Imperial College London

Integrated, whole systems perspective on land use for resolving conflicts between the 3 global securities: energy, climate and food

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Workshop on Sustainable Biofuels: addressing Indirect Land Use Change

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FAPESP
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eit Knowledge & Innovation Community
Climate-KIC

Key issues

- **Food security**: particularly in developing countries, investment urgently needed in energy service provision into, and infrastructure for, agriculture – bioenergy is an enabler for food security (Lynd & Woods, A new hope for Africa. *Nature;* 2011)
- **Energy security**: dangerous for biomass supplies for bioenergy to be sourced as a residual of the demand signal- policies need to be comprehensive (link energy policy with agricultural development policy)
- Current policy debate (EU + US) has halted biofuels growth and resulted in dis-investment in advanced (2G) options… strongly negative implications for investments in lignocellulosic biorefining technologies to address agriculture's major problems
- ILUC factors are a major obstacle to sustainable development. Serious questions about their scientific basis will not go away- LUC is important.
  - World energy prices, Deforestation rates, Future crop yields- even with declining crop yields (v high calculated ILUC) bioenergy could be playing a critical role in reducing yield declines and delivering safe and nutritious foods (Woods et al. Energy and the Food System. *Phil Trans B;*. 2010)
- **Climate security**: Integrating agricultural landscapes needs new tools + perspectives to enable farmers to manage land sustainably.

High Level Panel of Experts on Food Security and Nutrition. Biofuels and Food Security V0 DRAFT (Jan 2013)

‘Any biofuel growth would exacerbate that challenge. At present, 100% of the world´s crop represents a raw chemical energy potential equal to only 13% of the world´s primary energy. When considering its relative efficiency with fossil fuels, its realistic maximum potential would be closer to 9% of primary energy today and only 4-6% in 2050. And this would consume 85% of the world’s freshwater diverted from rivers and aquifers..

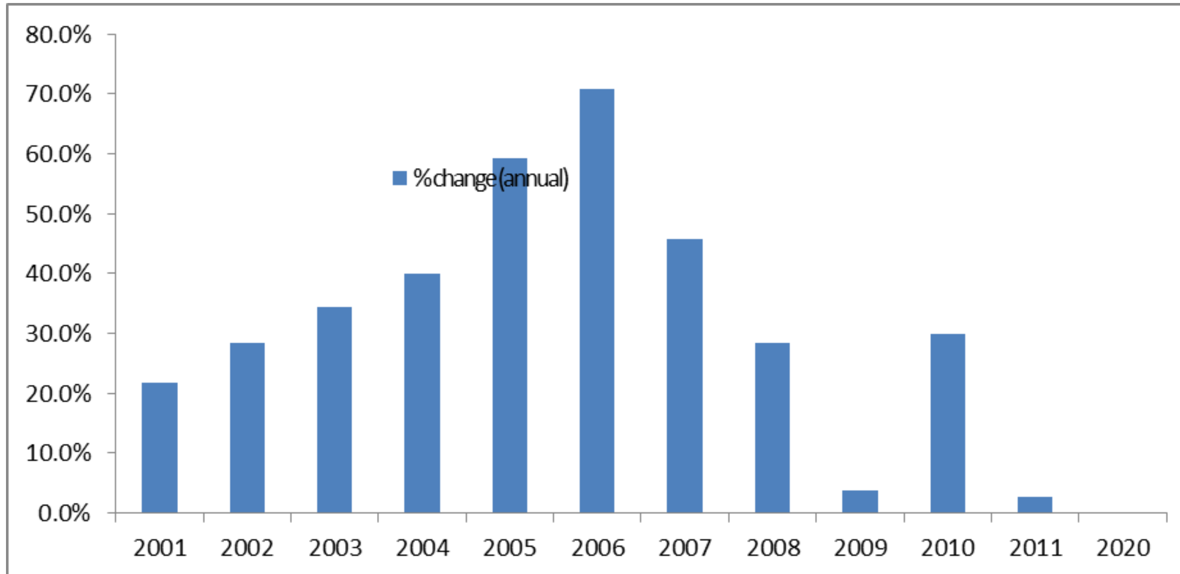
As cellulosic ethanol is not necessarily more land or water efficient than crop-based biofuels (after accounting for feed by-products of grain-based biofuels), the use of productive land for cellulosic biofuel crops would not substantially alter this equation.

