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# The role of primary producers in agricultural waste management: Perceptions and challenges in the transition to a circular economy

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**Abstract:** This study aims to evaluate the perceptions of Spanish primary producers on waste management practices and different regulatory and administrative proposals. In addition, it identifies the socioeconomic and technical factors influencing these perceptions and highlights the types of agricultural residues that present the greatest management challenges for primary producers. To achieve these objectives, a survey was conducted among 396 primary producers throughout Spain. Results revealed two distinct groups of producers: younger, more educated individuals who showed higher awareness of waste management and older, less educated producers who perceived waste management as less critical. The study also analysed the magnitude of the relationships between these influencing factors and waste management perceptions. Agricultural plastics, biomass, and used oil emerged as the most problematic waste types. The findings suggest the need for a national strategy to improve agricultural waste management in Spain, including awareness campaigns, financial incentives, and stricter regulations to ensure sustainable practices.

**Keywords:** agricultural economics; regulatory proposals; socioeconomic factors; stakeholder engagement; sustainable development

Primary production (agriculture and livestock) plays a significant role in wealth and employment within many regions. In the European Union, it contributes 1.8% of the GVA (gross value added), increasing to 6.5% with agri-food product processing and commercialisation. Spain, the fourth-largest food producer in the EU, attributes 3.0% of its GVA to primary production, rising to 9.2% with downstream stages (Maudos and Salamanca 2023). Furthermore, primary production plays a key role in maintaining the territorial balance of rural areas, both in Europe and in Spain. This is because it remains one of the few activities that provide wealth and employment in these regions (Herranz de Rafael and Fernandez-Prados 2018). However,

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the environmental impacts triggered by primary production cannot be ignored. Negative effects include the loss of genetic diversity, soil erosion, fertility loss, contamination, depletion of water resources, and global. These impacts result from greenhouse gas emissions, poor water planning, and the use of zoosanitary products, fertilisers, and phytosanitary products (Ritchie et al. 2022). Mismanagement of agricultural waste, such as dumping and burning, generates many of the problems indicated above (Sayadi-Gmada et al. 2019; Castillo-Díaz et al. 2022). Waste from farming includes organic elements like agricultural biomass, manure, and animal carcasses, as well as inorganic components like agricultural plastics, personal protection equipment, and construction waste (MITECO 2023). Additionally, some of these agricultural residues have been described as causing challenges for primary producers (agriculture and livestock farmers) in managing them (Sayadi-Gmada et al. 2019).

Therefore, the emission of agricultural waste contradicts the environmental sustainability policies promoted by states (Sayadi-Gmada et al. 2019). These environmental policies have been thoroughly revised since 2015, following the signing of the 2030 Agenda and the adoption of the 17 Sustainable Development Goals (SDGs) (UN 2015). The EU has reformed policies through the European Green Deal, aiming for a carbon-neutral footprint by 2050 while transitioning to the circular economy (CE). Among this group of strategies, plastics, specifically those from primary production, are identified as one of the main pollutants of ecosystems. In addition, the strategies prioritise the improvement of waste management systems and protocols in the framework of the circular economy to reduce ecosystem pollution (European Commission 2018; Castillo-Díaz et al. 2022).

However, the success of actions and policies to improve waste management is influenced by the perceptions of those involved, i.e. the population. This relationship is also observed in the context of primary production (Meng et al. 2015; Galati et al. 2020; Duque-Acevedo et al. 2022). Previous research in European agricultural systems has identified a lack of perception among some primary producers regarding the need to manage agricultural plastic waste, leading to harmful waste treatment practices (Meng et al. 2015; Galati et al. 2020; Herrera et al. 2023; Rizzo et al. 2024). However, no such research has yet been conducted on Spanish primary production as a whole, which is one of the largest productive sectors in the EU. Conducting this research would provide a knowledge base on the perceptions of primary producers regarding agricultural waste management, contributing to the formulation of strategies. Moreover, there are various types of waste whose management poses challenges for agriculture and livestock farmers, although the identification of these types of waste remains unclear, highlighting the need to address this gap (Dupis 2009; Sayadi-Gmada et al. 2019; Castillo-Díaz et al. 2022; Duque-Acevedo et al. 2022).

In this context, the general objective of this work was to examine the perception of Spanish primary producers on the management of agricultural waste, their position on several measures to improve such management, the sociodemographic and technical factors that influence these perceptions, as well as the magnitude of the relationships between these factors and the perceptions of primary producers, in order to determine the types of agricultural waste that represent the greatest challenge in their management. To this end, the following specific objectives were considered:

*i*) To identify the perception of Spanish primary producers on the management of their agricultural waste.

*ii*) To identify the position of Spanish primary producers with regard to various measures aimed at improving the management of agricultural waste.

*iii*) To detect the sociodemographic and technical factors that influence the perception of Spanish primary producers on the management of their agricultural waste.

*iv*) To analyse the magnitude of the relationships between sociodemographic factors and perceptions of agricultural waste management and regulations of primary producers in Spain.

*v*) To determine which types of agricultural waste represent the greatest challenge for Spanish primary producers in their management.

To achieve these objectives, the article is divided into five sections, following the introduction. First, the theoretical framework of the research is presented. Second, the methodology used is described. Third, the main results obtained are specified. Fourth, these results are discussed. Finally, the main conclusions of the study are presented.

## Theoretical framework

The theoretical framework of this research is divided into two sections:

***Influence of primary producers' perception on waste management.*** According to the Theory of Planned Behaviour, an individual's attitude towards a specific action significantly influences their intention to perform it (Icek 1985). In the case of European pri-

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mary producers, their perception of the importance and necessity of managing waste from agri-food activities may determine the extent to which these practices are implemented to ensure proper waste treatment (Liu et al. 2018; Galati et al. 2020; Rizzo et al. 2024). Therefore, this could also influence the entire Spanish primary production sector.

Furthermore, several measures can facilitate the management of agricultural residues (e.g. training courses, traceability systems or new regulations for residue management). Primary producers may adopt a favourable or unfavourable stance towards these measures, depending on factors such as implementation costs, potential impact on productivity and long-term sustainability (Sayadi-Gmada et al. 2019; Castillo-Díaz et al. 2022). The following hypotheses are proposed:

$H_1$: The majority of agricultural producers have a positive perception of agricultural waste management.

