Imperial College London

What are the key decision making criteria for bioenergy policy makers?
How can GSB's geospatial analysis help?

Jeremy Woods

GSB Workshop,

Oak Ridge National Laboratory

12th June 2013

eit Knowledge & Innovation Community
Climate-KIC

Key issues

- Food security: particularly in developing countries, investment urgently needed in energy service provision into agriculture – bioenergy is an enabler for food security (Lynd & Woods, A new hope for Africa. *Nature;* 2011)
- ‘Sustainable Intensification’ = New tools + perspective urgently needed to enable farmers to manage land sustainably. Agricultural landscape integration perspective is a major opportunity for innovative farming and new markets in both Developed and Developing countries.
  - How translatable are Brazilian agri-developments, sugarcane ethanol (plus CHP) and Integrated crop–livestock zero tillage systems (ICLZT; Landers, FAO, 2007), to African contexts?
  - What is the unique role for bioenergy?
- Investing in land is very risky (see Land Matrix; 2013)

EU Policy development(s): ILUC & food security

- Amendments to the Renewable Energy Directive (2009) being considered:
  - Strengthening of ‘sustainability criteria’
  - ILUC factors
  - Food crop cap

- Both the ILUC factors and food crop cap are aimed at limiting food security problems

Proposed revisions to the RED (October, 2012)

(COM(2012) 595 final)

- ‘The use of foodbased biofuels to meet the 10% renewable energy target of the Renewable Energy Directive will be limited to 5%. This is to stimulate the development of alternative, socalled second generation biofuels from non-food feedstock, like waste or straw, which emit substantially less greenhouse gases than fossil fuels and do not directly interfere with global food production.’
  - [is grandfathered i.e. current production is protected and which almost reaches the 5% limit now. Is likely to be lobbied upwards]
- ‘For the first time, the estimated global land conversion impacts – Indirect Land Use Change (ILUC) – will be considered when assessing the greenhouse gas performance of biofuels.’
  - [In my view far too simplistic to work- is a reporting requirement.]

THERE IS SUBSTANTIAL DISAGREEMENT ABOUT THE POTENTIAL SCALE OF BIOENERGY

Estimating the scale of impact(s)

	Units	Impact range
Energy provision	EJ	120 – 155[a]
	EJ	78 – 139[b]
Biomass supply needed	Gt oven dry biomass	7 – 9[c]
	Gross market value to supply industry	$700 Billion
Mitigation potentials[1]	Gt CO_2eq abatement/yr (C-neut)	4.5 – 9.0[d]
	Gt CO_2eq abatement/yr (50% savings)	2.2 – 4.5[d]
Land area demand est	Mha	220 – 860[e]

Notes:

a: median case scenario (IPCC SRREN. Chum et al. 2011)

b. van Vuuren et al 2012 (Cosust)

c. based on 18 GJ/odt biomass

d. mitigation potentials are estimated based on 1. 2009 energy and GHG emissions intensities (IEA ETP 2012) providing 2. an emissions factor for energy rated emissions of 58 million tonnes CO_2eq per EJ primary energy supplied in 2009. 'C-neut' = Carbon neutrality of bioenergy (savings of 58 MtCO_2eq/EJ Bioenergy); and '50% savings' = 29 MtCO_2eq/EJ savings c.f. 2009 baseline (note Table 2.13, Chum et al 2011 SRREN).

e. order of magnitude assumption based on Murphy et al, 2011. Low estimate is based on achieving 20odt biomass/ha (similar to current Brazilian sugarcane and eucalyptus yields @ 18 GJ/odt) to provide 78EJ. High estimate based on supply of 155EJ at yield of 10odt/ha. Note that net land demand estimates for bioenergy are complex and uncertain due to likely use of low value biomass derived from residues and wastes and that could be generated by more efficient use of biomass in alternative sectors and from traditional bioenergy and through technological innovation. In practice, in our opinion, net land demand is likely to be at the lower end of the scale above and could be lower than the low estimate provided

