Anaerobic Digestion of Biowaste
An Ecosanitation Solution for Developing Countries

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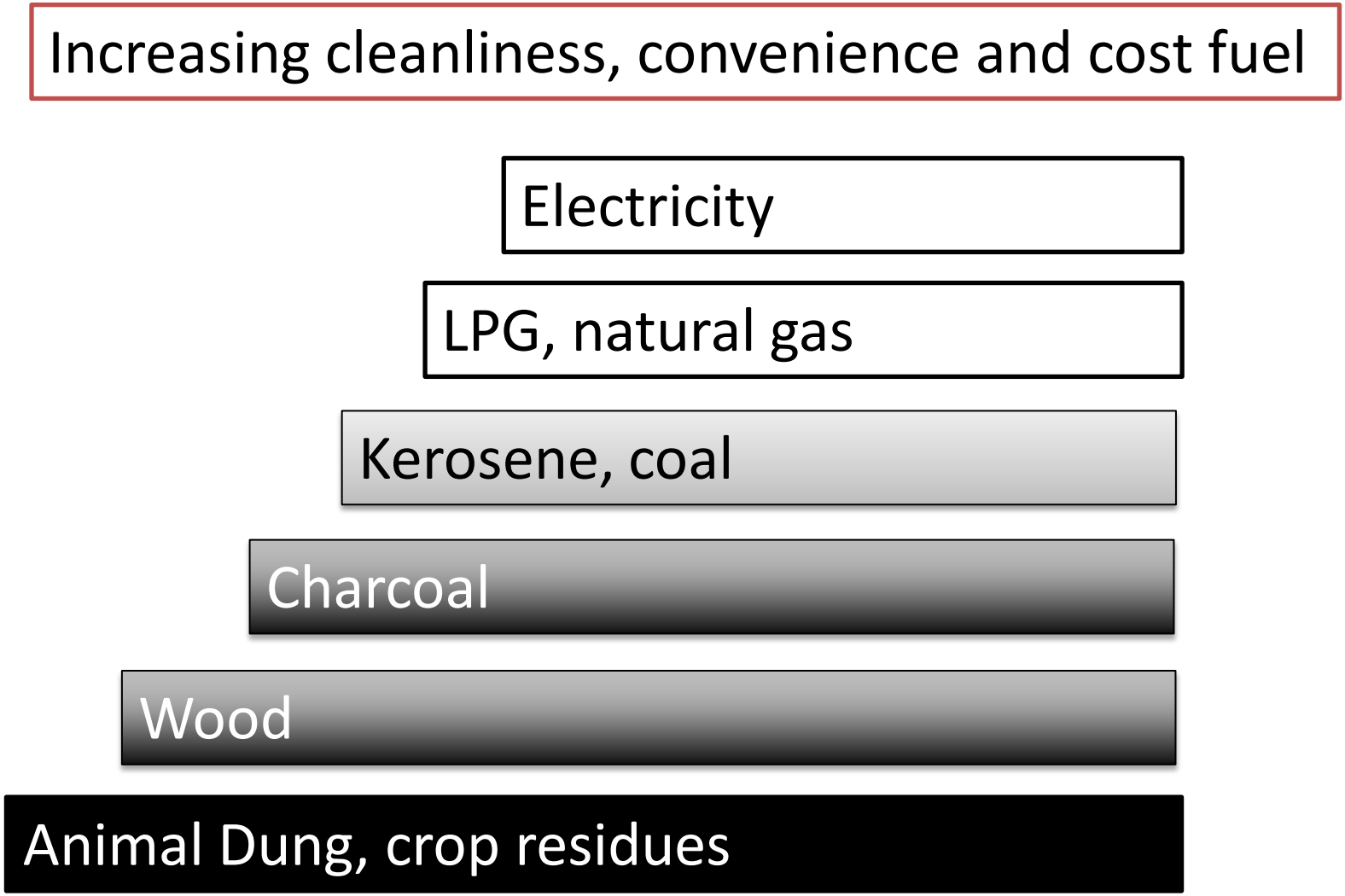
Some Challenges….

- Up to 90% of rural households rely on biomass fuels
  - Wood
  - Charcoal
  - Animal dung
  - Crop residues

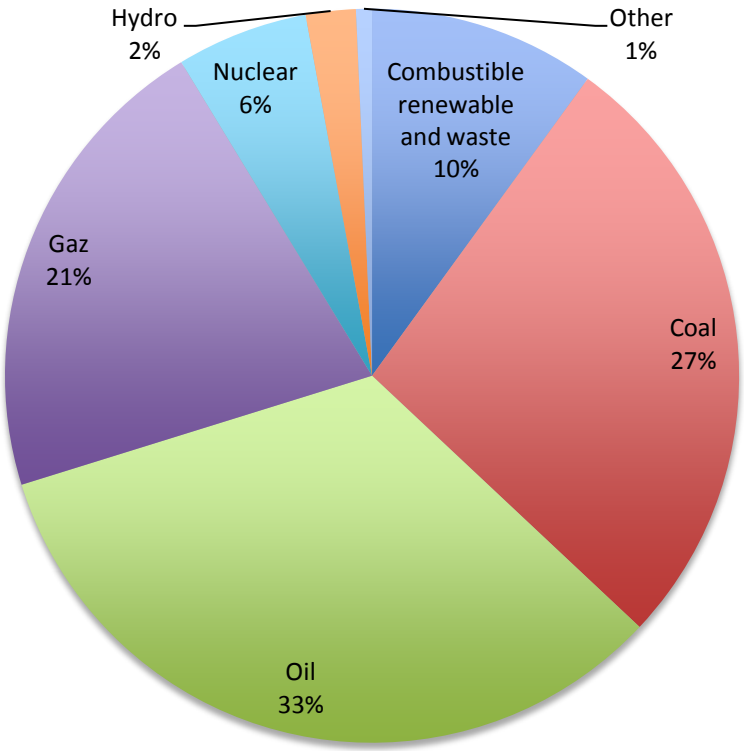
- Consequences
  - Indoor air pollution
  - Chronic health problems
  - Deforestation
  - Soil quality depletion
  - Natural disaster



