STRAP

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Comparative analysis of knowledge and opinions of local communities on sustainability of bioenergy in the Philippines and China

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1 Introduction

The concept of low-carbon society (LCS) has recently become an important instrument to limiting global temperature increase below 2°C. LCS should be compatible with the principles of sustainable development, contribute to global reduction in greenhouse gases (GHG) emissions, promote use of low-carbon energy sources and production technologies, and adopt low-energy consumption behaviour (Skea & Nishioka 2008). Renewable energy resources and technologies are important to achieving LCS visions (Nakata et al. 2011). However, the relative contribution of the different renewable energy sources to a sustainable transition to LCS depends on the complexity of the systems. An energy system has three levels including the energy resources forming the primary energy, conversion technologies supplying secondary energy, and energy demand sectors comprising different energy consumers. Among the renewable energy sources, bioenergy presents an enormous policy challenge for sustainable transition to LCS due to inevitable trade-offs at different levels (Acosta-Michlik et al. 2011): (ii) Competing land use between food and fuel production, biodiversity protection and bioenergy production, and first and second generation feedstock production; (ii) Competing sources between domestically produced and imported biomass products and their feedstock; and (iii) Competing conversion technologies due to diverse range of options available to use and develop bioenergy. The trade-offs result in diverging social perception on and policy strategies for bioenergy sustainability due to contextual differences across countries. Moreover, bioenergy's complex system involves not only alternative products and competing sectors, but also diverse actors interacting at and across different levels. As a result, bioenergy production not only provides opportunities but also causes conflicts in the course of fulfilling any diverging private and public interests along and within these inter-linkages (Faaij 2006).

A better understanding of human perception on the sustainability issues confronting bioenergy system, i.e. feedstock resources, conversion technologies, and energy demand, will help develop appropriate policy for complex but promising renewable energy sources. PIC-

STRAP (Integrated sustainability assessment of bioenergy potentials in Asia: An application of a hybrid approach on trade-offs and pathways) project contributes to this challenging task through application of integrated and trans-disciplinary approach, highlighting social perception and policy preferences that affects transition to low carbon and sustainable societies. PIC-STRAP adopts a novel hybrid approach called STRAP (Sustainability TRade-offs and Pathways), which is guided by the hypothesis that trade-off decisions on achieving a balance among economic, social and ecological goals are necessary conditions for assessing development pathways in bioenergy (Acosta-Michlik et al. 2011). The overall aim of the PIC-STRAP project is to develop sustainable transition criteria towards low-carbon societies using hybrid analytical tools that allows systematic investigation of trade-offs and pathways in the development of first- and second generation bioenergy in Asia, in particular China, India and the Philippines. This paper presents the results of sustainability trade-offs in the Philippines and China using cluster and conjoint analyses. Its main objective is to compare the knowledge and opinions of local people on the contribution of bioenergy to economic stability, social equity and ecological balance in these two Asian countries. The paper is structured as follows: Section 2 highlights bioenergy policy and trends in the Philippines and China; Section 3 presents the methods used for data collection and analyses; and Section 4 discusses the results of the cluster and conjoint analyses.

2 Bioenergy policy and trends

2.1 Philippines

Energy demand in the Philippines was growing at an average annual rate of negative 0 .3 percent from 24.4 to 23.8 MTOE (i.e. Million Tons of Oil Equivalent) from 1999 to 2009 (DOE 2009) despite the increase in gross domestic product (GDP) and population (NSCB 2009). The economy has been growing at an average annual rate of 4.5 percent, with GDP increasing from 918.2 to 1,432.0 billion Pesos from 1999 to 2009. The average annual growth rate of the population was 2.1 percent, increasing from 74.7 million to 92.2 million for the same period. The negative growth in energy demand is also reflected in the constant decline in energy (-4.0 percent), oil (-6.4 percent) and electricity (-0.4 percent) intensity over the same period. The declining trend in energy consumption and intensity has been mainly contributed to the decline in energy demand in residential applications and in agriculture, which showed an average annual growth rate of -2.8 and -2.1 percent, respectively. The continuing increase in the prices of petroleum prompted the consumers to utilize energy in more prudent ways (Salire 2007). After the transport sector (36.5 percent), the residential sector (26 percent) accounted for the largest share in total domestic energy demand. Whilst energy demand declined, energy supply continued to increase, albeit at a slow rate of 0.4 percent per year from 38.1 to 39.6 MTOE. The self-sufficiency level in energy increased from 48.6 percent in 1999 to 59.2 percent in 2009 as a result of the increase in indigenously supplied energy. Renewable energy such as geothermal energy and biomass are important indigenous sources of energy in the Philippines. The energy from biomass, which is mostly derived from forest and agriculture residues, and bagasse, is mainly used for traditional household cooking. Thus, there is a potential for increasing household welfare through improvement in the use of biomass (Samson et al. 2001).

Like in many other countries, the Philippines is implementing various bioenergy policies to reduce dependence on imported oil, enhance economic growth, increase energy efficiency and contribute to climate change mitigation. The most prominent policy is the Biofuels Act of 2006, which mandates a 2 percent blend of biodiesel into all diesel fuel in 2008 and 10 percent blend of bioethanol into all gasoline fuel in 2010. According to the DA, the objectives of Biofuels Act are as follows: (1) developing and utilizing indigenous renewable and sustainably-sourced clean energy sources to reduce dependence on imported oil; (2) mitigating toxic and greenhouse gas (GHG) emissions; (3) increasing rural employment and income; and (4) ensuring the availability of alternative and renewable clean energy without the detriment to the natural ecosystem, biodiversity and food reserves of the country (Bento 2008, Naylor et al 2007, Clancy 2008, Sydorovych and Wossink 2008). The Biofuels Act also provides an incentive of a zero-rated specific tax on the biofuels component of blended gasoline or diesel. Other incentives include an exemption from value-added tax for the sale of raw materials in the production of biofuels, exemption from wastewater charges under the Clean Water Act, and the extension of financial assistance from government financial institutions for the production, storage, handling, and blending of biofuels (Ceccon and Miramontes 2008).

