Policy for Sustainable Biorefineries

Joanna Sparks, Biomass Policy Fellow
BBNet Conference 2024

Supergen Bioenergy

BBNet Biomass Biorefinery Network

Sustainable biorefineries

In groups **you** are going to draw your vision of a sustainable biorefinery

What is a sustainable biorefinery?

Introduce yourselves

Nominate a person to write and a person to feedback

Discuss and draw your vision

Feed back

Doesn't have to be perfect <u>or to scale</u>

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Table 1	
Beatrice	Ifie
Ed	Robinson
Richard	Evans
Andrew	Fleming
Veronica	Ongaro
Mark	Gronnow
Fanran	Meng
David	Raine
Laura	Faas
Maira	Anam
Samantha	Cook
Longinus Ifeanyi	Igbojionu
Ariyan	Amirifar
Davide	Poggio
Fatemeh	Khodaparastan
Roberto	Chiocchio

Table 2	
Katrin	Besser
Walid	Omara
Christine	Parry
Dana	Heldt
India	Higgins
Erinc	Bahcegul
Kjartan	Sandnes
Patricia	Thornley
Ewa	Marek
Jai	Lad
Emmanouil	Papaioannou
Micaela	Chacon
Robin	Hoeven
Maureen	Okibe
Ife	Bolaji
Mauro Adriel	Rinaldi
Malcolm	Glendenning

Table 3	
Gavin	Milligan
Katalin	Kovacs
Rolf	Kraehenbuehl
Philip	Metcalfe
Graham	Bonwick
Andrew	Ellis
Anna	Duden
Samson	Oyeyinka
Ashraf	Alkhtib
Ioanna	Dimitriou
Nasim	Farahmand
Ushna	Khalid
William	Newell
James	McGregor
Deborah	Rathbone
Ryan	Watkins
Jonathan	Wagner

Table 4	
Gregg	Beckham
Nigel	Minton
Michael	Lewis
Huw	Parry
Catherine	Birch
Yvonne	Armitage
Zeinab	Zandieh
Meng	Zhang
Rashmi	Deshpande
Henry	Madubuike
Nick	Sweygers
Roger	Romero
Chloe	Uyl
Daniel	Chaplin
Nicholas	Tenci
Ian	Tebble

Table 5	
Philippe	Soucaille
Beth	Redfern
Dimitris	Charalampopoul
Jason	Hallett
Dan	Taylor
Thierry	Tonon
Mark	Corbett
Jonathan	Wagner
Siddharth	Gadkari
Bethan	Highley
Bipro Nath	Dubey
Kareemuddin	Shaik
Muhammad	Javed
Prince	Okoro
Bjartur	Hilmisson
Emily	Newcombe
Lucy	Talbot

Table 6	
Alexandra	Lanot
Laura	Martin
Claire	Halpin
Finn Lillelund	Aachmann
Daniel	Latham
Rebecca	Wheeler
Omotola	Olagunju
Tom	McMurray
Federico	Sabbadin
Christine	Steffen
Anh	Phan
Hemaka	Bandulasena
Fernando	Russo Abegão
Stephen	Wright
Daya	Pandey
Brandon	Ma

Table 7	
Jonathan	Todd
Neil	Dixon
Leonardo	Gomez
Elisa	Capuzzo
David	Bott
Stephen	Boothroyd
Colin	Miles
Alexander	Nicholls
Joe	Penhaul Smith
Janina	Hoßbach
Eleonora	Campos
Yujie	Mao
Abdullahi	Adamu
Yongqiang	Liu
Chidinma Angela	Tennison-Omovoh
Anna	Zhenova

What is a sustainable biorefinery?

Introduce yourselves

Nominate a person to write and a person to feedback

Discuss and draw your vision

Feed back **In 3 sentences**

Have you thought about….

Until ~ 9.30

Scale Location Feedstock Technology Product

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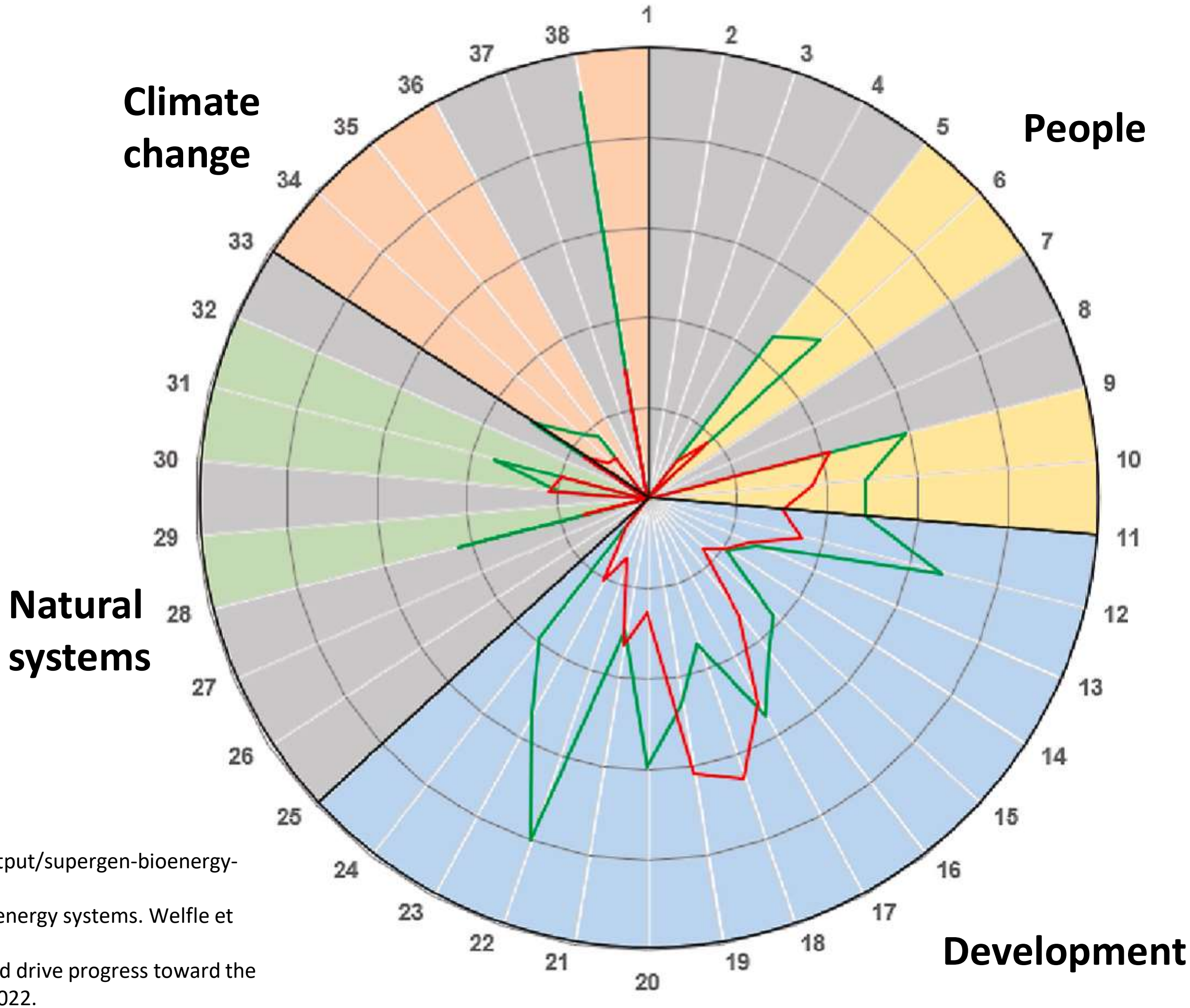
Sustainable biorefineries

Sustainability

Biomass systems come with sustainability risks and benefits



Bioeconomy Sustainability Indicator Model - www.supergen-bioenergy.net/output/supergen-bioenergy-hub-bioeconomy-sustainability-indicator-model-bsim/
Sustainability of bioenergy – Mapping the risks & benefits to inform future bioenergy systems. Welfle et al. Biomass and Bioenergy, 2023.
Mapping the sustainability of bioenergy to maximise benefits, mitigate risks and drive progress toward the Sustainable Development Goals. A. Welfle and M. Röder. Renewable Energy, 2022.

