Advancing the Transition to Bioeconomy: A Systems Approach
Background (What is bioeconomy? Do we all have a common vision?)

Benefits and challenges of bioeconomy

What is needed for the transition to a sustainable bioeconomy?

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Conclusions
First time widely-used definition of bioeconomy

"biotechnology offers technological solutions for many of the health and resource-based problems facing the world. The application of biotechnology to primary production, health and industry could result in an emerging bioeconomy where biotechnology contributes to a significant share of economic output”"

OECD The Bioeconomy to 2030 Designing a Policy Agenda, 2009
The EU Bioeconomy Definition

"... encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, bio-materials, bio-energy and bio-products."

EU bioeconomy strategy, 2012
"... encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, bio-materials, bio-energy and bio-products."

EU bioeconomy strategy, 2012
some examples of bio-products and energy

- corn
- wood
- algae
- organic waste

- Pharmaceuticals
- Bioplastics
- textile
- Construction material
- Bio fuel & energy

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Bioeconomy policies around the world
Different visions of bioeconomy

Bibliometric analysis of 453 scientific articles to identify the key interpretations of the bioeconomy concept

1. **A bio-technology vision** emphasises the importance of **bio-technology research and application** and commercialization of bio-technology in different sectors. **Economic growth and job creation.** Global clusters and central regions

2. **A bio-resource vision** focuses on the role of R&D related to **biological raw materials**, as well as on the **establishment of new value chains.** **Economic growth and sustainability.** Rural and peripheral regions - importance of external linkages

3. **A bio-ecology vision** highlights the importance of **ecological processes** that optimise the use of energy and nutrients, promote biodiversity and avoids monocultures and soil degradation. **Sustainability, conservation of eco-systems.** Rural and peripheral regions - development of locally embedded economies
Bioeconomy has tremendous potential for growth and substantial benefits. It may:

- address key environmental challenges;
- reduce use of fossil based raw materials —> reduced GHG emissions;
- replace non-degradable with degradable materials;
- diversify energy sources —> improved energy supply security;
- provide healthier and longer lives;
- create new “biomass” businesses —> increase the multifunctionality and scope of the agricultural and forestry sectors, new technology for processing, manufacturing of new value-added products, valorisation of waste streams etc.
- increase employment, stimulating the regional development.

In the EU:
- 13% increase in bioplastic production
- With this rate the production quadruples by 2030.
- 300 new refineries, 47 Bil. EUR investment

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Global biomass supply in 2011 by biomass constituents,
Total: 11.4 bn t dry matter

- Protein: 1.23 bn t (11%)
- Sugar/starch: 2.63 bn t (23%)
- Oils and fats: 0.51 bn t (4%)
- Others: 1.41 bn t (12%)

Cellulose: 5.62 bn t (49%)

Figure 2: Global biomass supply 2011, by biomass constituents (Source: FAO 2014; own calculations)

Global biomass demand in 2011 by sectors,
Total: 12.1 bn t dry matter

- Material use: 1.26 bn t (10%)
- Bioenergy: 1.98 bn t (16%)
- Biofuels: 0.14 bn t (1%)
- Plant-based food: 1.70 bn t (14%)
- Feed: 7.06 bn t (58%)

Figure 3: Global biomass demand 2011, by sectors (Source: FAO 2014; own calculations)

Study available at www.bio-based.eu/markets
Future Global Biomass Demand?

The trend in **increasing demand for biomass** will continue, not only as food and feed, but also as materials and fibres, and feedstock for fuel/energy production.

- **Changing consumption patterns**
- **The growing global population**

Global production of bioplastics expected to more than triple until 2019, with land requirements increasing from 1.1 to 1.4 Mio. Hectares of cropland.

Increasing demand for biofuels —> production is expected to expand rapidly to 120-180 million hectares of cropland by 2020.
Bioeconomy may also generate severe negative impacts on the environment and society:

- Conversion of ecologically fragile and valuable lands to agriculture to supply the increased demand for biomass
- Conflicts for land (land grabbing)
- Possible CO₂ emissions from such conversions

- Intensification of production in agriculture and forestry
  - Depleted and contaminated water resources,
  - Loss of biodiversity → loss of ecosystem functioning!
  - Soil degradation, decreased soil quality

- Food security, higher prices for food?

