NARDI FUNDULEA, ROMANIA ROMANIAN AGRICULTURAL RESEARCH, NO. 38, 2021
www.incda-fundulea.ro Print ISSN 1222–4227; Online ISSN 2067–5720

ENVIRONMENTAL MONITORING AND ANALYSIS OF THE CROP WASTE COLLECTION SYSTEMS: MODEL EVIDENCE FROM ALBANIA

Ionica Oncioiu[1], Ana Maria Ifrim[1], Cătălin Petcu[2], Steliana Rodino[3*]

[1]Faculty of Banking and Finance, Accountancy and Business Administration, Titu Maiorescu University, 189 Calea Văcăreşti, District 4, Bucharest, Romania

[2]Faculty of Electrical Engineering, University Politehnica of Bucharest, 313 Splaiul Independenţei, District 6, Bucharest, Romania

[3]Bucharest University of Economic Studies, 6 Romană Square, District 1, Bucharest, Romania

[*]Corresponding author. E-mail: steliana.rodino@yahoo.com

ABSTRACT

Circular economy, from sustainability point of view, seeks to design replicable models for the recycling and reuse of waste, to avoid loss of resources. In agricultural sector, a model for crop waste collection could lead to reaching a superior level of efficiency of natural resources management. Rapid economic growth has led to an increase in agricultural waste quantities in Albanian regions (Tirana, Durrës, Elbasan, Berat, Shkodra and Vlorë), necessitating an integrated approach to crop wastes (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings), rather than establishing a separate management system for each type of waste. The present study aims to evaluate the management of crop waste policy and to design a model for estimation of the recycling and collection rate evolution as crop waste management indicators. To perform this analysis, a mathematical algorithm was used to estimate a confidence interval for the recycling rate, which, if exceeded, will negatively affect crop waste production growth. This model will be further developed for creating estimation on Romanian reality, to evaluate a possible future scenario for waste management from agricultural production.

Keywords: crop waste, sustainability, agricultural waste management, zero waste.

INTRODUCTION

The change in the environmental policy at a global level was achieved by switching from the need to protect the environment (air, water, soil) to the need for the integration of the concept of zero waste and polluting emissions (Liao et al., 2018). In this sense, the circular economy deals with contemporary environmental issues such as waste recycling, achieve sustainability, biodiversity loss, climate change and reuse crop waste (Lakatos et al., 2018; Rada and Cioca, 2017; Eriksson et al., 2014; Rodino et al., 2019). One of the main driving forces for this trend in all countries was the general increase in consumption (Rada et al., 2018; Laurent et al., 2014; Xiao et al., 2017). The level of crop waste production (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings) seems to be correlated with economic growth (Boer et al., 2010; Abd Kadir et al., 2013).

The studies regarding the effectiveness of agricultural waste management systems and the implementation of crop waste policies show also an increased tendency in crop waste generation (e.g. Yuan et al., 2018; Kullaj, 2004; Hussein and Sawan, 2010).

In this context, the European Union's new waste management guidelines include measures aimed at greater recycling and reuse during the life cycle of products to benefit both the environment and the economy (Lazarevic et al., 2012; Eriksson and Finnveden, 2017).

The proper waste management and its transformation into a resource is fully supported by the EU legislation this area.

In the current context of transition to bioeconomy, there is a high potential for reuse of agricultural residues (for e.g. for energy generation), but supporting policies are needed. Further analysis at national and

Received 4 May 2020; accepted 4 September 2020. First Online: September, 2020. DII 2067-5720 RAR 2021-16

regional and local level is required for evaluation of biomass potential for use in circular economy in each region.

On its pathway to EU integration, Albania must comply with EU regulatory framework thus being able to provide an example of building on other countries already achieved knowledge and transforming it into a good practice example.

Considering that a good strategy will always start from a detailed analysis, the purpose of this article is to present a vision for the future of crop waste generation in several Albanian regions, based on the present agricultural production patterns. This model will help to evaluate agricultural waste management options from the point of view of environmental implications.

MATERIAL AND METHODS

The paper is structured in the following way: firstly, we investigated the current level of crop waste recycling in Albania and how the authorities understand the need to adapt to the recycling practices in view of the tax impact of crop waste collection, as well as the coercive measures taken to impose recycling. Furthermore, the empirical results and discussions are presented. In the final section, we discuss the conclusions.