Thinking about sustainability

Identify the sustainability ***risks*** and ***benefits*** associated with your vision of a sustainable biorefinery

Think about the feedstocks, technologies, products, and other aspects as well as the system as a whole

Think about sustainability in terms of people, development, climate, and natural systems

Until ~ 9.55

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Sustainable biorefineries

Policy for sustainable biorefineries

Until ~ 10.10

What kind of policy or regulatory interventions might be needed to support the delivery of your sustainable biorefinery vision?

And how could policy and regulation ensure the system is sustainable?

Think about policy relating to feedstock, technology, innovation, skills, products, markets

Think about regional, national, international level activity

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Policy for sustainable biorefineries

Supergen | Bioenergy

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High Value Biorenewables

USING BIOLOGICAL SYSTEMS TO DEVELOP HIGH VALUE PRODUCTS AND PROCESSES

Policy makers' briefing note

Many industries essential to the UK economy are increasingly under domestic and international scrutiny from economic, societal and environmental perspectives. The result is a demand to replace fossil-based chemicals and processes with sustainable alternatives that simultaneously meet the needs of industry and its supply chains, support a growing population, and promote the net zero circular economy and protect the natural environment. The industries impacted include pharmaceuticals, agrochemicals, foods, home and personal care, cosmetics, and fine chemicals.

The UK is a global leader in the research and development underpinning the use of biological systems and bio-based feedstocks to produce high-value, low-volume products (>£10 per kg, and <1000 metric tonnes per year). Specifically, those made using industrial biotechnology (IB)[1] and referred to as 'high value biorenewables' are the focus on this briefing and the associated report. They range from small bio-derived molecules to large and complex biological molecules (e.g., polymers, proteins, and enzymes) and even cells. The process of making high value biorenewables using plants, algae, microbes and enzymes is summarised in Figure 1. Inputs required vary by the platform used: plants and algae use light, carbon dioxide, water, and nutrients, whereas microbes and enzymes convert biomass feedstocks (e.g., crops, forestry biomass, wastes and residues) or bio-derived compounds (e.g., sugar or polymers from biomass feedstocks) into desired products.

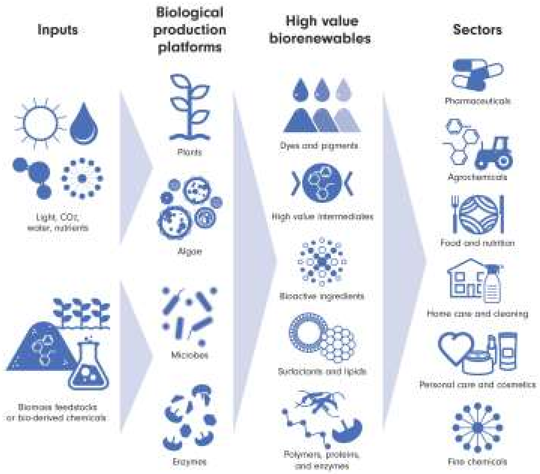

Figure 1. Production of high value biorenewables using biological systems

[1] **Industrial biotechnology (IB)** uses biological systems to turn biological resources into products with industrial and/or societal value (e.g. chemicals, materials, or energy). Industrial biotechnology can employ naturally occurring biological systems or systems that have been engineered to improve performance in industrial conditions or make different products.

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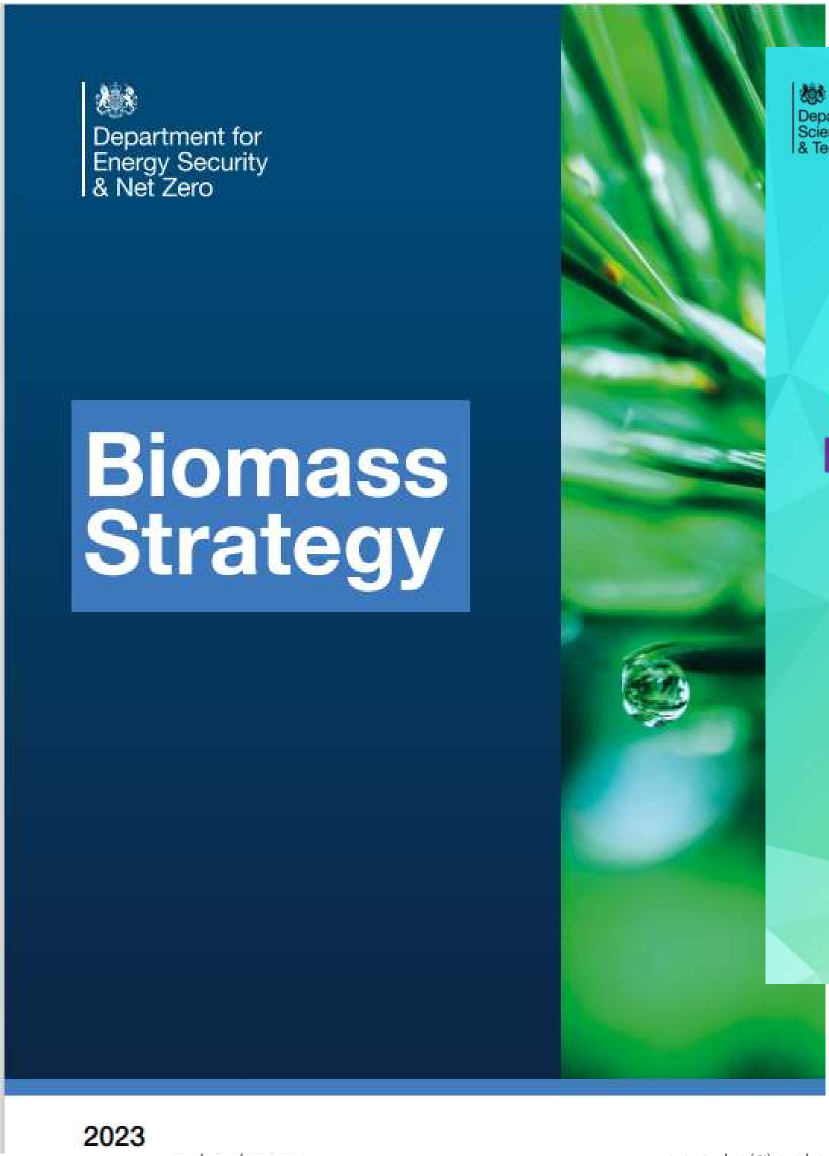
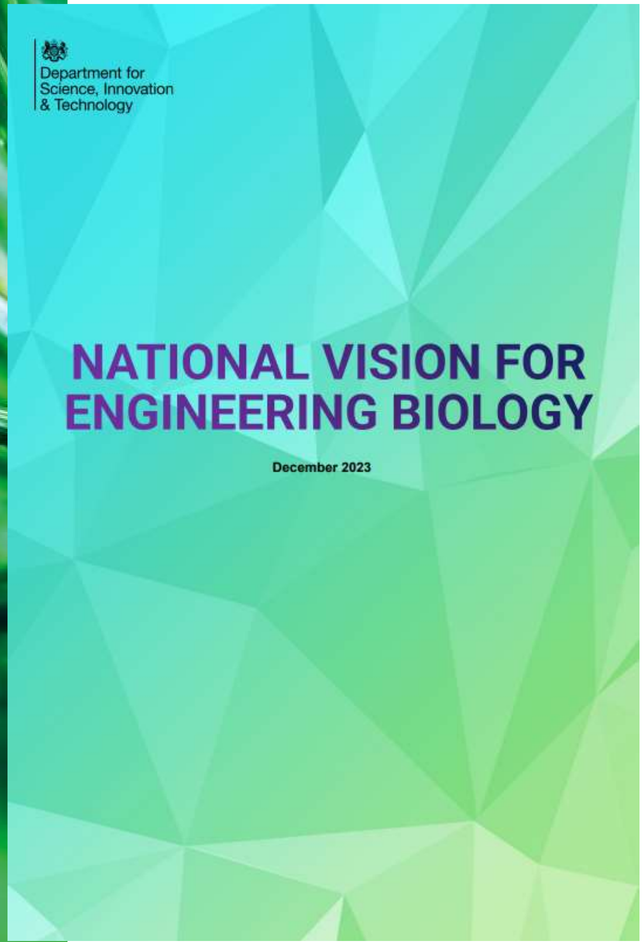

