry to identify concrete progress.

For the EU, coordination of links with effective MEPs is vital, and the European Parliament's Agriculture Committee is well-placed to discuss and focus on matters specific to the industry[57]. In addition to the efforts of UK MEP Anthea McIntyre (her report on the Horticulture Industry of 2014 is one of the very few devoted to the subject), others such as Jan Huitema (NL) could be highly influential for the Interreg2Seas BioBoost regions.

Case studies, especially when analysed for economic as well as technological impacts, can be important drivers for circularity uptake by producers and the downstream markets. Success stories are newsworthy and provide opportunities to sensitise audiences about the value of circularity as a mindset and the need to overcome resistance to investment, process disruption and buying behaviour. In addition to the BioBoost activities and case studies, there are examples from other horticultural regions. Aqua4C-TomatoMasters, for example, developed glasshouse-warmed rainwater, which is used to improve performance in farmed fish while the effluent is returned to the tomato glasshouses after treatment as nutrients[58]. Other EU regions are also seeking to establish Black Soldier Fly larvae production, for oils and proteins for animal feed, using co-products as substrates.

Demand-side instruments play an important role in many bioeconomy strategies. Development of short-chain supply can be important in reducing wastage of still-edible produce. Demand-side concepts of quality and unhelpful specifications distort the potential for strategic resource efficiency; notably, where "the appearance of products, fruit for example, is too often treated as the reason to waste it even though the products are healthy and nutritious."[59] This situation is highly relevant for horticulture and is an action point for the UK WRAP's Courtauld Commitment and the Food Waste policy in UK, which has set out an intention to prevent retailers from requiring such specifications.

The EU's School Fruit, Vegetables and Milk scheme[60] is also important in maximising use of edible produce and reducing wastes. Public procurement programmes for bio-based products would strongly assist development of process streams, but it may require policy change to remove requirements to choose least-cost options. Financial inducements may provide a focus, e.g. the UK government has stated that it intends to introduce a tax on plastic packaging with less than 30% recycled plastic[61].

There are few such inducements to maximise value-extracted materials in foods and drinks; certification systems could help; such as the REDcert^2 certificate, for sustainable agricultural raw materials use in the food and feed industries and biomass for material purposes in the chemical industry[62]. The certification programme stemmed from sustainability standards for biofuels and bioliquids and has been extended to include value chains that are relevant for horticultural circular bioeconomy.

7.4. Investment from Government

The Dutch Government will introduce support funding for real-life actions in agriculture and horticulture, linking the 'Living Countryside' section of the Inter-Administrative Programme with a Regional Portfolio, aiming to support circular-agriculture initiatives[63]. This brings national government, municipalities, provinces and water authorities together. Action in North Brabant[64] and establishment of a Brightlands Agrifood venture fund in Limburg, based at Greenport Venlo and with a share in >€20M to invest[65], are likely to have impact.

The EAFRD (European Agricultural Fund for Rural Development) is a potential source of support for projects in horticulture. Its 2014-2020 budget was >€96B, devolved via specific fund programmes in each member state; approximately 20 out of 500 projects supported some aspect of horticulture. There should be good scope for horticulture in the next period (2021-2027).

The current UK support for innovation in agriculture and food ***Transforming Food Production***; part of the Clean Growth strategy, allows the provision of loans alongside private equity investment[66] and a forthcoming sustainability programme from Defra will have development grants in agriculture as one strand of support[67]. The Horticulture Industry could be encouraged to find projects eligible for such support, in the UK and through similar programmes in other European countries.

A recent study by SAPEA https://www.sapea.info/topics/sustainable-food/ (A sustainable food system for the European Union) which gives Science Advice for Policy by European Academies is also important to mention. In its abstract "*Food systems also contribute significantly to greenhouse gas emissions. this can be addressed by reducing waste or directing it back into the supply chain.*" The same for the EU Green Deal – Farm to Fork strategy - https://www.euractiv.com/section/agriculture-food/news/eu-bets-on-bioeconomy-to-deliver-farming-aspects-of-the-green-deal/. As this Strategy has been emphasizing, this is exactly the aim of BioBoost.

