Role of bioenergy in enhancing energy, food and ecosystem sustainability

Dr. Lilibeth Acosta-Michlik
University of the Philippines Los Banos

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- Integrated sustainability assessment of bioenergy potentials in Asia: An application of a hybrid approach on trade-offs and pathways (PIC-STRAP)
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- Partners: Dr. D. Magcale-Macandog, University of the Philippines Los Baños
  Dr. X. Cui, Beijing Normal University
  Dr. K.S.K. Kumar, Madras School of Economics
  Dr. L. Acosta-Michlik, Potsdam Institute for Climate Impact Research

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- Definition: Bioenergy refers to energy from biomass
- Categories: (1) raw biomass - use for heating and cooking (e.g., wood)
  (2) processed biomass - use to generate energy for transport, industry and household purposes (e.g., bioethanol, biodiesel)

Bioenergy	Food Crops	Non-Food Crops
First generation	Sugar-rich like sugarcane, beets	
	Starch-rich like corn, wheat, cassava	
	oil-rich like soya, palm, coconut	Oil-rich like jathropa
Second generation		Agriculture and forest residues
		fast-growing trees/perennial grass
		Algae

Country	Bioethanol (million litres)			Biodiesel (million litres)		
	Feedstock	2010	2014	Feedstock	2010	2014
Philippines	sugarcane	10	110	Coconut oil	124	112
India	Molasses	1522	2036	Jatropha, Pongamia	90	130
China	Corn, Wheat, Cassava	2179	2787	Waste vegetable oil	568	1133

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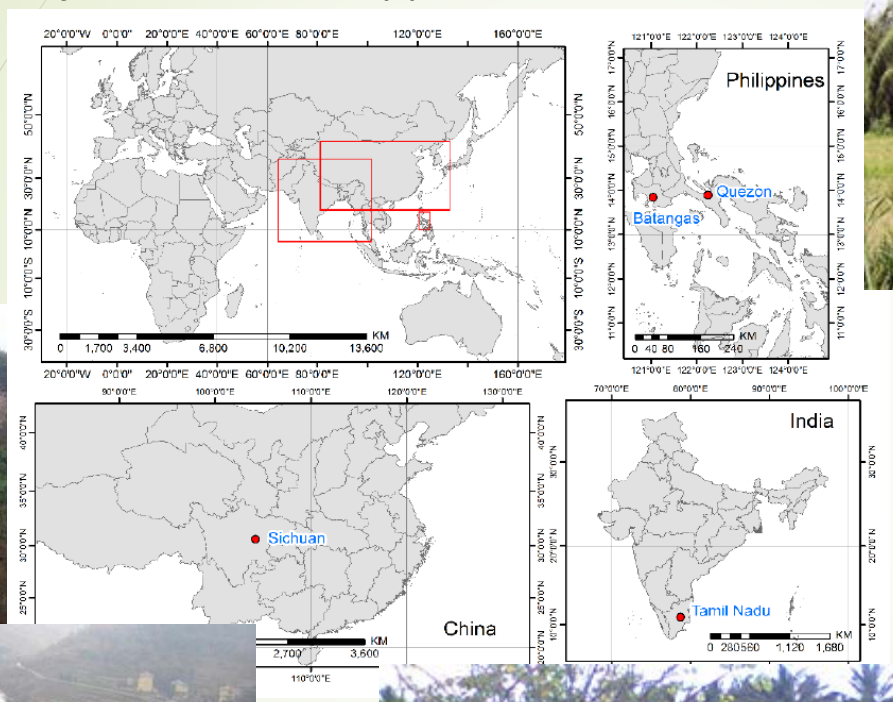
- Policy objectives: energy security, clean and renewable energy, source of foreign revenue and rural income, rural development, economic growth, etc.

Bioenergy	Advantages	Disadvantages
First generation	Potential source of rural income and development	Compete land use for food production
	Mature technologies at local SME scale	environment degradation and biodiversity loss
		Cause social exclusion and conflicts
Second generation	Less competition on land use for food production	Less organic fertilizer from crop residues
	Less production inputs like labor, water, fer	Cutting trees cause carbon emission
		Technology not yet mature

Role of bioenergy in enhancing energy, food and ecosystem sustainability

- Case study areas in the Philippines, India and China



Infanta Municipality

Wujing Village

Tirunelveli District

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- Online and field survey in the Philippines, India and China

Knowledge and Familiarity	Philippines		India		China	
	AGRI	NON-AGRI	AGRI	NON-AGRI	AGRI	NON-AGRI
Familiar with the term bioenergy	74.0	87.0	100.0	100.0	36.5	63.8
Work is related to bioenergy	28.4	6.1	95.6	94.3	7.7	11.2
Bioenergy affects food security	62.4	42.0	50.0	21.4	15.4	50.9
Bioenergy is good for the economy	94.7	95.0	98.9	100.0	98.1	92.2

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- Conjoint questionnaire and survey