To support and comply with the provisions of the Biofuels Act, the DA has been pursuing the Biofuel Feedstock Program, which provides (1) production support services, (2) extension support, education and training services, (3) credit facilitation, (4) research and development, (5) irrigation support services, other infrastructure and postharvest & development services, and (6) marketing development to promote the use of coconut and jathropa for biodiesel and sugarcane, cassava, and sweet sorghum for bioethanol (Bento 2008). The Act also allows oil companies to import biofuels until 2010 to meet these policy targets. Whilst there were no reported obstacles during the transition to a higher biodiesel blend due to adequate local supply (Corpuz 2009), the bioethanol situation was less stable. To comply with the bioethanol mandates, local companies have been importing bioethanol due to supply scarcity and price volatility. In 2009 ethanol accounted for 0.30 percent of the total indigenous energy supply and 0.10 percent of the total domestic energy supply. Despite concerns about the impacts of importing bioethanol on local production, the government approved further imports in 2011 to meet its biofuel blending targets (DA-BAR 2011). The local supply of biodiesel and bioethanol is largely produced from coconut and sugarcane; both are traditional crops in the Philippines. Other potential biomass for bioenergy production includes jathropa for biodiesel, and cassava and sweet sorghum for bioethanol. The ethanol yields per hectare per year are 4,550 liters for sugarcane, 1,395 liters for cassava, and 6,000 liters for sweet sorghum (SRA 2008). The biodiesel yields per hectare are 630 liters for coconut and 1,892 liters for jatropha (DOE 2010). The government supports the production of jatropha for biodiesel because it is a non-staple crop and grows on marginal lands.

2.2 China

China's economy has experienced remarkable growth since economic reforms initiated in 1978. Annual average growth rate of gross domestic product (GDP) reached nearly 10% in the last three decades. The rapid growth of China's economy also led to a rapid rise in demand for energy that also gave rise to mounting concerns in the country about its national energy security. Despite the rapid growth of domestic energy production, demand has grown even faster. China has shifted from being a net energy exporter to being an importer since the late 1990s and is becoming one of the largest importers in the world in recent years (Qiu, Huang et al. 2010). Despite rapid development of energy demand, many Chinese rural households still depend heavily on traditional biomass energy for heating and cooking (Démurger and Fournier 2011). China is facing increasing energy pressure. Given the energy security concerns, the search for alternative sources of energy has become a top policy priority of the Government of China (Qiu, Huang et al. 2010).

Renewable energy and energy efficiency (REEE) policies become a national priority for the Chinese government, particularly since 2005 in six sectors: electricity, industry, transportation, buildings, and local government. Fortunately, unlike many other national governments, the Chinese central government is blessed with a sound financial position, which allows significant investment in REEE. In 2012, spending on energy conservation and environmental protection totaled 200 billion RMB (Lo 2014). S&T program funds and investment in energy related areas make it possible for Chinese researchers to cooperate with their international partners in various ways. The MOST and NDRC also cooperate to promote the development of energy. The National Development and Reform Commission (NDRC) NDRC and MOST Ministry of Science and Technology (MOST) of China co-fund several international cooperation energy projects. In 2007, the "Renewable and New Energy International Cooperation Program" was launched by the NDRC and MOST together. It focuses on large capacity wind farms, biomass power plants, and transfer technology from biomass to liquid fuel. In 2007, MOST and the Italian Environment Protection Foundation initiated the "Demonstration and Industrialization Project of Producing Biodiesel from Jatropha curcas L. in Sichuan" and has established several pilot plantations of Jatropha curcas L. in the Sichuan province (Lo 2014).

China's biofuel industry has expanded rapidly since early 2000s. Bioethanol production reached 1.35 million tons in 2007. Four large-scale state-owned bioethanol plants in Heilongjiang, Jilin, Henan, and Anhui provinces were constructed in 2001. The total annual bioethanol production capacity of these four plants, which mainly use maize as feedstock, is approximately 1.5 million tons. In 2007, China set up another bioethanol plant based on cassava in Guangxi Province, which started operation in early 2008. The annual production capacity of this plant in the initial stage is 0.2 million tons. Chinese government has established the medium and long-term development plan, at the end of 2020 (Liu, Liu et al. 2013). By the end of 2007, there were about 10 biodiesel plants operating in China. Most of them use industrial waste oil and waste cooking oil as feedstock. The total annual production capacity for all of these plants is less than 0.2 million tons. Biodiesel production needs a stable supply of lipid or vegetable oil as feedstock, but China is short of those feedstocks. These two policy documents specified the following major support policies during the implementation of the pilot testing program:

- First, the 5% consumption tax on all bioethanols under the E10 program was waived for all bioethanol plants;
- Second, the value-added tax (normally 17%) on bioethanol production was refunded at the end of each year;
- Third, all bioethanol plants received subsidized ''old grain" (grains reserved in national stocks that are not suitable for human consumption) for feedstock. 1 This subsidy is jointly provided by the central and local governments;
- Fourth, a subsidy was offered by the central government to ensure a minimum profit for each of bioethanol plants. That is, if despite all three support mechanisms described above, any bioethanol plant were to record a loss in the production and marketing of bioethanol, it would receive a subsidy from the Government that equals the gap between marketing revenues and production costs plus a reasonable profit that the firm could have obtained from an alternative investment. This subsidy is estimated for each plant at the end of each year. Besides these four support policies, the Government of China also ensured markets for the bioethanols produced by these state-owned plants. Bioethanol produced by private plants was not allowed to enter the market.

China is now the third largest bioethanol producer in the world after the United State and Brazil. While there are several potential feedstock crops available for bioethanol production, lack of land for feedstock production is one of major constraints in China's bioethanol expansion.

3 Methods

3.1 Segmentation of conjoint preferences

Segmentation seeks to combine homogeneous population into a group with similar preferences or to segregate heterogeneous population into groups with dissimilar preferences. Although there is no single segmentation approach, it can generally be described as forward or backward and a-priori or post-hoc (Andrews and Currim 2003). The initial foci of segmentation in forward approach are the respondents' basic characteristics (e.g. demographics) or distinct attitude towards an issue, and in backward approach are the preferences from conjoint analysis. In both approaches, segmentation can be determined using expert judgement (i.e. a-priori approach) or clustering techniques (i.e. post-hoc approach). A-priori segmentation is also referred to as conceptual approach where the grouping criteria are known in advance, whilst post-hoc segmentation is data-driven approach requiring quantitative techniques to analyse the data (Dolnicar 2002). Cluster analysis is the most widely adopted technique for post-hoc segmentation (e.g. Hoek et al. 1996, Dolnicar 2002, Dillon and Mukherjee 2006), which is thus often referred to as cluster-based segmentation (Green et al. 2001).