$H_2$: The majority of Spanish primary producers will adopt a favourable stance towards measures aimed at improving the management of agricultural residues when these are perceived as beneficial to the sector and their individual farms.

Previous research has shown that a lack of environmental awareness or clear information about the benefits of proper waste management may hinder the adoption of sustainable practices (Meng et al. 2015; Galati et al. 2020; Rizzo et al. 2024). Additionally, the lack of incentives or technical resources has been recognised as a barrier to implementing waste treatment protocols (Castillo-Díaz et al. 2022). Therefore, it can be inferred that a favourable perception of the need for waste management will positively influence proper disposal.

Additionally, variables such as age, education level, and income of primary producers have been identified as key factors influencing their perception of agricultural waste management, which may either positively or negatively affect these perceptions (Meng et al. 2016; Muise et al. 2016; Pérez Urdiales et al. 2016; Galati et al. 2020). The following hypotheses are proposed:

$H_3$: The perception of primary agricultural producers towards waste management depends on sociodemographic factors and technical characteristics.

$H_4$: The perceptions of producers regarding waste management will have either a positive or negative cumulative effect on the significant sociodemographic and technical factors within this relationship.

***Challenges in waste management for farmers.*** According to the Spanish Ministry for Ecological Transition and Demographic Challenge (MITECO), agricultural waste generated by primary producers can be classified into two main groups: organic and inorganic. Organic waste includes manure, agricultural biomass, wood, and agro-industrial residues, while inorganic waste includes packaging from plant protection products, fertilisers, and veterinary products, among others (MITECO 2023). Each type of waste requires a specific treatment depending on its classification as hazardous or non-hazardous (Sayadi-Gmada et al. 2019; Castillo-Díaz et al. 2022). However, previous research has noted that agriculture and livestock farmers face difficulties in managing these wastes (Sayadi-Gmada et al. 2019; Castillo-Díaz et al. 2022). In regions like Almería (Spain), farmers have experienced the rejection of mixed or degraded materials, such as plastics contaminated by direct contact with the soil, complicating proper disposal (Sayadi-Gmada et al. 2019). This issue has also been reported in the Canary Islands (Dupis 2009). Therefore, the following hypothesis is proposed:

$H_5$: Several types of agricultural residues pose different management challenges to primary producers, with plastic residues representing the greatest challenge.

## MATERIAL AND METHODS

This section describes the methodology used.

### Production area and system studied

This research focused on Spain, a prominent EU member with the fourth-largest primary production (PP) system. It includes 914 871 farms, with 633 856 (69.3%) for crop production and 169 576 (30.7%) for livestock (INE 2022). Galicia, Castile and Leon, Extremadura, and Andalusia have the highest density of agricultural and livestock farms. High-density subsectors include olive fields, non-citrus fruit trees, and arable crops (Figure 1). In 2023, agricultural production in Spain was EUR 65.081 million (MAPA 2024). The most economically important sub-sectors were fruit, vegetables and pork [Table S1 in the Electronic Supplementary Material (ESM)].

### Experimental design

***Questionnaire design.*** The content of the questionnaire was developed based on previous research conducted in the same field, which identified primary producers' perceptions of the need to manage their waste (Meng et al. 2015, 2016; Galati et al. 2020). Additionally, the scope of the questionnaire was expanded to identify the most problematic types of waste for primary

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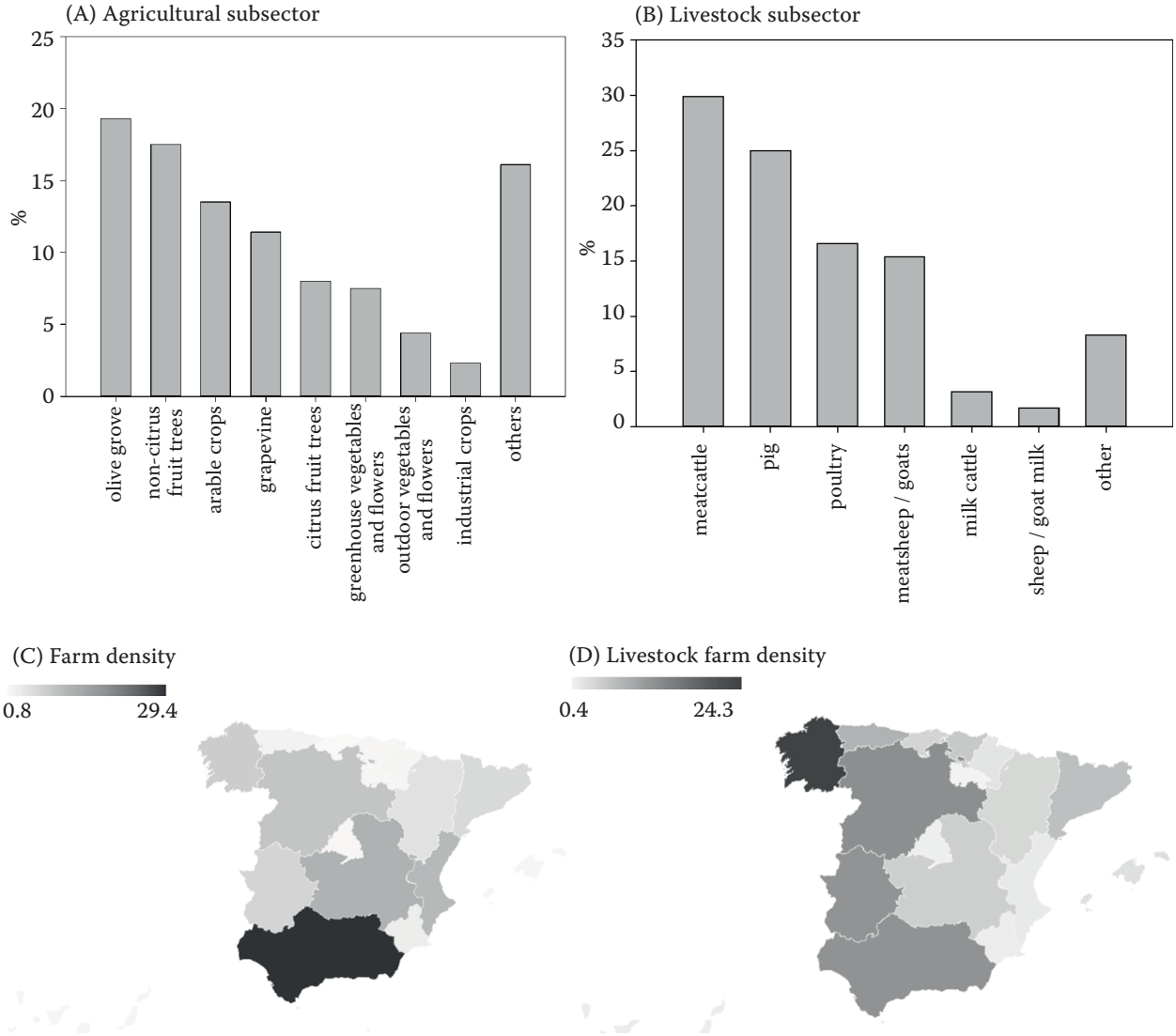