Energy Policy 39(2011) : 7505-7517

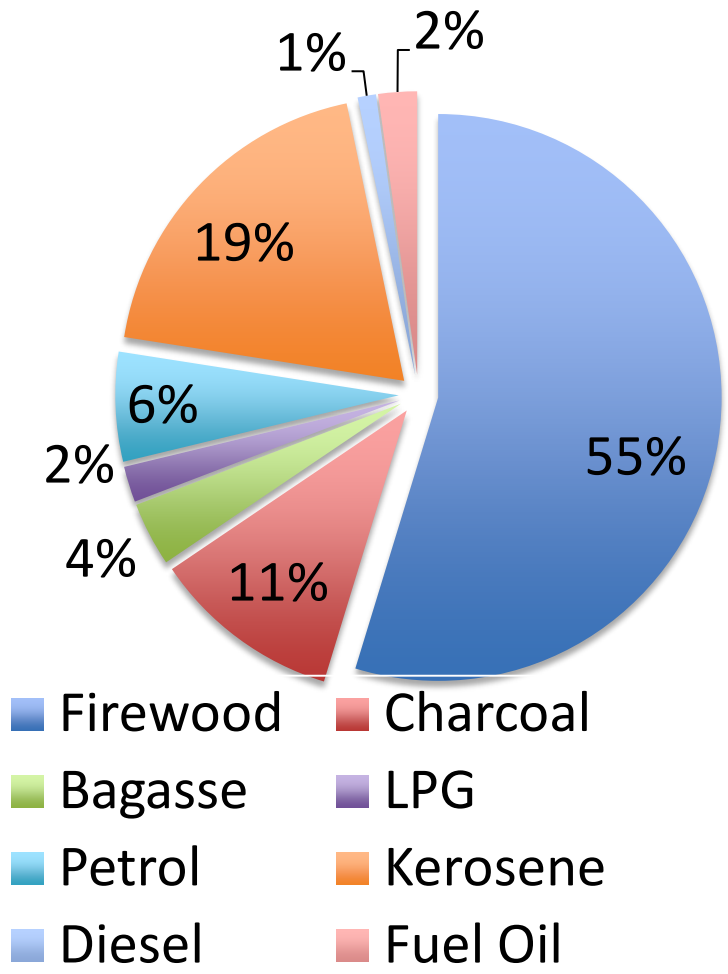
Energy consumption pattern

World



(IEA, 2010)