According to Andrews and Currim (2003), when segmentation is based on cluster analysis of conjoint part worths (or utilities) then one is following a backward post-hoc approach. In this paper, we followed a forward post-hoc approach where we use information on respondents' perception on bioenergy to create well-defined segments of conjoint preferences. Specifically, the heterogeneity in the population is captured in covariates describing the knowledge and opinions of the respondents on the effects of bioenergy on food security and economic growth. These covariates are used in the model as segments to define utility (i.e. preference/part-worth) structures of respondents who have similar knowledge and opinions. In cluster-based segmentation, Green et al. (2001) explained that the data are allowed to speak for themselves in terms of finding groups who share similar needs, attitudes, trade-offs, or benefits. The cluster analysis follows the two-step approach described in Hair et al. (1995), which combines both hierarchical and non-hierarchical clustering procedures to arrive at the most realistic cluster solution for the data set. The two-step approach is the most appropriate method for clustering population using categorical variables (Shih et al. 2010, Dymnicki & Henry 2011). These variables are the responses of the respondents to the following survey questions:

Question:	Response variables:
Are you familiar with the term "bioenergy" (also known as biofuels)?	1 = yes 2 = no
In your opinion, is bioenergy good or bad for the economy in your country?	1 = yes 2 = no
Do you think the use of biomass from food crops for bioenergy production increases food prices and thus affects food security (i.e. food affordability and availability) in your country?	1= yes 2 = no 3 = do not know

The number of clusters for segmentation was identified by running different cluster analyses for different cluster numbers and comparing the cluster quality based on the measure of cohesion and separation (SPSS 2007). After identifying the optimal number of clusters from the two-step clustering approach using SPSS software, matrix scoring[1] was carried out to identify the cluster attributes or typologies of the segmented population. Conjoint analyses were then applied to each population segment, which represent a distinct typology.

Conjoint analysis (also known as choice models or experiments) is a practical technique for measuring preferences that is widely used in different scientific fields including psychology, transport, economics, and environment. Farber & Griner (2000) provide a summary of the application of conjoint analysis for environmental valuation. Considerable attention has been given to this technique both in academe and industry to measure preferences through utility trade-offs among products and services (Lee et al. 2006, Green & Srinivasan 1990), particularly in agro-environments (e.g. Tano et al. 2003, Stevens et al. 2002, Moran et al. 2007, Blamey et al. 2000). Conjoint technique is suitable for analysing human decisions, particularly for understanding the process by which individuals develop their preferences for products or services (Sayadi et al. 2005). The preferences are assumed to be influenced, on the one hand, by the individual's subjective perceptions on the presented choices and, on the other hand, by its economic, social and cultural environment. Conjoint measurement assumes that a product can be described according to the levels of a set of attributes, and the consumer's overall judgement with respect to that product is based on these attribute levels (Sayadi et al. 2009). In choice-based conjoint (CBC) analysis, a set of attributes and their respective levels define the respondents' choices. Specifically, the combinations of attribute levels define the choice tasks in conjoint surveys. A conjoint study leads to a set of part-worths or utilities that quantify respondents' preferences for each level of each attribute (Orme 2010). It is a measure of relative desirability or worth so that the higher the utility, the more desirable is the attribute level (Orme 2006).

In this paper, the responses from the survey were analysed using a Hierarchical Bayes Choice-based Conjoint (HCBC) model that is able to capture preferences of individuals (i.e. respondent level) and groups of individuals (i.e. segment level) (Orme 2009):

(1) $Y_i = X_i \beta_i + \varepsilon_i$

(2) $\beta_i = \Theta z_i + \delta_i$

Where in the first equation $\boldsymbol{Y_i}$ is a vector of the responses from the choice tasks, $\boldsymbol{X_i}$ is a matrix of the attribute levels, $\boldsymbol{\beta_i}$ is the $\boldsymbol{p}$-dimensional vector of regression coefficients representing the utilities, and ε_i is a $\boldsymbol{p}$-dimensional vector of random error terms. In the second equation, Θ is a $\boldsymbol{p}$ by $\boldsymbol{q}$ matrix of regression coefficients (i.e. utilities), $\boldsymbol{z_i}$ is a $\boldsymbol{q}$-dimensional vector of covariates and δ_i is a $\boldsymbol{p}$-dimensional vector of random error terms. The HCBC model is called hierarchical because it models respondents' preferences as a function of a lower- or individual-level (within-respondents) model and an upper-level (pooled across respondents) model (Orme & Howell 2009). According to Lenk et al. (1996), hierarchical Bayes analysis creates the opportunity to recover both the individual-level part-worths and heterogeneity in part-worths, even when the number of responses per respondent is less than the number of parameters per respondent. The parth-worths were calculated using HB/CBC module of the

[1] Matrix scoring is a method to synthesize the collected survey data and a common technique that has been widely used in participatory research for assessing the relative importance of different activities in people's livelihoods (DFID 2002).

SSIWeb Sawtooth software (Orme 2010). Using the part-worths or utilities, we also calculated the importance of each attribute by dividing the utility range with the sum of the attributes' utility ranges, where the range is the difference between the highest and lowest utility.

3.2 Survey framework and design

Following the STRAP framework, we characterise sustainability using three dimensions – economic stability, social equity, and resource productivity (Table 1). These dimensions are represented by determinants, which are issues or phenomena that significantly influence the nature of sustainability. For determinants that are not directly measurable, indicators provide a benchmark to quantify and simplify the concept or idea they represent. A more detailed discussion on the interconnections and interdependencies between the different determinants and indicators of social, economic and ecological dimensions of sustainability is available in Acosta-Michlik et al. (2011). In the context of bioenergy development, economic stability depends on energy security, technology progress and market organisation, social equity is influenced by food security, social welfare and social justice, and resource productivity is associated with production potential, resource capacity and land management. These determinants represent economic, social, and environmental issues, which many policies aim to address to attain sustainability. The focus of the policies may not necessarily represent the preferences of the society, and these social preferences are manifested on the perceived importance of the individual indicators for each determinant. These indicators are related to human basic needs affecting energy, food, income, property rights, productivity, etc.

The determinants of economic stability, social equity and resource productivity represent the attributes and the indicators for these sustainability determinants represent the attribute levels in the survey design. In the discussion of the results, we will also refer to the sustainability determinants as attributes and sustainability indicators as attribute levels to conform to the terminologies that are used in conjoint analysis. Each attribute level is further defined according to its desirability for the society, which aims to make the respondents decide on trading-off between more and less desirable levels of the sustainability indicators (Table 1). Each attribute has a total of 6 levels – 3 desirable and 3 undesirable attribute levels. The possible combinations of the different attribute levels make up the different options in a choice task. Table 2 presents an example of a choice task for the different sustainability dimensions. In the survey questionnaire, the respondents were given 5 choice tasks (1 fixed task and 4 random tasks) for each of the sustainability dimensions. In each choice task the respondents were asked to choose only one among three options. The options are linked to a given type of biomass, which can be either first generation (i.e. sugar-rich crops, starch-rich crops and oil-rich crops) or second generation (i.e. agriculture/forest residues, fast-growing trees, and perennial grasses) bioenergy crops. We used the feedstock attribute levels as reference for each option so that the respondents can explicitly link their choice decisions to the types of biomass.

