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# Economic Development, Food Demand and the Consequences for Agricultural Resource Requirements (Indonesia)

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*We analyse food demand patterns of Indonesian households from a resource intensity perspective, and quantify the impact of changed demand patterns on the use of three major resource inputs – fossil fuel, land and water – in agricultural production. Using Indonesian Family Life Survey (IFLS) data, 13 major food items (which constitute 70% of food expenditure) are categorised into low, moderate and high resource intensity, and income elasticity and Engel curves are estimated for the period from 1997 to 2007. Our results show that income growth in Indonesia is associated with demand patterns that are more resource intensive. By 2007, per capita requirements of fossil fuel, land and water increased by 42.7% (3.13 MJ), 44.9% (1.24 $m^2$) and 50.4% (2.1 KL) respectively relative to 1997. The results imply that at least for Indonesia, changed food demand patterns resulting from economic development will increase the demand for natural resources substantially.*

Keywords: Demand analysis, Economic Development, Natural Resource Management, Indonesia

*JEL codes: D1, O13, Q18*

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## 1. Introduction

In this paper, we analyse the implications of change in food demand patterns of Indonesian households from a resource intensity perspective. Food demand is a core element of household behaviour strongly affected by economic development. Economic development underpinned by income growth drives changing food consumption patterns, reflective of emerging tastes and preferences for a variety of different foods. The literature has documented the changing nature of food demand in developing countries, characterised by increased consumption of meat and processed goods at the expense of traditional staple items (Blandford 1984; Herrmann and Röder 1995; Rae 1997). Diverse empirical findings suggest a convergence towards affluent 'westernized' consumption patterns on account of economic development across developing countries (Popkin 2006; Regmi et. al 2008). However, conventional analysis of dietary food demand, whilst important in its own right overlooks wider implications that can result from food demand. This paper extends existing analysis to consider the impacts of changing food demand patterns in developing countries upon natural resource use.

Approximately 50% of land (Smith et al. 2007), 70% of water (FAO 2002) and 3% of fossil fuel consumption (Woods et al. 2010), encompassing 10-12% of greenhouse gas emissions (Woods et al. 2010; Smith et al. 2007), are used globally for agricultural production activities. However, not all agricultural activities are equal; the seminal work of Pimentel and Pimentel's (1979) shows the disparities in resource input requirements across food items. This is particularly important for developing countries as they account for the largest change in food consumption patterns (Gerbens-Leenes et al. 2010). The income growth associated with economic development relaxes budget constraints, enabling households to purchase a wider range of food items often associated with high resource input requirements.

We look at: (i) the nature of demand for food as organised by low, moderate and high resource intensive categories; and (ii) the net difference in the per-capita level of resource inputs (fossil fuel, land, water) required to satisfy a unit of an average food consumption basket on account of demand changes over time. Given agriculture's significant use of major global resources, analysing the nature of demand patterns from a resource use-perspective is imperative, especially for developing countries.

We consider the developing economy of Indonesia, which has experienced significant changes in food demand patterns. A number of factors such as strong GDP growth per capita (3.7% per annum for 1970-2011, Tambunan 2006; UNSD 2013), rapid rural-urban migration (4.2% per annum since 1995, UNDESA 2012) and improved literacy rates (from 75.3% in 1990 to 86.8% in 2007, UNSD 2013), – have all contributed to changes in food demand. These factors have increased the shadow value of home production and the preference for leisure, which in turn affected household food preferences away from traditional staple food items.

Significant changes in household demand have encouraged a strong response in the supply side, manifested through the ‘supermarket revolution’, which supply a range of processed convenience foods that align with the preferences of households (Toiba et al., 2012 and Reardon et al., 2012).While previous studies found an elastic expenditure behaviour towards meat, milk and eggs (see, for example, Kakwani 1977, Timmer and Alderman 1979, Dixon 1982),[1] recent studies demonstrated stronger demand for meats and processed goods (see, for example, Pangaribowo and Tsegai 2011).

Indonesia’s economic development therefore provides an ideal platform to consider whether economic development is associated with food demand patterns that are more resource intensive. The long run nature of the Indonesian Family Life Survey (IFLS) data used in this research spanning ten years is also conducive to estimate the net change in resource use which can be linked to food demand changes. After organising food items based on measures of resource intensity, our paper applies demand estimation techniques to demonstrate the absolute and relative changes in resources over the study period that would be required to meet demand changes. We find that economic development can be linked with a more resource intensive food demand profile.

To the best of our knowledge, our paper provides the first country-specific study linking economic development, food demand and agricultural resource requirements, raising a complex

[1] See also Deaton (1990), Jenesen and Manrique (1998), Fabiosa et al, (2005) and Widodo (2006) for further evidence.

set of consequences in a world of increased resource scarcity. While economic development is desirable from perspectives of economic wellbeing in general, the implications placed on natural resources as elicited by changed demand patterns need to be considered. The results question the paradigm of 'development' from a food demand perspective, and what developing (and developed) countries should strive to perpetuate in terms of 'desirable' consumption profiles.

The rest of the paper is organized as follows: Section 2 outlines the empirical methods applied in answering the research questions. Here, a description of the data, techniques in categorising food by resource intensity, demand analysis techniques and estimation of the additional resource use resulting from changed demand is outlined. Section 3 reports results for the estimated Engel curves and income elasticity of demand measures in illustrating demand behaviour from the perspective of resource use. The consequences for resource use across three key agricultural inputs are then estimated by comparing net changes in resource use attributable to changes in demand. This section also provides a discussion of important implications that arise from the estimated results as well as recognising limitations inherent to the study. Section 4 concludes the paper where key implications and areas for future research are identified and discussed.

## 2. Estimation Method

In this section we present a simple approach to calculate the resource intensity required to produce key food items. This approach recognises the influence of trade relationships that will complicate the fundamental conditions by which food items are produced. We outline the key methods used in our study, including Engel curve estimation, and income elasticity measures. The novel approaches to measure additional resource used attributable to changed demand patterns, in both absolute and relative terms are also presented.

The theoretical objective that underpins consumption is the maximisation of utility subject to a budget constraint. Any value difference between two comparable goods should be attributable to the level of inputs embodied into the goods. The production of consumer goods is supported by a variety of inputs which ensure that the good will align with consumer preference in seeking utility maximisation. Therefore the value of the good can be somewhat justified by the input levels supporting production. Such 'high value' goods are preferred to those with fewer inputs, on account of better achieving utility maximisation, reflected through a higher willingness to pay. We therefore start with categorizing food into resource intensity. Household demand behaviour is modelled on the traditional demand frameworks of Engel curves and income elasticity estimation, how they support analysis of household demand for food is also provided. Finally, the estimation method of additional resource needs attributable to changed food demand is derived to illustrate the tangible impacts that economic development has for resource use.

### *2.1. Categorizing food by resource intensity*

We offer a simple approach to the development of a resource intensive scale considering three resource inputs – land, water and fossil fuel. Research that organises agricultural production by a comprehensive 'resource intensive' measure is not very common. The existing literature (Gerbens-Leens et al. 2002, Sainz et al. 2003) focuses on estimating resource use in agriculture only from a fixed perspective, such as land use which highlights the shortfall of research methodology. This offers increased scope for developing calculations of agricultural resource input requirements with changed demand, as required for our research.