Department for
Energy Security
& Net Zero
Biomass
Strategy
2023


Department for
Science, Innovation
& Technology
NATIONAL VISION FOR
ENGINEERING BIOLOGY
December 2023


Draft Bioenergy Policy Statement
March 2024
Scottish Government
Riaghaltas na h-Alba

How should biogenic carbon (carbon from biological sources) be accounted for in LCA?

Life Cycle Initiative

Consensus building process across 4 to 5 Working Groups:

1. Temporal aspects.
   How should inventories and impact assessment reflect biogenic absorptions/emissions over time?

2. End of life, reuse and recycling.
   How should biogenic carbon be handled in cradle-to-gate, cradle-to-grave, and cradle-to-cradle systems?

3. System boundaries.
   a) Avoided impacts/benefits and what these might be.
   b) Uptake to include within system boundaries.

4. Standards and adoption barriers.
   To what extent is institutional inertia / ongoing practice a barrier to consistency?

Interested in joining a Working Group?

Please complete form by 19th April

Email Sam Cooper: en8sc@bath.ac.uk

Flash presentations

3rd BBNet Conference

Enhancing sustainability in lignocellulosic biorefineries: enzymatic valorization of xylan from residual plant biomass

Ornella Ontañon, Laura Navas, Juliana Topalian, Mercedes Garrido, David Leudo Orozco, Caio de Mello Capetti, Vanessa Arnoldi, Igor Polikarpov, Leonardo Gomez, Eleonora Campos

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Poster 05

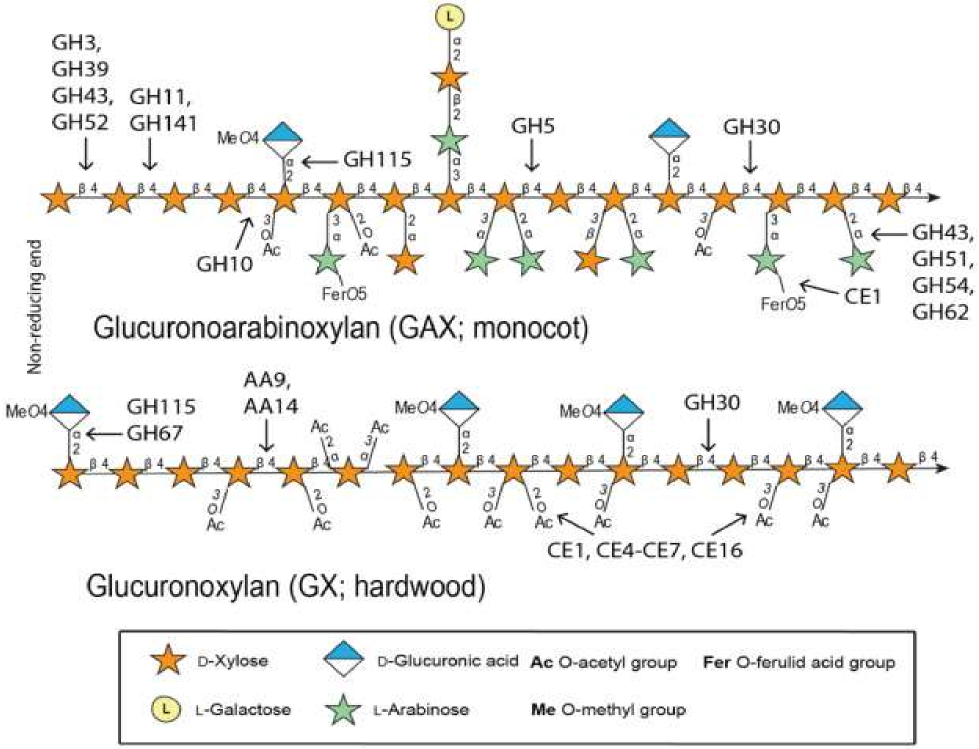
Enzymes for Agroindustrial Bioprocesses Lab

Institute of Agrobiotechnology and Molecular Biology (IABIMO)
National Institute of Agricultural Research (INTA)-CONICET,
Buenos Aires, Argentina

April 10- 12, 2024

Xylans

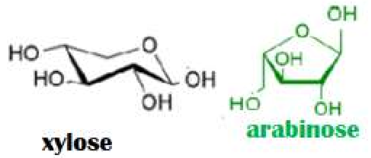
Xylan is the second most abundant polysaccharide of terrestrial plant cell walls.
It is formed by a backbone of **β-(1,4)-linked D-xylose** residues, that can present α-L-arabinofuranosyl and/or α-(methyl)-glucuronic acid decorations.



