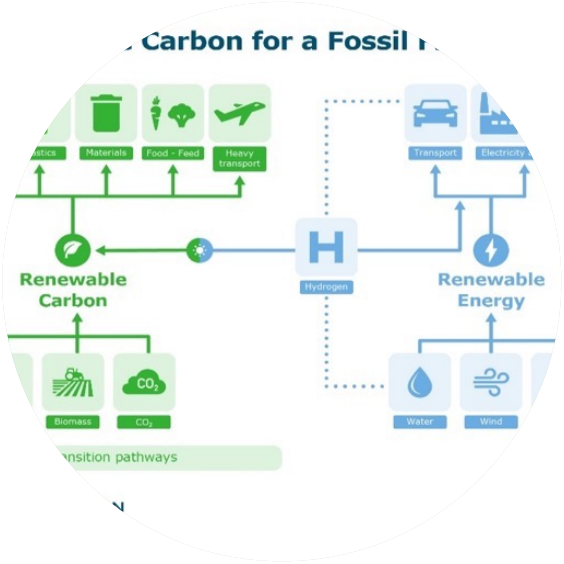
Circular bio-based production systems in the context of current biomass and fossil demand

WUR-nova webinar series

11 October 2021, Dr Harriëtte Bos



WAGENINGEN
UNIVERSITY & RESEARCH

Why a bio(based) economy?

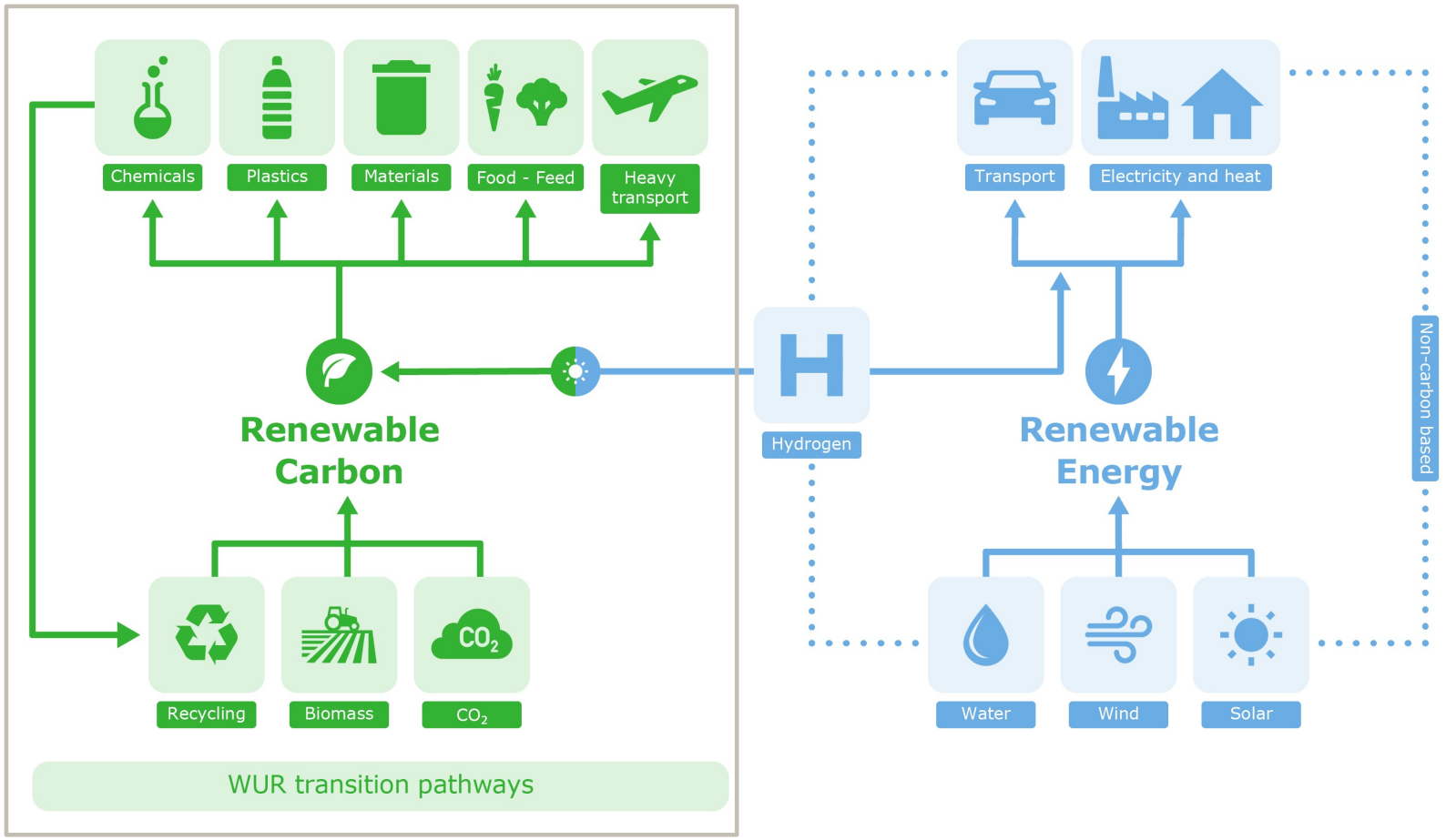
- 30 years ago: agricultural overproduction in EU: agrification
- 20 years ago: environmental issues
- 10 years ago: oil supply, climate change, geopolitics, economic potential

- Now: circular economy and climate change: renewable carbon

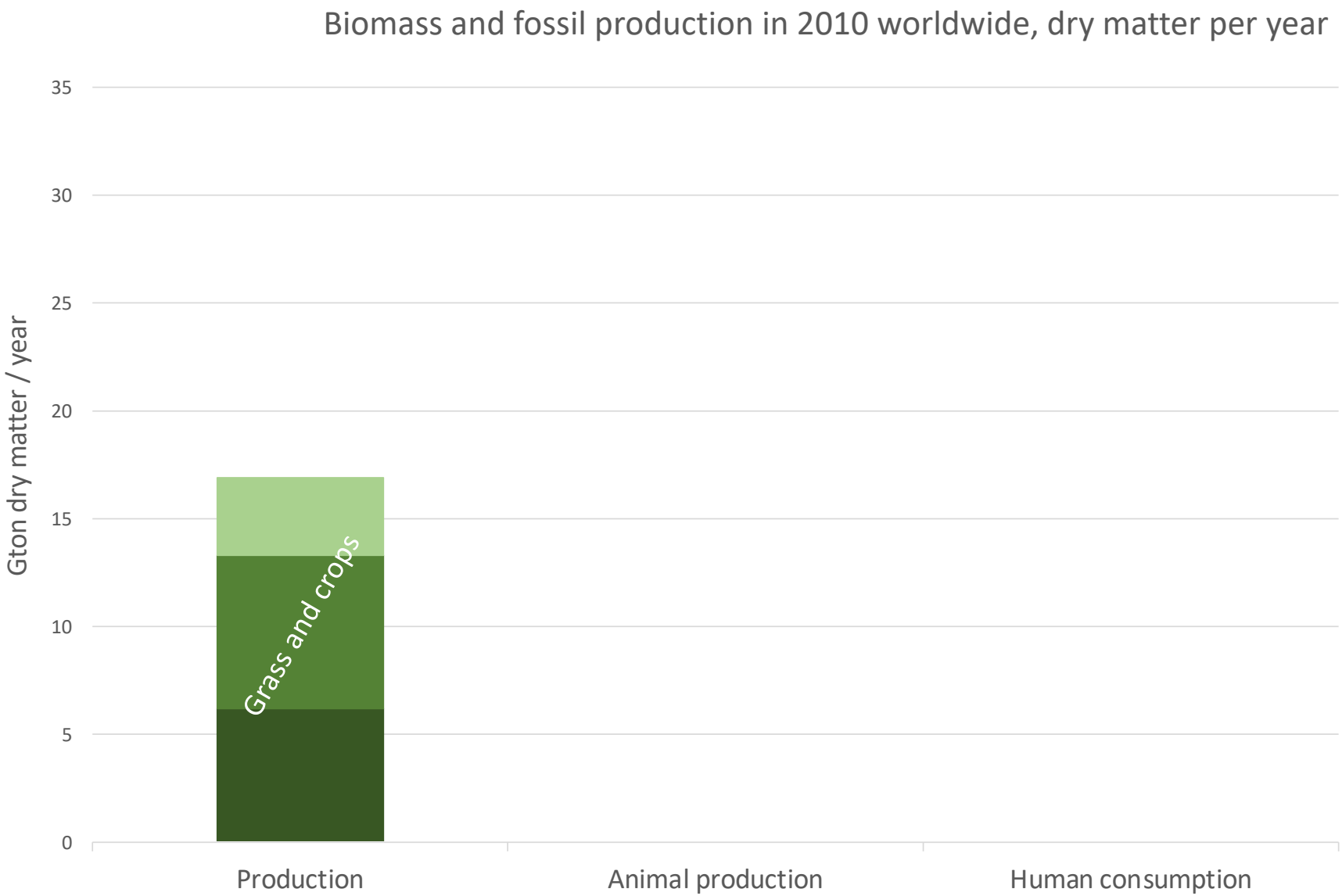
WAGENINGEN
UNIVERSITY & RESEARCH

Wageningen Fossil Free challenge

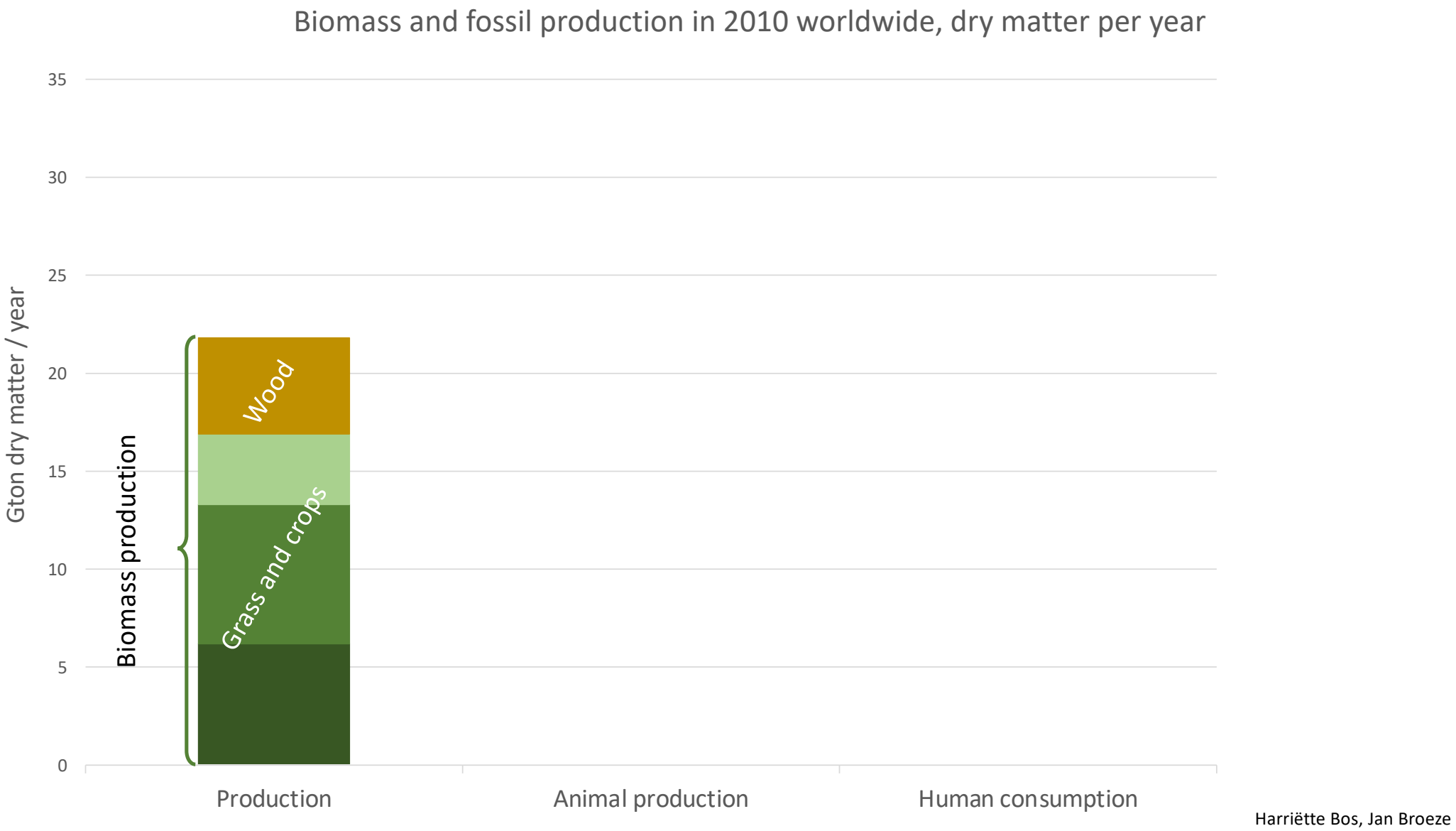
Renewable Carbon for a Fossil Free society



