

Land, climate and global development pathways: implications for biofuels and the bioeconomy

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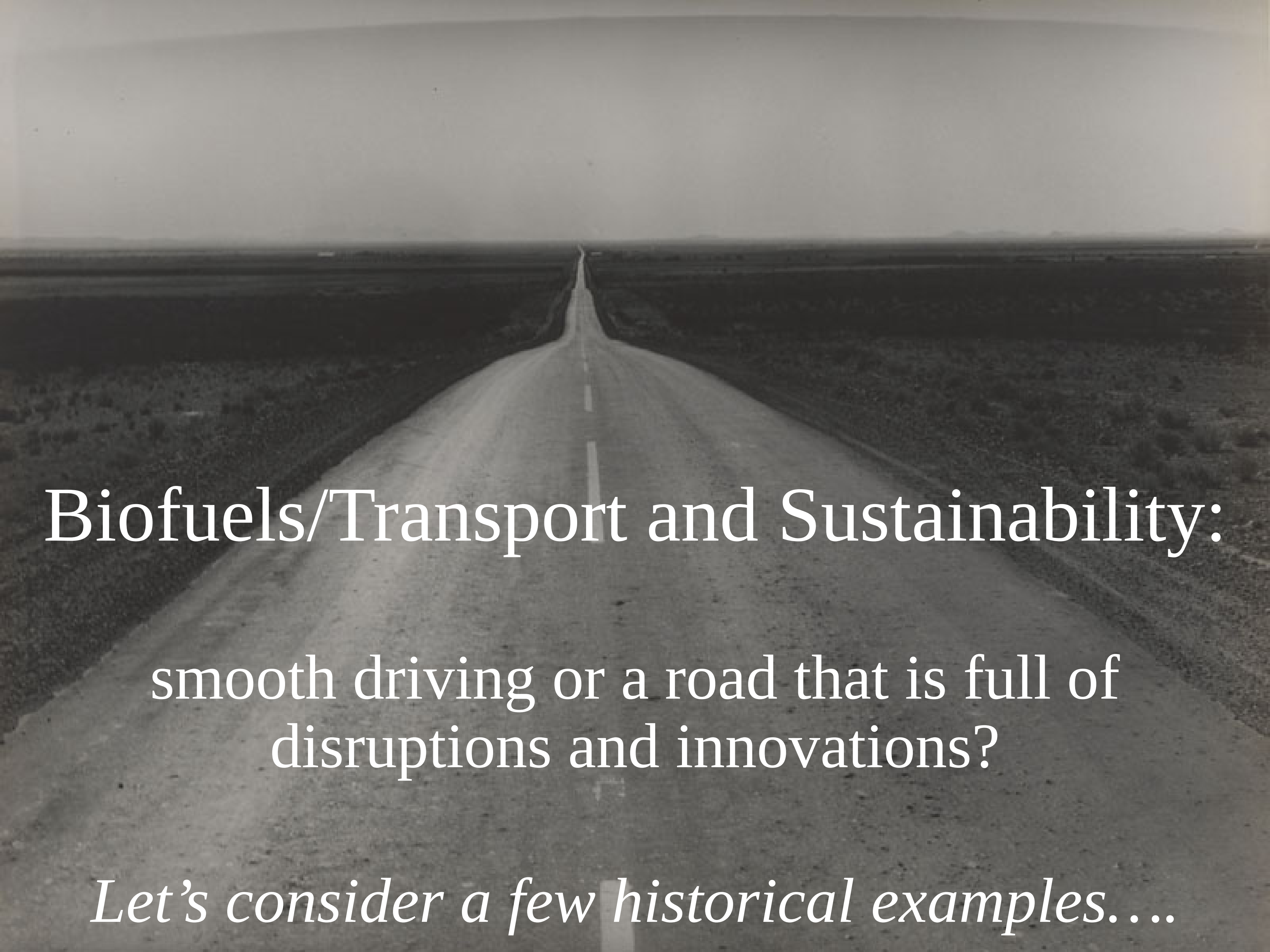
Stockholm Environment Institute

- SEI founded in 1989 from predecessor: **Beijer Institute**
- Based on 1972 UN Conference on the Human Environment (came to be known as the **Stockholm Conference**).
- **Mission:** support decision-making and induce change towards sustainable development

www.sei.org



Biofuels/Transport and Sustainability:

smooth driving or a road that is full of disruptions and innovations?

Let’s consider a few historical examples….

The advent of the horseless carriage! - Game-changing or disruptive innovation

Easter Morning, **1900**,
5th Avenue, New York City
Can you see an **automobile**?

Source: US National Archives.

Easter Morning, **1913**,
5th Avenue, New York City
Can you see a **horse**?

Source: George Grantham Bain Collection.

Importance of mobility in a fast-moving economy

Envars önskevagn

MORRIS 1936

å den svenska marknaden.

PRIS FRÅN KR. 2995:—

MORRIS

En brittisk kvalitetsprodukt

42

Stilfullt utförande, komfortabel inredning, rymlig och bekväm • Hydrauliska bromsar, synkroniserad växellåda, 5,25—16" ringar • Bensinförbrukning endast 0,6 liter pr mil — skatt kronor 60:— pr år.

En vagn som i allt är en stor vagn utom i priset

Begär katalog över 1936 års modeller

FÖRENADE BIL AKTIEBOLAGET

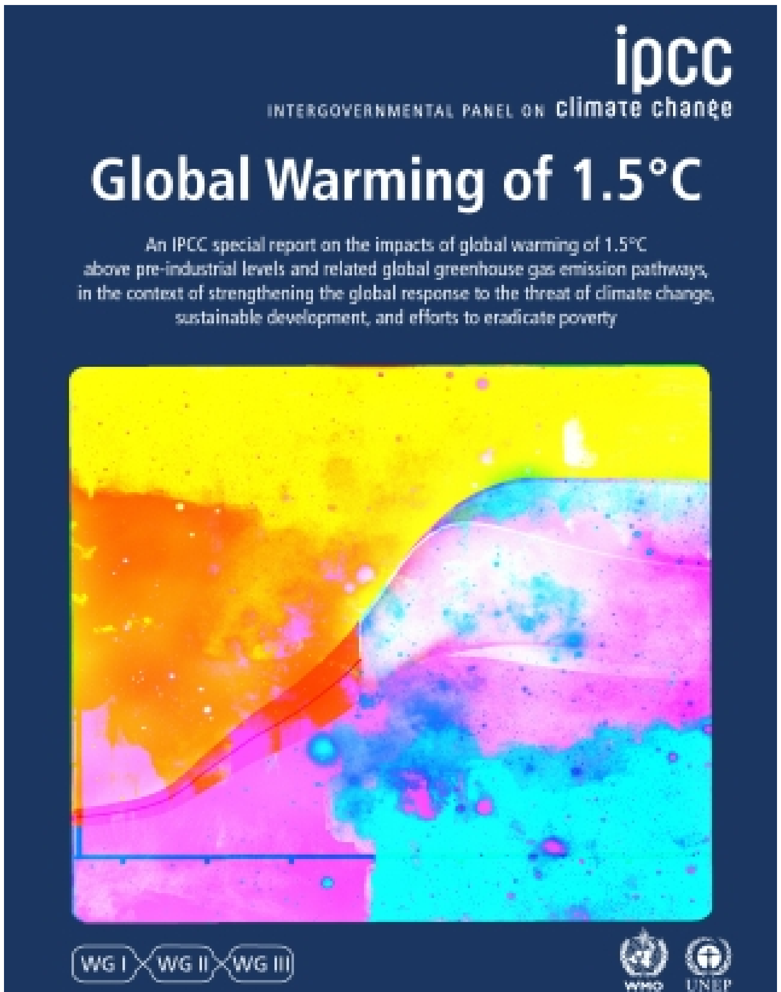
MALMÖ	GÖTEBORG
Ö. Tullgatan 6. Tel. 280 43.	St. Badhusgatan 18. Tel. 205 13.

