Supplementary Material

Table S1: Scoring for SDGs with a moderate likelihood of interaction with biomass supply chains for modern bioenergy

SDG	Target(s)	Linked with	Score	Category	Interactions Identified	Supporting Literature
1. No poverty	Poverty & Development (1.1, 1.2, 1.4)	All – supply or use	+2	Co-benefit	Access to modern (bio)energy is fundamental to human development and can free up resources for other productive uses. Jobs and opportunities related to bioenergy and biomass supply can reduce poverty.	[1–3]
		All-supply or use	-1	Safeguard	Large-scale biomass demand for bioenergy may promote concentration of income and/or increase poverty if appropriate policies and governance are not in place.	
	Exposure & Vulnerability (1.5)	All- use	+1	Co-benefit	Well-designed bioenergy infrastructure using local fuels can directly improve resilience of communities to disasters, related disruptions in supply of imported fuels.	[4–6]
		Forest	+2	Co-benefit	Forest biomass can be sourced from forest fire management efforts, directly reducing vulnerability to increasing wildfires because of climate change.	[7–9]
		Ag. residue	+1	Co-benefit	Having a secondary revenue stream from crop land can help to hedge against crop losses due to disasters, may still produce biomass even if crop itself is lost.	[10]
	Reduce Poverty (1.1, 1.2)	Waste	+1	Driver/co-benefit	In developing countries, biogas may replace more expensive cooking fuels (particularly liquefied petroleum gas) and digestate can be used as fertilizer, reducing overall household expenditures. Waste generally is a low-cost fuel.	[11]
3. Good health and well-being	Air & Soil Pollution (3.9)	All- use	+2	Co-benefit	Modern bioenergy equipment can reduce health risks and mortality related to contamination air pollution and indoor smoke when replacing diesel, fuel oil, kerosene or traditional biomass.	[2,3,11–14]
		Energy crop	+1	Co-benefit	Energy crops can remove pollution (e.g. particulate matter, NOx, SOx) from the atmosphere and water, and remove heavy metals from soil.	[15–17]
			-1	Safeguard	Pesticides, fertilizer and fossil fuels used to grow and harvest energy crops could increase soil, water and air pollution.	
		Waste	-1	Safeguard	Incineration of waste may increase air pollution and soil contamination. Digestate can be high in heavy metals and must be properly dealt with.	[18,19]

SDG	Target(s)	Linked with	Score	Category	Interactions Identified	Supporting Literature
6. Clean water and sanitation	Water Quantity & Quality (6.3, 6.4)	Forest	+1	Co-benefit	Areas could be reforested, or left as forest, in order to supply biomass. Depending on species of tree and location, this could have a positive impact on regional water levels and quality.	[20]
			-1	Safeguard	If forest biomass harvest and cultivation practices are carried out unsustainably (e.g. excessive fertilizer or pesticide application) or too close to a water body, there could be a negative impact on water quality.	
		Waste	+1	Co-benefit	Waste streams (e.g. leachate, manure) may be diverted from water bodies to capture energy potential.	[18,21]
			-1	Safeguard	Incineration and other waste to energy (WTE) facilities can cause soil and water pollution through leaching, similar to landfills.	[18,19]
		Ag. residue	-2	Safeguard	Indiscriminate removal of residues can increase runoff and soil erosion, impacting the quality of nearby bodies of water. Evapotranspiration may increase and ability of soil to retain water may decrease, therefore increasing the need for water inputs. Impacts from residue removal depend on local factors including soil type, topography, and climate.	[22,23]
	Water & Related Ecosystems (6.3, 6.4, 6.6)	Energy crop	+2	Driver/Co-benefit	Energy crops may filter pollutants, reduce runoff, or even treat wastewater, particularly if planted on degraded land or to replace annual agriculture crops, thereby improving water quality and helping to protect important ecosystems.	[15,16,24,25]
			-2	Safeguard	Planting energy crops could increase evapotranspiration or use of water for irrigation, leading to the overuse of freshwater and ground water resources, particularly if forests or other natural ecosystems are displaced. Pesticides and fertilizers applied to energy crops may make it into bodies of water, and cause ecotoxicity.	
10. Reduced inequalities	Empowerment & Equalization (10.1, 10.2)	All-supply or use	+1	Co-benefit	Development of decentralized bioenergy systems, particularly in developing regions and rural towns, improves local economic opportunities for low-income populations and can enable a more democratic and participatory approach to management of energy and resources. Impacts are amplified when biomass supply is local. If land access is improved to supply local bioenergy system, empowerment and equalization of marginalized populations is possible.	[10,26–28]
			-1	Safeguard	If land is taken from marginalized populations to supply large scale bioenergy and biofuel facilities, this reinforces, or 'locks-in', current structures of unequal distribution of power and resources.	[16,29]
	Assistance to Least Developed Countries (10.b)	All- use	+1	Enabler	Increased foreign assistance to developing countries may enable development and improvement of energy infrastructure, including bioenergy and enhanced cookstoves.	[2]