One method of estimating size is by using the confidence interval estimate (Mastellone, 2015; Crowder and Reganold, 2015) and focus on Albanian regions (Tirana, Durrës, Elbasan, Berat, Shkodra and Vlorë). The indication of an estimated, isolated (punctual) value cannot be considered as more than satisfactory without reference to the range of variation and probability. Since sample estimators are random variables, one of the important issues is to express the accuracy of estimation or probability of estimation. However, the probability value *P* represents a certain interval (x_1, x_2) according to the relationship:

$$P = Prob(x_1 < X < x_2) = \int_{x_1}^{x_2} f(x)dx \quad (1)$$

to which that parameter belongs. This establishes a range called trust interval, which has the property of containing the true value of the respective size with the probability *P*, even before any experience. Considering a_0 the true value of a characteristic, for which a punctual estimation $\hat{a}$ is obtained from sampling experiments. We believe that deviation $|\hat{a} - a_0|$ is less than a ε value with a very high β probability (0.90, 0.95 or 0.99):

$$P(|\hat{a} - a_0| < \varepsilon) = \beta \quad (2)$$

or

$$P(\hat{a} - \varepsilon < a_0 < \hat{a} - \varepsilon) = \beta = 1 - \alpha \quad (3)$$

The point value $\hat{a}$ is calculated from a sample and it defines the confidence interval limits: $a_1 = \hat{a} - \varepsilon$ and $a_2 = \hat{a} + \varepsilon$ (Figure 1).

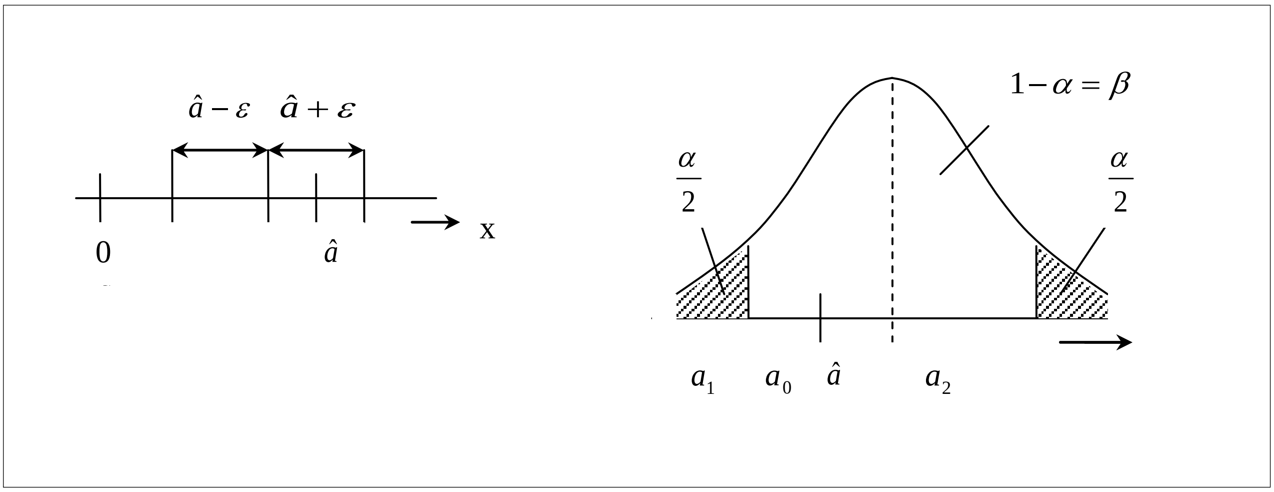

Figure 1. The trust interval interpretation chart and the confidence interval with bilateral symmetric risk

The probability that the predicted indicator belongs to the critical range is marked with α and it is called “level of significance”. Also, the likelihood of belonging to the confidence interval is called a confidence level and is equal to $1-\alpha=\beta$. The level of significance α also represents the “likelihood” or probability that true value falls outside the considered confidence range.

According to the way the risk is placed against the limits of the confidence interval, it can be: confidence interval with bilateral risk (symmetrical and asymmetric), or unilateral risk confidence interval (left or right).

The symmetrical bilateral confidence interval (Figure 1) is the interval at which the risk is placed with equal values ($\alpha/2$) on both sides of the extreme values of the interval:

$$P(a_0 > a_2) = P(a_0 < a_1) = \frac{\alpha}{2} \qquad (4)$$

Considering the risks at the lower α_i and upper α_s uneven sides, the boundaries of the interval are defined by the equations $P(a_0 > a_2) = \alpha_s$ and $P(a_0 > a_1) = \alpha_i$ with the level of significance $\alpha = \alpha_i + \alpha_s$.

