Statistical Office of the Republic of Serbia

Estimation of Household Waste in the Republic of Serbia using R software

Melinda Tokai

melinda.tokai@stat.gov.rs

From municipality waste to household waste

Municipality waste in Serbia consists of:

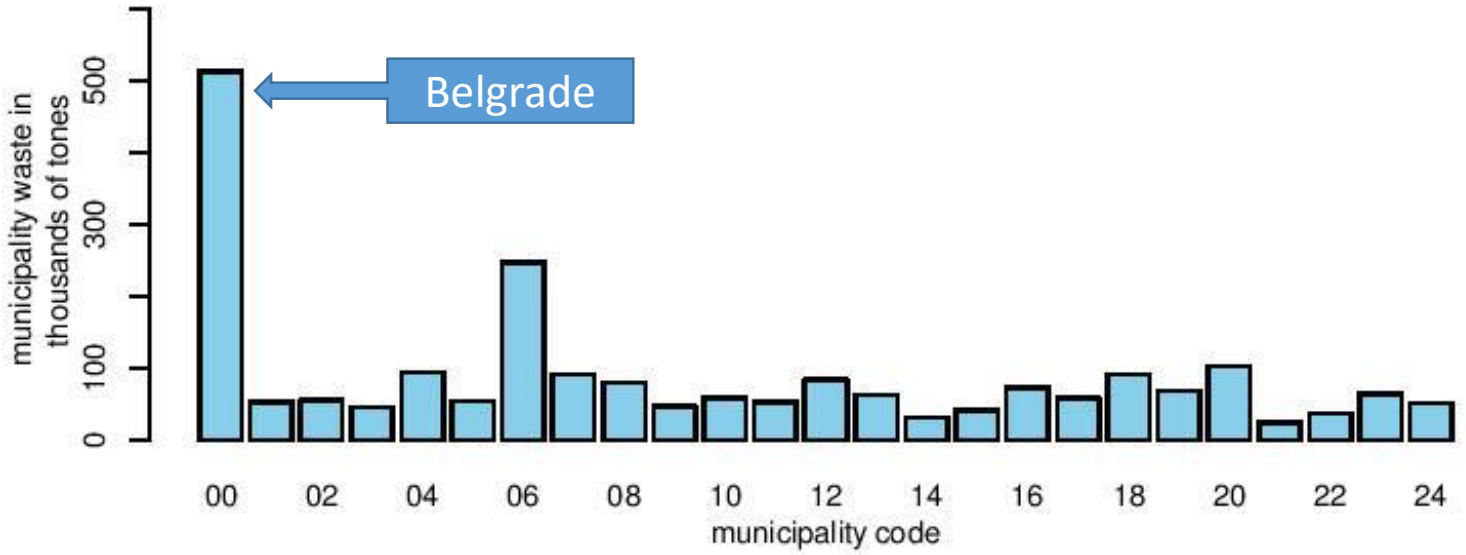
- Household waste
- Waste generated by trade and services activities
- Waste generated by tourists

From municipality waste to household waste

- Regression models based on trade and services activities and tourism
- The part of the municipality waste not explained by the model was ascribed to pure household waste
- Validity check - results are related to:
  - usual population and
  - average number of inhabitants per occupied dwellings

Analyzing the data

- Two regression models: one for all except Belgrade and one for the Belgrade municipalities (Belgrade differs significantly from the rest of the data)



Estimation – counties except Belgrade

- The model for all the counties except Belgrade is given by:

$$\log y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \varepsilon_i, \qquad i = 1, \dots n \qquad (1)$$

