

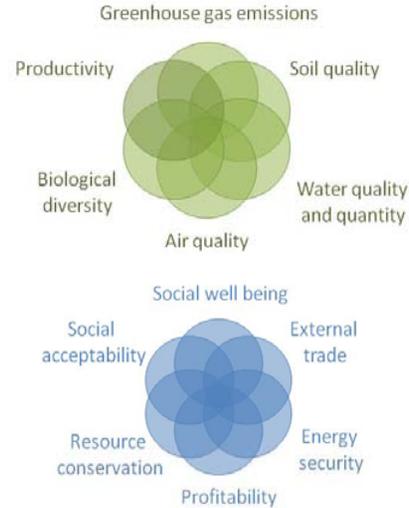
Environmental sustainability indicators

Category	Indicator	Units
Soil quality	1. Total organic carbon (TOC)	Mg/ha
	2. Total nitrogen (N)	Mg/ha
	3. Extractable phosphorus (P)	Mg/ha
	4. Bulk density	g/cm ³
Water quality and quantity	5. Nitrate concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	6. Total phosphorus (P) concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	7. Suspended sediment concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	8. Herbicide concentration in streams (and export)	concentration: mg/L; export: kg/ha/yr
	9. storm flow	L/s
	10. Minimum base flow	L/s
	11. Consumptive water use (incorporates base flow)	feedstock production: m ³ /ha/day; biorefinery: m ³ /day

Category	Indicator	Units
Greenhouse gases	12. CO ₂ equivalent emissions (CO ₂ and N ₂ O)	kgC _{eq} /GJ
	13. Presence of taxa of special concern	Presence
Biodiversity	14. Habitat area of taxa of special concern	ha
	15. Tropospheric ozone	ppb
Air quality	16. Carbon monoxide	ppm
	17. Total particulate matter less than 2.5µm diameter (PM _{2.5})	µg/m ³
Productivity	18. Total particulate matter less than 10µm diameter (PM ₁₀)	µg/m ³
	19. Aboveground net primary productivity (ANPP) / Yield	gC/m ² /year

McBride et al. (2011) *Ecological Indicators* 11:1277-1289.

Categories of indicators of environmental and socioeconomic sustainability



Socioeconomic sustainability indicators

Category	Indicator	Units
Social well-being	Employment	Number of full time equivalent (FTE) jobs
	Household income	\$ per day
	Work days lost due to injury	Average number of work days lost per worker per year
Energy security	Food security	Percent change in food price volatility
	Energy security premium	\$/gallon biofuel
External trade	Fuel supply stability	Fuel price volatility: standard deviation of monthly percentage price changes over one year
	Terms of trade	Ratio (price of exports/price of imports)
Profitability	Trade volume	\$(net exports or balance of payments)
	Return on investment (ROI)	% (net investment/initial investment)
	Net present value (NPV) ²	\$(present value of benefits minus present value of costs)

Category	Indicator	Units
Resource conservation	Depletion of non-renewable energy resources	MT (amount of petroleum extracted per year)
	Fossil Energy Return on Investment (fossil EROI)	MJ (ratio of amount of fossil energy inputs to amount of useful energy output)
Social acceptability	Public opinion	% favorable opinion
	Transparency	% of indicators for which timely and relevant performance data are reported
	Effective stakeholder participation	Number of documented responses to stakeholder concerns and suggestions reported on an annual basis
	Risk of catastrophe	Annual probability of catastrophic event

Dale et al. (In review) *Ecological Indicators*

Interactions Among Climate Change, Energy and Land Use [Dale, Efroymson, and Kline (2010) *Landscape Ecology* 26:755-773]

Climate Change > Energy

- Energy options
- Intensity of use
- Distribution of supply and demand for energy

Energy > Climate Change

- Greenhouse gas emissions and carbon sequestration
- Local weather and air quality

Climate Change > Land Use

- Productivity
- Suitability for life forms and management practices
- Distribution of land uses
- Human settlement patterns

Energy > Land Use

- Energy extraction, production, and distribution footprint
- Infrastructure and settlement plans

Land Use > Climate Change

- Release of greenhouse gases
- Amount of carbon sequestration
- Weather changes
- Vulnerability to climate change

Land Use > Energy

- Options for energy extraction, infrastructure, and production
- Efficiency of energy production
- Demand for energy