To analyse the confidence interval for the values presented in Table 1, the confidence interval for the theoretical average μ of a characteristic will be analysed with a normal distribution in which the σ dispersion is known (Figure 1).

RESULTS AND DISCUSSION

The value for average residues resulting from the main crops cultivated in Europe was previously evaluated in the scientific literature (Scarlat et al., 2019). As it can be observed in Table 1 there is a comparable amount within the Eastern European countries and Albania. This amount is higher than the average European values. Therefore, the present analysis on Albanian model could be upscaled to Eastern European regions.

Table 1. The percentage of residue to main agricultural crops in Eastern Europe and Albania (data retrieved from Scarlat et. al, 2019)

Country	Crop					
	Wheat	Barley	Oat	Maize	Rapeseed	Sunflower
Bulgaria	1.2	1.1	1.2	0.9	1.2	1.9
Latvia	1.2	1.2	1.2	0	1.3	–
Lithuania	1.1	1.1	1.2	0.9	1.2	–
Romania	1.2	1.1	1.2	0.9	1.3	2
Albania	1.2	1.1	1.2	0.9	–	1.9
Moldova	1.3	1.2	1.3	1	1.4	2.1
Ukraine	1.2	1.2	1.2	0.9	1.3	2
Europe	1	1	1.1	0.8	1	1.9

In Albania, the organic wastes can amount up to 80 percent of the total solid wastes generated in any farm and the agricultural waste management is the most serious environmental problem, yet remains unsolved, affecting the life of inhabitants, the environmental pollution and economic development of the country (https://www.eea.europa.eu/countries-and-regions/albania).

The evolution of the crop waste per inhabitant in Albanian regions: Tirana, Durrës, Elbasan, Berat, Shkodra and Vlorë (Ministry of Agriculture and Rural Development, 2019; INSTAT, 2018; European Environment Agency, 2018) is the consequence of rapid agricultural development (Table 2).

Table 2. Crop waste generation per capita (tones)

Region	Year				
	2012	2013	2014	2015	2016
Berat	0.341	0.327	0.341	0.266	0.476
Shkodra	0.296	0.237	0.341	0.342	0.242
Durrës	0.513	0.462	0.411	0.420	0.438
Tirana	0.491	0.343	0.405	0.513	0.469
Elbasan	0.266	0.195	0.138	0.138	0.278
Vlorë	0.584	0.539	0.558	0.558	0.265

Source: Ministry of Agriculture and Rural Development, European Environment Agency and INSTAT - Annual survey on urbane waste

The insignificant crop waste recycling in Albania is the result of a deficiency in the process of separate collection of the generated waste. As a consequence of this statistics, collected crop waste is taken to garbage areas, which are located miles away from each other. Tirana, Durrës, Elbasan, Berat, Shkodra and Vlorë collect approximately 750 tons of packaging waste, which constitutes 30 percent of the total volume of crop waste. In additional, wastes contribute to the conservation of natural resources and the environment, while simultaneously establishing resource efficiency in production (Environmental Policy in Albania, 2017).

The algorithm described in the previous section was applied to the centralized statistical information found in the data provided by the Center for Regional and Local Development Studies Albania – CRLDS, European Environment Agency, Ministry of Agriculture and Rural Development and Albania Institute of Statistics (INSTAT, 2018). In the centralization of Table 3 it can be noticed that, on the background of an increase of the crop waste generation and collection rates as a result of economic growth, the recycling rate does not decrease substantially.

Table 3. Centralization of recycling rate data and collection rate of crop waste

Region	Recycling rate of crop waste	Collection rate of crop waste			
	2016	2013	2014	2015	2016
Berat	2.6%	13.4%	16.0%	17.5%	17.1%
Shkodra	2.8%	28.1%	27.4%	27.5%	27.7%
Durrës	3.6%	30.9%	30.0%	35.3%	35.3%
Tirana	3.7%	31.0%	29.0%	28.0%	27.4%
Elbasan	3.4%	19.8%	19.5%	18.0%	17.6%
Vlorë	2.6%	24.0%	22.1%	19.4%	17.9%

Source: Ministry of Agriculture and Rural Development European Environment Agency and INSTAT - Annual survey on waste

To perform this analysis, the mathematical algorithm presented above will be used, which will lead to the identification of confidence intervals in which the collection rate of crop waste will not influence the recycling rate negatively (Table 4).