7.5. Future projected changes and considerations:

There are a number of behavioural and political considerations that are likely to have an impact on this area in the future. Policy makers could work with academics and small or large businesses to enable better uptake of valorisations and better understanding by the public and other stakeholders.

- What is future legislation potential?
- Legislation should cover broad areas and seek synergy between the EU and the UK
- Improving data production and access to enable waste reduction and valorisation; such as an active map of what Fresh Produce is produced in a given area; this would enable better predictions for the future and more efficient reactive value chains
- Social and environmental aspects need to be rationalised and connected at Government level across the three regions and beyond
- Consideration of whether producers/retail are made to be more responsible for environmental impacts due to waste; in terms of CO2 production and landfill
- The Dutch focus could be an exemplar as new legislation is being drafted

Appendix 1

Findings and conclusions from 7 key areas identified from a UK WRAP study that was commissioned to build on BioBoost activities

Use of by-products and residues along the Supply Chain for Higher Valorisation

- The BioBoost inventory highlighted the most significant Fresh Produce 'waste' products, which were green waste and crop co-products in the UK, Belgium and the Netherlands
- These should therefore be the focus of new ideas and innovations along the whole supply chain
- Realisation of value from biomass can be assisted by building infrastructure for clusters (platforms)
- The Greenery in the Netherlands and the Greenport area of Zuid-Holland are examples of the whole supply chain working in collaboration.
- The Eastern Agri-Tech Innovation Hub is a good example of knowledge exchange between industry, academia and local government etc.
- The Hub model could be replicated in other areas, facilitating localised knowledge exchange and support for SME's and research producing innovative ideas for higher valorisation of surplus food

Redistribution to charity

Since publication of the WRAP report, a UK governmental initiative has been launched that aims to help growers and others in the industry reduce edible food surplus and waste by enabling it to be redistributed to charity offsetting the costs this would usually incur. The initiative is supported by a £4M DEFRA fund, which has been tendered to redistribution charities such as FareShare, which have set up a 'Surplus with Purpose Fund'. The fund is open to companies seeking to unlock new or hard to reach surplus (or 'waste') food further up the supply chain. It aims to offset the costs faced by food producing companies seeking to redistribute their edible surplus comestibles to charities and community groups helping vulnerable people.

Another Example of Redistribution to Charity: 'The Brighton and Hove Surplus Food Network'

The B & H Surplus Food Network is an alliance of organisations tackling food waste by working with suppliers to distribute surplus to people in need in Brighton, Hove and surrounding areas. The network aims to increase the amount of food being saved from going to waste by connecting with each other, local businesses and organisations providing food to vulnerable people. They estimate that in Brighton and Hove, 30,000 tonnes of food is wasted per year by businesses and 39,000 households. Membership of the network includes FareShare Sussex, the Food Waste Collective, the Real Junk Food Project Brighton, Sussex Homeless Support, the Sussex Gleaning Network, and UK Harvest and is co-ordinated by Brighton & Hove Food Partnership. The website gives information for volunteers as well as to the donators. They are the first UK city to publish a food strategy: https://bhfood.org.uk/category/resources/food-strategy/ which has had a significant impact on waste and was funded by the Big Lottery Fund and local City Council. Having local city council involvement is important, allied to local awareness by running many courses and events throughout the year. This example uses many of the 'best practices' listed above: using local markets, short transportation time, local produce going to local charities, involving local government and community.

Consistent metrics and measurement

A fundamental theme that emerged from stakeholder engagement and associated desk studies identified the need for standardised, consistent measuring, to monitor produce and bi-products or 'waste' throughout the supply chain for different categories of crops, particularly by growers. This would enable growers to anticipate and address reasons for occurrence and identify potential for improvements. There are many reported incidences where growers had not weighing or measured produce at all, or where there was inconsistent weighing or measuring techniques between growers and pack houses. This could include weighing before or after washing or pre-processing step(s), therefore erroneously including field debris of various kinds in some reported measurements. The type of measurement system could also lead to incomparable metrics, such as use of more precise weighbridge vs less precise 1 tonne boxes in potatoes. Yields from fields may be amalgamated thus confounding the ability to understand yield per hectare. Measurement before or after e.g. over-small products were removed and discarded.