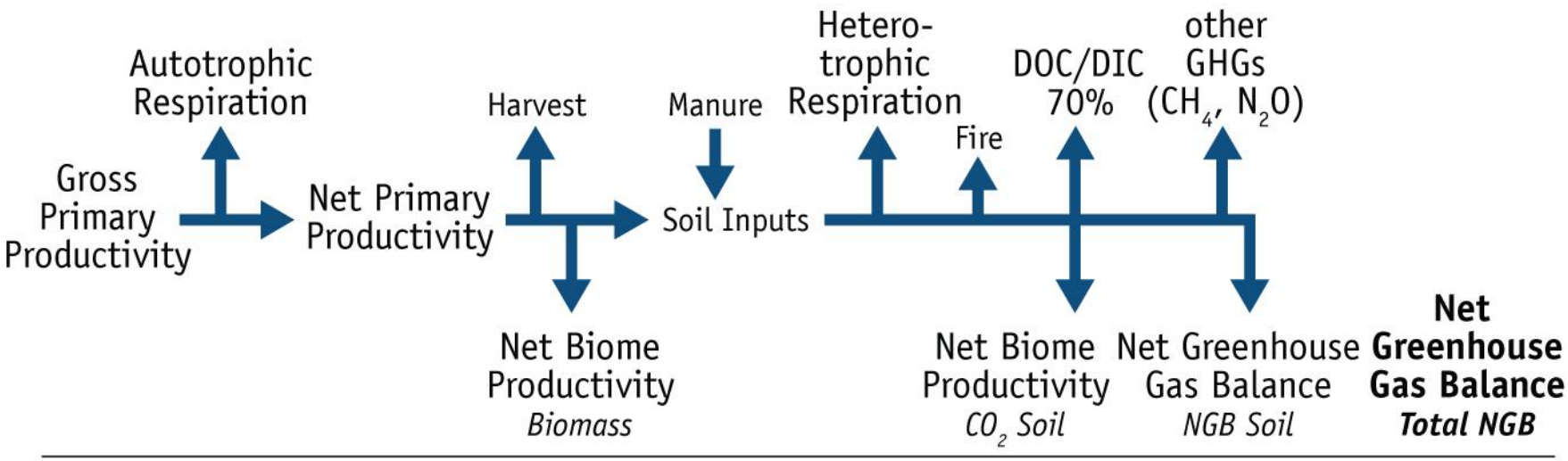
[1] Note: Chum et al (IPCC SREN, 2011) state; 'Carbon mitigation potential. The mitigation potential for electricity generation from biomass reaches 1,220 Mt CO2eq for the year 2030, a substantial fraction of it at costs lower than USD2005 19.5/t CO2. From a top-down assessment, the economic mitigation potential of biomass energy supplied from agriculture is estimated to range from 70 to 1,260 Mt CO2eq/yr at costs of up to USD2005 19.5/t CO2eq, and from 560 to 2,320 Mt CO2eq/yr at costs of up to USD2005 48.5/t CO2eq. The overall mitigation from biomass energy coming from the forest sector is estimated to reach 400 Mt CO2/yr up to 2030.

Global human appropriation of NPP doubled in the 20thC (Krausmann, Erb, Haberl, Searchinger et al, PNAS 2013)

A 250 EJ/y bioenergy scenario by 2050 would increase HANPP from 27-29% to 44% and caution against a further increase. Conclude that:

- *Bioenergy at levels contemplated by the International Energy Agency and in IPCC-SRREN would have a transformative effect on the planet. As the world faces large new demands for food and timber products, that experience suggests caution in refocusing the energy economy on bioenergy, and stresses the importance of developing improved practices for sustainable intensification of land use.*

Is HANPP the right perspective?
Will not all be a direct draw-down of NPP



Schulze et al., 2009

Humans, animals and crops are ‘leaky’ and much biological carbon (and nutrients) can be recycled and reused.

Still, overall global photosynthetic productivities must be raised or NPP will be mined.

Can we model NPP and its offtake more acurately?

Understanding potentials

Jayant Sathaye (Lawrence Berkley and IPCC) outlines the following progression from theoretical to practical / realisable potentials:

1. Biological/theoretical potential
2. Technological potential
3. Economic potential
4. Ecological potential
5. Realistic potential/implementation

ICCT (2013): A POLICY-ORIENTED REASSESSMENT OF BIOENERGY POTENTIAL ESTIMATES.