For the present purpose, we have taken 13 food items from IFLS data. The reasons behind this selection are described in the next section. Analysing food demand patterns with respect to resource intensity requires the 13 food items be categorised with respect to resource input requirements in production. Three major agricultural resource inputs – fossil fuels, land and water – underpin the organisation of the resources into their respective categories. Table 1 displays the food items corresponding to categories of low, moderate and high resource production requirements.

[Table 1 about here]

The organisation of the food items into the above categories is based upon the findings of agronomic research concerning levels of resource inputs for fossil fuels, land and water. Appendix item I reports the full details of the input requirements for individual food items estimated from the previous research. Table 2 shows the level of resource inputs across the three groups averaged for the 13 food items. The final column reports on the relative resource needs averaged across all inputs. The input scale indicates that food items in the moderate resource category require 1.4 times more resources relative to the low category, whereas the high category is 15.54 times more relatively resource intensive than the low.

[Table 2 about here]

An additional concern is Indonesia's trade patterns, which have important impacts upon the required resource input levels. As production systems within Indonesia differ to foreign production systems in underlying characteristics and technology, inconsistent resource input requirements exist for equivalent food items (Pimentel and Pimentel 1979). However, FAO trade statistics and food balance sheet data over the decade 1997-2007 reported in Appendix item III shows that Indonesia relies upon both domestic and international production sources in meeting food demand profiles.

Therefore, resource requirements in an industrialised production setting have been incorporated in addition to domestic production resource requirements in recognition of Indonesia's trade profile. The resulting resource input figures reflect the average of the resource input requirements across the industrialised and domestic production contexts where appropriate. This inclusion captures the dynamics of Indonesia's food trade, where industrialised countries have continued to supplement Indonesian food stocks despite the self-sufficiency policy agenda.

The defined food categories, organised by resource input requirements, form the basis for the demand analysis and additional resource use estimation.

*2.2 Engel Curve Estimation*

Engel curves are estimated for food items organised by both dietary and resource intensive means. Engel curves (Engel 1857) provide useful insight into how household expenditure decisions compare across commodities, or between a subset of commodities as income (expenditure) changes. The analysis of food demand from a dietary perspective is necessary to establish whether the IFLS data used conforms to the broader literature which cites convergence in developing countries towards an affluent, westernised diet. Engel curves are used to establish the demand patterns from a dietary perspective. Upon establishing this empirical relationship, analysis concerning resource intensity proceeds on the basis of being underpinned by convergence towards affluent food consumption patterns from a dietary perspective, which dominate findings of the wider literature.

Conventional estimation of Engel curves is based on a parametric model. This approach originated through the contributions of Working (1943) and Leser (1963), modelled as

$$Y_1 = \alpha_1 + Y_2\beta_1 + X'\beta_2 + \varepsilon_1 \qquad (1)$$

where $Y_1$ is the food budget share of the household, $Y_2$ is the log household total expenditure, $X'$ is a vector of observed household demographics, and $\varepsilon_1$ is the unobservable error assumed to satisfy $E(\varepsilon_1|Y_2)=0$.

The accurate estimation of the parametric approach depends upon the specification of a functional form that reflects the underlying distribution of the data (Howe et. al 1979; Deaton 1985, Kneip 1994). In addition, endogeneity remains a notable concern. As total expenditure is often determined by expenditure shares of commodities themselves, this variable will commonly be endogenous to the model (Blundell et. al 1998). Furthermore, total expenditures may be mismeasured from expenditure surveys given the infrequent purchase of particular commodities (Meghir and Robin 1992). This notion is applicable to food, given that differences in the perishable nature of food items impact upon the size and frequency of purchase. These issues show that any estimation, parametric or otherwise, of Engel curves should account for endogeneity and mismeasurement of household expenditure to preserve the integrity of estimated curvatures.

We use Lewbel's (2012) two-stage estimation approach, which controls for issues of mismeasurement and endogeneity of household expenditure. The triangular system for the relevant Engel curves is presented as

$$Y_1 = \alpha_1 + Y_2\gamma_1 + X'\beta_1 + \varepsilon_1 \qquad (2)$$

$$Y_2 = \alpha_2 + X'\beta_2 + \varepsilon_2 \qquad (3)$$

where the $Y_1$ is food category budget share, $Y_2$ is the log real total expenditure and $X'$ is a vector of exogenous regressors entering into the estimation.

Typically, $Y_1$ is estimated by identifying instruments for $Y_2$ that satisfy the standard exclusion restrictions[2] if $\beta_1 \neq 0$. Lewbel (2012) proposes that instrument identification can be achieved independent of the exclusion restrictions, provided that there is a set of exogenous variables Z (equivalent to *X'* in this estimation) with heteroskedastic errors in $(\varepsilon_1, \varepsilon_2)$. The set of variables compromising *X'* and equivalently *Z* are: natural logarithm of household income, household size, average age of household members, household location dummy (rural/urban) and maximum education level of household head.

In the first stage, the endogenous variable $Y_2$ is regressed on the $Z$ vector defined above and the vector of residuals $\xi$ are obtained

$$Y_2 = \alpha + Z'\gamma + \xi. \qquad (4)$$

The estimated residuals are used to create instruments in estimating equation (4) through the form

$$X_j = \left(Z_j - \bar{Z}\right)'\xi \qquad (5)$$

where $Z_j$ is the estimated mean-centred residual for the given exogenous variable, $\bar{Z}$ is the centred mean of $Z_j$, $\xi$ is the vector of errors and $X_j$ is the estimated instrument.

Application of the Breusch-Pagan test of heteroskedasticity strongly rejects the null of homoskedasticity for the residuals, satisfying Lewbel's condition for heteroskedastic errors in the first stage estimation. The instruments generated from equations (4) and (5) are used to estimate $Y_1$ in the second stage. Hence identification for $Y_1$ is provided in the absence of the standard exclusion restriction assumptions for instrumental variables. Appropriate identification using

[2] The standard exclusion restrictions specify that identification for $\beta_1$ is provided when the variable $Z_i$ is uncorrelated with the error terms and the correlation between the endogenous regressor and $Z_i$ is different from zero.

Lewbel's (2012) method is sufficient for controlling for endogeneity and mismeasurement, reinforcing the integrity of the estimated coefficients.[3]

Engel curves are estimated for the expenditure share relationship relating to the five food categories (staples, fruit/vegetables, dried food, animal products, condiments) and resource intensive categories (low, moderate, high) using the method outlined above. Initial estimation concerning food categories will establish whether household behaviour is consistent with wider empirical findings surrounding transitions to westernised food consumption. This provides the platform in extending the analysis of food demand towards a resource-use perspective provided that this caveat is satisfied. The estimated coefficients arising from this process are used to predict the share of the category's food expenditure across households, resulting in the estimated Engel curve.

*2.3 Income Elasticity of Demand*

We estimate income elasticities for each resource intensive category, supplementing the Engel curve results. The income elasticity is important when assessing how a household will respond to a change in income, when considered across a range of household income levels. Controlling for core household demographics facilitates insights into the effect that development has upon food demand patterns in the way households allocate additional income across food categories. This is empirically measured through specifying a simple log-log regression function

$$\ln Q_{ijkty} = \alpha + \beta_1 \ln P_{ijkty} + \beta_2 \ln Y_{ijkty} + \beta X_{jt} + \beta Z_{ct} + \varepsilon_{ij} \qquad (6)$$

where $i$=1,2,…,12 (food item); $j$=1,2,…,$n$ (household); $k$=1,2,3 (resource intensive food category); c=1,2…,321 (community); $t$= 1997,2000, 2007 (survey year); $y$=1,2,3,4 (income quartile). P, Y, X, and Z represent price, income, demographic, and community characteristics, respectively.