Table 1 Dimension, Determinants and indicators of bioenergy sustainability

Determinants (Attributes)	Indicators (Attribute levels)	Level of desirability	
		More desirable	Less desirable
1. Economic Stability			
Energy security	1. Domestic energy demand	Low	High
	2. Domestic energy supply	High	Low
	3. Foreign energy trade	Low import	High export
Technology progress	1. R&D investment	High	Low
	2. Technology deployment	High	Low
	3. Energy efficiency	High	Low
Market organisation	1. Market incentives	High	Low
	2. Market infrastructure	Good	Poor
	3. Trade constraints	Low	High
2. Social Equity			
Food security	1. Food self-sufficiency	Increase	Decrease
	2. Purchasing power	Increase	Decrease
	3. Affordability of food	Increase	Decrease
Social welfare	1. Livelihood sources	Increase	Decrease
	2. Job opportunities	Increase	Decrease
	3. Household lifestyle	Improve	Worsen
Social justice	1. Equal property rights	Hinder	Support
	2. Home displacement	Prevent	Cause
	3. Land dispossession	Prevent	Cause
3. Resource Productivity			
Production potential	1. Potential level	Very high High Moderate	Very low Low No potential
	2. Feedstock sources*	Crop/forest residues Fast-growing trees Perennial grasses	Starch-rich crops Sugar-rich crops Oil-rich crops
Resource capacity	1. Effects of population pressure	Production potential unaffected	Production potential affected
	2. Pressure on natural resources	Put less pressure	Put more pressure
	3. Effects landscape and species diversity	Improve diversity	Destroy diversity
Land management	1. Effects on nature conservation	Support	Conflict
	2. Compatibility with organic farming	Compatible	Incompatible
	3. Availability of good farming practices	Available	Not available

*Following the sustainability concept for bioenergy (Acosta-Michlik et al. 2011), first generation crops are less desirable than second generation crops as sources of feedstock for bioenergy production.

Table 2 Example of a choice task in the conjoint survey on sustainability of bioenergy

Sustainability Dimension	**Types of Biomass**		
	Sugar-rich crops	Oil crops	Fast-growing trees
Economic Stability			
1. Energy security	Low domestic energy demand	High domestic energy demand	Low domestic energy supply
2. Technology progress	High R&D investment	Low R&D investment	High technology deployment
3. Market organisation	High market incentives	Low market incentives	Good market infrastructure
Choose one option:	□	□	□
Social Equity			
1. Food security	Increase food self-sufficiency	Increase purchasing power	Increase affordability of food
2. Social welfare	Increase livelihood sources	Increase job opportunities	Improve household lifestyle
3. Social justice	Hinder equal property rights	Cause home displacement	Cause land dispossession
Choose one option:	□	□	□
Resource Productivity			
1. Production potential	Very high potential	Moderate potential	Very low potential
2. Resource capacity	Potential affected by population pressure	Put more pressure on natural resources	Improve landscape and species diversity
3. Land management	Support nature conservation	Compatible with organic farming	Available good farming practices
Choose one option:	□	□	□

The SSIWeb Sawtooth software was used not only to analyse the responses of the respondents (i.e. compute utilities and importance), but also to construct the choice tasks and prepare the conjoint questionnaire. We use complete enumeration as a random tasks generation method and traditional full profile design. Moreover, the software package includes a statistical test (i.e. logit efficiency) to validate the survey design prior to its implementation. It is useful to validate the survey design to identify the optimal number of options and choice tasks as well as number of questionnaire versions that will yield statistically significant results for a given number of respondents. The different versions of the questionnaire have different sets of options and choice tasks, except for the fixed task. The WEB-platform of the software was used to conduct the survey through the internet. For respondents who do not have access to internet, we converted the same survey into CAPI (Computer Aided Personal Interview) module, which refers to data collection using a laptop or a personal computer not connected to the internet. The survey was pre-tested in the field using the CAPI module, which enabled the interviewers to collect suggestions on how to improve the questionnaire. For example, the pre-testing revealed that linking the options to specific type of biomass helps to reduce the level of abstraction of the conjoint choices. In addition to the choice tasks presented in Table 2, the survey includes questions about (1) the respondents' personal and employment background, (2) opinion and general knowledge on the bioenergy sector, and (3) the crops which are relevant to their work. Moreover, the respondents were asked to rate the potential contribution of not only bioenergy crops, but also other sources of energy (i.e. fossil, other renewables) in promoting economic growth in the country.

4 Results and discussion

4.1 Respondents' categories and opinions

Figure 1 shows the distribution of the respondents according to demographic categories including age, education, work, domicile, and region. The demographic characteristics of respondents in the Philippines and China are very similar, except for the fields of work. Around 60 percent of the respondents are below 31 years old and less than 3 percent are above 60 years old. The participation of respondents with high education (i.e. university level) is very high in both countries at approximately 80 percent. This can be explained by the nature of the survey, where educated persons can be easily access online. The field survey allowed us to reach less educated respondents, particularly farmers with no access to internet. They represent about 20 percent of the total respondents who have reached only secondary school. At least 60 percent of the Philippine and Chinese respondents live in urban and suburban areas and 25-30 percent in agricultural areas. Only negligible number of respondents has their domicile in forest or mountain areas and in industrial or commercial areas. The respondents work in public agency, private company, farm/agriculture, and academe/research. Those that do not fall in any of these work categories are included in "others". There is relatively similar distribution of the Philippine respondents according to these five work categories. The Chinese respondents are dominated by professionals from the academe. The respondents were asked in the survey to identify the crops that are relevant to their work and the results for this question is summarised in Figure 2. The work of the surveyed respondents is related to many crops, which are either currently used (i.e. sugar, coconut, rapeseed) or have the potentials (i.e. jathropa, sorghum, cassava) as biomass feedstock for bioenergy production in Asia. The crops related to the work of respondents in the Philippines are mainly coconut and rice, while those in China are trees, farm/forest residues and potato.

Figure 1 Distribution of respondents according to different demographic categories