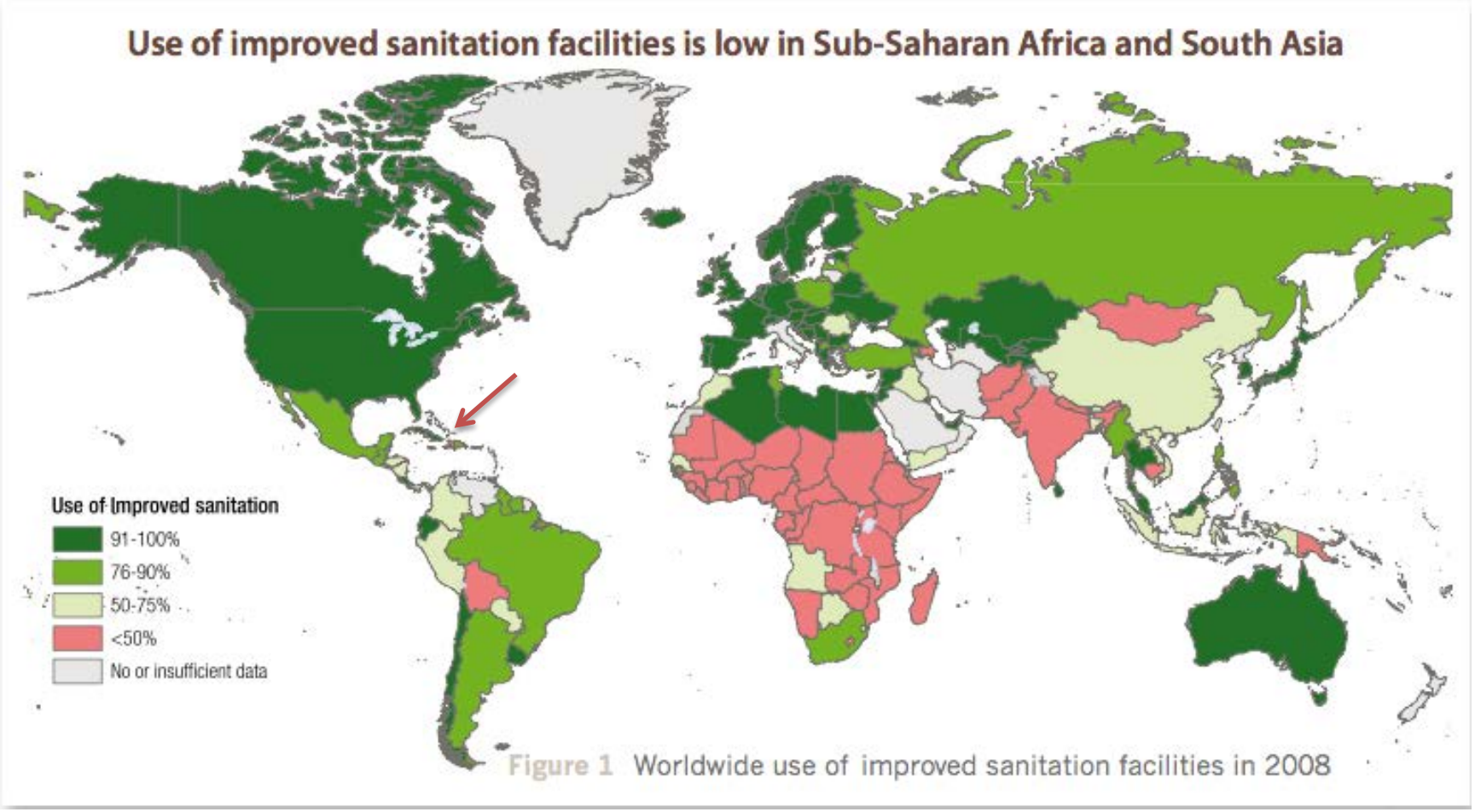
Haiti



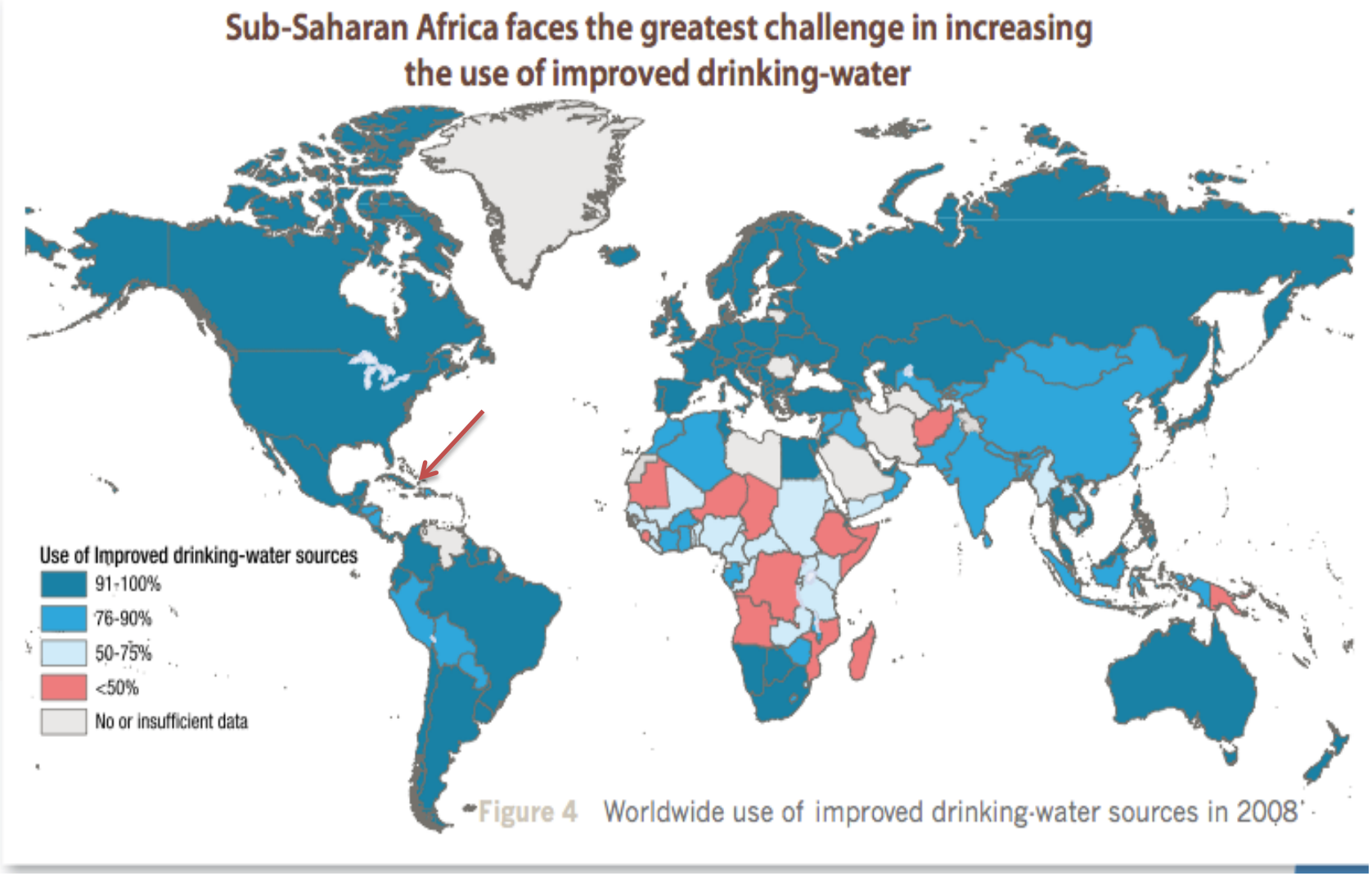
Water and sanitation

- More than 1.1 billion people lack access to improved drinking water
- 2.6 billion live without improved sanitation services
- 80% of all illnesses are caused by water-borne diseases
- Diarrhoea the leading cause of childhood death (*WHO, 2010)*
- *Developing countries are mostly affected*

