



The Basis of Biomass Sustainability

Göran Berndes, IEA Bioenergy & Chalmers University, Sweden

Renewable Energy Institute event, 18 January 2024

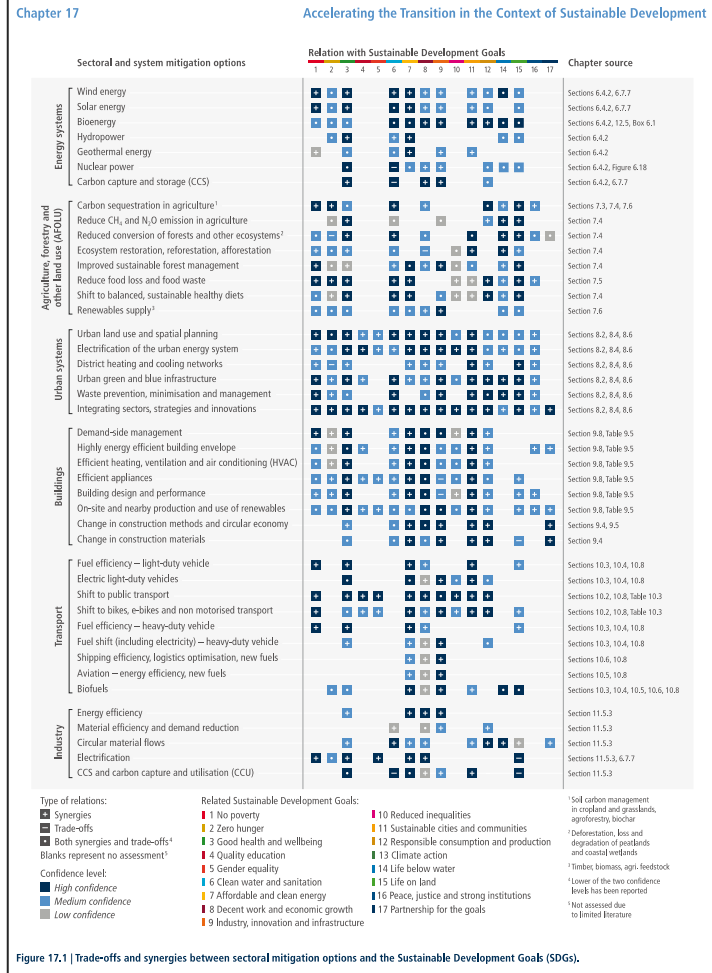
Biomass for Net Zero - Deployment in Japan in Light of Latest Global Discussions



CHALMERS

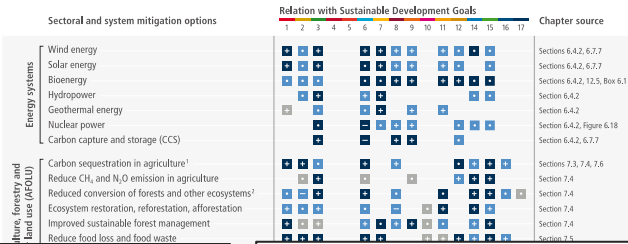
Not today...

- Bioenergy relevant in all sectors
- Multiple bioenergy-SDG linkages
- Synergies & tradeoffs
- Governance is important



Not today...

Chapter 17 Accelerating the Transition in the Context of Sustainable Development



Chapter source
 Sections 6.4.2, 6.7.7
 Sections 6.4.2, 6.7.7
 Sections 6.4.2, 12.5, Box 6.1
 Section 6.4.2
 Section 6.4.2, Figure 6.18
 Section 6.4.2, Figure 6.18
 Sections 7.3, 7.4, 7.6
 Section 7.4
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IEA Bioenergy
February 2022

How can biomass supply for bioenergy deliver multiple benefits and contribute to sustainable development goals?
 Report from Joint IEA Bioenergy and GBEP Workshop
 held online on 15 - 16 June 2021

IEA Bioenergy
February 2022

- Type of relations:
- Synergies
 - Trade-offs
 - Both synergies and trade-offs¹ (blanks represent no assessment)
- Confidence level:
- High confidence
 - Medium confidence
 - Low confidence
- Related Sustainable Development Goals:
- 1 No poverty
 - 2 Zero hunger
 - 3 Good health and wellbeing
 - 4 Quality education
 - 5 Gender equality
 - 6 Clean water and sanitation
 - 7 Affordable and clean energy
 - 8 Decent work and economic growth
 - 9 Industry, innovation and infrastructure
 - 10 Reduced inequalities
 - 11 Sustainable cities and communities
 - 12 Responsible consumption and production
 - 13 Climate action
 - 14 Life below water
 - 15 Life on land
 - 16 Peace, justice and strong institutions
 - 17 Partnership for the goals

¹ Soil carbon management in cropland and grasslands, agroforestry, biochar
² Deforestation, loss and degradation of peatlands and coastal wetlands
³ Timber, biomass, agri. feedstock
⁴ Lower of the two confidence levels has been reported
⁵ Not assessed due to limited literature

Figure 17.1 | Trade-offs and synergies between sectoral mitigation options and the Sustainable Development Goals (SDGs).