Figure 1. Subsectorial and territorial characterisation of the Spanish primary sector: (A) agricultural subsectorial importance (in %); (B) livestock sub-sectional im-portance (in %); (C) territorial distribution of agricultural farms (in %); (D) territorial distribution of livestock farms (in %)

Source: Own elaboration based on the Agricultural Census 2020 (INE 2022)

producers to manage. Furthermore, the structure of the questionnaire was designed following guidelines provided by both administrative bodies and prior studies (González-Alzaga et al. 2022; MTASE and INSHT 2019). The questionnaire underwent scrutiny by key stakeholders in the Spanish primary production sector, such as researchers, administration, and enterprises, to ensure alignment with the research goals, as recommended by previous studies (Duque-Acevedo et al. 2022).

Ultimately, the questionnaire comprised four blocks, predominantly featuring closed-response questions, with one exception:

– Characteristics of primary producers and their farms: This block characterised the surveyed individuals and their farms, employing multiple-choice or yes/no questions to gather information on several dynamics, like activity, sex, age, education level, years of experience, techno-economic characteristics of their farms, and more.

– Degree of knowledge of CE: Utilising a multiple-choice question, this block assessed the participants' understanding of the CE concept, following the definition by Kirchherr et al. (2017).

– Level of waste management and associated problems: This section determined the waste management

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level on surveyed farms, identifying challenges faced during waste delivery to treatment plants. Open-ended responses were sought to discern the most problematic waste while avoiding undue influence on participant perspectives.

– Perception of the need for waste management: This block gauged the perception of waste management necessity on the part of Spanish agricultural and livestock farmers. Utilising statements from prior research, respondents provided feedback on personal attitudes, environmental perception, subjective norms, perceptual control, and positions on regulatory proposals while using a Likert graduated scale for nuanced responses.

***Sample design and data collection strategy.*** The questionnaire was integrated into the Google Forms online survey platform for efficient distribution and data collection. The form reached 1 776 agri-food cooperatives in Spain, representing 48.4% of the national total. These cooperatives facilitated dissemination among their affiliated agricultural and livestock farmers through contacts provided by Cooperativas Agro-alimentarias de España or their regional confederations. The data collection period spanned from December 10, 2022, to March 31, 2023. Within this timeframe, 396 primary producers actively participated in the survey. The achieved confidence level stood at 95%, with a maximum error rate of ± 2.15% (Appendix 1 in the ESM). The description of the population of primary producers is identified in Figures S1 and S2 and Table S2 in the ESM.

**Statistical methods**

The statistical treatment applied to the results was as follows:

In the first stage, exploratory factor analysis (EFA) was applied to the data using principal component analysis (PCA). The purpose of this method was to identify the producer profiles present in the sample. Subsequently, a cluster analysis was conducted to detect the presence of a group of primary producers with a positive perception of waste management practices and related regulatory proposals. Furthermore, the analysis sought to determine which sociodemographic factors significantly influenced ($P$-value ≤ 0.001) these perceptions and the stance toward various measures aimed at improving agricultural waste management. Specifically, this analysis aimed to validate or reject hypotheses $H_1$, $H_2$ and $H_3$. The varimax method was applied during EFA, as recommended by prior research (Hair et al. 2010). The quality of the data was validated using the Kaiser-Meyer-Olkin test (KMO; 0.877) and Bartlett's sphericity test ($P$-value of 0.000), ensuring their suitability for the statistical techniques. Additionally, to assess the reliability of the questionnaire employing a Likert scale, Cronbach's analysis yielded a result exceeding 0.7 (Mollaei et al. 2023). PCA analysis revealed the existence of two principal components.

Following the PCA, the K-means clustering algorithm was applied to perform cluster analysis, alongside an ANOVA to evaluate the clusters. The number of clusters was determined based on factors derived from the PCA (Ben-Hur and Guyon 2003), categorising the primary producer population into two clusters. This classification enabled the identification of active and passive environmental behaviours (in terms of their perception of agricultural waste management), guiding the development of strategies to enhance waste management in Spanish primary production.

In the second stage, a stepwise linear regression model was employed using the sociodemographic and technical variables identified as highly significant ($P$-value ≤ 0.001) in the ANOVA conducted during the K-Means analysis. The dependent variables ($y$) used were years dedicated to primary production, the age of the respondents, and the respondents' education level. In total, three stepwise linear regression models were calculated. Conversely, the independent variables ($x$) initially introduced into the models were those not previously used as dependent variables, as identified in the research dataset. The purpose of this analysis was to validate or reject hypothesis $H_4$. The stepwise linear regression allowed for the detection of the magnitude of the relationship between a significant independent variable and a dependent variable, as well as determining whether this impact was positive or negative. Prior to the regression analysis, all assumptions required for the multiple linear regression model were verified (Pope and Webster 1972). The specific equations for the three calculated models can be found in Appendix 1 in the ESM

All statistical analyses were conducted using the SPSS v.28 statistical software package for Windows (IBM, Armonk, NY, USA).

