

# Perception and awareness of circular economy options within sectors related to agriculture in Argentina.

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## Abstract

The current socio-economic model based on a linear approach is being challenged by resource scarcity, negative environmental impacts and socio-economic constraints. Consequently, cycling approaches or circular economy (CE) paradigm is gaining attention. Business as usual is no longer possible and the model and criteria proposed by circular economy are a sustainable alternative that effectively couples natural with human-made systems. A model in which citizens in each of their social roles have a lot to say and do. However, implementation in Argentina is very slow and it is only applied at some level by companies or in urban residues recycling in a small number of cities. Additionally, social skepticism and lack of information about what circular economy embraces is still perceived. The objective of this exploratory paper is to identify the present level of awareness, the current situation and the expectations regarding the transition towards a circular economy approach within Argentina's agricultural sectors based on an opinion and perception survey. The aim of the study is to establish a baseline understanding and an interpretative framework to aid researchers and policymakers in promoting and increasingly implementing circular economy criteria in specific sectors. The study analyzes by a descriptive statistic a survey (n=534) of selected actors related to the agricultural sector, i.e., farmers, agronomists (including agricultural engineers, veterinarians, and biologists), agrifood companies, and also directly related sectors, such as education and public administration. The anonymous questionnaire was divided into three parts: i) demographic characterization, ii) general awareness about transition towards circular economy (concept, current situation, features, advantages, drivers, obstacles and governance) within the region where the respondent operates, and iii) specific aspects within each selected sector. Results showed that the selected sectors perceived a common vision about the concept of CE "as a more sustainable production and consumption model", and with some differences, they have mainly sensed that the transformation process is still both not initiated and at its initial steps. Respondents selected to focus on recycling/reusing as well as on the integration between productive units. Political, economic and environmental awareness as well as technological skills have been chosen as barriers. Consequently, they chose to invest on education and research, noticing the citizens/society as the main agent of transformation. Since the challenge is to find organized and progressive steps to build interactions, programs, actions and legislation to favor the integral (between sectors) and internal (within a sector) transition, indicators for monitoring as well as policies, priorities and perspectives have been highlighted to contribute to boost the transformation towards a circularity approach.

*Keywords: agriculture, circularity, education, farmers, questionnaire, survey.*

## 1. Introduction

### 1.1. Overview of Circular Economy (CE) worldwide. A special focus on Argentina

For decades the operation of socio-economic systems following a linear approach has been disassembled from the functioning of natural systems where flows cycle with no waste. However, due to resource scarcity, negative environmental impacts and increasing waste quantities (Andrade 2017, Earth.org, 2021, IPCC, 2021), the current linear paradigm of production is being revised under the circular economy (CE) approach (Ghisellini, et al., 2016). Business as usual is no longer possible. Circular economy is a production and consumption approach focused on using a lower amount of material, having a lower impact on the environment, increasing the use of renewable energy and improving the restoration options of the system, all of which implies a change in living and consumption patterns. Moreover, it aims to conciliate economic and environmental goals and performance, with innovative approaches (e.g., the adoption of closed loops and restorative physical and economic cycles and processes for maintenance, repair, reusing, and refurbishment, remanufacturing and recycling) (van Lagen et al., 2021; Ghisellini and Ulgiati, 2020; Ghisellini et al., 2016).

The circular economy concept stemmed from different ideas and emerged in the 1990s (McDowall et al., 2017; Su et al., 2013). Since then, it has been increasingly disseminated. Germany was one of the first countries to implement it in 1996, followed by Japan and China (Su et al., 2013).

Ghisellini et al. (2016) identified levels of implementation and argued that the transition towards a circular economy followed different patterns in China (top down) and in Europe (bottom up), presenting a more horizontal and dynamic interaction between actors in the latter case. In this paper was adopted the idea exposed by these authors in order to consider CE as a path to design an economic pattern aimed at optimizing production and consumption by appropriately using, reusing and exchanging resources. In order to achieve it, the process components of production and consumption systems need to benefit by interacting with each other.