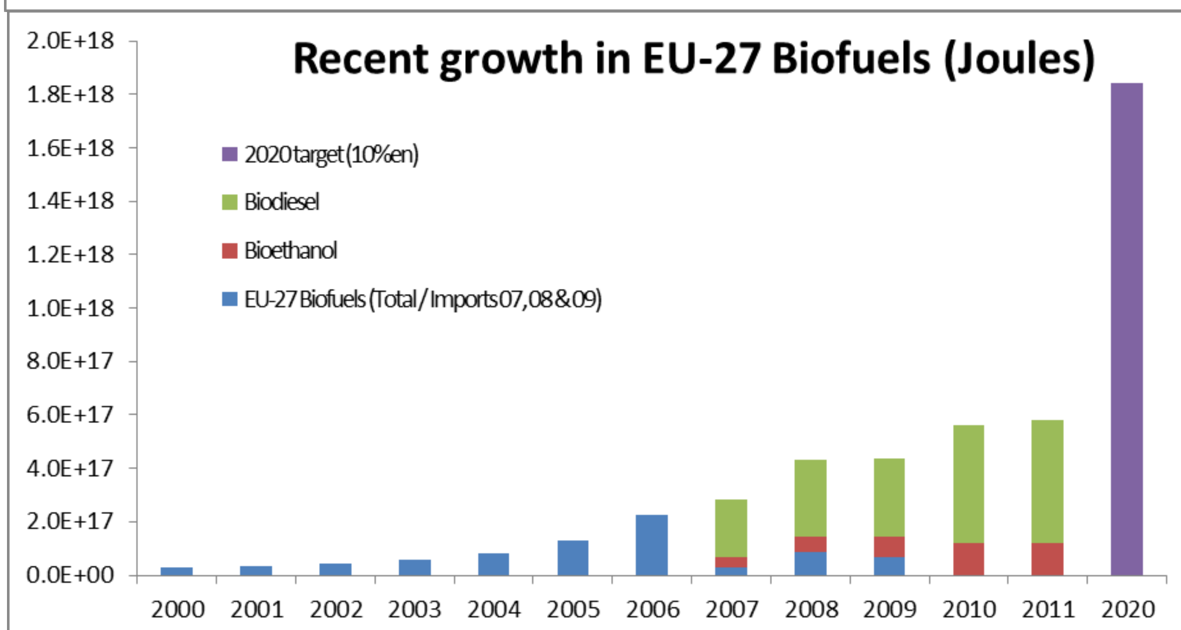
The fundamental problem lies in the relative inefficiency of biomass for energy as plants are unlikely to transform more than 0.5% of solar energy into biomass energy, with a final fuel energy yield down to only 0.1-0.2%. When food, feed, energy and carbon storage demands have to be considered jointly, given the orders of magnitude at stake, one can assume that bioenergy cannot provide a significant source of the world’s total energy.’

EU Policy uncertainty has halted biofuel growth since 2008

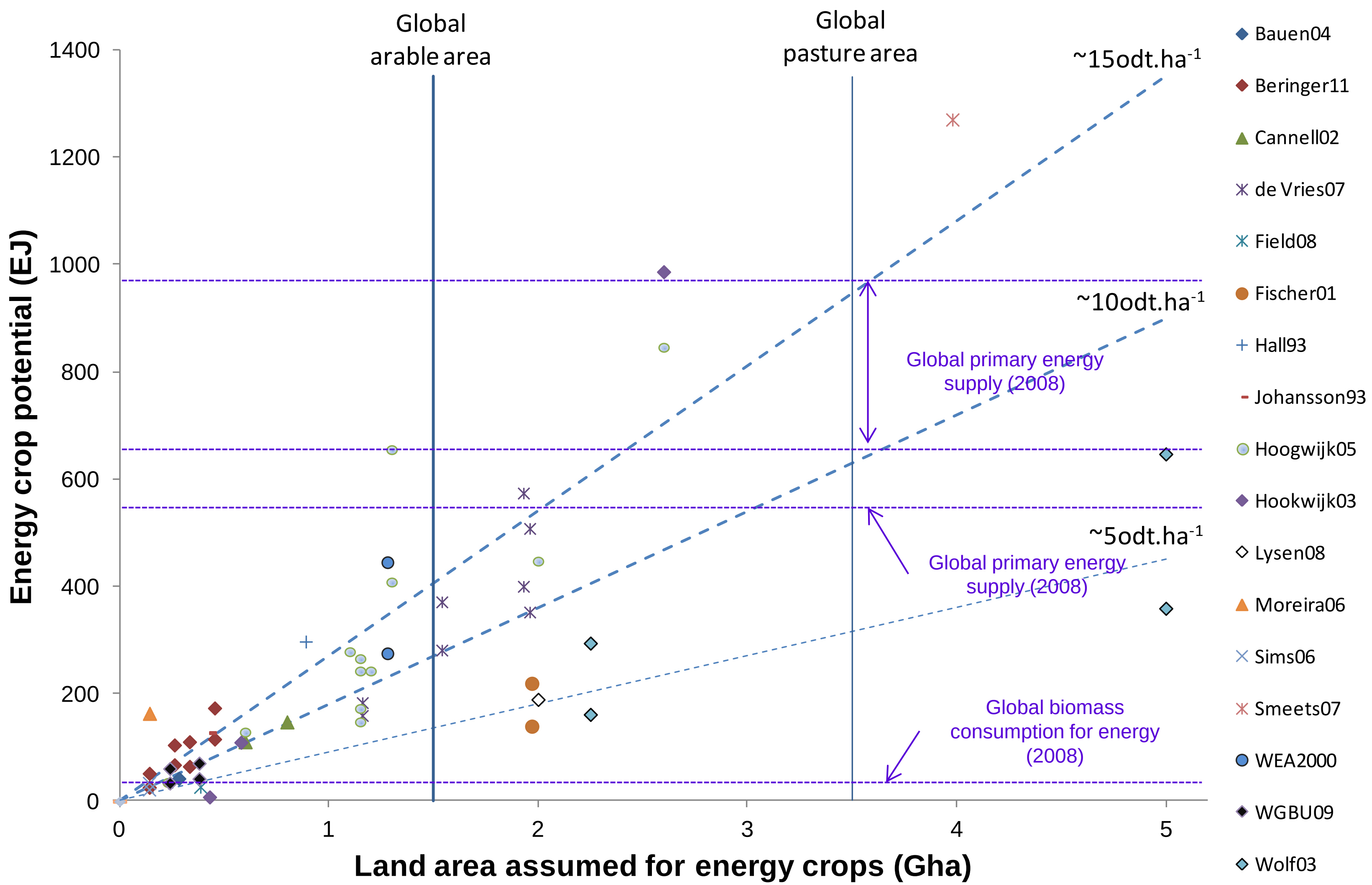
Uncertainty around the revisions to the RED, particularly around:

- ILUC factor(s)
- multiple crediting for wastes & residues
- Cap on food-based biofuels



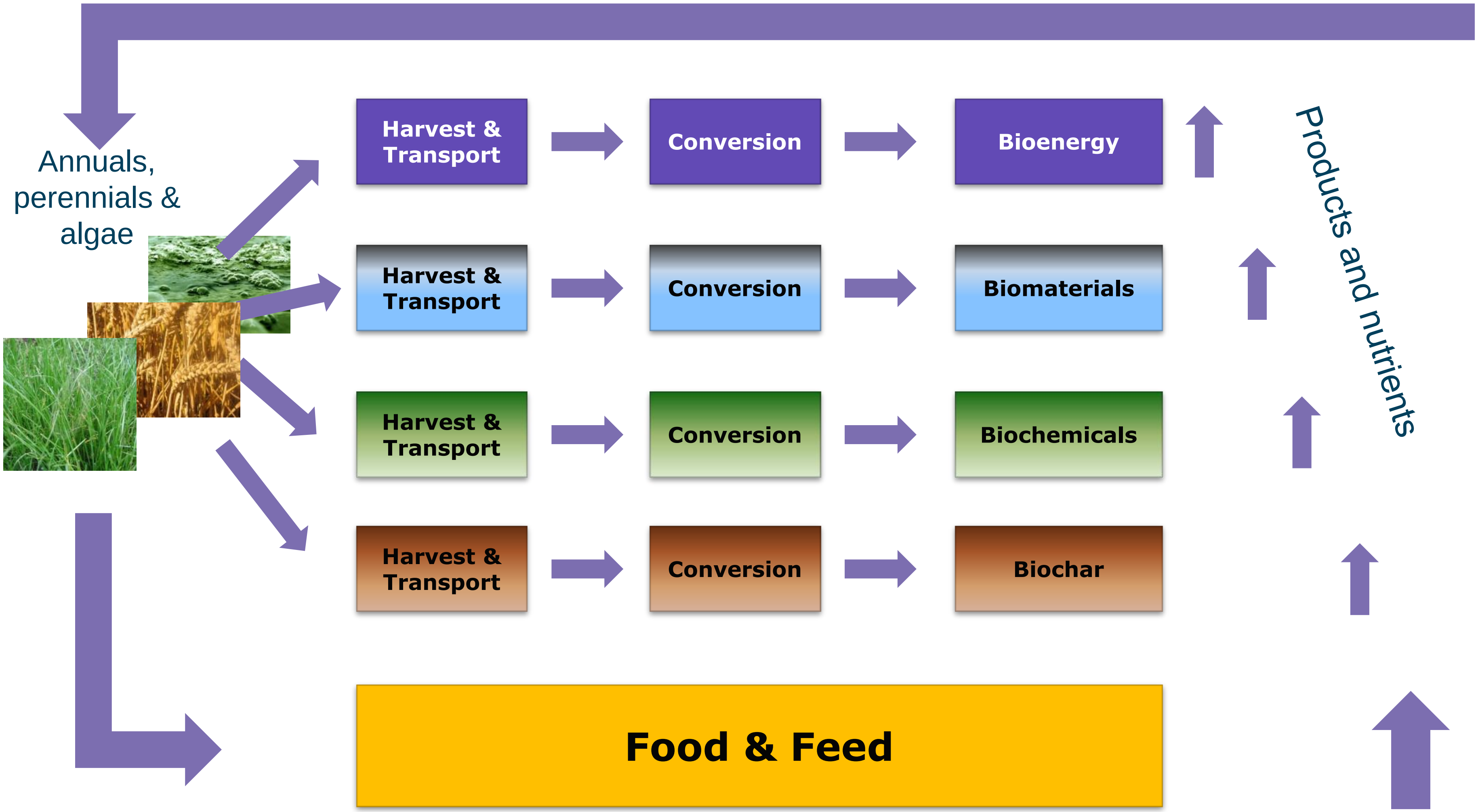


Global Potentials for Energy crops (Slade et al, 2011)



Slade et al. (2011) Energy from biomass: the size of the global resource. Imperial College Centre for Energy Policy and Technology & UK Energy Research Centre, London

