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## **Food Waste in Rural Households**

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## Introduction

Food waste occurs in both the distribution and consumption stages (Gustavsson et al., 2011). Waste at the distribution stage represents a direct loss to the distributor and the emphasis on cost reduction provides constant incentives to minimize it. In developed economies, households are the largest contributors to food waste. For example, in the United Kingdom about 22% of food and drink (or 330 kg per household per year) is wasted in households (WRAP, 2009). A portion of food waste is avoidable. In Denmark, the avoidable food waste is estimated at 105 kg per year (EPA, 2012), in Finland, avoidable food waste is estimated at 63 kg per year (Silvennoinen et al., 2014), while 65% of the 330 kg of food waste in a British household, or about 215 kg is considered as avoidable (WRAP, 2009).

Prevention is the preferred strategy to eliminate most food waste. In a recent study, residents in 25 out of 28 EU countries named consumers as primarily responsible for reducing food waste (Flash Eurobarometer 425, 2015). Admittedly, some food waste could be deterred if purchase and consumption choices were different. Yet, some food will be wasted in spite of the best intentions of very conscientious consumers. The amount of wasted food is a direct outcome of the decision to purchase food, and consumer decisions have been considered in the context of consumer and household characteristics in empirical studies.

Food waste is viewed unfavorably not only because it is perceived as a senseless waste of resources used to produce it, but increasingly because it adds to the overall waste burden and has negative environmental consequences including greenhouse gas emissions (Bio Intelligence Service, 2010; FAO, 2013). Household waste reduction decreases the environmental impact that accumulates through the production, processing, and distribution of food (Williams and Wikstrom, 2011). Alternative uses for food waste have been studied including home composting and reduction of moisture content to minimize food waste volume.

This paper examines factors that influence the amount of food waste in rural households. Rural households generally face accessibility constraints and their food purchases may be well planned given the possibility that the nearest food retail outlet is remote and transportation may not be readily available and costly. Attempts to reduce food waste not only call for knowledge about factors that are associated with food waste, but must recognize that the amount of waste varies according to food categories and degree of preparation. For example, bread or baked goods may result in less waste than fresh vegetables that require peeling, cleaning, etc. Additionally, food waste may be influenced by location within a region and the location of the region with respect to other regions of a country.

This study identifies factors associated with the self-reported share of wasted (edible or inedible) food by rural residents from a region in eastern Poland. The region is classified among the 20 poorest regions of the European Union (EU) (Rosner and Stanny, 2014). The reported food waste accounts for four food categories: bread and baked goods; fruits, vegetables, and potatoes; the uneaten portion of home-cooked meals (the so-called “plate waste”); and all other food waste. The extension of the study is the identification of consumer features that influence the willingness to separate household food waste for the purpose of local production of biogas. Food waste, especially if unavoidable, can supplement other locally available feedstock (from agriculture and forestry) to produce energy that can be used in rural settings by public institutions like schools, county libraries, community centers, and sports facilities.

In Poland, a total of 293 kg of solid waste was generated per capita in 2013 (GUS, 2015). It has decreased by 7% since 2010, but the figures for the share of food waste are not available. Overall, biodegradable waste represented 20.8% of solid waste in Poland in 2009. A total of 1.231 million tons of solid waste was composted or used in fermentation facilities. The volume

accounted for 13.2% of the total solid waste and increased by 1.25% as compared to 2012. It included food waste from households and the hospitality sector.

Estimates for waste of selected foods exist, but are based on limited sample size. For example, Śmiechowska (2016) reports 1.8kg (i.e., 7.2%) of not consumed (presumably wasted) bread and baked goods per month out of a total purchase of 25kg for a single, 4-person rural household. The rural household involved in the study utilized the non-consumed bread as animal feed, but EU regulations ban the use of food waste as animal feed. Such an option can only be exercised at a household level, where own food waste is used as feed for animals as own meat supply. However, even in Poland, the majority of rural households no longer farms or is engaged in rising animals that could consume food waste. Bakery goods, mostly bread, accounted for 27% of edible food waste in Norwegian households (Hanssen et al., 2016) although households from rural areas wasted about one half of the amount reported wasted in urban households. For example in Denmark, some perceive bread as “more culturally acceptable to throw away” (Halloran et al., 2014) and such perceptions may reflect the relatively low cost of bread.