IEA Bioenergy
International Energy Agency

Approaches to sustainability compliance and verification for forest biomass
 Project report
 IEA Bioenergy, Task 45
 January 2023

Technology Collaboration Programme

land

Article

Contribution of Biomass Supply Chains for Bioenergy to Sustainable Development Goals

M. Jean Blaz, Boris Gagnon, Andrew Klein and Bjørn Kallst

Special Issue
 Edited by
 Dr. Ruediger van der Helm, Dr. Annette Grosse and Prof. Dr. Daniela Thies

MDOI

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Land use for bioenergy: Synergies and trade-offs between sustainable development goals

Irene Vera^{a,*}, Birka Wickle^a, Patrick Lamers^a, Annette Grosse^a, Anna Reppe^a, Ben Heikens^a, Carsten Zangl^b, Daniel Mayer^c, Esther Ranka^d, Francesco Cherubini^e, Christa Berner^f, Henrike Jäger^g, Luis Sebastian^h, Martin Jungingerⁱ, Miguel Brandão^j, Nidien Scott Besten^k, Vanessa Domingos^l, Jozsef Hertz^m, Flor van der Walⁿ

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ABSTRACT
 Bioenergy offers a unique combination of GHG reduction and potential in providing global climate change mitigation. Assessing the sustainability of biomass production and conversion is a key challenge for bioenergy. This paper reviews the literature on the sustainability of biomass production and conversion, and identifies the key trade-offs and synergies between bioenergy production and conversion. The paper highlights the need for a holistic approach to bioenergy sustainability, taking into account the entire value chain from land use to end-use. The paper also discusses the role of policy in promoting sustainable bioenergy production and conversion.

IINAS
International Institute for Sustainable Innovation and Strategy

GBEP
Global Bioenergy Partnership

Sustainability governance of bioenergy and the broader bioeconomy

Technical Paper prepared for IEA Bioenergy Task 45 and the Global Bioenergy Partnership (GBEP) Task Force on Sustainability

Final draft

prepared by
 Leini Harju, Uwe R. Fritsche & Joha van Dam
 IINAS - International Institute for Sustainability Analysis and Strategy

Prepared with funding from the German Ministry for Food and Agriculture (BMEL) and IEA Bioenergy Task 45

Pamplona, Darmstadt & Utrecht, August 2021

Today...

Biomass, carbon cycle, and climate

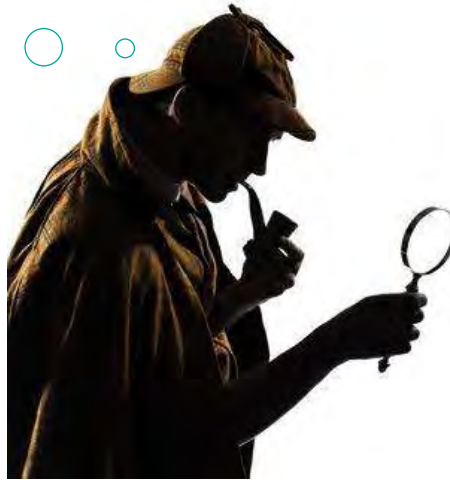


Beneficial land use change



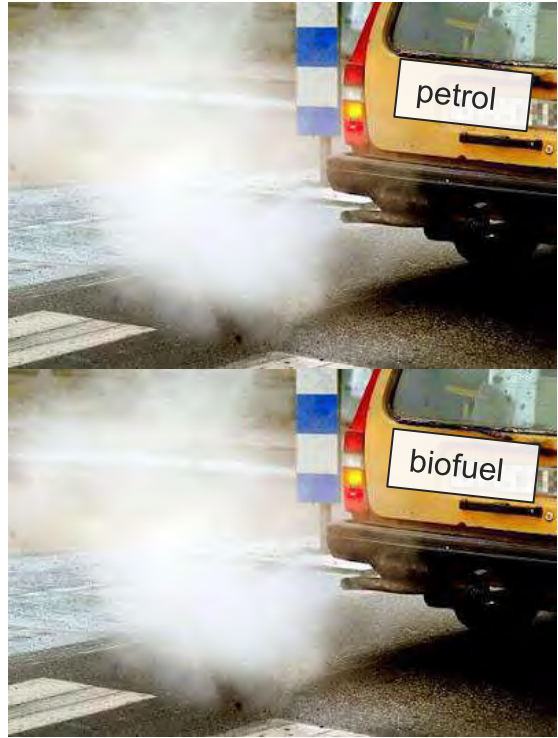
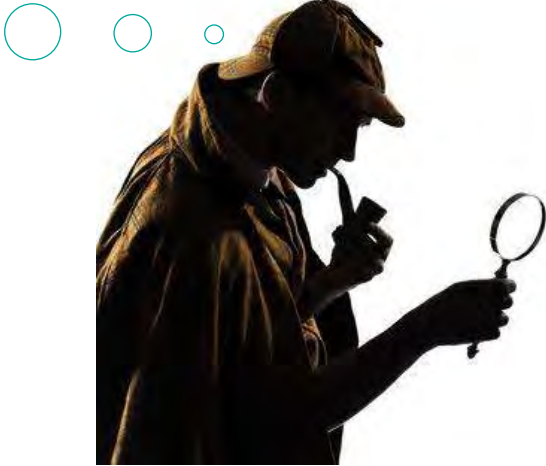
Biomass, carbon cycle, and climate

~~I don't see any
difference... both cars
emit CO₂ that warms the
world...~~



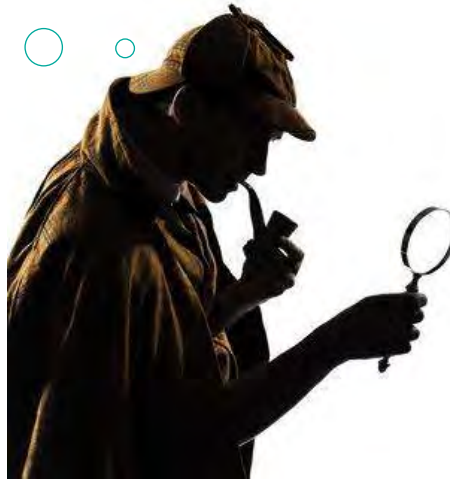
Biomass, carbon cycle, and climate

~~Besides for supply chain emissions biofuel use does not contribute to climate change since the emitted CO₂ was previously removed from the atmosphere...~~



