Perennial biomass crops for energy and for climate positive regenerative agriculture

Session 3 – Sustainable biomass feedstock base in Europe – Opportunities and challenges
European Technology and Innovation Platform Bioenergy
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www.bioenergycrops.com Emiliano Maletta / CEO director@bioenergycrops.com

Bioenergy Crops Ltd. is an international group founded in 2012. We focus on the production, evaluation and optimization of biomass from residues and dedicated plantations

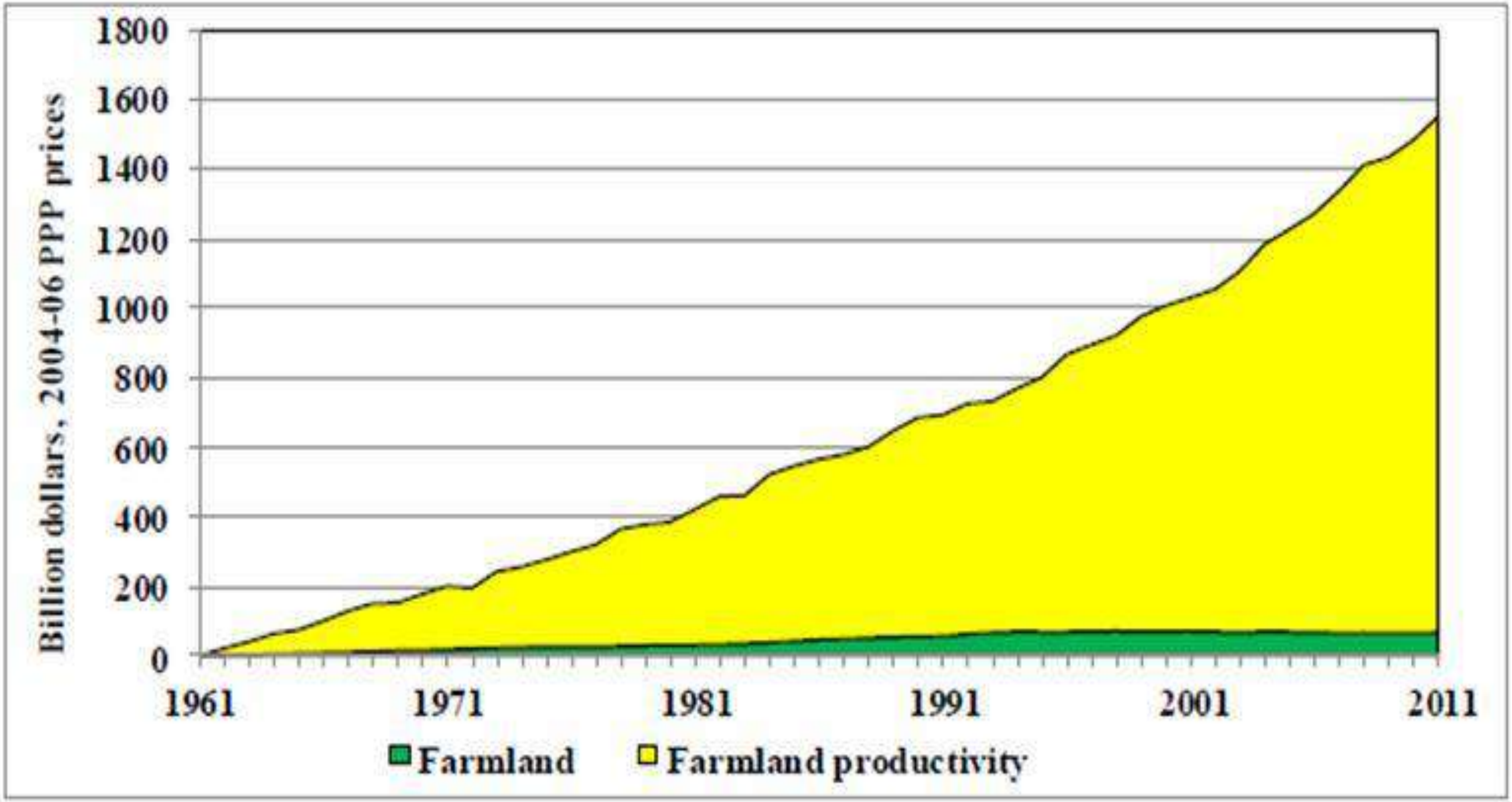
<u>Director:</u>
Emiliano Maletta (UK/Spain)

<u>Team members</u>
Tomas Gotthold (Argentina/Perú/Brazil)
Charles Hefner (Dominican Republic/Brazil)
Luciano Valeri (Argentina/Paraguay)
Adrian Zappa (Argentina/Paraguay)
Enrique Riegelhaupt (Argentina/Mexico)
Roman Molás (Poland)
Hector Maletta (Perú/Spain)
Juan Carlos Torres (Spain)
Sebastián García (Argentina)
Ignacio Navarro (Greece)
Juan Mato Paredes (Spain/Colombia/UK)
Marinho Gonçalves (USA, Ghana)