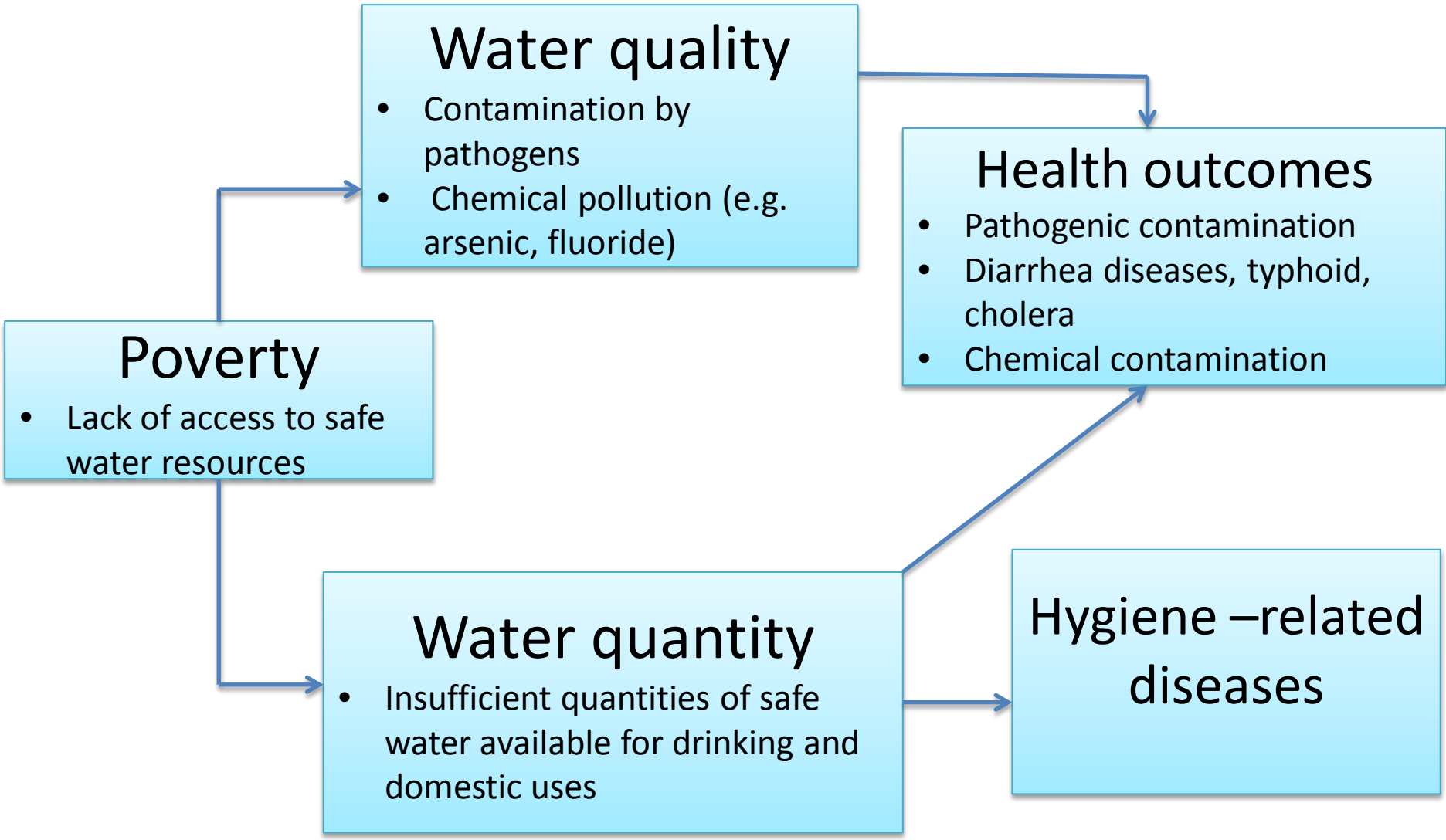
Improved sanitation coverage



Improved drinking water coverage



Water, sanitation, and public health



Municipal waste management

Developed Country →

← Developing Country

Waste disposal

Wastewater…….

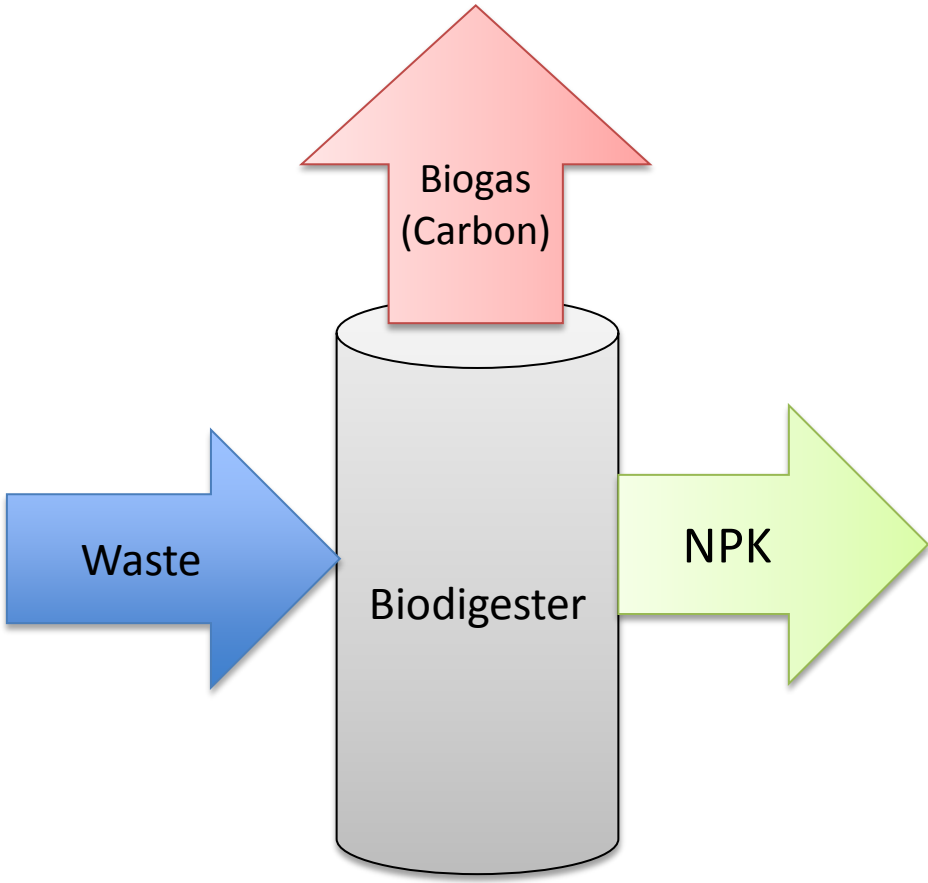
Urgent needs in developing countries

- Affordable and environmentally friendly energy source
- Basic sanitation and access to drinking water
- Reduction indoor air pollution