SDG	Target(s)	Linked with	Score	Category	Interactions Identified	Supporting Literature
11. Sustainable cities and communities	More Sustainable, Inclusive Cities (11.3)	All- use	+1	Driver/Co-benefit	Decentralized bioenergy can be a part of a sustainable urbanization plan that promotes efficient use of local resources, reduces per capita fossil fuel consumption, lowers the emissions impacts of energy generation and enables local participation in energy generation and resource management.	[4,28,30,31]
	Urban-Rural Linkages (11.a)	All-supply	+1	Co-benefit	Rural development and job creation can be supported by development of urban bioenergy infrastructure supplied by biomass from rural areas.	[32–35]
	Regional Planning, Support for Cities (11.a, 11.b, 11.c)	All-supply or use	+1	Enabler	Regional planning may lead to support for rural biomass provision for urban energy. Improved policies around resource efficiency and disaster risk planning, as well as financial support for sustainable development and use of local materials in developing countries, may directly support and promote bioenergy development.	[26,36,37]
	Safe, Affordable Housing (11.1)	Forest	+1	Co-benefit	A market for biomass could increase the competitiveness of lumber production in some regions and potentially result in lower or more stable lumber costs.	[38,39]
	Air Quality (11.6)	Forest/ Ag. Residue	+1	Co-benefit	Crop residue or slash pile burning, and fire risk may be reduced surrounding communities if residues are used for energy in modern bioenergy technology with emissions controls; local air quality could be improved.	[10,20,40–42]
		Energy crop	+1	Co-benefit	Planting energy crops close to urban centers or peri-urban centers could help improve air and water quality and reduce heat island effects.	[43]
	Environmental Impact of Cities (11.3, 11.6)	Waste	+1	Co-benefit	If waste streams are diverted to energy, more may be collected, and higher proportion may be adequately dealt with. Land requirements for landfills may be reduced if waste is used for energy.	[18,19,21]

Table S2. Scoring for SDGs with a low likelihood of interaction with biomass supply chains