BIOENERGY CROPS

Regenerative agriculture for biobased industries

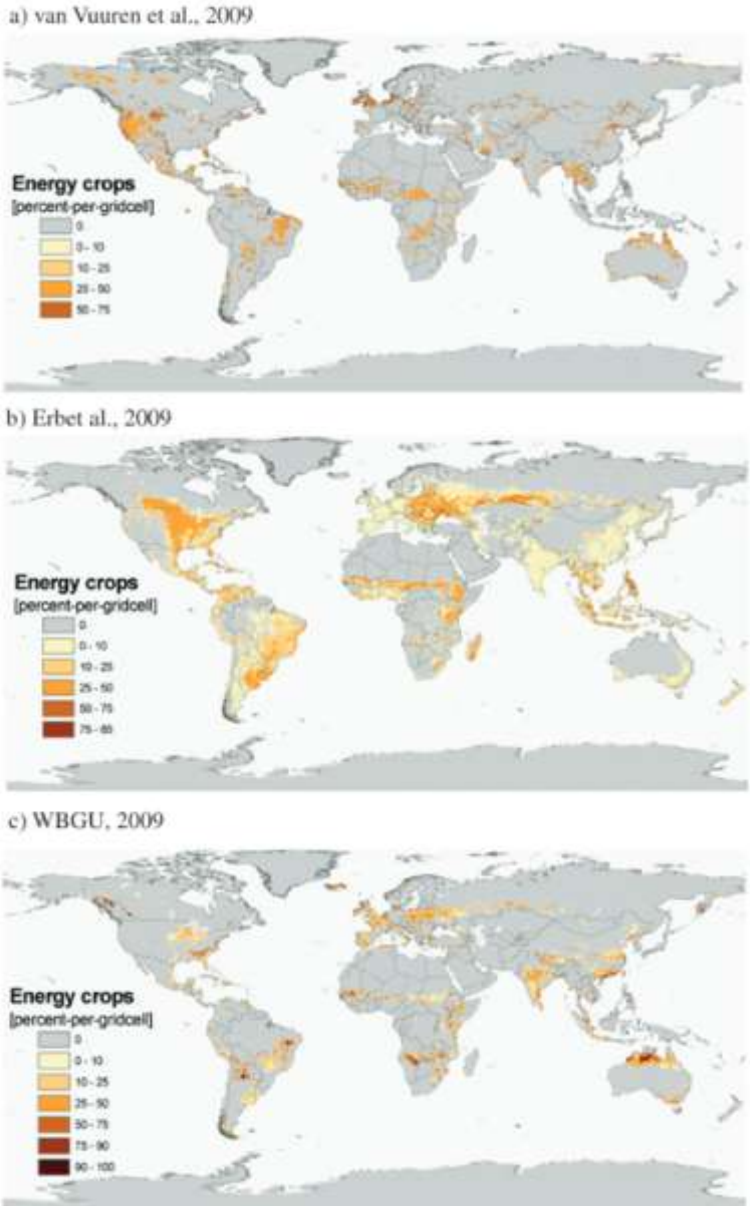
BIOENERGY CROPS LTD
Registered office Address:
Skytax, 37th Floor 1 Canada Square, Canary Wharf, London, England, England, E14 5AA

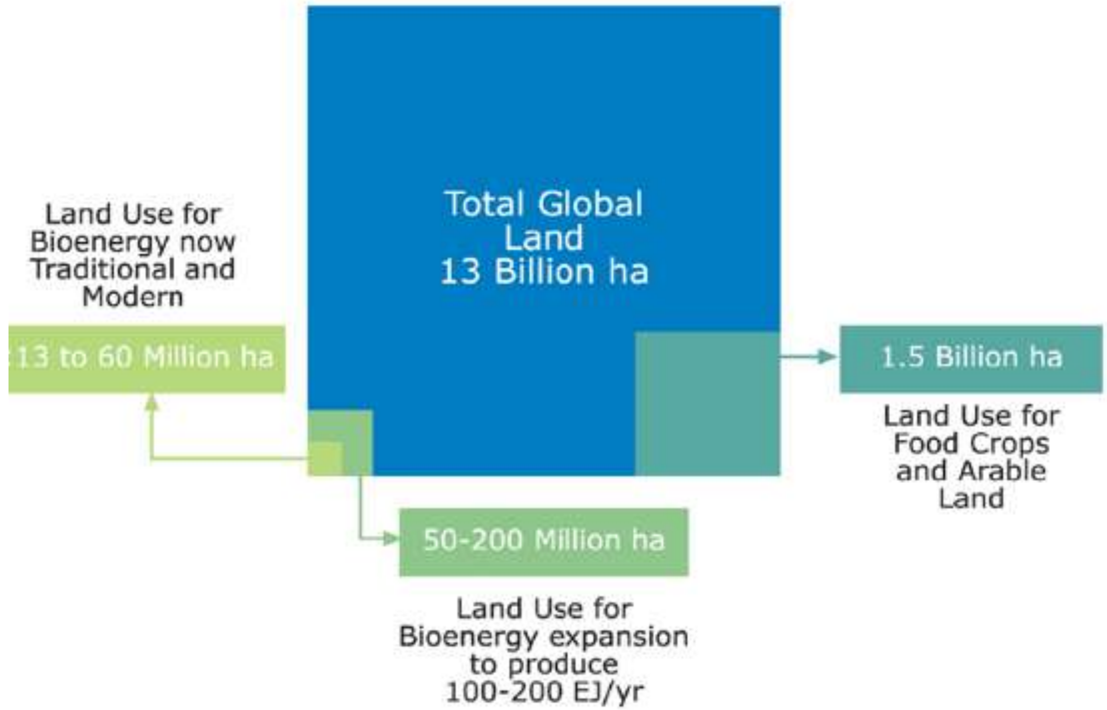


Above right: World net agricultural production (food and non food), 1961-2012. Below right: Contribution of extra farmland and increased farmland productivity to growth in world agricultural output . Values of Ag output in billion of "Purchasing Power Parity" (AgPPP)dollars at 2004-06 prices. Source: Maletta (2015) elaborated with data from FAO. Source: Maletta (2015). Available at: http://bit.ly/1X6q6ix

	Land uses	Total land	Prime and good land				Marginal land			
			Total	VS	S	MS	Total	mS	vmS	NS
A	**All land uses**	**13295**	**4495**	**1315**	**2187**	**993**	**8800**	**1111**	**1627**	**6061**
B	Under forest	3736	1601	453	854	293	2135	342	530	1263
C	Built up land area	152	116	41	61	14	37	12	10	15
D	Other land, strictly protected [a]	638	107	30	50	27	530	39	59	432
E=A-B-C-D	**Land with some rain-fed potential**		**2671**	**791**	**1222**	**659**	**1746**	**718**	**1028**	
F=G+H	**Land used for crops (1999-2001)** [b]	**1559**	**1260**	**442**	**616**	**201**	**299**	**120**	**104**	**75**
G	Rain-fed	1283	1063	381	516	166	220	93	84	43
H	Irrigated	276	197	61	100	35	79	27	20	32
I=E-F	**Net balance** [c]		**1412**	**349**	**606**	**458**	**1521**	**598**	**923**	

(a) Includes only protected land that is not presently used for crops, or built up, or under forest (e.g. wildlife reserves).
(b) Arable land and land with permanent crops, excluding cultivated permanent meadows and pastures.
(c) Includes suitable and land that is marginally or very marginally suitable, excluding the non-suitable (NS) class.
Adapted from Alexandratos & Bruinsma 2012:104 (rows reordered; headings slightly modified). Totals may not exactly add up due to rounding.