- Concerns regarding design and end-of-life management of bioplastics, with little clear standards defining their recyclability, biodegradability or compostability

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What is needed? (1)

- **a systems level redesign** of the existing economic system and the socio-ecological regime

- sustainable production of biomass. It sustains, not reduces the life support mechanism of the Earth

- valuation of natural capital and ecosystem services

- innovation - technology, business systems, product design, legal frameworks

- new institutional arrangements that can interlink independently addressed policies from a wide range of areas/sectors in the whole biomass value chain

- changes in consumption preferences

- societal acceptance, address the SDGs, paradigm shift…
What is needed? (2)

agreeing on legal frameworks, formulating policies and governmental measures, industrial investments and achieving societal acceptance are extremely complex issues in this redesigning process.

the overall system solutions requires:

- disciplinary, interdisciplinary and, most importantly, transdisciplinary research with broad stakeholder engagement and cross-sectoral collaboration from the whole biomass value chain

- strong need for a systems thinking approach and innovation

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**Environment**
- Biodiversity
- Land use change

**Economics**
- Large financing requirements for capital projects
- Food security
- Land rights

**Social**
- Public perception of GM technologies
- Varying levels of support
- Policy inconsistency

**Technology**
- Climate change agreements
- Energy obligations

**Political**
- Food security
- Land rights

**Legal**
- Biodiversity
- Land use change

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**CO₂**

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The UK’s National Centre for Biorenewable Energy, Fuels and Materials

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Overall aim is to develop the competencies necessary for participating PhD students to

adopt **systems approach** in order to identify and assess the full range of technological, economic, social and ecological challenges and opportunities in transition to a circular bioeconomy; and

lead the way in **innovative inter/trans-disciplinary research** for a sustainable circular bioeconomy in the international arena.

BIOECONOMY-GRS will act as a **collaborative learning platform** at Lund University allowing **researchers** and **Ph.Ds**, across faculties/disciplines and research areas, as well as non-academic **stakeholders** to meet with each other in order to identify, carry out and communicate innovative, analytically advanced and yet problem-oriented research for a sustainable future circular bioeconomy covering the whole biomass value chain.
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www.cec.lu.se/bioeconomy

FORMAS funded, 4 years project

The Swedish Research Council Formas
Committed to excellence in research for sustainable development

Co-funded by public/private organisations

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Cross faculty/discipline

- 3 Faculties (Natural Science - Engineering - Political Science)
- 4 Centres/Institutes (CEC, IIIEE, CIRCLE, LUCSUS)
- 5 Departments (Physical Geography & Ecosystem Science, Biology, Chemical Eng., Biotechnology, Sociology, Political Science)

- 20 PhD students each year - education/training/networking activities i.e. courses, seminars, workshops etc.

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Working methodology for an effective/efficient communication and deeper understanding

**SYSTEMS SCIENCE BASED & STAKEHOLDER PARTICIPATORY GROUP MODELLING PROCESS**

**PHASE 1: CONCEPTUAL MODELLING & SYSTEMS ANALYSIS**

- **Step 1: Definition** - problem statement, setting systems boundaries, identification of key components of the system
- **Step 2: Clarification** - in depth systems analysis of the system with Causal Loop Diagramming, where cause-effect relations, feedbacks and time delays between the system components are identified
- **Step 3: Confirmation** - test and validation of conceptual model represented by Causal Loop Diagrams

**GROUP MODELLING WORKSHOPS**
- Workshop 1
- Workshop 2
- Workshop 3
- Workshop 4

**PHASE 2: SYSTEM DYNAMICS MODELLING & INTEGRATED SCENARIO ANALYSIS**

- **Step 4: Model formulation** - conversion of Causal Loop Diagrams into a numerical dynamic model in computer environment with relevant data
- **Step 5: Model evaluation** - test and validation of the dynamic model
- **Step 6: Model implementation** - presentation of model as decision support tool for the analysis of alternative policy options under different scenarios

**GROUP MODELLING WORKSHOPS**
- Workshop 5

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Thank you for your attention!

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