SDG	Target(s)	Linked with	Score	Category	Interactions Identified	Supporting Literature
4. Quality education	Access to Education (4.1, 4.3)	All – supply or use	+1	Enabler	Quality education in a society increases its human capital. Knowledge and skills can be drawn upon to promote sustainable development, creating conditions where alternative energy sources, including bioenergy, is more likely to be explored and implemented.	[2,13,16,44]
				Co-benefit	Programs developed to train operators and managers of (community-based) bioenergy systems and local supply chains can lead to more opportunities for apprenticeships and technical training.	
5. Gender equality	Women's Safety & Worth (5.1, 5.4)	All- use	+2	Co-benefit	Cleaner cooking fuels and modern technologies can reduce health risks related to indoor smoke and wood fuel collection faced disproportionately by women.	[3,11,14,16,18]
	Equal Land & Resources for Women (5.a)	All- supply	+1	Co-benefit	Bioenergy projects could improve women's access to land and resources if planning and governance is inclusive and/or done at community scale.	[16,44]
			-1	Safeguard	Large-scale bioenergy projects and increased demand for biomass could potentially lead to changes that deny women, who have fewer and/or weaker land rights and access to other productive resources than men, control of high-value land.	
	Women's Workload (5.4)	Ag. Residue/ Waste	+1	Co-benefit	Using crop residues or waste to produce bioenergy for home or on-farm use can reduce labour required for crop processing, again a task typically carried out by women.	[11,18,19]
14. Life below water	Ocean Eutrophication Acidification (14.1,14.3)	All - supply or use	+1	Co-benefit	Growing biomass sustainably can help sequester carbon while reducing overall GHG emission when used in bioenergy systems. This can lead to reduced acidification of oceans and seas.	[2,16,44]
		All – supply or use	-1	Safeguard	If deployment of bioenergy increases nutrient pollution and GHG emissions, rates of ocean eutrophication and acidification will be increased.	
	Reduce Marine Pollution (14.1)	Waste	+1	Co-benefit	Waste streams may be diverted from oceans or seas if used for energy.	[18]

SDG	Target(s)	Supply chain	Score	Category	Interactions Identified	Supporting Literature
16. Peace, justice and institutions	Effective Institutions, Governance (16.6, 16.7, 16.8)	All - supply	+1	Enabler	The existence of effective, accountable institutions, inclusive, participatory decision-making and increased participation of developing countries in global governance increases the likelihood that proper safeguards are in place to ensure sustainable biomass supply.	[2,44]
	Participatory Governance (16.7)	All - use	+1	Enabler	Development of locally governed, community-scale bioenergy projects may lead to increase opportunities for participation in local decision-making.	[2,4,45]
17. Partnerships for the goals	Cooperative Agreements, Multi-Stakeholders (17.6, 17.16)	All - supply or use	+1	Enabler	Because of the complexities of many bioenergy supply chains, partnerships and co-operative agreements are often formed to ensure projects are successful. Bioenergy projects often involve multiple stakeholders.	[2,44,46,47]
	Domestic Resource Mobilization	All - supply or use	+1	Enabler	Biomass used for energy is sometimes sourced domestically and can displace imported/domestic fossil fuels. With local bioenergy, money spent on energy remains within the community/region, as opposed to most money spent on fossil energy that leaves the region. Increased jobs, industry also lead to new tax revenue.	[4,48]

Table S3: Case study summary

Case #	Case Study Title and Description	Status	Continent	Biomass Type	End Use	SDG														
						1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**Sustainable Biogas in China**: On farm chicken manure for biogas production.	I	AS	W	Electricity	X	X					X	X	X			X			
2	**Energy From Straw in China**: Power production from straw.	S	AS	AR	Electricity		X					X	X	X		X				
3	**Biogas from Farm Crops in Italy**: Double-cropping farming for biogas production.	I	EU	EC	Electricity	X	X					X		X						X
4	**Agroforestry Management in Sweden**: Willow cops for wastewater filtration.	I	EU	EC	CHP						X	X	X							X
5	**Wood Chip Boilers in Switzerland:** Wood processing residues for district heating.	I	EU	F	District heat							X	X	X		X	X			
6	**Wood Chip Heat in the Netherlands**: Wood from agriculture land maintenance.	I	EU	AR	District heat							X	X	X		X		X		
7	**Straw-based Heating in Denmark**: Agriculture residues as district heating fuel.	I	EU	AR	District heat		X					X	X	X		X				
8	**Wood Residue-based Power in Sweden**: Large scale urban biomass CHP plant.	I	EU	F	CHP							X	X	X		X	X			X
9	**Agriculture Residue Bio-Hub in Austria**: Fuel pellets from agriculture residues.	I	EU	AR	Process heat		X					X	X				X			
10	**Agriculture Residues for Gasification in France**: Winery residues used for energy.	I	EU	AR	Process heat							X	X	X			X	X		
11	**Agriculture Residues for Pellets in France**: Residues from animal feed production.	P	EU	AR	Process heat							X	X	X			X			
12	**Agro-prunings for Energy in Italy**: Olive tree pruning residues used in CHP.	P	EU	AR	CHP		X					X	X				X	X		
13	**Biowert Grass Biorefinery in Germany:** Biogas from 'grass juice' by-product.	I	EU	W	CHP						X	X	X			X	X			