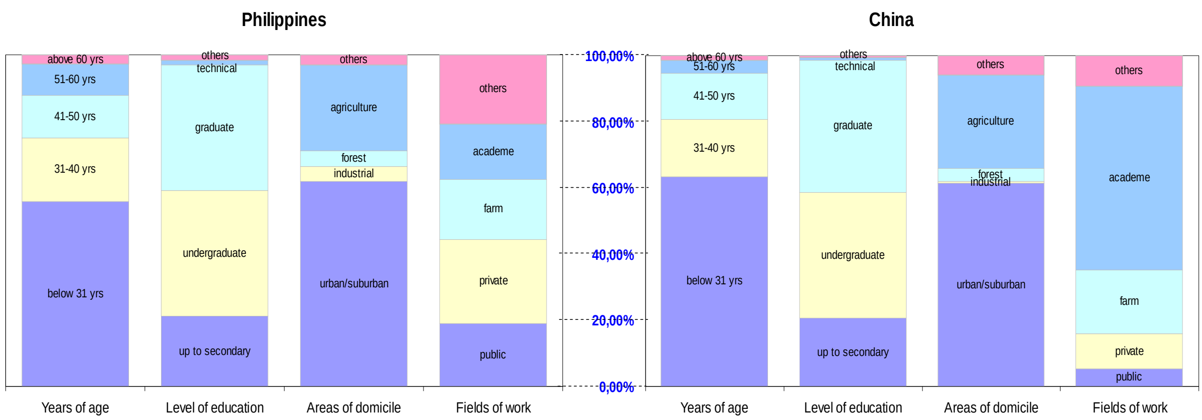


Figure 2 Crops related to the work of the respondents

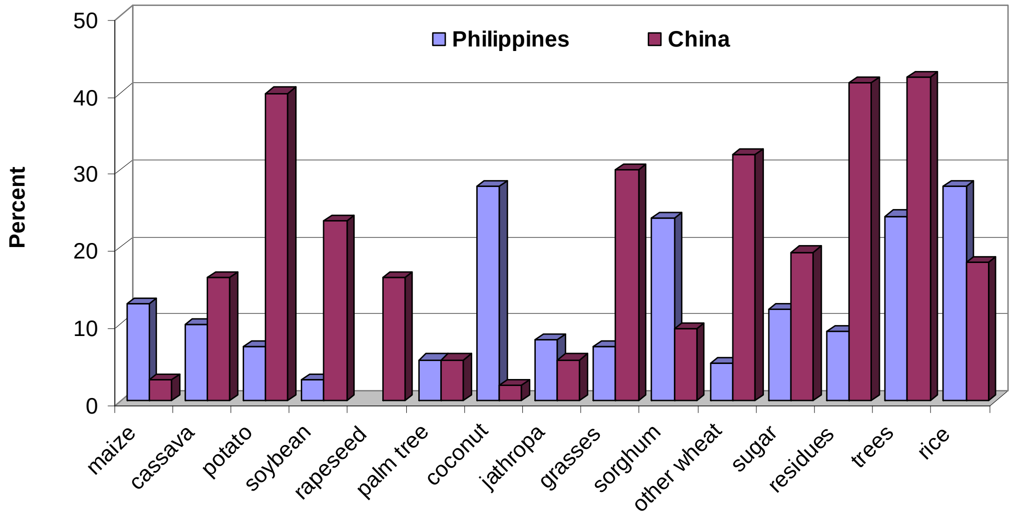


Table 3 presents the differences in the knowledge and opinions of respondents according to their demographic categories. Knowledge and opinions on bioenergy vary not only according to the demography but also country. In the Philippines, when asked if their work is related to bioenergy, only 15.61 percent of the respondents answered "yes". For respondents who work in agriculture or farm, only seven percent thinks that their work is related to bioenergy. This is somehow contradictory to the share of respondents who are engaged in the production of bioenergy feedstock (Figure 2). The reasons for this include the weak link between the actors (i.e. biomass producers, biofuel companies) along the bioenergy production chain and the lack of knowledge of the biomass producers on their role in the bioenergy production system. Discussions with respondents during CAPI surveys revealed that the coconut producers, which represent 28 percent of total respondents, have not established either contact or contract with biofuel producers. Moreover, although some of the sugar producers (i.e. farmers) are already in contact or negotiating with biofuel processing companies, the farmers still do not consider their work as related to bioenergy production. They consider themselves as sugar producers, who can supply raw materials to any processing companies (i.e. not only biofuels) that need sugar products.

The number of Philippine respondents who are familiar with bionergy is also lowest among farmers or farm workers with only 13.35 percent (Table 3). There is thus a general lack of awareness on bioenergy in the farm sector. But overall, familiarity with bionergy is high with 91 percent of all respondents who answered "yes" to the question "Are you familiar with the term bioenergy?" In terms of age, most young respondents with age below 31 years are familiar with bioenergy although their work is not related to it. Less than half of them think that bioenergy production does not affect food security and almost all think that it is good for the country. Overall, most respondents across all age categories (94 percent) are convinced about the positive effects of bioenergy on the Philippine economy. The descriptive analysis of the survey data shows that awareness on bioenergy is very much dependent on the level of education and profession. Respondents with lower level of education (i.e. up to secondary school) are less familiar with bioenergy. Almost all the respondents with graduate levels (i.e. Master, Doctoral), who account for a significant share in the number of total respondents (37 percent), are familiar with bioenergy. Many of them are working in academe and research. In all fields of work, there is a general opinion that bioenergy affects food security. Only 33 percent of all respondents think otherwise. In Mindanao, the number of respondents who thinks that bioenergy does not affect food security is much lower at only about 27 percent.

Table 3 Knowledge and opinions of respondents on bioenergy, percent of total respondents in each demographic category

Demographic categories	Philippines				China			
	Knowledge on bioenergy		Opinion on bioenergy		Knowledge on bioenergy		Opinion on bioenergy	
	Work is related to bioenergy	Familiar with the term "bioenergy"	Bioenergy does not affect food security	Bioenergy is good for the economy	Work is related to bioenergy	Familiar with the term "bioenergy"	Bioenergy does not affect food security	Bioenergy is good for the economy
Years of age								
Less than 31	7,41	53,4	20,15	53,16	16,13	65,26	21,05	92,63
Between 31and 40	2,65	17,48	7,04	17,72	100,00	61,54	23,08	92,31
Between 41 and 50	2,38	10,68	3,16	12,14	50,00	9,52	0,00	100,00
Between 51 and 60	2,38	8,5	1,94	8,74	100,00	16,67	16,67	100,00
More than 60	0,79	1,7	0,97	2,67	0,00	0,00	0,00	50,00
Levels of education								
Secondary school	2,12	17,03	5,84	20,19	50,00	25,00	25,00	100,00
Undergraduate	5,31	35,28	14,36	36,5	18,18	57,89	19,30	91,23
Graduate	7,43	36,25	12,17	34,55	15,22	76,67	25,00	93,33
Technical training	0,8	1,46	0,24	1,46	0,00	100,00	0,00	100,00
Others	0	1,7	0,49	1,7	0,00	0,00	0,00	100,00
Areas of domicile								
Urban/sub-urban	10,08	59,61	21,41	57,18	25,67	61,02	20,56	94,24
Industrial/commercial	1,06	3,89	1,46	4,38	0,00	100,00	0,00	100,00
Forest/mountain	1,86	4,62	1,95	4,38	0,00	83,33	33,33	100,00
Farm/agriculture	2,39	20,68	7,3	25,3	9,09	26,19	7,14	92,86
River/coastal etc.	0,27	2,92	0,97	3,16	16,67	58,33	33,33	91,67
Fields of work								
Public agency	4,23	17,72	6,8	16,99	40,00	62,50	25,00	100,00
Private company	2,12	23,54	8,98	24,27	11,11	56,25	18,75	93,75
Agriculture/farm	1,06	13,35	4,61	17,48	0,00	0,00	0,00	100,00
Academe/research	5,29	16,5	5,34	15,53	10,53	68,67	21,69	91,57
others	2,91	20,63	7,52	20,15	50,00	71,43	28,57	92,86
All categories	15,61	91,75	33,25	94,42	17,28	54,00	18,00	94,00