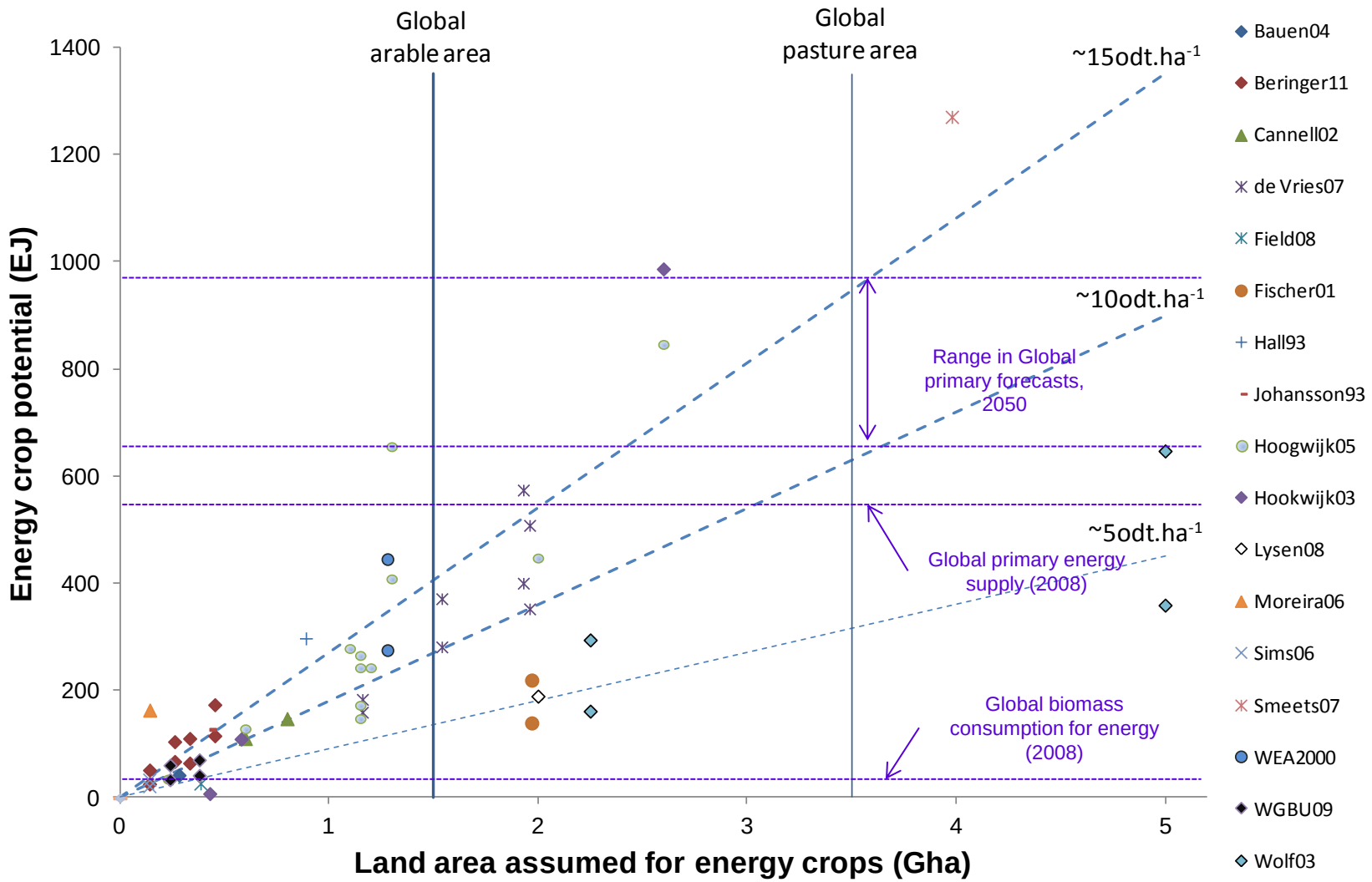
For EP ENVI Committee Hearing, 20th Feb 3103.

Key modelling assumptions reviewed:

1. Future Demand for Food, Water, and Materials
2. Food crop yield gains
3. Energy crop yield gains
4. Environmental concerns
5. Harvesting and transport logistics
6. Costs
7. Political feasibility

'we find that the realistic and sustainable potential of **global primary bioenergy in 2050 may be about 100 EJ yr^{-1}**, which, converted to **biofuel using current technology would be ~37 EJ yr^{-1}**. This finding suggests that current projections for biofuel demand in 2050 may be overly optimistic.'

Energy crop yield estimates vs land demand estimates. Slade et al. 2011 (UKERC)



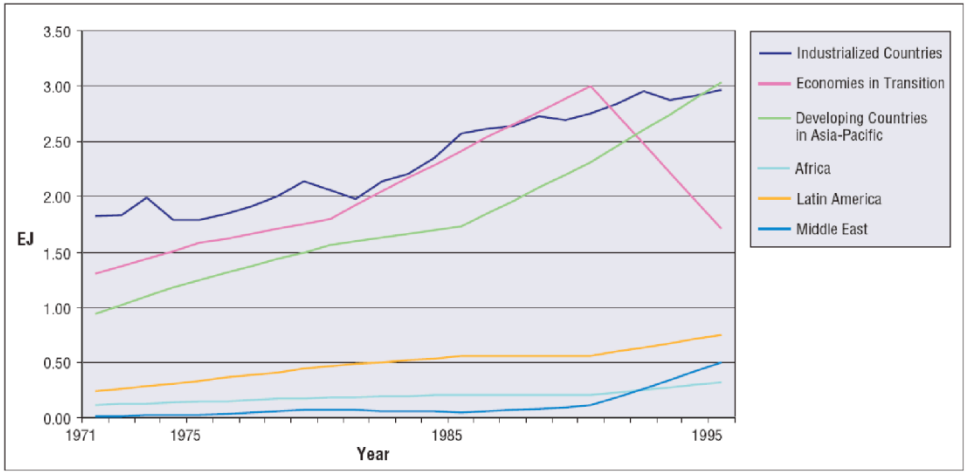
Slade et al. (2011) Energy from biomass: the size of the global resource. Imperial College Centre for Energy Policy and Technology & UK Energy Research Centre, London