## RESULTS

The results of this study are presented in three main sections:

**Clustering based on perception producer type**

The K-means cluster analysis segmented the population of 393 agricultural and livestock farmers into

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homogeneous groups based on the results provided by the PCA factor analysis. Three surveys were excluded from this analysis because the required information was not available. The 393 agricultural and livestock farmers were placed in two groups: active (group 1) and passive (group 2), based on their environmental perception of managing agricultural residues and their stance on regulatory proposals for waste management.

The most relevant variables are presented in Figure 2, while the remaining variables are presented in Tables S3 and S4 in the ESM. The statistical treatment has identified statistically significant differences in primary producers' perceptions regarding agricultural waste management (Tables 1 and S5 in the ESM). Additionally, this analysis has identified that some of the variables influencing this perception are related to the respondents' socioeconomic characteristics and technical aspects of their operations (e.g. age, education level, income, farm size, subsector specialisation, etc.). However, the only variables that showed a high degree of significance ($P$-value ≤ 0.001). The clusters are defined as follows:

***Cluster 1 – Passive***. Comprising primary producers classified as environmentally passive ($N$ = 107, 27.3% of the sample), this group exhibits a lower perception of environmental attitudes and advocates for less strict application of regulatory proposals. That is, they hold a more negative perception of waste management and view it as less of a necessity.

Characteristics of Cluster 1:

*i)* Older and more experienced in agricultural and livestock tasks (average 34.2 years).

*ii)* Lower education level.

*iv)* Larger farms in terms of surface area and economic size.

*v)* Greater ignorance of the CE.

*vi)* A higher proportion specialising in olive grove or vine cultivation.

***Cluster 2 – Active***. Comprising environmentally active primary producers ($N$ = 286, 72.7% of the sample), this group leans towards environmentally friendly practices. They advocate for more stringent regulatory proposals to protect the environment, identify agricultural and livestock farmers involved in waste dumping, and seek expanded training in waste management. That is, this group of agricultural and livestock farmers has a positive perception of agricultural waste management and considers it a necessity.

Characteristics of Cluster 2:

*i)* More educated, younger, and less experienced in agricultural tasks (average of 13.7 years).

*ii)* Smaller farms in terms of surface area and economic size.

*iii)* 71% are aware of CE, and 23% have heard of it.

*iv)* Similar waste management levels between clusters.

*vi)* Higher proportion specialising in greenhouse vegetable production in the 'environmental active' cluster.

The results presented above validate hypotheses $H_1$, $H_2$ and $H_3$. The cluster analysis revealed a majority favourable perception of agricultural waste management ($H_1$), as well as support for the adoption of regulatory and administrative proposals outlined in the survey ($H_2$). Additionally, it identified the significant sociodemographic and technical factors that influence this perception ($H_3$), with the most influential variables being years dedicated to primary production, respondents' age, and education level ($P$-value ≤ 0.001).

**Magnitude of relationships between variables**

Table 2 provides insights into the adjusted $R^2$ and significance levels of the multiple linear regression models. These models consider the significant social factors identified in the cluster analysis (Table 1) as dependent variables (i.e. years of dedication to primary production, age and education level). Notably, age and years of dedication to primary production emerged as parameters that exhibited a significant and robust fit with independent variables. Conversely, education demonstrated a comparatively lower fit.

Through the standardised β coefficients identified in Table 3, the magnitude of the relationships within the stepwise linear regression model can be determined, highlighting the variables with the greatest influence at each stage of the process. Additionally, the sign of the standardised β coefficients indicates whether the independent variables exert a positive or negative influence on the dependent variables. This analysis allowed the validation of hypothesis $H_4$, as detailed below:

The years of dedication to primary production exhibited a direct proportional magnitude significance to various variables, including the main source of income, years dedicated to primary production, general environmental care attitudes (*GECA*), and knowledge of the circular economy (CE). Intriguingly, it displayed an inversely significant proportional magnitude with education environmental perception as a necessary environmental practice (*RP*), and the presence of waste management problems (Table 3; model 1).

The calculated model allowed for the identification of the magnitude of the relationship between the respondents' age and the independent variables. While