Elasticities are estimated for each food item $i$ within a resource category $k$. Individual item elasticities are weighted by their expenditure share of the relevant category, before being

[3] Work completed by Emran and Hou (2013), Baum et al. (2013) and Mishra and Smyth (2012) further demonstrate the value of the approach in providing robust identification in the absence of the standard exclusion restrictions.

aggregated in accordance to the definition of the category. Aggregating individual item weighted elasticities maintains accuracy compared to the aggregation across heterogeneous food items prior to estimating a grouped elasticity. Elasticities will be estimated with respect to income quartiles, by urban/rural locality and a pooled measure, to illustrate the differences in food demand profiles across a variety of Indonesian households.

### *2.4 Additional Resource Requirements*

The estimation of additional resource needs attributable to changed food demand is the final component in analysing economic development and resource use. While the concept of additionality is inherently challenging to establish in most applications, quantifying the net change in resource use attributable to demand changes provides a basis to illustrate the tangible impacts that economic development has for resource use. The estimates are based upon the resource scale outlined in section 2.1, which is assumed to remain constant throughout the study period[4]. Both 'absolute' and 'relative' changes to resource requirements are considered.

#### 2.4.1 Absolute Requirements

Estimating absolute additional resource use is completed for the three resource inputs of fossil fuel energy, land and water. Four expressions have been constructed to compare the amount of resources used to satisfy food demand through the study period:

| Term | Description | Interpretation |
|---|---|---|
| $Base_i = (q_{ir}c_{0i})$ | Resource input (r/kg) required for the resource intensive category, weighted by share of total consumption in resource terms (1997) | Resource level required to satisfy given share of consumption in 1997 |
| $D_{1ir} = (q_{ir}c_{1i})$ | Resource input (r/kg) required for the resource intensive category, weighted by share of total consumption in resource terms (2007) | Resource level required to satisfy given share of consumption in 2007 |
| $D_{2ir} = (Base_i Exp_{0i})$ | Baseline resource use multiplied by real expenditure growth[5] from 1997-2007 | Resource level required to satisfy a share of consumption in 1997 when taking into account real expenditure growth |
| $D_{3ir} = (Base_i Exp_{1i})$ | Baseline resource use multiplied by real | Resource level to satisfy a share of |

[4] Assuming constant resource input requirements over the study period can lead to both upward and downward bias in estimation. The former can occur from failing to recognize any improvements in technology and production efficiency which can potentially reduce input requirements. The latter can be attributable to increased scarcity in resource use which drives production to rely on increasingly marginal resources, impacting efficiency.

[5] See item III in appendix.

| | | |
|---|---|---|
| | expenditure growth from 1997-2007 and change in budget share[6] from 1997-2007 | consumption in 2007 taking into account real expenditure growth |

Where $i$ = resource intensive category (low, moderate, high); $r$ = resource input (fossil fuel, land, water); $q_{ir}$ = resource input *(r/kg)* for resource intensive category $i$; $c_{0i}$ = weight of resource intensive consumption to total food consumption organised by resource intensity, per capita for category $i$ in 1997; $c_{1i}$ =$c_{0i}$ as for 2007; $Exp_{0i}$ = real expenditure growth between 1997 and 2007; $Exp_{1i}$ = Product of $Exp_{0i}$ and change in budget share between 1997 and 2007.

Drawing upon the four terms listed above, three measures are constructed to estimate differences in resource inputs through demand changes. Each measure is to be interpreted in terms of the additional resource input amount required to satisfy a given unit (measured in kilograms/litres) of an individual's consumption profile.

| Number | Measure | Description |
|---|---|---|
| 1 | $\left(\sum_i D_{1ir} - \sum_i Base_i\right)$ | Difference in resource requirement to produce a unit of food between consumption profiles of 1997 and 2007 |
| 2 | $\left(\sum_i D_{2ir} - \sum_i Base_i\right)$ | Difference in resource requirement accounting for the real expenditure growth between 1997-2007 for a constant consumption weight |
| 3 | $\left(\sum_i D_{3ir} - \sum_i Base_i\right)$ | Difference in resource requirement accounting for both real expenditure growth and change in the budget share for a given change in consumption profile between 1997-2007 |

Measure 1 provides an estimate for the resource requirement disparity on account of a change in the consumption weight alone. Measure 2 compares the resource requirement accounting for real expenditure growth alone between the two study periods. Measure 3 compares the resource requirement accounting for real expenditure growth, and changes in demand from 1997-2007.

2.4.2. Relative Resource Requirements

This approach computes the average relative growth factor in resource requirements for each of the resource intensive categories across inputs as

$$\gamma_{ir=}\frac{\alpha_{ir}}{low_r} \qquad (7)$$

[6] See item IV in appendix.

$$\bar{\gamma}_i = \frac{(\sum_r \gamma_{ir})}{3} \qquad (8)$$

where $i$ = low, moderate, high (food category); $r$= fuel, land, water (resource input); $a_{ir}$ = resource input/kg output; $low_r$ = resource input for low resource category; $\gamma_{ir}$ = resource use relative to low; $\bar{\gamma}_i$ = average relative resource use across all inputs.

This measure calculates the relative resource use accounting for real expenditure growth and changes in the budget share from 1997-2007. Denote real expenditure growth by $\beta_{0i}$ and real expenditure growth weighted by the change in budget share as $\beta_{1i}$. The difference between the product of average relative resource use ($\bar{\gamma}_i$) with expenditure growth for resource category i, for constant ($\beta_{0i}$) and changed ($\beta_{1i}$) demand (expenditure share weighted by budget share change), demonstrates the relative amount of resources used for each category from the change in demand. Aggregating these differences provides the net relative difference in resource use:

$$(Relative\ difference_i) = (\beta_{1i}\bar{\gamma}_i) - (\beta_{0i}\bar{\gamma}_i). \qquad (9)$$

**3. Data and Empirical Results**

*3.1. Data*

We use the Indonesian Family Life Survey (IFLS) data, a longitudinal survey that collects a variety of socioeconomic and health indicators at the household and community level. Four survey rounds have been conducted in years 1993, 1997, 2000 and 2007 to date (Strauss et al. 2009). Recontact rates have been maintained above 90% between the rounds, and the survey represents approximately 83% of the Indonesian population. (Strauss et al. 2009). As the earliest IFLS round of expenditure methodologies are inconsistent with later rounds, IFLS1 (1993) has been omitted from the analysis. Nonetheless, insights into long-run household behaviour are still possible through considering data from the 1997, 2000 and 2007 survey rounds.

The IFLS records a rich array of household and community demographic variables with the most relevant aspect of the IFLS for this study relating to household food expenditure and consumption data. The IFLS records expenditure information (recall period of one week) for 38 individual food items. While a measure of consumption that is recorded in quantity terms (an essential component in modelling food demand behaviour) is absent from the dataset, the IFLS records food price information at the community level[7]. Only 13 food items recorded at the household level match with items recorded at the household level. The 13 items which are consistent account for approximately 70% of total food expenditure. This ensures that analysis results will still remain relatively robust.