Bread and baked goods are, next to fruits and vegetables, among the most often wasted foods, while representing a core food item in the diet of the majority of Poland’s residents. Therefore, the amount of wasted bread and handling of the volume that has not been eaten is not well documented. But bread and baked goods are established as a good feedstock for biogas production (Kot et al., 2015).

In Poland, a new law was passed in 2013 imposing the organization of solid waste collection on local governments. Under the law, all households had to register with a local government and enter the solid waste removal contract. Fees, paid also to the local government, are structured according to the household size and offer a choice of collection of sorted or

unsorted waste. Sorting involves common recyclables such as paper and cardboard, plastics, metal, and glass. Large items and electronics are typically collected at pre-specified dates a couple of times a year, but bio-waste is discarded with other non-recycled solid waste since bio-bins (like, for example, in Germany (Ntoka et al., 2011) and multi-compartment bins are not available (Waste Management Sweden, 2014). Biodegradable waste ends up in landfills and the recovery and use of biogas for energy generation is infrequent.

#### Survey data

The lack of data on the subject of food waste in households by category requires collection of data and, because of data collection management considerations and cost, such data tend to be specific to a particular area. National surveys are likely to be costly or miss differences in food waste resulting from household location, including rural vs. urban setting, or regional differences and the associated consumption choices. The study applies survey data collected among residents of 13 villages in the Lubelskie Voivodship in Poland, near the eastern EU border with Belarus and Ukraine. The region is considered among the least developed parts of the EU. The level of development is reflected, among others, in the below national average population density and per capita income.

The drafted survey instrument was tested on a small group of potential respondents who completed it without the enumerator's assistance. The pilot test did not reveal difficulties in understanding or answering the questions. Printed copies of survey instruments were delivered to randomly selected residents (a convenience sample) in villages in the Biala Podlaska, Tomaszow Lubelski, and Zamosc districts of Lubelskie Voivodship. Questionnaires were left in each household that accepted the initial inquiry to participate in the survey. The questionnaire was self-administered by a respondent, and collected by an enumerator within a few days. The main

criteria for selecting a household was its location within the boundaries of one of the villages. The survey began on July 1 and ended on August 12, 2013. Among the specific questions were those asking a respondent to estimate the share of a food or food group that in their opinion was wasted in their household. Typically, the least often wasted foods are meat and meat products, fish and fish products, and dairy. Therefore, the food groups identified in the questionnaire included bread and other baked goods, other foods including fruits, vegetables, and potatoes (the latter are an important staple in Poland), uneaten food served at main meals during the day, and “all other”. Another question probed for the respondent’s willingness to save household food waste and allow it to be collected for the generation of biogas at a local facility. The respondents also shared information about themselves and their households, providing socio-economic and demographic information. A total of 200 completed questionnaires were collected. Overall, the self-reported waste volume of the four specific food categories was less than five percent of the total food volume used by households.

#### *Descriptive statistics and variable selection*

Participants in the survey were on average 42 years old. The median age was estimated at 38.5 years in 2011, suggesting that the age of respondents was fairly representative of the national average. About one in four respondents had college education. The percent of married respondents in the sample was 73.0 percent (country average is 47.8 percent). The share of married households is noticeable larger in the sample, but larger households tend to waste more food.

#### *Empirical model*

Food waste occurs in practically every household. The volume of wasted food is reflected in the truncated nature of the dependent variable (the reported percent of wasted food product).

Such truncation at 0 (non-negativity of food waste volume) requires the selection of a suitable estimation approach. This study uses the Tobit modeling technique in the estimation of four equations linking consumer and household characteristics with the percentage of wasted food type.

Among the wasted foods, bread and baked goods are commonly eaten at breakfast, supper, and as a light in-between meal that is common in Poland. Fruits are eaten as a snack or dessert, vegetables are a part of any meal, but mostly served as a side dish, while potatoes are a common main meal staple. The uneaten main meal leftovers can contain any type of food. Consumption habits suggest that the amount of wasted food in each category is fairly independent of each other. Therefore, each equation modeling the percentage of food waste in a given category is independently estimated. This approach is further supported by the variability of personal preferences in food consumption across demographic and socio-economic characteristics of consumers and often unpredictability of specific food choices.