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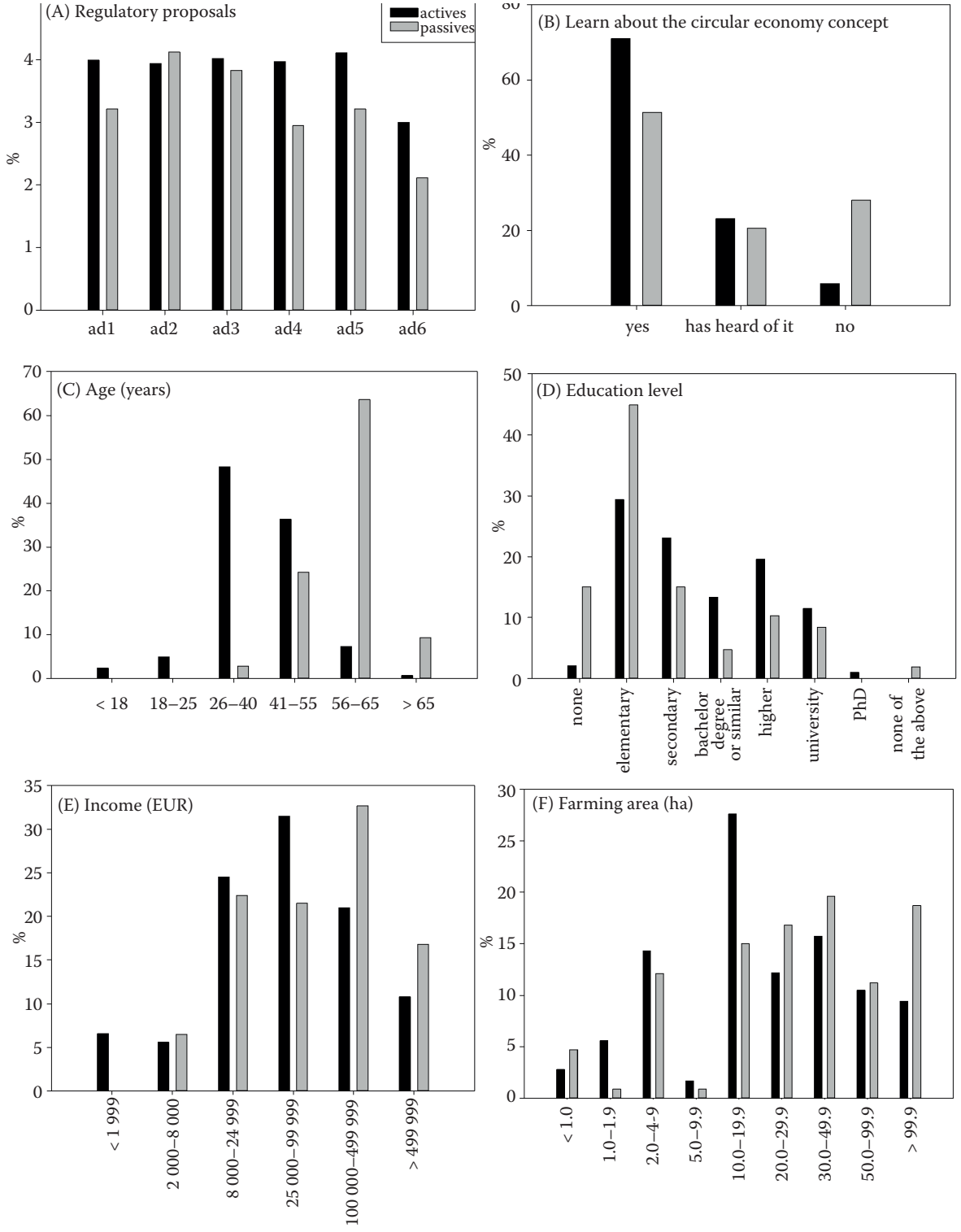


Figure 2. Main descriptors of the group (A) regulatory perception; (B) knowledge of the concept of CE; (C) age; (D) education level; (E) income; (F) area of operation.

Scale: 1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5: = strongly agree; CE – circular economy

Source: Authors' own elaboration

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Table 1. ANOVA analysis

| Parameter | Root mean square | d*f* | Fisher's *F* test | *P*-value |
|---|---|---|---|---|
| Recycling waste in agriculture or livestock farming is an absolute necessity | 1.061 | 391 | 39.671 | *** |
| Years of dedication to primary production | 33.678 | 391 | 973.934 | *** |
| Recycling waste from my farm is a best practice | 1.109 | 391 | 18.967 | *** |
| Recycling my farm waste is good for the environment | 1.118 | 391 | 17.477 | *** |
| Recycling my agricultural waste improves the ecological image of my agricultural or livestock farming activity | 1.538 | 391 | 21.085 | *** |
| Managing my farm waste helps to justify good practices to consumers | 1.040 | 391 | 19.312 | *** |
| Most people who are important to me think that recycling waste in agriculture or livestock agriculture is absolutely necessary | 1.010 | 391 | 21.582 | *** |
| Most of the people who are important to me think that I should recycle waste from my farming activity | 0.996 | 391 | 18.988 | *** |
| Human beings seriously affect the environment | 1.304 | 391 | 46.224 | *** |
| Every living thing must be cared for | 0.783 | 391 | 21.950 | *** |
| The administration should improve my training in the management of agricultural waste | 0.937 | 391 | 51.056 | *** |
| The administration should increase environmental control to sanction agricultural or livestock farmers who carry out bad waste management practices | 1.400 | 391 | 57.322 | *** |
| The administration should implement a traceability system to identify agricultural and livestock farmers who do not manage their waste | 1.531 | 391 | 40.927 | *** |
| The administration should tighten environmental regulations | 1.887 | 391 | 32.793 | *** |
| Age | 0.608 | 391 | 237.183 | *** |
| Education level | 2.326 | 391 | 17.668 | *** |
| Income | 1.619 | 391 | 9.218 | ** |
| By recycling, I contribute to reducing the amount of agricultural or livestock waste | 1.532 | 391 | 7.630 | ** |
| Agricultural subsector | 8.667 | 391 | 6.691 | ** |
| Surface area of the farm | 4.595 | 391 | 6.772 | ** |

**, *** significant differences at *P*-value ≤ 0.01 and *P*-value ≤ 0.001, respectively; variables with a *P*-value ≤ 0.05 are shown in the table; variables with *P*-value > 0.05 can be found in Table S6 in the Electronic Supplementary Material (ESM)
Source: Authors' own elaboration

a significant direct proportional magnitude is observed with farm income and the age of respondents, a surprising finding emerges concerning the variable of general environmental care attitudes (*GECA*), indicating a significant inverse proportional magnitude. This unexpected inverse magnitude with *GECA* prompts a nuanced interpretation (Table 3; model 2).

The education level of respondents showed a direct positive relationship with the source of income, sex, and *GECA*. However, an inverse relationship was observed with primary production commitment (*PC*), age, *RP*, and social norms (*SN*) (Table 3; Model 3).

**Identifying the most problematic waste for primary producers**

67% of surveyed primary producers reported encountering difficulties in managing certain waste generated on their farms. Primary reasons cited for these challenges included limited collection points, especially for items like used oil, gloves, and ropes; the rejection of waste due to dirtiness or degradation, particularly in the case of agricultural plastics; and the absence of suitable infrastructure for treating specific by-products on farms, such as infrastructure for manure maturation.