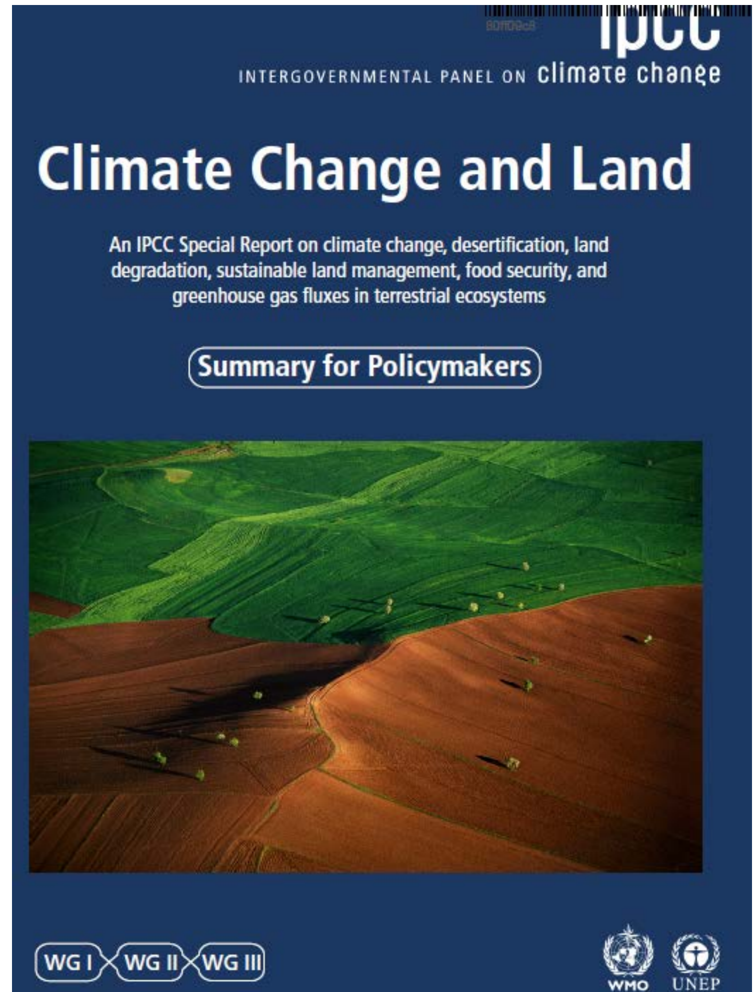
Återförsäljare antagas å de platser, där vi icke tidigare äro representerade.

Compare to avg fuel consumption, EU today~5 l/100km

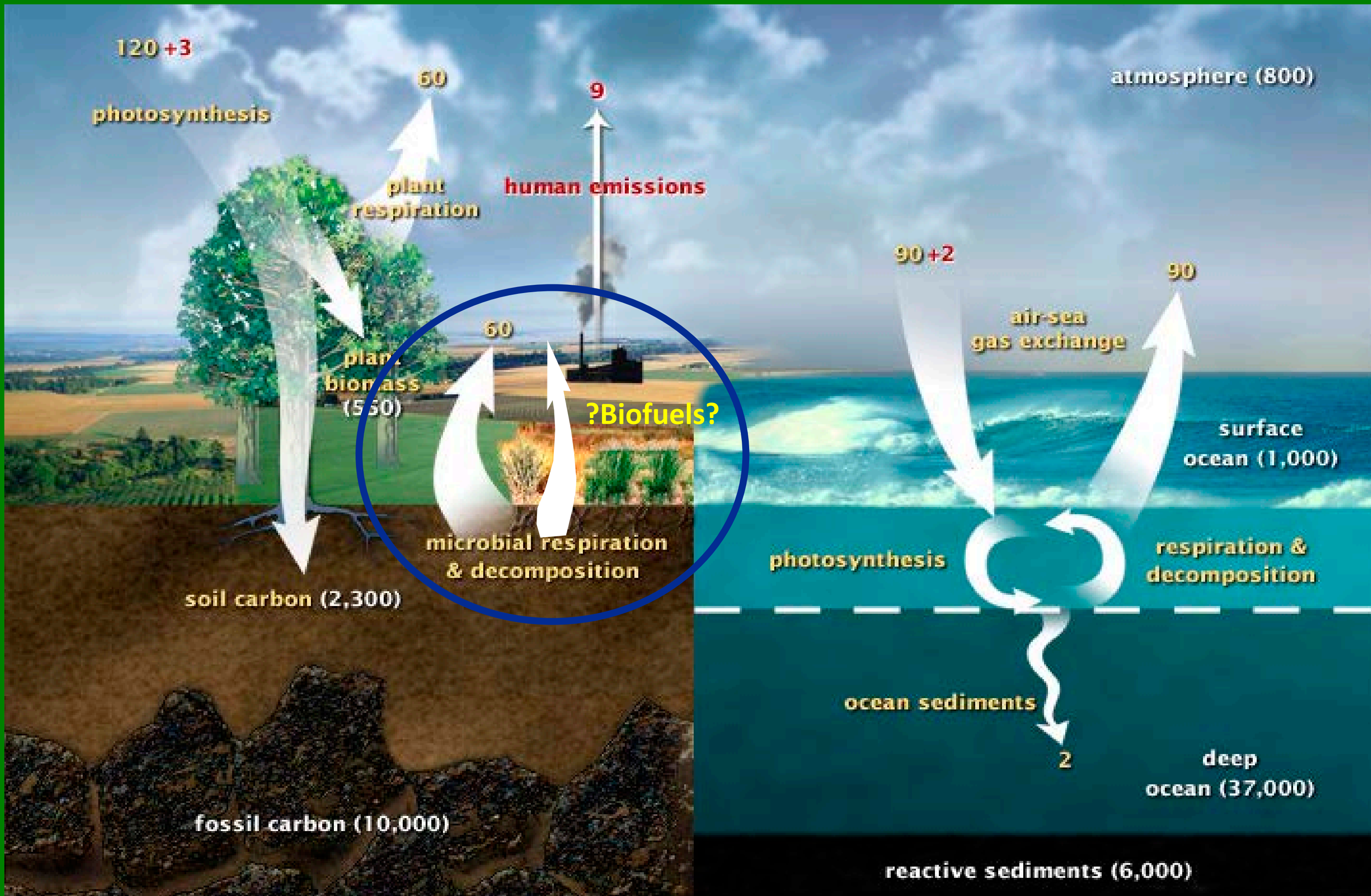
Slow Progress on Fuel economy! - has been poorly valued compared to power, comfort, convenience

Now we must value climate stabilisation and resilience: so what alternative pathways for land use, biofuels/bioenergy and development?



