137 experts from 24 countries

Land use
Feedstocks
Technologies
Benefits & Impacts
Policy

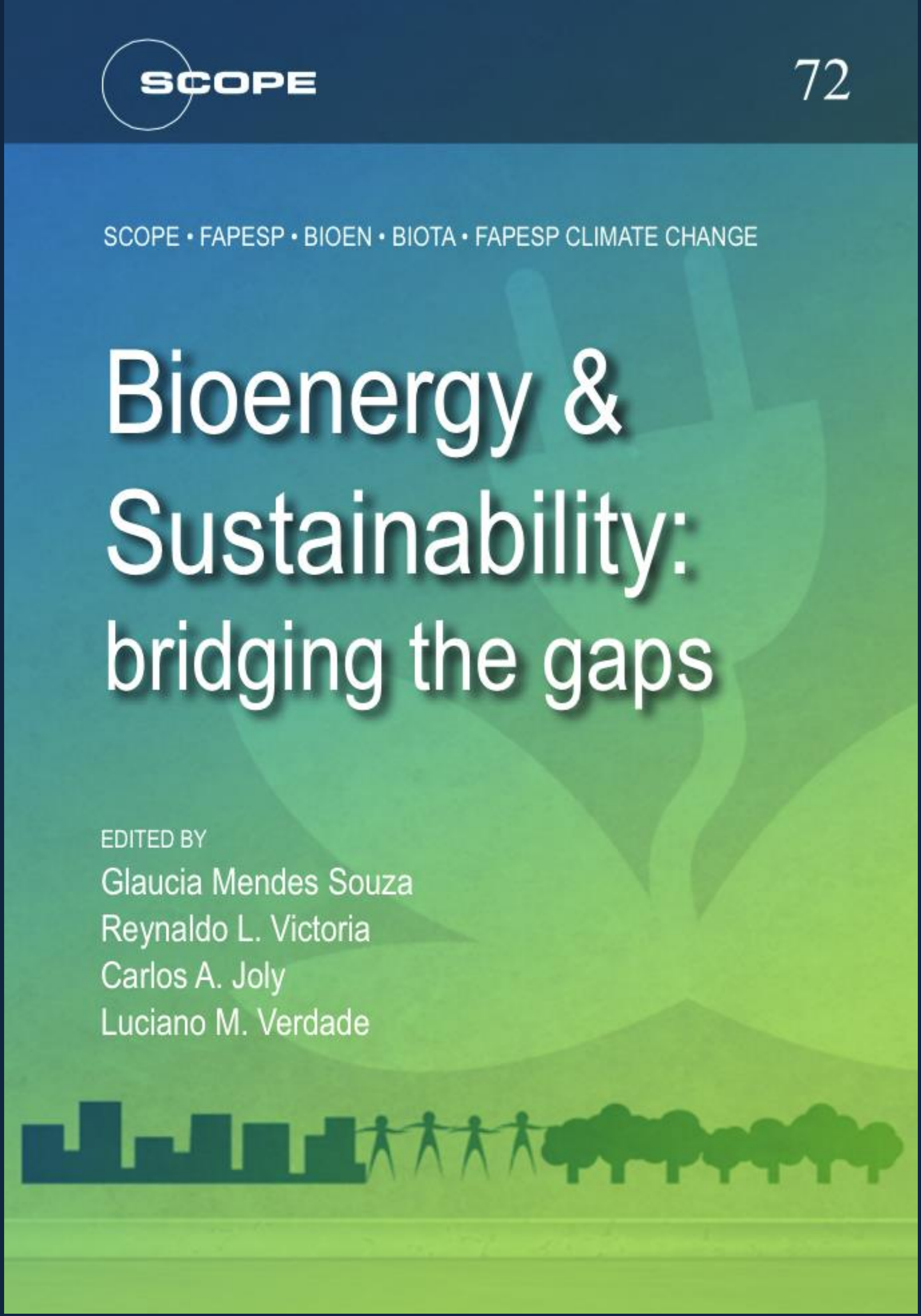
Bioenergy now
Bioenergy expansion
Energy security
Food security
Environmental and climate security
Sustainable development & Innovation

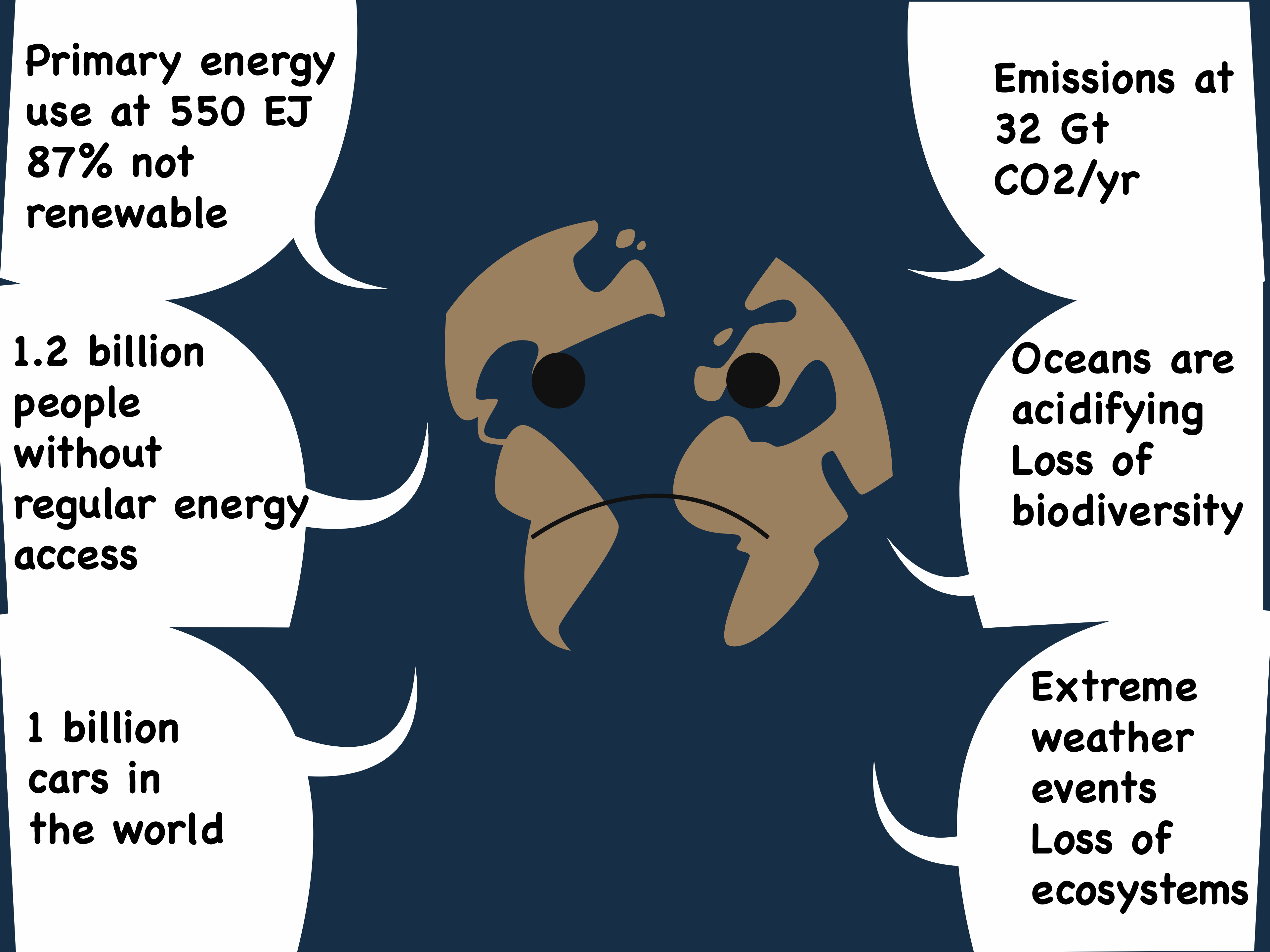
Developed and developing regions

Numbers, cases, solutions, gaps of knowledge, the much needed science to maximize bioenergy benefits

779-page Ebook

Download at http://bioenfapesp.org




Primary energy use at 550 EJ
87% not renewable
1.2 billion people without regular energy access
1 billion cars in the world
Emissions at 32 Gt CO2/yr
Oceans are acidifying
Loss of biodiversity
Extreme weather events
Loss of ecosystems

Climate change is arguably the biggest environmental and developmental challenge facing humankind.
Urgent action is needed to limit future warming to 2ºC, and the longer such action is delayed the more difficult it becomes.