To ensure that all food consumption quantity is calculated in consistent units, prices are converted to kilograms or litres where appropriate. In the case of missing prices at the community level, the average price at the province is used as a replacement proxy for the missing price. Consumption, expenditure and other demographic variables measured in time units have been converted to annual terms where necessary to ensure consistency. As households were surveyed over a full year, any bias caused by seasonal availability of food is controlled for when scaling from weekly to yearly consumption behaviour given the staggered nature of the sampling timeframe (Strauss et. al 2009).

Aside from food expenditure and prices, a variety of other demographic variables have been incorporated from the IFLS to control for various economic and noneconomic factors affecting food demand. A fundamental measure of household income is not provided with a single specification and has been constructed from a range of indirect measures for the purposes of this study. The variables used here consist of salary, farm business income, asset income outside business activity, non-labour earnings, self-employment income and transfer income. These variables were scaled up to be measured in yearly terms where necessary. The exhaustive list of all variables extracted from the IFLS for our analysis is listed in Appendix item II. Core variables are listed below in Table 3.

[Table 3 about here]

[7] Deaton and Zaidi (2002) argue that when quantity data is absent from consumption information, price data from the relevant community is the next preferable alternative for calculating consumption quantity amounts. Incorporating price information with expenditure amounts allows for the quantity consumed per household to be estimated.

### *3.2. Descriptive Statistics*

Household demographics indicative of economic development outcomes are presented in Table 4. The data covers 7,566 surveyed households in 1997, 10,256 in 2000 and 12,977 in 2007. Descriptive statistics highlight the impact that income and location (rural/urban) has upon key demographic variables. Economic development is associated with households exhibiting higher education outcomes, smaller family sizes, commonly headed by a male, to be found in an urban locality. The significant income gap between the poorest and richest quartiles will be a major factor in determining food consumption.

[Table 4 about here]

### *3.3. Engel Curves*[8]

Engel curves are first estimated for five food categories aligning with food items grouped by dietary means- staples, fruit/vegetables, dried food, animal products and condiments. Table 5 shows the food items corresponding to their respective dietary food category.

[Table 5 about here]

Table 6 and Table 7 report the elasticity coefficients for Lewbel's (2012) Engel curve estimation technique, where the variables of average household age, household head education level, rural-urban locality and household income are used to provide identification on household expenditure. The two-stage least square (TSLS) regression results show that for a unit rise in household expenditure, the budget share falls most rapidly for staple food items and the least for animal products, consistently across 1997-2007. This indicates that as household expenditure rises, households spend less on staple food items relative to animal products.

[Table 6 about here]

[8] See appendix item VI for dietary and resource Engel curves (1997-2007). The drawn Engel curves omit outliers beyond 2 standard deviations from the mean.

These results show that household behaviour is consistent with our expectation. For a rising expenditure (income), households will allocate a greater share of this towards animal and processed goods at the expense of traditionally consumed staple items. These results confirm from a dietary perspective, the empirical consensus linking economic development and food favouring affluent, westernized consumption patterns. Therefore any significant results when analysed from a resource intensity perspective for Indonesia may also be appropriate for other developing countries, strengthening the significance of forthcoming results.

The estimation of Engel curves for the three resource intensity food categories (Table 1) demonstrate the implications of economic development for resource use. The Lewbel (2012) technique, with the same vector of exogenous variables *(Z)* is again used in estimation. The resource intensity TSLS regression results are presented in Table 7. These results show that for a rising household expenditure, the proportion of expenditure on low resource intensive items falls at a greater rate when compared to moderate and high resource items.[9]

[Table 7 about here]

These results show for rising expenditure that a household will allocate a greater share of expenditure towards high resource intensive items. This is confirmed through the magnitude of the expenditure change: real expenditure grew by a factor of 1.13 for low resource items, compared to 1.46 and 1.29 respectively for moderate and high resource intensive items. Despite falling budget shares across each of the resource intensive (and dietary) categories consistent with Engel's law, the absolute amount of real expenditure has still risen over the study period. These findings have profound implications: economic development, a key driver of household expenditure, is associated with higher expenditure levels towards food items which require more resources in their production. Notwithstanding the advantages of economic development, these results suggest that this phenomenon will also accelerate the demand for non-renewable resources such as land, water and fossil fuel.

[9] The abnormally small coefficient for the higher resource category in 2000 may be explained by the underlying economic conditions within Indonesia during this time from the Asian Financial Crisis.

*3.4 Elasticity*

The log-log model outlined in section 2.3 allows for weighted income elasticities to be calculated for the sample. Results by rural/urban location and income quartiles, in addition to the aggregate sample are reported in Table 8. For the aggregate sample, income elasticity rises with the corresponding level of resource intensive categories. The elasticity measures remain similar between the survey waves, dismissing any strong dynamic effects on Indonesian food demand patterns over the period considered.

[Table 8 about here]

Our results show that income elasticity depends on the household location. Urban households display higher income elasticity across all three resource categories. For example in 2000, a unit change in income will result in a 8.7% increase in the quantity demanded for the high food resource group by a rural household, compared to a 11.6% increase from an urban household. These results are therefore consistent with the premise of food demand being linked to regional development within Indonesia (Pangaribowo and Tsegai (2011). Nevertheless, in both rural and urban localities high resource intensive food items are associated with increased income elasticity.

Results by income quartile highlight the impact of income upon demand patterns across the food categories. The poorest households (quartile 1) have abnormally low elasticity figures across all waves. This result defies the expected results according to Engel law, where a poorer household is expected to allocate a significant share of any additional income towards food consumption. Households in the second and third quartiles display the highest income elasticity This challenging result may be explained by the income level recorded across many of the poorest households as being zero or even negative.[10] This may implicate the integrity of elasticity estimation given the significant presence of zero income entries which would bias the OLS estimation. The wealthiest households' income elasticity is lower compared to middle income counterparts, yet still higher than the poorest households. This indicates that the

[10] There were 1,405 household in 1997; 1,154 in 2000; and 1,980 in 2007 where a per capita annual income was recorded to be at or below zero. A negative income is possible given that the income variable was indirectly constructed from a range of other variables, as no definitive measure of household income was provided.

wealthiest households will allocate a smaller share of additional income to food relative to those in lower income brackets. This is not to say that the absolute level of expenditure will also be lower.

Increasing household affluence will generate an increasing tendency to spend additional income on food items that are more resource intensive. This effect is mitigated once the household falls into the highest income quartile, suggesting that income elasticity growth may approach a level of saturation. As illustrated through the Engel curves, a household with high levels of expenditure will already be favouring higher resource intensive food items relative to a poorer household. Furthermore, food items displaying the greatest resource input requirements are consistently associated with higher income elasticities across all income levels.

The implications of food demand behaviour which generates increased food resource input requirements are broad. Rising food prices on account of increasingly scarce resource inputs, acceleration of environmental degradation and economic incentives to engage in comparatively inefficient food production are examples of the consequence potentially arising from the Indonesian food demand patterns. Our results expose the range of implications that unfetter from economic development relating to natural resource management, as no previous research has linked food demand patterns being more resource intensive on account of economic development.

*3.5. Additional Resource Use*

We now turn to the results which describe the net effects of demand on per-capita resource use in both absolute and relative terms. Table 9 reports on the absolute per capita resource needs across the three inputs and estimate terms developed in section 2.4. Appendix item VII contains the input numbers for each estimate.