[Suchova et al., 2022 (doi: 10.1016/j.biotechadv.2022.107981)](https://doi.org/10.1016/j.biotechadv.2022.107981)

Products derived from xylans are of great biotechnological interest because of their bioactive properties

FERMENTABLE SUGARS

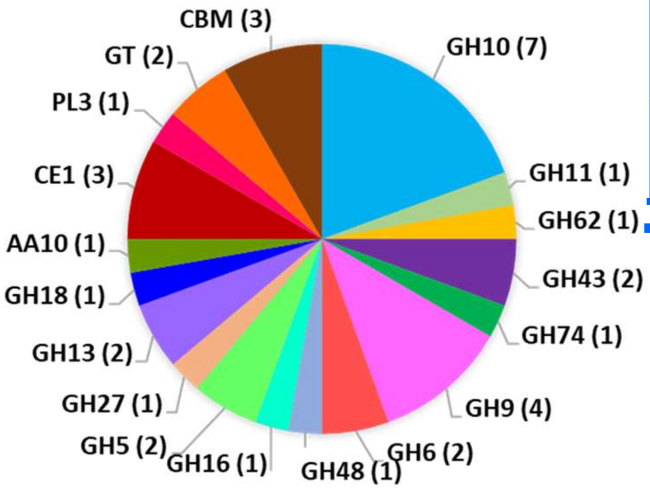


PRECURSORS OF BIOMEDICAL COMPOUNDS

XYLO-OLIGOSACCHARIDES (XOS)

Prebiotics, non-caloric sweeteners, immunomodulators (plants)

Carbohydrate Active Enzymes secreted by *Cellulomonas* sp. B6

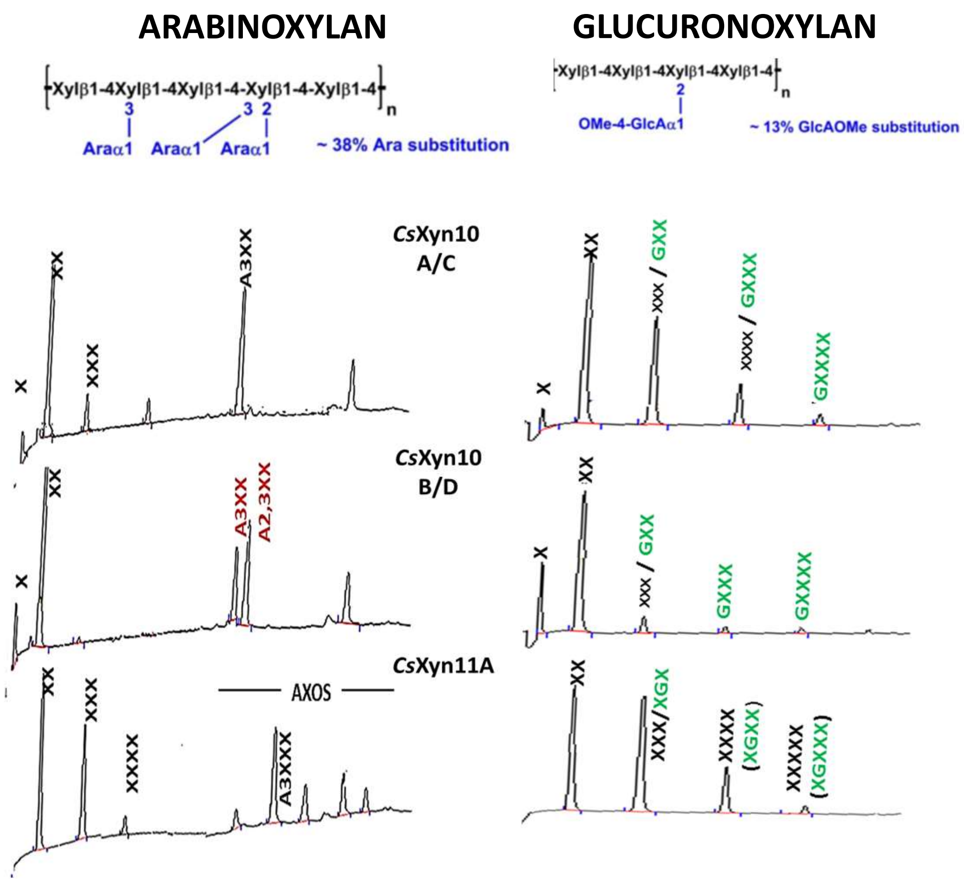


Xylanases
35% of all secreted CAZymes are GH10
3 % GH11

ABF 24 %
Based on emPAI analysis of WB-cultures

Other intracellular CAZymes relevant for xylan degradation:
ABF GH51
AGU GH67

Product profile of xylanases



Biochemical properties of recombinant xylanases

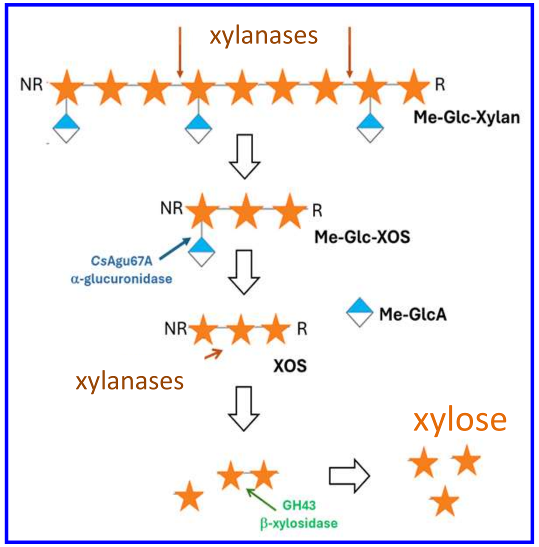
Enzyme	Max Activity U/mg(*)	Optimal conditions		Stability (***)	
		Temperature(**)	pH	40°C	45°C
*Cs*Xyn10A	263 (± 19,0)	50°C (50- 55°C)	6	88%	52%
*Cs*Xyn10B	60.8 (± 14,0)	55°C (45- 50°C)	7	100%	100%
*Cs*Xyn10C	164.9 (± 13.6)	45°C (40- 55°C)	6	38%	0%
*Cs*Xyn10D	209.6 (± 15.8)	45°C (40- 55°C)	6	81%	57%
*Cs*Xyn11A	72.4 (± 5.8)	30°C (25- 40°C)	6	72%	19%

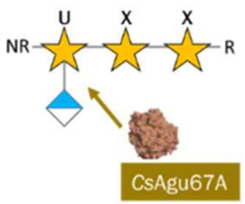
(**) 100% activity (Temperature range with ≥75% activity)
(***) Residual activity afer 4 h of pre-incubation at the indicated temperature.

Ontañon et al., AMB, 2021, doi: 10.1007/s00253-021-11305-y

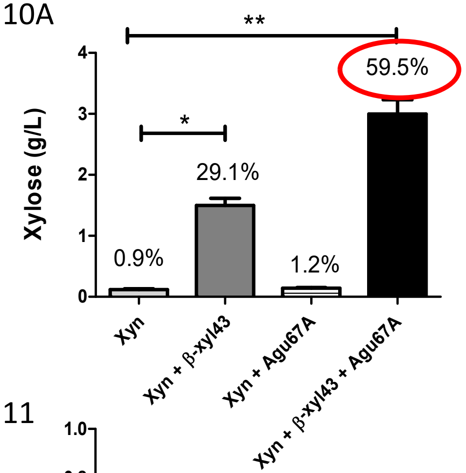
Glucuronoxylans degradation by xylanases combined with a GH67 α-L-glucuronidase