A single Tobit equation can be represented as:

$$Y_{im}^* = X_i' \beta_m + \varepsilon_i, \quad i = 1, 2, \dots, N, \text{ and} \quad (1)$$

$$Y_i = Y_i^* \quad \text{if } Y_i^* > 0$$

$$Y_i = 0 \quad \text{if } Y_i^* \leq 0,$$

where  $N$  is the number of observations;  $Y_i$  is the observed dependent variable, and  $Y_i^*$  is the latent (unobserved) variable;  $\beta$  represents the vector of parameters, and  $\varepsilon_i$  are the error terms for the equation which is normally distributed with a mean of zero and variance  $\sigma^2$ .

Separately, a binary dependent variable equation was specified to model the decision to agree to separate waste for the purpose of local biogas production. The yes/no nature of the decision suggested the use of the probit technique to identify the factors that encourage or



impede such a choice. To implement a possible collection system depends on the willingness to participate in the process.

The explanatory variables used in the specified empirical model are commonly used in consumer studies including socio-economic and demographic characteristics of a respondent and their household. The variables are, among others, income, age, gender, household size, presence of children, and employment status. These variables capture factors identified in earlier studies as associated with food waste. Income and education are associated with possible large food spending, but the better educated would be expected to waste less food if food waste is their concern. Larger households tend to consume more food but could also waste more. The current study adds a square measure of household size implying that the empirically tested effect on the volume of wasted food can change as the number of household members increases. Similarly, age and age squared of a respondent can capture changes in amount of wasted food, and, presumably, oldest respondents are less wasteful.

Additionally, in the equation modeling the decision to sort food waste for the purpose of biogas production, time of traveling on foot and by car to the workplace or school are included because rural residents commonly combine food shopping when returning from work. A substantial amount of time spent on getting to and from a job implies rather difficult access to food outlets and careful food shopping. Disciplined food shopping can be expected to result in less food waste. Also, the degree of willingness to separate household waste for the purpose of biogas production requires time and may limit allocation of time to other activities.

## Results

### *Factors influencing food waste in four categories*

Results are remarkably different across the four food waste categories. It appears that bread and baked goods waste is positively associated with university education, listing farming as occupation, and long distance to work place on foot, but inversely related to a long commute by car. Fruit, vegetable, and potato waste was affected by 13 out of 16 explanatory variables. Age, household size, squared household size, and long distance to work place if traveling on foot as well as willingness to sort food waste for the purpose of local biogas production increased waste. Income, three forms of employment (full-time, part-time, and farming), and age squared lowered the volume of fruit and vegetable waste. Uneaten portions of meals increased as household size increased, in married households, and if the respondent was male. Moreover, volume also increased if the respondent was willing to sort waste to locally produce biogas. Among the factors increasing other types of food waste was income.

The ordered probit results of willingness to sort food waste to produce biogas was positively influenced by socio-economic and demographic factors. Those more likely to decide to sort food waste for the purpose of biogas production have completed university education. The results are consistent with expectations that education favors higher environmental awareness and encourages behavior consistent with environmentalism. Similarly, those with higher income were more likely to decide to sort food waste. It has been reported in other studies that higher income is associated with a higher level of food waste and households participating in the current survey recognize they can convert wasted food into a useful resource. The positive effect of part-time employment on the decision to sort seems to capture the attitudes of individuals who work, but because of part-time employment likely are flexible in using their time.

The self-reported amount of wasted food varied across categories. In general, the amount of waste was small. Among reasons for the relatively limited amount of wasted food could be the overall economic conditions of the region and rural household location. The average per capita income in Lubelskie Voivodship amounted to 88.5% of the national average in 2015 (GUS, 2016) and was similar at the time of conducting the survey in the summer of 2013. In addition, rural households had 29.6% lower per capita income than urban households in 2014. The national average monthly per capita expenditure on food and non-alcoholic beverages represented 24.9% of all household expenditures in 2013 (GUS, 2016). The share was larger in farm households, 31% in 2014 (GUS, 2016), and households of the retired, 26.9% in 2014, but households of the employed for wages spent 23.2% of their income on food and non-alcoholic beverages. Overall, the surveyed households had less income and food expenditure share was larger likely resulting in frugal spending including food purchases.