Biomass, carbon cycle, and climate

~~Biofuel use causes huge CO₂ emissions because of the carbon opportunity cost...~~



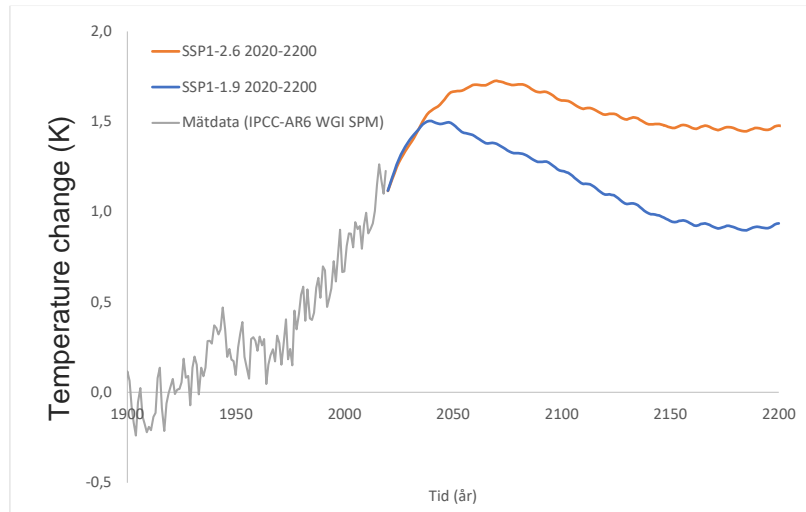
Illustration

The next few slides show how the use of fossil fuels and bio-based fuels affects the global average temperature

Focus is on the fossil/biogenic carbon in the fuels

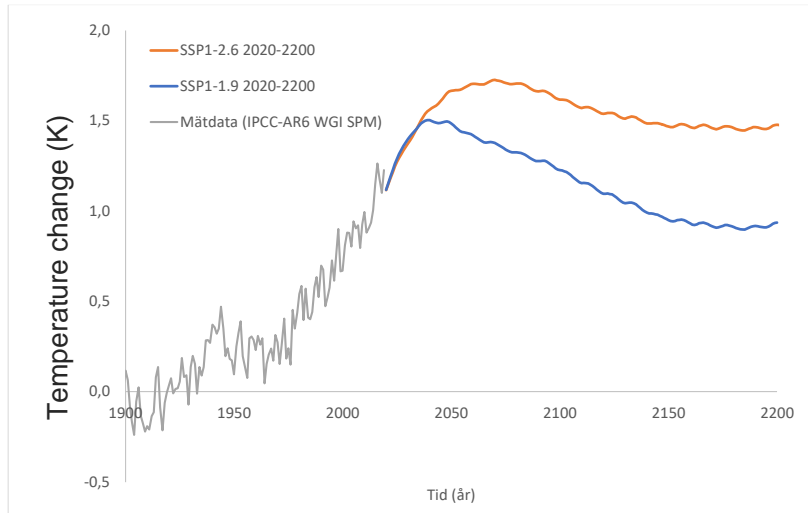
The diagram below shows how the global average temperature changes over time in the IPCC scenarios SSP1-1.9 and SSP1-2.6 that were used for climate modelling and research associated with the sixth IPCC assessment report.

These IPCC scenarios are used in this illustration of the temperature impacts of using fossil fuels and bioenergy.



QUESTION:

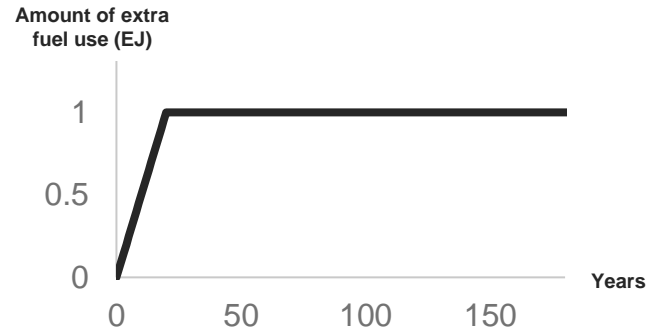
How will the global average temperature deviate from the development that is shown in the diagram, when some extra fuels are used?



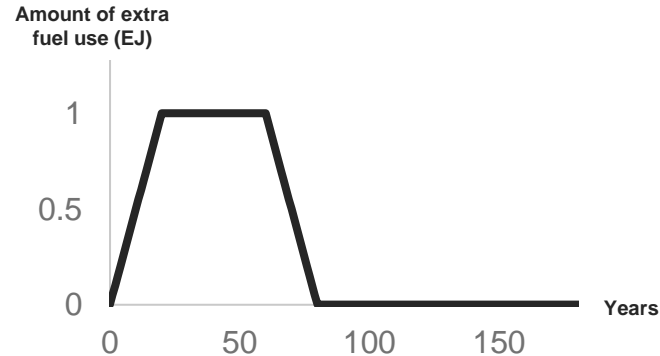
TWO SCENARIOS, SHOWN BELOW

The extra fuel is either coal, fossil gas, or bio-based fuels obtained from forests managed for production of (primarily) sawtimber and pulpwood.