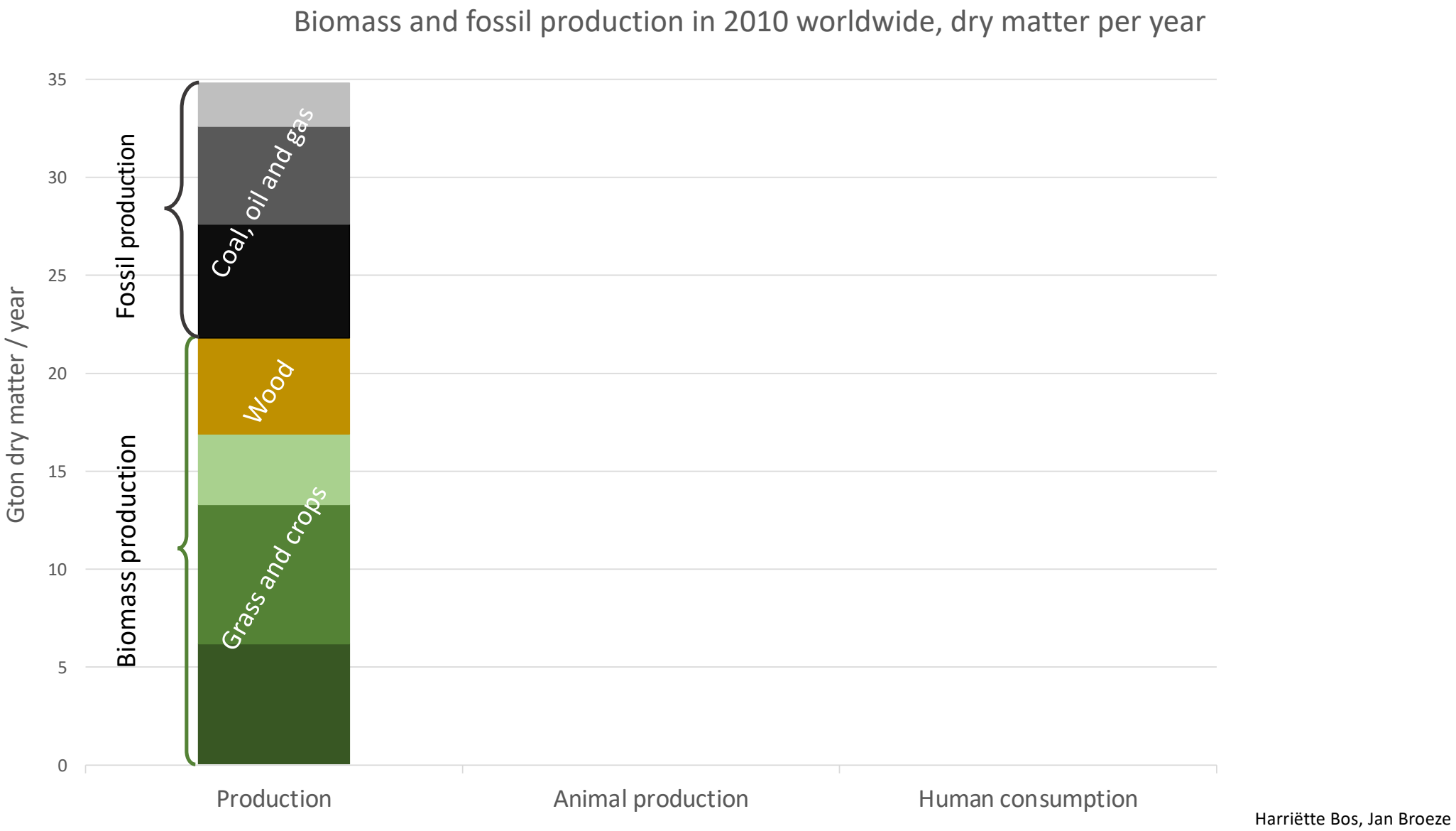
WAGENINGEN
UNIVERSITY & RESEARCH



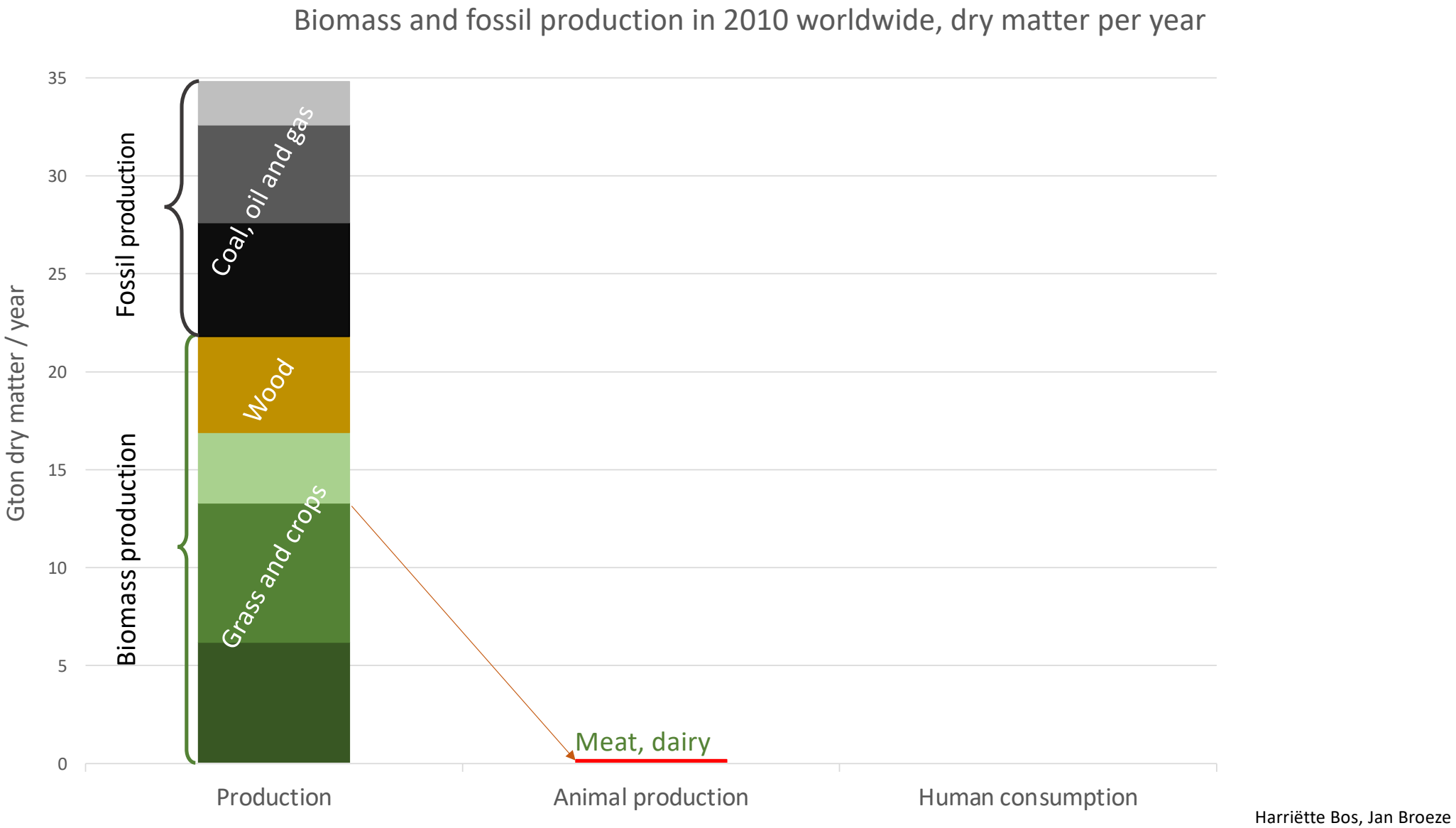
Harriëtte Bos, Jan Broeze



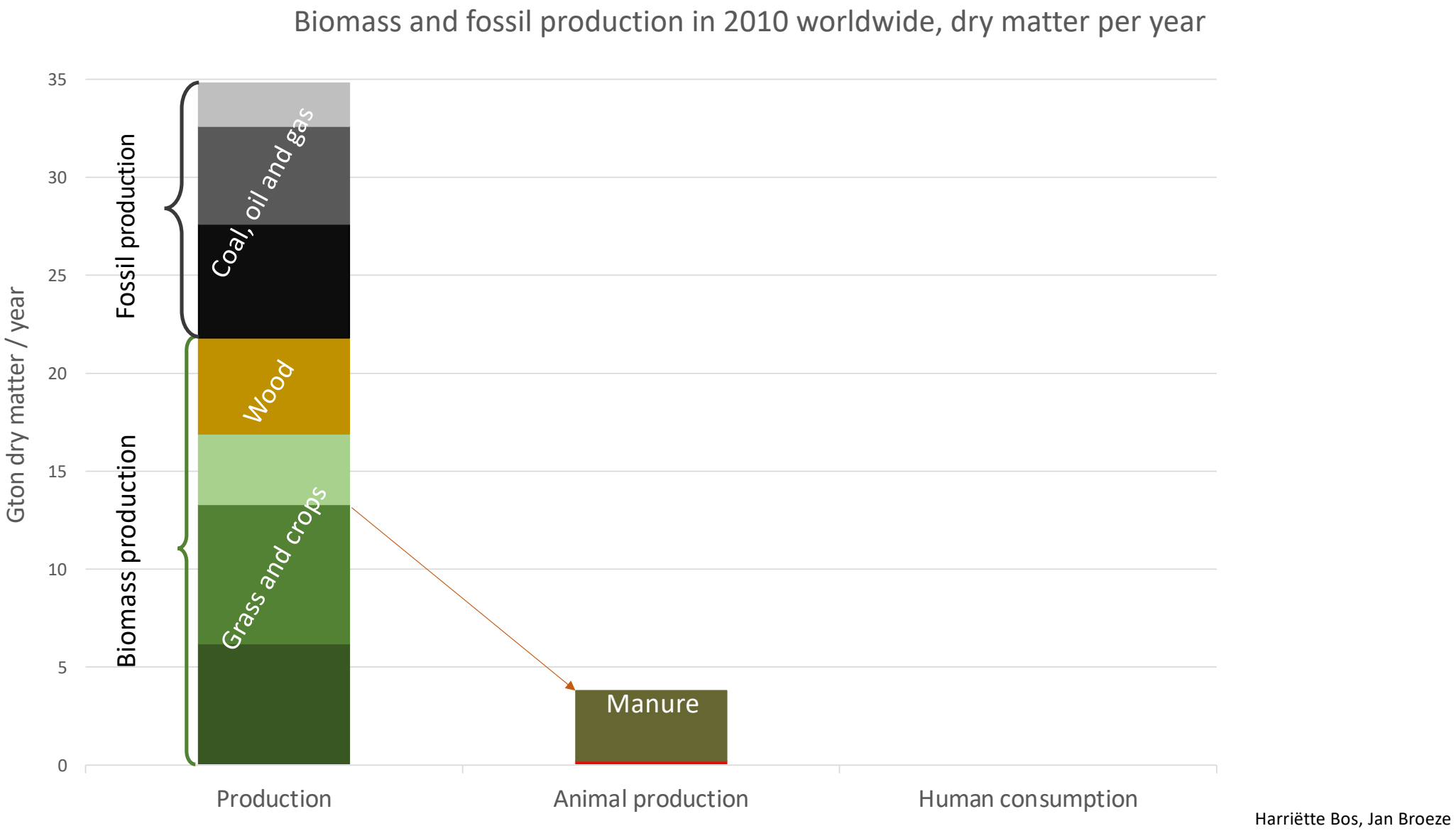
Harriëtte Bos, Jan Broeze



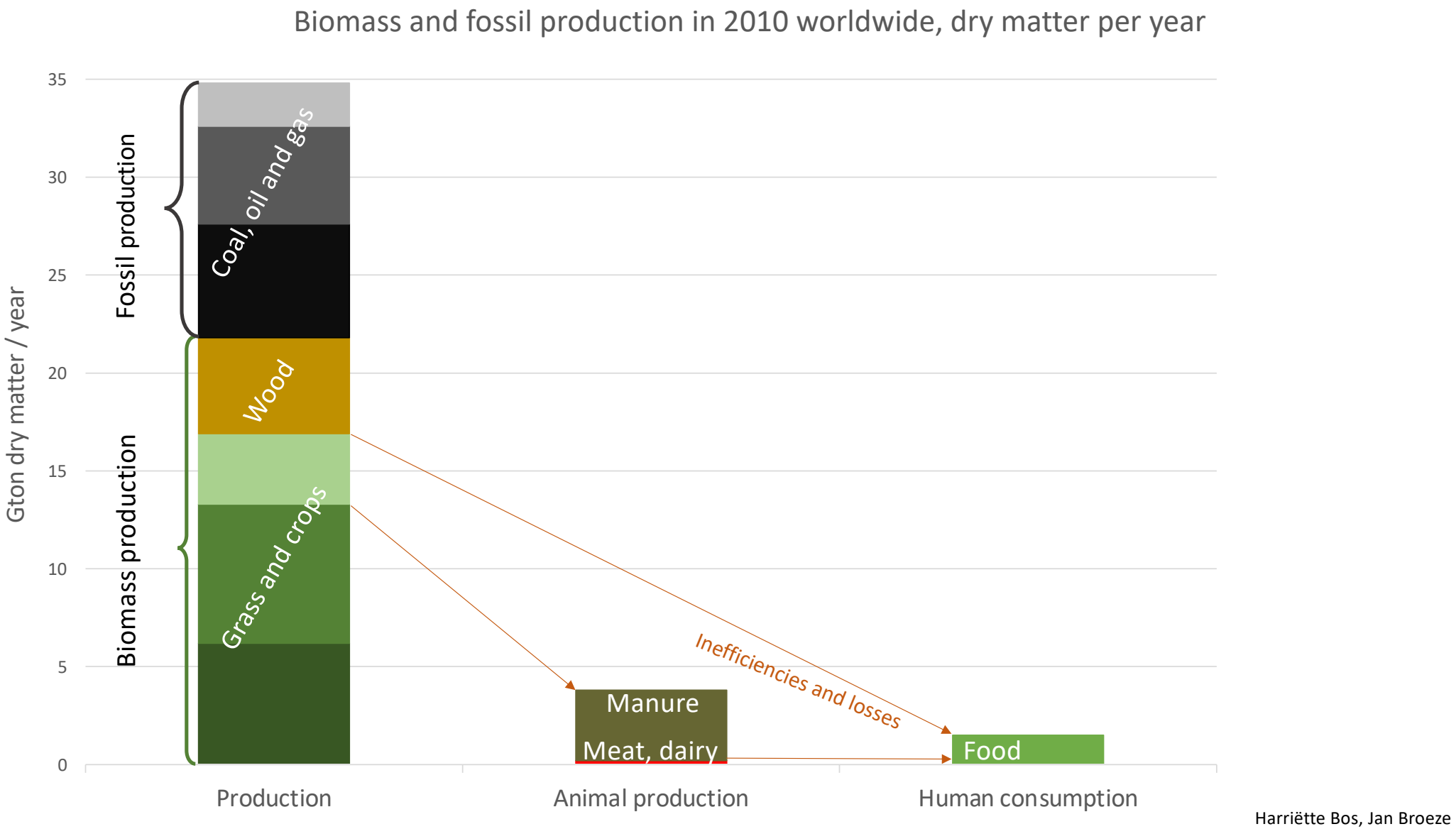
Harriëtte Bos, Jan Broeze



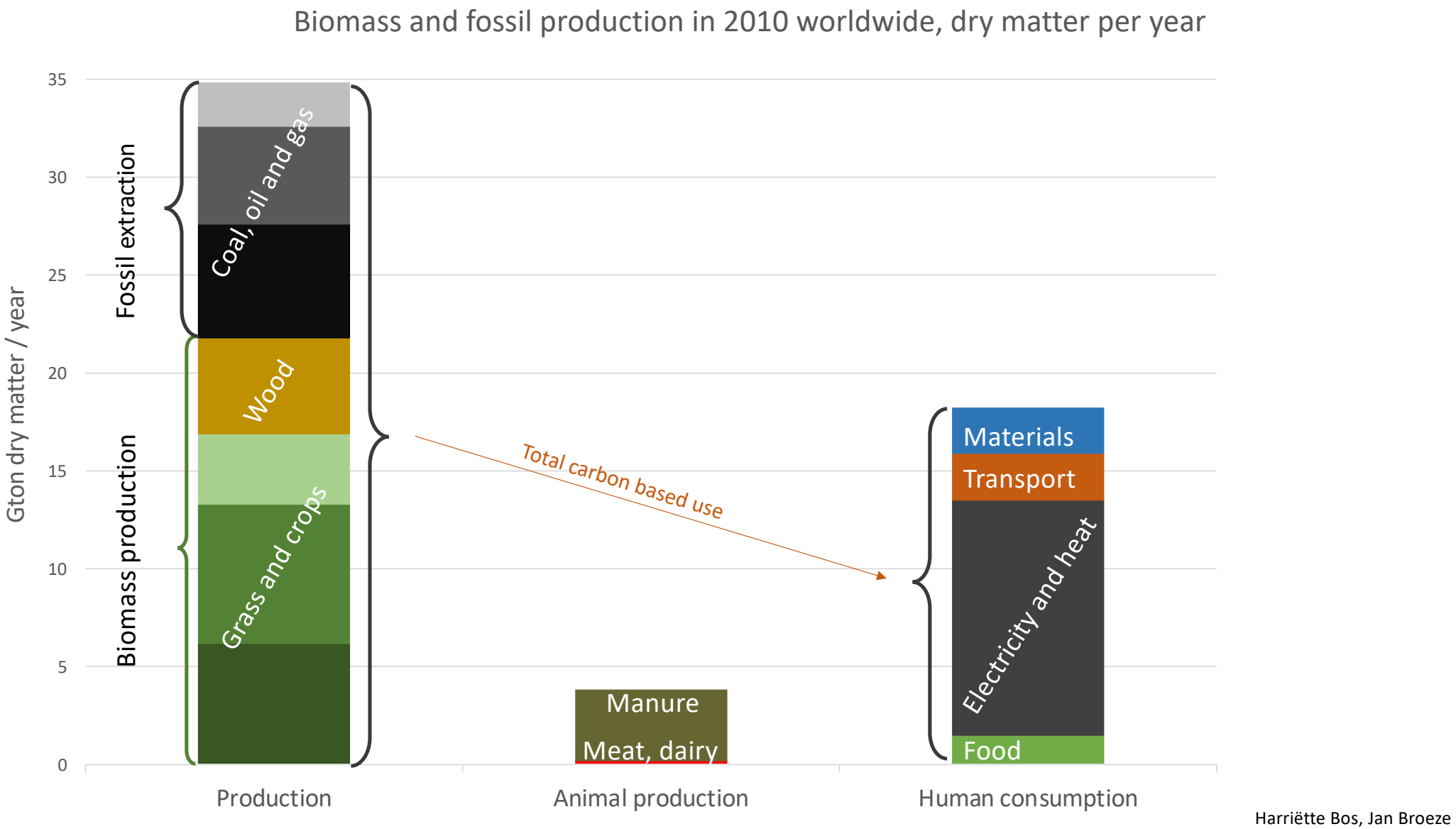
Harriëtte Bos, Jan Broeze



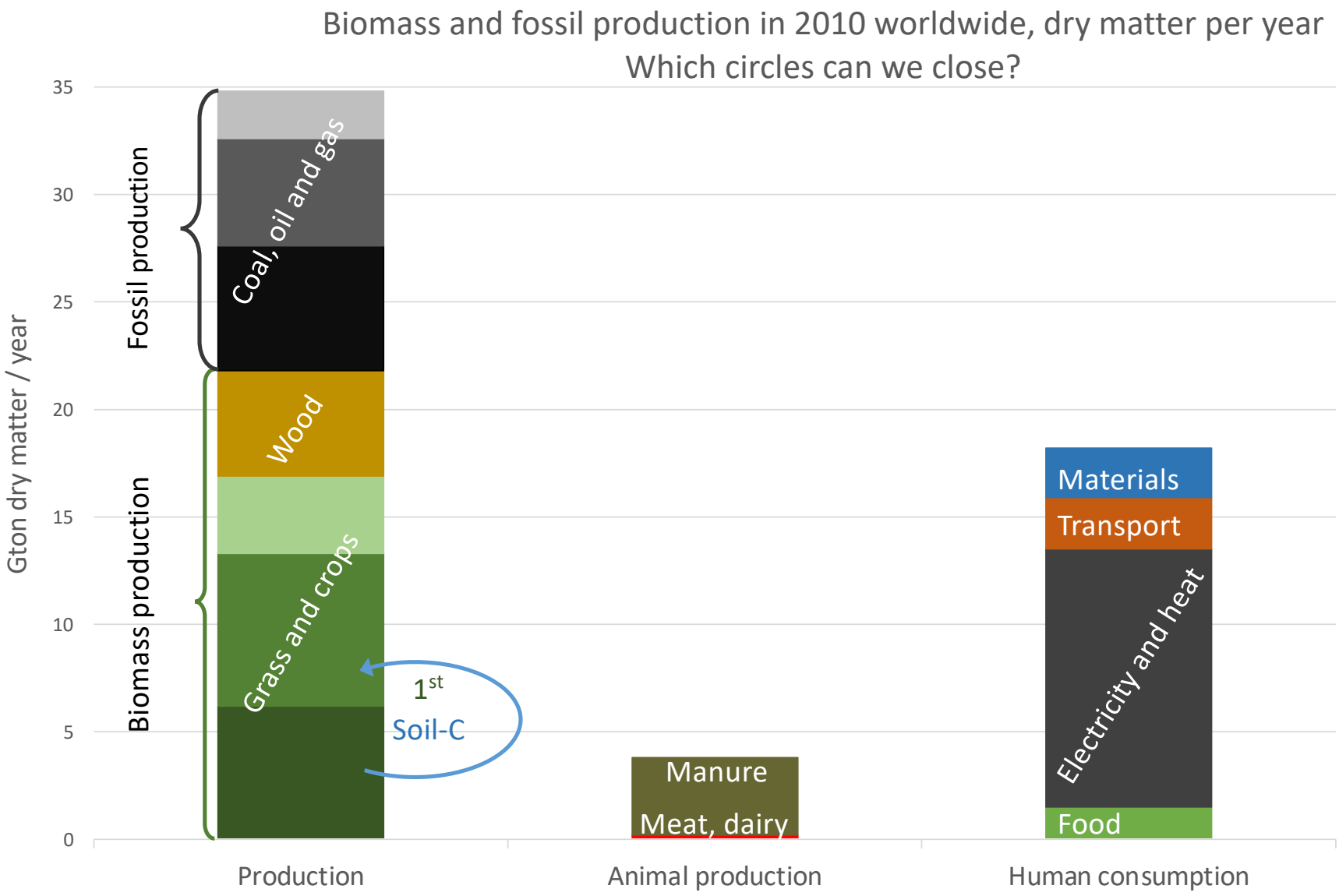