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Table 2. Main descriptors of stepwise multiple linear regression models

| Model | Dependent variable | Adjusted $R^2$ | $F$ | $P$-value |
|---|---|---|---|---|
| 1 | years of dedication to PP | 0.560 | 34.621 | *** |
| 2 | age | 0.553 | 33.364 | *** |
| 3 | education level | 0.301 | 12.254 | *** |

***significant differences at $P$-value ≤ 0.001; independent variables, along with their non-standardized β, SD, standardized β, $t$-values, and $P$-values, are presented in Table 3; PP – primary producers
Source: Authors' own elaboration

Table 3. Multiple linear regressions relating the years dedicated to primary production, the age and the education level to the other factors of the respondents (perceptions) and the technical and economic parameters of their farms

| Model | Parameter | β non-standardised | SD | β standardised | $t$ | $P$-value |
|---|---|---|---|---|---|---|
| **Years of dedication to primary production[a]** | | | | | | |
| 1 | constant | 2.109 | 0.411 | – | 5.126 | *** |
| | main source of income[b] | 0.601 | 0.116 | 0.221 | 5.204 | *** |
| | *GECA*[b] | 0.249 | 0.060 | 0.234 | 4.157 | *** |
| | *RP*[b] | –0.207 | 0.061 | –0.174 | –3.417 | *** |
| | waste management problems[b] | –0.292 | 0.077 | –0.138 | –3.813 | *** |
| | years dedicated to PP[b] | 0.059 | 0.004 | 0.648 | 16.298 | *** |
| | knowledge of circular economy[b] | 0.104 | 0.044 | 0.087 | 2.343 | ** |
| **Age[a]** | | | | | | |
| 2 | constant | –2.534 | 4.632 | – | –0.547 | n.s. |
| | income[b] | 1.558 | 0.368 | 0.185 | 4.230 | *** |
| | *GECA*[b] | –2.345 | 0.657 | –0.200 | –3.571 | *** |
| | education [b] | 7.000 | 0.429 | 0.638 | 16.298 | *** |
| **Education level[a]** | | | | | | |
| 3 | constant | 2.131 | 0.596 | – | 3.574 | *** |
| | *EA*[b] | 0.442 | 0.104 | 0.262 | 4.237 | *** |
| | *PC*[b] | –0.459 | 0.083 | –0.246 | –5.535 | *** |
| | main source of income[b] | 1.137 | 0.186 | 0.265 | 6.124 | *** |
| | age[b] | –0.290 | 0.070 | –0.184 | –4.169 | *** |
| | sex[b] | 0.705 | 0.208 | 0.147 | 3.394 | *** |
| | *RP*[b] | –0.762 | 0.241 | –0.138 | –3.160 | ** |
| | *SN*[b] | –0.437 | 0.108 | –0.243 | –4.065 | *** |
| | *GECA*[b] | 0.486 | 0.129 | 0.245 | 3.765 | *** |

**, *** significant differences at $P$-value ≤ 0.01 and $P$-value ≤ 0.001, respectively; n.s – no significant differences; [a]dependent variable; [b]independent variable; variables with a $P$-value ≤ 0.05 are shown in the table; variables with a $P$-value > 0.05 can be found in Table S7 and S8 in the Electronic Supplementary Material (ESM) (annexes); *GECA* – the respondent's general environmental care attitudes; *RP* – the respondent's position on regulatory proposals; PP – primary producers; *EA* – environmental perception; *SN* – subjective norms; *PC* – the respondent's perceptual control
Source: Authors' own elaboration

Among the categories of waste posing significant challenges for primary producers, both organic and inorganic waste were identified (Figure 3). Organic waste encompasses agricultural biomass generated after crop cycles and manure. Inorganic waste primarily consists of various types of plastics used in agriculture and livestock, including plastic containers, ropes, gloves, mulching plastic, solarisation plastic, silage plastic,

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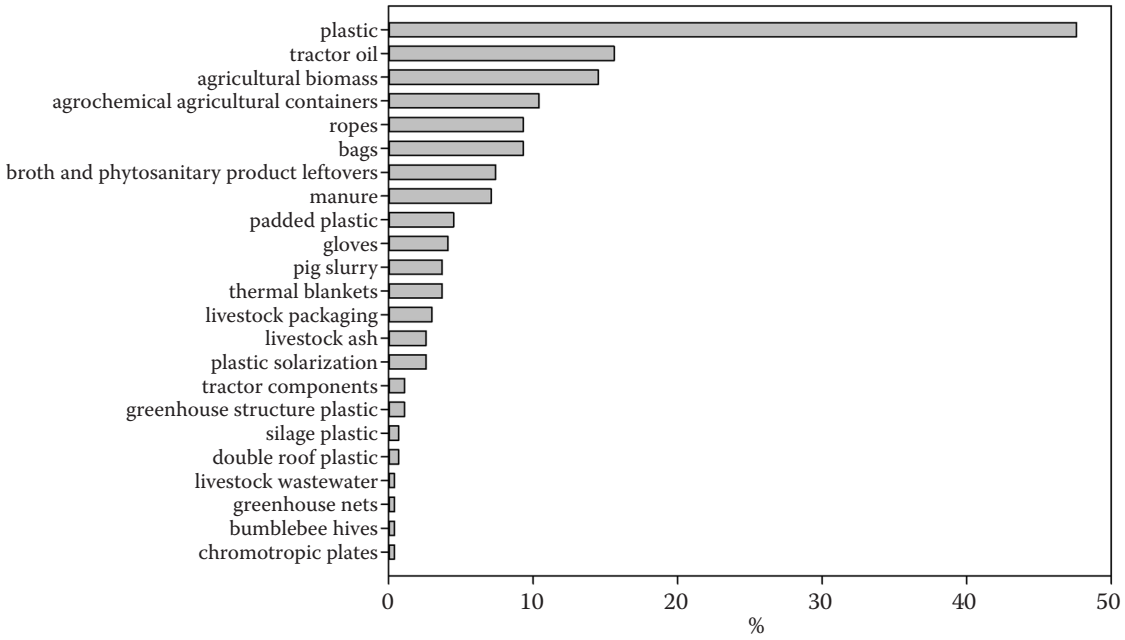


Figure 3. Type of waste that causes the greatest management difficulties for Spanish primary producers

Source: Authors' own elaboration

etc., along with oils used in agricultural machinery. In this way, the results obtained have validated the third hypothesis of this research and have advanced the understanding of the most problematic types of waste for primary producers to manage.