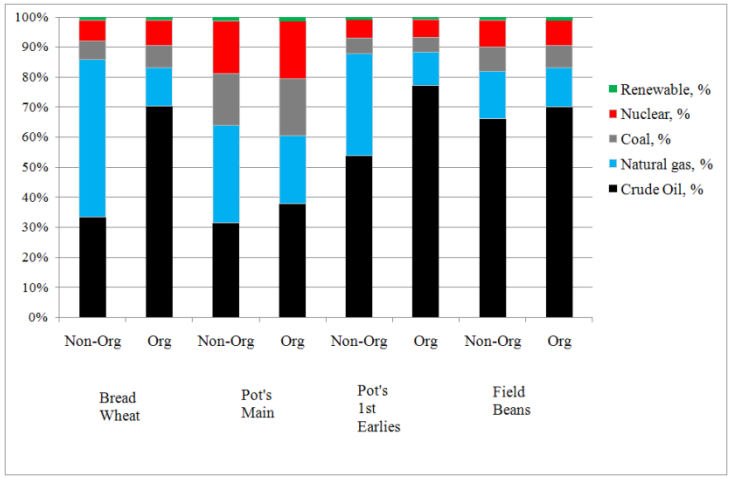
Four ways to expand biomass supply

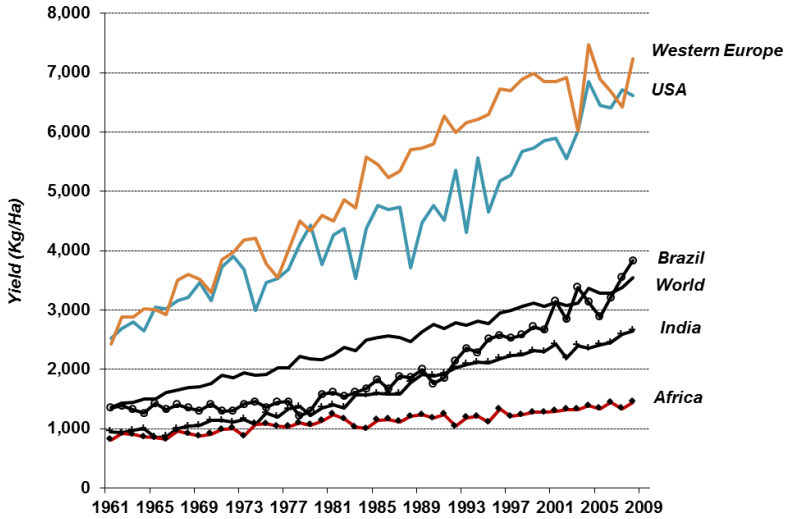
1. Increase the area of land used to grow biomass
2. Increase the yield of crops
3. Exploit ‘waste’
4. Increase efficiency / resilience

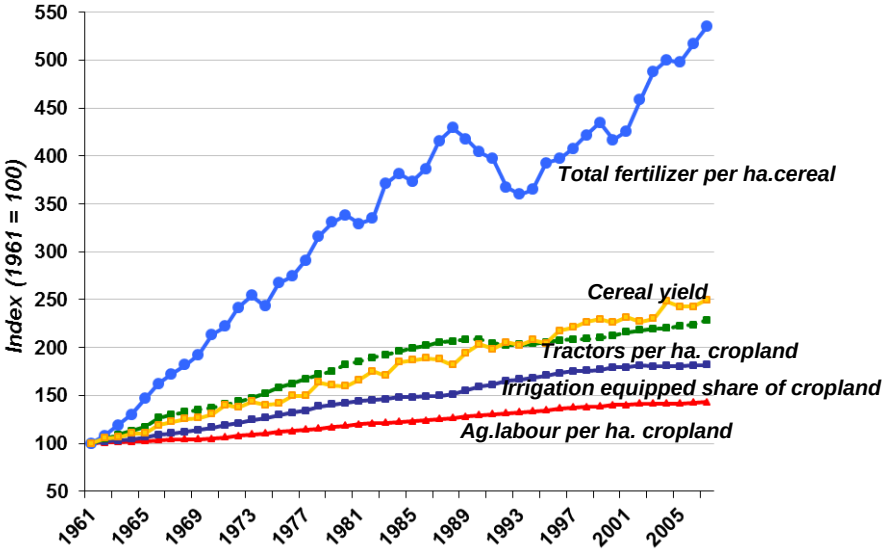
Most existing assessments focus on ‘1’ or ‘2’: in practice will be a combination of all four options:
E.g. Zambia, 2010, 2011 and 2012 (Jayne GFS 2012):
‘In 2010, 2011, the government of Zambia spent 2-3% of GDP stabilising food prices. In 2012, Zambia had a 1.5 million tonne maize surplus… however it only has the capacity to export 70k tonnes per month, taking 20 months to export the 1.5 million tonnes by which time most would be unsuitable for human consumption…’