Table 4. Calculating the confidence interval for each Albanian area surveyed for the collection rate of crop waste

Region	$\bar{x} - 1.96\frac{\sigma}{\sqrt{n}} < \mu < \bar{x} + 1.96\frac{\sigma}{\sqrt{n}}$	
Berat	$0.141912 < \mu < 0.178088$	$14.19\% < \mu < 17.81\%$
Shkodra	$0.273716 < \mu < 0.279784$	$27.37\% < \mu < 27.98\%$
Durrës	$0.301073 < \mu < 0.356427$	$30.12\% < \mu < 35.64\%$
Tirana	$0.273036 < \mu < 0.303964$	$27.30\% < \mu < 30.40\%$
Elbasan	$0.176593 < \mu < 0.197907$	$17.66\% < \mu < 19.79\%$
Vlorë	$0.181787 < \mu < 0.235213$	$18.18\% < \mu < 23.52\%$

At the same time, the Table 4 shows that recycling is no longer optional, it has to become a lifestyle at a national level, and that agricultural waste management (inclusive crop waste) represents a very important aspect of the environmental chapter in the case of any country wishing to join the EU.

To this end, Albania, as well as other candidate countries for EU membership proposed reduction in storage at 30%, the recovery of waste by means of recycling, composting and 70 percent turning waste into energy. According to Albanian authorities, objectives regarding agricultural waste management will be achieved country-wide by the competent authorities of crop waste collection and separation units post-collecting them (24th OSCE Economic and Environmental Forum, 2016).

The prediction findings of future crop waste generation rates can facilitate of significant changes in regulations regarding waste minimization and recycling. For all that, in order to reduce the gaps in the reuse and recycling of crop waste, Albanian authorities must provide the necessary resources to develop and implement effective crop waste management policies, establish the necessary infrastructure for the collection and recycling of crop waste, and set up business partnerships that support and improve the recycling process.

In light of the results, the present prognosis model for crop waste generation is often used to provide justification for crop waste policy measure adoption and in the planning of recycling facilities and collection service. Accurate predictions of crop waste quantities produced can determine successful planning and operation of a crop waste management system. This model can be used for replication in other countries facing the same crop waste management issues, such as Romania.

CONCLUSIONS

By creating added value, circular economy should be operational at local or regional levels and thus contribute to the creation of new jobs, new products and services or improving the economic competitiveness (Sundqvist, 2016). They can be correlated with a reduction of the production of crop waste (corn stalks, sugarcane bagasse, drops and culls from fruits and vegetables, prunings), thus contributing to combating climate change (Thiyageshwari et al., 2018).

Albania is facing a problematic situation in this area because it currently has the lowest rate of separate collection and recovery of crop waste, even though countries have an obligation to achieve a recycling level of at least 50% for agricultural waste by 2025 (European Environment Agency, 2018). Life-cycle thinking and assessment helps decision-makers consider the impact of a crop product on the environment throughout its life in order to intervene at each stage and reduce its environmental impact (Amoding, 2007). Yet success depends on the recycling technologies used and on a high level of crop waste collection and management.

The results of this model can be implemented as a useful decision support tool for crop waste of the studies regions, as well as for other regions facing problems with agricultural waste management. The public and the decision-makers must be aware that recycling brings benefits to both the environment and the economy by providing raw materials to create new products and fostering innovation and job creation. In this respect, more attention should be paid to prediction models of crop waste.

Overall, several lessons can be learned from this study regarding crop waste disposal rates. First, it is recommended that authorities are to devote more resources in collecting statistics on crop waste recycling because accurate crop waste projection cannot be made without a source of data.

Second, the results generated by the study's models merely show that the crop waste reduction is not mission-impossible for Tirana, Durrës, Elbasan, Berat, Shkodra and Vlorë (and similarly Albanian regions as well) because predictive models do always determine the future. This model will be further developed for creating estimation on Romanian reality, to evaluate a possible future scenario for waste management from agricultural production.

FUNDING

This work was cofinanced from the European Social Fund through Operational Programme Human Capital 2014-2020, project number POCU/380/6/13/125015 "Development of entrepreneurial skills for doctoral students and postdoctoral researchers in the field of economic sciences".

ACKNOWLEDGEMENTS

The authors would like to thank Mrs. Luiza Hoxhaj, executive director of Center for Regional and Local Development Studies Albania - CRLDS for providing data presented in this article.

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