In a recent report, (Tompkins *et al*. 2018) it was suggested that industry-wide action should be taken to gather consistent, robust and reliable data throughout the supply chain. Information on actual performance can be used to inform future decision-making and to ground-truth and improve models. The collection and analysis of accurate data can increase understanding of crop (and hence supply) variability and problem areas which need to be addressed.
Graded yield is of primary importance to growers because this determines the economic return. True gross margins and attendant food waste (including methods/cost for disposal) is therefore necessary to enable accurate comparison between fields, growers and techniques.

Advice from stakeholders and potential actions:

Stakeholder discussions yielded a set of key actions and advice that can potentially maximise impact:

- Set targets and clear objectives to growers for making improvements; measure consistently throughout (a sometimes varied) supply chain to understand performance
- Develop industry-wide standard protocols for when, where, what and how measurements are taken - recording information about activities (merging harvests, rejecting defective crops e.g tubers, grading, packing, storage)
- Once yield is accurately measured, use predictive forecasting and determine the cause of technical problems/'waste' occurring, in order to take action
- Identify the priority targets where growers/processors can make the most difference
- Share Best practice and encourage grower collaboration with clear communication and inter-business understanding throughout the supply chain
- Staff training in why metrics are needed, increase understanding of benefits and methods of measurement
- Increase use of digital tools and predictive modelling (such as the NIAB CUF Potato Yield Model – PYM) to assist decision making and supply chain planning, particularly in years with challenging field conditions (such as disease or inclement weather)
- Use of models with standardised fields (such as planting date, 50% emergence date, ground cover readings, date of defoliation, test dig data) which can provide structure and improve rigour of data collection

- Supply chains should use common data standards and metrics to ensure that growers can improve performance across the board. This standard should operate across the industry to maximise impact.

Data standards should include protocols for collecting data during the season, for example canopy cover and test digs and at the end of the season. For some fresh produce, data collection would depend on the nature of the crop. Specific guidance should detail how to measure the yield of the crop, and key developmental stage when it should be measured. Data gathered should include key metrics needed to evaluate crop performance relevant to the crop. For potatoes, this includes: planting date, date of 50%, emergence Plant, stem and tuber counts and quality information.

Summary of current best practices identified in industry:

- Staff training on waste identification; appointing designated champion with overall responsibility
- Waste auditing or mapping of hotspots and easy wins along the supply chain
- Seasonal mapping of hotspots to allow pre-scheduling of promotions by retail
- Agreed objectives responsibility and economics for improvement between stakeholder businesses
- Ensure terminology for measuring waste, data standards and units are consistent between suppliers and along the whole supply chain where possible. Use of bar-code scanning and tracking
- Participation in targeted schemes (e.g. Courtauld 2025; UK NFU Fruit and veg pledge)
- Publish waste statistics to promote progress engage with the public and encourage further work
- Benchmarking between organisations (this is a long-term goal)

Communication and Information Sharing along the Supply Chain

Throughout the best practices identified, there was an overarching theme identified by stakeholders of the need for communication, to enhance the way businesses interact and support efficient working practices. One large retailer highlighted the importance of visiting suppliers to form a good relationship and mutual understanding of problems faced by growers. Conversely, retailers need to share details of their criteria and business challenges with growers. Through this mutual understanding, problems along the supply chain can be tackled more efficiently and quickly.

Summary of some effective web portals and software:

- Microsoft Dynamics – Intelligent client relations
- Consus Fresh – software supplier, specialising in factory and pack-house management systems for the fresh produce and chilled produce sectors
- Harvest Yield – used to power their job tracking
- Kisanhub – Connect enterprise staff and agronomists with growers to manage crops through informed decisions, understand risk and uncertainty in the supply chain
- Muddy Boots – Supply chain & farm management software

Yield/Supply and Demand Forecasting

Stakeholder interviews suggested that there is opportunity to reduce fresh produce surplus and waste through increased flexibility on specifications (UK WRAP have produced guidance for quality specifications). This may work in conjunction with seasonal mapping of supply and demand, which may be used to plan ahead for specification and volume negotiations throughout the year. For example, soft fruit such as strawberries sell larger volumes in summer, but are highly weather dependent in terms of shelf life, and customer demand.