Activity on Blue Agave Bagasse

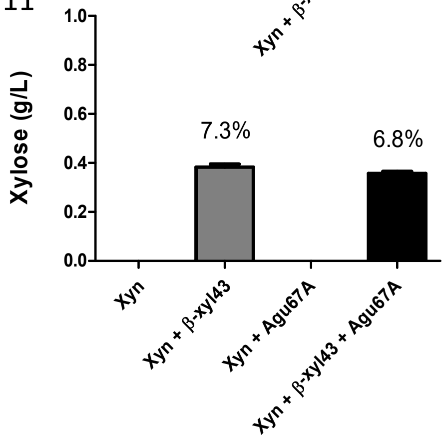




*Cs*Xyn10A

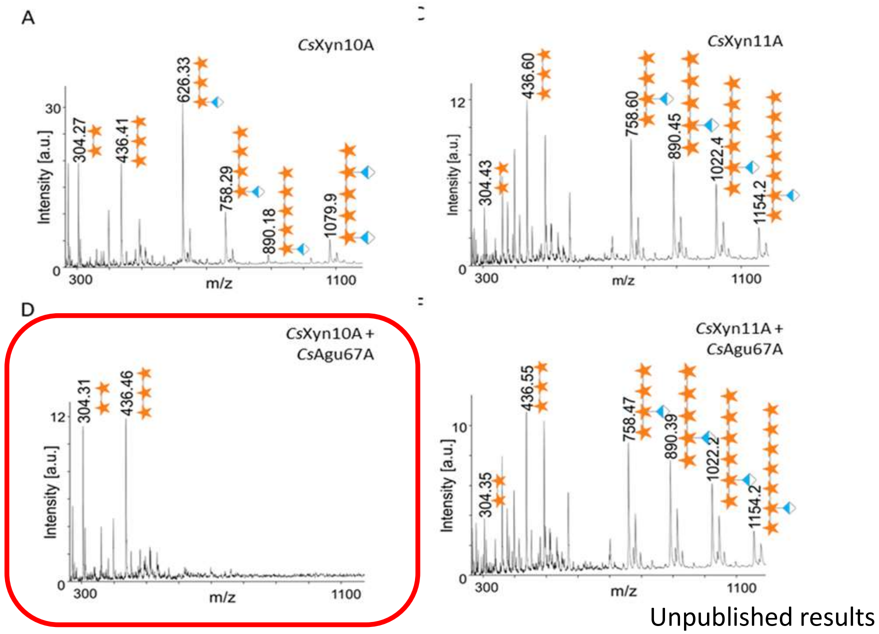


*Cs*Xyn11



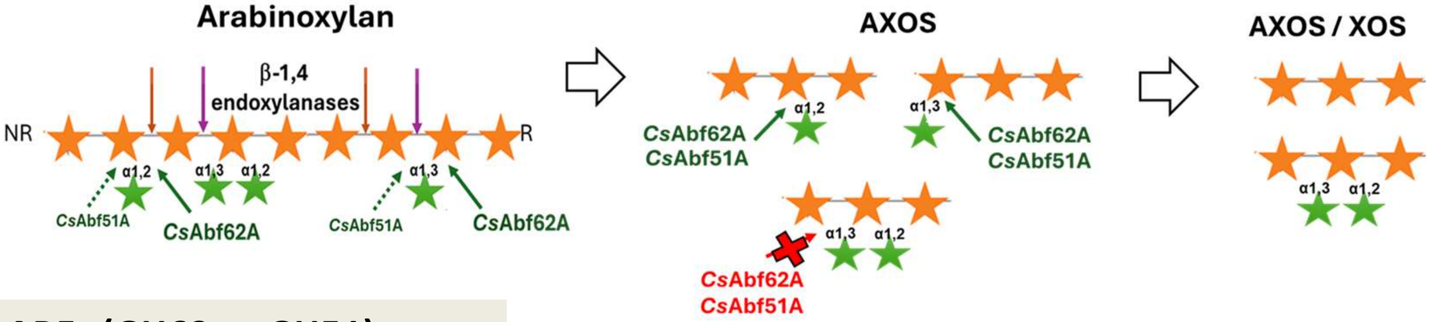
Agave

Agave Bagasse
(~25% xylan)

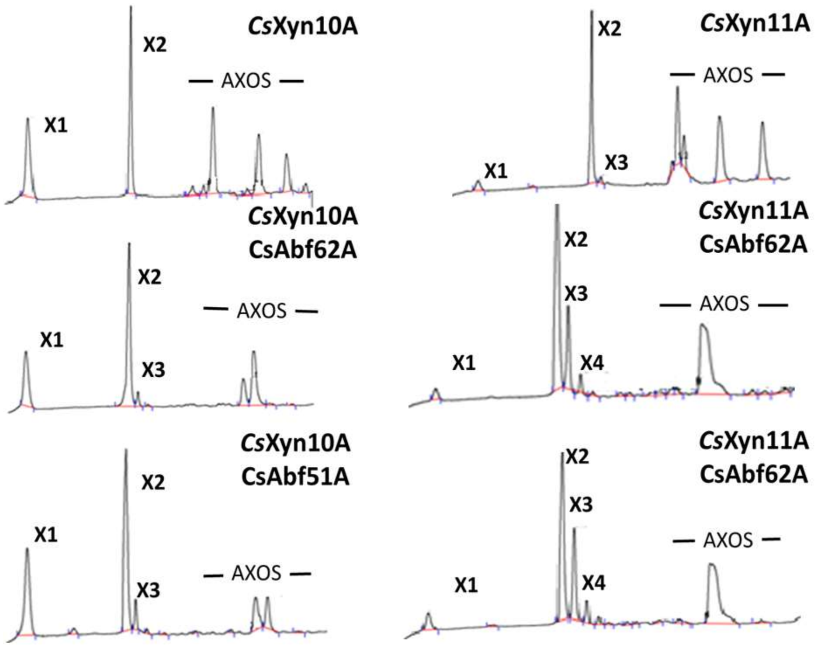


Unpublished results

Arabinoxylan from wheat deconstruction by the combination of xylanases and α-L-arabinofuranosidases



Xylanases + ABFs (GH62 or GH51)



Garrido et al., AMB, 2022, doi: 10.1007/s00253-022-12061-3

Prebiotic properties of XOS/GXOS/AXOS
(promote growth and metabolism of beneficial gut bacterial strains)
on-going work

CONCLUSION

- **Xylanases and xylan debranching enzymes allow us to generate an array of decorated/undecorated XOS for multiple applications, such as prebiotics production from different sources of biomass.**

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Juliana Topalian
Victoria Hracek
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Breeana Urbanowicz (Univ. of Georgia, USA)
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Funding
AGENCIA INTA CONICET

Thank you for your attention!