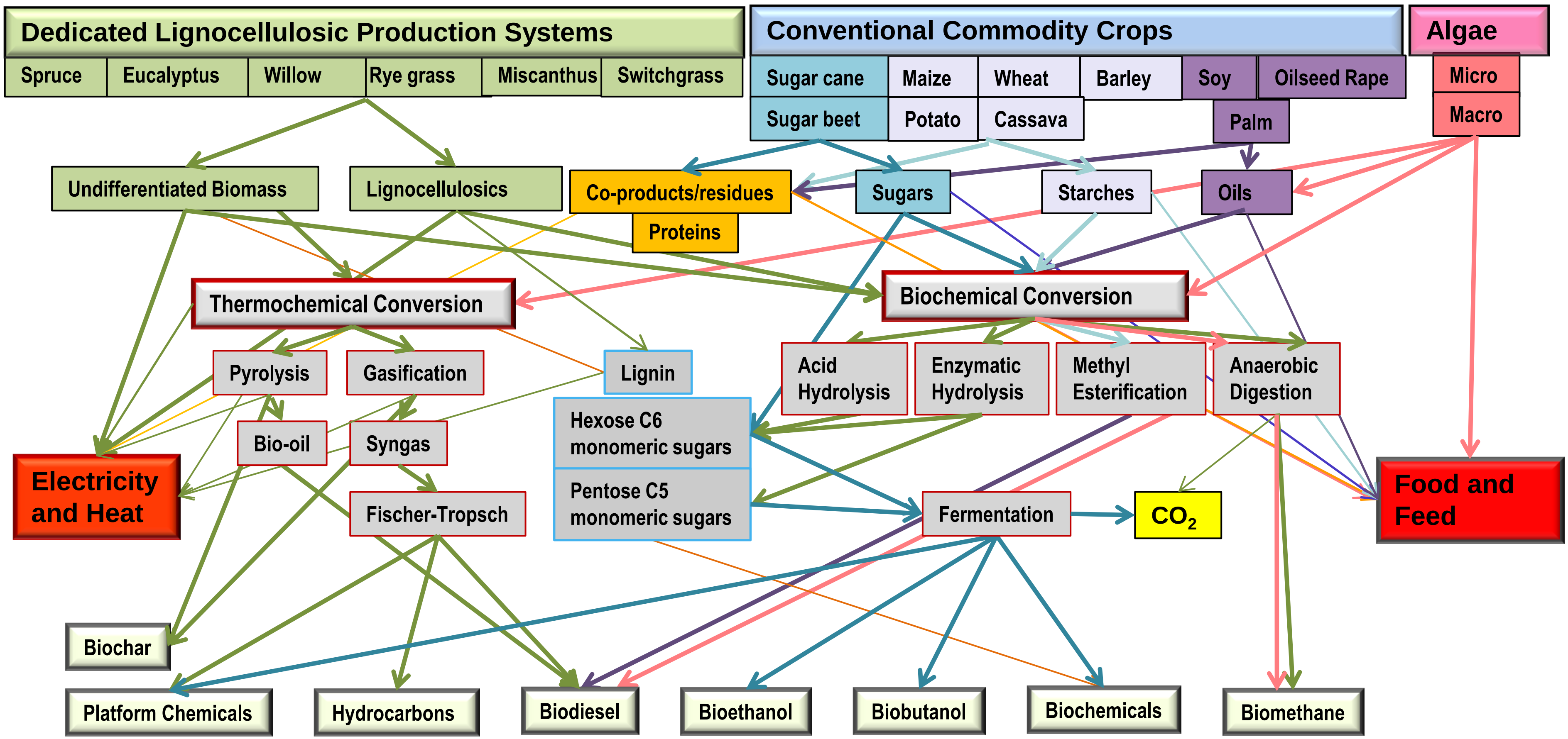
Opportunities: Integrating Biomass supply chains (food + non-food) adds flexibility, resilience and reduces waste



ADMIT Biorenewables, 2012 (www.climate-kic.org)

Feedstock and technology pathways for biorenewables:

Many options, opportunities and threats!



House J.I., et al. Chapter 7. Mitigating climate risks by managing the biosphere. In: Cornell S.E., Prentice C.I., House J.I., Downy C.J. (Eds) Understanding the Earth System. CUP. 2012. ISBN:9781107009363

Using bioenergy to address agriculture's major problems?

4 major problems in agriculture:

- Stagnating yields
  - Increased demand more likely to be provided by increased land area
  - Yield gaps need closing + continued research and development
- Decreasing biodiversity
  - Diffuse, difficult to quantify but serious
- Decreasing carbon stocks
  - Damage to soil productive capacity particularly from declining SOM
  - Associated GHG emissions from land use change
- Nutrient losses / soil erosion and associated declining water quality and increased GHG emissions

Integrating perennial crops with annual crops can help manage the impacts of food crop intensification and deliver significant amounts of biomass for bioenergy

Closing the 'yield gap'

Requires:

1. better management & genetics,
2. increased nutrient inputs, and closed-loop systems
3. increased energy inputs along the entire supply chain