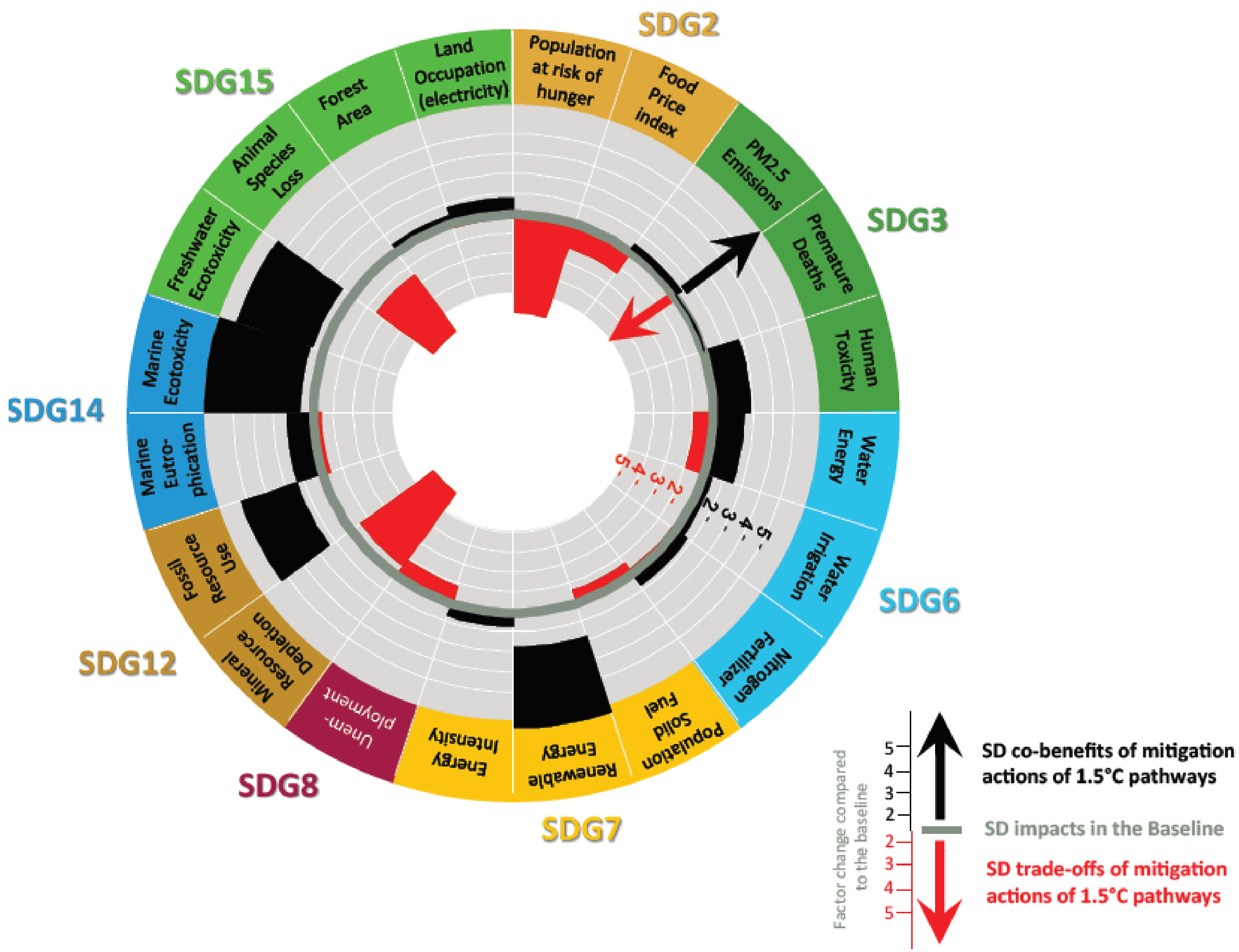


The Carbon Cycle (source: NASA)



10^9 tons (Pg) C per year. Yellow: natural fluxes. Red: human contributions. White: Stored.
http://earthobservatory.nasa.gov/Features/CarbonCycle/

The IPCC 1.5 report identified co-benefits (or synergies) and trade-offs between 1.5C pathways and specific indicators across different SDGs; note that food security and biodiversity are in RED