Considering this perspective, the CE concept embraces a challenging and systemic approach, promoting a framework that integrates environmental, economic and social issues, dimensions of sustainable development (Dong et al., 2021; Rodriguez-Anton et al., 2021; van Kruchten, 2020; Schroeder et al., 2018).

Circular economy has been implemented in cities and regions (OECD, 2020), in agriculture (Basso et al., 2021; de Boer and van Ittersum, 2019), companies (EMF, 2021; WEF, 2021) and in urban residues management (SEI, 2021; EEA, 2015). The shift towards a circularity approach is

challenging, but its adoption could be more feasible within a multiphase framework (Moric et al., 2020). Furthermore, just as Pilgeram (2013) and Ikerd (2007) argue that sustainability is not a destination but a direction, the same can be applied to CE since it can be considered a path to be built over time and on previous steps.

Some countries with which Argentina trades products, such as China and Europe, among others, have been implementing criteria for promoting circular economy within state regulations or laws for several years (EU, 2020; Li and Lin, 2016). In this sense, Manuel Albaladejo<sup>1</sup> (2020) states that new trade agreements will emphasize new certifications and standards for entering the market, including environmental and labor practices. Therefore, there is a commitment to promote circular economy in the production of Latin American goods destined to the European Market.

In Argentina, there have been isolated laws dealing with management of specific residues and urban wastes (Martinez and Porcelli, 2018). Recently, as a result of policies aimed at decreasing imports and increasing local inputs production, a technical circular economy Roundtable was created (MAyDS, 2019). However, it seems that the implementation of certain CE criteria has already started to be applied in industries (CEADS, 2019) for recycling solid urban residues as a national strategy and in certain cities (USE, 2021; Becerra et al, 2020; SAyDS, 2005). Machin Ferrero et al. (2022) have studied the environmental implications of the current production of lemon in Argentina as baseline and its shifts towards biorefineries which apply circular economy principles. Moreover, a joint collaboration has recently established between National University of Río Cuarto and the Artic Centre of the University of Lapland to co-create knowledge related to circular economy and bioeconomy with emphasis on food sovereignty and sustainability (Raheem et al., 2022).

Within Argentina's agricultural sector, the gross value of agricultural crops and livestock production, represents 7.3% of the national GDP (INDEC 2021, average 2010-2020) produced mainly in the Pampas region<sup>2</sup>. This region, an original prairie biome, concentrates more than 84% of maize (*Zea mays* L.), soybean (*Glycine max* L.) and wheat (*Triticum aestivum* L.) production, as well as 63 % of livestock (MAGyP 2021). Primary agricultural production and industrialization represents 59% of total national exports (INDEC 2021, average 2009-2019), ranking in the first ten places on the lists of grain commodities and soybean-oil exports in the world (FAOSTAT, 2021,

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<sup>1</sup> Manuel Albarejo, representative of the United Nations Industrial Development Organization (UNIDO) in Uruguay, is one of the leading promoters of circular economy in Latin America. His 2020 interview by Chile's País Circular was originally published in Spanish at <https://www.paiscircular.cl/industria/manuel-albaladejo-la-economia-circular-es-el-punto-de-encuentro-entre-la-agenda-productiva-y-la-ambiental-hoy-es-imposible-entender-una-sin-la-otra/> and translated into English at <https://www.greengrowthknowledge.org/blog/circular-economy-brings-together-productive-and-environmental-agendas>. Last accessed June 2021

<sup>2</sup> Pampas Region: includes six provinces of Central Argentina: Buenos Aires, Santa Fe, Córdoba, Entre Ríos, La Pampa and San Luis

average 2009-2019). Therefore, the agricultural and agribusiness sectors are an important source of foreign exchange revenue and also of labor, representing 13.4% of total employment in 2019, (Calzada and Treboux, 2019).