Summary of current practices identified in industry:

- Field walks (either by grower, PO or retailer)
- Use of drones / aircraft for mapping and monitoring
- Sharing information via web portals
- Planning meetings and verbal updates along the supply chain between growers, POs and retailers
- Planned promotions or slowdowns to adjust demand to expected supply
- Creation of new classes / lines to sell wider specification food and Use of flexible and temporary specification modifications
- Site visits between businesses; assisted by shared lists of key contacts and grower groups

Maintaining Product Quality

The following points have been identified as being best practices to be used in industry for maintaining product quality:

- Map damage hotspots
- Optimise delivery route
- Maintain optimum temperature along supply chain
    - Provide chilled space for products during storage / minimise time spent out of chill chain
- Specific innovations of relevance to each crop
    - Sensor technology e.g. of crop during storage
    - Refrigeration
    - Precision cropping
- Use of existing technology to address waste hotspots
    - Optimising routes to reduce transit time
    - Monitoring and analysis of stock levels and date labels to prevent excess (and shortage), communication of this information to suppliers and POs

Best practice; alternative markets for surplus/out of specification edible food

Best practice in terms of identifying alternative markets for surplus/out of specification edible food, could extend to embrace associated by-products along the supply chain, through processing steps, which would be classified as 'inedible', but which could be valorised into higher value products. This could include, for example, tomato leaves for use as packaging or nutshells for health and beauty products. Challenges for these developing markets may include the small volume of feedstocks and difficulties in matching supply timings and volumes with demand by the secondary producer. A recent survey of growers, producers and retail have identified the following key practices to be addressed to pursue this opportunity.

Summary of current best practices identified by some industries and stakeholders:

- Waste mapping is required to predict when surpluses might occur
- Publish/identify organisations that are potentially to take surplus produce
- Investigate local alternative uses for products in advance of availability (processing, health and beauty options, prisons and hospitals)
    - Various food and drink surplus networks (e.g. WRAP in UK)
    - Identify potential markets/contacts for products: e.g. innovative research ideas
- Sell to staff, use for in-house catering
- Remainder after addressing each of above could be supplied by contract for composting, stock feed, AD and biofuel to minimise landfill

Appendix 2

The Legal, Legislative and Advisory Situation within the Areas (see Chapter 5)

There is increasing activity across the three areas; little actual policy but significant advisory work relating to waste, food waste, food surplus, co-products, by-products or circular economy. Key points are detailed in the table below. Policy and research on waste reduction and use of co-products is often devolved; in the UK to agencies or independent organisations, which themselves commission work from UK experts' groups**.** One key UK agency is WRAP**.** Both Belgium and the Netherlands have national policy which is being used to assist and encourage local activity; details are given below according to country.

Detail/ name of activity and lead document(s)	**Policy or Statement**	**National, Local or Regional Policy - or Advisory**	**Discussion and detail**
Health and Harmony: The future for food, farming and the environment in a Green Brexit Feb. 2018 (Cm9577)	UK Government are working with the Agriculture and Horticulture Development Board (AHDB) to encourage stronger resource efficiency and sustainable growth. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684003/future-farming-environment-consult-document.pdf	UK National /local advisory at present	Legislation and policy is lacking both at national and local government levels in the UK. Many companies are trying to develop and implement sustainable activities, but there is as yet no government imperative or policy. AHDB is the official government supported umbrella organisation for all farm producers see A case study on AB Agri; use of co-products from British Sugar p24 Sustainable farming P25.
Interaction with Producer Organisations (PO's) and Producer Cooperation	Government encourage farmers to benchmark themselves against the best and commit to Continuing Professional Development (CPD). They will be encouraged to invest in new technologies and processes {Government} propose to maintain special status of POs, including derogations from competition rules.	UK Policy/ Advisory	Knowledge sharing is important, producer cooperation, and farmer-to-farmer learning to kick-start a wider culture of excellence. Agriculture and horticulture are increasingly high-tech, capital-intensive industries. This will increase their profitability, tackle crop/livestock diseases and improve health. Collective decision-making is not the traditional model for UK farmers, but the modern supply chain means attitudes must change. Farmers could benefit from strength they can achieve through cooperation.
25 Year Environment Plan; 'A Green Future. The '25 Year Plan to Improve the Environment', sets out ways to improve the environment.	UK Industrial Strategy promotes a regenerative, circular economy. Public engagement activities (2019-20) link to waste reduction initiatives; clean air / pro-environmental behaviour.	UK National policy /strategy paper	UK Government intends to develop standards for biodegradable plastic bags; part of emerging "national Bioeconomy Strategy" (recognising the need to avoid microplastics pollution). See P82, 84, 89,90 https://www.gov.uk/government/publications/25-year-environment-plan