More fuel use “forever”



More fuel use “for a while”



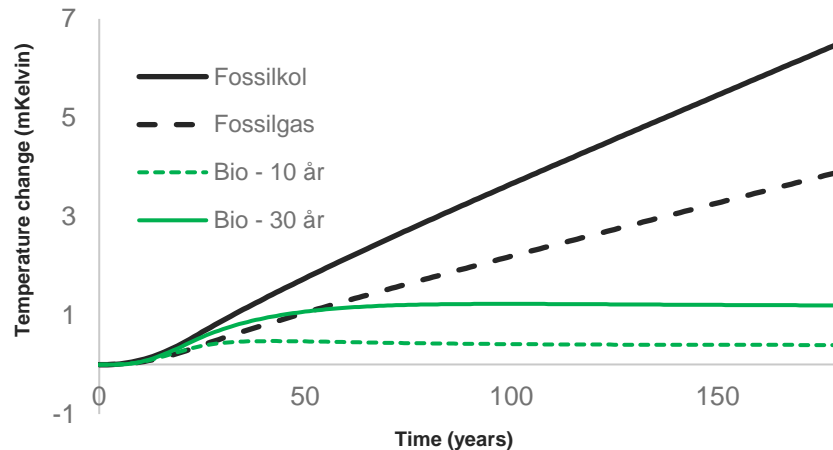
The bio-based fuels are produced from:

- forest residues that would decompose in the forest within 10 or 30 years if not used for energy
- wood that would otherwise be used for producing other products with 10- or 30-year residence time in society

No other changes in the forest sector besides this increased forest biomass use for energy



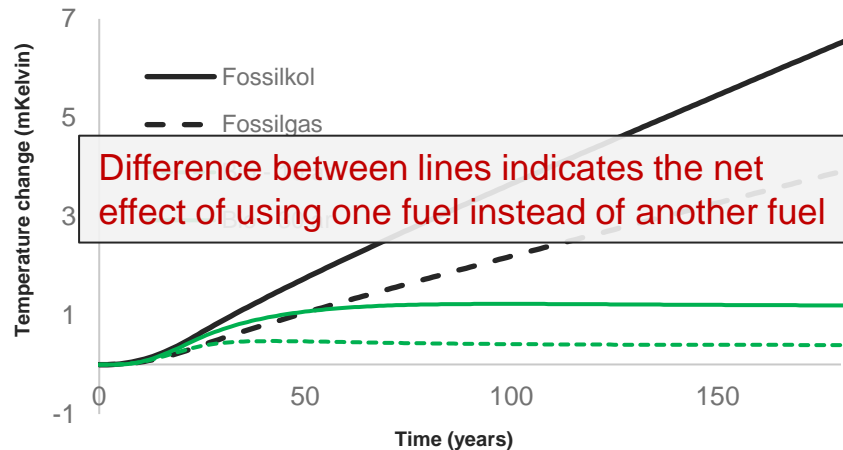
Temperature impact of using more fuel “forever”



For fossil fuels, there is a temperature increase that is linearly related to the cumulative CO₂ emissions from chimneys and exhaust pipes

This is not the case for biobased fuels. Instead, the temperature impact stabilises at a level that is determined by what type of biomass is used

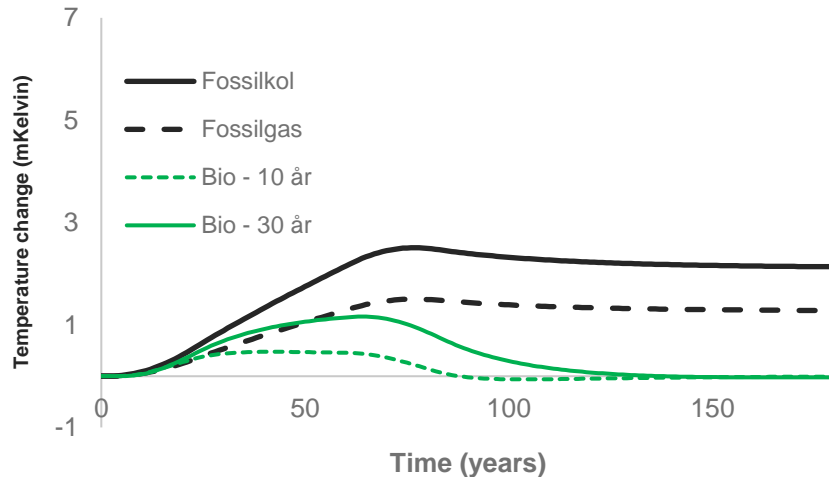
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For fossil fuels, there is a temperature increase that is linearly related to the cumulative CO₂ emissions from chimneys and exhaust pipes

This is not the case for biobased fuels. Instead, the temperature impact stabilises at a level that is determined by what type of biomass is used

Temperature impact of using more fuel “for a while”

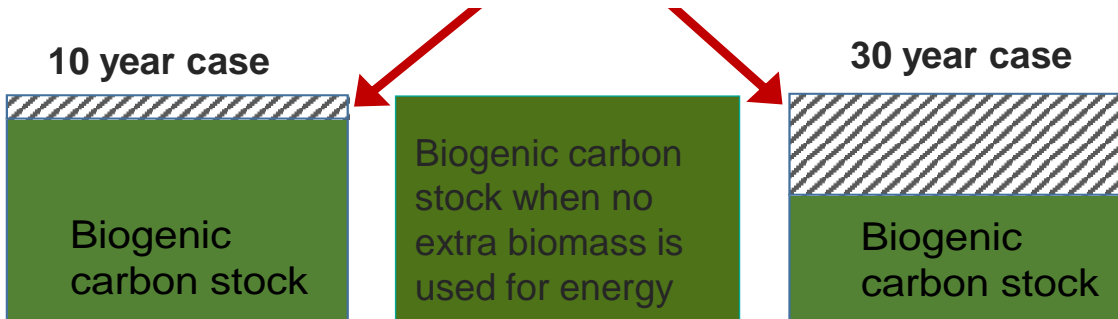


The temperature impact from fossil fuel use remains a long time after the fuel use has ended