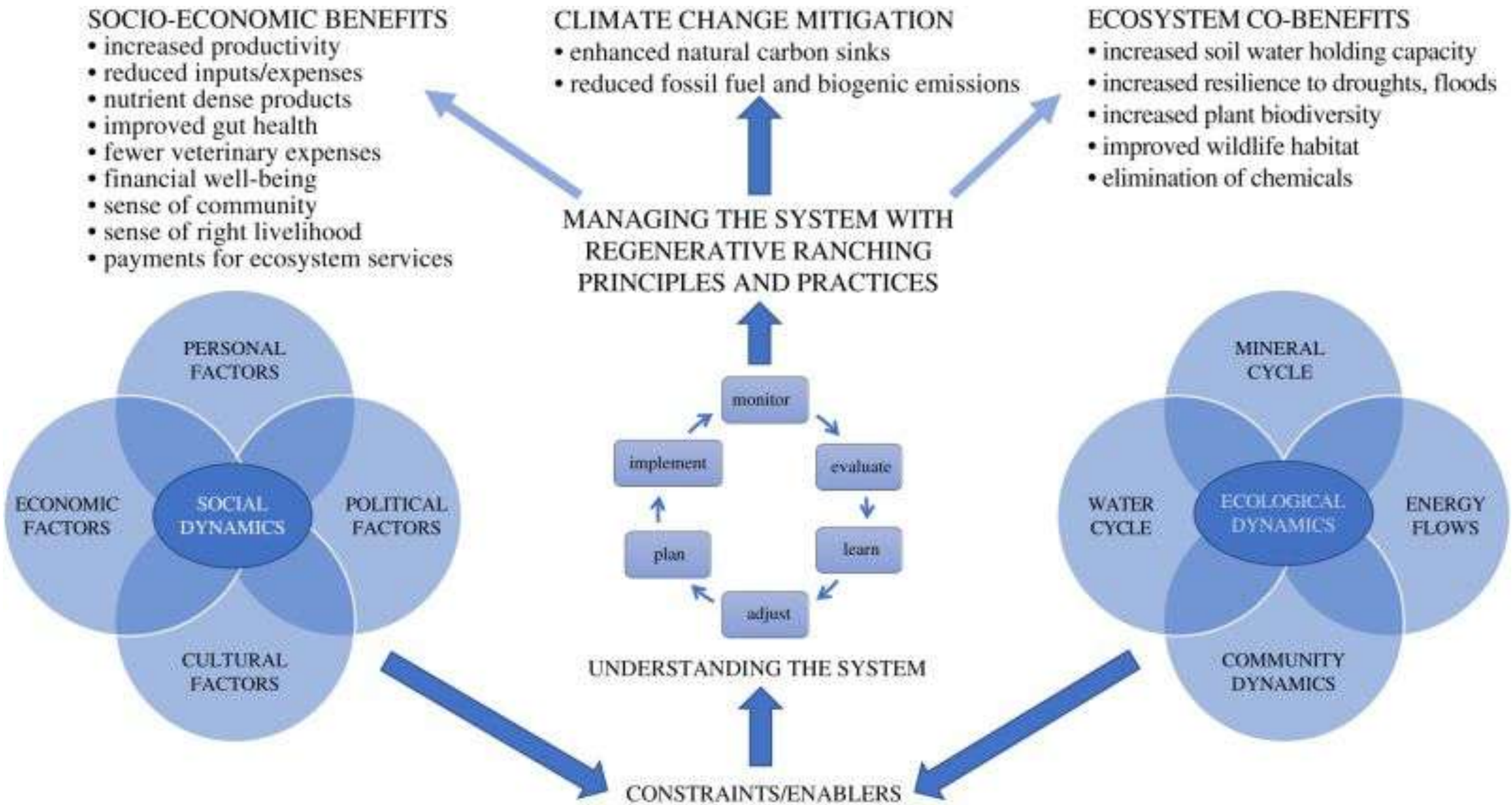




Global land use for bioenergy. Approximate numbers. Source: Souza et al 2015

IIASA: Suani T. Coelho et al (2012)
http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter20_bioenergy_hires.pdf

Regenerative dynamics of our model



Perennial energy crops network in EU

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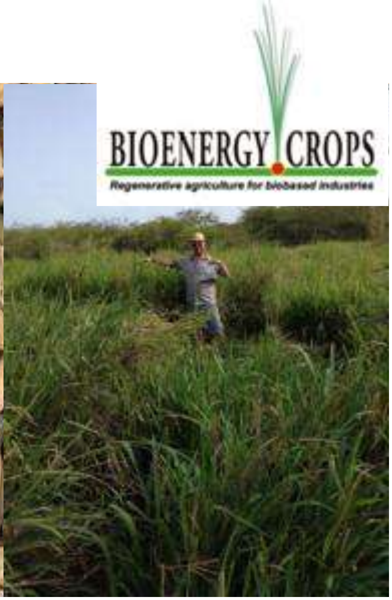
- Temperate areas with high yielding cool and warm grasses
- Experience and large networks in Italy, Spain, Poland, UK, Sweden, Romania, Croatia, Germany Netherlands, Portugal, France, Greece and Turkey
- **Short rotation coppice** including legumes trees, poplars/willows, siberian elm, Eucalyptus, Robinia (black locust). Bush biomass crapping models are yet scarce.
- **Giant reeds, Switchgrass, Miscanthus and several C3 grasses** with demonstrated viability in marginal lands

Grasses in the tropics

- Several New hybrids
- Drought tolerant grasses
- Yields: 20-45 dry ton/ha range very well documented
- Silage / chopped / baling options
- Drying methods for biorefinery well demonstrated
- Combinations with legumes
- CAPEX (100-500 U$D/ha) / OPEX (15-60 U$D/ODT)



Elephant / Napier, PMN and Energy cane

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7000ha (Veracruz, Mexico)

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- Pedigreed planting material available
- Yields: 20-70 dry ton/ha range very well documented
- Silage / chopped / baling options
- Nursery and seedstock area required
- Manual and mechanized harvesting (several options)
- Harvest frequency and crop lifetime change from site to site
- CAPEX (1000-2500 U$D/ha) / OPEX (30-45 U$D/ODT)