Intensification, energy demands and agricultural yields



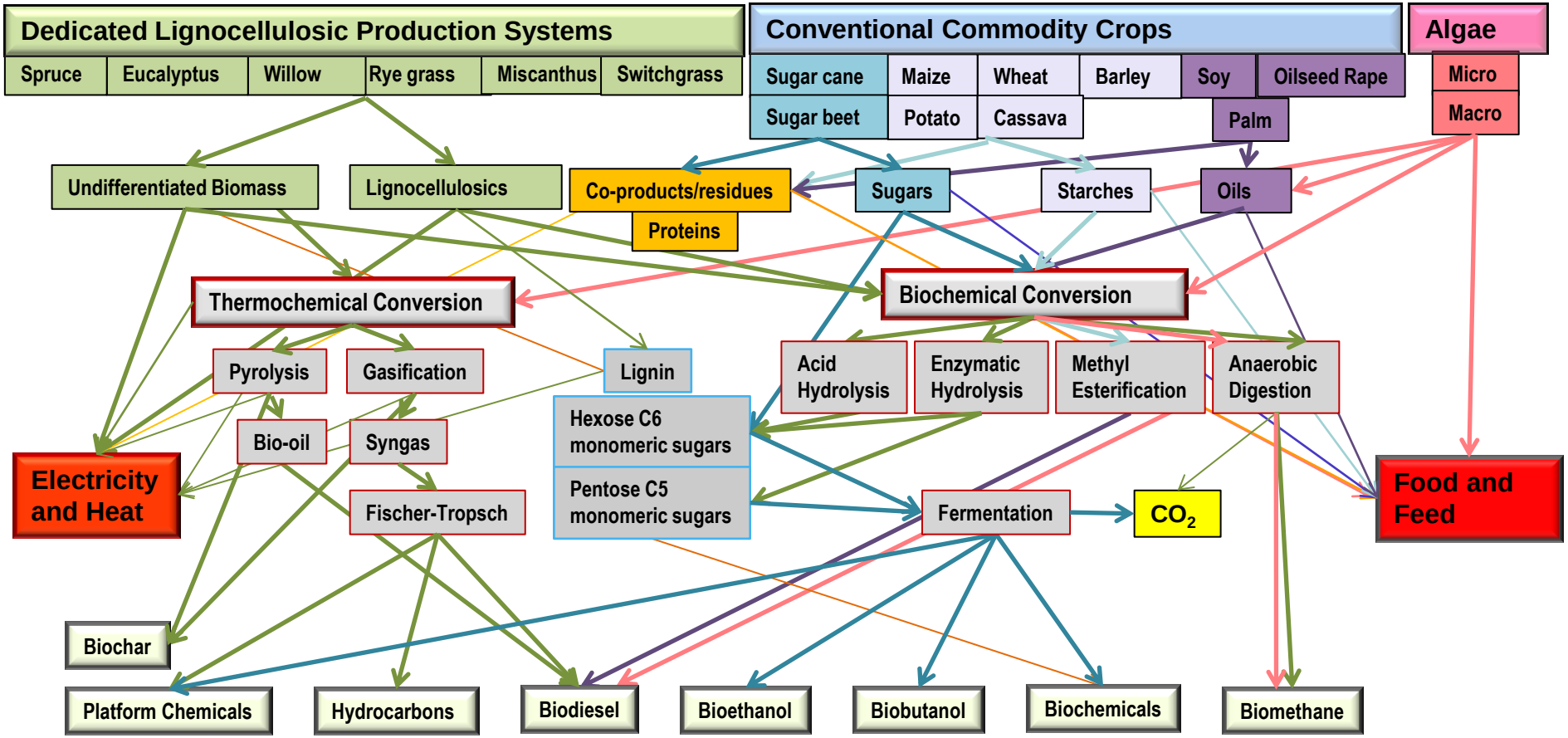






Feedstock and technology pathways for biorenewables:

Many options, opportunities and threats!