WRAP **The Courtauld Commitment 2025**	A voluntary Bioeconomy Strategy by signees; reducing food supply chain emissions and waste. UK Government aims to make the way we eat and drink in UK more sustainable; aiming to cut the greenhouse gas intensity of food and drink consumed in the UK, and per capita UK food waste by 20% by 2025www.wrap.com. Through WRAP, UK Government is working to develop a cross-sector (business, government and NGOs) commitment to tackle plastic waste; to make the way we eat and drink sustainable and cut greenhouse gas intensity by 20% via food and drink consumed in the UK, and per capita UK food waste by 2025. Making data more available to support processes such as industrial symbiosis	UK National, Advisory And Policy/ Strategy	This sets the UK on a path to meet an even more ambitious UN target of halving per capita global food waste at retail and consumer levels by 2030. Government has pledged to "Continuing to work closely with WRAP, food businesses, local authorities and other organisations to meet Courtauld 2025" . It aligns with the Ellen MacArthur Foundation's New Plastic Economy and has an initial focus on plastic packaging. It sets the UK on a path to meet an ambitious UN target – halving per capita global food waste at retail and consumer levels by 2030. WRAP/Courtauld Group will work towards **no** food waste entering landfill by 2030 Where two or more industrial facilities or companies join up and the wastes or by-products of one become the raw materials of another. We must also develop business models that challenge inefficient production practice. We will work with industry to explore options for making waste tracking data universally digitised.
Resources and waste Strategy for England	**https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england**	UK Strategy/ Advisory	We will: "Make sure that resources are used more efficiently and kept in use for longer to minimise waste and reduce its environmental impacts by promoting reuse, remanufacturing and recycling". "Work towards eliminating all avoidable waste by 2050 and all avoidable plastic waste by 2042".
Our Waste, Our Resources: A Strategy for England	Creating waste / by-products during manufacturing can't always be avoided. One company's rejects can be another's raw materials. UK Government want to i**ncentivise** businesses to do this.	UK National Strategy	To achieve this UK Government is developing a model for realising resource efficiency savings, working with businesses through 'resource efficiency clusters'. The publication is at: www.gov.uk/government/publications
Redistribution of surplus food	Funding for charities	UK Policy national and regional	To redistribute surplus food from food businesses to those in need**www.gov.uk**
NFU - National Union of Farmers policy; Current activity includes response to government consultations	https://www.nfuonline.com/cross-sector/environment/waste The NFU has joined major British retailers and food companies in pledging to help halve food waste by 2030.	UK National; policy /Strategy	The NFU has built strong networks with Defra, the Environment Agency and the European Commission to ensure any regulation is consistent and proportionate. Much of the activity is currently focused on plastic use; e.g. Plastic Packaging Tax and Reform of the UK Packaging Producer Responsibility System. In 1919, UK