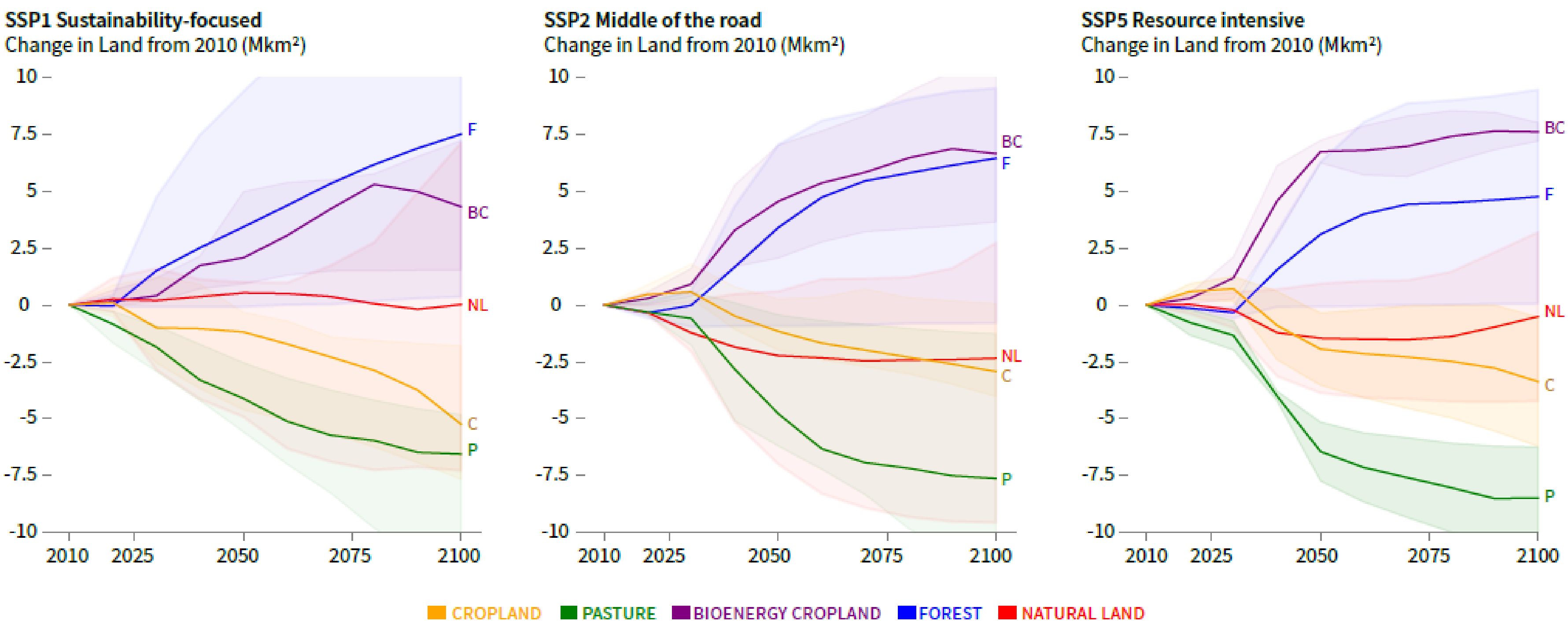


IPCC Land report showed that different scenarios lead to different changes in land use to reach goals, with bioenergy requirements increasing as sustainability overall decreases

A. Sustainability-focused (SSP1)
Sustainability in land management, agricultural intensification, production and consumption patterns result in reduced need for agricultural land, despite increases in per capita food consumption. This land can instead be used for reforestation, afforestation, and bioenergy.

B. Middle of the road (SSP2)
Societal as well as technological development follows historical patterns. Increased demand for land mitigation options such as bioenergy, reduced deforestation or afforestation decreases availability of agricultural land for food, feed and fibre.

C. Resource intensive (SSP5)
Resource-intensive production and consumption patterns, results in high baseline emissions. Mitigation focuses on technological solutions including substantial bioenergy and BECCS . Intensification and competing land uses contribute to declines in agricultural land.



Criteria for different response options in relation to key indicators for climate stabilisation, resilience, sustainable land use and development aims

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *Gt CO_2-eq yr^{-1}*	Adaptation *Million people*	Desertification *Million km^2*	Land Degradation *Million km^2*	Food Security *Million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
Positive	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
Positive	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligible	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
Negative	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
Negative	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

Variable: Can be positive or negative — no data — na not applicable

Confidence level

Indicates confidence in the estimate of magnitude category.

- *H* *High confidence*
- *M* *Medium confidence*
- *L* *Low confidence*

Cost range

See technical caption for cost ranges in US$ tCO_2e^{-1} or US$ ha^{-1}.

- ●●● High cost
- ●● Medium cost
- ● Low cost
- — no data

Positive effect (qualitative analysis)

Positive eller negative effect (qualitative analysis)

Bioenergy/BECCS and Reforestation

Bioenergy and BECCS

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
H	L			L	● / ●●●

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2\ yr^{-1}$ in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2\ yr^{-1}$ when it is a low carbon energy source {2.7.1.5; 6.4.1.1.5}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.4.5.1.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.4.3.1.5; 6.4.4.1.5}.

Mitigation	Adaptation	Desertification	Land degradation	Food security

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}

Reforestation and forest restoration

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
M	M	M	M	M	●●

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.4.5.1.2}.

Mitigation	Adaptation	Desertification	Land degradation	Food security

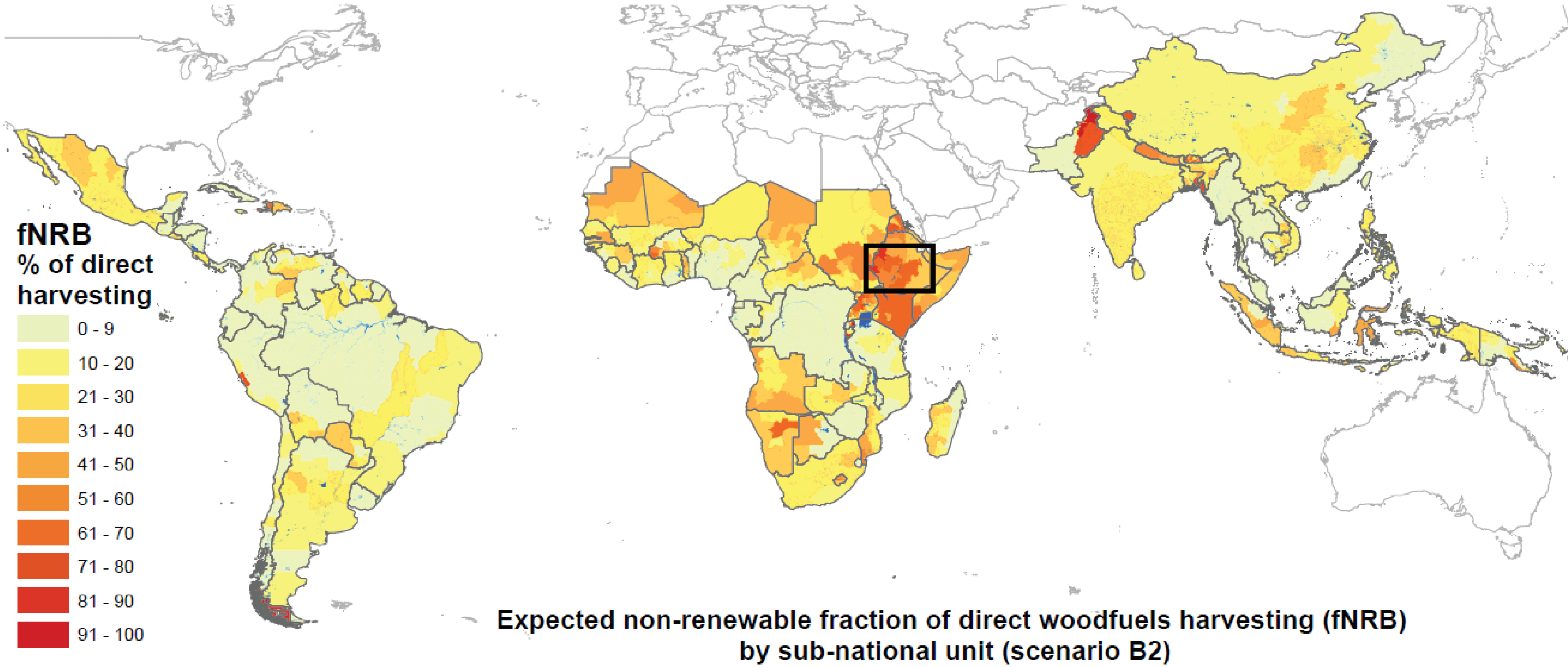
Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

Figure SPM 3.b, IPCC SRCCL, 2019

GHG emissions from land use impacts of traditional (woody) biomass > 2% of global; nearly as high as aviation sector!