The results show that changes in food demand which have been empirically established through Engel curve and income elasticity estimation, require increased resource inputs. All results are non-negative, aside from Estimate 1 for the moderate resource intensive category on account of the fall in consumption share for this category from 1997-2007. Estimate 3 shows definitively that on a per-capita basis, changes in demand measured through consumption and budget shares accounting for real expenditure has increased fossil fuel (MJ's), land ($m^2$) and water (KL) resource inputs by 3.13, 1.24 and 2.1 units respectively, to satisfy consumption relative to the base period.

[Table 9 about here]

We also consider the relative increase of additional resources from changing demand behaviours. Table 10 reports aggregate resource measure for the averaged relative resource input intensity between the three categories. The base case is inclusive of real expenditure growth over the study period, and is compared to a variable budget share which represents changed demand. The resulting terms are interpretable as relative resource units, rather than reference to a specific amount of resource input.

[Table 10 about here]

The results show the net effect of changed demand patterns leading to an outcome where the resource requirement is 8% higher compared to the status quo. These effects are more than offset by the growth in demand for moderate and high resource intensive categories, with the aggregate value reflecting this.

It is assumed that growth in real food expenditure will translate to an increase in the amount of resources necessary to supplement production. The quantification both in absolute and relative terms demonstrate for the study period, when controlling for changes in real expenditure, that demand patterns lead to an increased resource requirement on a per-capita basis within Indonesia.

The results should be recognised in the context of the increase in Indonesia's population by some 34.1 million people over the study period. This effect compounds the impacts of rapid economic development, placing increasing demand on global resource inputs required in agricultural production to meet Indonesia's expanding food consumption profile. Our results are likely to reflect a similar trend in comparable Asian countries, highlighting the need for further empirical research. Understanding other developing countries' (particularly in Asia where the strongest levels of population growth are expected) demand for resource intensive foods will provide important evidence into the impacts that economic development is presenting to natural resource use.

## 4. Conclusions and policy implications

This research presents an analysis of food demand patterns of Indonesian households from the perspective of resource requirements. Results from the Engel curve and income elasticity estimations show that households demand food items that require a greater amount of resource inputs. These demand effects are exemplified when considered across different income levels and locations, consistent with economic development. We also quantified the additional resource inputs used as a result of changed demand patterns over the study period. After controlling for real expenditure growth, these results show that fossil fuel, land and water input requirements increased significantly.

These results raise several key policy challenges regarding natural resource management. Our quantified association concerning economic development and increased natural resource use will motivate inquiry into the economic policies of demand management of natural resources, on account of changing food demand patterns. Implications of policies addressing supply and/or demand side approaches concerning the agricultural supply chain in the context of resource use should be explored. Alternatively, an appraisal of the natural transitions stemming from the free-market mechanism, functioning as an economic institution, and the associated welfare implications could be considered. These further policy studies become particularly important considering that the transition towards affluent food consumption patterns in current developed nations occurred at a gradual rate, relative to the rapid changes in economic restructuring and hence food demand present in developing countries (Gerben-Leens et. al 2010).

This study serves as the foundation to conduct similar empirical analysis into other developing countries regarding food demand and resource use. Forthcoming research should strengthen the consensus that economic development is associated with food demand patterns that are more resource intensive. By highlighting the stark disparities in the resource inputs necessary to produce different food items, this paper suggests that without appropriate policy responses, demand patterns following economic development may impact on food affordability, access and environmental degradation. The outcomes of economic development may well promote a future where food security is an inherently challenged panacea on account of in food demand being increasingly resource intensive.

Key limitations of the current research should be recognised. Firstly, the quality of food consumed over the study period has not been accounted for, a factor that will affect dynamic food demand. Secondly, the availability of food substitutes and intertemporal household consumption factors has not been included in the demand model, which may impact upon the nature and magnitude of results. Finally, we have made the significant assumption that the resource inputs required for food production remain constant over the study period. Improved production technology (improved efficiency), or the use of increasingly marginal resource inputs (reduced efficiency) are factors which would impact input requirements. It is therefore unlikely to expect resource input requirements to remain static over the study period. In fact, the method by which the Indonesian resource input figures were produced was developed and applied without reference to any previous methodology. The accuracy of our 'back of the envelope' method used to estimate the resource input intensity could be improved if an index that recognised factors such as resource price, environmental cost and productivity, in the context of different production regions, were applied. An index which controls for heterogeneous regional effects relating to resource scarcity, input intensity and price may be a heroic ambition, considering the breadth of such a measure.

**Table 1:** Food Items Categorized by Resource Intensity

| **Low** | **Moderate** | **High** |
|---|---|---|
| Rice | Noodles, Rice Noodles, other chips | Beef, buffalo, goat |
| Cassava/Tapioca | Tofu/Tempe | Chicken, duck |
| Sago/Flour | Granulated Sugar | Fish, Oyster, Shrimp, Squid |
| Other Staples (potatoes, yams) | Milk (fresh, canned, condensed) | Cooking Oil |
| Green Vegetables | Salt | Bottled Water |
| Fruits | Salted Fish | |

**Table 2**: Level of Resource Inputs Required Across Three Food Categories*

| Food Category | Fossil Fuel (MJ/kg) | Land ($m^2$/kg) | Water (KL/kg) | Average Relative Change ($\bar{y}$) |
|---|---|---|---|---|
| Low | 2.35 | 1.02 | 0.868 | 1 |
| Moderate | 8.08 | 1.51 | 1.98 | 1.4 |
| High | 26.73 | 12.6 | 22.494 | 15.54 |

* See Appendix item II for detailed food items individual resource input requirements. Fossil fuels are measured in mega joules (MJ) = $10^6$ joules; land measured in square metres ($m^2$); water measured in kilolitres (KL) = 1000 litres.

**Table 3:** Key Variables and Their Definitions

| Variables | Units | Description |
|---|---|---|
| Income | Indonesian Rupiah (IDR) | Annual per capita household income constructed from salary, farm business income, asset income outside business activity, non-labour earnings, self employment income and transfer income |
| Price | IDR | Per unit price (kg or litres) for food item |
| Expenditure | IDR/capita | Annual per capita expenditure on food item/group |
| Consumption Quantity | (kg or litres)/capita | Calculated annual consumption quantity |
| Education of Household Head | 1-9 | Level of education attained by household head. 1=elementary 9=post-graduate |
| Household Size | Persons | Total persons in household |
| Average Household Age | Years | Average age of household |
| Marital Status | Dummy Variable | 1 if household head is married, 0 if otherwise |
| Distance to nearest market | Km | If market is not located in community, how far to nearest? |
| Distance to nearest financial institution | Km | If financial institution is not located in community, how far to nearest? |

**Table 4** Descriptive Statistics

| | Pooled | Poorest (25%) | Richest (25%) | Rural | Urban |
|---|---|---|---|---|---|
| Household Size | 6.01 | 6.19 | 5.35 | 5.82 | 6.19 |
| Highest Education Level | 4.81 | 3.91 | 5.96 | 3.99 | 5.67 |
| Age of household head | 46.56 | 49.16 | 43.74 | 46.84 | 46.25 |
| Proportion of male headed household | 0.82 | 0.74 | 0.88 | 0.82 | 0.81 |
| Income per capita (annual) | 8,188,074 | 166,338 | 30,300,000 | 4,279,000 | 12,300,000 |
| =n | 30799 | 7700 | 7699 | 12936 | 17863 |