			Government launched its 'Step up to the Plate' campaign built on a number of innovations put forward by UK Government in the Resources and Waste Strategy.
Policy Paper, UK launched landmark **Resources and Waste Strategy** Dec. 2018	https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england	UK National policy/ strategy	Businesses and manufacturers will pay the full cost of recycling or disposing of their packaging waste, under a UK government strategy launched by Environment Secretary Michael Gove. The move will overhaul England's waste system, putting a legal onus on those responsible for producing damaging waste to take greater responsibility and pay for it.
The Extended Producer Responsibility (EPR)	Waste reduction will be funded by industry; they will pay higher fees if their products are harder to reuse, repair or recycle https://www.gov.uk/government/consultations/packaging-waste-changing-the-uk-producer-responsibility-system-for-packaging-waste	UK Policy national	EPR will encourage sustainable design, subject to consultation. EPR for packaging will raise between GBP500 million (≈ EUR 556.2 million) and GBP1 billion (≈ EUR 1.11 billion) annually for recycling and disposal.
AHDB Horticulture – UK Levy organisations	Safe disposal of waste produce is covered by a series of advisory documents supported by research	UK Advisory	No actual strategy exists within the AHDB or the AHDB horticultural group at present. https://horticulture.ahdb.org.uk/search/node/waste
Growing the Bioeconomy; Improving lives & strengthening UK economy: A national bio-economy strategy to 2030 UK government 2018**.**	Reducing plastic waste and pollution by developing a new generation of advanced, environmentally sustainable plastics, such as bio-based/ biodegradable packaging and bags (whilst avoiding microplastic pollution)	UK National Policy	**https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761856/181205_BEIS_Growing_the_Bioeconomy__Web_SP_.pdf**
Netherlands/Nederland			
Nederland Circulair in 2050 Part of beleidsartikel 21 - Duurzaamheid	Programme to transition towards a circular and no-waste economy in 2050	Dutch National Policy	No longer treat waste as merely waste, but try to find new ways to utilise it. https://www.afvalcirculair.nl/onderwerpen/beleid-circulaire/rijksbreed-programma/
Grondstoffen akkoord 2017 **(Raw Materials Agreement)**	Agreement of intent to arrive at transition agendas for the Circular Economy. The Raw Materials Agreement contains	Dutch National Agreements	https://www.rijksoverheid.nl/onderwerpen/circulaire-economie/documenten/rapporten/2017/01/24/grondstoffenakkoord-intentieovereenkomst-om-te-komen-tot-

	agreements reached by the State Government with other parties on measures to accelerate the transition to the circular economy.		transitieagenda-s-voor-de-circulaire-economie
Transitional agenda's **1) Biomass & Food** **2) Plastics** **3) Manufactoring** **4) Construction industry** **5) Consumer goods**	Together with the signatories of the Raw Materials Agreement, the Government has drawn up 5 transition agendas. For sectors and chains that are important for the economy but also tax the environment.	Dutch National Agreements	https://www.rijksoverheid.nl/onderwerpen/circulaire-economie/nederland-circulair-in-2050
Landelijk afvalbeheerplan LAP3 implemented since 28-12-2017	Policy to deal with the transition towards a circular economy.	Dutch Plans for different sectors. Policy	Focuses on waste chain management (separation, collection and recycling) https://lap3.nl/beleidskader/ https://lap3.nl/sectorplannen/
VANG (van afval naar grondstof) – huishoudelijk afval	Focus on managing household waste (food, textile, paper, non-recyclable materials)	Dutch, Local - Assistance programme for the municipality	https://www.vang-hha.nl/ Uitvoeringsprogramma VANG-HHA 2018-2020 (pdf, 318 kB)
Gemeenschappelijk landbouwbeleid (common Agricultural policy)	Two focuses – 1) sustainable, safe and affordable food. 2) Assist farmers generating income	Dutch National Mandatory Policy	https://www.rvo.nl/onderwerpen/agrarisch-ondernemen/glb?utm_campaign=9250096761&utm_source=google&utm_medium=cpc&utm_content=416566700300&utm_term=%2Blandbouwbeleid%20%2Bnederland&adgroupid=89067977490
Toekomstvisie Kringlooplandbouw (2018)	Vision on the development of a circular agriculture and horticulture.	Dutch National Policy	https://www.rijksoverheid.nl/documenten/richtlijnen/2018/09/01/landbouw-natuur-en-voedsel-waardevol-en-verbonden-nederland-als-koploper-in-kringlooplandbouw
Belgium - Flanders/België – Vlaanderen			
Bioeconomy in Flanders	Focus and support for the BioEconomy in Flanders	Regional Policy - Advisory	https://www.vlaanderen.be/publicaties/bioeconomy-in-flanders-the-vision-and-strategy-of-the-government-of-flanders-for-a-sustainable-and-competitive-bioeconomy-in-2030