For biobased fuels, the temperature impact declines towards zero after the fuel use has ended

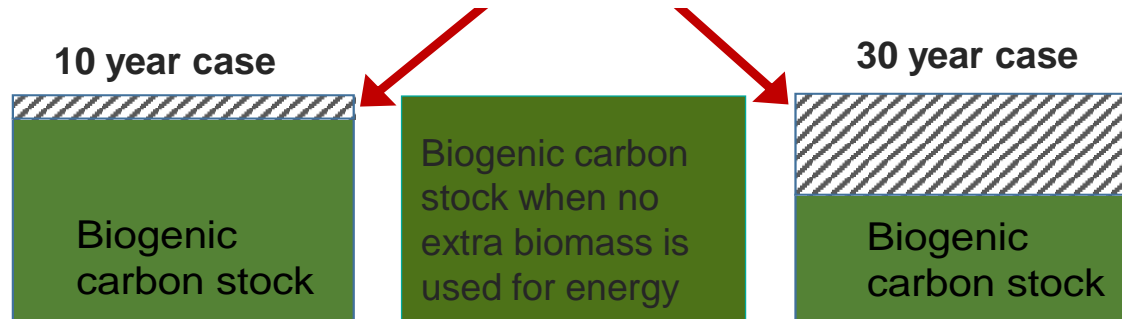
The temperature impact is determined by the change in carbon storage in soils and vegetation, and in biobased products, which depends on what type of biomass is used to produce the fuels

Dashed = biogenic carbon that ends up as CO₂ in the atmosphere



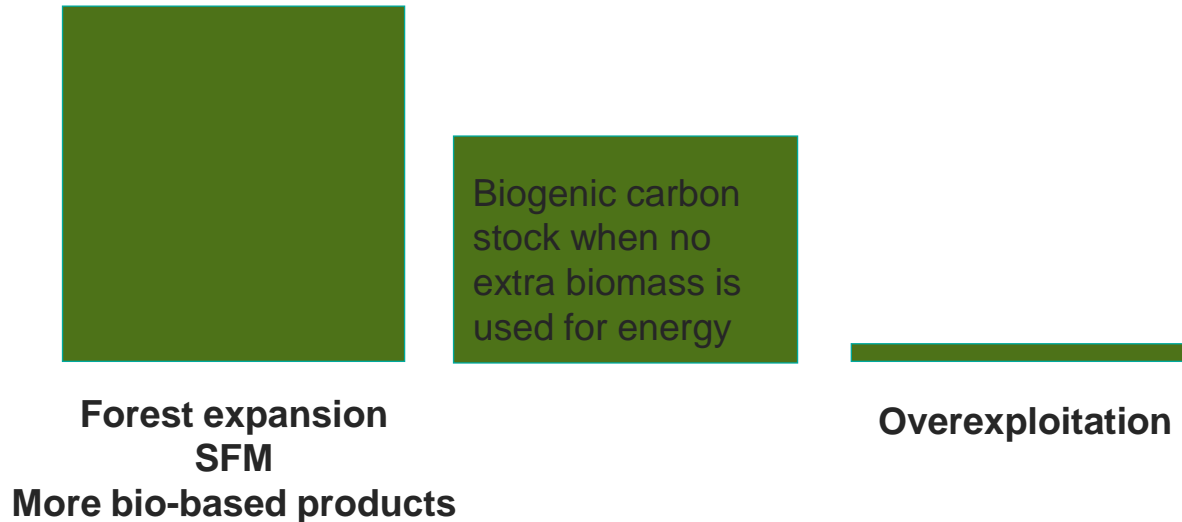
We assumed that there were no other changes in the forest sector besides the increased forest biomass use for energy

Dashed = biogenic carbon that ends up as CO₂ in the atmosphere



We assumed that there were no other changes in the forest sector besides the increased forest biomass use for energy

But the forest sector may change also in other ways



Biomass, carbon cycle, and climate



- Bioenergy's supply-chain emissions can be reduced a lot but **biogenic carbon balance will remain critical determinant of the climate benefit**
- **Carbon storage** in vegetation, soils and bio-based products **can both increase and decrease** when the land sectors change to provide more biomass for energy
- Much confusion around biomass, carbon cycle, and climate: important to explain matters and **dispel misconceptions**

If there is still time...

Biomass, carbon cycle, and climate



Beneficial land use change



Beneficial land use change

Global Environmental Change

Beneficial land use change: Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture

Other Epublink¹, Pål Björnsjö², Göran Bonner³, Nicolle Scarlat⁴, José-Francisco Fontúrbel⁵, Brian Glendon⁶, Anders Östlund⁷, Elia Mola-Velazquez⁸, Fernando J. Díaz⁹

Abstract

Beneficial land use change (LUC) is a key element for the EU Green Deal. This study assesses the potential of LUC to reduce environmental impacts from EU agriculture. We evaluate the impact of expanding biomass plantations on agricultural land, focusing on nitrogen (N) and phosphorus (P) cycles. Our results show that strategic expansion of biomass plantations can significantly reduce N and P losses from agricultural land, leading to improved water quality and reduced greenhouse gas emissions. This LUC strategy is particularly beneficial in regions with high agricultural intensity and high N and P losses. Our findings suggest that LUC can be a key tool for reducing the environmental footprint of EU agriculture.