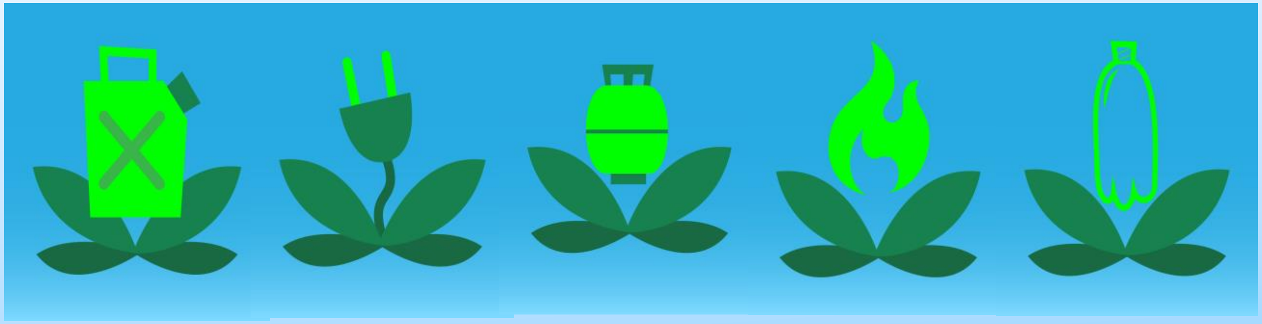
"Double the share of renewable energy, double efficiency improvement rate, and give universal access to modern energy by 2030."

SE4ALL: Sustainable Energy for All (United Nations Program)

Bioenergy now: only 4% of primary energy use, just under 2% of oil equivalent for the globe as a whole but expect it to grow to 25-30% by 2035-2050.

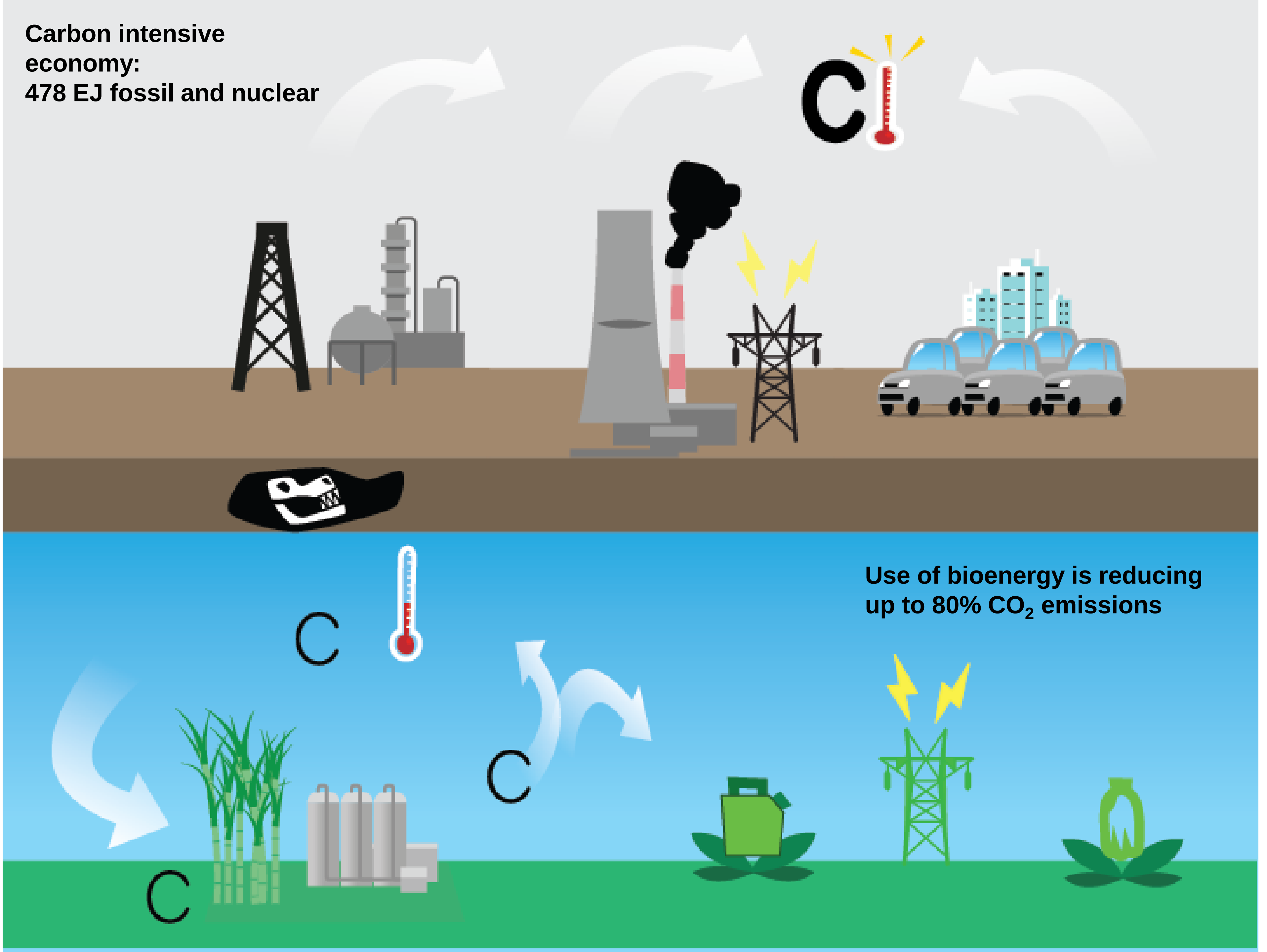
Our low carbon future

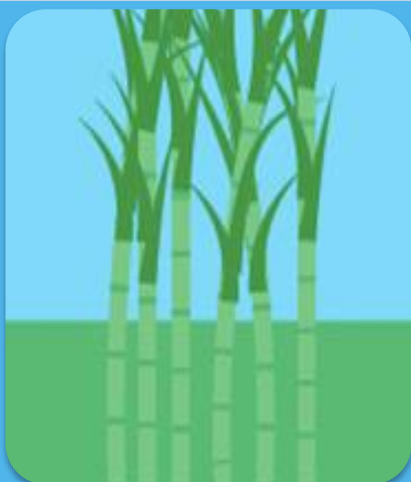
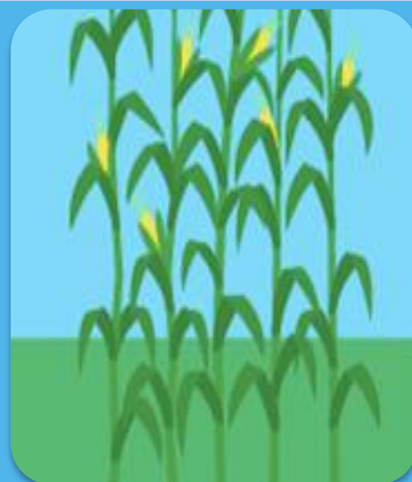
Today mankind has at its disposal an astounding variety of new applications and technology platforms for transforming biomass into efficient and valuable energy services across most end-use sectors.

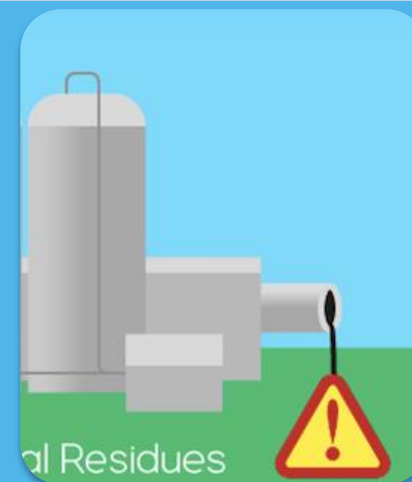


Large-scale displacement is possible within major markets

- 50 countries, including many developing countries, now have biofuels mandates, many driven by climate change.
- USA: biofuels represent almost 10% of the volume of gasoline used in vehicles
- Brazil: biofuels represent almost 40% of the volume of gasoline used in vehicles
- Scandinavia: 20% of the total energy supply in Sweden.