Circular Economy in Flanders	'Circular Flanders'; a hub and inspiration for the Flemish circular economy. This partnership of governments, companies, civil society and the knowledge community will take action together.	Regional Policy - Advisory	https://vlaanderen-circulair.be/en
Action Plan Sustainable Biomass	This action aims to stimulate the prevention, separate-collection and recycling of residual biomass streams with a view to cost, raw material and energy savings.	Regional Policy – Advisory	A revised plan for 2021-2025 is in preparation. https://www.ovam.be/sites/default/files/atoms/files/Action%20Plan%20for%20the%20Sustainable%20Management%20of%20Biomass%20Streams%202015-2020.pdf
Action Plan Food Loss	The "Ketenroadmap voedselverlies 2015-2020" was the action plan to reduce food losses in Flanders by 15% by 2020. A new plan for 2021-2025 is in preparation	Regional Policy – Advisory	https://www.voedselverlies.be/actieplan-2020 https://www.voedselverlies.be/sites/default/files/atoms/files/ketenroadmap_ondertekend_keten_en_ministers_kleur.pdf
Samenwerking in de landbouw	Sharing knowledge and equipment between different sectors within the agricultural sector and food supply chain	Cooperation platform, advisory	Stimulating further cooperation, on national and international levels https://lv.vlaanderen.be/sites/default/files/attachments/samenwerking_in_de_landbouw.pdf https://www.innovatiesteunpunt.be/nl/inspiratie/co%C3%B6peratief-ondernemen
Afval regulering	Focuses on optimal use of primary natural resources and recycling; Minimizing waste streams	National and local Policy and mandatory	https://www.vlaanderen.be/natuur-en-milieu/afval https://ovam.be/overzicht-afval-en-materialen (overview of local initiatives)

Appendix 3

The WRAP 28 Courtauld Commitment, 2025; Reducing food supply chain emissions and waste

The commitment addresses key issues, including reducing waste from consumers by for example rolling out guidance on applying 'Use By' dates only where there is a food safety reason to use it, and looking across supply chains to find efficiencies. Reductions achieved will be measured using global best practice methodology. Contracting parties – including food businesses and local authorities – are also guided by elements of the Plan for Public Procurement and Catering Services, including the 'balanced scorecard', which ranks a range of relevant criteria (sustainability in production, health and nutrition, resource efficiency, social-economic value). These criteria will help to deliver environmental improvements, including entrenching UK production standards, reducing food waste, encouraging the use of seasonal fresh produce and encouraging menus to identify and celebrate the provenance of the food on offer.

Recycling food waste is also a key priority. The WRAP Courtauld Group will work towards no food waste entering landfill by 2030. Many local authorities have introduced separate collection of food waste and we will work to support an increase in numbers so that the amount of food waste sent to landfill declines. We will also take action to support the redistribution of unsold edible and nutritious surplus stock from food businesses to individuals in need. In 2018WRAP announced a new £0.5m fund for charities who redistribute surplus food from food businesses to those in need.

'The Resources and Waste Strategy'

A strategy to help ensure that producers pay the full net costs of disposal or recycling of packaging they place on the market by extending producer responsibility – up from just 10 percent currently.

1. Review producer responsibility schemes for items that can be harder or costly to recycle including cars, electrical goods, batteries and explore extending it to textiles, fishing gear, vehicle tyres, certain materials from construction and demolition, and bulky waste such as mattresses, furniture, and carpets
2. Introduce a consistent set of recyclable materials collected from all households and businesses, and consistent labelling on packaging so consumers know what they can recycle, to drive-up recycling rates
3. Ensure weekly collections of food waste, which is often smelly and unpleasant, for every household – restoring weekly collections in some local authorities. This will be subject to consultation which will also consider free garden waste collections for households with gardens, to reduce greenhouse gas (GHG) emissions from landfill
4. Introduce a deposit-return scheme, subject to consultation, to increase the recycling of single-use drinks containers including bottles, cans, and disposable cups filled at the point of sale
5. Explore mandatory guarantees and extended warranties on products, to encourage manufacturers to design products that last longer and drive up the levels of repair and re-use
6. Introduce annual reporting of food surplus and waste by food businesses. Should progress be insufficient, the government will consult on introducing mandatory targets for food waste prevention
7. Clamp-down on illegal movements of waste at home and abroad by introducing compulsory electronic tracking of waste, and tougher penalties for rogue waste crime operators if they mislabel their waste to circumvent tax rules.

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