Harriëtte Bos, Jan Broeze



Harriëtte Bos, Jan Broeze

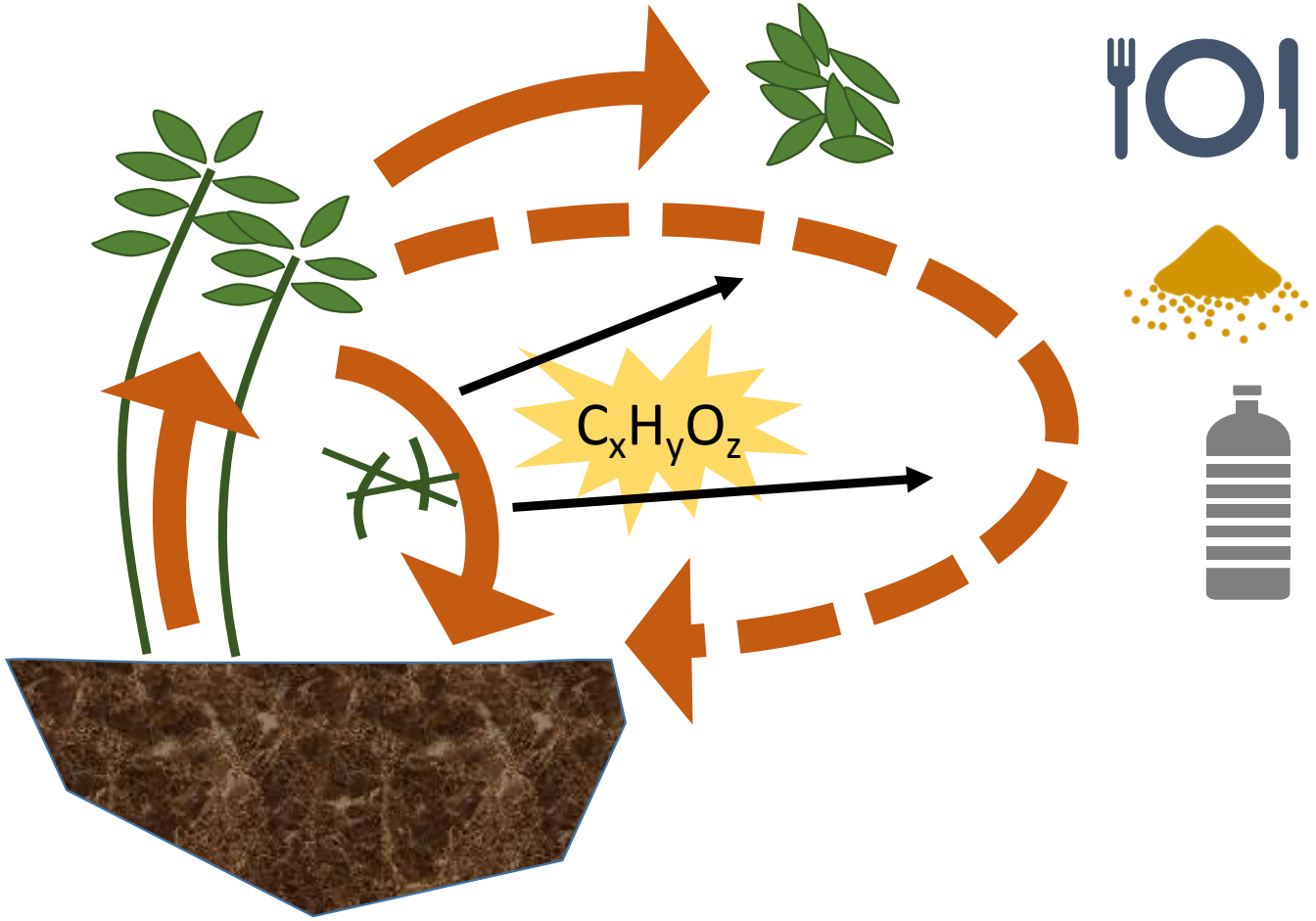


Harriëtte Bos, Jan Broeze

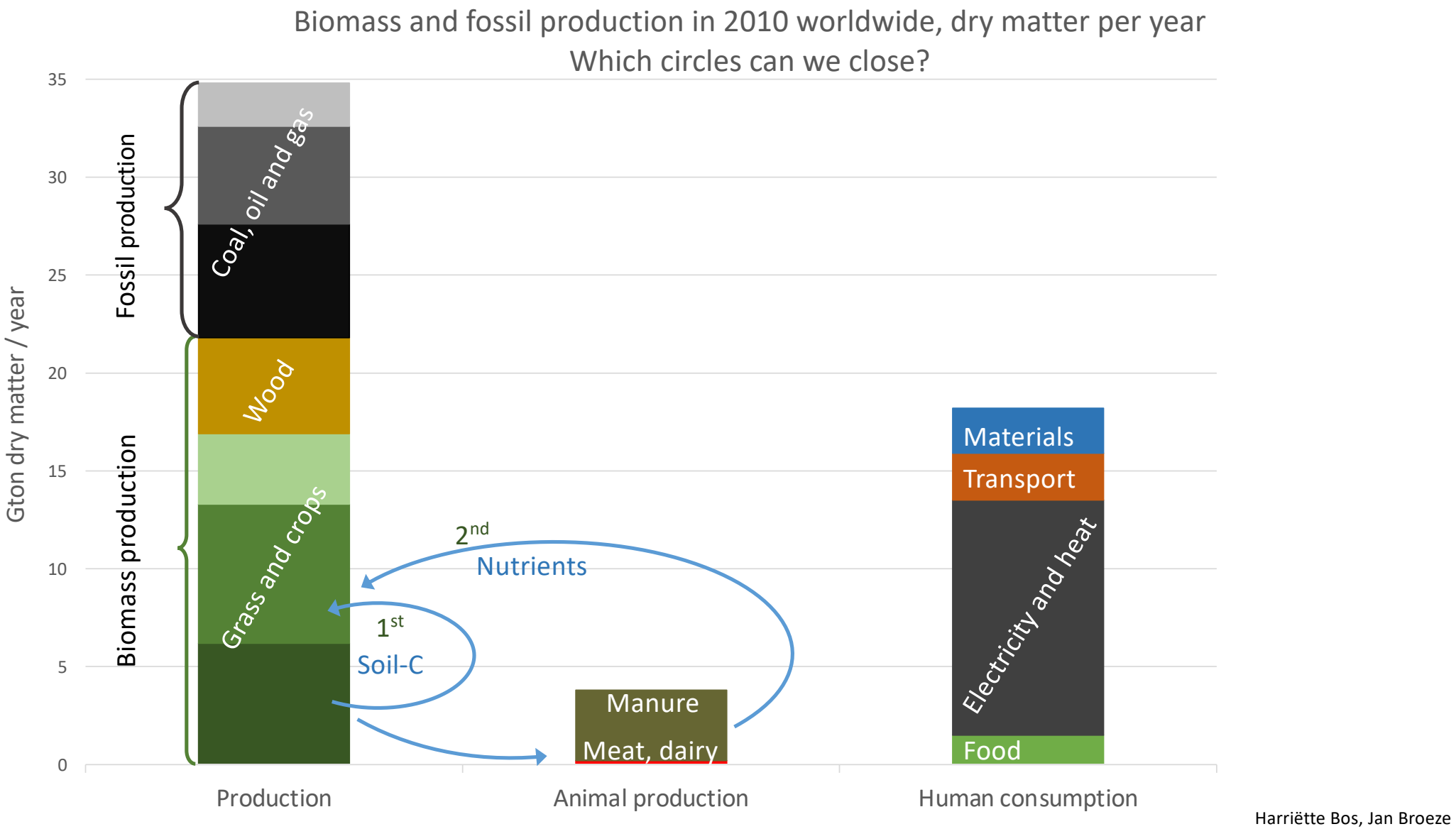


Harriëtte Bos, Jan Broeze

1st circle: soil carbon through management and improved use of side-streams

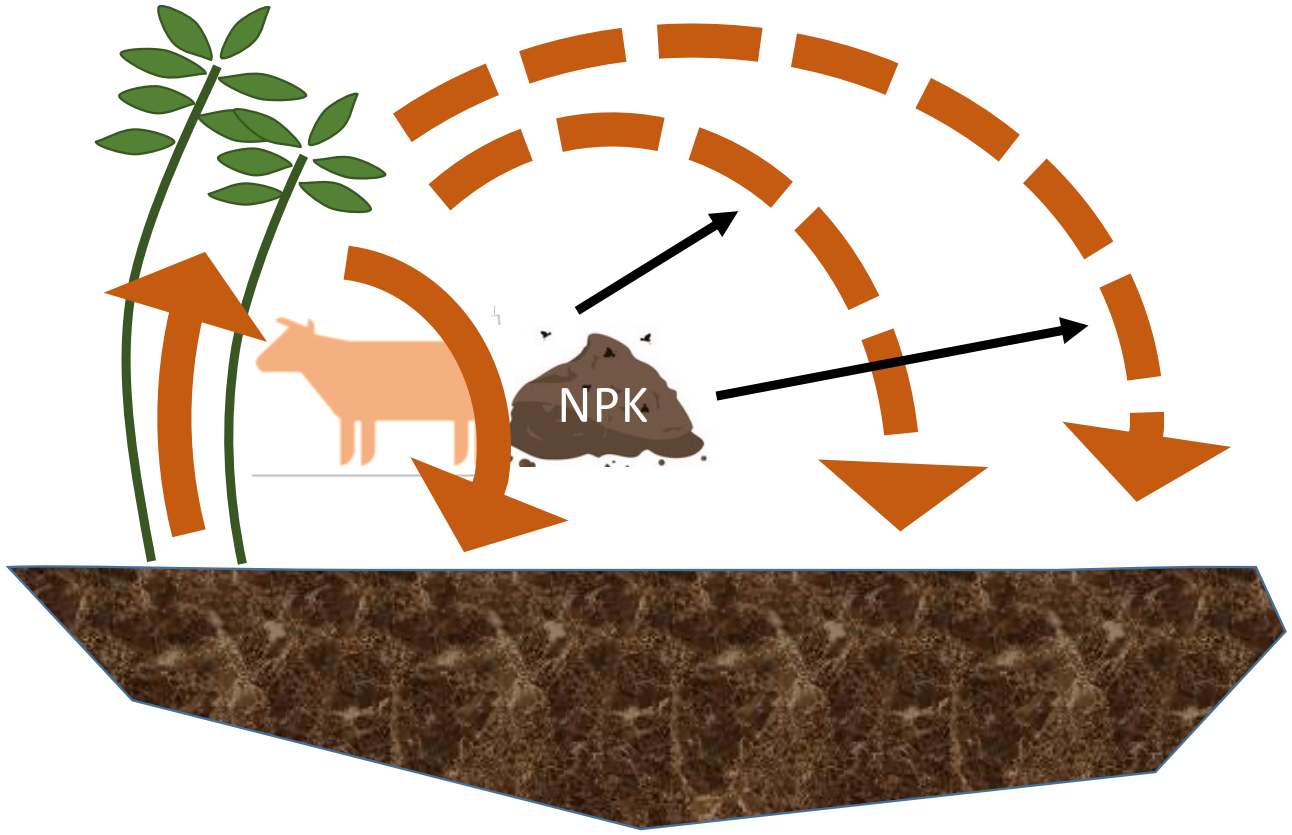


Harriëtte Bos, Jan Broeze

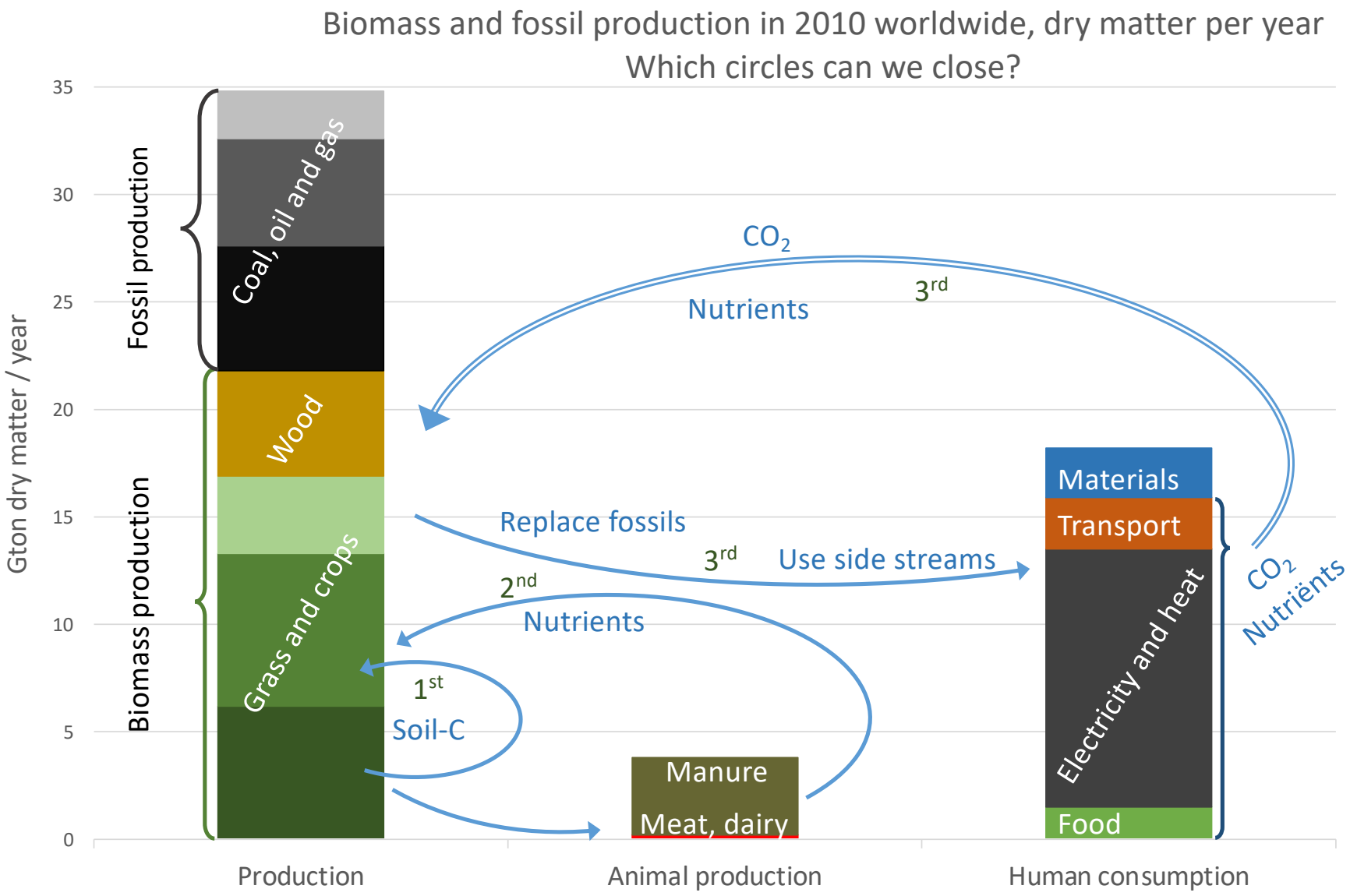