Carbon intensive economy:
478 EJ fossil and nuclear
Use of bioenergy is reducing up to 80% CO_2 emissions



Biofuels - over 100 Billion L – 4.2 EJ - less than 1% of our primary energy use

Sugarcane Ethanol
Up to 7,200 L/ha

GHG emissions 80% lower than gasoline

Maize Ethanol

Up to 3,900 L/ha

GHG emissions 35-52% lower than gasoline

Conventional Ethanol
83 Billion L
3.1 EJ
6.8 Million Ha of land

Oil Palm, soy, rape Biodiesel

Up to 5,700 L/ha

GHG emissions

29-65% lower than diesel

Biodiesel
23 Million tonne
1.1 EJ
6.3 Million Ha of land

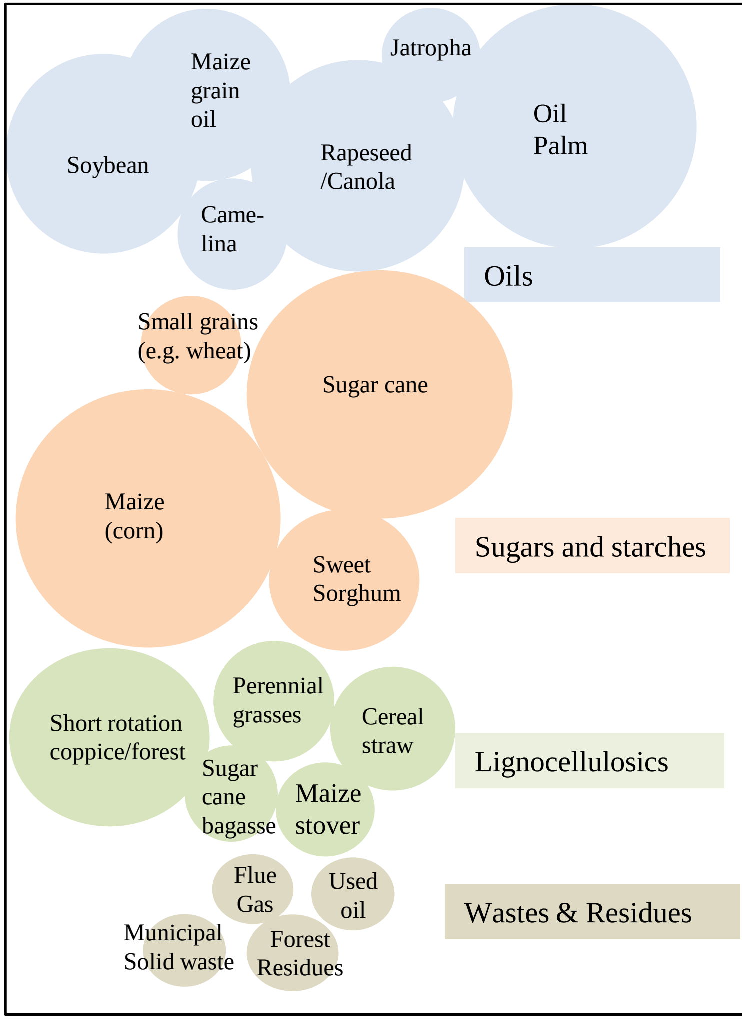
Waste Oil Renewable Diesel (HVO)

GHG emissions

45-70% lower than diesel

HVO
6 Million tonne
0.1 EJ
<0.1 Million Ha of land

Macedo, Nassar et al.Chapter 17 Green House gas emissions



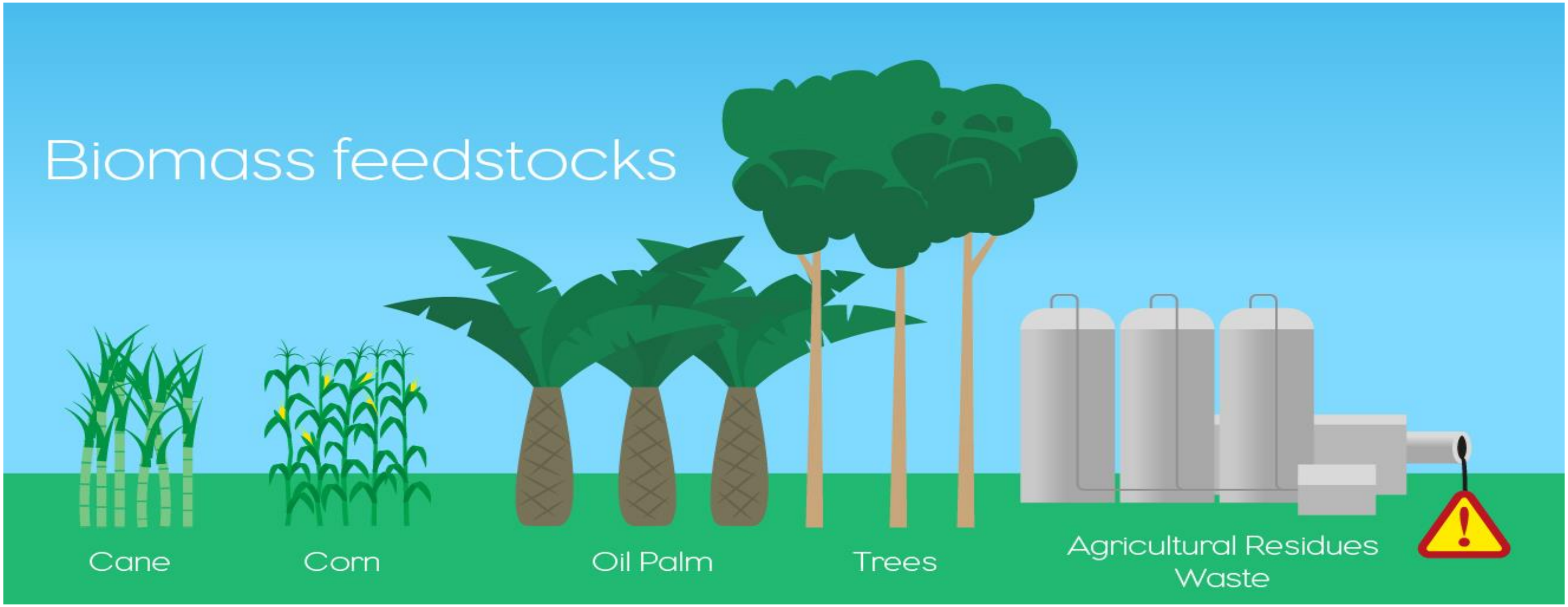
	Usage	Technical costs	Development time	Sustainability
Oils	Transport Fuels	L	L	L-M
Sugars and starches	Transport Fuels	L	L	L-H
Lignocellulosics	Heat & Power	L	H	M-H
	Transport Fuels	H	H	M-H
Wastes & Residues	Heat & Power	L	L	M-H
	Transport Fuels	H	L	M-H

Promoting high yielding bioenergy crops that are more efficient in their use of water and soil nutrients

Expand bioenergy production synergistically with food production, by encouraging the diversification of farmed landscapes that provide multiple environmental benefits

Long, Karp et al, Chapter 10, Feedstocks

Agroforestry integration



Integrated food/forest/energy systems, i.e. growing energy crops and food or fiber crops in synergy, can be accomplished with:

- spatial approaches (strategic placement on the landscape)
- temporal approaches (crop rotations and succession plantings)
- at a system level, with residue recovery, nutrient and energy recycling and waste reduction addressing sustainability challenges of our conventional food and energy systems.

Harmonizing forestry and agriculture policies is fundamental for the implementation of integrated approaches to sustainable production and supply of bioenergy.

Richard and El-Lakany, Chapter 13

Integrated new biorefinery systems are on the way: no carbon waste!

Wood pellet production as of 2011 has grown to 22 million metric tons (1 EJ)

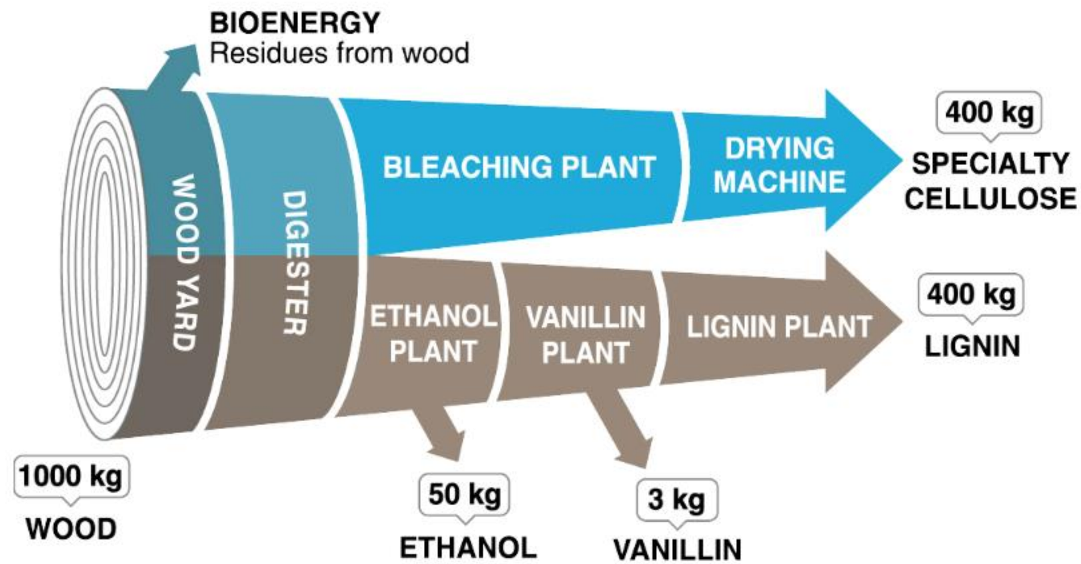
Lignocellulosic biofuels are going through first commercialization stages

Production of biobased chemicals and co-products may help decrease costs of advanced biofuels production

Bio/thermo/chemical catalytic conversion integrated processes to produce renewable transportation fuels

If high throughput plants can be mass produced at small to medium scales, their environmental footprints could become smaller and the cost may be reduced sufficiently for chemicals applications.