## DISCUSSION

The overall objective of this study was to examine the perceptions of Spanish primary producers regarding agricultural waste management, their stance on various measures to improve such management, the sociodemographic and technical factors that influence these perceptions, and the magnitude of the relationships between these factors and producer perceptions. Additionally, the study aimed to identify the types of agricultural waste that represent the greatest challenges for management.

First, the results suggest that Spanish primary producers generally hold a positive perception of waste management. Cluster analysis identifies two primary producer groups: environmentally active and environmentally passive (Table 1 and Figure 2). The statistical analysis validated hypotheses $H_1$ and $H_2$, confirming that a significant portion of the sample had a favourable perception of waste management, consistent with findings from similar studies in agricultural models in Italy (Galati et al. 2020). However, our results provide validation on a national scale, rather than a localised one. Additionally, the surveyed population displayed a favourable normative perception toward regulatory measures.

In this context, and based on the results obtained, actions must be taken to improve the perception of Spanish agriculture and livestock farmers so that they recognise agricultural waste management as a necessity. To achieve this, it would be important to develop a series of measures aimed at this objective, although they should be implemented in an orderly manner, through a strategy and/or regulations if necessary. Additionally, the social, economic, and technical variables identified as significant by this research should be considered (Table 2). The strategy should include awareness-raising measures, the establishment of subsidies for waste management, incentives for delivering by-products and/or utilising them on farms, and strict penalties for those who illegally dump waste in the environment (Sayadi-Gmada et al. 2019; Piñeiro et al. 2020; Arias et al. 2022; Castillo-Díaz et al. 2022; MITECO 2023).

Second, the results revealed the sociodemographic and technical factors that influence the perceptions of Spanish primary producers the most, validating hypothesis $H_3$ (Table 1 and Figure 2). The study revealed that increasing age, reduced education, and larger economic and agricultural sizes decrease the inclina-

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tion for regulatory control and robust waste management strategies. Only age, education level, and years dedicated to primary production showed a high level of significance ($P$-value ≤ 0.001). Consequently, the perception of primary producers regarding waste management as a priority decreases. These findings are similar to those reported by previous research, which observed this behaviour (Meng et al. 2016; Muise et al. 2016; Galati et al. 2020). However, these results differ from those obtained in other studies conducted in various agricultural systems across the European Union. In those studies, the authors indicate that an increase in farm size improves both the effectiveness of waste management and the perception of agricultural waste management as a necessity (Meng et al. 2015). It is important to note that this difference in findings may be due to two primary factors. First, there may be a higher degree of professionalisation in operations with a waste treatment plan. Second, there may be fewer challenges in managing waste in these operations. As observed, 67% of the farmers surveyed in our study reported this issue.

Third, the results from the multiple linear regression analysis allowed us to detect the cumulative magnitude of the relationships between the study's independent variables and their influence on the dependent social and technical variables, which were highly significant (e.g. age, education level, and years dedicated to primary production) (Tables 2 and 3). This analysis validated hypothesis $H_4$. Interestingly, while general environmental care attitudes (*GECA*) were positively correlated with years dedicated to primary production, an inverse relationship was found with age. This pattern suggests that farmers with more experience in the sector perceive a greater need to manage their waste, leading to more favourable perceptions. These individuals may be more integrated into the territorial environment of their production systems and more concerned with protecting their natural surroundings. Furthermore, they may possess greater knowledge about the necessary pre-treatments for agricultural waste before it is sent to the management facility, which could reduce rejection rates. It is important to note that older producers do not always correspond with those with more experience, as some individuals may have transitioned from other economic activities before entering agriculture (Meng et al. 2015; Badsar et al. 2023; Rizzo et al. 2024).

Fourth, the study identified agricultural plastics, used oil, and biomass as the most challenging waste types for primary producers due to limited collection points and waste management facility availability (Figure 3). These findings validated hypothesis $H_5$. The administration is urged to increase efforts, enhance waste collection infrastructure, and develop guidelines for good waste management practices, as we have previously indicated. Additionally, these results allow the administration to determine which types of waste management facilities should be prioritised, either for implementing new installations in the treatment network or improving existing ones. They also help the administration identify which waste management protocols need to be enhanced through complementary measures.

## CONCLUSION

The results of this study show that the agricultural and livestock sectors in Spain face significant challenges in managing waste generated on farms. Although two groups of producers were identified based on their perceptions of waste management, one group holds a negative view of these practices. This unfavourable perception is mainly influenced by factors such as age, educational level and farm structure, which contribute to lower adoption of sustainable practices and generate several problems in waste management.

However, the challenges of waste management are not only due to negative perceptions. Structural limitations also complicate management efforts, such as the rejection of certain waste types (e.g. plastic) at treatment centres and the inadequacy of collection infrastructure. These factors make it difficult for producers to manage their waste efficiently and sustainably, thus increasing the risk of inappropriate practices that negatively impact the environment.

To address these challenges, it is essential to promote an agricultural waste management plan that considers all the factors identified in this research. This plan should include targeted incentives, clear and effective regulations, and the development of sufficient infrastructure for waste collection and treatment in rural areas. Furthermore, it should be implemented in an integrated manner alongside a training and awareness program that equips producers with the tools, knowledge, and motivation needed to improve their waste management practices and contribute to a more sustainable and environmentally conscious agricultural sector.

While this research offers significant contributions to understanding agricultural waste management, two key limitations should be noted. First, the sampling design provides generalisable results at a national scale but limits precision at the subsector level. Second, there is a potential for respondent bias, as the anony-

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mous survey included sensitive questions, which may have led to socially desirable responses.

Future research should focus on identifying waste generation levels by subsector and quantifying the waste converted into by-products after applying appropriate treatment methods.

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## REFERENCES

Arias O., Pulgar J.A., Soto M. (2022): Application of organic wastes to soils and legislative intricacies in a circular economy context. Clean Technologies and Environmental Policy, 24: 1871–1888.

Badsar M., Moghim M.,Ghasemi, M. (2023): Analysis of factors influencing farmers' sustainable environmental behavior in agriculture activities: Integration of the planned behavior and the protection motivation theories. Environment, Development and Sustainability, 25: 9903–9934.