In China, although overall only 17.28 percent of the respondents (i.e. less than 2 percent higher than in the Philippines) think that their work is related to bioenergy, the variance across demographic categories much larger than in the Philippines. None of the respondents working in agriculture thinks that their work is linked to bioenergy, although farmers account for significant share in crop-related work (Figure 2), e.g. potato 28 percent, sorghum 29 percent, other wheat 58 percent, sugar 10 percent and crops residues 47 percent of all respondents. Moreover, none of the farmers is familiar with bioenergy. Hence like in the Philippines, farmers are not aware of the potential link of their work to bioenergy sector. All farmer respondents think that bioenergy affects food security, but it is nonetheless good for the Chinese economy. Note that on the question on food security (see section 3.1) the issue of increase in food prices was also raised. Obviously, there is little understanding on the link of food prices to, on the one hand, purchasing power of communities and, on the other hand, economic growth.

Like the farmers, all respondents working in public agency also think that bioenergy can contribute to economic growth in China. Moreover, majority of the respondents (i.e. above 90 percent) from other professions also think the same. This is in contrast to the Philippines where, regardless of the profession, only less than 25 percent of the respondents think that bioenergy is good for the Philippine economy. The favourable opinion of Chinese respondents can be attributed to the strong policy support for bioenergy, making China the world's third largest bioethanol producer. As a result, most respondents regardless of demographic characteristics think that bioenergy is good for the economy. Nonetheless, only relatively small proportion of the respondents thinks that bioenergy does not affect food security. Significant share of Chinese respondents whose work is related to bioenergy are with ages 31-40 and 51-60 years, but familiarity to bioenergy is relatively low particularly for the older group of respondents. The case is however the opposite for other demographic categories of respondents, with familiarity being high although work is not related to bioenergy. This include respondents with age less than 31 years, education of at least undergraduate, domicile outside farm or agriculture, and work in private company and academe.

4.2 Respondents' cluster typologies

To create the segments for the conjoint analysis, we used three variables in clustering the respondents including familiarity with bionergy and opinion on the effects of bioenergy on food security and economy. The relationship of the respondents' work to bioenergy was excluded because it turned out to be an irrelevant variable in the cluster analysis. This can be explained by the low number of the respondents (i.e., below 20 percent) who indicated that their work is related to bioenergy (Table 3). Three clusters were identified from the two-step cluster approach with a total respondent share of 30.1, 22.3 and 47.6 percent in the Philippines and 23.3, 48.0 and 28.7 percent in China (Figure 3). There is thus relatively equal distribution of respondents not only among the three clusters but also between the two countries. The cluster with the largest number of respondents is cluster 3 in the Philippines and cluster 2 in China. The fit of the model for the Philippines is better than China, which can be explained by the larger number of observations in the former country.

Figure 3 Respondent distributions from the two-step cluster analysis

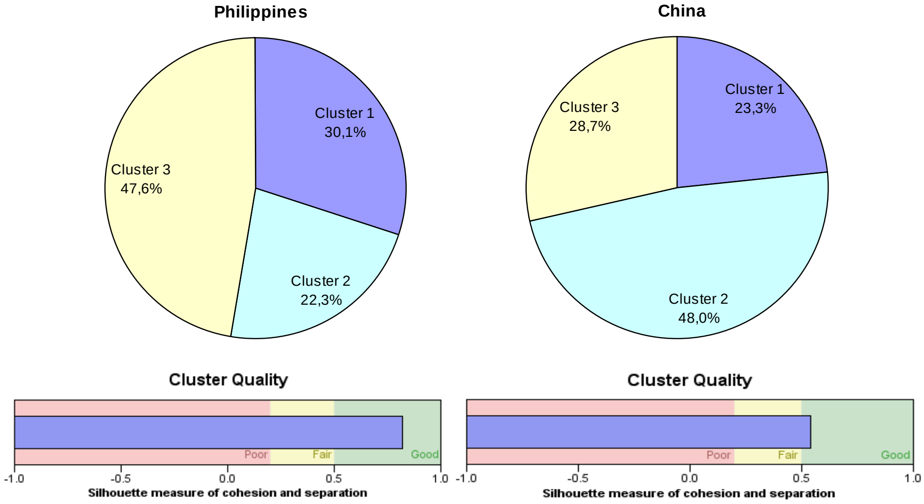
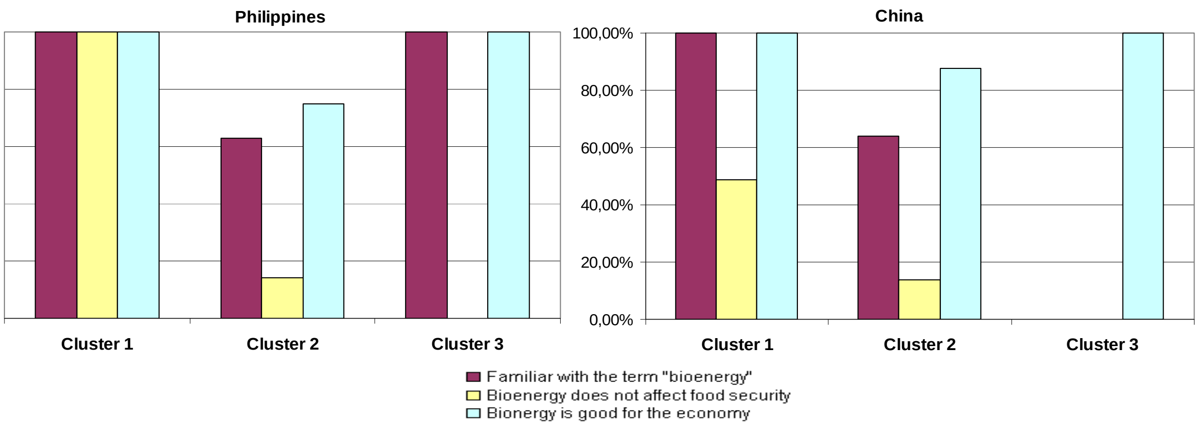


Figure 4 shows the distribution of the input variables in the three clusters. Cluster 1 is characterised by respondents who are familiar with bioenergy and thinks that its production is good for the economy. Moreover, all Philippine respondents and half of the Chinese respondent in cluster 1 have the opinion that bioenerggy does not affect food security in the Philippines. We describe the respondents in cluster 1 as "idealist" typology because of their optimistic opinions on bioenergy production. Like in cluster 1 the respondents in cluster 3 in both the Philippines and China are convinced about its positive effect on the economy. All Philippine respondents in cluster 3 are all familiar with bioenergy, but none of the Chinese respondents in this cluster think so. However, all respondents in both countries have the opinion that bionergy affects food security. We thus describe the respondents in cluster 3 as "realist" typology because they recognise the existing land use competition between bioenergy and food production. Cluster 2 is a combination of the other two clusters and shows almost similar pattern in the Philippines and China. Not all respondents in cluster 2 are familiar with bioenergy, with only about 60 percent of respondents in both countries. More than 70 percent of Philippines respondents and more than 80 percent of Chinese respondents think that bioenergy is good for the economy. Only about 14 percent of both Philippine and Chinese respondents in cluster 2 are concerned about bioenergy's negative effect on food security. We describe the respondents in this cluster as "ambivalent" typology because they do not have a clear opinion on the effects of bioenergy on food security and economy.