**Table 5** Dietary Food Categories

| Staple | Fruit & Veg | Dried Foods | Animal Products | Condiments |
|---|---|---|---|---|
| Rice | Green Vegetables (beans, spinach etc.) | Noodles, Rice noodles | Beef, buffalo, goat | Cooking Oil |
| Cassava/Tapioca | Fruits (banana, papaya etc.) | Other chips | Chicken, duck | Bottled Water |
| Sago/Flour | | Tofu/Tempe | Fish, Oyster, Shrimp, Squid | Granulated Sugar |
| Other Staples (potatoes, yams) | | | Salted Fish | Salt |
| | | | Milk (fresh, canned, condensed) | |

**Table 6** Engel Expenditure Share Coefficients For Dietary Food Categories*

| Food Category | 1997 | 2000 | 2007 |
|---|---|---|---|
| Staple | -0.582 | -0.708 | -0.707 |
| Vegetable/Fruit | -0.361 | -0.287 | -0.56 |
| Dried Food | -0.478 | -0.435 | -0.682 |
| Animal Products | -0.202 | -0.024 | -0.331 |
| Condiments | -0.466 | -0.422 | -0.61 |

*All significant at the 1% level or greater

**Table 7** Engel Expenditure Share Coefficients for Resource Intensive Food Categories*

| Food Category | 1997 | 2000 | 2007 |
|---|---|---|---|
| Low Resource | -0.397 | -0.541 | -0.717 |
| Moderate Resource | -0.33 | -0.333 | -0.549 |
| High Resource | -0.181 | -0.008 | -0.5 |

*All results significant at the 1% level or greater

**Table 8** Income Elasticity (Weighted)*

| Food Group | Year | Pooled (Aggregate) | Rural | Urban | Income Quartile 1 | Income Quartile 2 | Income Quartile 3 | Income Quartile 4 |
|---|---|---|---|---|---|---|---|---|
| Low | 1997 | 0.078 | 0.056 | 0.112 | 0.035 | 0.218 | 0.089 | 0.223 |
| | 2000 | 0.082 | 0.065 | 0.099 | 0.015 | 0.157 | 0.084 | 0.057 |
| | 2007 | 0.071 | 0.065 | 0.078 | 0.005 | 0.147 | 0.112 | 0.059 |
| Moderate | 1997 | 0.089 | 0.082 | 0.099 | 0.028 | 0.3116 | 0.151 | 0.133 |
| | 2000 | 0.089 | 0.077 | 0.097 | 0.045 | 0.146 | 0.114 | 0.019 |
| | 2007 | 0.084 | 0.083 | 0.083 | -0.011 | 0.067 | 0.204 | 0.086 |
| High | 1997 | 0.113 | 0.108 | 0.119 | 0.062 | 0.322 | 0.170 | 0.227 |
| | 2000 | 0.103 | 0.087 | 0.116 | 0.017 | 0.142 | 0.242 | 0.066 |
| | 2007 | 0.098 | 0.097 | 0.100 | -0.014 | 0.189 | 0.245 | 0.113 |

*All results are significant at the 10% level or greater

**Table 9** Estimate Results For Additional Resource Use (Absolute*)

| | Estimate 1 $\left(\sum_i D_{1ir} - \sum_i Base_i\right)$ | | | Estimate 2 $\left(\sum_i D_{2ir} - \sum_i Base_i\right)$ | | | Estimate 3 $\left(\sum_i D_{3ir} - \sum_i Base_i\right)$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | Fuel | Land | Water | Fuel | Land | Water | Fuel | Land | Water |
| Low | 0.05 | 0.02 | 0.017 | 0.19 | 0.08 | 0.069 | 0.08 | 0.03 | 0.029 |
| Moderate | -0.32 | -0.06 | -0.076 | 0.97 | 0.18 | 0.229 | 0.81 | 0.15 | 0.191 |
| High | 0.55 | 0.25 | 0.449 | 1.09 | 0.51 | 0.915 | 2.24 | 1.06 | 1.882 |
| Aggregate | 0.26 | 0.21 | 0.39 | 2.25 | 0.78 | 1.213 | 3.13 | 1.24 | 2.103 |

*See appendix item VII for detail into the absolute input requirements.

**Table 10** Estimate Results For Additional Resource Use (Relative)

| Food group | No Demand Change $(\beta_{0i}\bar{\gamma}_i)$ | Changed Demand $(\beta_{1i}\bar{\gamma}_i)$ | Difference $(\beta_{1i}\bar{\gamma}_i - \beta_{0i}\bar{\gamma}_i)$ |
|---|---|---|---|
| Low | 1.13 | 1.02 | -0.11 |
| Moderate | 3.51 | 3.93 | 0.42 |
| High | 21.35 | 23.13 | 1.78 |
| Aggregate | 25.99 | 28.08 | 2.09 |

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## *Appendix*

**Item I** Food Items and Individual Resource Inputs

| *Resource Category* | *Food Item* | *Fossil Fuels (MJ/kg)* | *Water (L/kg)* | *Land ($m^2$/kg)* |
|---|---|---|---|---|
| *Low* | *Rice* | *6.91* [a, b, c] | *1912* [j] | *2.12* [g] |
| | Cassava | | *1240* [h] | *1* [g] |
| | Potatoes/other Staples | *4.75* [c] | *500* [j] | *0.63* [g] |
| | Sago/Flour | *2.02* [d] | | *0.77* [g] |
| | Vegetables | *0.81* [c] | *190* [h] | *0.83* [g] |
| | Fruits | *2.16* [c] | *500* [h] | *0.64* [g] |
| *Moderate* | Noodles, rice noodles, shrimp chips, other chips | *5.17* [b] | *900* [j] | |
| | Tofu, Tempe | *12* [b] | *5000* [h] | *2.66* [h] |
| | Granulated sugar | *14.1* [d] | *1020* [h] | *0.164* [g] |
| | Fresh, canned, condensed milk | *16.2* [b] | *1000* [h] | *1.7* [b] |
| | Salt | *2.5* [e] | | |
| | Salted Fish[b] | | | |
| *High* | Beef | *37.5* [b] | *100000* [j] | *31.46* [b] |
| | Poultry | *27.8* [b] | *2390* [h] | *7.26* [b] |
| | Fish/Seafood | *33.61* [d] | *5000* [h] | *9.68* [b] |
| | Cooking Oils | | *5080* [h] | *2* [b] |
| | Bottled Water | *5.6-10.2* [f] | *1* | |

***Sources****: a = FAO (2000) b = Sainz R.D. (2003) c = Pimentel (2006) d = Pimentel and Pimentel (2007) e* = (Tzilivakis et. al 2005) f = Gleick and Cooley (2009) g = FAO (2011) h = Chang et. al (2012) i = Liu and Savenije (2008) j = Pimentel et. al (1997)