Agriculture, in Argentina, due to its relevance in the country economy and performance, needs to be competitive in a global trade market where regional/local products offered by competitors are being optimized and more sustainable in the long run. By adopting the criteria offered by the CE approach seems Argentina can benefit from this production paradigm from the environmental, economic, social and logistic perspectives, as well as from the networking collaboration. In this moment of incipient development, knowing the state of progress, expectations and existing barriers is crucial for researchers and policy makers, who seek to drive the process of implementing circular economy criteria.

Therefore, the objective of this exploratory paper is to identify the level of awareness, the current situation and the expectations regarding the transition towards a circular economy approach within agricultural related sectors of Argentina based on an opinion and perception/awareness survey.

## **1.2. Framing Perception in CE**

Perception is the highly cognitive process of selecting, organizing, storing and interpreting information gathered by our five senses (Solso et al., 2007). Ou (2017) defines it as a process of attaining awareness or understanding from sensory information, in which the perception process involves selection, organization and interpretation of environmental stimuli (information).

In solving environmental problems, all actors (citizens, entrepreneurs, educators, administrators and politicians) have a central role (plurality of perspectives). From this approach, researchers have provided us with an adaptation of complex systems theory to the sphere of scientific policy (Funtowic and De Marchi, 2000). These authors have introduced the concept of reflexive complexity (characteristic of social, technical or mixed systems, which include human beings, actors with perception, perspective and motivation) differentiating it from ordinary complexity (biological systems, in which there is an absence of self-awareness and purpose). Complex systems are defined as those that cannot be apprehended by a single perspective, but rather by a plurality. Therefore, in order to apprehend the senses/feelings related to the environment, the hermeneutic approach (the comprehension and interpretation of the facts from the perspectives of the subjects in their interaction with the social environment) can help us (Scholz, 2015). Combined with the hermeneutical approach, this paper focused on the areas of the subject's behavior (Bleger, 2006), that is, the area of the mind and body as well as the area of the external world, as a phenomenal

manifestation whose unity is the behavior itself, highlighting that "behavior always implies coexisting manifestations in the three areas". The authors of this paper understand that an interaction between the three areas occurs, leading to the manifestation of behavior or actions over time. This framework is suitable for investigating the level of information, knowledge and perception citizens have regarding the environment.

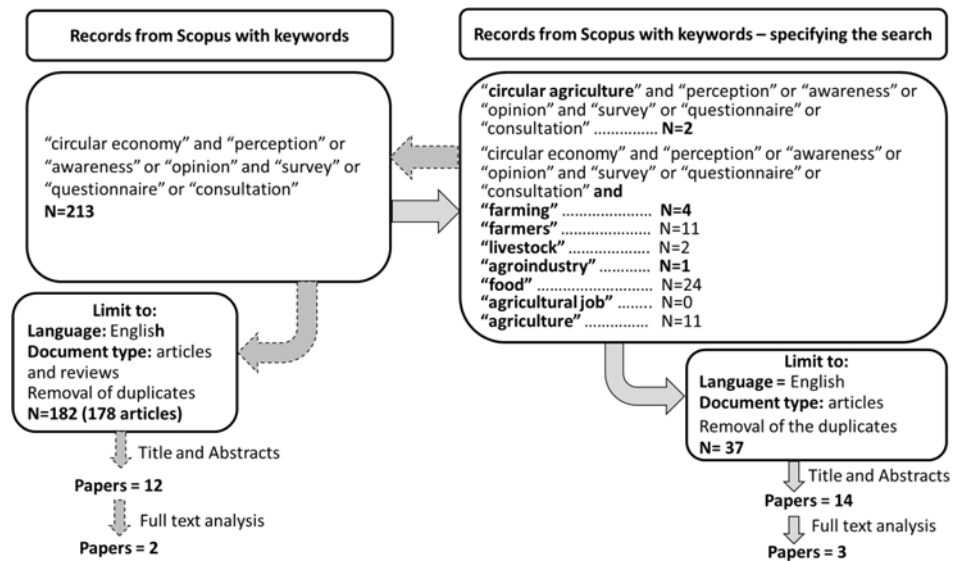
### **1.3. Study Foundation**

Perception, awareness and public opinion in relation to circular economy is a field of increasing interest. A preliminary literature review, performed as starting point for the present research, took into account scientific papers published in journals indexed within the Scopus database, based on selected keywords directly addressing the objectives of the study. About 925 records since 2005, of which 83% published from 2019 to date, were selected under the keyword search of "circular economy" & "perception" or "awareness or "opinion".