Figure 4 Knowledge and opinion of respondents on bioenergy by cluster typologies



The results of the matrix scoring reveal the characteristics of the three cluster typologies (Table 4). The idealist typology in the Philippines and China consists mainly of respondents whose age is less than 40 and live in urban and suburban areas. Significant number of idealist respondents in China is working in the academe. But they are represented in various professions in the Philippines. Common characteristic of idealist typology in both countries is the importance of science as source of information on bioenergy. Idealist respondents in China consider fossil as the most important source of energy to promote economic growth, while those in the Philippines think otherwise. In the latter country, fossil combined with renewable energy including bioenergy is considered good source of energy. Overall, higher share of Philippine respondents with idealist typology consider first and second generation bioenergy feedstocks as important energy sources.

Like the idealist typology, ambivalent typology is characterized by respondents with age less than 40 and domicile in urban and suburban areas in the Philippines and China. There are very few Chinese respondents with age above 40 years in this cluster. The Philippine respondents with ambivalent typology have mainly undergraduate and lower level of education. Ambivalent typology in China is dominated by respondents with academic profession. Whilst farmers are largely represented in ambivalent typology in the Philippines, no single farmer has ambivalent typology in China. After academe and science, media and internet are very important for respondents with ambivalent typology not only in the Philippines but also in China. They thus have very similar sources of information with the idealist typology. The respondents with ambivalent typology consider fossil as important source of energy not only in China but also in the Philippines. The proportion of respondents with this opinion is however lower in the latter (33.70 percent) than in the former (52.78 percent) country. About 20 percent of both Philippine and Chinese respondents with ambivalent typology think that bioenergy is important for the economy.

The Chinese respondents with realist typology have very different characteristics from those with other typologies. They have age above 40 years and domicile in farm and forest. There is far larger number of respondents with undergraduate and secondary education. A significant number of respondents (67.44 percent) with realist typology in China are farmers and whose main sources of information are their family, friends and neighbours. The share of respondents who think favourably of fossil fuel in promoting Chinese economy is much lower for realist typology than the other two typologies. Nonetheless, hardly any of them think that bioenergy feedstocks are useful for the economy. In the Philippines, realist typology has relatively similar knowledge and opinion with the idealist and ambivalent typologies, albeit with different proportion of respondents. This is particularly evident on their opinions on energy sources. Compared with ambivalent typology, there are more respondents with realist typology who consider fossil combined with renewable energy including bioenergy is considered good source of energy. In contrast to idealist typology, respondents with realist typology strongly prefer fossil and strongly reject bioenergy as sustainable sources of energy. This conforms to the opinion of all respondents in the realist typology that bioenergy affects food security. When given the choices between the different sources of biomass feedstock, they think that sugar-rich crops and fast growing trees have very high potential to contribute to sustainable production of bioenergy.

Table 4 Characteristics of the respondents according to cluster typologies

	Philippines			China		
	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)
Personal information						
Age is less than 40 years	83.87	68.48	72.45	97.14	97.22	39.53
Age is more than 40 years	16.13	31.52	27.55	2.86	2.78	60.47
Domicile is urban/sub-urban/industrial	71.54	58.70	66.33	74.29	75.00	30.23
Domicile is farm/agriculture/forest	25.20	38.04	30.61	17.14	18.06	67.44
Education is secondary/undergraduate level	57.72	67.39	56.12	45.71	48.61	86.05
Education is graduate/technical level	40.65	30.43	42.35	54.29	50.00	13.95
Field and location of work						
Public agency	21.77	17.39	17.86	5.71	6.94	2.33
Private company	28.23	21.74	25.51	5.71	13.89	9.30
Agriculture/farm	10.48	29.35	17.35	0.00	0.00	67.44
Academe/research	16.13	13.04	18.88	77.14	65.28	20.93
Source of information						
Media&Internet	64.92	45.11	63.01	37.14	39.58	13.95
Public officials	45.97	31.52	54.08	11.43	13.89	9.30
Academe/science	79.03	64.13	76.02	62.86	62.50	25.58
Family/friends/neighbours	26.21	19.02	29.08	8.57	9.72	31.40
work colleagues/partners	41.77	28.98	44.49	12.86	7.64	4.65
Opinion on energy sources						
Fossil	27.42	33.70	47.45	51.43	52.78	18.60
Fossil and renewables	46.77	28.26	49.49	22.86	19.44	4.65
Bioenergy	49.19	19.57	0.51	22.86	19.44	4.65
- sugar-rich	37.10	19.57	37.76	11.43	12.50	4.65
- starch-rich	39.52	21.74	33.16	28.57	23.61	4.65
- oil-crops	44.35	26.09	40.82	11.43	16.67	6.98
- agric/forest resideues	37.90	19.57	30.61	22.86	11.11	2.33
- fast growing trees	39.52	14.13	34.69	14.29	8.33	0.00
- perennial trees	29.84	13.04	28.06	17.14	11.11	0.00

4.3 Conjoint preferences of bioenergy sustainability

The results of the logit analysis to estimate the preferences (or utilities) between the different types of biomass in each sustainability dimension (i.e. economic stability, social equity and resource productivity) are presented in Table 5. The preferences for the first- and second-generation biomass vary among sustainability dimensions, across cluster typologies and between countries. In terms of economic dimension of sustainability the respondents with idealist typology favour the use of second-generation feedtocks like farm/forest residues and fast-growing trees for bioenergy production in the Philippines and China. Least preferred for bioenergy are first-generation feedstocks like starch-rich crops in the Philippines and oil-rich crops in China. The feedstock preferences to promote social equity are not as evident as for economic stability. Only farm/forest residues and sugar-rich crops have statistically significant coefficients. The former feedstock is preferred in both countries, and the latter is least accepted in the Philippines. First-generation feedstock like starch-rich crops are least preferred for promoting ecological balance in both countries. Like in economic and social dimensions, farm/forest residues turned out to be highly preferred for ecological dimension of sustainability. The Philippine respondents with idealist typology prefer oil-rich crops, which can be ascribed to the importance of coconut as bioenergy feedstock. This feedstock is not preferred among Chinese respondents.