Harriëtte Bos, Jan Broeze

2nd circle: livestock production and circular nutrient management

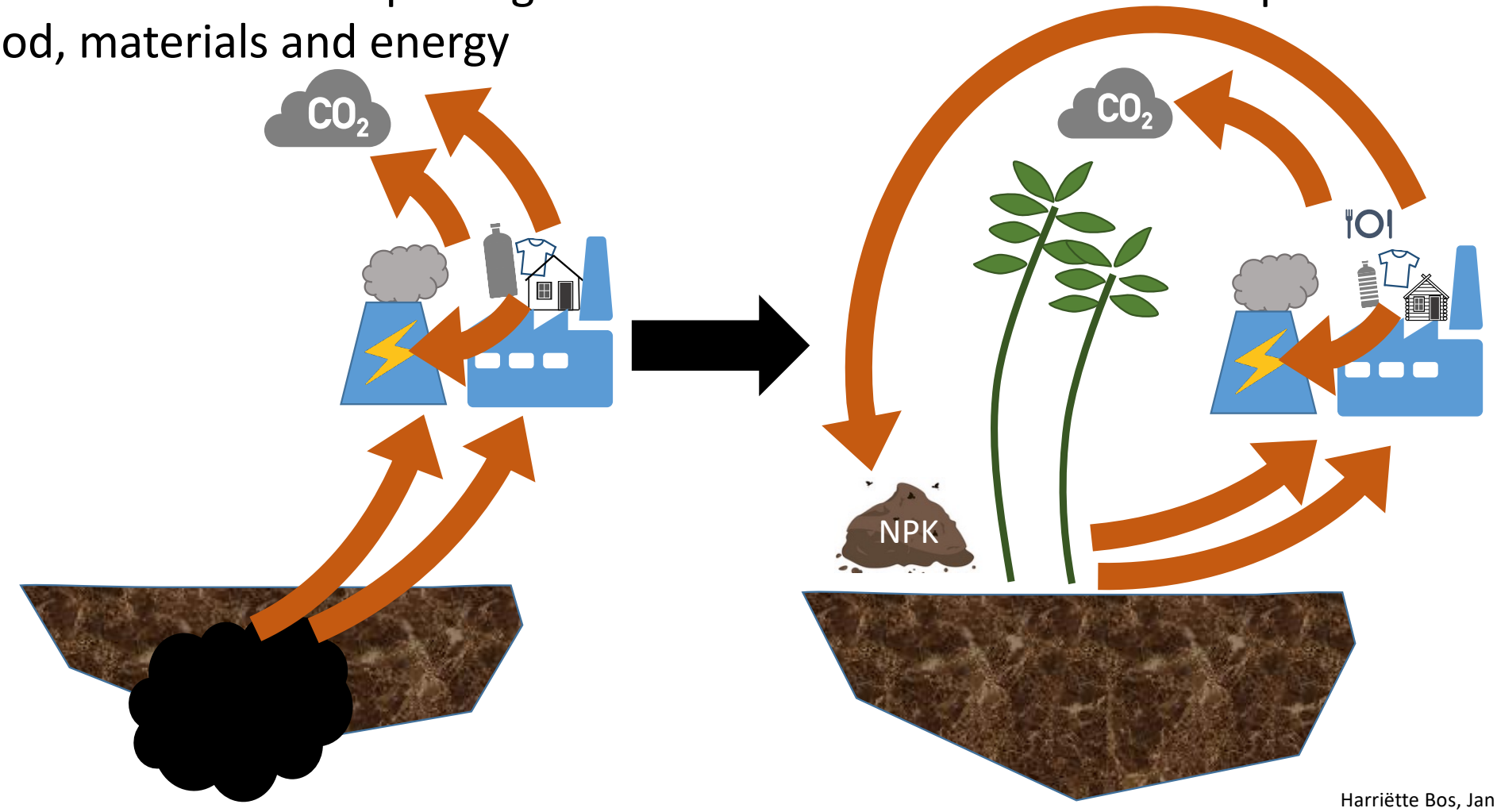


Harriëtte Bos, Jan Broeze

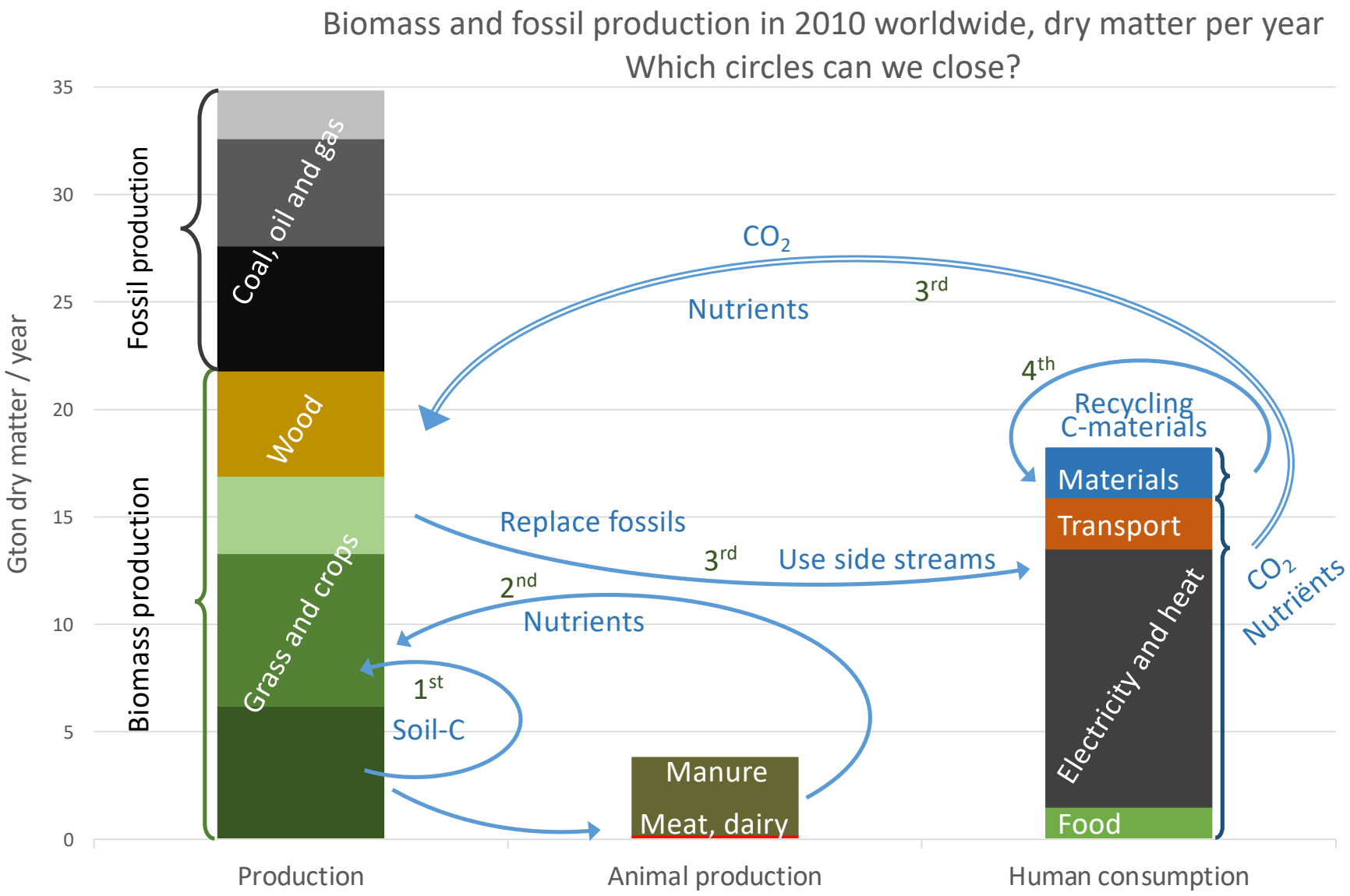


Harriëtte Bos, Jan Broeze

3rd cycle: replacement of fossil sources by renewables, valorisation of side stream and recapturing carbon and nutrients after consumption of food, materials and energy