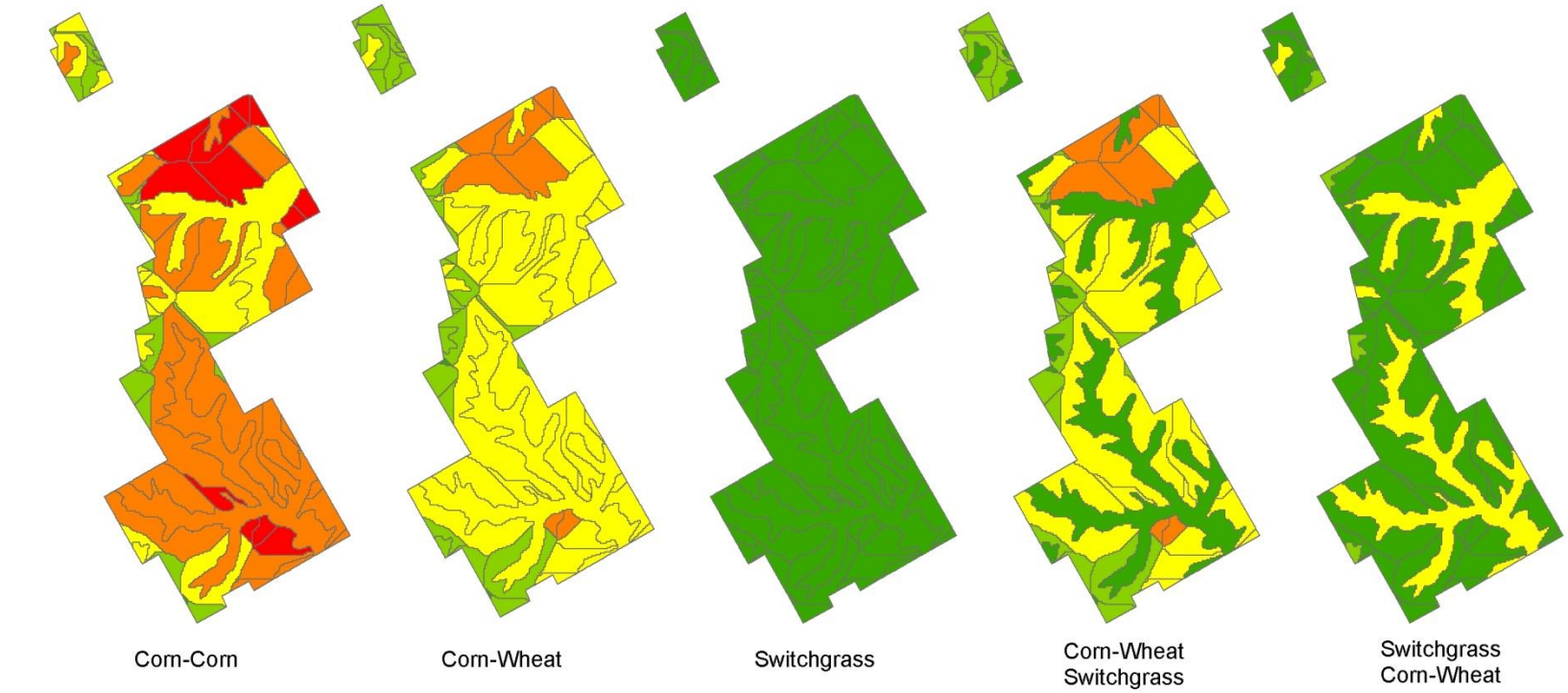


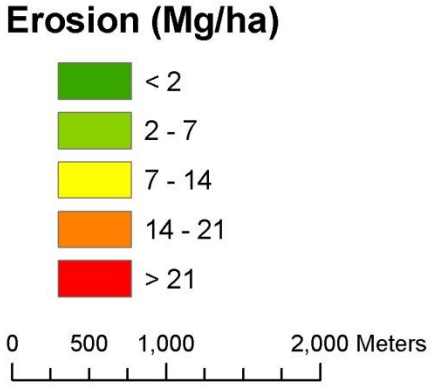
House J.I., et al. Chapter 7. Mitigating climate risks by managing the biosphere. In: Cornell S.E., Prentice C.I., House J.I., Downy C.J. (Eds) Understanding the Earth System. CUP. 2012. ISBN:9781107009363

4 major problems in agriculture: What should industry do?

- Stagnating yields
  - Increased demand more likely to be provided by increased land area
  - Yield gaps need closing + continued research and development
  - Increased cost of oil
- 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 GHG emissions
- [loss of high quality land to urbanisation. Cassman, 2012]

Current policy uncertainty has halted growth & investment in biofuels.
Solution: A new perspective on integrated land management needs to be developed.
Industry must be pro-active rather than re-active.





Erosion: Onsite Impacts

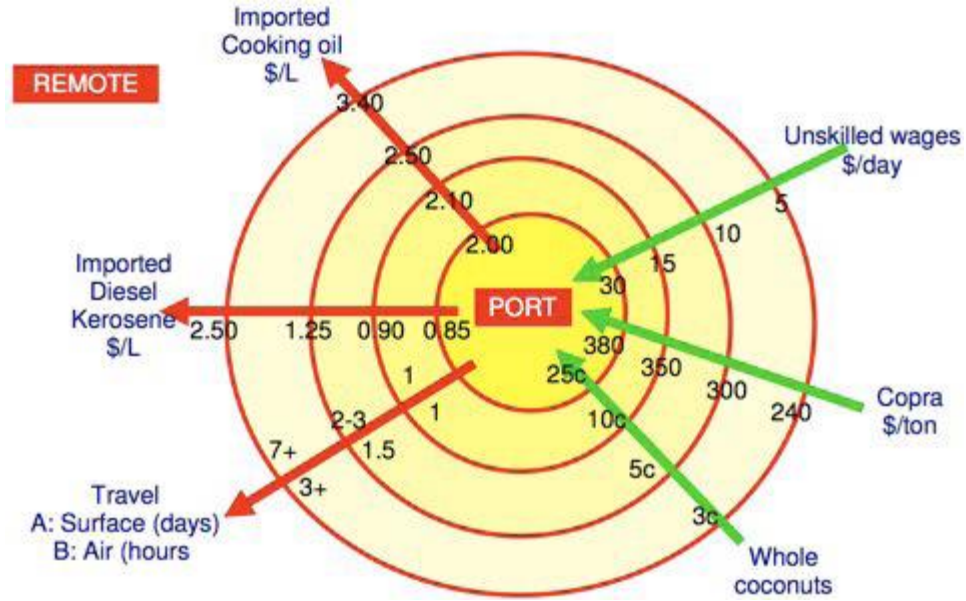
- Cropping systems / tillage control erosion
- erosion can be highly localized
- perennial bioenergy crops locations

Tom Richard (Penn State) quoting Kemanian 2009

WHERE WILL THE INVESTMENTS COME FROM?