Short Rotation Forestry in the tropics

Short Rotation Coppice / Forestry

Emiliano Maletta / CEO - info@bioenergycrops.com

Semi-arid Lands: Grasslands, Legume Trees, Native Shrubs

- Improve soil condition and increase land value
- Develop appropriate feedstock collection and processing systems
- Optimize logistic chains by densification, storage and transportation improvements
- Characterized biomass in most cases
- Benefits developing wildfire prevention programs

Agroforestry for biomass

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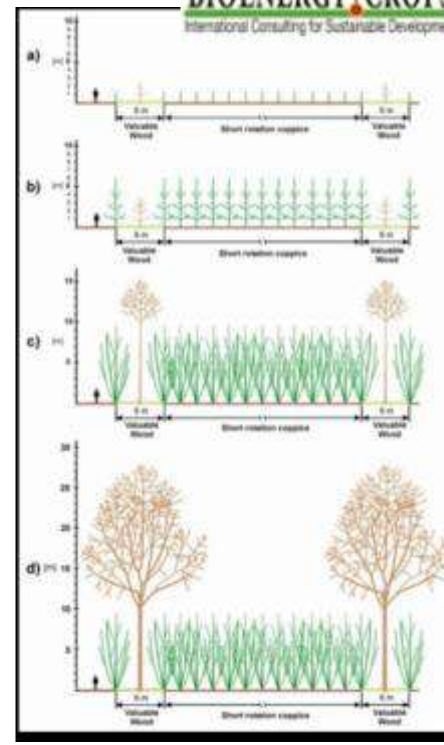
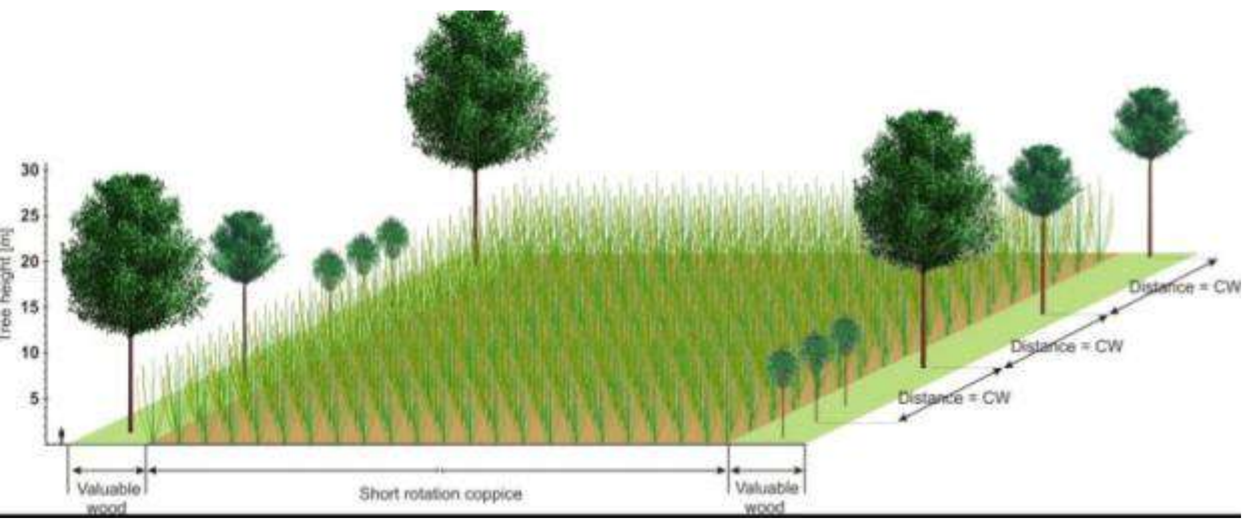
- Food / fodder / energy
- Improve land use change
- Can use legume, energy, or fruit trees.
- Regionally specific design
- Pruning / waste integration
- Shade tolerant grasses
- Specialty varieties and biomass
- Lowest impact biomass
- High value-added
- Increased resilience





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Woody biomass / machinery

- Planting materials and low cost cuttings / nursery
- Commercial equipment for planting and harvesting equipment
- Biodiversity, including several co-existing species
- Legume trees with none N fertilizer requirements
- CAPEX (1000-3000 U$D/ha) / OPEX (35-60 U$D/ODT)

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Bio fertilizers and biochar for soil amendment

Very well demonstrated in large scale in many countries

Low production costs (local)

Bio-products including ashes, anaerobic digestate and vinasses

Realistic logistic models when producing solid and liquid bio-fertilizers

Activated compost-biochar fertilizers (e.g. gypsum, P rock, food and Ag waste)

Commercial & low tech Biochar plus heat applications

Reduce fossil imported fertilization also for neighboring organic food production

Ag eq / spreaders / applicators

Biochar as soil amendment

Compost production models with biochar

Increments in Soil organic matter

Increments in Carbon sequestration

pH corrections

Thermal energy coupled to pyrolizers and carbonizers

MINING SECTOR AND RECLAMATION LANDS

Post mining damaged lands are cultivated or reforested in the framework of **social responsibility** to protect or rehabilitate soils