Case #	Case Study Title and Description	Status	Continent	Biomass	End Use	SDG														
14	**Algae Cultivation for Biofuels in the United States**: Low-water growing system.	P	NA	EC	Transport fuel						X	X		X						
15	**Grass Intercropping for Biofuels the United States:** Joint plantation with pines.	S	NA	EC	Transport fuel						X	X						X		
16	**Introduction of Switchgrass for Biofuels in the US:** Crops converted to improve water.	S	NA	EC	Transport fuel		X				X	X								
17	**Perennial Intercropping for Conservation in the US:** Switchgrass integrated with crop.	P	NA	EC	Transport fuel		X		X		X	X		X						
18	**Bioenergy Crops as Riparian Buffer Zones in the United States**: To protect watersheds.	S	NA	EC	Liquid fuel		X				X	X		X						
19	**Living Snow Fences in the United States**: Willow trees as highway snow barriers.	S	NA	EC	N/A							X	X	X			X	X		
20	**Wood Pellet Supply Chain in the United States:** Wood pellets for global export.	I	NA	F	Electricity							X	X	X			X			X
21	**Wood Residue Biorefinery in Canada:** Wood and harvest residue for biofuel.	P	NA	F	Liquid fuel							X	X	X			X			X
22	**Forest Management for Energy Chips in Canada**: Biomass from stand improvement.	I	NA	F	Building heat				X			X	X	X		X	X			X
23	**Indigenous Wood Pellets in Canada: W**ood residue distribution center**.**	I	NA	F	Building heat				X			X	X	X				X		X
24	**Indigenous Wood-Chips in Canada:** Wood chip production from fire-killed trees.	I	NA	F	District heat				X		X	X	X	X				X		
25	**Wood Pellets in Canada:** Wood pellets for commercial building heating systems.	I	NA	F	Building heat							X	X	X			X			X
26	**Tree-Crop System for Biomass in Australia:** Alley crops to improve water.	S	OC	EC	N/A		X				X	X								X
27	**Indigenous Land Design in Australia:** Restoring degraded land with energy crops.	S	OC	EC	N/A							X						X		X
28	**On-farm Biogas Production in Australia:** Pig manure for biogas.	I	OC	W	Electricity		X					X		X			X			

Case #	Case Study Title and Description	Status	Continent	Biomass	End Use	SDG														
29	**Sugarcane Biofuel Production in Brazil:** Improving water use in biofuel production.	I	SA	EC	Transport fuel						X	X							X	
30	**On-Farm Biogas Production in Brazil:** Upgrading biogas from manure to fuels.	I	SA	W	Transport fuel	X	X				X	X	X				X			
31	**Biogas from Sugarcane in Brazil:** Biogas from vinasse - sugarcane byproduct.	I	SA	W	Electricity						X	X						X		
32	**Agriculture Residue for Energy in Kenya**: Food production residue for process energy.	I	AF	AR	CHP	X	X					X		X			X			
33	**Bioenergy from Sugarcane Residues in South Africa:** Gaging potential bioenergy.	S	AF	AR	Electricity		X					X	X	X	X					
34	**Agroforestry for Food in Zambia:** Intercropping for food and energy security.	I	AF	EC	Building heat		X		X	X		X						X		X
35	**Agriculture Briquettes in Tanzania**: Briquette production from rice husks.	I	AF	AR	Building heat		X					X					X			X
36	**Renewable Energy Technologies in Gahan**: Female led biofuel initiative.	I	AF	AR	Process heat	X		X		X		X						X		
37	**Biomass Pellets in Rwanda**: Promoting biomass pellet use and new cook stove use.	I	AF	F	Building heat			X				X	X				X			X

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