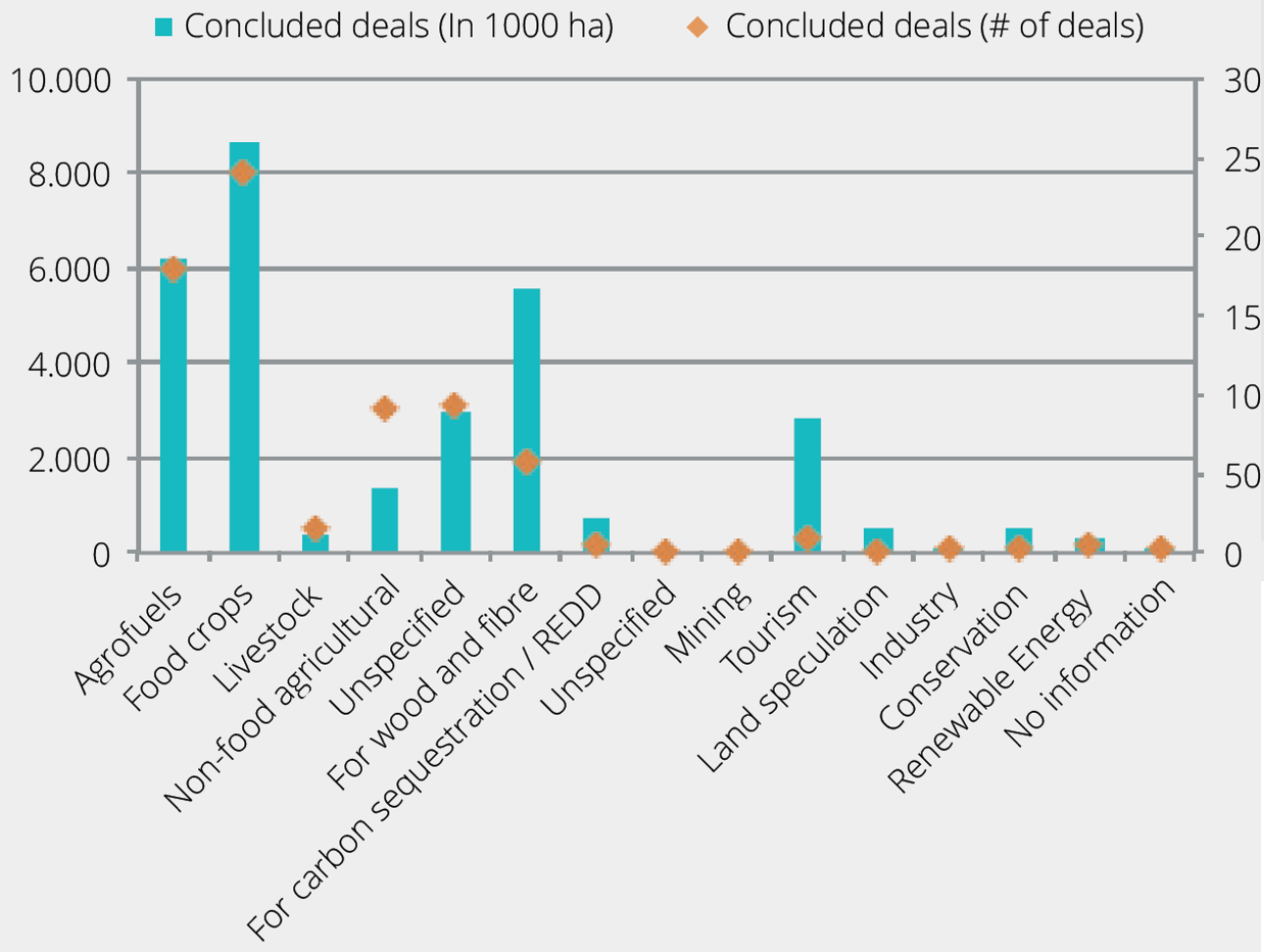
The need for locally produced energy in agriculture

'The rural double penalty'



Over the 40 years to 2010, per capita world food production grew 17%, while in Africa it fell 10%, as population growth outstripped agricultural output. A major problem faced by African farmers is the steep cost of transport, which means that African farmers pay two to six times the global cost of fertilisers.