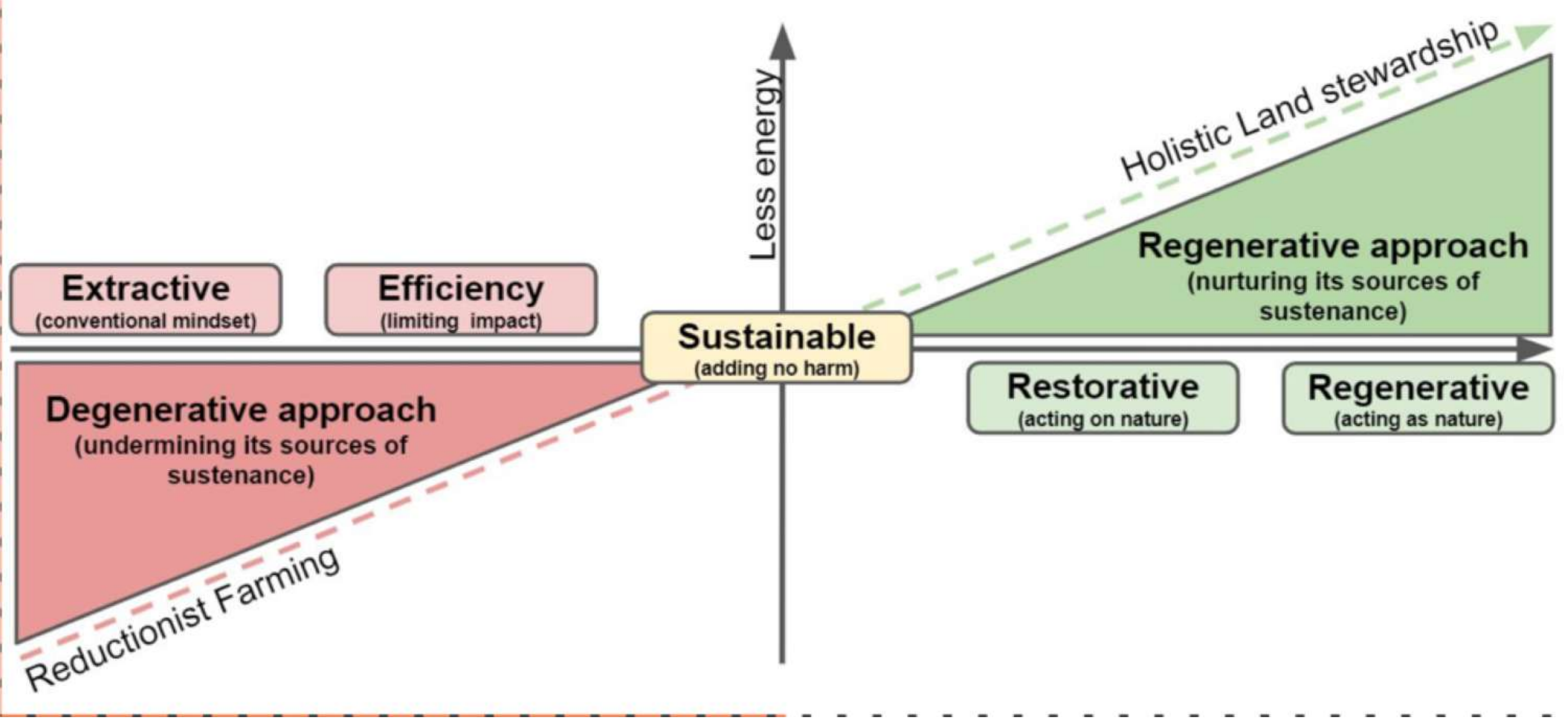
Soil regeneration strategies by the promotion of biomass cropping systems and soil restoration through intercropped perennial grasses and legumes, agroforestry, alley cropping and afforestation activities.

Clean energy
is often required during processing.

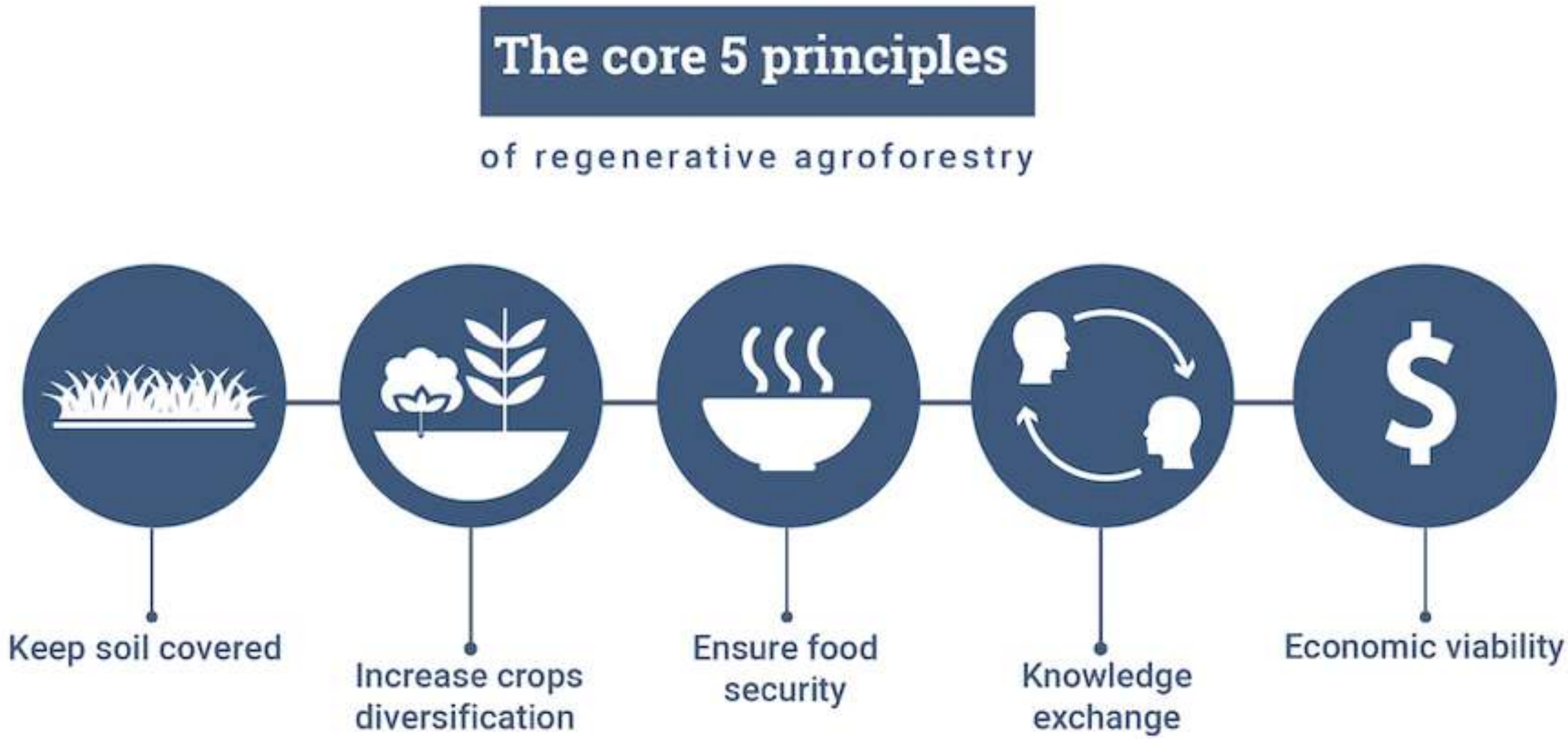
Co-products (including food, fodder and livestock).