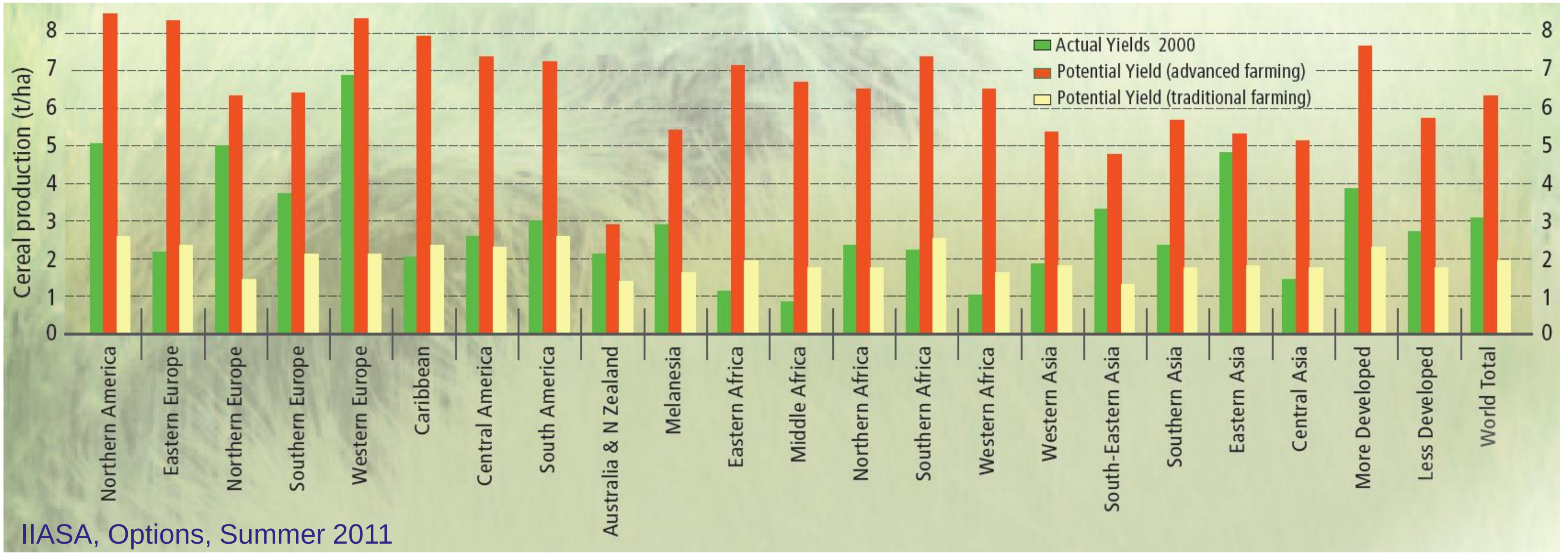
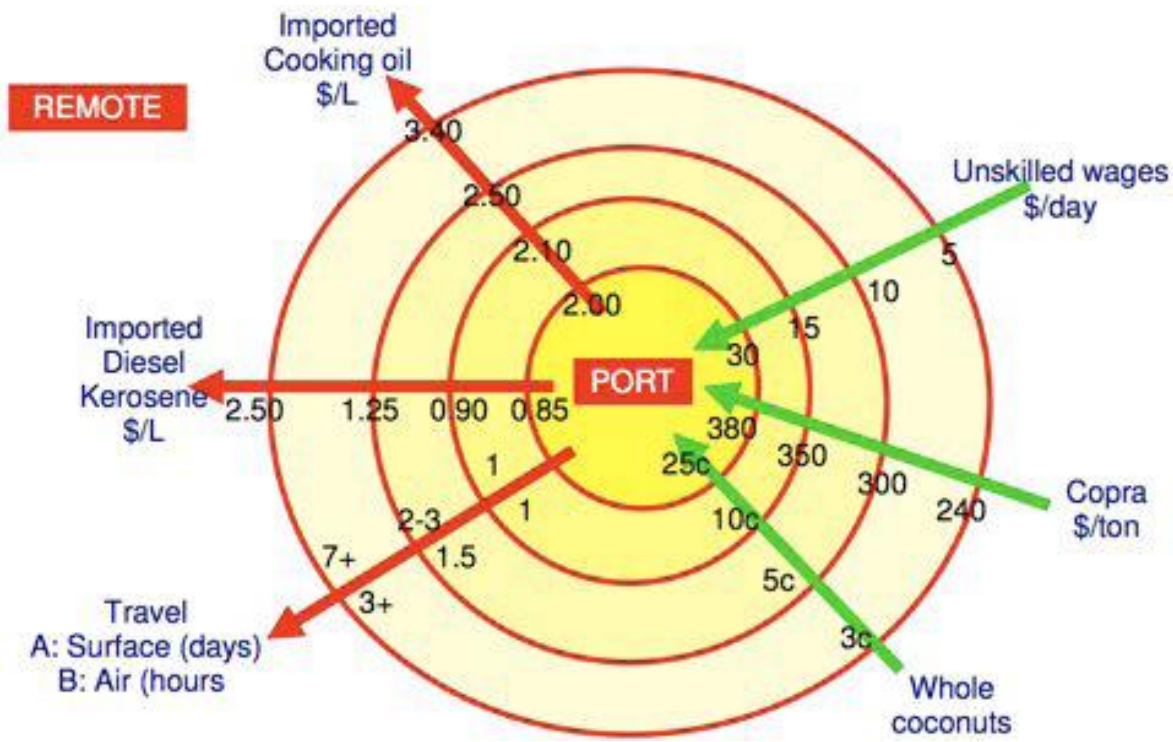


Figure : Assessing the 'yield gap' - actual yields (t/ha) versus potential yields from advanced farming (IIASA, Options, Summer 2011)

The double rural penalty- a unique role for bioenergy



Etherington (2006) in Angelou (2011)

Energy costs, in particular, increase as transported into rural areas and costs of transporting goods to markets (also energy cost) increase the further from the market products are produced. Increasingly vulnerable with increased volatility in energy prices