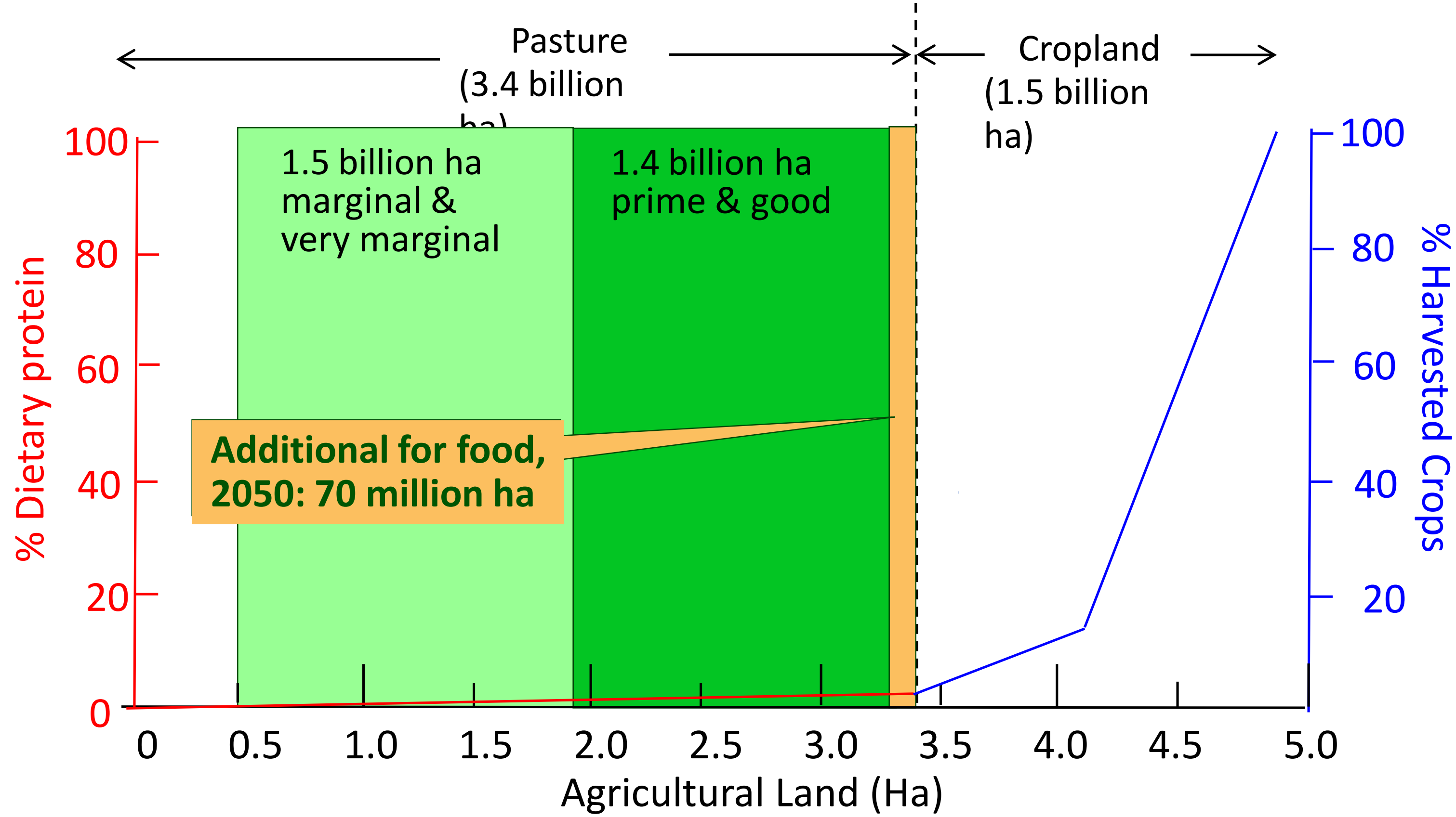
Integrated Responses to replace traditional biomass supports multiple SDGs:

- Reduced indoor air pollution leads to improved health (SDG 3, 7)
- Less time gathering wood frees time for women and children (SDG 1, 5)
- Reduced land degradation and GHG emissions (SDG 13, 15)
- Access to modern energy services improves adaptive capacity (SDG 2, 7, 13)



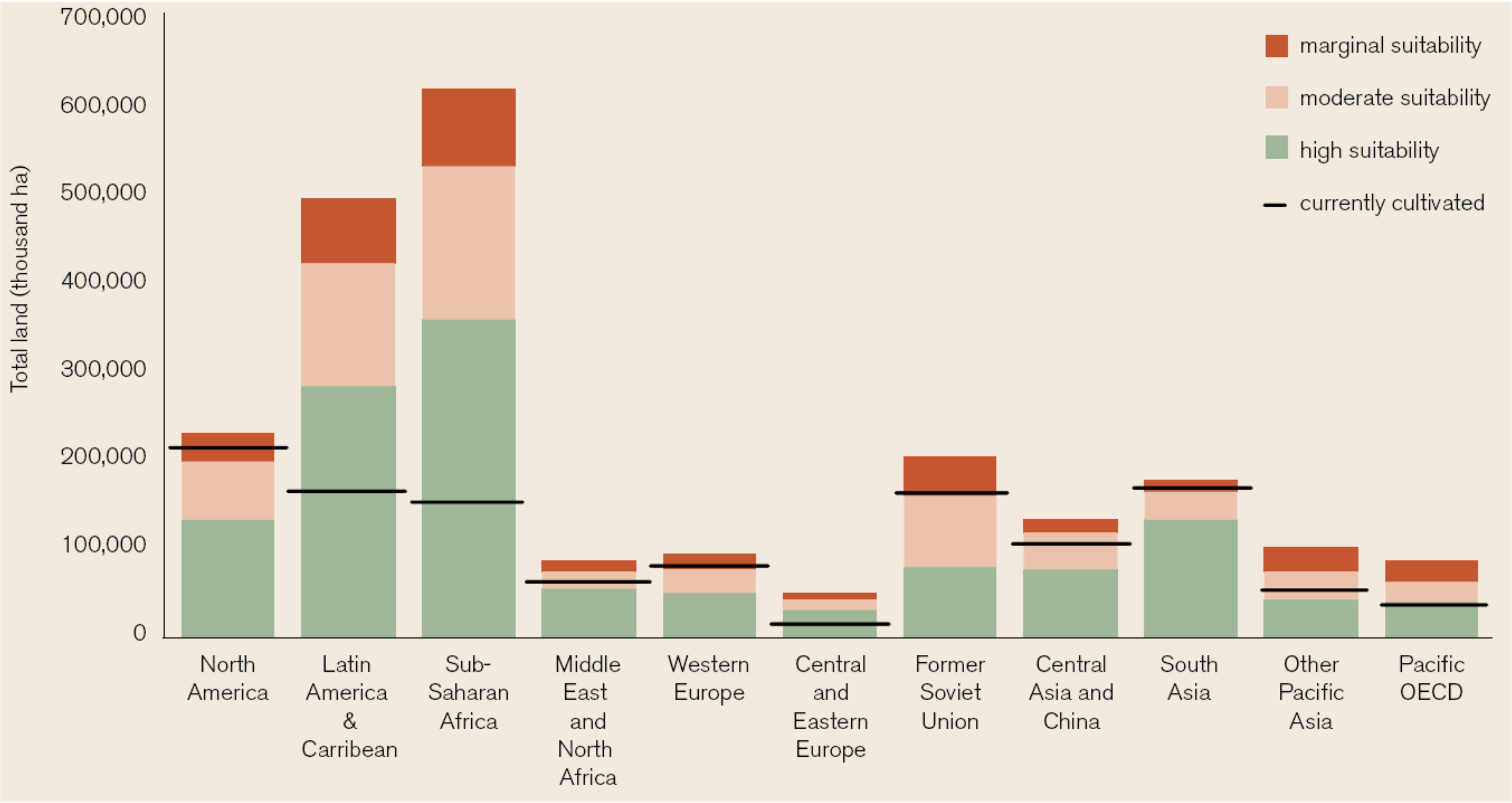
Source: Bailis, 2015 (Figure shows "hot spots" of non-renewable woody biomass use)