1. Introduction

The expansion of food crops has been a powerful driver of global land use change in the last century, resulting in a significant loss of natural habitats and biodiversity. This loss has led to a decline in ecosystem services, such as carbon sequestration, water regulation, and soil fertility. The expansion of biomass plantations, on the other hand, can provide a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. This study evaluates the potential of LUC to reduce environmental impacts from EU agriculture.

Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy

Oskar Englund¹, Elia Mola-Velazquez², Pål Björnsjö³, Christel Cederberg⁴, Joana Dimitrakou⁵, Nicolle Scarlat⁶, Göran Bonner⁷

Abstract

The agricultural sector can contribute to climate change mitigation by reducing its greenhouse gas (GHG) emissions, improving carbon sequestration in soils, and providing biomass to substitute for fossil fuels and other GHG-intensive products. The current use of grass in crop rotations is limited, and its potential is not fully realized. This study evaluates the potential of large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy. We assess the impact of grass on GHG emissions, soil carbon sequestration, and biomass production. Our results show that large-scale deployment of grass in crop rotations can significantly reduce GHG emissions, increase soil carbon sequestration, and provide biomass for energy and other products. This strategy is particularly beneficial in regions with high agricultural intensity and high GHG emissions. Our findings suggest that large-scale deployment of grass in crop rotations can be a key tool for reducing the environmental footprint of EU agriculture.

1. Introduction

The agricultural sector is a major source of greenhouse gas (GHG) emissions, contributing to climate change. The expansion of grass in crop rotations can provide a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. This study evaluates the potential of large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy.

communications earth & environment

Strategic deployment of riparian buffers and windbreaks in Europe can co-deliver biomass and environmental benefits

Oskar Englund¹, Pål Björnsjö², Elia Mola-Velazquez³, Göran Bonner⁴, Joana Dimitrakou⁵, Christel Cederberg⁶, Nicolle Scarlat⁷

Abstract

Riparian buffers and windbreaks are important features of the European landscape, providing a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. The current use of riparian buffers and windbreaks is limited, and their potential is not fully realized. This study evaluates the potential of strategic deployment of riparian buffers and windbreaks in Europe as a multifunctional climate mitigation strategy. We assess the impact of riparian buffers and windbreaks on GHG emissions, soil carbon sequestration, and biomass production. Our results show that strategic deployment of riparian buffers and windbreaks can significantly reduce GHG emissions, increase soil carbon sequestration, and provide biomass for energy and other products. This strategy is particularly beneficial in regions with high agricultural intensity and high GHG emissions. Our findings suggest that strategic deployment of riparian buffers and windbreaks can be a key tool for reducing the environmental footprint of EU agriculture.

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Riparian buffers and windbreaks are important features of the European landscape, providing a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. This study evaluates the potential of strategic deployment of riparian buffers and windbreaks in Europe as a multifunctional climate mitigation strategy.

Land conversion from annual to perennial crops: A win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration

Ji Chen¹, Paul Erik Larue², Ulte Jørgensen³

Abstract

Land conversion from annual to perennial crops can provide a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. The current use of land conversion is limited, and its potential is not fully realized. This study evaluates the potential of land conversion from annual to perennial crops as a win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration. We assess the impact of land conversion on GHG emissions, soil carbon sequestration, and biomass production. Our results show that land conversion from annual to perennial crops can significantly reduce GHG emissions, increase soil carbon sequestration, and provide biomass for energy and other products. This strategy is particularly beneficial in regions with high agricultural intensity and high GHG emissions. Our findings suggest that land conversion from annual to perennial crops can be a key tool for reducing the environmental footprint of EU agriculture.

1. Introduction

Land conversion from annual to perennial crops can provide a range of ecosystem services, including carbon sequestration, water regulation, and soil fertility. This study evaluates the potential of land conversion from annual to perennial crops as a win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration.

Original Article

Towards multifunctional landscapes coupling low carbon feed and bioenergy production with restorative agriculture: Economic deployment of grass-based bioenergies

Julien Van den Broek¹, Elia Mola-Velazquez², Pål Björnsjö³, Christel Cederberg⁴, Joana Dimitrakou⁵, Nicolle Scarlat⁶, Göran Bonner⁷