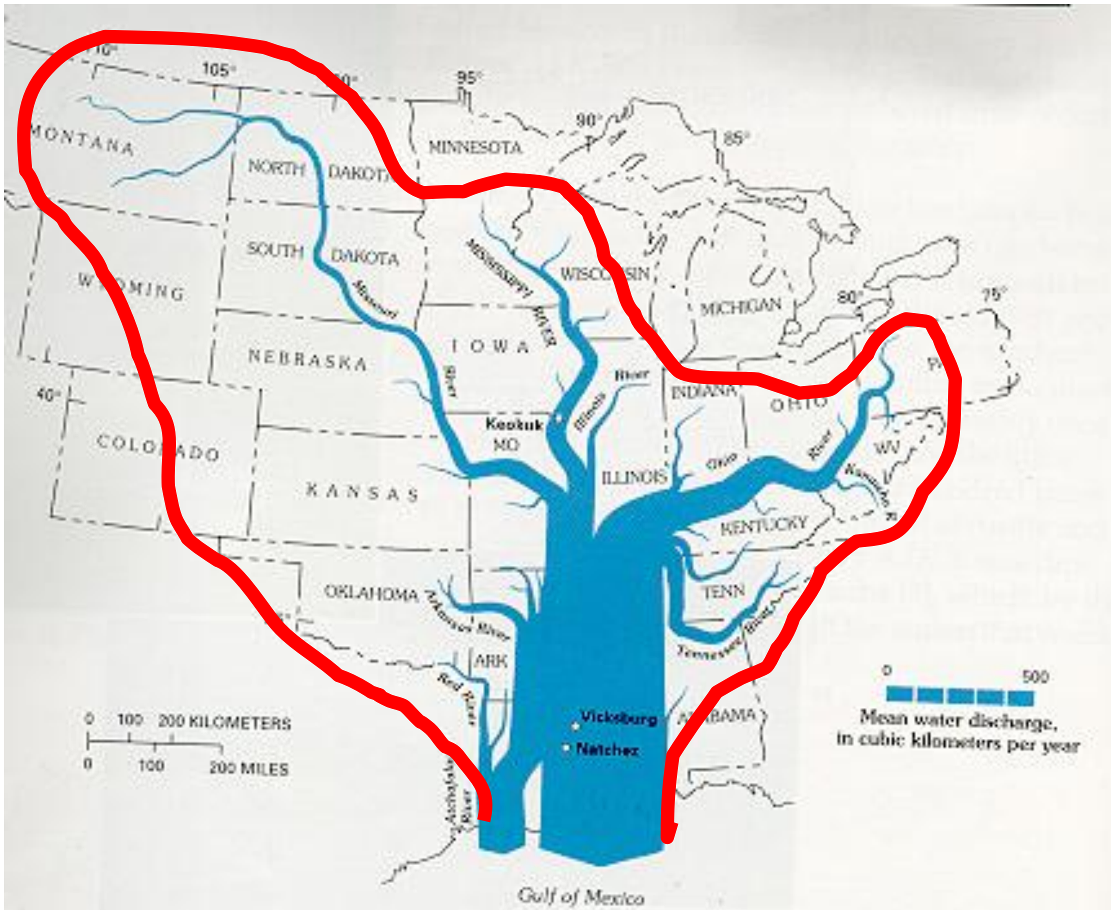
Need for integrated land and water / hydrology and biodiversity perspective

Two examples:

- US nutrient management and perennial crop integration (Richards, 2012)
- Gémesi et al (2011). Effects of Watershed Configuration and Composition on Downstream Lake Water Quality. *J. Environ. Qual.* 40:1–11 (2011). doi:10.2134/jeq2010.0133.
  - *'Configuration variables such as contagion, the cohesion of cropland and urban land, and the aggregation index of forest were very important and more important than variables assessing landscape composition (e.g., percentage farmland).'*

'50% of Europe's waterways are in serious decline' Gerry Boyle, Director, Teagasc, Ireland. Dublin EU Bioeconomy Stakeholders Conference (15 Feb 2013)