Better jobs. Social aspects to become potential benefit for communities.

The common denominator behind all regenerative approaches is the intention to move beyond sustainability (adapted from Mang & Reed, 2012).



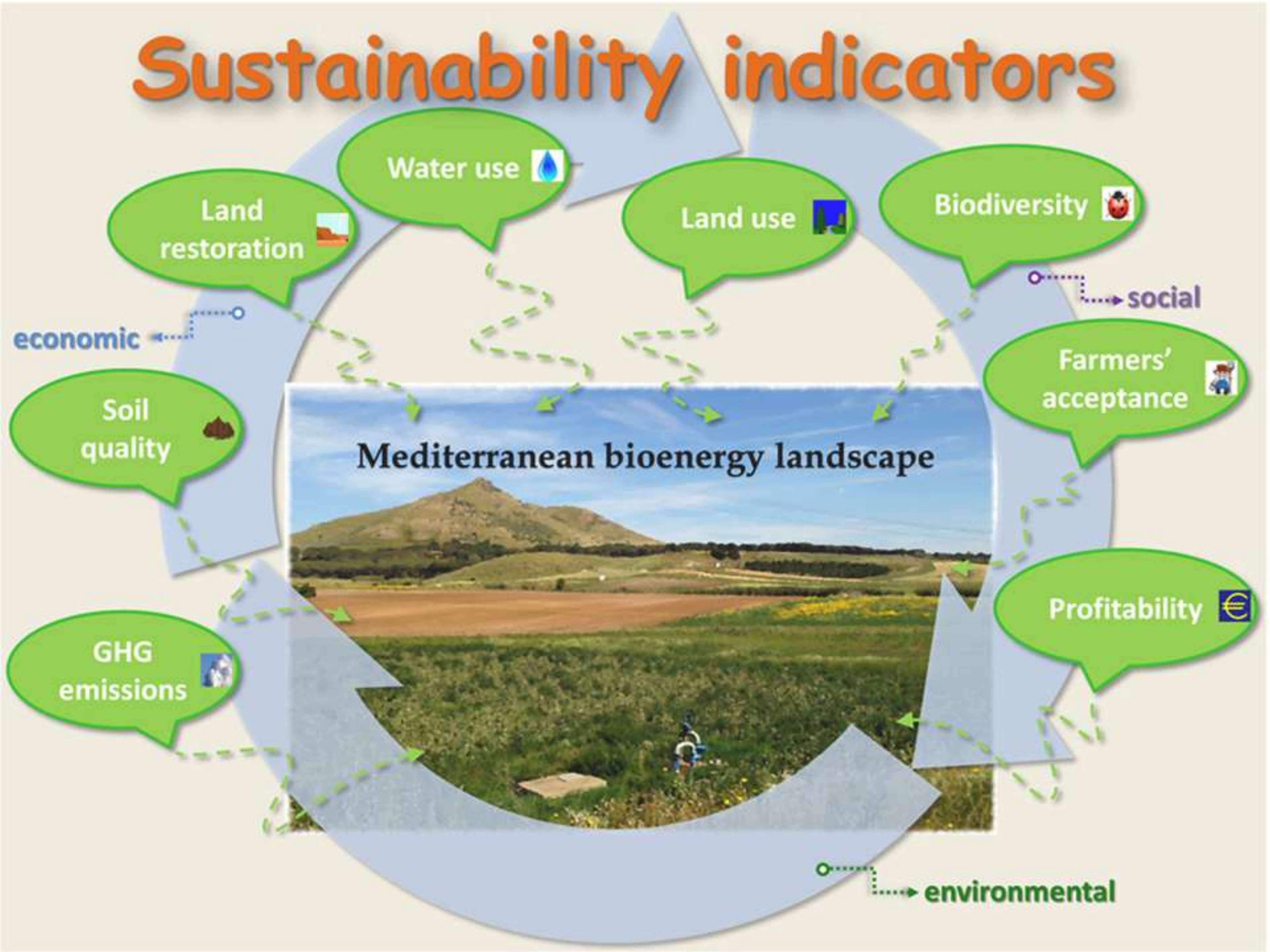
Source: Smith, S. (2020). Farm Carbon Cutting Toolkit.



Source: Elevitch, C.. D. Niki Mazaroli, D. Ragone (2018)

5 goals of regenerative agriculture:

1. **Soil**: Contribute to building soils along with soil fertility and health.
2. **Water**: Increase water percolation, water retention, and clean and safe water runoff
3. **Biodiversity**: Enhance and conserve biodiversity
4. **Ecosystem health**: Capacity for self-renewal and resiliency
5. **Carbon**: Sequester carbon


Sustainability indicators
Water use
Land restoration
Land use
Biodiversity
social
economic
Farmers' acceptance
Soil quality
Mediterranean bioenergy landscape
Profitability
GHG emissions
environmental

Environmental issues regarding perennial agriculture in marginal lands

Roots of intermediate wheatgrass, a perennial grain candidate compared to those of annual wheat (at left in each panel)

Biodiversity

- Pollinators, butteflies, bees
- Soil web: evidence on meso fauna
- Mites and rodents
- Birds
- Mammals shelter

Factors influencing

- Chemicals
- Harvest frequency

Photo: Roger Sampson (Reap/Canada) on swithgrass cultivated for biomass

Marginal lands I: Reference models. How they look? What they are producing today? How improvement is measured and valued