Cumulative food supply curve



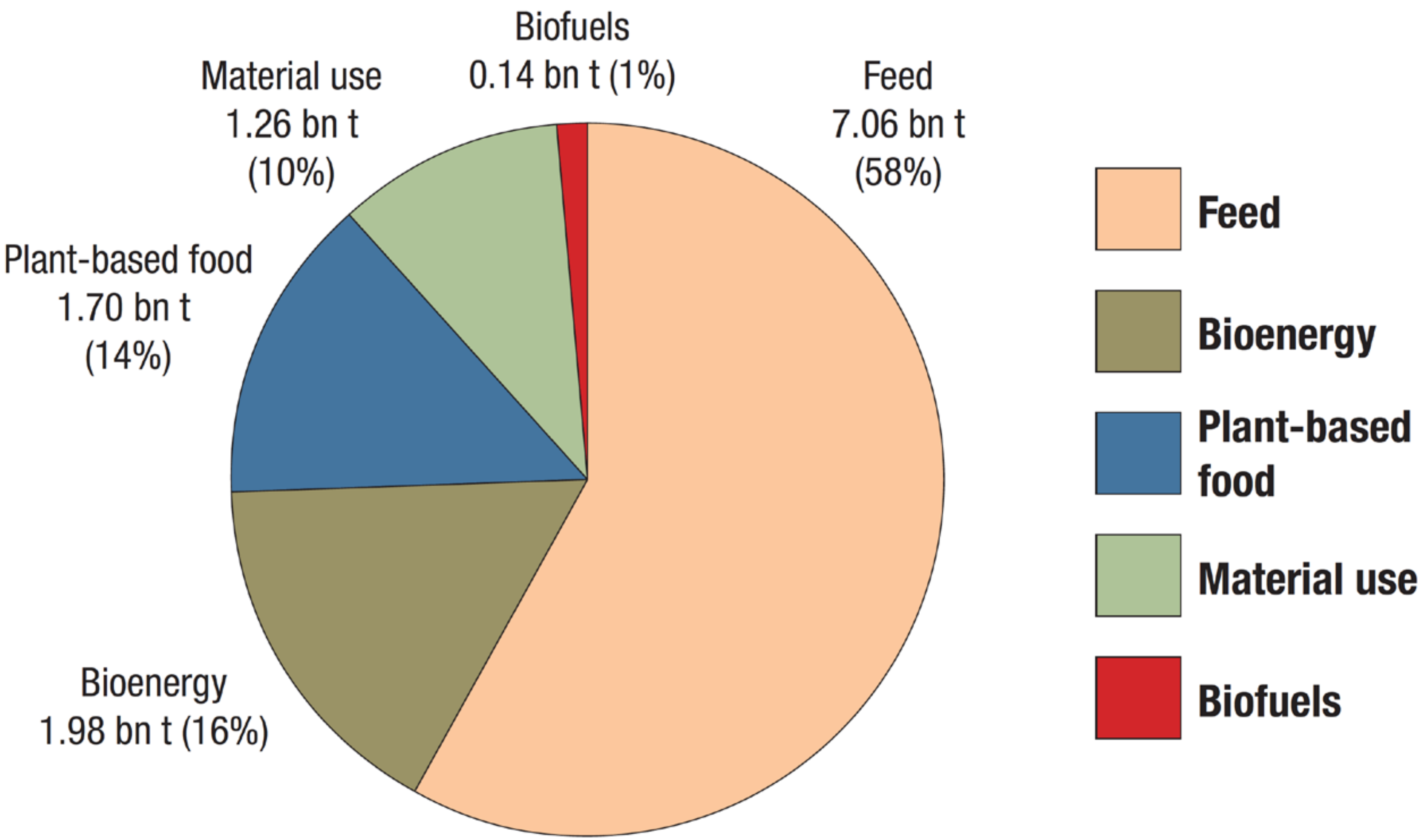
- 2.7% of dietary protein on land used for pasture only (Woods et al., 2016)
- 86% of food & feed production from 58% of cropland (West et al. Science, 2014).
- Potential cropland and anticipated demand from FAO, 2017

Global Land Use and Availability (2017)



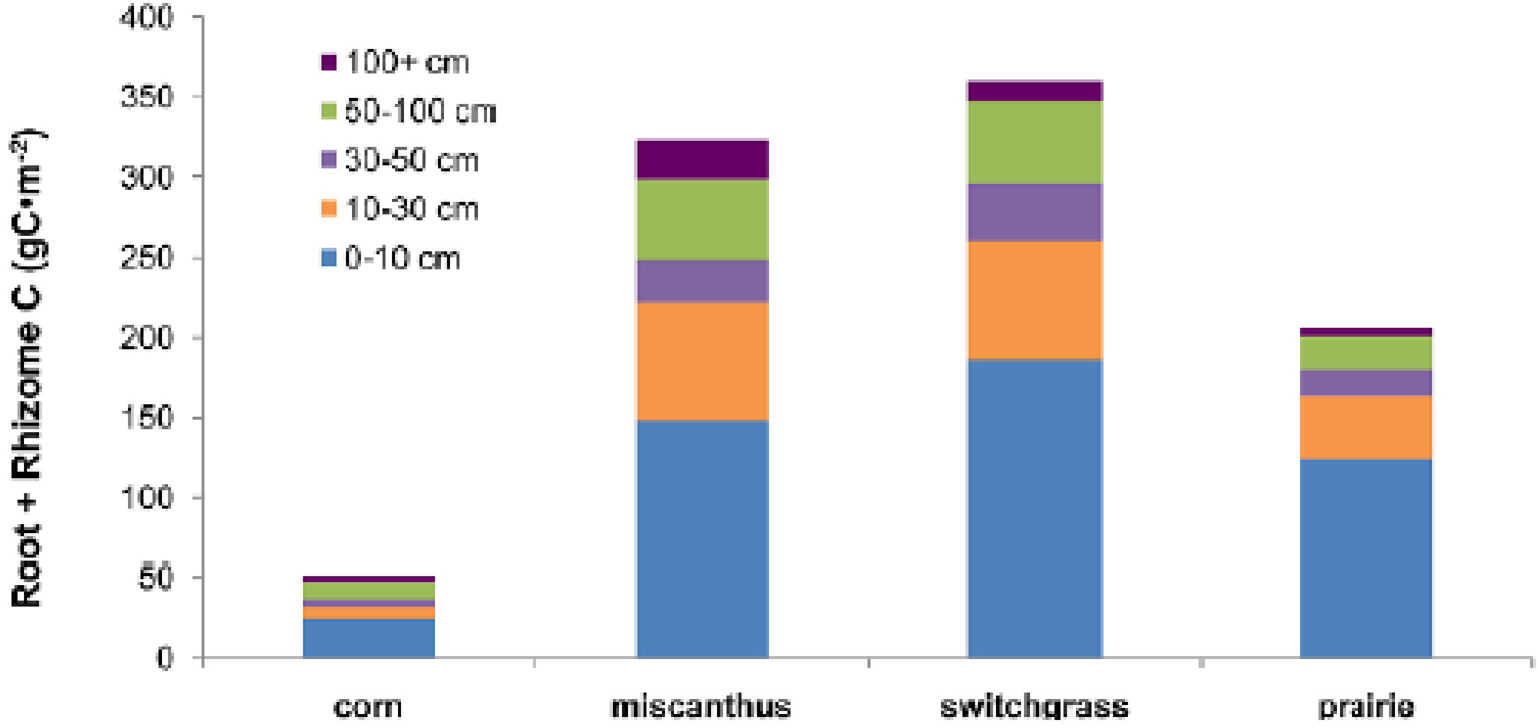
- Latin America & Caribbean and Sub-Saharan Africa are the two regions where substantial amount of suitable land for agriculture is available due to large amounts of pastures and low population density