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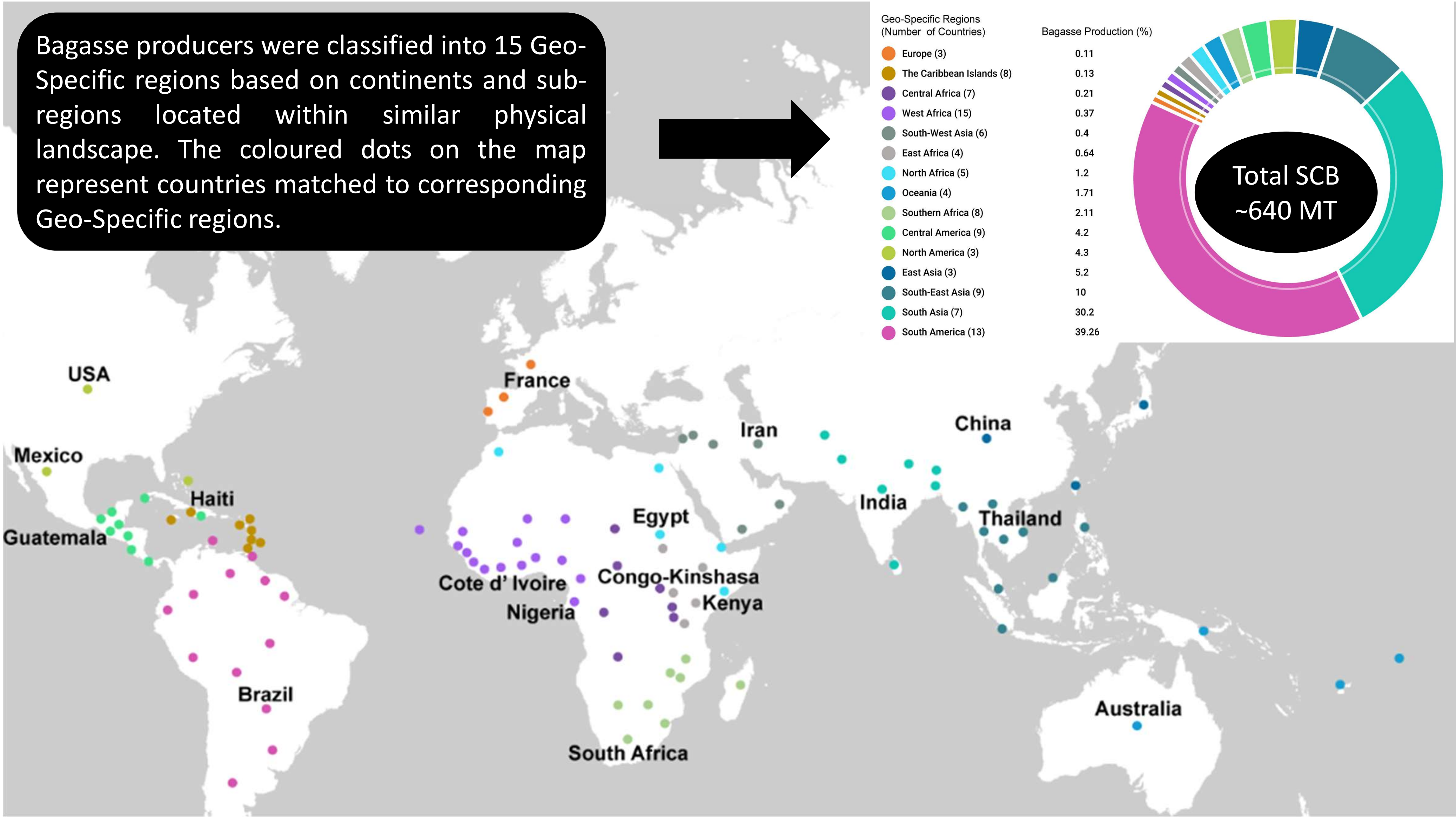
Poster 05

Classification of Global Bagasse Production by Geo-Specific Regions

Bagasse producers were classified into 15 Geo-Specific regions based on continents and sub-regions located within similar physical landscape. The coloured dots on the map represent countries matched to corresponding Geo-Specific regions.



❑ 300 kg of SCB derived from every tonne of sugarcane processed

❑ ~24% of global SCB derived from 'South East Asia', 'East Asia', 'North

Slide 1

BMD(&CE0 I think this looks good - its quite similar to the previous poster. My main comment would ve if you can provide any of the insights or trends that you have noticed about the geo-specifics of the production and/or use?

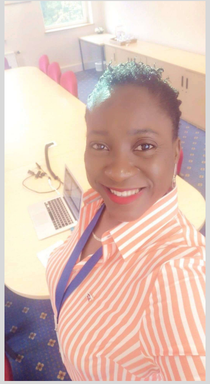
Bussemaker, Madeleine Dr (Chemi, 2024-03-22T09:56:09.985

BMD(&CE1 It also might be useful to add some methods on the poster - how did you class different regions?

Bussemaker, Madeleine Dr (Chemi, 2024-03-22T09:57:04.955

BMD(&CE1 0 also do the dots each represent a country?

Bussemaker, Madeleine Dr (Chemi, 2024-03-22T09:57:42.237



Geo-Specific Classification of Global Sugarcane Bagasse Production and Use

Maureen Chiebonam Okibe,

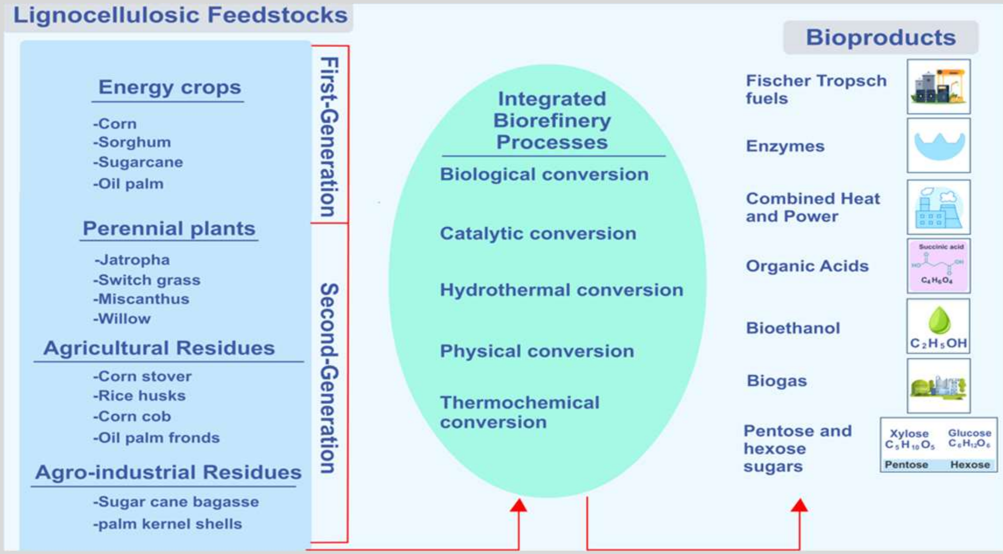
Michael Short, Franjo Cecelja, Madeleine Bussemaker