Mississippi river watershed, yield, and nitrogen yield

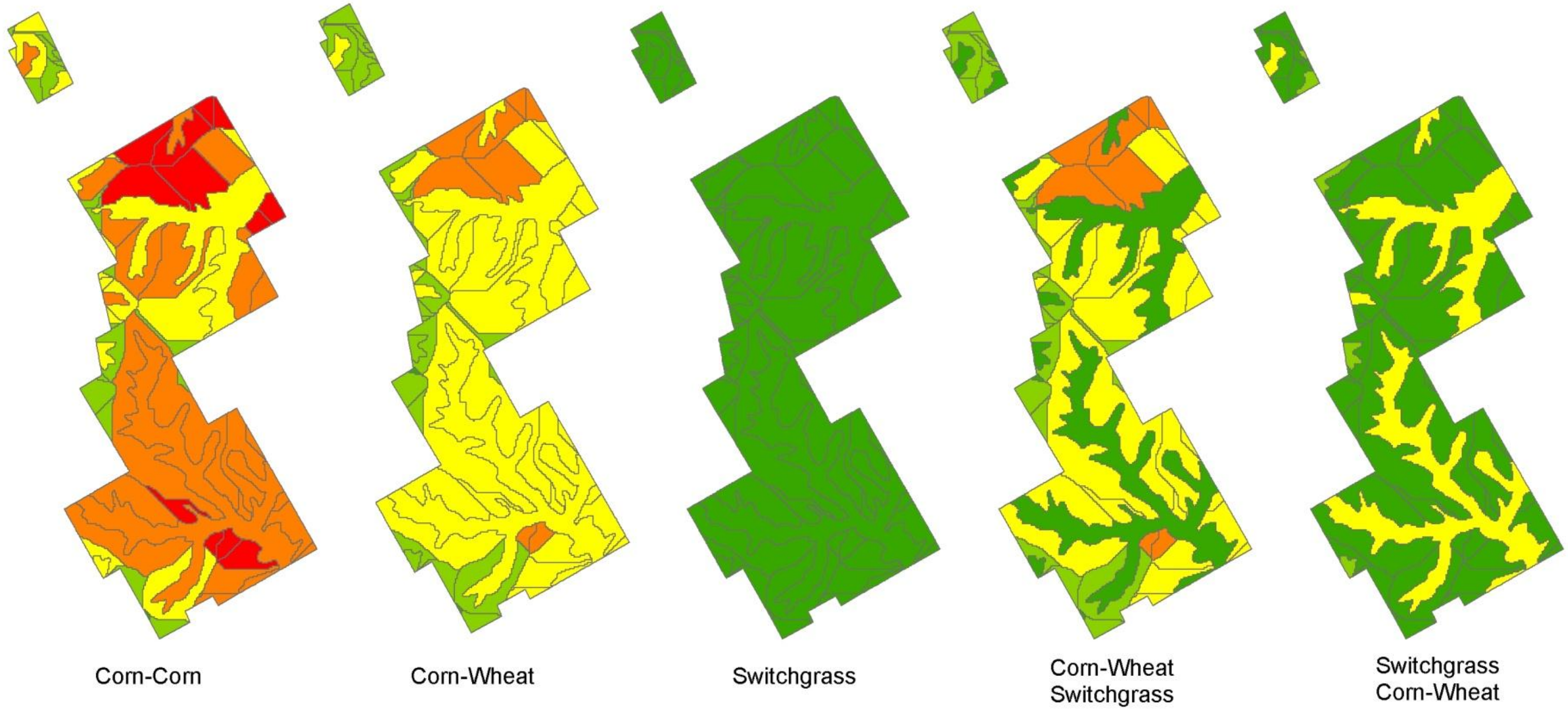


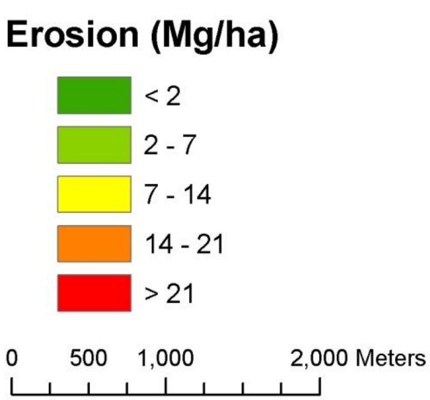
Natchez Q » 500 km3/yr

Q_N = 1.5 Mt N/yr

(~ 4300 t/day)

Source: Goolsby et al. 2001. Nitorgen inputs in the Gulf of Mexico. J.Env.Qual 30:329–336





Erosion: Onsite Impacts

- Cropping systems / tillage control erosion
- erosion can be highly localized
- perennial bioenergy crops locations

(Kemanian 2009 in Richards GSB Presentation, 26th Oct 2012, Campinas)

Expand those buffers!

And increase carbon stocks…

Riparian buffer on Bear Creek in Story County, Iowa

Source: USDA

Mosaic Planting of Eucalyptus plantation

What path to take?

Virtually all studies assessing the potential for sustainable **bioenergy** look for ‘unused,’ ‘degraded’ or ‘idle’ land to locate bioenergy crops onto.

In practice maximum value and utility may only be gained when biomass production for the **bioeconomy** is integrated directly into local agricultural (and livestock) systems

2 possible outcomes:

1. Bioenergy competes with food production and environmental resources or is marginalised to low productivity / high cost land
2. Bioenergy supports food production through close integration

It is dangerous to leave biomass supply to be a residual of demand signals

Tools & Solutions

Only smart policy + support for integrated (knowledge intensive) farming can enable option ‘2’. Do the policy proposals on the table offer this?

- 5% cap on conventional biofuels
- ILUC Factors

These options are too focussed on a ‘residual demand’ approach – too far removed from supply chain