Harriëtte Bos, Jan Broeze



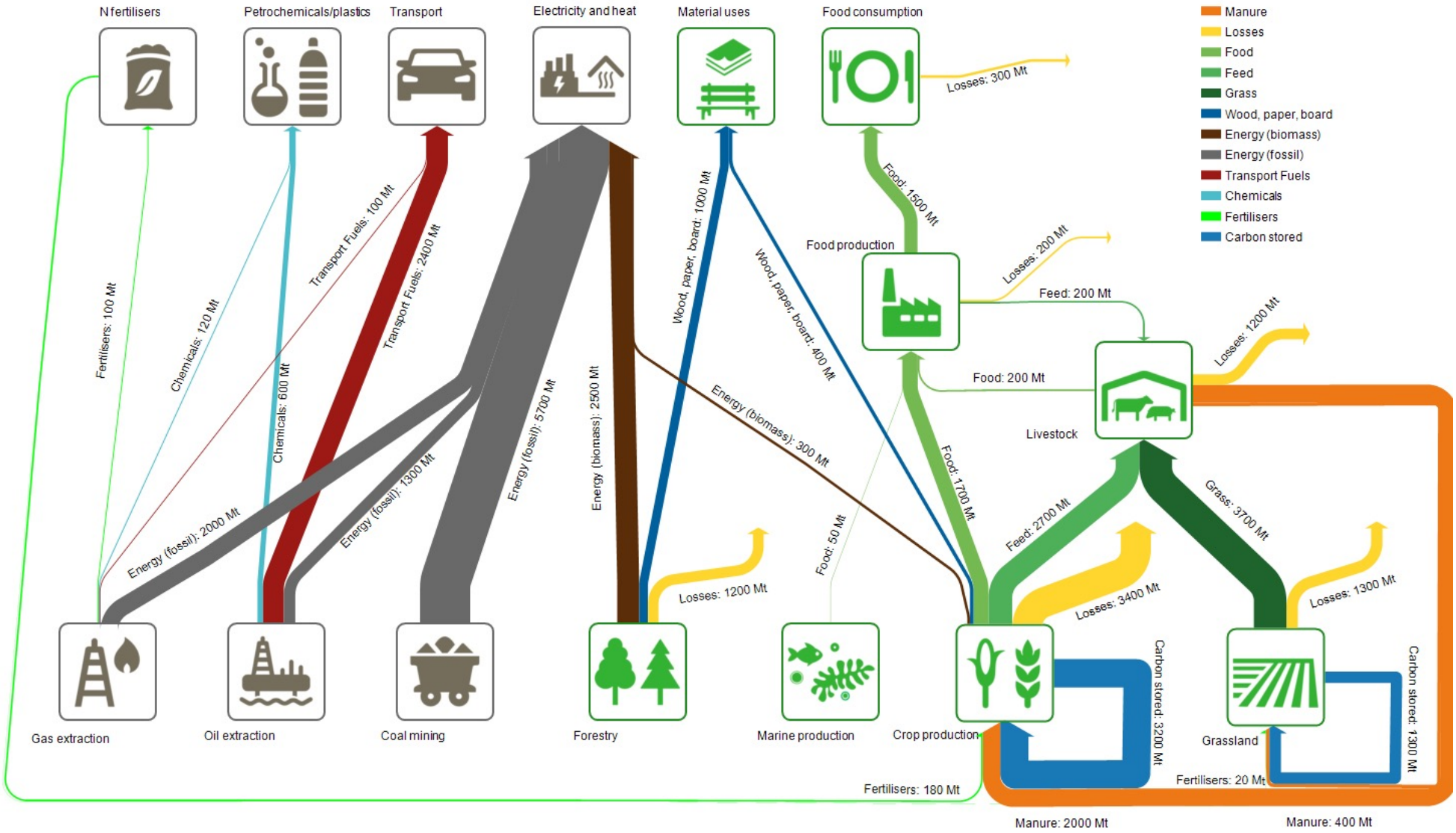
Harriëtte Bos, Jan Broeze

4th cycle: carbon capture in materials, reuse, refurbish, recycle

Harriëtte Bos, Jan Broeze

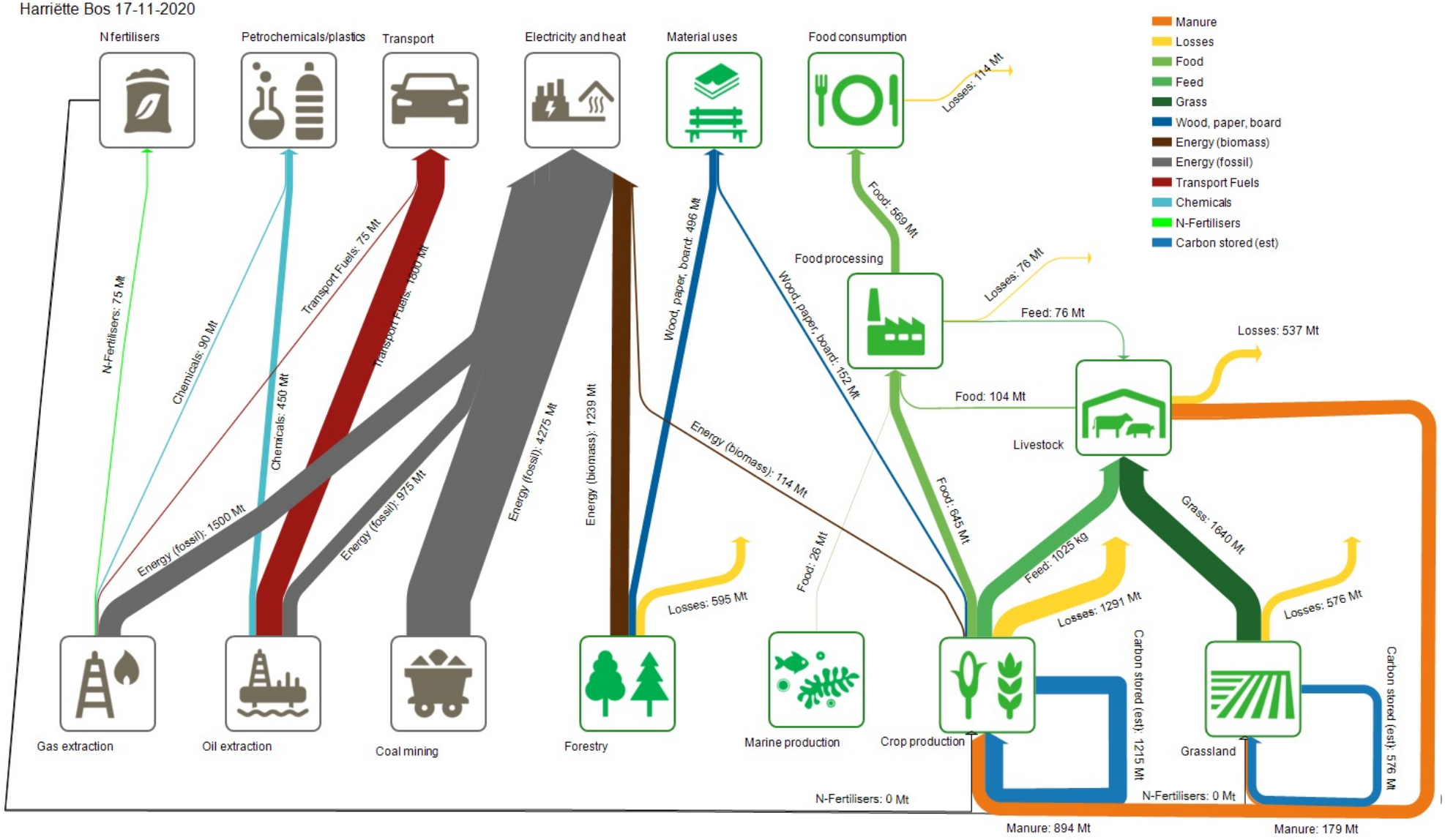
World-wide C-based system

Harriëtte Bos, Jan Broeze 12-9-2019



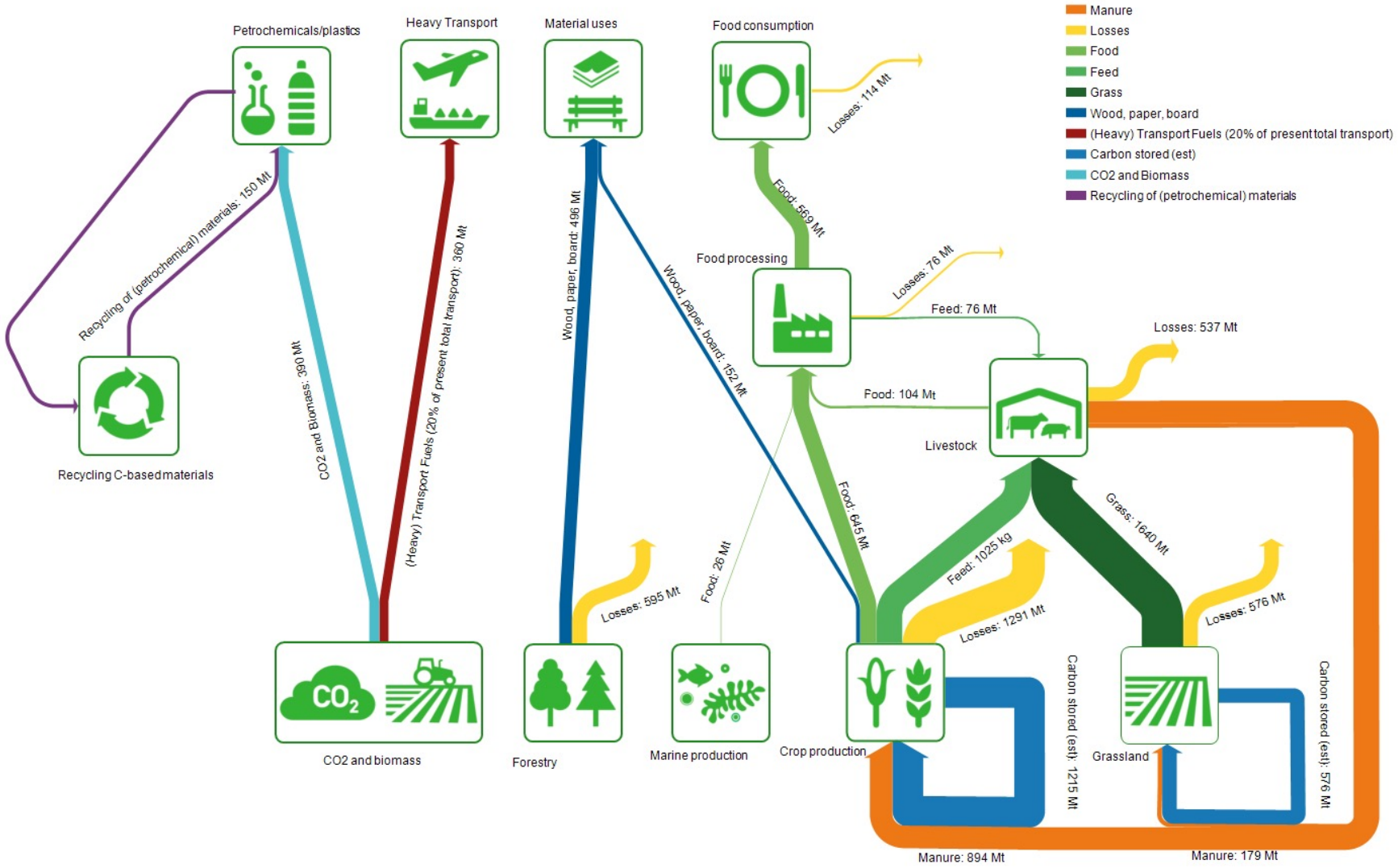
World-wide carbon flows expressed in MTon C atoms

Harriëtte Bos 17-11-2020

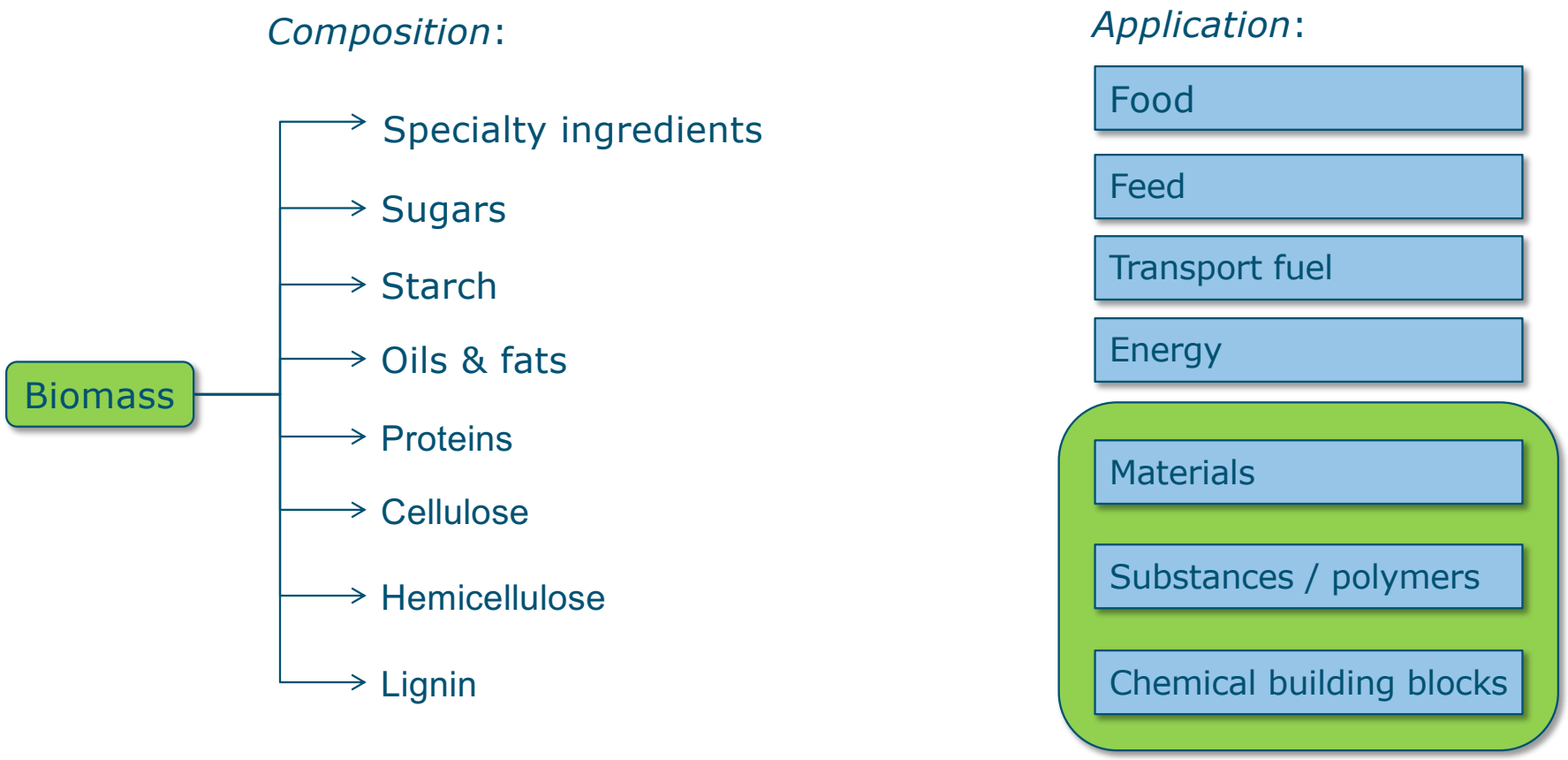


DRAFT Renewable carbon challenge. Present carbon (C) use world wide, (excluding energy) DRAFT

Harriëtte Bos 3-12--2020 Units are Mton C content

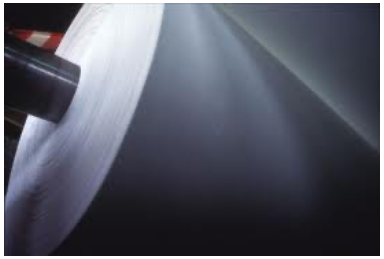


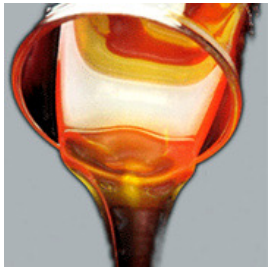
Plant biomass; what's in it, what can we do with it



Classification non-food applications

- Materials:
  - *fibres* for paper, fabrics and composites
  - *wood* for timber and energy
- Substances:
  - *starch* for plastics, glues and additives
  - *bio-oil* for paints, inks and transport fuels
- Chemical building blocks:
  - *lactic acid* for additives and polymers
  - *diols* for polyester and nylon polymers
  - *furans* for resins and fuels





WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

Who are involved in production?