Global use of biomass by major category



Study available at www.bio-based.eu/markets

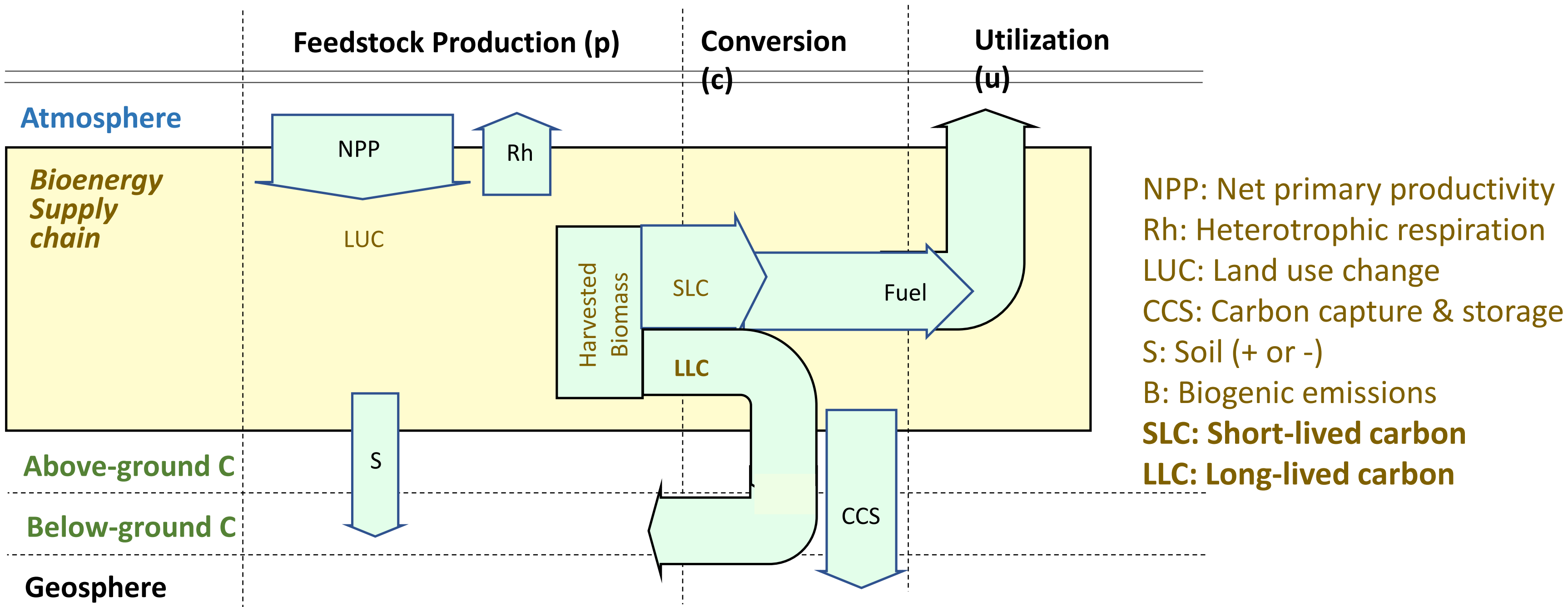
Perennial bioenergy crops and cellulosic sources of biomass can accumulate soil carbon better than annual crops



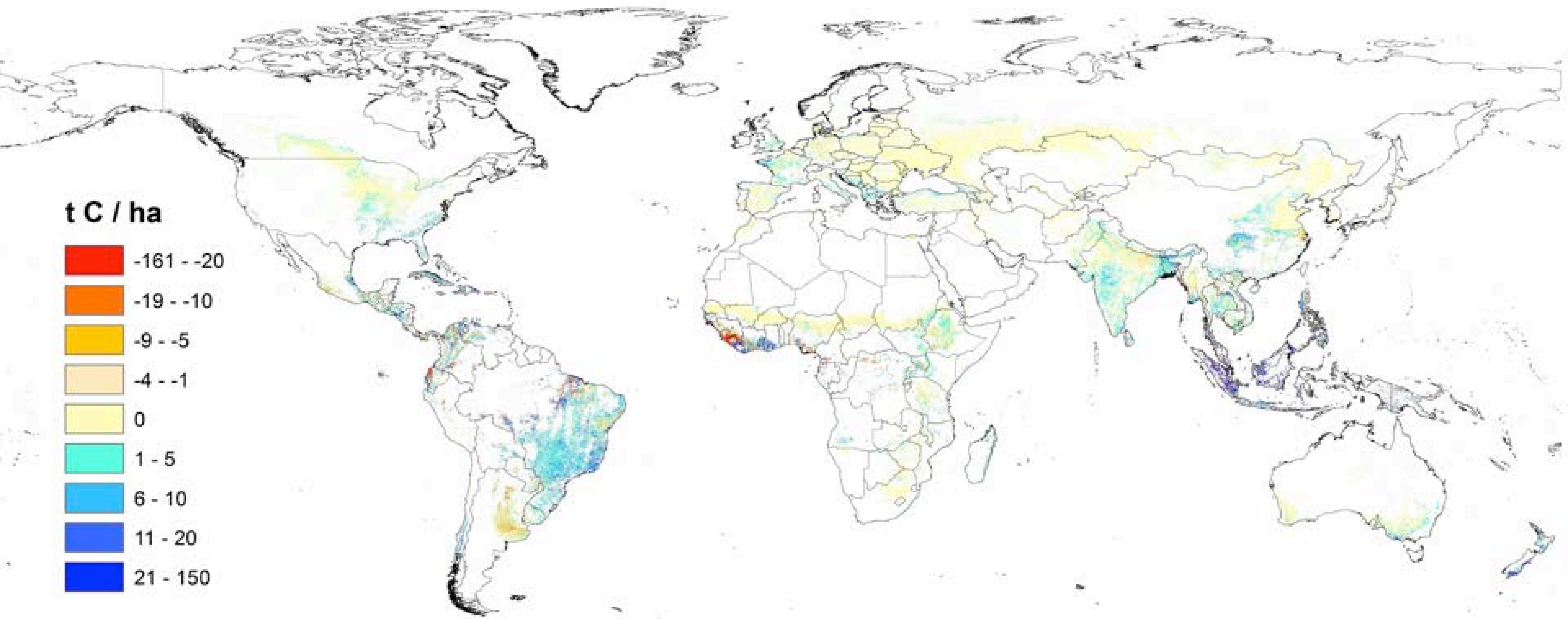
Cellulosic Biofuel Feedstock Supply Chain with negative emissions at scale

