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Planning and design of sustainable biomass waste management and bioenergy production

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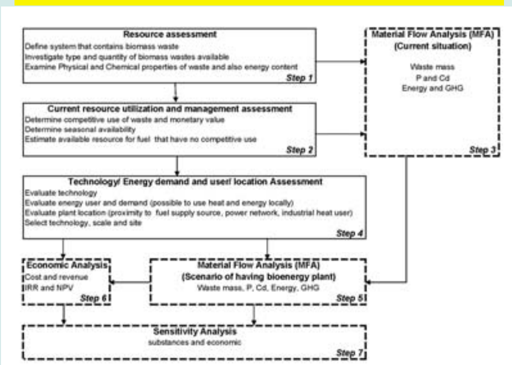
OBJECTIVE

To develop an analytical tool that can provide a comprehensive analysis of alternative systems for management of biomass waste. This tool can support the design of systems that optimize the use of biomass waste in providing energy, reducing GHG emissions and recycling P, while controlling Cd soil contamination.

BACKGROUND

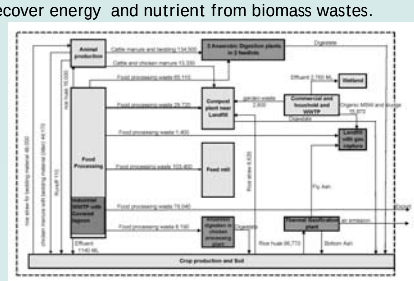
Agriculture produces biomass waste in numerous forms including food processing waste, animal manures and crop stubble. In Australia, agriculture also heavily relies on phosphate fertilizers. Such biomass wastes can potentially be used as a renewable energy source via incineration, gasification or anaerobic digestion. Alternatively, after composting type processing, it can be returned to improve the nutrient and drainage structure of agricultural soils. This reduces the demand for phosphate rock based fertilizers, and hence their associated Cd contamination. A key question is what tradeoffs and synergies might exist between these energy and recycling activities.

METHODOLOGY

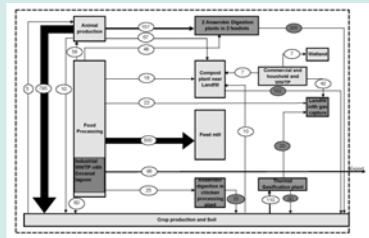


RESULTS

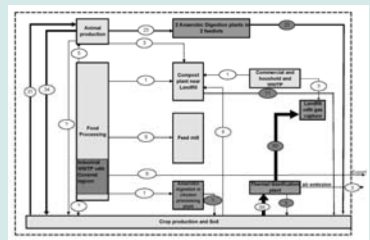
Our case study is the Murrumbidgee Irrigation Area (MIA) in southwest of NSW. At present there is no bioenergy plant or energy recovery from biomass in the region. In this scenario, several bioenergy plants are constructed in the region to recover energy and nutrient from biomass wastes.



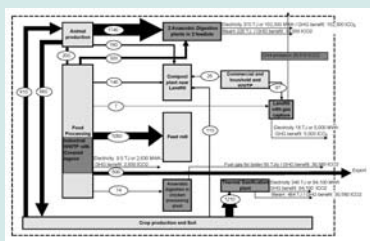
Scenario biomass waste flow diagram in MIA in 2006 (tonnes/year)



Scenario P Flow diagram in MIA in 2006 (tonnes/year)



Scenario Cd flow diagram in MIA in 2006 (kg/year)



Scenario Energy/GHG flow diagram in MIA in 2006(TJ/year/tCO2/year)

Bioenergy plants in the scenario with respect to their capacity, energy, GHG benefits, cost, revenues and overall economic assessment.

Items	1.Anaerobic digestion plant in feedlot 1	2.Anaerobic digestion plant in feedlot 2 (co-digestion with food waste)	3. Rice straw gasification plant and gas turbine	4.Anaerobic digestion plant in chicken processing plant
Total waste input quantities (t/y)	87,600	112,000	96,800	82,00
Type and quantities (t/y) of waste input	Manure-85,000	Manure-49,500	Rice straw-96,800	DAF sludge-8,200
	Paunch material 2,600	Food waste-62,500		
Energy / GHG benefits				
Electricity potential (MW)	6	5	10	n.a.
Electricity production (MWh/y)	54,500	47,800	94,100	n.a.
Heat recovered (GJ/y)	117,000	104,000	535,000	53,000
GHG abatement(t CO_2)	61,900	54,400	125,000	3300
Cost				
Capital cost ($ millions)	40	54	37	1
Annual O&M ($ millions/y)	2	2.7	1.3	0.04
Fuel cost($ millions/y)	0	0	1.9	0
Fuel collection and storage cost ($ millions/y)	0	0	4.2	0
Revenue				
Electricity sale ($ millions/y)	4.3	3.8	7.5	n.a.
Stream sale ($ millions/y)	0.7	0.6	2.9	0.3
Renewable energy credits($ millions/y)	1.6	1.4	2.8	0.03
Digestate sale ($ millions/y)	0.4	0.6	n.a.	0.02
Gate fee ($ millions/y)	0	3.8	0	0
Economic analysis				
Pay back period (years)	10	9	7	3
NPV($ millions)	2	4	11	1
IRR(%)	14	15	21	54

IMPLICATIONS

The bioenergy plant scenario we presented for the MIA has identified a number of benefits in terms of renewable energy production, GHG emission reductions, increasing Phosphorus recycling into land and reduced Cadmium contamination of soil. Despite the high cost of constructing these bioenergy plants in the region, the NPV and implicit IRR of the projects appears attractive.