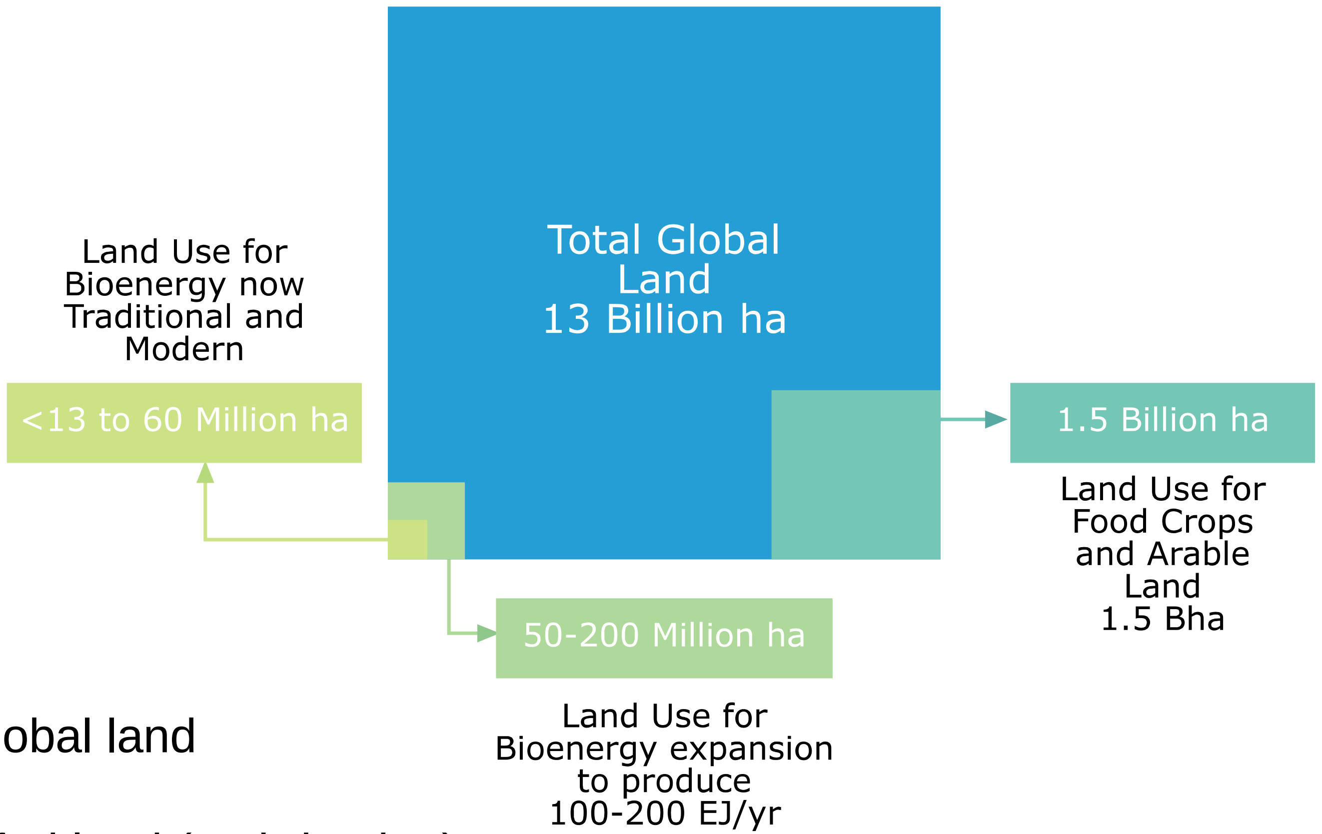
Lignin conversion to chemicals and materials also offers potential additional value streams for an integrated biorefinery, with a range of possible renewable aromatics, which are common building block molecules produced currently from fossil fuels.



Specialty cellulose	Lignin	Vanillin	Bioethanol
Construction materials	Concrete additive	Food	Car care
Cosmetics	Animal feed	Perfumes	Paint/varnish
Food	Agrochemicals	Pharmaceuticals	Pharmaceutical industry
Tablets	Batteries		Biofuel
Textiles	Mining		
Filters	Oil field chemicals		

Chapter 12 – Convertion Technologies and Engines
Chum, Nigro et al

At a global level, land is not a constraint but availability is concentrated in two main regions, Latin America and Sub-Saharan Africa.
This land is being used predominantly for low intensity animal grazing.

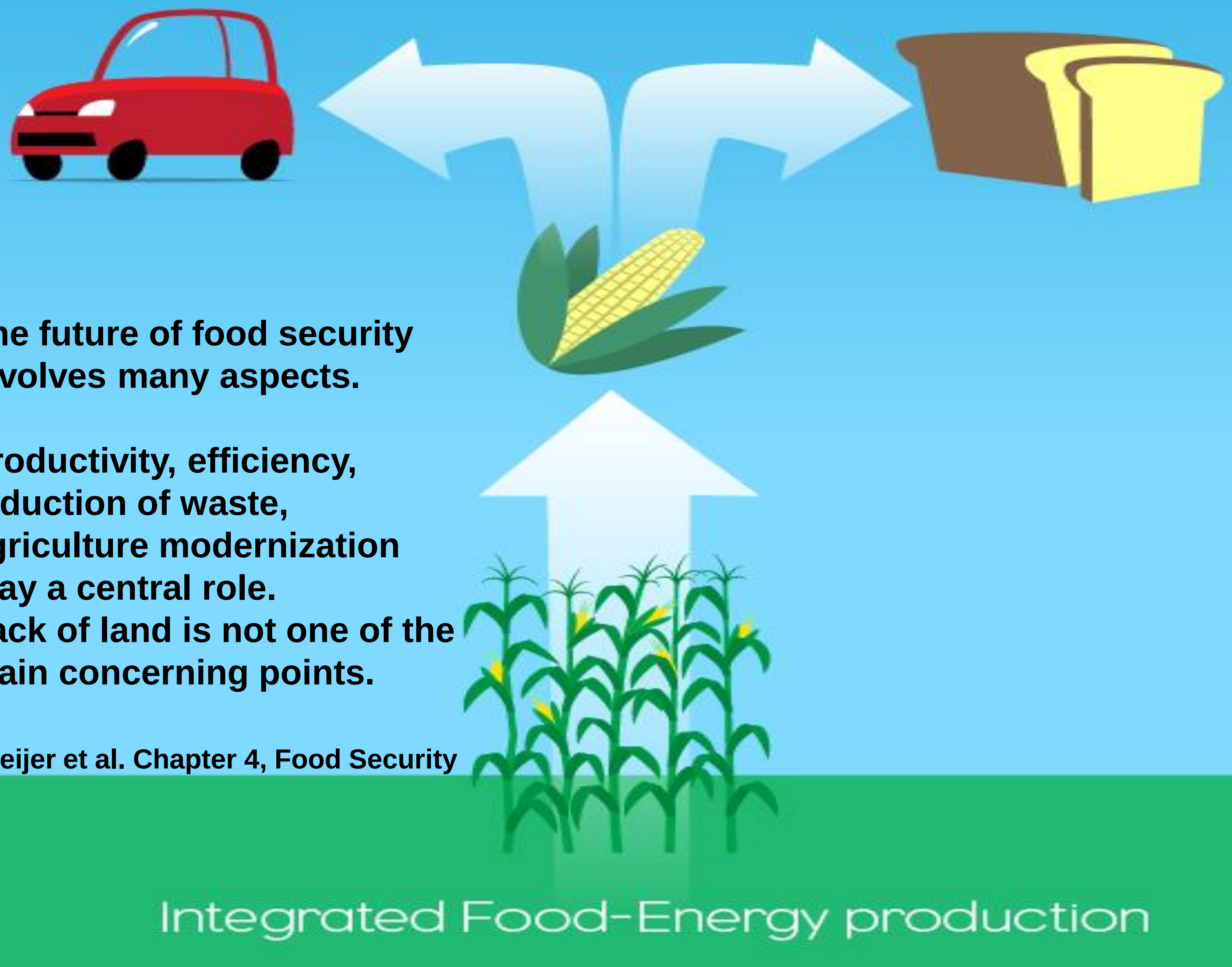


0.4 to 1.5% of global land
or
5 to 20% of rainfed land (no irrigation)

Woods et al. Chapter 9, Land Use


Existing pastureland could support almost four times the numbers of animals. Bringing the poorest-performing pastures up to 50% of their maximum attainable density would more than double the global stock of grazing animals.
CO_2
CO_2
C
Actions to improve pasture conditions, along with livestock production intensification, can effectively make large amounts of land available for alternative uses.