Ben-Hur A., Guyon I. (2003): Detecting stable clusters using principal component analysis. Functional Genomics, 1: 159–182.

Castillo-Díaz F.J., Belmonte-Ureña L. J., Batlles-dela-Fuente A., Camacho-Ferre F. (2022): Impact of the new measures related to the circular economy on the management of agrochemical packaging in Spanish agriculture and the use of biodegradable plastics. Environmental Sciences Europe, 34: 94.

Dupis I. (2009): Residuos Agrarios: Guia para la Intervención Municipal. Gran Canaria, Asociación Insular de Desarrollo Rural de Gran Canaria: 101. (in Spanish)

Duque-Acevedo M., Belmonte-Ureña L. J., Terán-Yépez E., Camacho-Ferre F. (2022): Perceptions and practices of reduction and valorization of agricultural waste biomass in south-eastern Spain. Journal of Environmental Management, 316: 115270.

European Commission (2018): A European Strategy for Plastics in a Circular Economy. Strasbourg, Office of the European Union: 19.

Galati A., Sabatino L., Prinzivalli C. S., D'Anna F.,Scalenghe R. (2020): Strawberry fields forever: That is, how many grams of plastics are used to grow a strawberry? Journal of Environmental Management, 276: 111313.

González-Alzaga B., Hernández A., Kim-Pack L., Iavicoli I., Tolonen H., Santonez T., Vinceti M., Filippini T., Moshammer H., Probst-Hensch N., Kolossa-Gehring M., Lacasaña M. (2022): The questionnaire design process in the European Human Biomonitoring Initiative (HBM4EU). Environment International Journal, 160: 107071.

Hair J.F., Black W.C., Tatham R.L., Anderson R.E. (2010): Multivariate Data Analysis. New York, Pearson Prentice Hall: 761.

Herranz de Rafael G., Fernandez-Prados J.S. (2018): Intensive agriculture, marketing and social structure: The case of south-eastern Spain. Agricultural Economics – Czech, 64: 367–377.

Herrera S.I.O., Kallas Z., Serebrennikov D., Thorne F., McCarthy S.N. (2023): Towards circular farming: Factors affecting EU farmers' decision to adopt emission-reducing innovations. International Journal of Agricultural Sustainability, 21: 2270149.

Icek A. (1985): From intentions to actions: A theory of planned behavior. In: Kuhl J., Beckmann J. (eds): Action Control. Berlin, Springer Nature: 11–39.

INE (2022): Censo Agrario. 2020. [Dataset]. Available at https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176851&menu=ultiDatos&idp=1254735727106 (accessed July 8, 2024; in Spanish)

Kirchherr J., Reike D., Hekkert M. (2017): Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127: 221–232.

Liu T., Bruins R.J.F., Heberling M.T. (2018): Factors influencing farmers' adoption of best management practices: A review and synthesis. Sustainability (Switzerland), 10: 1–26.

MAPA (2024): Anuario de Estadística. [Dataset]. Available at https://www.mapa.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/default.aspx (accessed Sept 12, 2024)

Maudos J., Salamanca J. (2023): Observatorio sobre el sector agroalimentario español en el contexto europeo Informe 2022. Almería, Cajamar Caja Rural e IVIE: 368. (in Spanish)

Meng T., Klepacka A.M., Florkowski W.J., Braman K. (2015): What drives an environmental horticultural firm to start recycling plastics? Results of a Georgia survey. Resources, Conservation and Recycling, 102: 1–8.

Meng T., Klepacka A.M., Florkowski W.J., Braman K. (2016): Determinants of recycling common types of plastic product waste in environmental horticulture industry: The case of Georgia. Waste Management, 48: 81–88.

MITECO (2023): Versión Inicial Del Plan Estatal Marco De Gestión De Residuos (PEMAR) 2023-2025. 2023–2035. Madrid, Ministerio para la Transición Ecológica y el Reto Demográfico del Gobierno de España: 238. (in Spanish)

Mollaei S., Minaker L.M., Robinson D.T., Lynes J.K., Dias G.M. (2023): Including sustainability factors in the derivation of eater profiles of young adults in Canada. British Food Journal, 125: 1874–1894.

https://doi.org/10.17221/225/2024-AGRICECON

MTASE, INSHT (2019): NTP 283: Encuestas: Metodología para su utilización. Madrid, Ministerio de Trabajo y Asuntos Sociales y Instituto Nacional De Seguridad e Higiene en el trabajo: 19. (in Spanish)

Muise I., Adams M., Côté R., Price G.W. (2016): Attitudes to the recovery and recycling of agricultural plastics waste: A case study of Nova Scotia, Canada. Resources, Conservation and Recycling, 109: 137–145.

Pérez Urdiales M., Lansink A.O., Wall A. (2016): Eco-efficiency among dairy farmers: The importance of socio-economic characteristics and farmer attitudes. Environmental and Resource Economics, 64: 559–574.

Piñeiro V., Arias J., Dürr J., Elverdin P., Ibáñez A.M., Kinengyere A., Opazo C.M., Owoo N., Page J.R., Prager S.D., Torero M. (2020): A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nature Sustainability, 3: 809–820.

Pope P.T., Webster J.T. (1972): The use of an F-statistic in stepwise regression procedures. Technometrics, 14: 327–340.

Ritchie H., Rosado P., Roser M. (2022): Environmental Impacts of Food Production. [Dataset]. Available at https://ourworldindata.org/environmental-impacts-of-food (accessed July 8, 2024)

Rizzo G., Migliore G., Schifani G., Vecchio R. (2024): Key factors influencing farmers' adoption of sustainable innovations: a systematic literature review and research agenda. Organic Agriculture, 14: 57–84.

Sayadi-Gmada S., Roc C., Rojas-Serrano F., Garc R., Lorbach-Kelle M.B., Manrique-Gordillo T. (2019): Inorganic waste management in greenhouse agriculture in Almeria (SE Spain): Towards a circular system in intensive horticultural production. Sustainability, 11: 3782.

UN (2015): Draft outcome document of the United Nations summit for the adoption of the post-2015 development agenda. Available at https://digitallibrary.un.org/record/800852?v=pdf (accessed May 25, 2024).

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