**Item II** IFLS Variables in Demand Analysis

| Variable Name | Units | Description | Household/ Community Level |
|---|---|---|---|
| Quantity Consumed | Kilograms or Litres | Annual per-capita consumption of food item | Household |
| Food Price | Indonesian Rupiah (IDR) | Per-unit price of food item | Community |
| Income | IDR | Annual per-capita income | Household |
| Household Size | Persons | Size of household in persons | Household |
| Rural/Urban | Dummy | 0 (rural) & 1 (urban) location of household | Household |
| Education Level of Household Head | Education Scale (1-9) | Records highest level of education completed by household head where 1 refers to elementary school and 9 refers to doctoral qualification | Household |
| Sex of Household Head | Dummy | 0 (female) & 1 (male) | Household |
| Average Age of Household | Years | Average age of all household members | Household |
| Economic Shock | Dummy | 0 (no) & 1 (yes) for an economic shock being experienced in the last 5 years | Household |
| Household Head Marital Status | Dummy | 0 (not married/other) & 1 (married) for household head | Household |
| Religion | Dummy | 0 (all other) & 1 (Islamic) religion practising household | Household |
| Child Share in Household | Percentage Units | Share of household members classified as a child (<15yrs) | Household |
| Adult Share in Household | Percentage Units | Share of household members classified as an adult(16-60yrs) | Household |
| Senior Share in Household | Percentage Units | Share of household members classified as a senior(>60yrs) | Household |
| Major Share of Income | Dummy | Vector of dummy variables reporting on the major source of income being from farm, asset, non-labour, self-employment, salary or transfers | Household |
| Community Size | Hectares | Size of village in hectares | Community |
| Slums in Community | Dummy | 0 (no slums) 1 (slums) exist in the village | Community |
| Population of Community | Persons | Population of the community | Community |
| Average Household Size in Community | Persons | Average size of households within community | Community |
| Presence of Financial Institution | Dummy | 0 (no institution) & 1 (at least one institution) | Community |
| Presence of Market | Dummy | 0 (no market) & 1 (at least one market) | Community |
| Presence of Factory | Dummy | 0 (no factory) & 1 (at least one factory) | Community |
| Village Midwife | Dummy | 0 (no midwife) & 1 (midwife) | Community |
| Medicine Post (Clinic) | Dummy | 0 (no post) & 1 (medicine post) | Community |
| Road Condition | Dummy | 0 (mostly non-sealed roads) & 1 (mostly sealed roads) | Community |
| Drinking Water Source | Dummy | 0 (other sources) & 1 (water can be accessed by tap or pump) | Community |

**Item III** Value of Agricultural Trade (IDR '000)

| Resource Category | Year | 1997 | 2000 | 2007 |
|---|---|---|---|---|
| Low | Export | 1636.43 | 1510.61 | 2821.77 |
| | Import | 3583.62 | 3574.92 | 7236.24 |
| | Domestic Production | 22561.93 | 16321.47 | 37307.43 |
| Moderate | Export | 84.93 | 228.86 | 299.63 |
| | Import | 1526.64 | 2027.53 | 4467.51 |
| | Domestic Production | 2660.53 | 1987.03 | 3589.08 |
| High | Export | 2326.04 | 1696.07 | 8744.84* |
| | Import | 5710.81 | 5907.04 | 13082.2 |
| | Domestic Production | 6268.26 | 3763.05 | 12336.4 |
| Total | Export | 4047.4 | 3435.5 | 11866.2 |
| | Import | 5710.8 | 5907 | 13082 |
| | Domestic Production | 31490.7 | 22071.6 | 53232.9 |

Source: FAO (2011); *The significant increase in value for the high resource intensive food export value can be accounted for exports in Palm Oil (controversial Indonesian agricultural activity). Over 90% of the rise in export value is attributable to this commodity alone. Omitting Palm Oil exports results in a trade value deficit for this category

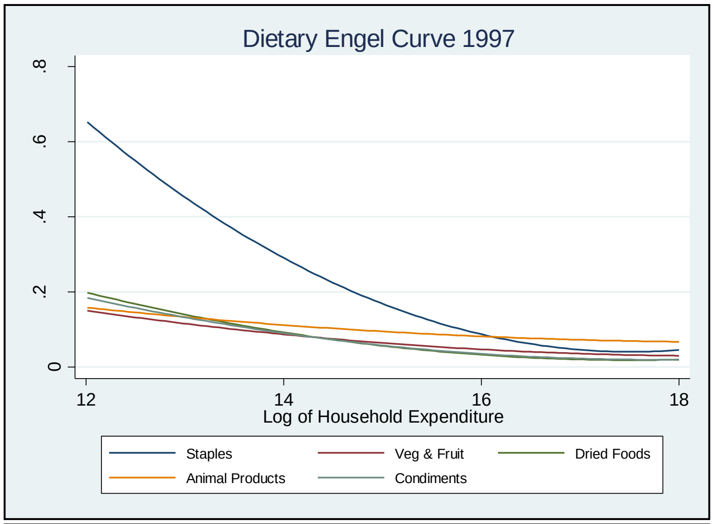
**Item IV** Household Real Expenditure Growth Across Resource Categories

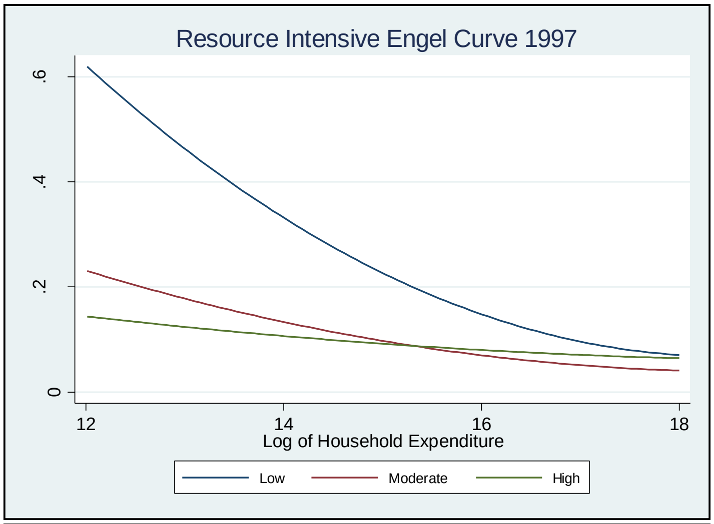
| **HH Exp (IDR) annual** | 1997 | 2000 | 2007 | Growth Factor 97-07 ($Exp_0$) |
|---|---|---|---|---|
| Low | 983,614 | 1,614,991 | 1,114,609 | 1.13 |
| Moderate | 507,452 | 911,367 | 742,058 | 1.46 |
| High | 567,241 | 1,000,827 | 732,059 | 1.29 |

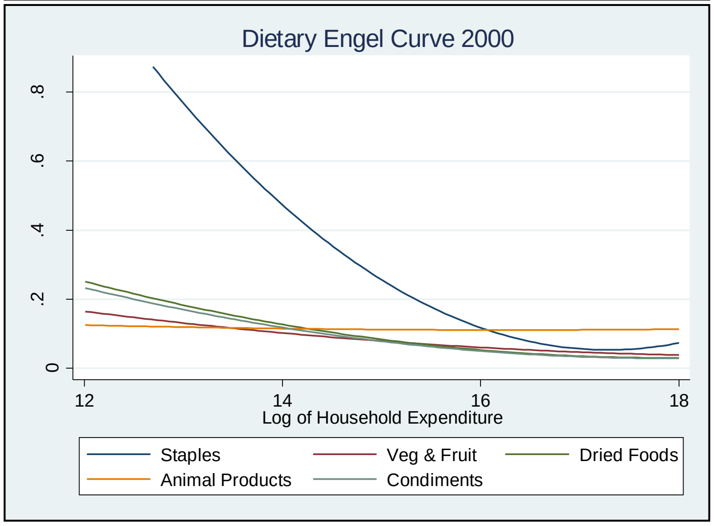
**Item V** Household Food Budget Shares For Food