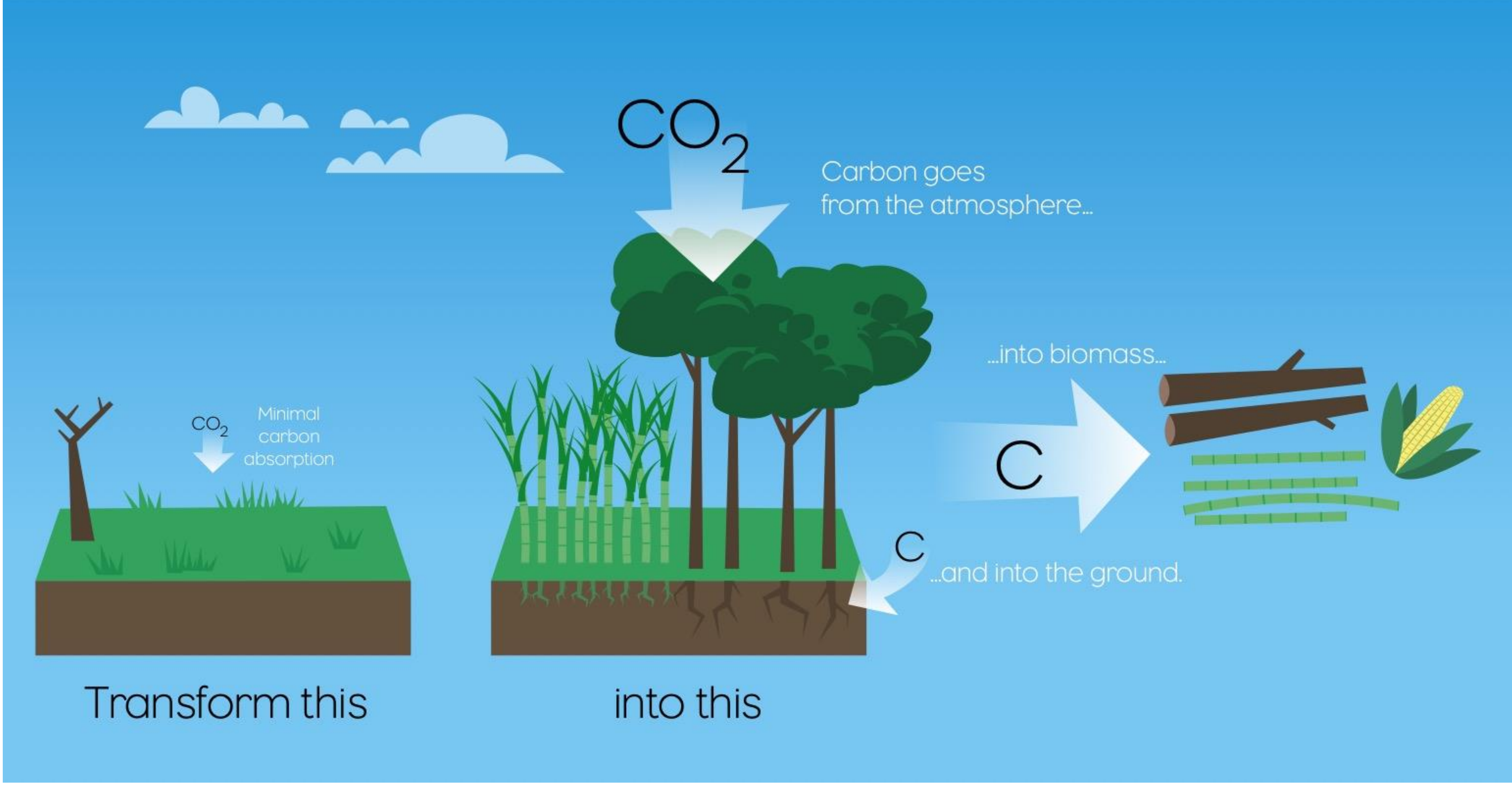
Land IS available to produce bioenergy



The future of food security involves many aspects.

Productivity, efficiency, reduction of waste, agriculture modernization play a central role.
Lack of land is not one of the main concerning points.

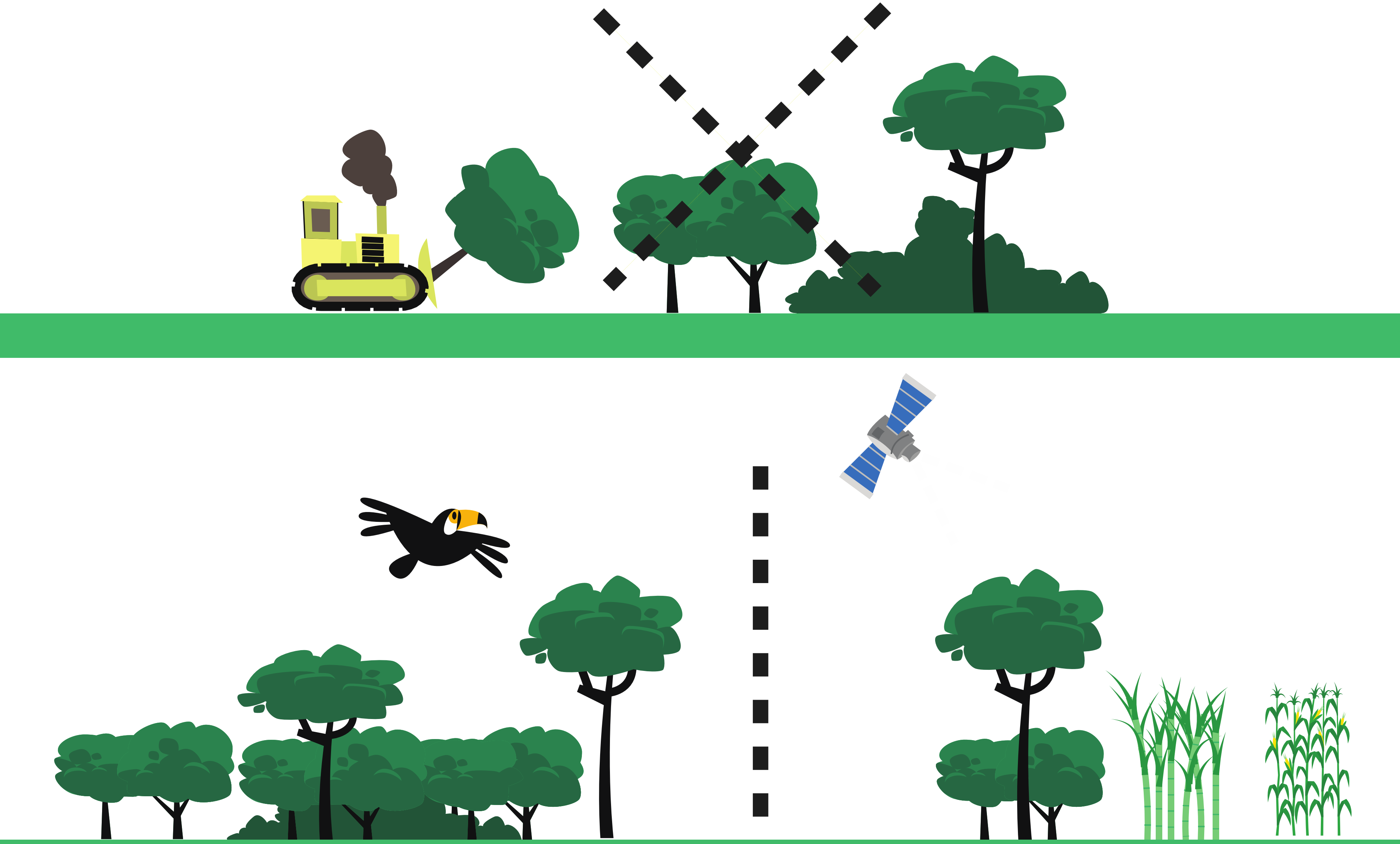
Osseweijer et al. Chapter 4, Food Security



Gross estimates of the potential for energy crops on possible surplus good quality agricultural and pasturelands range from 140 to 290 EJ/yr.