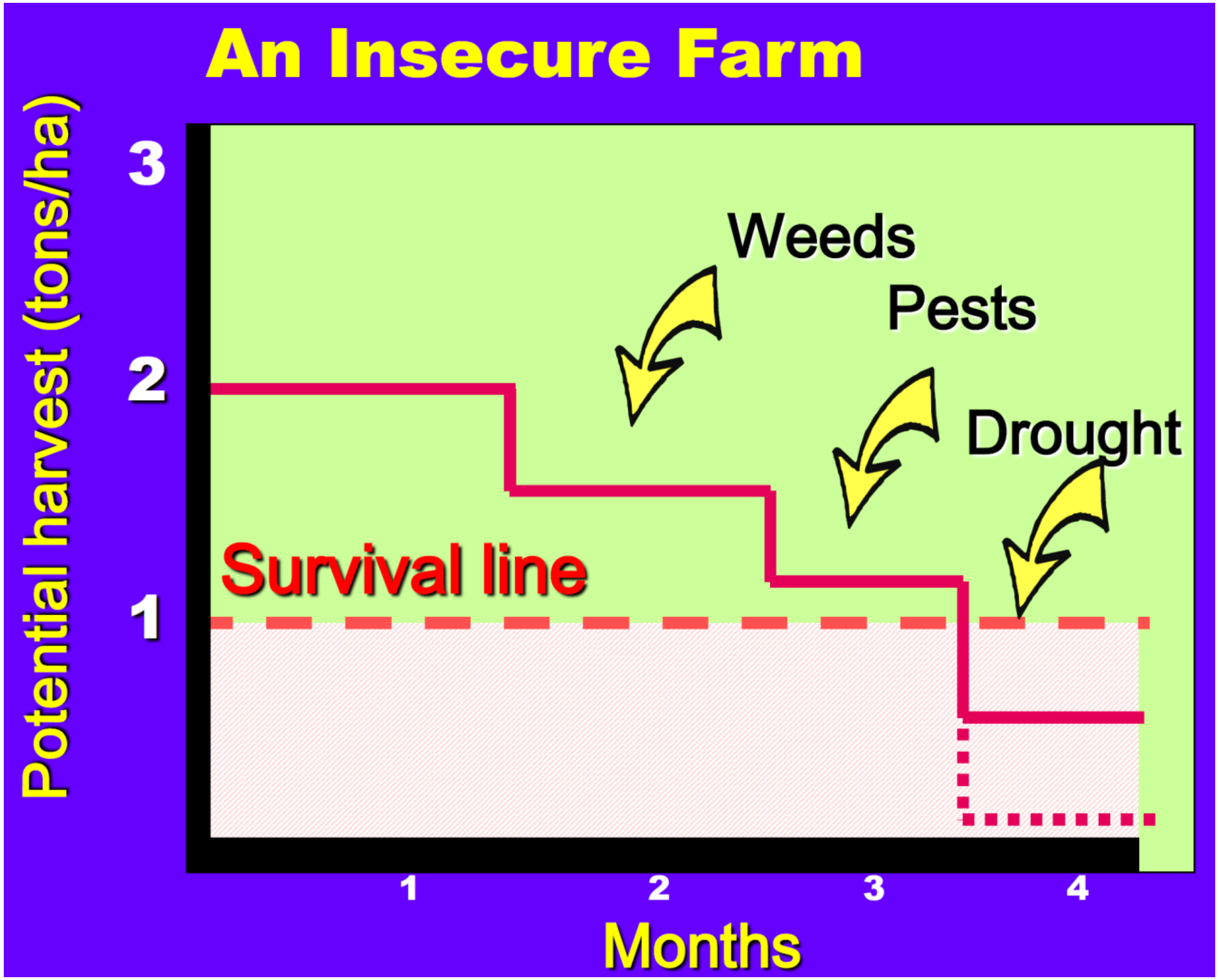
- support for advanced biofuels

Support needs to be at land-use level

Climate-KIC’s Bioeconomy Platform is working on 5 interlinked innovative solutions:

1. Farmer-level carbon stock management tools (possibly trading)- ‘high carbon landscapes’
2. Farm-to-landscape level nutrient ‘trading’ schemes and novel tools (water quality + soil erosion control)
3. Novel crops and cropping systems
4. Biorefining to maximise value, biomass conversion efficiencies and minimise losses
5. Policy-level interventions (e.g. revisions to RED, FQD, CAP, setting maximum daily nutrient loads, enabling farm/landscape level carbon / nutrient ‘trading’)

The social / developmental context is important e.g. Smallholder farming in Sub-Saharan Africa (Conway, 2013)



How do we build bioenergy into the core of sustainable rural livelihoods & across multiple scales?

Conway G. (2012). Can we feed the world sustainably?'

www.imperial.ac.uk/africanagriclutaruldevelopment

Bioenergy Development Options - scale matters

Large Scale

1. Sugarcane to EtOH
2. Palm / Soy Biodiesel

Integration & transition

Small Scale

1. Sweet Sorghum – micro-distillery
2. Woodlot gasification elec. (Hosahali)

Mill-owned estate

Very competitive globally

Little Value Added to Local Communities

Export potential

Small-holder led

Higher cost base
Less globally competitive

High Value Added to Local Communities

Export potential

Multi-product cropping

e.g. sweet sorghum

Economics Uncertain

Complex- Value Added to Local Communities High risk

Local Markets
Social Issues
Crop not well characterised

Single Bioenergy Product

e.g. multi-species woodlot

Value Added to Local Communities High Risk

Complex food-fuel-cash-crop interactions

Key constraints

- Technology innovation- some conversion technologies are mature but significant R&D is needed, particularly to reduce costs (e.g. Lynd, this meeting)
- Feedstock supplies: how much biomass is needed and where will those supplies come from? How to ensure these supplies are sustainably produced and not competitive with food?
- Perceptions around land constraints and adverse environmental impacts of increasingly intensive land management and biomass production systems (e.g. Foresight. The Future of Food and Farming (2011). The [UK] Government Office for Science, London.)
- A lack of an integrated perspective on the three ‘securities’- climate, energy & food and on role of landscape-level planning & management.
- Lack of scientific consensus
- Long term investment options, particularly for feedstock supply
- The social dimension – how to build bioenergy into sustainable development pathways. In particular how to reconcile different scales of implementation of agriculture and forestry production systems in different developmental contexts
- Bioenergy is uniquely placed to provide productive solutions to food, energy and climate security but not if we continue to develop a siloed non-integrational approach

Thank You

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- http://www3.imperial.ac.uk/icept
- www.climate-kic.org

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