BEFORE

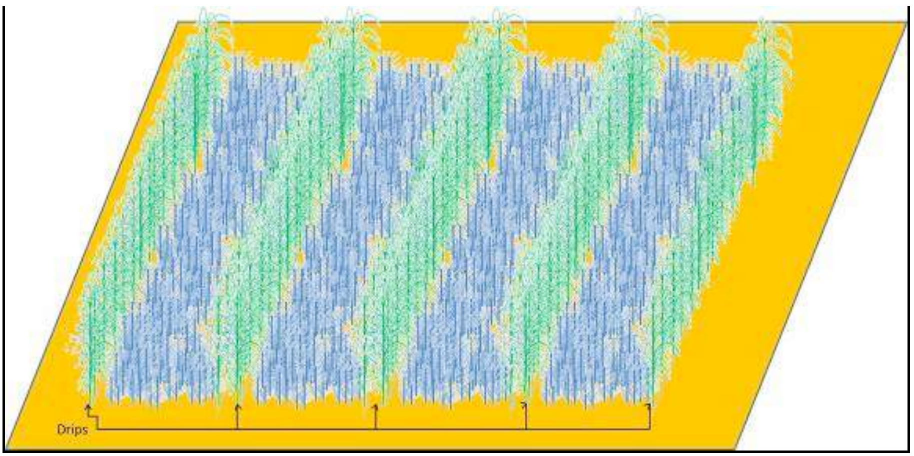
- Erosion during strong storms in wet season (intense rainfall washing top soil)
- Naked soil not sustainable management
- Depleted and unfertile soil with desertification process
- Carbon mostly flowing to towards the air (low photosynthesis)
- Low fauna activity because ecological constraints and equilibrium breakage
- No social benefit for anybody (farmers, workers, community, etc.)
- Diesel is imported to produce power in this island with extrenly high tariff (0.50 $/wkh).
- Coral reef impacted

AFTER

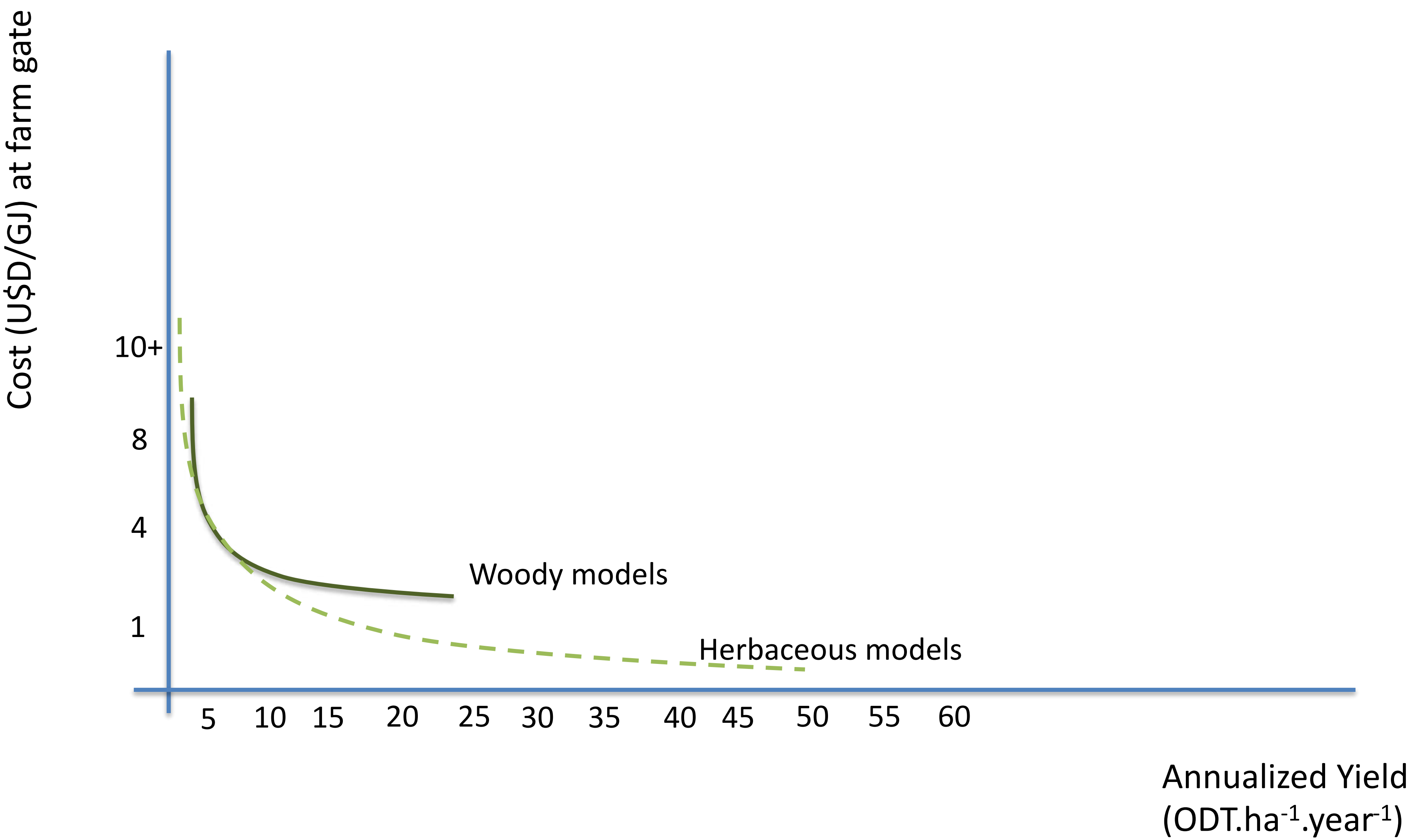
- Reduced erosion and higher rainfall harvest in watershed
- Higher green covers and Sustainable Landscape management
- Organic matter and soil conservation (improvement of topsoil)
- Carbon sequestration (less CO2 in the air) because of higher productivity each year
- Higher biodiversity (soil microbial and fauna activity, mites, birds, etc.)
- Employment for farmers, workers, power station and lower tariff
- Local cheaper renewable energy (less import dependence and impacts on Oil in Mexican Gulf)
- No impact in coral reef (beach is few miles from here)

Water economy and agroforestry models

- Intercropping
- Focus on rain-fed areas for low footprint feedstock
- Efficient water management
- GIS, plant/soil/water interface sensors to improve management capacity and productivity
- Rotational schemes (irrigation on establishment)
- Rainwater harvesting / ponds
- Slope agriculture / terracing / agroforestry
- Irrigation for selected high value-added products
- Perennial crops when possible to improve resilience



Emiliano Maletta | www.bioenergycrops.com | CEO – Email: director@bioenergycrops.com