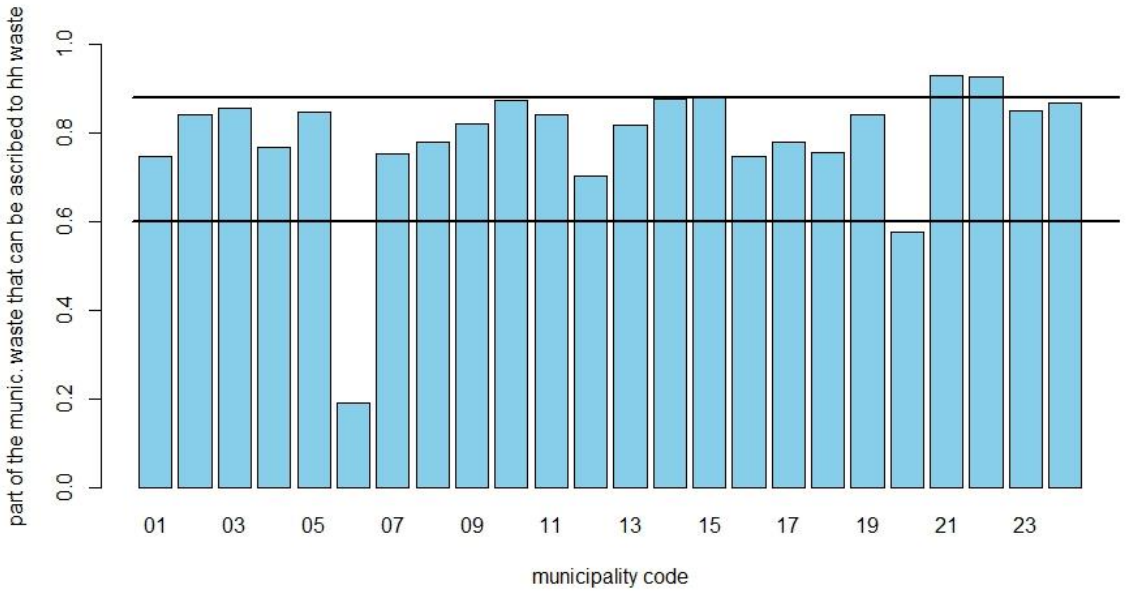
  - n - number of counties (n=24);
  - y_i - municipal waste amount;
  - x_{1i} - number of trade and service employees per inhabitant;
  - x_{2i} - ratio of tourist overnights stays and usual population.

Estimation – counties except Belgrade

Table1. Regression summary for model (1): municipality waste amount for Serbian counties without Belgrade			
Model (1)			
Coefficients	Estimate	Standard Error	t-value
$\hat{\alpha}$	1.084e+01	8.792e-02	123.311
$\hat{\beta}_1$	6.610e-05	7.451e-06	8.871
$\hat{\beta}_2$	6.758e-03	6.052e-02	0.112
Residual standard error = 0.05154 on 21 degrees of freedom Multiple R-Squared=0.791			

Estimation – counties except Belgrade

- The estimated pure household waste is approximately 70% of the municipal waste
- For some counties the part of the municipality waste that can be ascribed to pure household waste is notably below (< 20%) or above (> 90%) the expected value and for these counties imputations were applied



Estimation – Belgrade municipalities

- For Belgrade the linear regression model is given by:

$$\log y_i = a + \beta_3 x_{3i} + \beta_4 x_{4i} + e_i, \qquad i = 1, \ldots n \qquad (2)$$

  - n - number of Belgrade municipalities (n=17);
  - y_i - amount of collected municipal waste;
  - x_{3i} - number of trade and service employees;
  - x_{4i} - number of tourist overnights stays.

Estimation – Belgrade municipalities

Table 2. Regression summary for model (2): municipality waste amount of Belgrade municipality			
Model (2)			
Coefficients	Estimate	Standard Error	t-value
$\hat{a}$	1.006e+01	1.813e-01	55.457
$\hat{\beta}_3$	3.268e-05	8.716e-06	3.750
$\hat{\beta}_4$	-6.274e-06	2.333e-06	-2.689
Residual standard error = 0.1072 on 14 degrees of freedom Multiple R-Squared=0.5222			