The low share of wasted food in the surveyed households is interesting because in some categories rural households consumed a larger volume according to 2015 figures. An average rural household consumed 4.3 kg of bread and baked goods monthly per capita, 26.5% more than in urban households. Bread and baked goods tend to represent one of the largest portions of food waste as discussed earlier. Also, the average monthly per capita consumption of fruits and vegetables amounted to 12.4 kg in rural households, which was 1.6% more than in urban households. Rural households consumed primarily more potatoes, 4.4 kg vs. 3.2 kg in urban households monthly per capita. Interestingly, Lubelskie Voivodship was among the top three voivodships in the country in terms of per capita monthly vegetable consumption, 9.8 kg (GUS, 2016). Vegetables, including potatoes, and fruit have been frequently identified as large contributors to food waste in earlier discussed studies.

The identified statistically significant factors influencing the amount of waste in each food category vary. Consequently, it appears that to reduce food waste requires a different approach if the goal is to alter consumer behavior. Marital status positively affects the amount of leftovers, but not other categories of food waste. This finding is consistent with the tendency in married households to over-serve to reflect the abundance of food. Not all parts of the meal are equally overserved, with potatoes, vegetables, or condiments being more likely to fall into that category. Moreover, males are more likely to have more leftovers than women. Men tend to eat more and may place additional food on their plate, but eventually not eat it or selectively eat only some types of food.

## Conclusions

Rural residents in Lubelskie Voivodship self-report a rather limited amount of food waste classified into four categories. The identified statistically significant different factors associated with the percent of food waste differ in each food category. Among socio-demographic characteristics, educational attainment level lowered the waste amount of bread and bakery goods. Advancing age is associated with an increase in wasted amount of fruit and vegetables, and, given the typical diet, likely involves potatoes; but waste in this category diminished among the oldest respondents. Household size leads to increased fruit and vegetable waste and larger amount of leftovers. Moreover, the waste share in both categories increases as the household size increases strongly suggesting that large households may be a primary sources of food waste for biogas production.

Households reporting a high income level are likely to waste lower amounts of fruits and vegetables and have less leftovers, but generate waste in other food categories, i.e., possibly waste more dairy and meat products than households with less income. Employment generally

led to less waste, except for farm households which waste relatively more bread and bakery goods.

The prospects for the possible collection of food waste for biogas production are reasonably good. Those with higher educational attainment levels are more likely to sort as are those with higher (rather than lower) incomes. Sorting must be made easy as indicated by the willingness to sort by the part-time employed, while full-time employed did not differ in their readiness to sort from the omitted employment categories. The latter includes pensioners, and although willingness to sort increases with age, the oldest respondents were unlikely to do so. Women are more likely to sort than men, but because women tend to be more often involved in food handling, such tendency could likely benefit an organized effort of food waste collection for local biogas production in rural Lubelskie Voivodship. Overall, the readiness to collect waste for biogas generation are influenced by similar characteristics as they are in urban areas or wealthier regions of the EU.

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Table 1. Descriptive statistics of selected demographic and socioeconomic characteristics of the surveyed respondents.

Variable name	Units	Mean <sup>a</sup>	Std. deviation	Min	Max
Gender	1=man; 0=woman	0.48	0.50	0	1
Age	In years	42.53	10.74	23	82
Education	1=university degree; 0=otherwise	0.255	0.437	0	1
Marital status	1=married; 0=otherwise	0.73	0.45	0	1
Household size	Number of household members	3.71	1.06	1	5
Employment status	1=fully employed; 0=otherwise	0.46	0.50	0	1
Farmer	1=farmer; 0=otherwise	0.29	0.45	0	1
Income <sup>b</sup>	Income category	3.17	1.13	1	5

<sup>a</sup> In case of binary variables the reported figure is a share.

<sup>b</sup> Income categories are: 1=...; 2=...; 3=2001-2500 PLN; 4=...; 5=...



Table 2. Tobit model estimation results of the percentage of wasted bread and baked goods, fruits and vegetables, meal leftovers, and other food by rural households.