Table 5 Logit estimation results of the utilities for the different types of biomass by sustainability dimensions and cluster typologies

	Philippines			**China**		
Attribute levels	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)
Economic Stability						
Sugar-rich crops	-0,07	-0,03	0,15*	0.10	-0.25*	-0.05
Starch-rich crops	-0,32***	0,21*	-0,05	-0.24	0.04	-0.18
Oil crops	-0,08	0,09	-0,07	-0.83***	0.02	0.18
Agric/Forest residues	0,30***	0,27**	0,22***	0.77***	0.34***	0.01
Fast-growing trees	0,20**	-0,24*	0,06	0.44**	0.09	0.16
Perennial grasses	-0,03	-0,30**	-0,31***	-0.23	-0.24*	-0.12
Social Equity						
Sugar-rich crops	-0,29**	-0,21*	-0,19**	-0.1	-0.48**	-0.12
Starch-rich crops	-0,04	-0,02	-0,01	-0.34	0.12	-0.12
Oil-rich crops	0,11	0,29**	-0,08	-0.26	-0.26	0.21
Agric/Forest residues	0,16*	-0,08	0,07	0.56**	0.15	0.22
Fast-growing trees	0,05	0,25**	0,16*	0.06	0.55***	0.00
Perennial grasses	0,01	-0,23*	0,05	0.08	-0.08	-0.19
Ecological Balance						
Sugar-rich crops	-0,13	0,16	-0,18*	0.09	-0.22	-0.15
Starch-rich crops	-0,34***	0,03	-0,17*	-0.55**	0.26*	-0.16
Oil-rich crops	0,27**	0,01	0,09	-0.4*	-0.26	0.05
Agric/Forest residues	0,19*	0,07	-0,09	0.37*	0.03	0.41*
Fast-growing trees	0,06	-0,01	0,48***	0.28	0.4**	-0.08
Perennial grasses	-0,06	-0,27**	-0,13*	0.23	-0.21	-0.08

Note: The asterisks ***, **, and * indicate coefficients significantly different from zero at α = 0.01, α = 0.05, and α = 0.10, respectively. The utilities are measures of preferences where (1) utilities with positive values are preferred over those with negative values, and (2) for positive utilities, the larger the utility values the higher the preference level. The signs and values of the utilities together thus measure the respondents' willingness to trade-off less desirable attribute level for more desirable one.

Unlike idealist typology which prefers farm/forest residues for all sustainability dimensions, the respondents with ambivalent typology consider this feedstock as useful only for economic stability. Perennial grasses are not preferred source of second-generation feedstock for promoting economic stability among Philippine and Chinese respondents with ambivalent typology. In the Philippines, this feedstock is also not preferred for social and ecological dimensions of sustainability. Fast growing trees appeared to be a relevant second-generation feedstock among respondents with ambivalent typology, albeit preferences are not quite consistent. In the Philippines, it is preferred for promoting social equity but not for economic stability. It China it is considered very important for social equity and ecological balance but not at all relevant for economic stability. As for the first-generation feedstock, the preferences are not consistent for the different sustainability dimensions. The Philippine respondents with ambivalent typology prefer starch-rich crops for economic stability and oil-rich crops for social equity. Moreover, sugar-rich crops are not preferred for the latter sustainability dimension. The Chinese respondents do not prefer sugar-rich crops for economic stability and social equity, and prefer starch-rich crops for ecological balance.

The respondents with realist typology generally reject the use of first-generation feedstocks for bionergy, except for sugar-rich crops to promote economic stability. This feedstock preference among realist may be attributed to the contribution of sugarcane in producing bioethanol and the policy support provided by the government to sugar sector in the Philippines. The Philippine respondents do not see the relevance of perennial grasses for economic stability. But they consider fast-growing trees as important second-generation feedstock to achieve ecological balance. The Chinese respondents with realist typology do not have clear preferences for the different first- and second generation feedstock, except for farm/forest residues, which are considered relevant for ecological balance.

Table 6 presents the relative importance of the sustainability determinants, which were computed from the individual utilities of the respondents in different cluster typologies. Overall, the Philippine respondents have the opinion that market structure is the most important determinant for economic stability, social welfare for social equity and land management for resource productivity. Market structure receives a score of more than 45 percent in terms of level of importance among the respondents with idealist and realist typologies, and about 39 percent among those with ambivalent typology. The relatively lower preference given to market structure in ambivalent typology is due to the higher importance of technology progress. The respondents in this typology, which are largely farmers and farm workers, thus think that technology, in particular energy efficiency, is important in achieving economic stability.

Table 6 Conjoint importance of sustainability determinants by cluster typologies

Sustainability dimensions	**Philippines**			**China**		
	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)	Idealist (cluster 1)	Ambivalent (cluster 2)	Realist (cluster 3)
Economic stability						
Types of biomass	19.89	20.53	18.25	33.87	29.68	29.35
1. Energy security	23.5	15.48	14.95	24.86	28.16	28.30
2. Technology progress	9.24	25.34	21.33	17.06	17.64	17.02
3. Market structure	47.38	38.65	45.47	24.21	24.52	25.33
Social equity						
Types of biomass	11.9	13.14	9.67	22.72	25.06	22.97
1. Food security	24.71	28.18	26.48	17.94	19.29	17.92
2. Social welfare	37.54	34.93	32.02	30.11	27.96	30.23
3. Social justice	25.85	23.74	31.83	29.22	27.69	28.88
Ecological balance						
Types of biomass	13.74	14.02	16.34	22.79	22.42	21.09
1. Production potential	26.37	26.5	24.64	18.67	18.18	19.09
2. Resource capacity	19.86	14.94	25.85	28.46	27.82	29.30
3. Land management	40.03	44.53	33.18	30.07	31.58	30.52

Respondents in all three cluster typologies, in particular idealist typology, consider social welfare as the most important determinant of social equity. The realist typology allocates almost similar level of importance to social welfare and social justice. As compared to other indicators of resource productivity, land management has the highest level of importance in all cluster typologies. For the ambivalent typology, it is as high as 44 percent. This is not surprising because farmers and farm workers, who largely represent the ambivalent typology, are more directly confronted with the productivity issues related to land management. The level of importance given to the different determinants of sustainability dimensions is generally higher among the Chinese than the Philippine respondents. Like in the Philippines, social welfare and land management are the most important determinants for social equity and resource productivity, respectively, for idealist typology in China. But for economic stability, the type of biomass is considered most important by the Chinese respondents with idealist typology. The most important determinants for economic, social and ecological sustainability are the same for idealist, ambivalent and realist typologies.

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