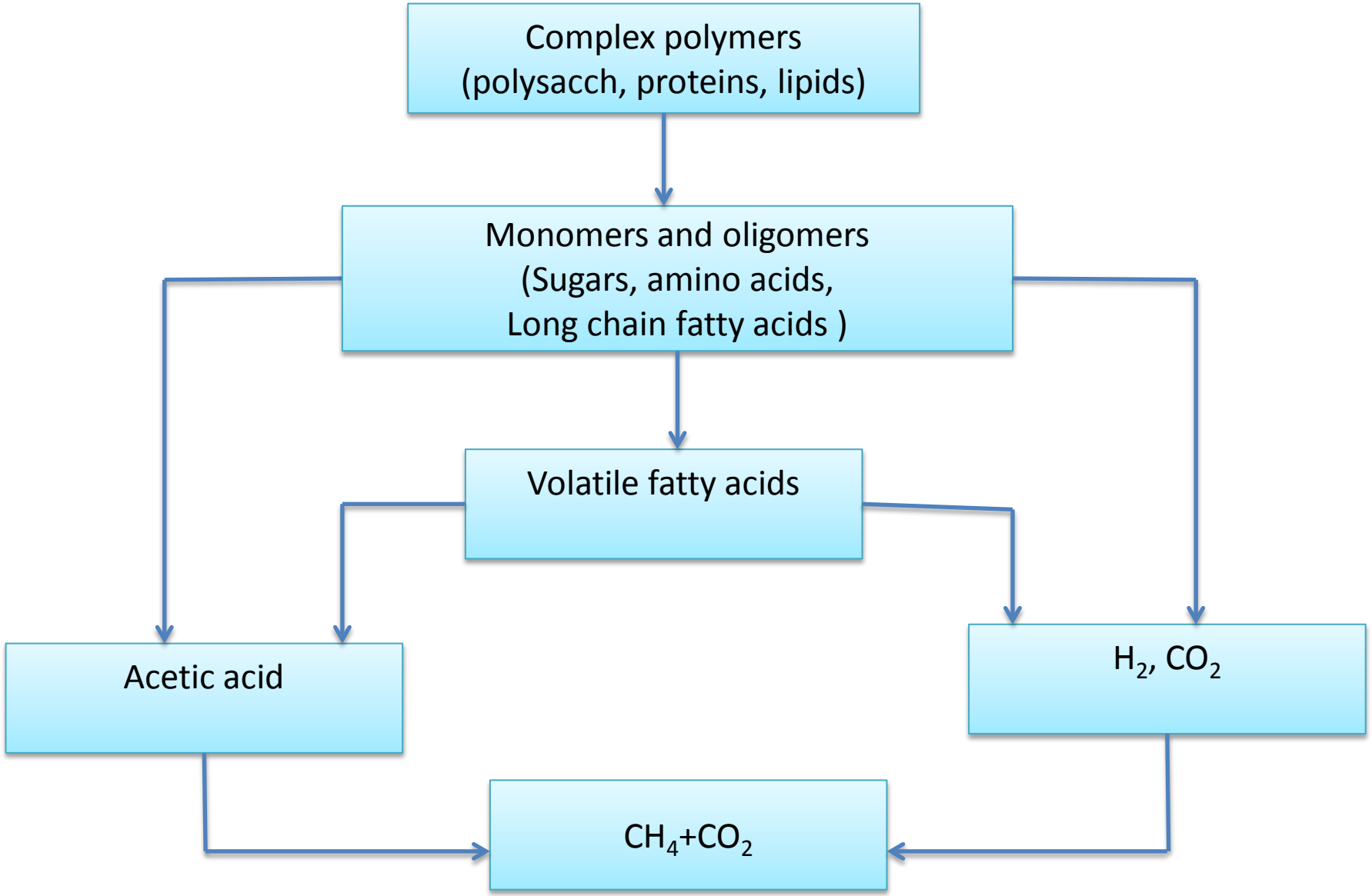
Anaerobic digestion technology can address all issues

Renewable fertilizer from anaerobic digestion

- Microbial degradation of organic matter
- Recycles plant nutrients and produces energy (biogas)
- Offsets the need for synthetic fertilizer



Anaerobic digestion process



Feedstock for anaerobic digestion

- Agricultural feedstock
  - Animal manure
  - Energy crops
  - Algal biomass
  - Crop residues
- Community based feedstock
  - Organic fraction of MSW
  - Sewage sludge
  - Grass clippings/garden waste
  - Food remains
- Industrial feedstock
  - Food/beverage processing
  - Dairy
  - Sugar industry

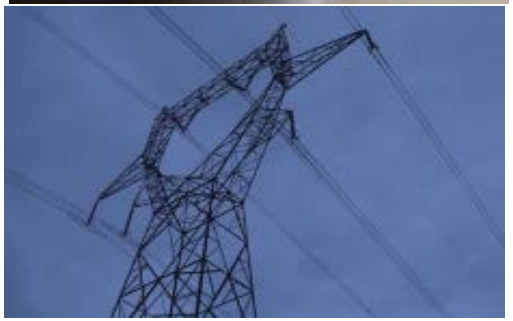
Types of digesters

- Batch versus Continuously
- Wet versus dry
- Two phase digestion versus single phase
- CSTR Continuously Stirred Tank reactor
- UASB Up- flow anaerobic sludge blanket
- Bag digester
- Covered Lagoon
- Fixed Film reactor