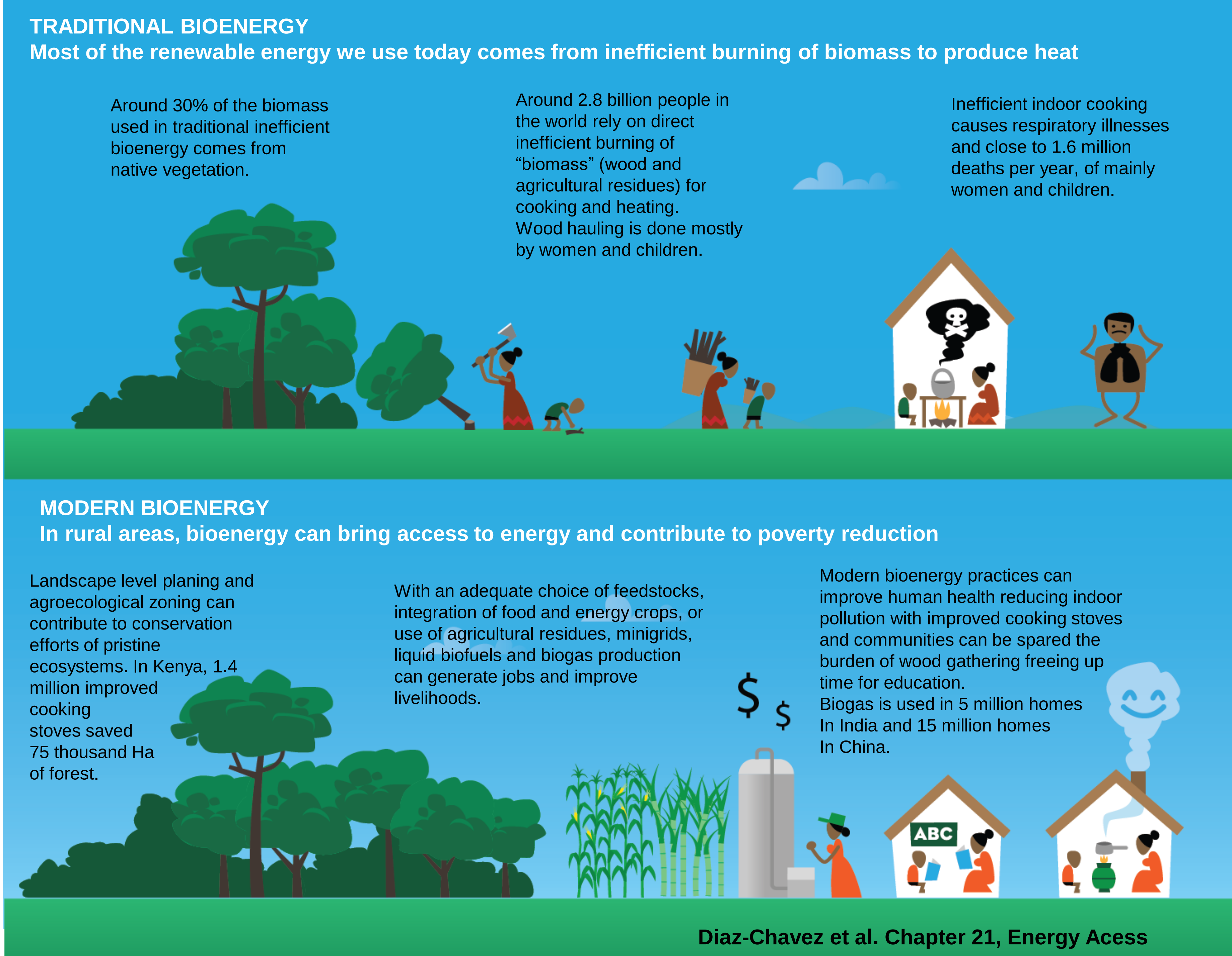
The potential contribution of water-scarce, marginal and degraded lands could amount to 80 EJ/yr.

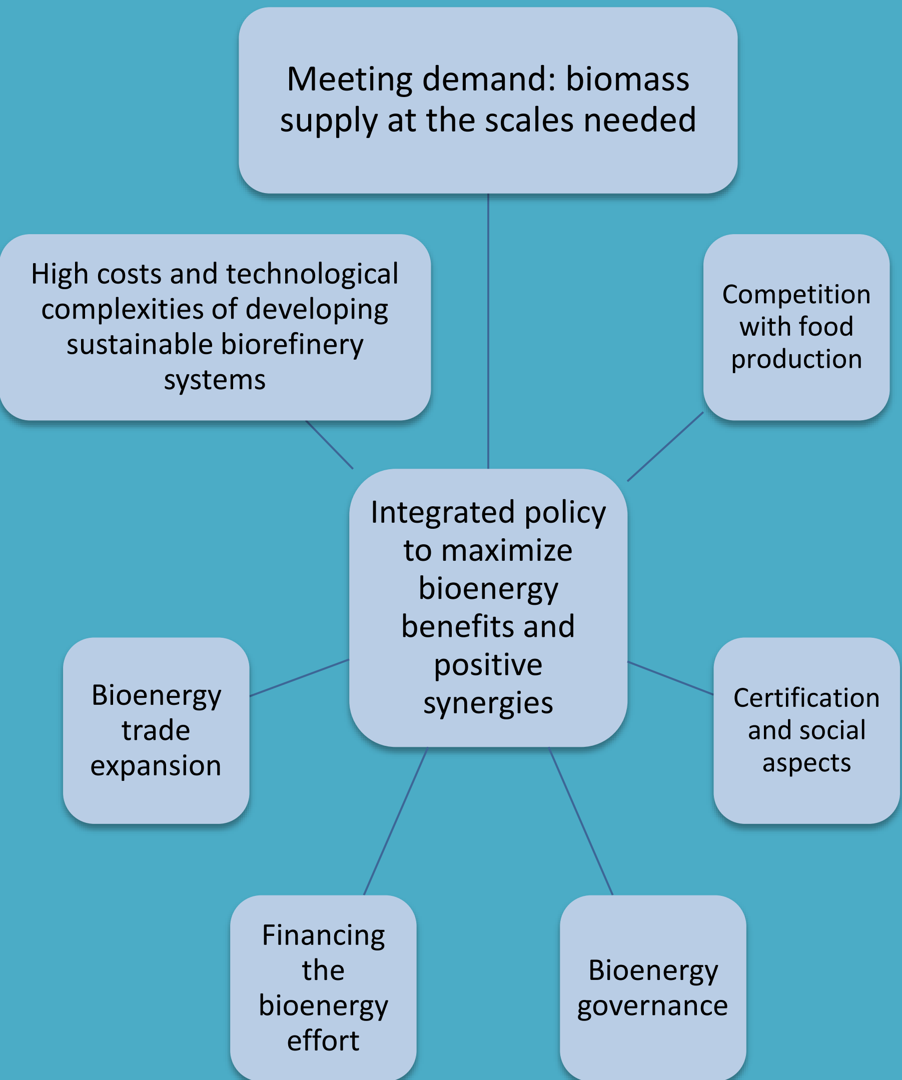
Breeding for "future-climate" resilience and extensive testing of feedstocks in expansion areas is needed.