Source: own ellaboration with data provided by Bioenergy Crops Ltd

Highly productive sites (20-70 odt/ha.yr)

Fertile soils, high organic matter, not serious chemical and physical limitations

Water availability / Etc allows $ many crops

Lower climatic risk / more stable yields

High opportunity costs (e.g. maize net margins)

Higher nitrogen response and productivity

More sustainable / lower inputs priority

Allow high establishment and fix costs (e.g. propagation, nursery)

Require lower collection AREA (km2) and less and transport / distances

Moderate and lower productive sites (4-25 odt/ha.yr)

Low organic matter, extr. pH; salinity, poor drainage and other limitations

Water restrictions limit crop margins

Extreme events are more frequent

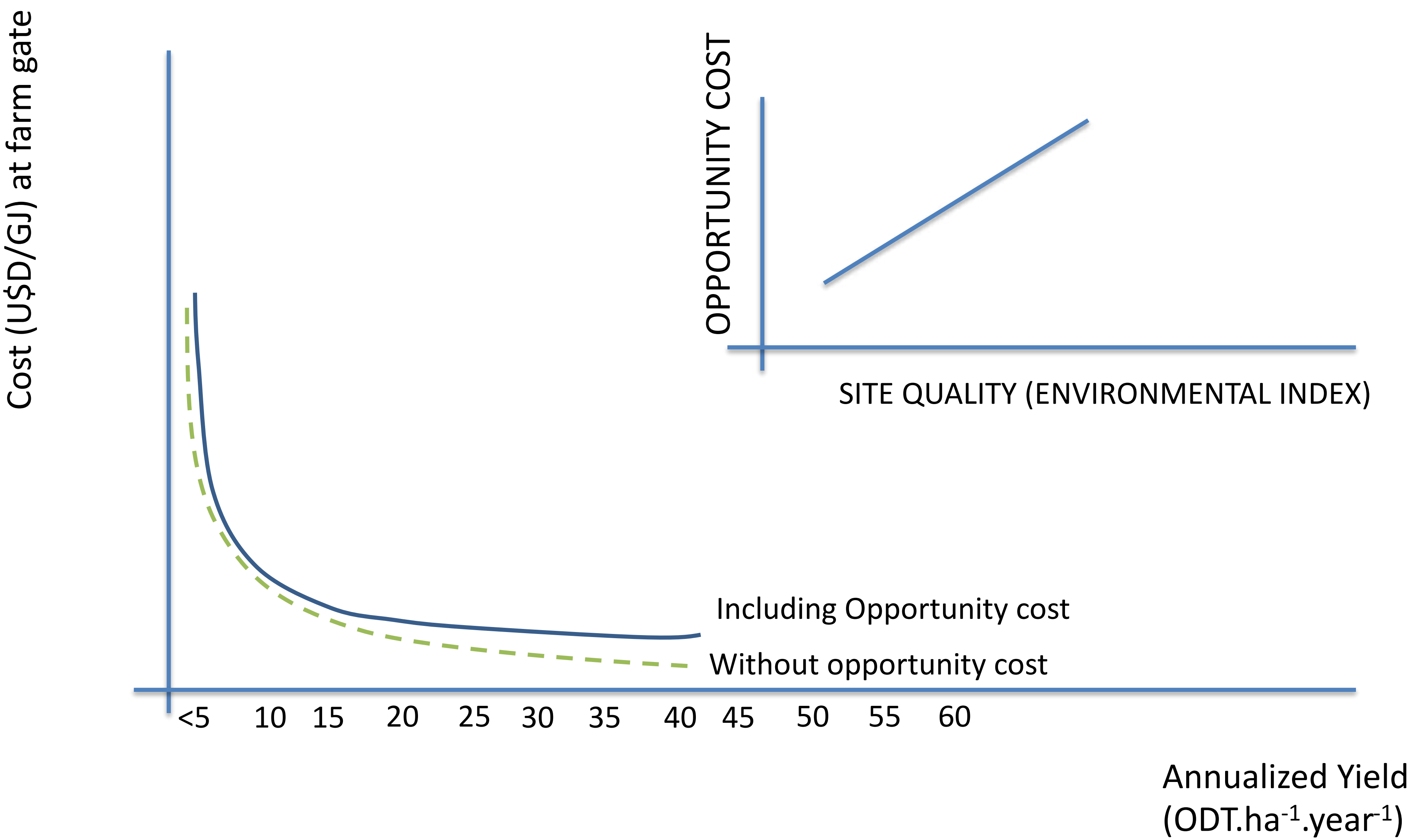
Low opportunity costs (e.g. lease land)

Low nitrogen response per hectare required.

Organic matter is a priority

Need low establishment and fix costs

Require HIGHER collection area (km2) and more transport / distances



Source: own ellaboration with data provided by Bioenergy Crops Ltd

Low footprint biomass delivered:

- Lowest production costs (€ / ODT)
- Low GHG emissions and carbon per energy produced (gCO2 / MJ)
- Low fossil energy used (fossil MJ input / total MJ output)
- Positive externalities (e.g. organic matter accumulation, biodiversity)

Require…

- Efficient cultivation / harvesting techniques
- Low cost establishment techniques
- Simple logistic models and harvesting operations
- Low or no irrigation water requirement (M3 / ha - m3 / odt or MJ)
- Low inputs: especially fossil sourced nutrients (e.g. Urea, CAN, etc.) dosages applied (N / ha – N / ODT or MJ)
- Yield stability and long term productivity & crop lifetime (ODT / ha.year)

Final remarks

- Marginal lands are very available for bioenergy even without food disruption even in several areas that have high energy costs, low rural income and current land degradation (e.g. Erosion low fertility).
- Perennial bioenergy crops help to improve soil organic matter, can be cost effective, and have high energy balance and very low (or even carbon negative footprint
- There are no “miracle crops” but realistic options with thousands of hectares and enough background to be promoted
- Marginal lands require optimized logistics, soil amendment and very strict sustainable criteria with options that improve current land use status
- High yields require high inputs, although there are many cultivated biomass systems that offer low cost feedstock even in areas with low productivity
- Policy making and promotion required to integrate regenerative aspects and facilitate implementation in larger scales

Thanks for your attention!

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Emiliano Maletta | www.bioenergycrops.com | Email: director@bioenergycrops.com