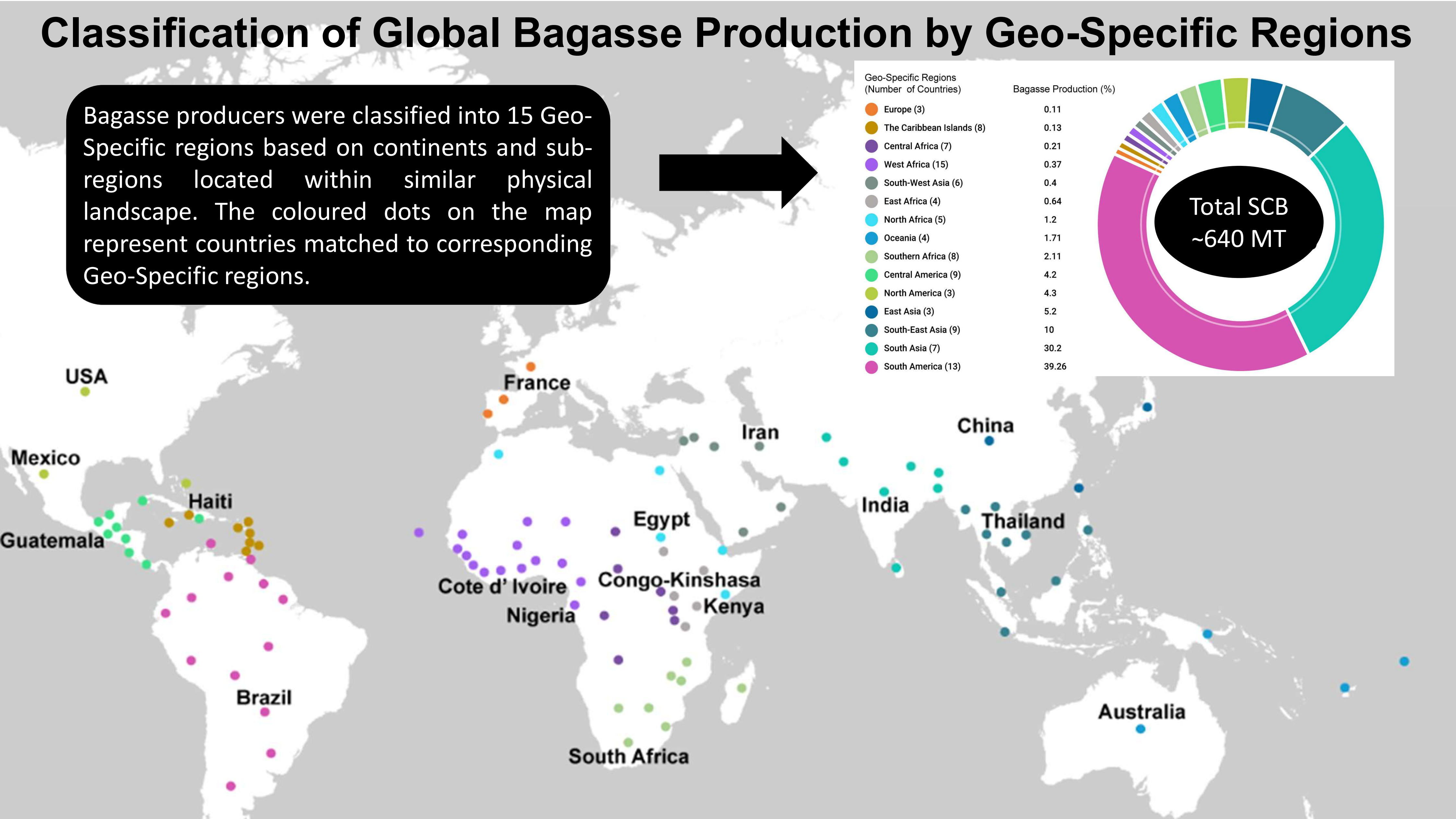
Department of Chemical and Process Engineering, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom.

Introduction

The demand for lignocellulosic feedstocks which are sustainable and renewable is increasing. Sugarcane bagasse (SCB) residues are fibrous materials derived from sugarcane processing. SCB is considered the world's biggest agro-industrial, second-generation lignocellulosic biomass. Recent study on the geo-spatial landscape of SCB producers identified Brazil, India, China and Thailand as the 'Principal Producers' (Okibe et al., 2023) of bagasse with tonnage >100 MT. The aim of this study was to reclassify SCB producers based on geo-specific regions. This will elucidate insights on the regional factors influencing the supply, production and use of bagasse on a global scale.

Lignocellulose for Sustainable Bioeconomy





Classification of Global Bagasse Production by Geo-Specific Regions
Bagasse producers were classified into 15 Geo-Specific regions based on continents and sub-regions located within similar physical landscape. The coloured dots on the map represent countries matched to corresponding Geo-Specific regions.
Geo-Specific Regions (Number of Countries)
Bagasse Production (%)
Europe (3) 0.11
The Caribbean Islands (8) 0.13
Central Africa (7) 0.21
West Africa (15) 0.37
South-West Asia (6) 0.4
East Africa (4) 0.64
North Africa (5) 1.2
Oceania (4) 1.71
Southern Africa (8) 2.11
Central America (9) 4.2
North America (3) 4.3
East Asia (3) 5.2
South-East Asia (9) 10
South Asia (7) 30.2
South America (13) 39.26
Total SCB
~640 MT
USA
Mexico
Haiti
Guatemala
France
Iran
China
Egypt
India
Thailand
Cote d' Ivoire
Congo-Kinshasa
Kenya
Nigeria
Brazil
South Africa
Australia

Findings & Discussions

- ❑ 300 kg of SCB derived from every tonne of sugarcane processed
- ❑ >100 countries (majorly from tropical and sub-tropical regions) produce ~640 MT of SCB globally every year with 70% from 20 countries
- ❑ ~40% of global SCB production originates from ‘South America’ region (13) with Brazil as the highest contributor to bagasse tonnage
- ❑ Only 7 countries from ‘South Asia’ region produce 30% of SCB globally
- ❑ ~24% of global SCB derived from ‘South-East Asia’, ‘East Asia’, ‘North America’ and ‘Central America’ regions
- ❑ ‘Southern Africa’ region (8) has the highest production within Africa
- ❑ ‘West Africa’ region (15) has the highest number of SCB producers globally but delivers significantly low bagasse production levels
- ❑ ‘Europe’ region is the lowest producer of bagasse registering 0.11% of global production from Spain, France and Portugal.

Conclusions:

- ❑ Reclassifying bagasse production by geo-specific regions may provide new insights on SCB valorisation opportunities
- ❑ Country-specific policies and geo-specific factors may affect the production and use of SCB in biorefineries

Future work:

- ❑ To investigate country-specific uses of SCB based on regions and the geo-specific factors affecting SCB production and use on a country-by-country basis.
- ❑ To conduct macro factors analysis on the regional influences affecting bagasse production and use which would inform country-specific policies
- ❑ To semantically model SCB knowledge on ontologies identifying existing trends

References:

Carus, M., & Dammer, L. (2018). The Circular Bioeconomy - Concepts, Opportunities, and Limitations. Industrial Biotechnology, 14(2), 83–91.

De Matos, M., Santos, F., & Eichler, P. (2019). Sugarcane world scenario. In Sugarcane Biorefinery, Technology and Perspectives (pp. 1–19). Elsevier.

Gikonyo, B. (2021). Sugarcane as biofuel feedstock : advances toward a sustainable energy solution.

Narisetty, V., Okibe, M. C., Amulya, K., Jokodola, E. O., Coulon, F., Tyagi, V. K., Lens, P. N. L., Parameswaran, B., & Kumar, V. (2022). Technological advancements in valorization of second generation (2G) feedstocks for bio-based succinic acid production. Bioresource Technology, 360, 127513.

Okibe, M. C., Short, M., Cecelja, F., & Bussemaker, M. (2023). Ontology Modelling for Valorisation of Sugarcane Bagasse (pp. 3363–3368).