Conservation of biodiversity is paramount

Joly et al.Chapter 16 Biodiversity and Ecosystem Services


TRADITIONAL BIOENERGY
Most of the renewable energy we use today comes from inefficient burning of biomass to produce heat
Around 30% of the biomass used in traditional inefficient bioenergy comes from native vegetation.
Around 2.8 billion people in the world rely on direct inefficient burning of “biomass” (wood and agricultural residues) for cooking and heating. Wood hauling is done mostly by women and children.
Inefficient indoor cooking causes respiratory illnesses and close to 1.6 million deaths per year, of mainly women and children.
MODERN BIOENERGY
In rural areas, bioenergy can bring access to energy and contribute to poverty reduction
Landscape level planing and agroecological zoning can contribute to conservation efforts of pristine ecosystems. In Kenya, 1.4 million improved cooking stoves saved 75 thousand Ha of forest.
With an adequate choice of feedstocks, integration of food and energy crops, or use of agricultural residues, minigrids, liquid biofuels and biogas production can generate jobs and improve livelihoods.
Modern bioenergy practices can improve human health reducing indoor pollution with improved cooking stoves and communities can be spared the burden of wood gathering freeing up time for education.
Biogas is used in 5 million homes In India and 15 million homes In China.
ABC
Diaz-Chavez et al. Chapter 21, Energy Acess



chapter 1

SCOPE Bioenergy & Sustainability

Technical Summary

Glaucia Mendes Souza[a†], Reynaldo L. Victoria[a], Luciano M. Verdade[a], Carlos A. Joly[b], Paulo Eduardo Artaxo Netto[a], Carlos Henrique de Brito Cruz[b,c], Heitor Cantarella[d], Helena L. Chum[e], Luis Augusto Barbosa Cortez[b], Rocio Diaz-Chavez[f], Erick Fernandes[g], Geoffrey B. Fincher[h], José Goldemberg[a], Luiz Augusto Horta Nogueira[i], Brian J. Huntley[j], Francis X. Johnson[k], Stephen Kaffka[l], Angela Karp[m], Manoel Regis L. V. Leal[n], Stephen P. Long[o], Lee R. Lynd[p], Isaias de Carvalho Macedo[b], Rubens Maciel Filho[b], André M. Nassar[q], Francisco E. B. Nigro[a], Patricia Osseweijer[r], Tom L. Richard[s], Jack N. Saddler[t], Jon Samseth[u], Vikram Seebaluck[v], Chris R. Somerville[w], Luuk van der Wielen[r], Marie-Anne Van Sluys[a], Jeremy Woods[f], and Heather Youngs[w]

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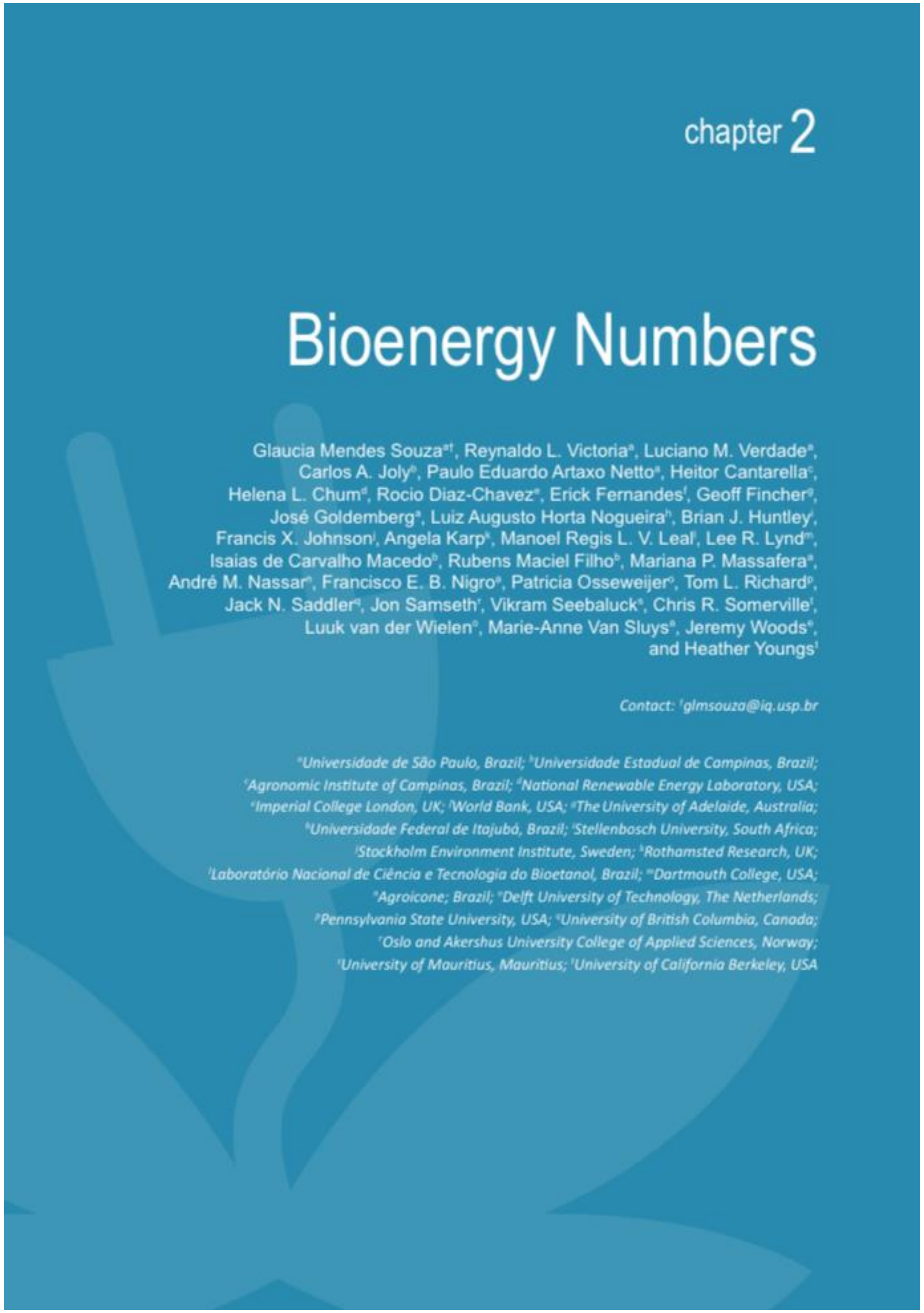

chapter 2

Bioenergy Numbers

Glaucia Mendes Souza[a†], Reynaldo L. Victoria[a], Luciano M. Verdade[a], Carlos A. Joly[b], Paulo Eduardo Artaxo Netto[a], Heitor Cantarella[c], Helena L. Chum[d], Rocio Diaz-Chavez[e], Erick Fernandes[f], Geoff Fincher[g], José Goldemberg[a], Luiz Augusto Horta Nogueira[h], Brian J. Huntley[i], Francis X. Johnson[j], Angela Karp[k], Manoel Regis L. V. Leal[l], Lee R. Lynd[m], Isaias de Carvalho Macedo[b], Rubens Maciel Filho[b], Mariana P. Massafera[a], André M. Nassar[n], Francisco E. B. Nigro[a], Patricia Osseweijer[o], Tom L. Richard[p], Jack N. Saddler[q], Jon Samseth[r], Vikram Seebaluck[s], Chris R. Somerville[t], Luuk van der Wielen[o], Marie-Anne Van Sluys[a], Jeremy Woods[e], and Heather Youngs[t]

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Chapter 2 - Bioenergy Numbers

The Brazilian Experience with Sugarcane Ethanol
The Role of Private Sector in Technology Development and Transfer
Implementation of Self Benchmarking Programs
The Cane Payment System
Recycling Vinasse through Fertirrigation
Use of Idle Land between Harvest and Planting of New Cane with nitrogen fixing crops

Biofuels from Agricultural Residues: Assessing Sustainability in the USA Case

Comparison of Biogas Production in Germany, California and the United Kingdom

Wood Pellets and Municipal Solid Waste Power in Scandinavia

Surplus Power Generation in Sugar/Ethanol Mills: Cases in Brazil and Mauritius
Bioelectricity from Sugarcane in Brazil: Evolution and Current Situation
Bio Electricity from Sugarcane in Mauritius: Progress and Prospects

The African Experience
Malawi, Mozambique, Zambia, Tanzania, Ethiopia, Sierra Leone, Zimbabwe
Jatropha Projects in Southern Africa

The Asia Experience
Thailand's Experience in Bioethanol Promotion
Palm in Malaysia: Combined Effects of Scale on Biomass Logistics and Conversion Costs


chapter 14

Case Studies

Manoel Regis L. V. Leal[*a†], Louis Jean Claude Autrey[b], Bundit Fungtammasan[c], Douglas L. Karlen[d], Isaias de Carvalho Macedo[e], Graham von Maltitz[f], David J. Muth Jr[g], Jon Samseth[h], Zilmar José de Souza[i], Luuk van der Wielen[j], and Heather Youngs[k]

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Integration of Sciences for Bioenergy to Achieve its maximum Benefits