Estimation – Belgrade municipalities

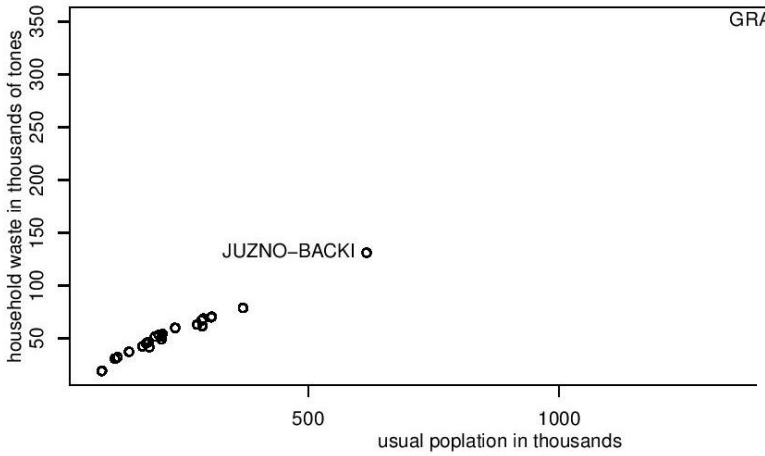
- The estimated pure household waste for Belgrade is 69% of the municipal waste.

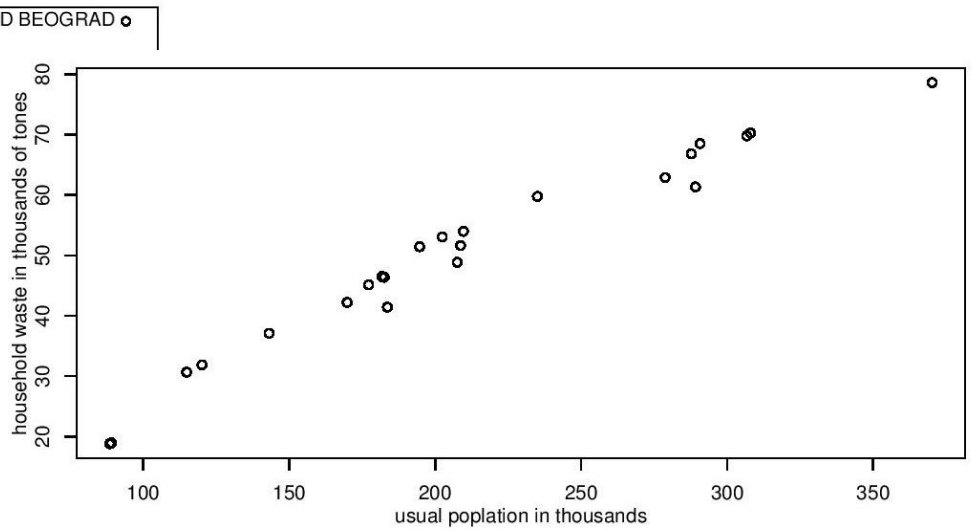
Estimation - conclusion

- 76% of the municipality waste is pure household waste
- For Belgrade this is 69%, because of the large number of tourist overnights and trade and service employees

Validity check

- To validate the results linear regression model was created for the estimated amount of pure household waste
- The predictors are the average number of inhabitants per occupied dwelling and the usual population.





Validity check

- The regression model is given by

$$z_i = b + \beta_5 x_{5i} + \beta_6 x_{6i} + \xi_i, \qquad i = 1, \dots n \qquad (3)$$

  - z_i - estimated amount of pure household waste;
  - x_{5i} - average number of inhabitants per dwelling;
  - x_{6i} - usual population

Validity check

Table 3. Regression summary for model (3): validity check			
Coefficients	Estimate	Standard Error	t-value
$\hat{b}$	-4.823e+03	5.721e+03	-0.4083
$\hat{\beta}_5$	4.022e+03	1.905e+03	2.111
$\hat{\beta}_6$	2.046e-01	1.989e-03	102.886
Residual standard error = 0. 3013 on 22 degrees of freedom Multiple R-Squared=0. 9979			

Conclusion

Due to Serbian collection system of municipal waste information data related to pure household waste in not available. Starting from the total amount of municipal waste in the Serbian counties, we presented a simple procedure to estimate the pure household waste considering only the selected non domestic variables. Note, that this was the first time for SORS to conduct this kind of estimation and this was the best we could come up with in the given time, but there are plans in the future to continue model development.

THANK YOU FOR YOUR ATTENTION

Question, comments, concerns?!