Variable name/ Parameter	Bread		Fruits & vegetables		Leftovers		Other food	
	Estimated coefficient	t-value	Estimated coefficient	t-value	Estimated coefficient	t-value	Estimated coefficient	t-value
Intercept	-11.6358 (14.2516)	-0.82	-13.0032 (10.9513)	-1.19	-4.0189 (32.0934)	-0.13	109.0841 (40.7971)	2.67
Education	2.1695 (1.3207)	1.64	1.5227 (1.0001)	1.52	0.8241 (2.9164)	0.28	-4.2070 (3.7465)	-1.12
Age	0.5078 (0.7936)	0.64	1.0713 (0.6142)	1.74	0.1879 (1.7658)	0.11	-1.2057 (2.2958)	-0.53
Age squared	-0.0055 (0.0091)	-0.60	-0.0115 (0.0070)	-1.63	0.0093 (0.0203)	0.05	0.0102 (0.0264)	0.39
Gender	-0.6185 (1.2770)	-0.48	0.1500 (0.9918)	0.15	5.2845 (2.8416)	1.86	-4.3758 (3.7169)	-1.18
Marital status	-1.2383 (2.0104)	-0.62	1.6526 (1.5685)	1.05	8.4129 (4.6182)	1.82	-7.4977 (5.8291)	-1.29
Household size	4.8198 (4.0638)	1.19	21.2991 (3.1764)	6.71	20.5978 (9.1338)	2.26	-44.9720 (11.8706)	-3.79
Household size squared	-0.0526 (0.0837)	-0.63	0.2488 (0.0646)	3.85	0.4261 (0.1863)	2.29	-0.6311 (0.2420)	-2.61
One child	2.3687 (1.8019)	1.31	-4.2722 (1.4029)	-3.05	-5.8470 (3.9766)	-1.47	8.2181 (5.2682)	1.56
Two or more children	-2.4427	-0.90	2.3214	1.10	0.1543	0.02	-2.3613	-0.30

	(2.7109)				(6.2554)			
Income	0.1091 (0.6295)	0.17	(2.1169) -1.1508	-2.35	-2.3811 (1.4082)	-1.69	(7.8702) 3.3314	1.82
Part-time work	-0.1833 (3.1973)	-0.06	(0.4896) -6.1392	-2.68	-7.7966 (6.9217)	-1.13	(1.8349) 14.1762	1.66
Employed fulltime	2.2275 (2.8796)	0.77	(2.2891) -3.2783	-1.61	-4.5473 (6.1366)	-0.74	(8.5552) 5.2557	0.70
Farmer	6.2612 (3.1684)	1.98	(2.0301) -3.7795	-1.65	-10.9137 (6.7306)	-1.62	(7.5061) 8.8739	1.03
Sorting for biogas	0.1194 (0.6792)	0.18	(2.2956) 0.9694	1.87	2.9974 (1.5684)	1.91	(8.5791) -2.5104	-1.31
Travel time 1	0.0939 (0.0209)	4.50	(0.5185) 0.1487	-1.63	0.0468 (0.0458)	1.02	(1.9192) -0.2817	-4.66
Travel time 2	-0.3468 (0.1552)	-2.23	(0.0161) -0.5283	3.85	-0.2555 (0.3455)	-0.74	(0.0605) 1.1251	2.55
			(0.1183)				(0.4416)	

Table 3. Ordered probit estimation results of the willingness to sort food waste for the purpose of producing biogas.

Variable name/ Parameter	Estimated coefficient	Standard error	t-value
Intercept	-1.0760	1.1700	-0.92
Education	0.6174	0.0085	2.70
Age	0.1099	0.0542	2.03
Age squared	-0.0011	0.0006	-1.79
Gender	-0.6228	0.1688	-3.69
Marital status	-0.2430	0.2558	-0.95
Household size	-0.3683	0.5030	-0.73
Household size squared	-0.0103	0.0137	-0.75
One child	-0.0306	0.1235	-0.25
Two or more children	-0.2008	0.2005	-1.00
Income	0.2915	0.0782	3.73
Part-time work	1.0041	0.3532	2.84
Employed fulltime	0.1164	0.2676	0.43
Farmer	0.1436	0.2700	0.53
Limit2	0.8032	0.1568	5.12
Limit3	1.9741	0.1844	10.70
Limit4	3.4757	0.2245	15.49