Integrated Policy

Sustainable Biomass Supply

Feedstocks

Logistics

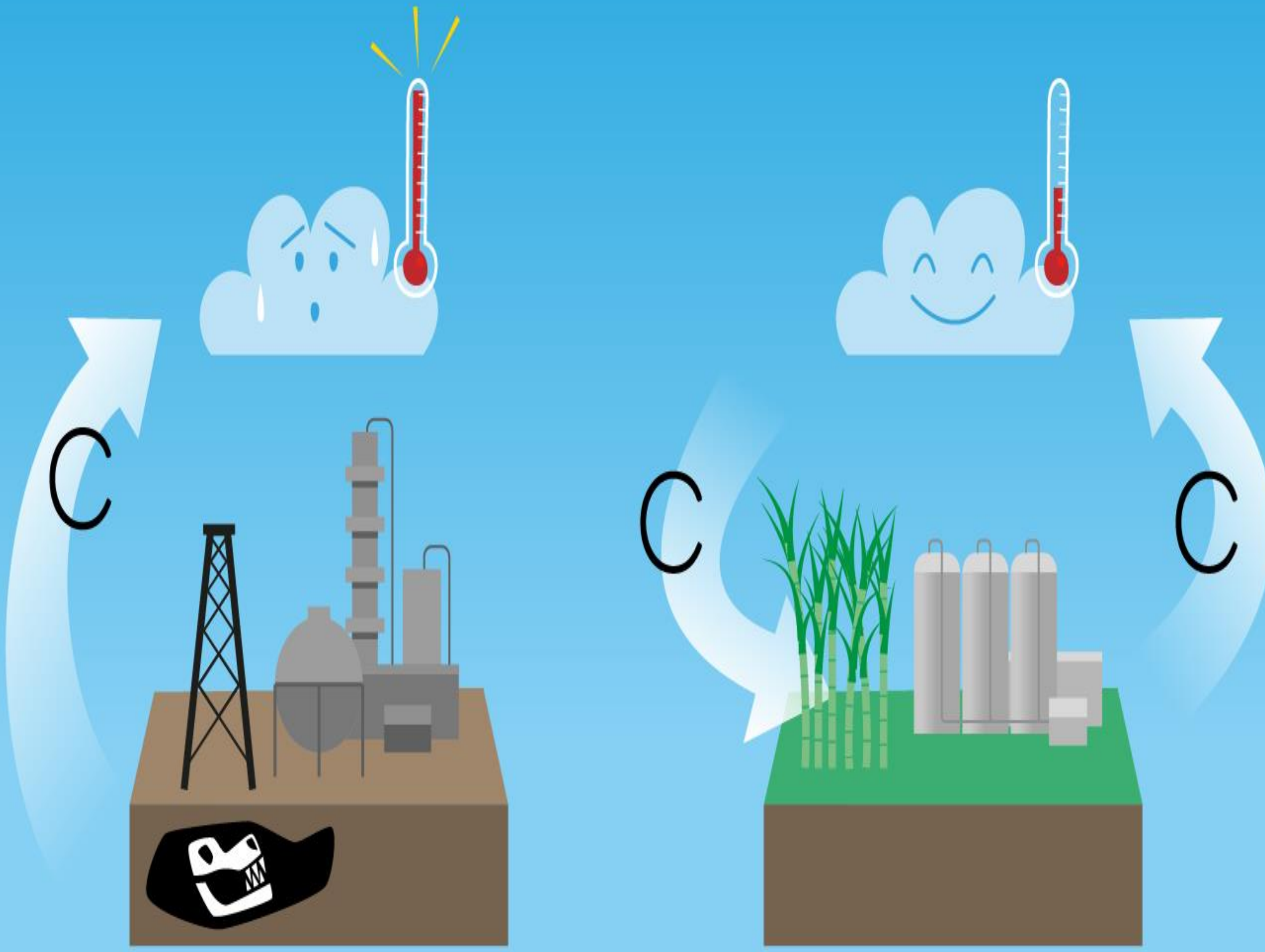
Technologies

Exploring Social and Environmental Benefits

Research on biomass production to increase yields	Research on biomass mobilization and fuels distribution	Research on conversion to energy, chemicals and co-products	Research on impacts
Biotechnology for energy crops	Harvest	Full biomass utilization	Land use changes
Cropping intensification	Transportation	Biochemical conversion	Carbon and nutrient cycles
Breeding	Storage	Thermochemical conversion	Biodiversity
Agro-forestry Integration	Densification	Hybrid systems	Emissions
Integrated food-energy systems	Pre-processing	Scaling-up	Pollutants
Pasture intensification	Matching feedstock to conversion process	Mills and Plants	Ecosystem services
Landscape level planning	Fully renewable processes	Resource use water energy	Livelihoods
Resource use water nitrogen	Infrastructure	Recycle or use of co-products	Policy
	Logistics	Integrated systems	Costs
		Biorefineries	Financing
		Engines	Trade

Souza et al. Chapter 7 – Much Needed Science

Bioenergy is advancing sustainability across the planet in pollutants reduction, energy efficiency, recycling, water use, development of a bioeconomy, reduction of emissions



It is time to get the bioenergy wagon rolling!

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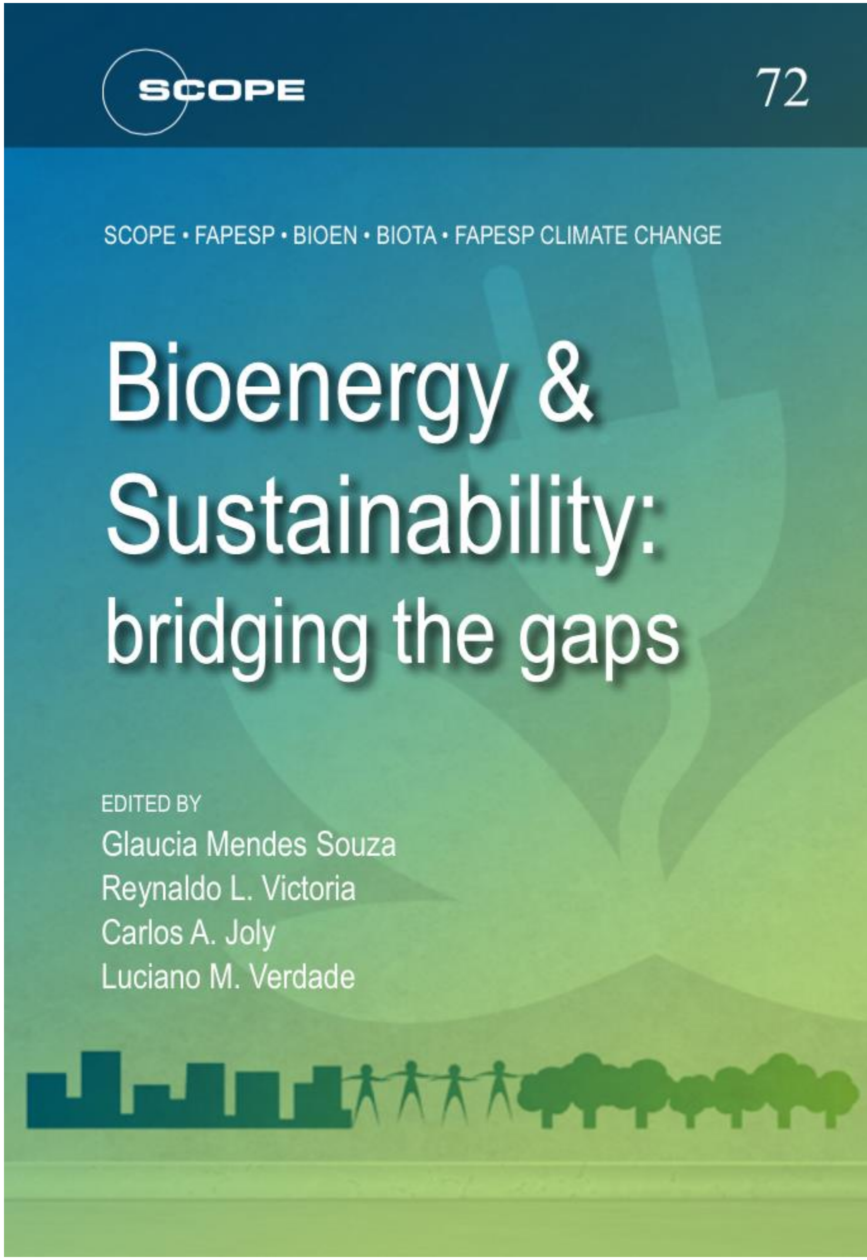

Global assessment of Bioenergy & Sustainability:
FAPESP BIOEN, BIOTA and Climate Change Programs in collaboration with SCOPE
Scoping meeting and Industry hearing: February 2013, at FAPESP, SP

Global assessment of Bioenergy & Sustainability:
FAPESP BIOEN, BIOTA and Climate Change Programs in collaboration with SCOPE
International RAP Workshop: December 2-6, 2013, at UNESCO, Paris

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