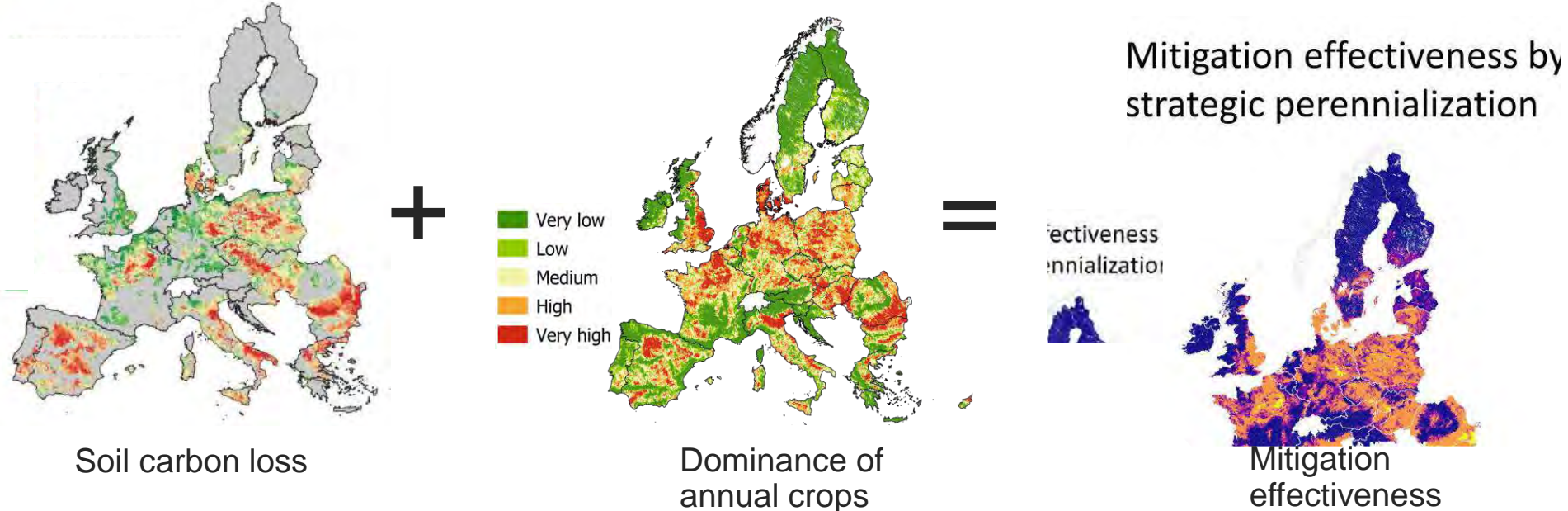
Abstract

The agricultural sector can contribute to climate change mitigation by reducing its greenhouse gas (GHG) emissions, improving carbon sequestration in soils, and providing biomass to substitute for fossil fuels and other GHG-intensive products. The current use of grass in crop rotations is limited, and its potential is not fully realized. This study evaluates the potential of large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy. We assess the impact of grass on GHG emissions, soil carbon sequestration, and biomass production. Our results show that large-scale deployment of grass in crop rotations can significantly reduce GHG emissions, increase soil carbon sequestration, and provide biomass for energy and other products. This strategy is particularly beneficial in regions with high agricultural intensity and high GHG emissions. Our findings suggest that large-scale deployment of grass in crop rotations can be a key tool for reducing the environmental footprint of EU agriculture.

1. Introduction

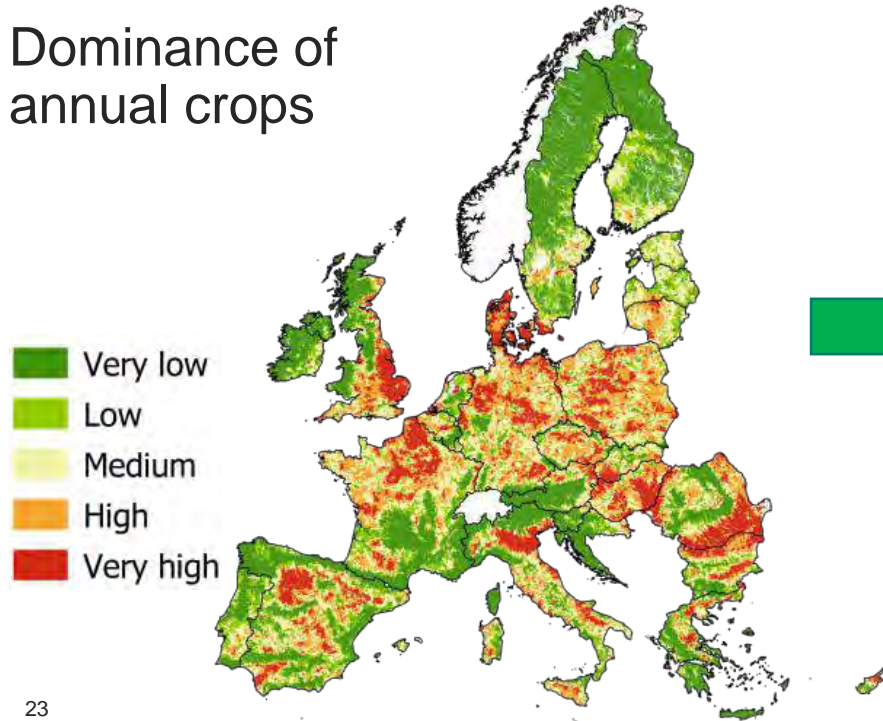
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Strategic integration of perennials