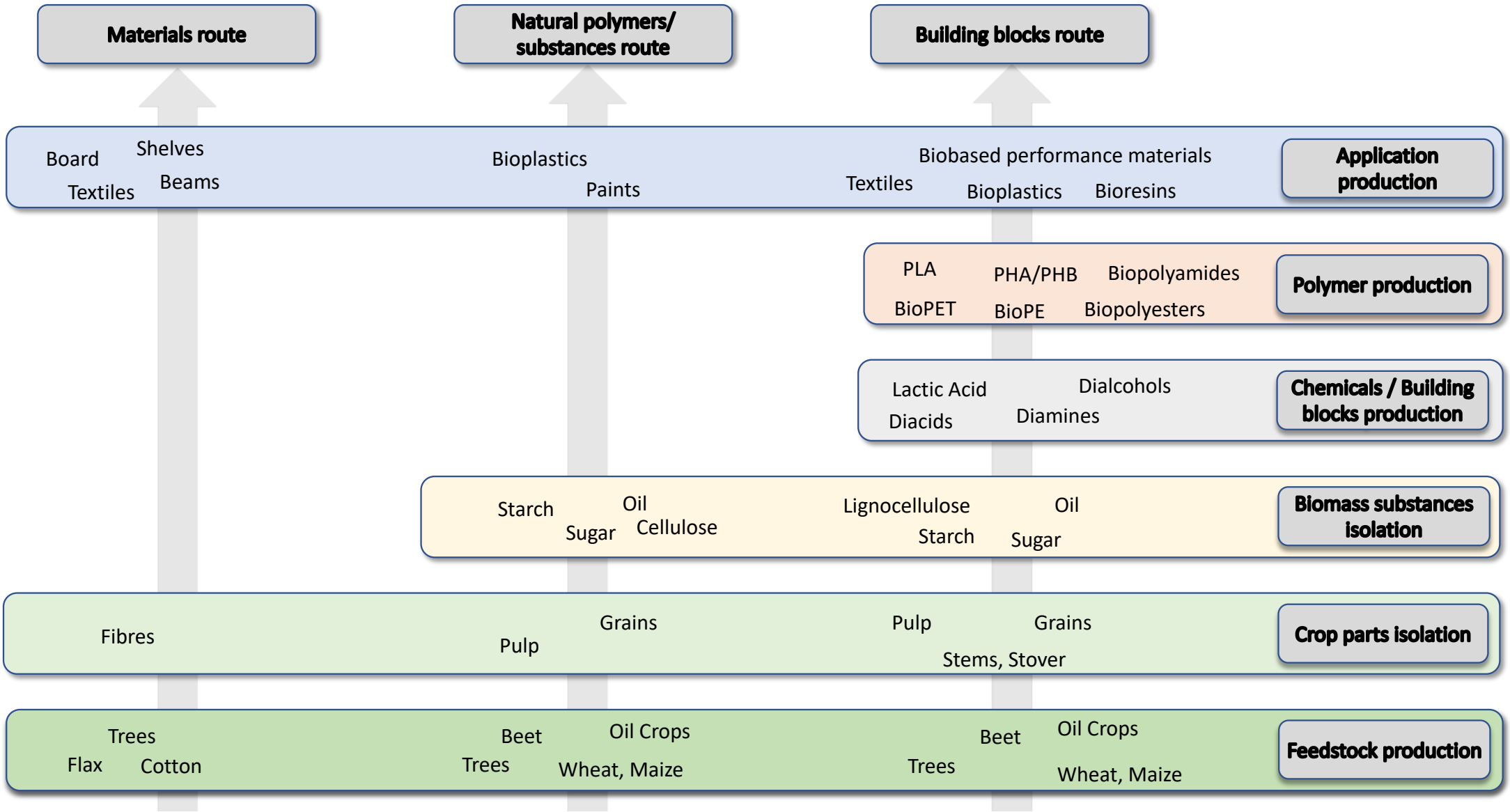
- Materials:
  - Mostly old established applications and relatively simple processes
  - Can be big (f.i. Paper industry), but also a lot of SME
- Substances/natural polymers
  - Often using relatively simple chemical conversions
  - Agri-industry (f.i. AVEBE, COSUN), and also SME
- Chemical building blocks:
  - Combination of agro and chemical sector
  - Biorefinery, white biotech, chemistry
  - New products and processes
  - Big potential for innovative applications

WAGENINGEN
UNIVERSITY & RESEARCH

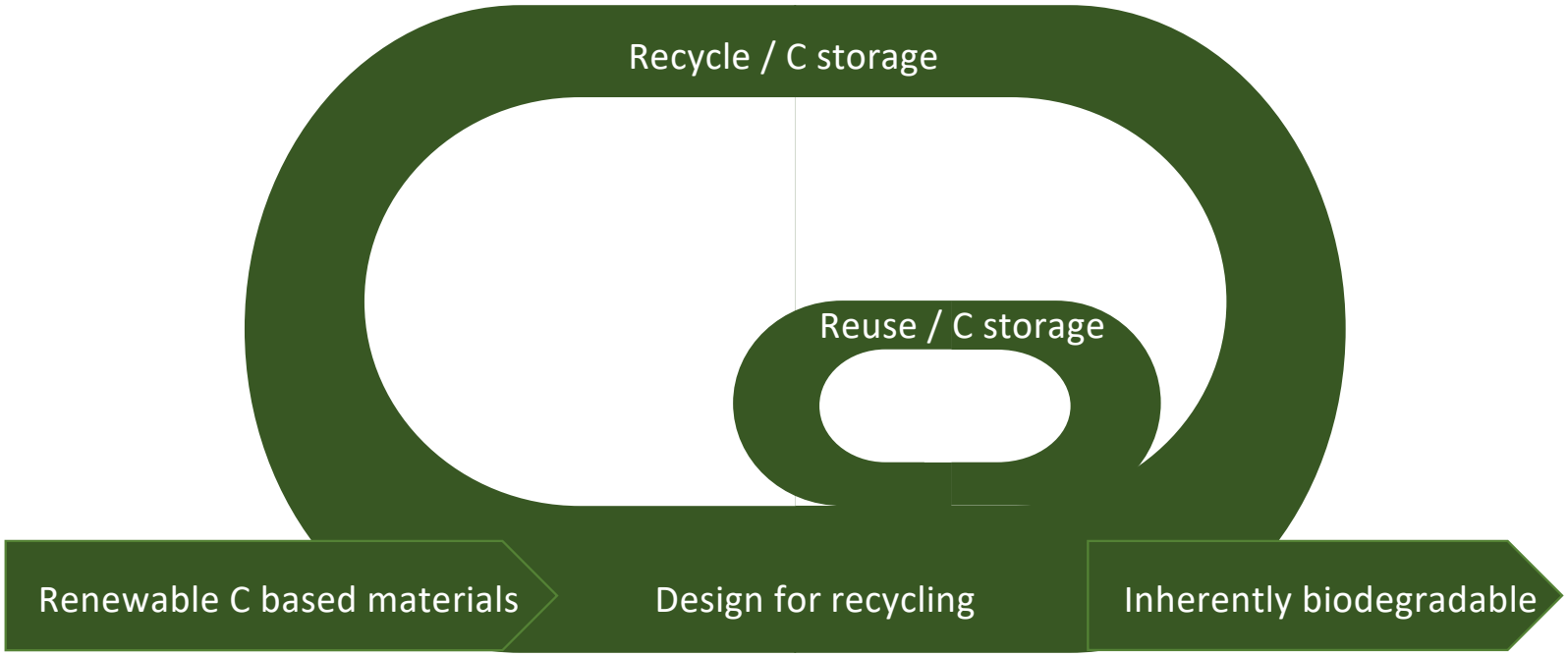
100years
1918 — 2018

Increasing innovation compexity

- Complexity, number of steps and number of stakeholders increase:
  - Materials
  - Substances/natural polymer
  - Building blocks


Materials route
Natural polymers/ substances route
Building blocks route
Board
Shelves
Textiles
Beams
Bioplastics
Paints
Biobased performance materials
Textiles
Bioplastics
Bioresins
Application production
PLA
PHA/PHB
Biopolyamides
BioPET
BioPE
Biopolyesters
Polymer production
Lactic Acid
Dialcohols
Diacids
Diamines
Chemicals / Building blocks production
Starch
Oil
Sugar
Cellulose
Lignocellulose
Oil
Starch
Sugar
Biomass substances isolation
Fibres
Grains
Pulp
Pulp
Grains
Stems, Stover
Crop parts isolation
Trees
Flax
Cotton
Beet
Oil Crops
Trees
Wheat, Maize
Trees
Beet
Oil Crops
Wheat, Maize
Feedstock production

Circular C-based materials

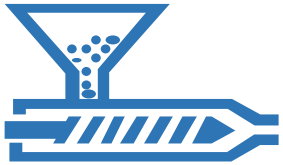


After EllenMcArthur Foundation

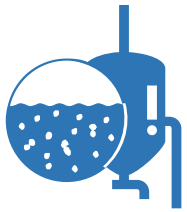
Recycling/circularity classification and methods

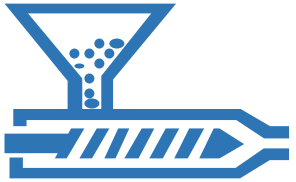
- Reuse: use the product again

- Mechanical recycling: collection, sorting, remelting/reprocessing into new product



- Chemical recycling: collection, sorting, (chemical) break-down towards the building blocks, repolymerising and reprocessing



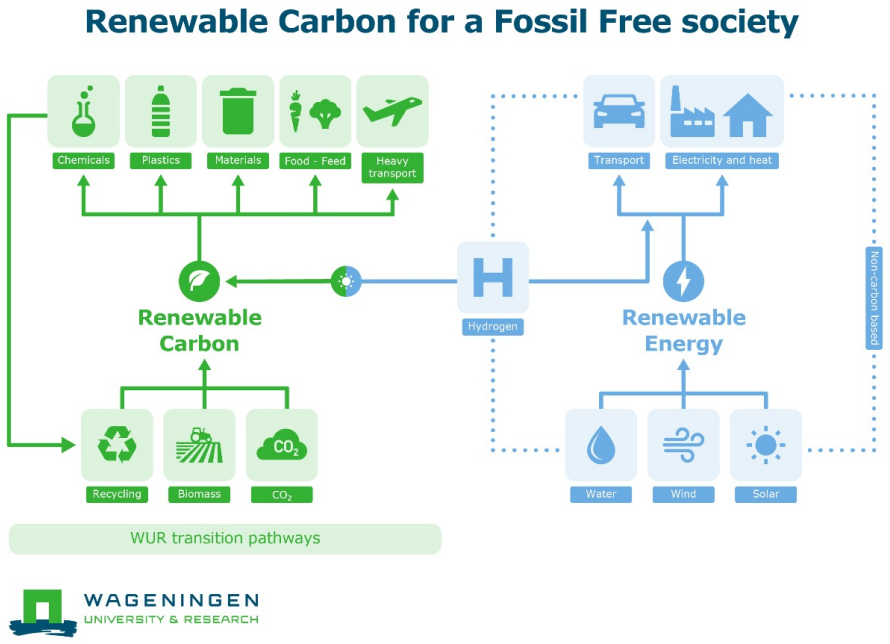


WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

Back to the renewable carbon transition

- Focussing on carbon based materials
- From a chemical/structural approach:
- How do the three transition pathways interconnect?



WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

--→ Increasing structural complexity ---→

Building blocks

WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

The *renewable carbon based materials* system

--→ Increasing structural complexity --→

Polymers

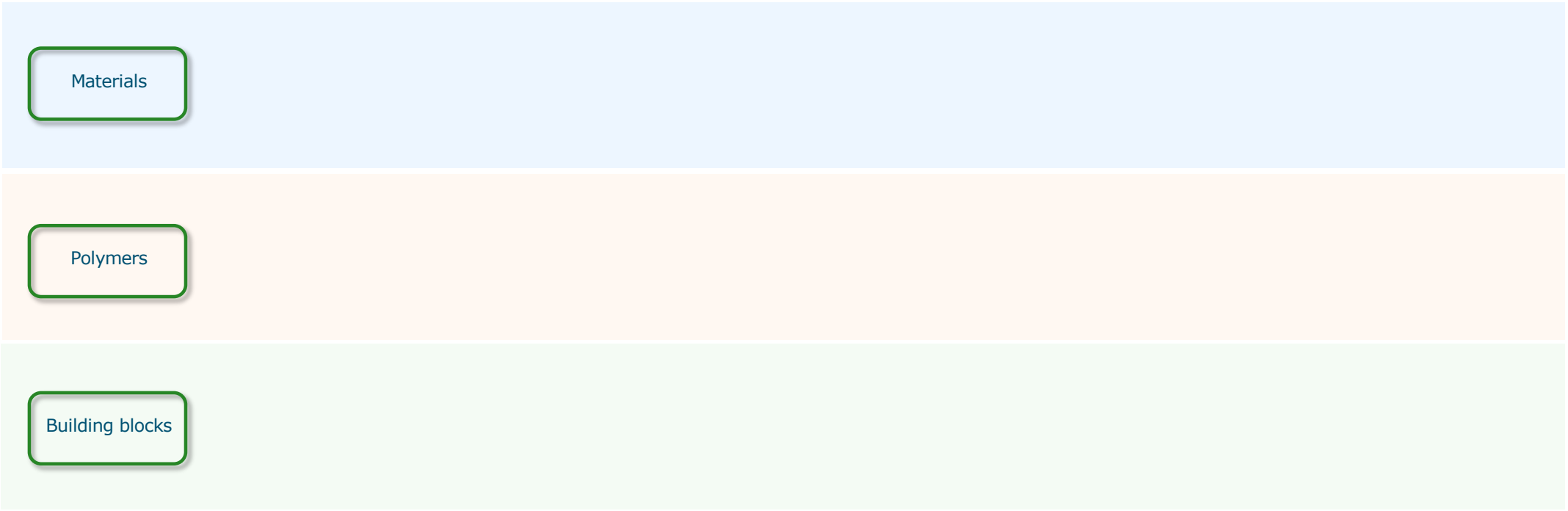
Building blocks

WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

The *renewable carbon based materials* system

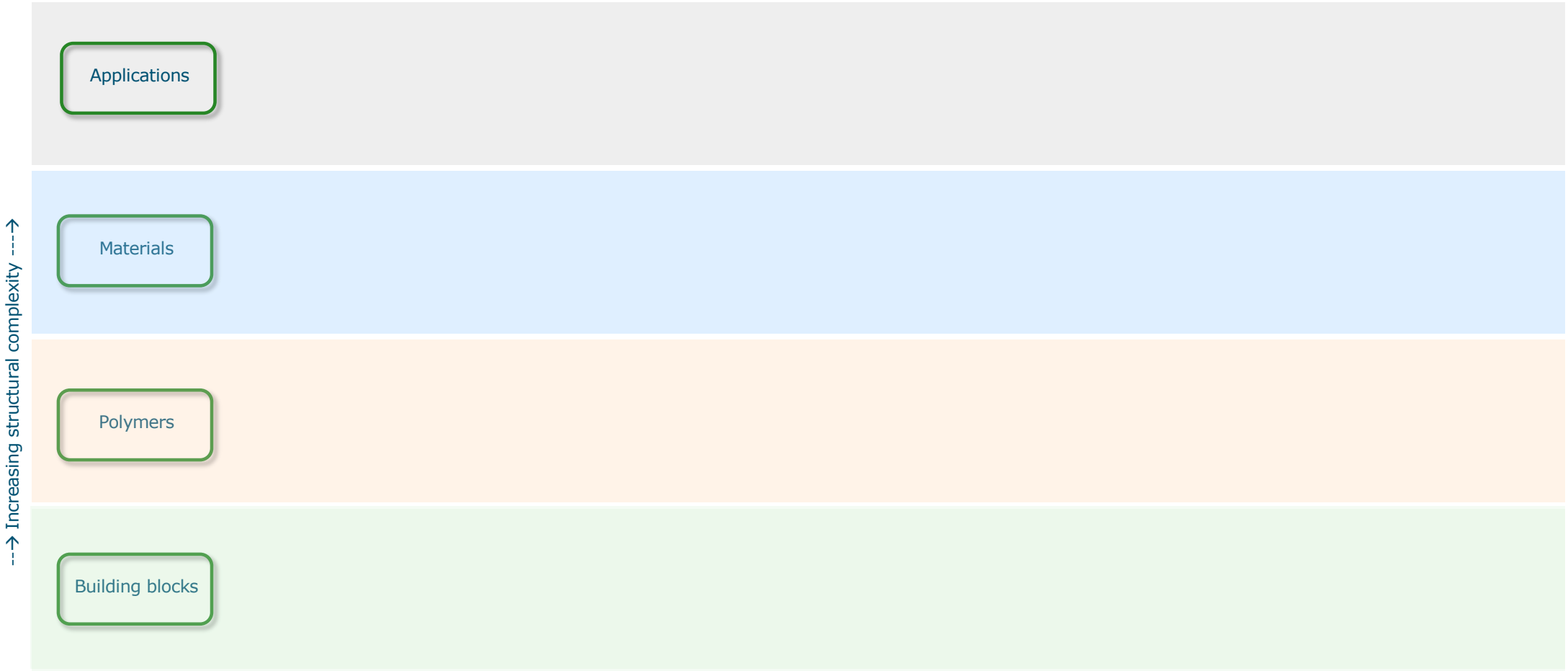
--→ Increasing structural complexity --→



WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

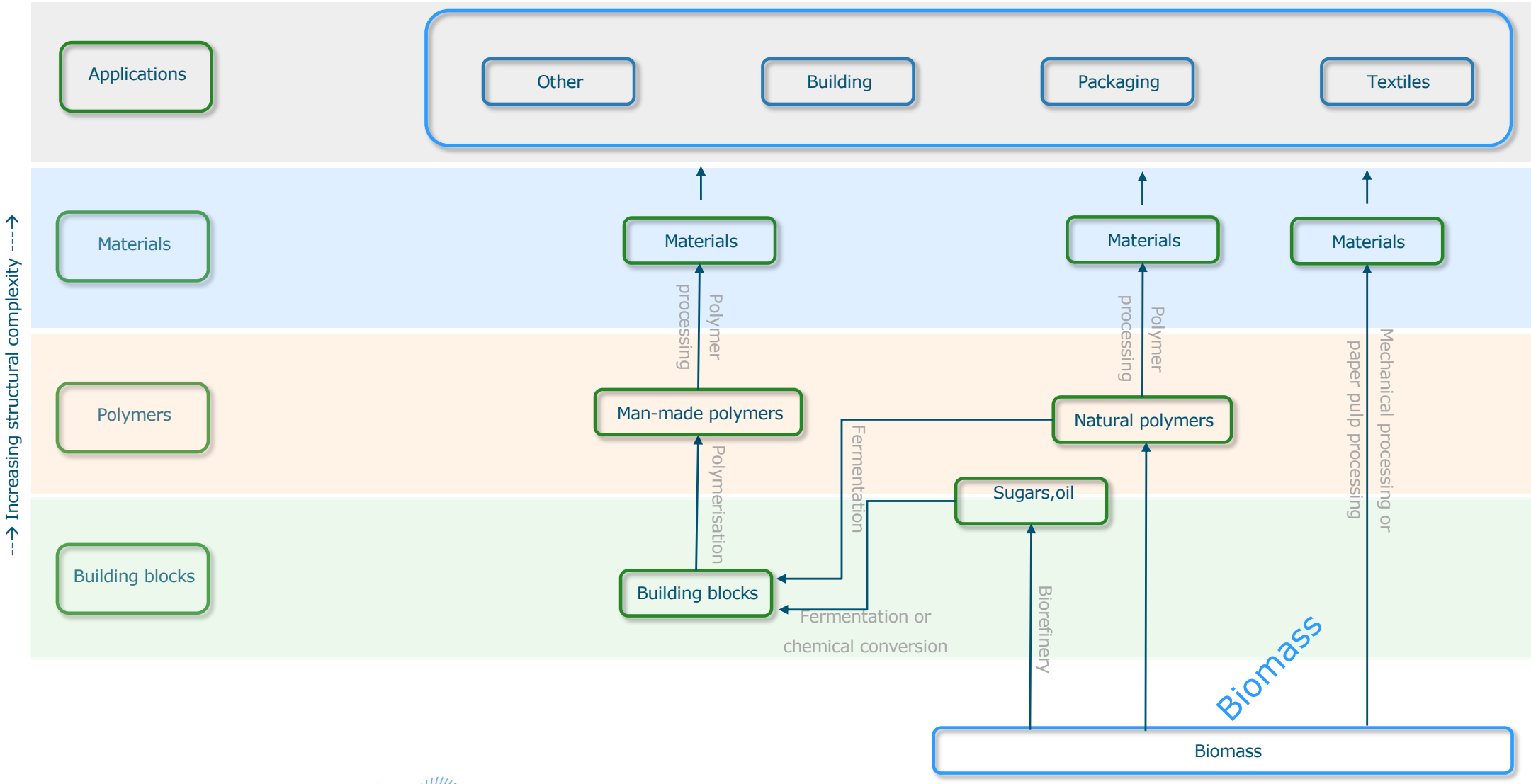
The *renewable carbon based materials* system



WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

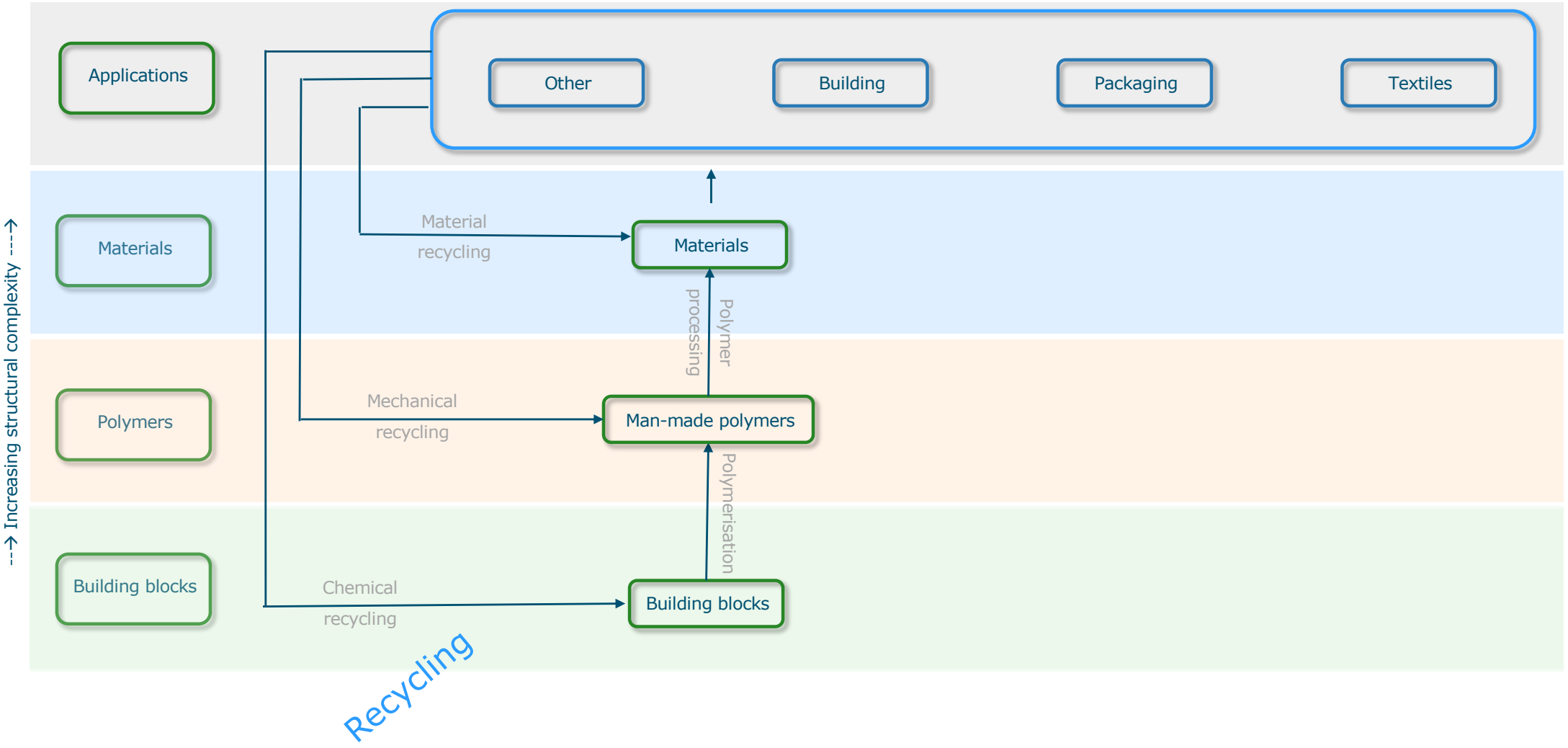
The *renewable carbon based materials* system



WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018

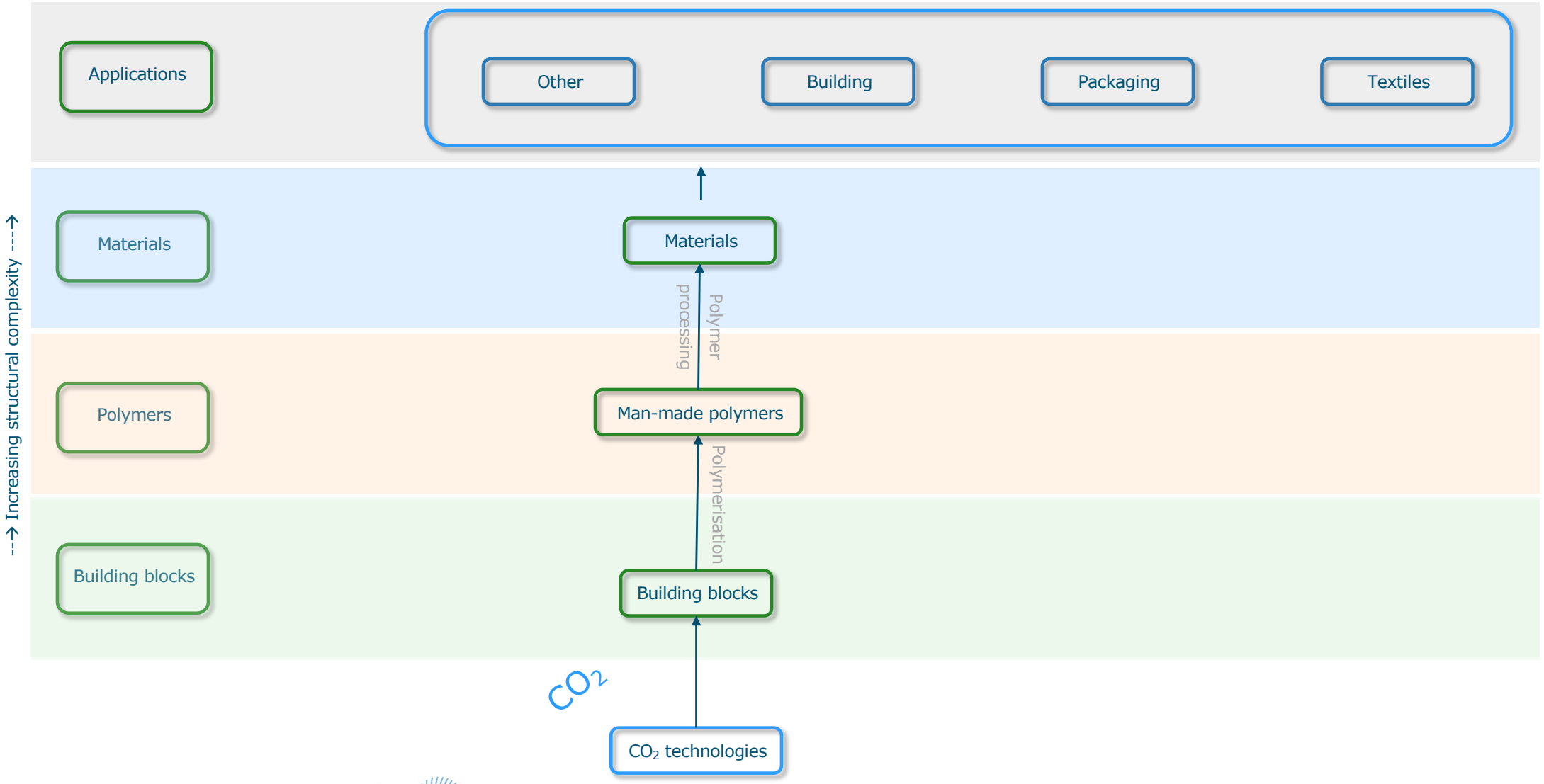
The *renewable carbon based materials* system



WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018

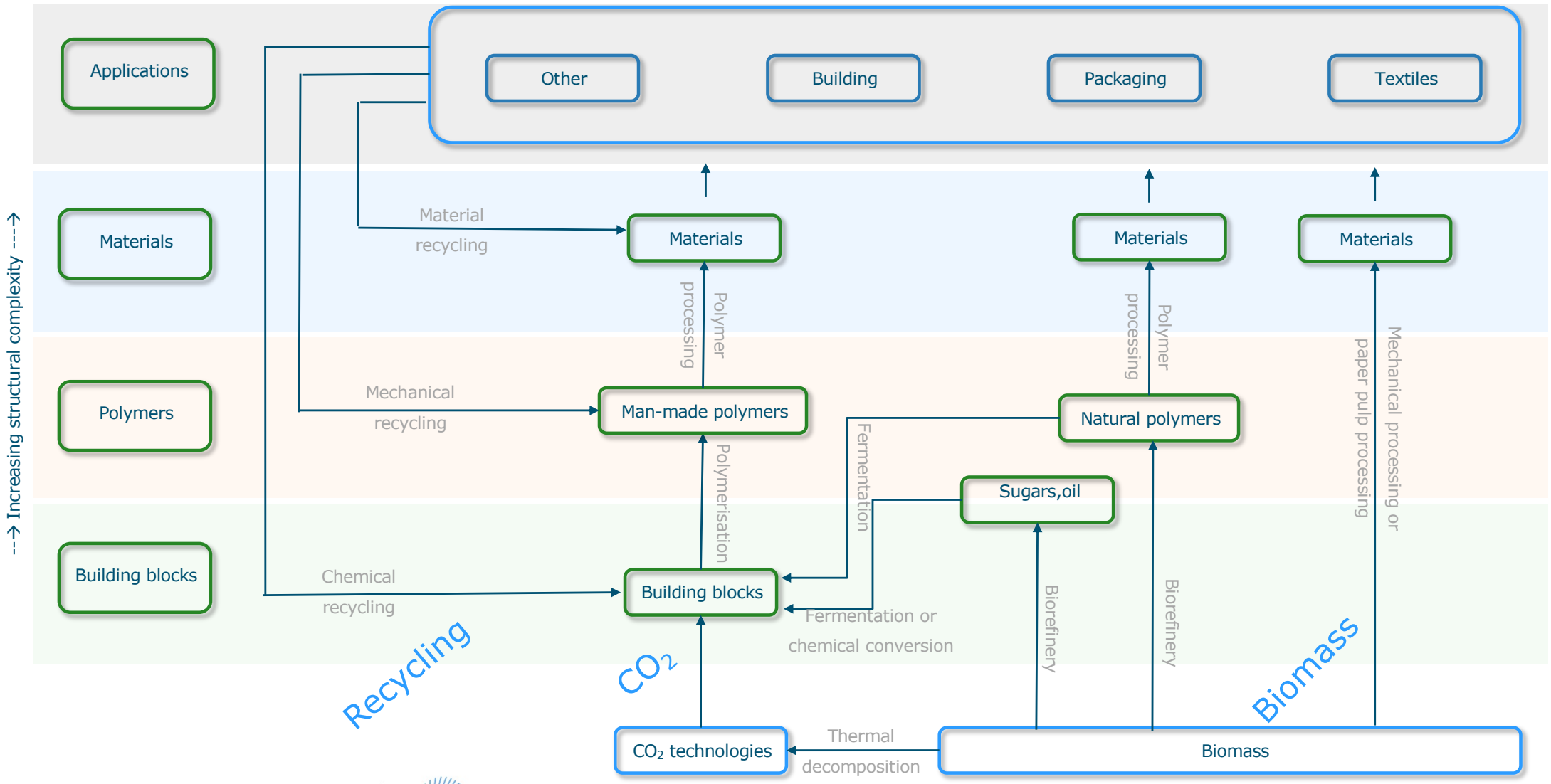
The *renewable carbon based materials* system



WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018

The *renewable carbon based materials* system



WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018

The *renewable carbon based materials* system

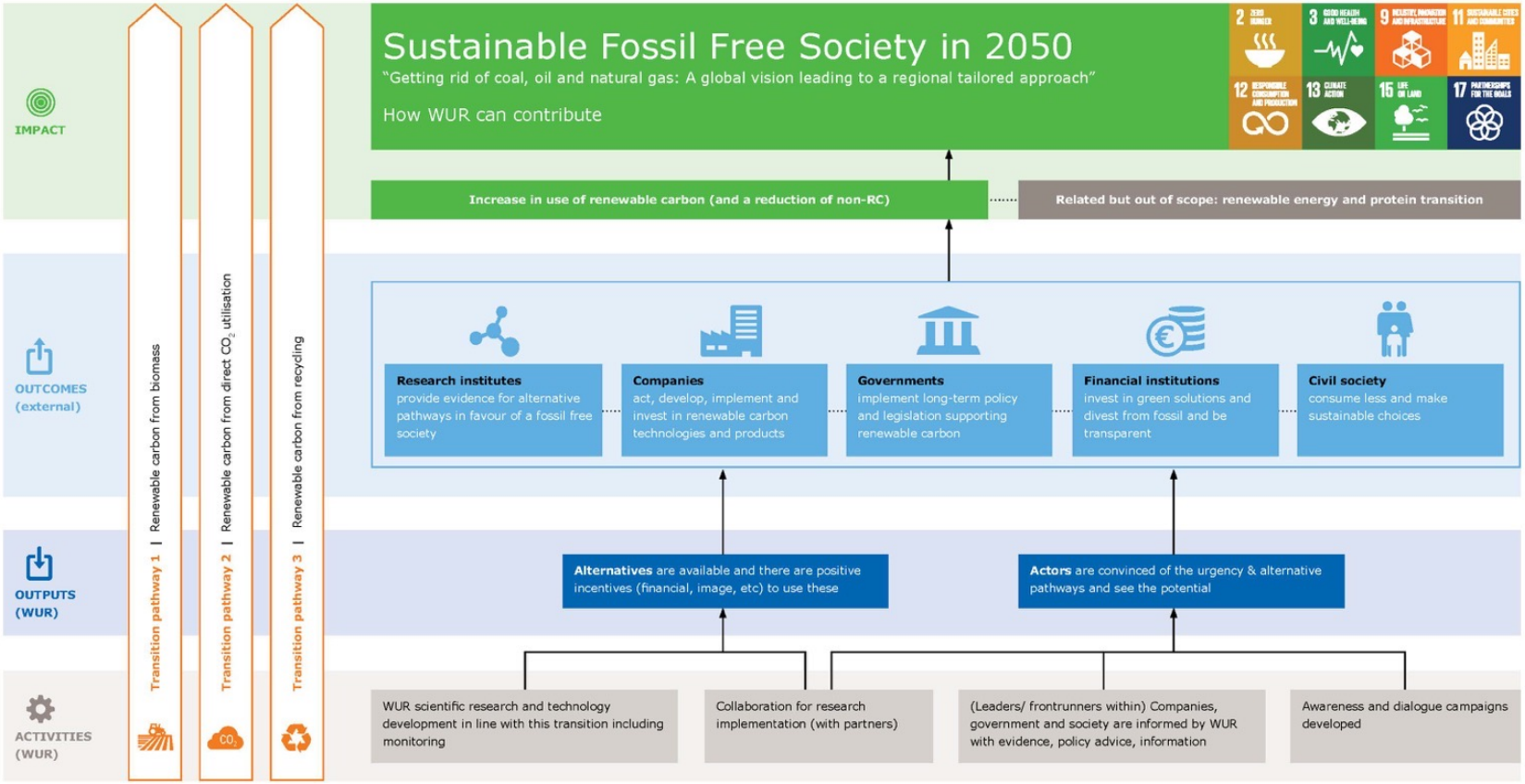
How to define the transition pathways?

Theory of Change thinking and visualisation:

- ToC is 'the description of a sequence of events that is expected to lead to a particular desired outcome' (forward thinking, forward storytelling).
- Making the ToC explicit will help to build, prove and improve ones contribution towards a Sustainable Fossil Free Society.
- A general ToC and a ToC for each of the pathways

WAGENINGEN UNIVERSITY & RESEARCH

100years 1918 — 2018



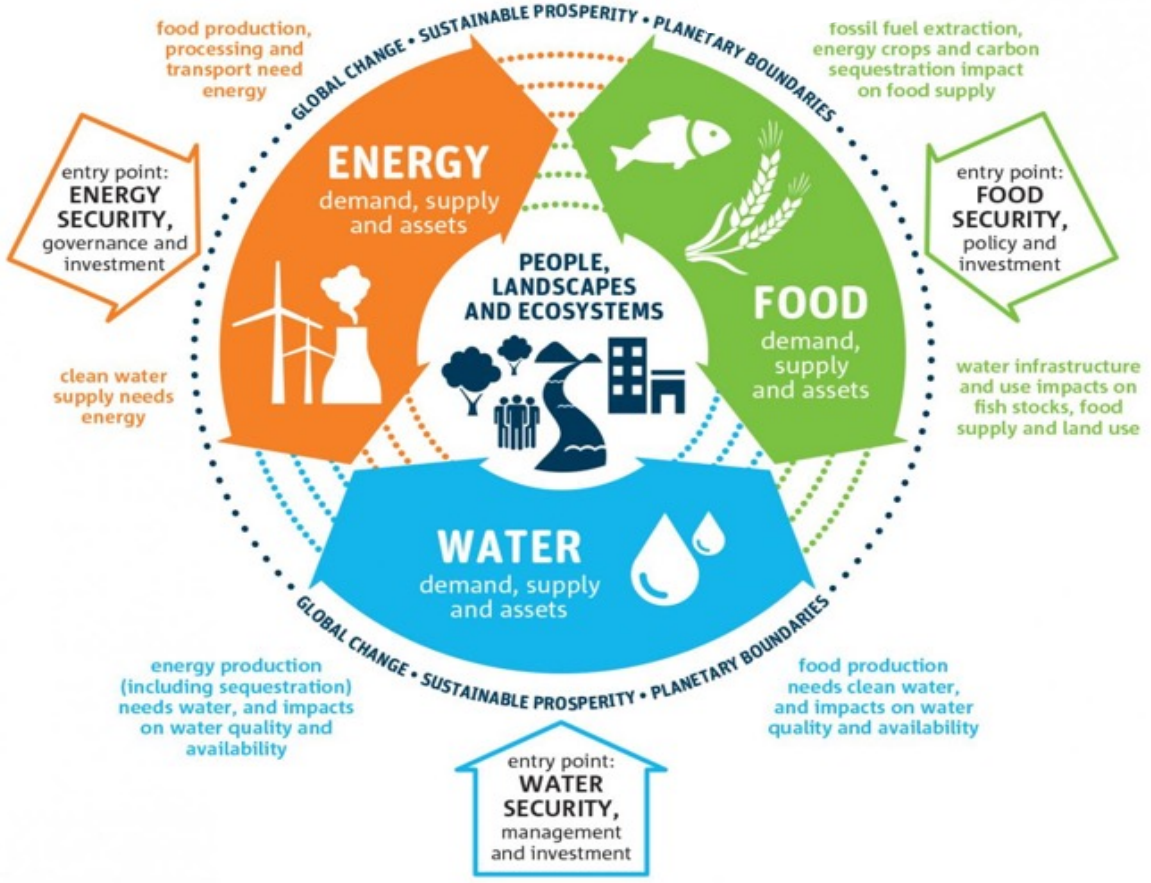
Assumptions

1 Agenda WUR aligns with agenda's of partners that are needed to make the foreseen transition.
2 The information is well understood and reaches the right people / organisations.
3 The external output is of such kind that it leads to raising awareness, dialogue and campaigns / lobby.
4 There is enough funding for the research programmes.
5 The entire WUR has incorporated this transition in their work and output.
6 There is a clear alternative pathway on which various actors can act and benefit from acting.
7 Actors have the willingness, ability, tools and resources to act on this new knowledge (resistance is overcome).
8 Market system dynamic is in favor of alternatives; Society norms and values aligns with alternatives
9 Implementation leads indeed to a sustainable fossil free society

Materials transition

Part of the greater challenge

- Additional entry point to the water food energy nexus
- Renewable carbon resource security



Source:
IWA, 2018
Sluijsmans, 2020

WAGENINGEN
UNIVERSITY & RESEARCH

100years
1918 — 2018

Perspective

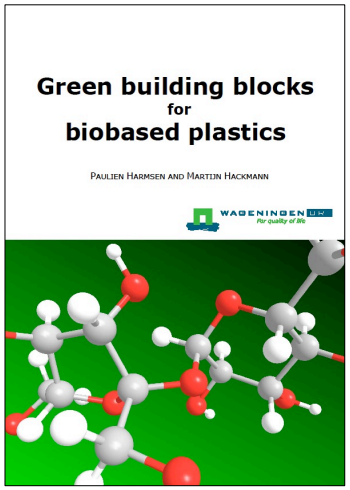
Biofpr
Biofuels Bioproducts & Biorefining

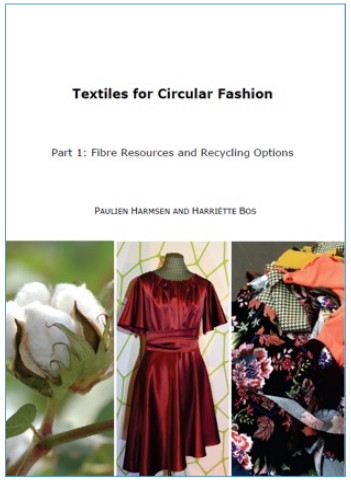
Circular bio-based production systems in the context of current biomass and fossil demand

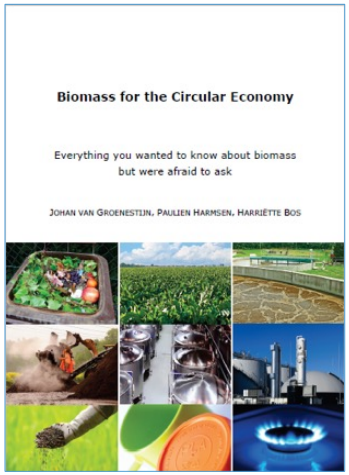
Harriëtte L. Bos, Jan Broeze, Wageningen-FBR, Wageningen, The Netherlands

**Received March 13 2019; Revised October 22 2019; Accepted December 13 2019;
View online January 20, 2020 at Wiley Online Library (wileyonlinelibrary.com);
DOI: 10.1002/bbb.2080; *Biofuels, Bioprod. Bioref.* 14:187–197 (2020)**

Abstract: In this article we explore the quantitative challenges posed by the intended circular biobased economy. To do this, we present the relative sizes, in terms of mass and energy, of the agro-food and







harriette.bos@wur.nl

www.groenegrondstoffen.nl

WAGENINGEN
UNIVERSITY & RESEARCH