Developing a UK political bioeconomy framework

Creating the policy conditions for sustainable biomass to achieve net zero

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Aston University

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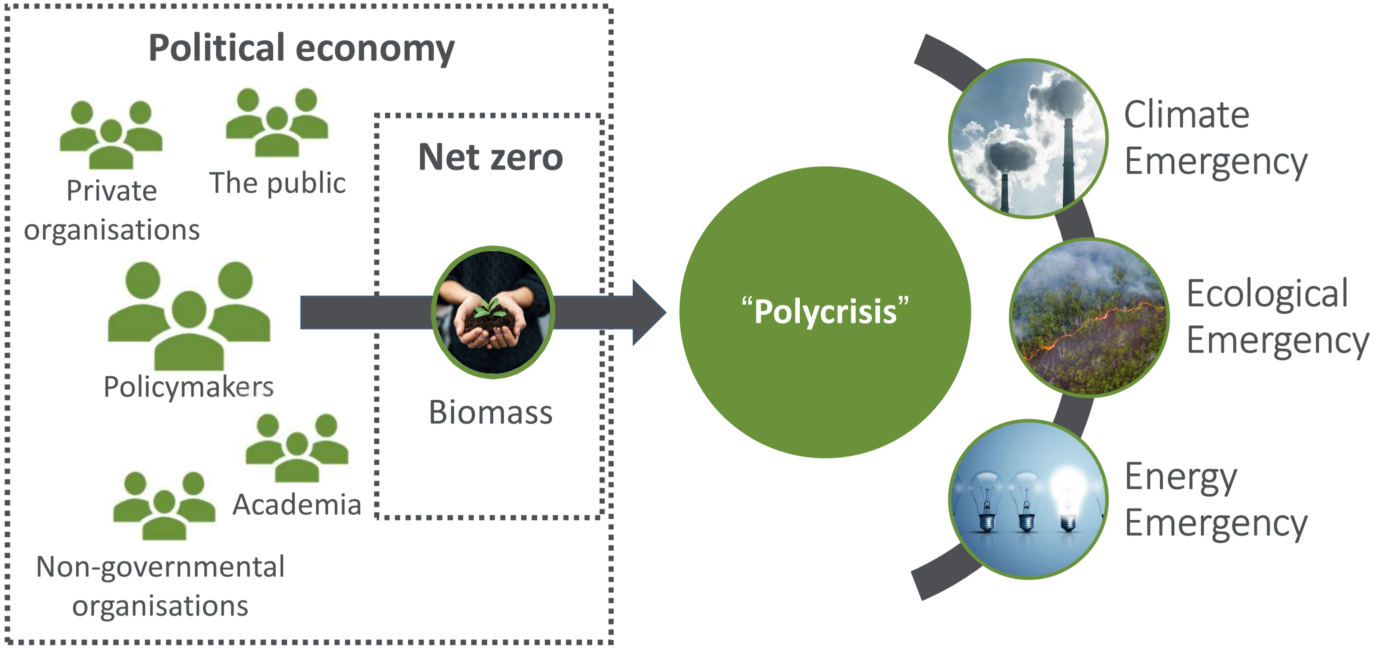
@DanJ_Taylor

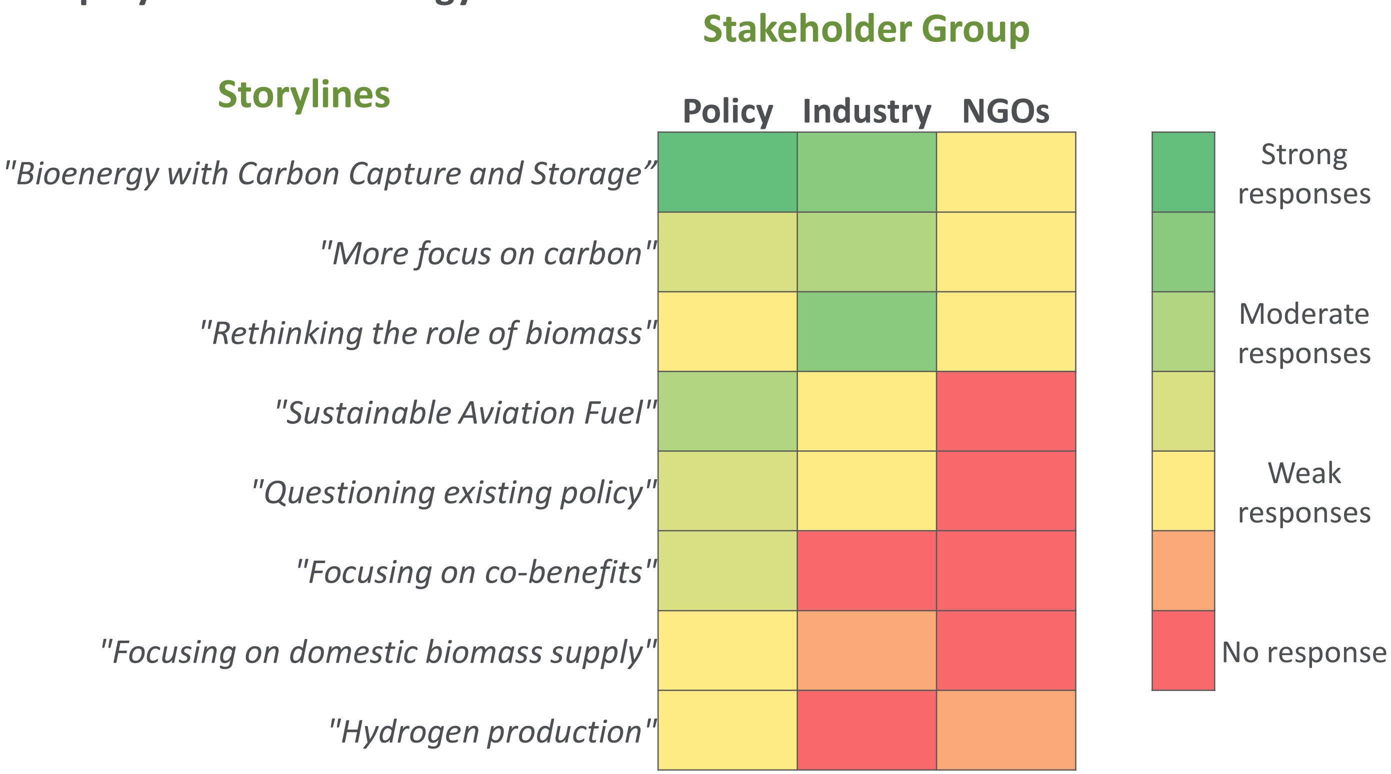
The political bioeconomy

- **Economic** systems, **political** institutions and decisions.
- Determines the distribution of **wealth, inequality, and benefits** amongst our economy.
- Brings in the **ecological element** to incorporate the use of **biomass, extracted from our natural environment**, to produce bio-based resources.



Implications for policy

What impact has the introduction of net zero had on the deployment of bioenergy in the UK?



- **Preliminary results from qualitative study** of semi-structured interview responses.
- Net zero is legitimising and encouraging **negative emission focus**.
- Policy focus **needs to go beyond the linear approach to carbon and cash**, to truly deliver **system-wide benefits that will mobilise sustained support** for sustainable biomass use.

Thank you for listening!

WIREs ENERGY AND ENVIRONMENT   WILEY

ADVANCED REVIEW

Designing biomass policy: The political economy of renewable energy for net zero

Daniel Taylor | **Katie Chong** | **Mirjam Röder**