Digesters in developing countries

Use of biogas

- Cooking
- Heating (water/air)
- Electricity
- Gas lighting



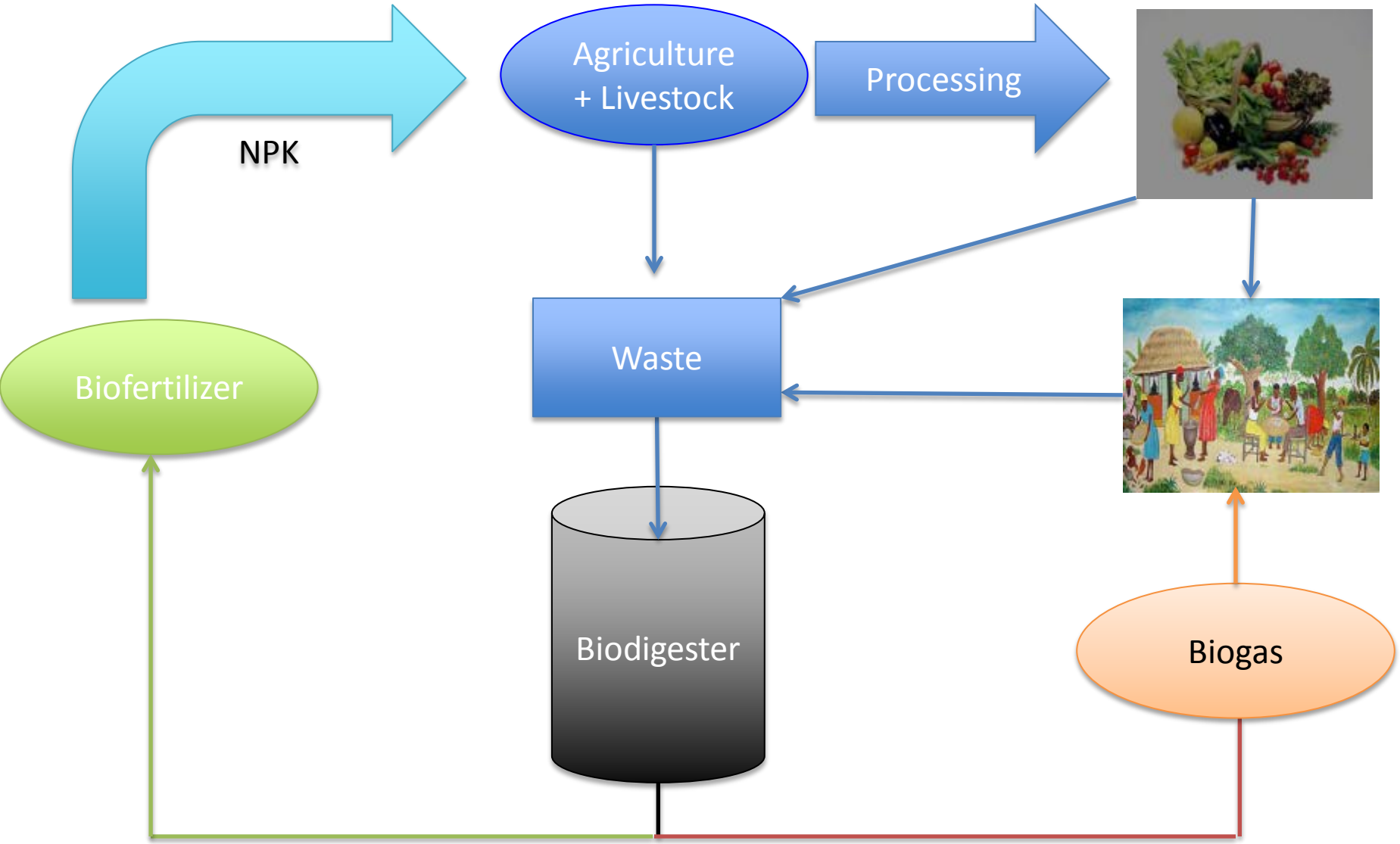
Biofertilizer generation

- Essential nutrients N,P,K , Mg
- Trace elements required by plants
- Presents in inorganic plant-available forms
- Positive effect on overall soil quality
- Close the natural and energy cycles
- **Biofetilizer= Increased crop yield at low cost**

Ecosanitation definition

Ecosanitation is a sustainable technology of waste management based on implementing the re-use and the recycling of nutrients and water as a hygienically safe, closed loop and alternative to conventional sanitation solutions

Ecosanitation approach



Ecosanitation : composting versus anaerobic digestion

Composting

Hot composting of human excreta before it comes into contact with soil or water

- Requires no water and zero waste process
- No environmental pollution, no odor
- Urine can be diverted
- Pathogen survival????
- No energy recovery