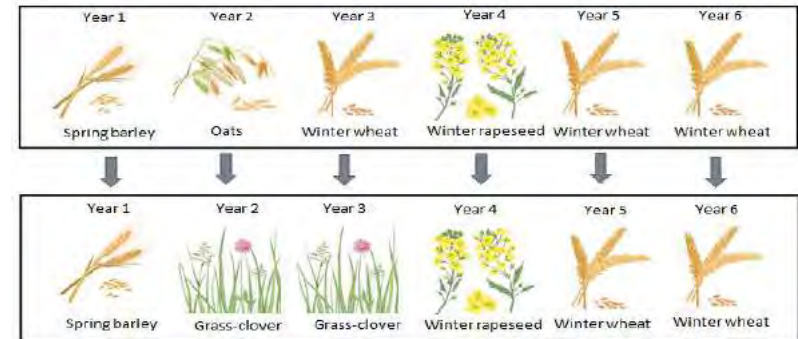


Strategic integration of perennials

Dominance of annual crops



Adjusted crop rotations

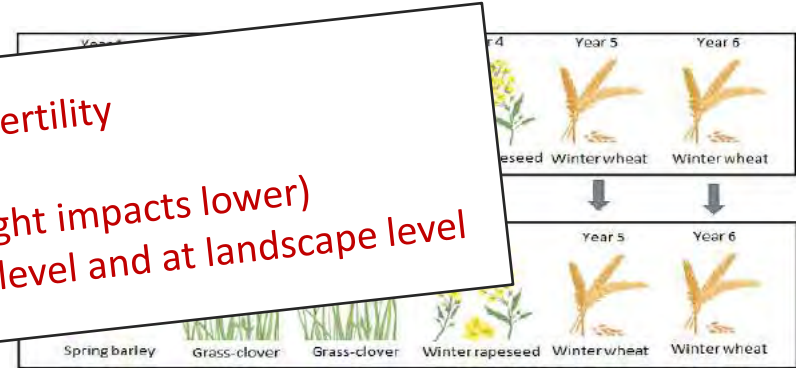
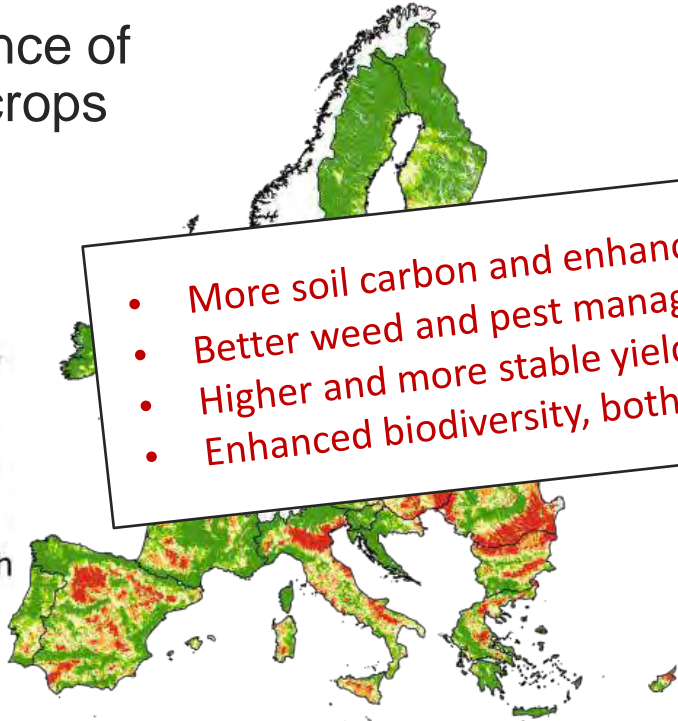


Strategic integration of perennials

Dominance of annual crops

Adjusted crop rotations

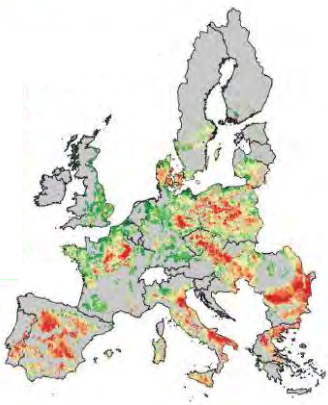
- More soil carbon and enhanced soil fertility
- Better weed and pest management
- Higher and more stable yields (drought impacts lower)
- Enhanced biodiversity, both at field level and at landscape level



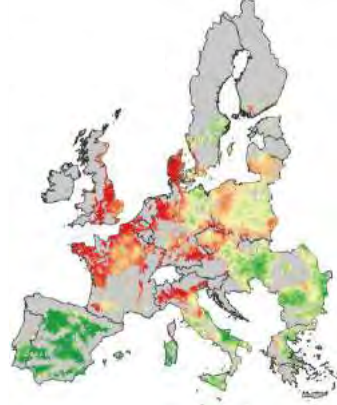
Strategic integration of perennials

Highest impact

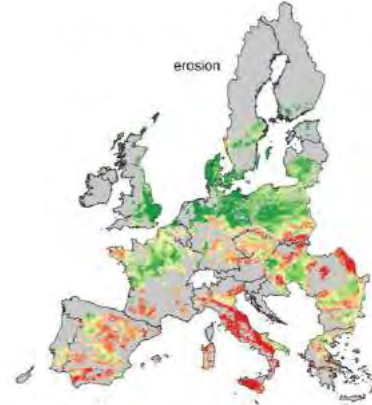
Lowest impact



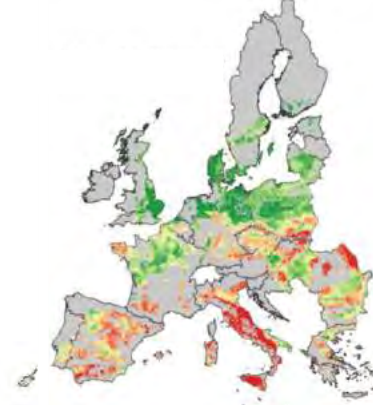
Soil carbon loss



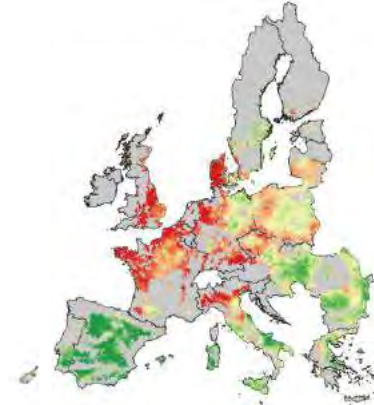
N emissions
to water



Recurring
floods



Water erosion



Wind erosion



The Basis of Biomass Sustainability

Thank you for listening!

Göran Berndes, IEA Bioenergy & Chalmers University, Sweden

Renewable Energy Institute event, 18 January 2024

Biomass for Net Zero - Deployment in Japan in Light of Latest Global Discussions

References

On slide 3

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Additional:

Cowie, A. L., et al., 2021. Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy, *GCB-Bioenergy*, pp. 1210-1231.

On slide 21

Englund, O., et al., 2020. Beneficial land use change: Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture. *Global Environmental Change*, 60, 101990.

Englund, O., et al., 2022. Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy. *GCB Bioenergy*, 15(2), pp.166-184.

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