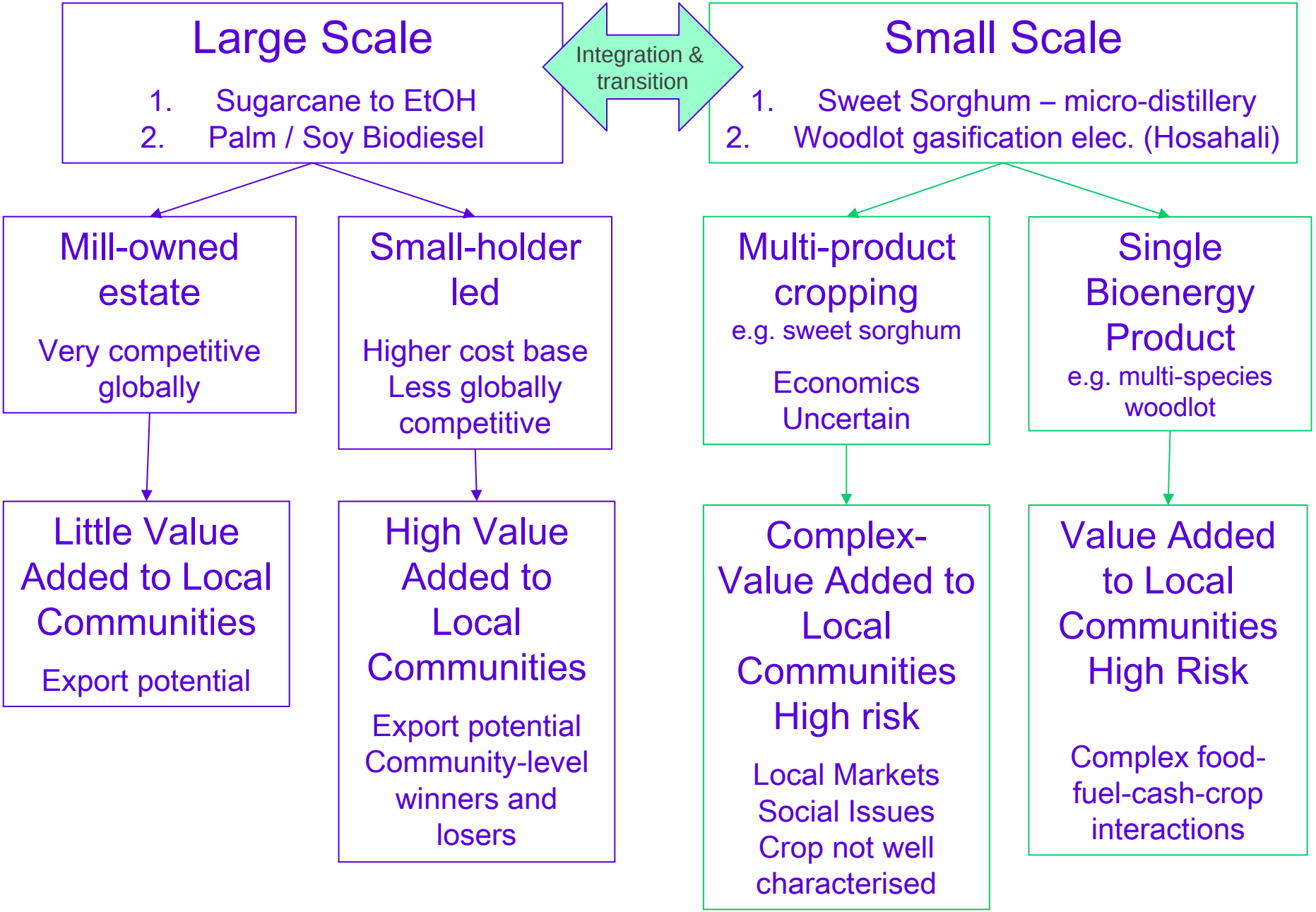
Investing in land or 'land grabbing'? (Land Matrix)



- An important number of deals starts operating on a contracted area of 14.4 million ha.
- So far, only little area actually come under production (1.7 million ha, i.e. only about 5 %).
- Significant failures at implementation stage can be observed.

Land Matrix Newsletter, June 2013. www.landmatrix.org
See also: http://www.bbc.co.uk/news/science-environment-22839149

Bioenergy Development Options - scale matters



Basis for sampling

Africa is Huge!

The following countries could fit within Africa:

	Area (sq. mi)
China	3,705,390
United States	3,618,770
India	1,266,595
Europe	1,905,000
Argentina	1,065,189
New Zealand	103,736
	11,664,680 sq. mi
	or 30,211,551 km^2

Africa's area: 11,707,000 sq. mi.
or 30,321,130 km^2

Copyright 1998 W. Bediako Lamouse-Smith and Joseph School

Thank You

The Economist, 24th June 2010

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

- Alongi Skenhall, S., Berndes, G., and Woods, J. (2013), Integration of bioenergy systems into UK agriculture - new options for management of nitrogen flows. *Biomass and Bioenergy* 54:219-226. Doi: j.biombioe.2013.04.002
- Lynd & Woods, Perspective: A new hope for Africa. *Nature* (2011) 474. doi:10.1038/474S020a)
- Murphy,R.J. Woods,J., Black,M.J., and McManus,M. Global developments in the competition for land from bio-fuels. *Food Policy* (2011) 36 S52–S61. doi: 10.1016/j.foodpol.2010.11.014.
- Woods,J., Williams,A., Hughes,J.K., Black,M.J., Murphy,R.J. Energy and the Food System. *Phil Trans R. Soc. B*. (2010) **365**, 2991-3006. doi:10.1098/rstb.2010.0172
- Smith, P., et al. Competition for Land. *Phil Trans R. Soc. B*. (2010) **365**, 2941-2957. doi:10.1098/rstb.2010.0127
- 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. Global Change Science for Application. Cambridge University Press. (2012). ISBN:9781107009363. http://www.cambridge.org/9781107009363
- Slade, R. et al. Energy from biomass: the size of the global resource (2011). Imperial College Centre for Energy Policy and Technology and UK Energy Research Centre, London. ISBN: 1 903144 108