Determinants (Attributes)	Indicators (Attribute levels) for Specific Type of Biomass		
	Sugar-rich Crops	Oil Crops	Fast-growing Trees
Economic Stability			
A. Energy security	Low domestic energy demand	High domestic energy demand	Low domestic energy supply
B. Technology progress	High R&D investment	Low R&D investment	High technology deployment
C. Market organization	High market incentives	Low market incentives	Good market infrastructure
Choose one option:			
Social Equity			
A. Food security	Increase food self-sufficiency	Increase purchasing power	Increase affordability of food
B. Social welfare	Increase livelihood sources	Increase job opportunities	Improve household lifestyle
C. Social justice	Hinder equal property rights	Cause home displacement	Cause land dispossession
Choose one option:			
Ecological Balance			
A. Ecosystem capacity	Potential affected by population pressure	Put more pressure on natural resources	Improve landscape and species diversity
B. Production potential	Very high potential	Moderate potential	Very low potential
C. Land management	Support nature conservation	Compatible with organic farming	Available good farming practices
Choose one option:			

Conjoint-based Choice Hierarchical Bayes method

$$Y_i = X_i \beta_i + \varepsilon_i$$

$$\beta_i = \Theta z_i + \delta_i$$

$$\omega_{ij} = \left(R_{ij} / \sum_{i=1}^{n} R_j \right) * 100$$

$$R_{ij} = \Theta_{ij}^{\max} - \Theta_{ij}^{\min}$$

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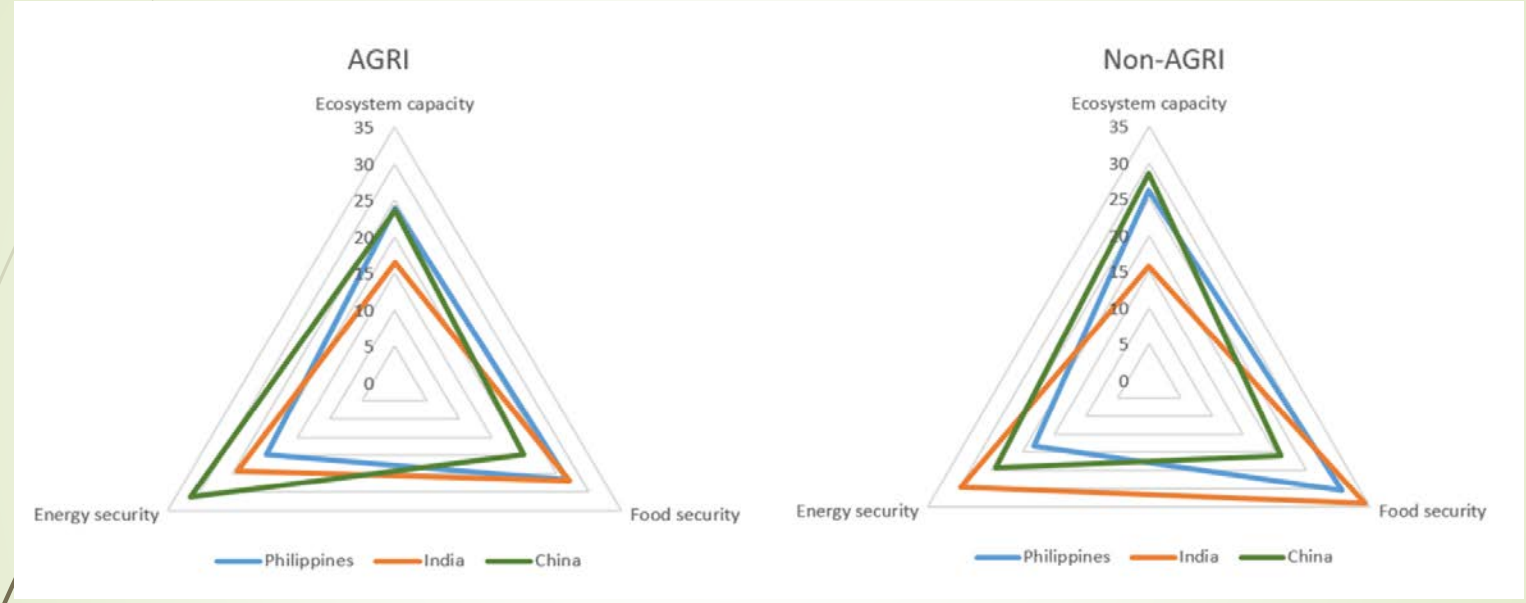
- Main results of the conjoint analysis



- Conjoint preferences revealed significant trade-offs among energy security, food security and ecosystem capacity in the Philippines, India and China.
- The preferred role of bioenergy for sustainable development reflects the social and economic concerns in the respective Asian countries:
  - Philippines - ecosystem degradation
  - India - food security
  - China - energy security and environmental condition
- Policy needs to carefully weigh the impacts of bioenergy development on sustainability issues that are closely interlinked in an energy-food-ecosystem nexus.

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- Recommendations on future regional actions/initiatives that may help to overcome already existing issues/gaps in the region:

1. Replication of conjoint survey in other major biofuels producing countries in Asia like Malaysia, Indonesia and Thailand

2. Identification of local technologies that are appropriate for production of biofuels at the farm level or for farmers' cooperative

3. Scientific investigation on the impacts of bioenergy on the biodiversity and ecosystem services, and how these impacts translate into decline in economic growth