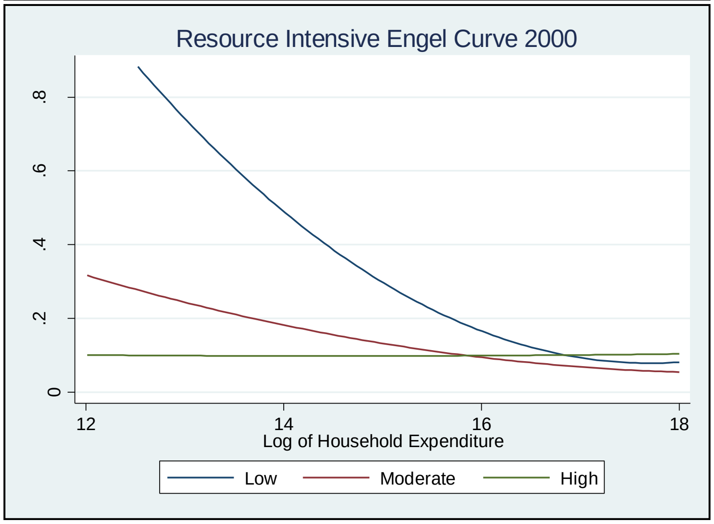
| **Budget Shares on Food** | 1997 | 2000 | 2007 | Change 97-07 |
|---|---|---|---|---|
| Low | 0.51 | 0.48 | 0.46 | 0.90 |
| Moderate | 0.25 | 0.28 | 0.28 | 1.12 |
| High | 0.24 | 0.24 | 0.26 | 1.08 |

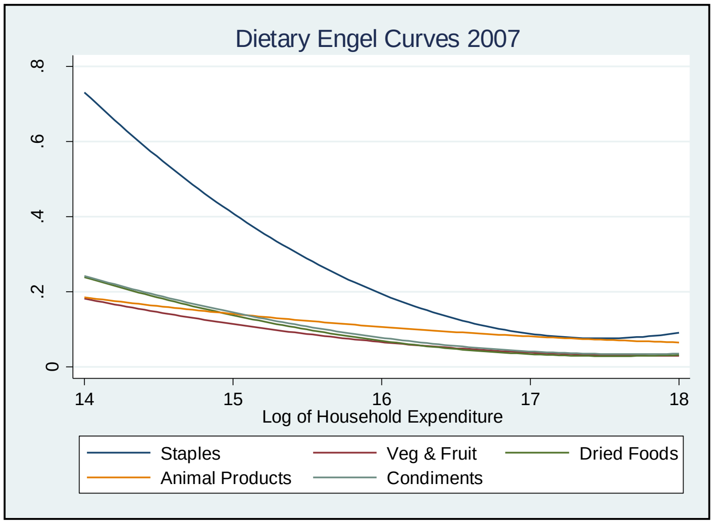
**ITEM VI** Engel Curves – Dietary and Resource (1997-2007)

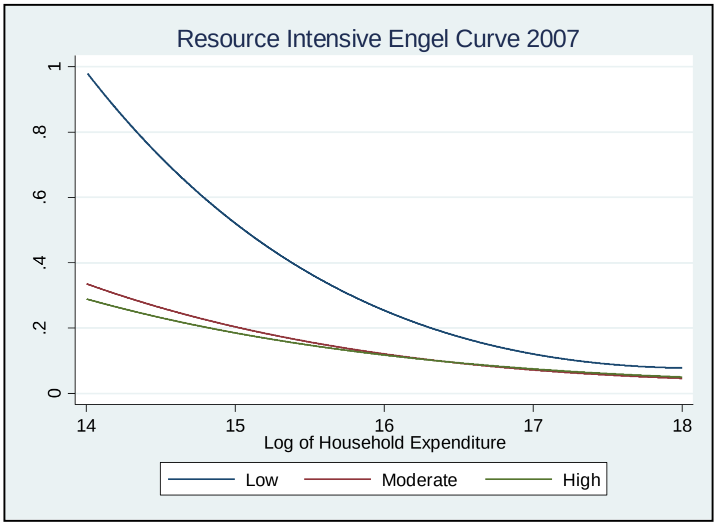


**Item VII** Input Figures For Absolute Net Resource Use

| **Fuel** | $q_{i, fuel}$ | $C_{0i}$ | $C_{1i}$ | $Base_i$ | $D_{1i}$ | $D_{2i}$ | $D_{3i}$ |
|---|---|---|---|---|---|---|---|
| Category (i) | Input (MJ/kg) | Consumption weight (1997) | Cons. Weight (2007) | $q_{ir}c_{oi}$ | $q_{ir}c_{1i}$ | $Base_iExp_{0i}$ | $Base_iExp_{1i}$ |
| Low | 2.35 | 0.6 | 0.62 | 1.41 | 1.46 | 1.60 | 1.49 |
| Mod | 8.08 | 0.26 | 0.22 | 2.10 | 1.78 | 3.07 | 2.91 |
| High | 26.73 | 0.14 | 0.16 | 3.74 | 4.28 | 4.83 | 5.98 |
| **Sum** | **37.16** | **1** | **1** | **7.25** | **7.51** | **9.5** | **10.38** |

| **Land** | $q_{i, fuel}$ | $C_{0i}$ | $C_{1i}$ | $Base_i$ | $D_{1i}$ | $D_{2i}$ | $D_{3i}$ |
|---|---|---|---|---|---|---|---|
| Category (i) | Input (MJ/kg) | Consumption weight (1997) | Cons. Weight (2007) | $q_{ir}c_{oi}$ | $q_{ir}c_{1i}$ | $Base_iExp_{0i}$ | $Base_iExp_{1i}$ |
| Low | 1.02 | 0.6 | 0.62 | 0.61 | 0.63 | 0.69 | 0.64 |
| Mod | 1.51 | 0.26 | 0.22 | 0.39 | 0.33 | 0.57 | 0.54 |
| High | 12.60 | 0.14 | 0.16 | 1.76 | 2.01 | 2.28 | 2.82 |
| **Sum** | **15.13** | **1** | **1** | **2.76** | **2.98** | **3.54** | **4.01** |

| **Water** | $q_{i, fuel}$ | $C_{0i}$ | $C_{1i}$ | $Base_i$ | $D_{1i}$ | $D_{2i}$ | $D_{3i}$ |
|---|---|---|---|---|---|---|---|
| Category (i) | Input (MJ/kg) | Consumption weight (1997) | Cons. Weight (2007) | $q_{ir}c_{oi}$ | $q_{ir}c_{1i}$ | $Base_iExp_{0i}$ | $Base_iExp_{1i}$ |
| Low | 0.87 | 0.6 | 0.62 | 0.52 | 0.54 | 0.59 | 0.55 |
| Mod | 1.91 | 0.26 | 0.22 | 0.50 | 0.42 | 0.73 | 0.69 |
| High | 22.49 | 0.14 | 0.16 | 3.15 | 3.60 | 4.06 | 5.03 |
| **Sum** | **25.27** | **1** | **1** | **4.17** | **4.557** | **5.38** | **6.27** |