Anaerobic digestion and ecosanitation

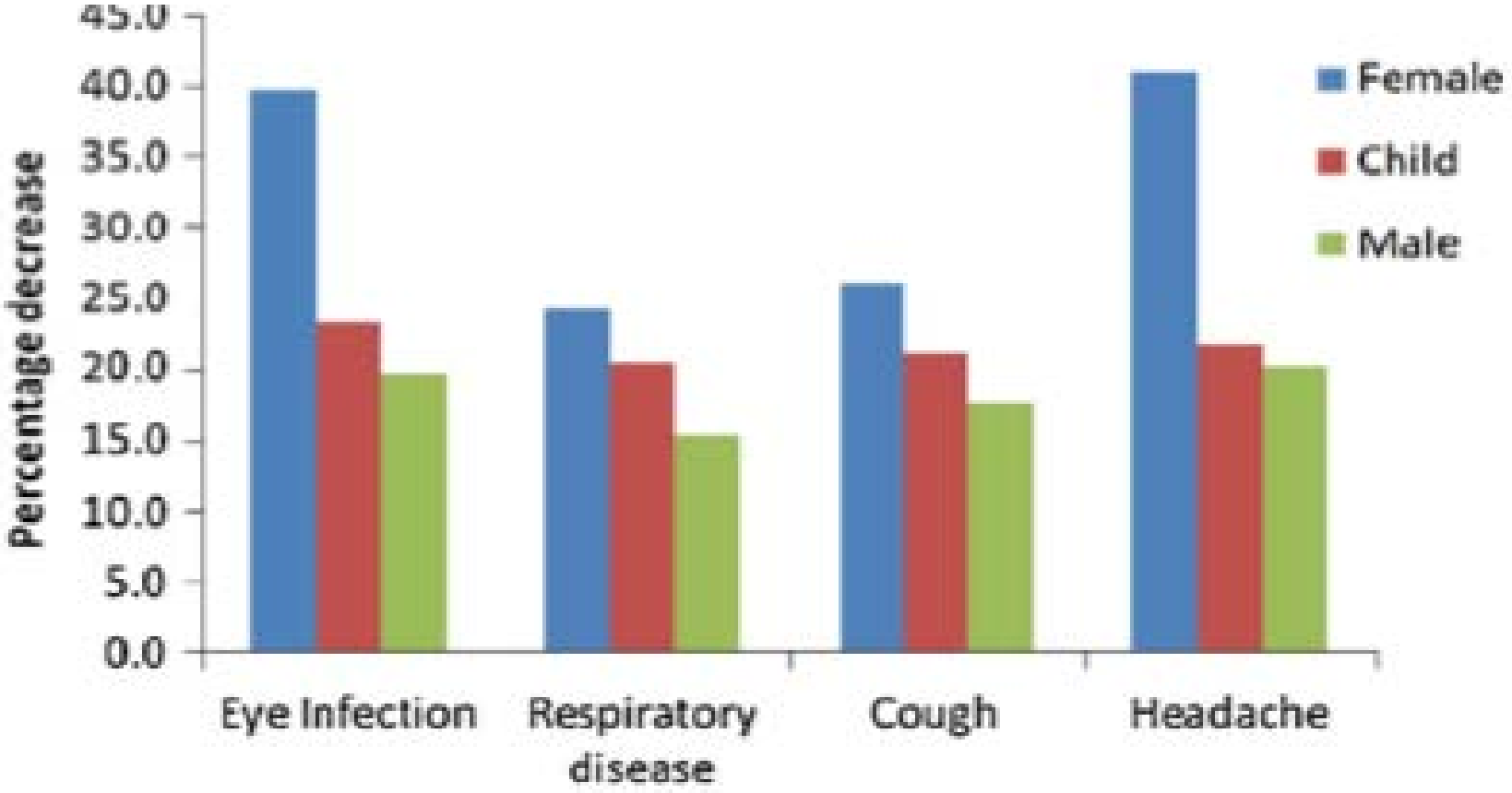
- Improvement of health by preventing introduction of pathogens to the water cycle
- Recovery and use of nutrients, water and energy
- Conservation of natural resources through the substitution of chemical fertilizers, reduction of water pollution and reduction of deforestation
- Preservation of soil fertility and augmentation of agricultural productivity
- Reduction of indoor air pollution
- Promoting human dignity and sustainable development

Composition and characterization of human wastes

Parameter	Faeces	Urine
Quantity (Wet/person/day, g)	70-520	1000-1500
Quantity (dry p/person/day, g)	30-70	50-70
Moisture content (%g/wet sample)	66-85	93-99%
Total solids (%g wet sample)	14-22	1.3-4
Volatile solids (%g dry sample)	79-84	0.4
COD (Total, g/L)	46.2-78.3	12.8
Nitrogen (g/person/day	5-7	15-19
Total phosphorus (g/person/day)	0.7-2.5	1.1-2.2
pH	-	7.1-9
Protein (g)	4-12	

Adapted from Resources, conservation, and Recycling 55 (2011) 400-408

Decrease in incidence of diseases among genders after installation of biogas in Nepal