Specifications (Source for scenarios: Lynd, L., 2019)

Avoid competition for land	• Use crop residues, double crops, degraded land
Substantial negative GHG emissions	• Non-fossil process energy (biogas, electricity) • Carbon capture & storage
Soil fertility, nutrient retention ≥ status quo	• Return process residues (including long-lived C) to soil
Large enough to offer meaningful climate benefits [1] Cherubini et al., 2018; [2] Fulton et al., 2015; [3] Scope, 2015.	• **With return of process residues, a much larger fraction of agricultural residues can be processed to biofuels.** ***Ag. Residues: 85 EJ[1] (+ double crops, degraded land)*** ***Anticipated difficult-to-electrify transport: ~ 50 EJ[3].*** ***Biofuels today: 2.3 EJ[2]***



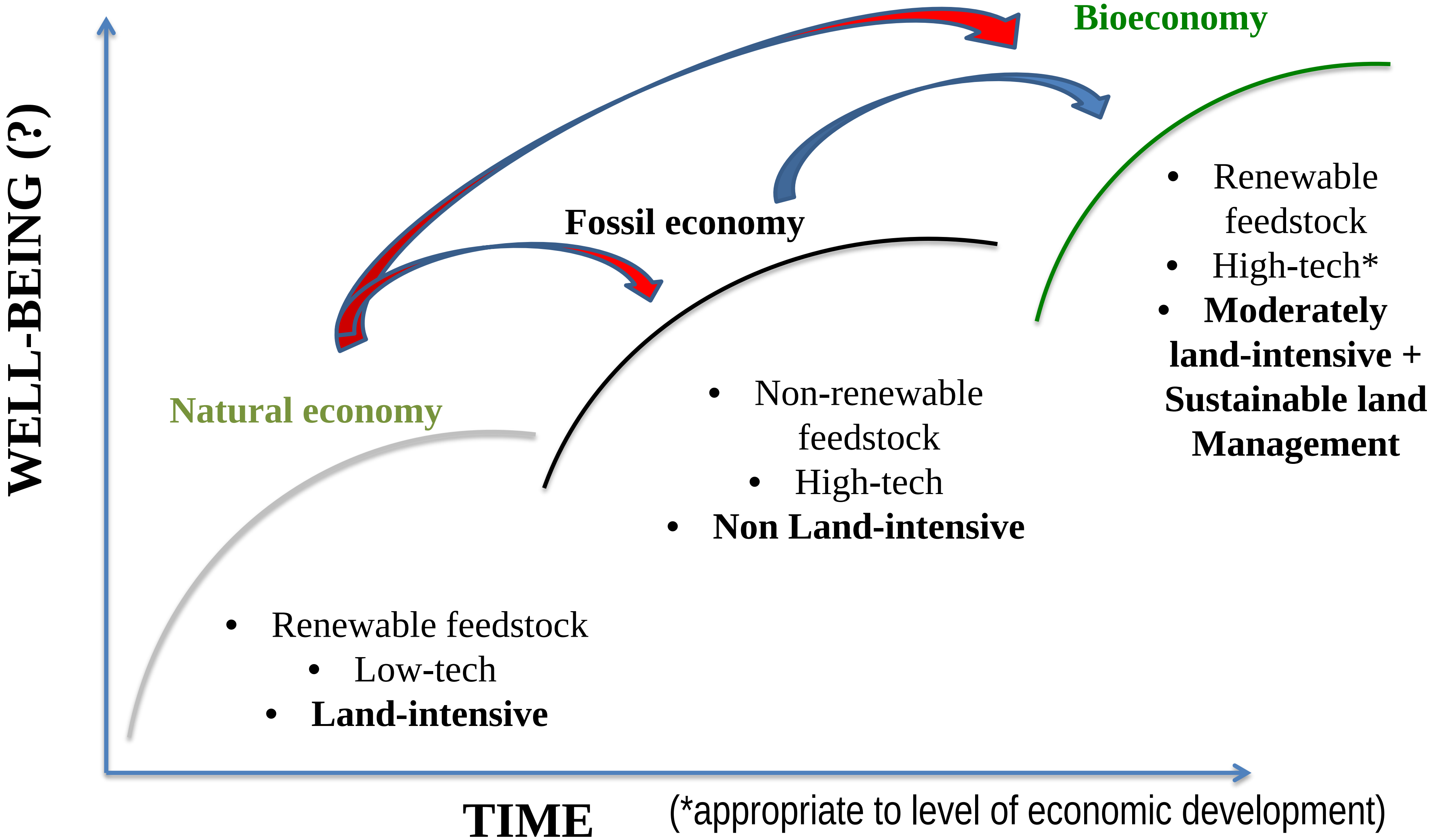
Some positive news: Change in Biomass Carbon on Agricultural Land - 2000 - 2010



- Trees on agricultural land make an important contribution to climate change mitigation: during the most recent decade they have sequestered 0.7 Gt CO_2 per year
- There are regional hotspots both of biomass increase and loss: identifying the drivers may help replicate positive trends and revert negative ones
- Improvements needed in such data sets and their incorporation in decision making

Zomer et al, 2016. Global tree cover and biomass carbon on agricultural land: the contribution of agroforestry to global and national carbon budgets. Nature Scientific Reports, 6:29987. DOI: 10.1038/srep29987

Biomass, biofuels, forests, land use in long-term can all be related to transitions over time to a sustainable bioeconomy



(Modified from Finnish Bioeconomy Strategy)

Governing Bioeconomy Pathways

An Initiative of the

Stockholm Environment Institute

https://www.sei.org/projects-and-tools/projects/sei-initiative-bioeconomy/

Contact: francis.johnson@sei.org

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Photo credit: Getty / yimwow