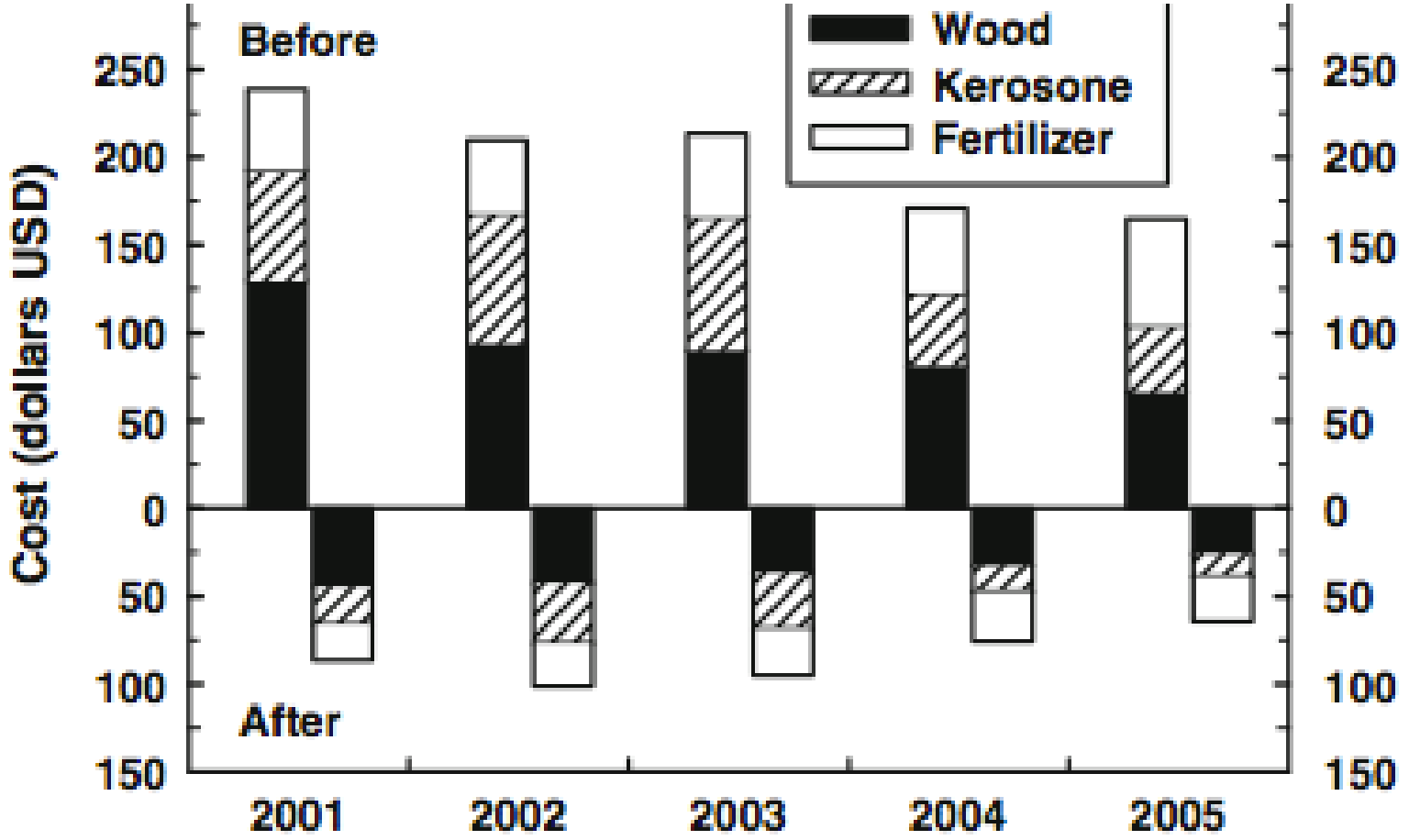
Renewable and Sustainable Energy Reviews 13 (2009) 2668–2674

Fuel used for cooking and lighting before and after the biogas installation in Nepal

	Before	After	Change	Percentage
Fire wood (bhari/month)	11.82	5.54	6.28	53.13
Kerosene (l/month)	2.89	1.38	1.51	52.25
Agriculture residue (bhari/month)	4.74	2.62	2.12	44.73
Dung cake (kg/month)	76.13	27.94	48.19	63.30
LPG (cylinder/month)	3.48	1.18	2.30	66.09
Coal (kg/month)	17.15	9.70	7.45	43.44
Saw dust	56.76	0.53	56.23	99.07
Candle (NRs/month/HH)	13.79	19.59	−5.80	−42.06
Solar (% of HH having)	15.52	7.20	8.32	53.61
Electricity (unit/month/HH)	53.68	53.98	−0.30	−0.56
Others	15.00	15.50	−0.50	−3.33

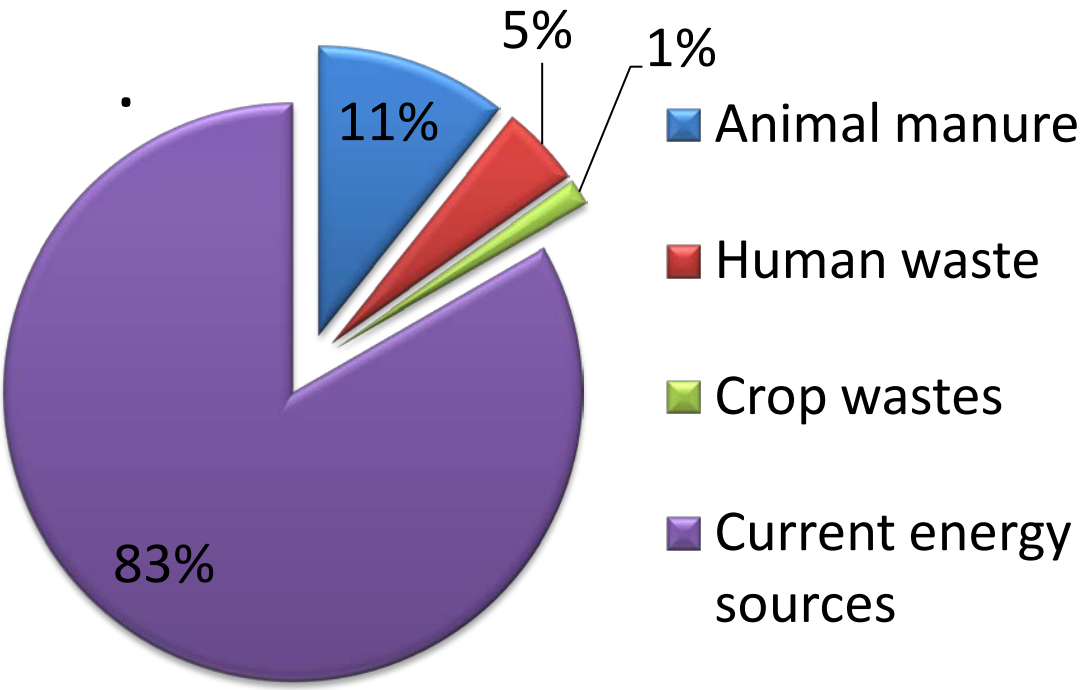
Renewable and Sustainable Energy Reviews 13 (2009) 2668–2674)

Average cost before and after implementation of biogas plants in India between 2001 and 2005



Human Ecol (2008) 36: 435-441

Biogas production potential of agricultural wastes and manures of Haiti



Percent contribution to total Haitian energy demand by methane from the anaerobic digestion of biowastes. Assumptions of 70% of all biowastes are collected

Anaerobic digester appropriate for Haitian rural areas