The search was further based on both a selection of terms (Figure 1) related to methodological aspects of each paper (e.g. "perception") as well as specific topics (e.g. "agriculture") that allowed to obtain a more focused set of publications. After including language limits and removal of duplicates, the search yielded 37 articles written in English, further selected based on title and abstract, yielding 14 articles, out of which only 3 papers deeply rooted in the agricultural topic of the present study, as follows. Bagagiolo et al. (2022), recruiting participants from an expo, have investigated the users' perceptions and the potential level of interest in using as fertilizer the compost of the organic fraction of municipal solid waste (also with focus on the participants' demographic characteristics); Majbar et al. (2022) identified the perceptions and willingness of farmers to produce and use compost in agriculture, and assessed the factors shaping these perceptions and willingness, including socio-economic, agricultural and individual factors. In these two last publications, the authors have completed a standard questionnaire through a face-to face interview during an agricultural exhibition; Case et al. (2017) conducted a survey for understanding the Danish farmers' decision about their current use of organic fertilizer, their interest in using alternative types in the future and their perception of the main obstacles or advantages in using organic fertilizers. Of course, the number of published papers related to circular economy in agriculture are many more, but when the analysis is restricted to "awareness", "perception" and other similar methodological terms coupled to "agriculture", the number of published papers decreases, in so calling for increased efforts for deeper perception by agricultural sector operators and stakeholders.

However, being this study also focused in the literature related to the appropriateness of tools for performing surveys and questionnaires, the 213 papers emerged from the keyword search were

further selected based on language and document type first, yielding 178 papers, and then based on full titles and abstracts, finally yielding 12 papers. The full text analysis allowed to identify 2 papers out of these 12, in addition to the 3 mentioned above (Figure 1).



**Figure 1:** Framework for screening scientific reference.

The articles of this backwards search addressed a variety of issues, among which the transition towards circular fashion consumption employing textile waste (Kim et al. 2021), the attributes that might be favorable for online business (Stein et al. 2020), and the possibilities of choosing products made of biodegradable material from bio-waste (Russo et al. 2019), Liu et al. (2009) and Van Langen et al. (2021), yielded data very useful to the present study, such as the survey modality, the type of analysis to be used and the main aspects to focus on for a comprehensive evaluation of results. The first authors performed a questionnaire survey to create a better understanding of public awareness and performance for the promotion of circular economy in Tianjin, China. The second authors developed a survey about the perception and level of awareness of stakeholder's groups (researchers, economists and administrators) selected for their expertise on the CE concept and governance of the transition process. Details about the 5 selected studies (Bagagiolo et al., 2022, Majbar et al., 2022, van Langen et al., 2021, Case et al., 2017, and Liu et al., 2009) and can be found in Table B1 of the Appendix, and constitute the starting point for the present work.

Therefore, after better framing the relevance of the topic and describing some literature as basement in the introductory review, the remaining part of the manuscript is structured as follows. Section 2 explains the survey design, the criteria used for the selection of agricultural actors, categories and each category's topics, as well as the way data were collected. Section 3 presents the results regarding to demographic characterization; an overview of the transition to a CE at a regional level

(part B of the survey); specific features within each selected sector for the transition to a CE (part C of the survey); and summarizes the workshop outputs from results shared with respondents. Section 4 discusses the results, suggesting policies, priorities and perspectives, as well as indicators for monitoring the transition. Section 5 presents the conclusion. The Appendices contain data details cited along the paper.

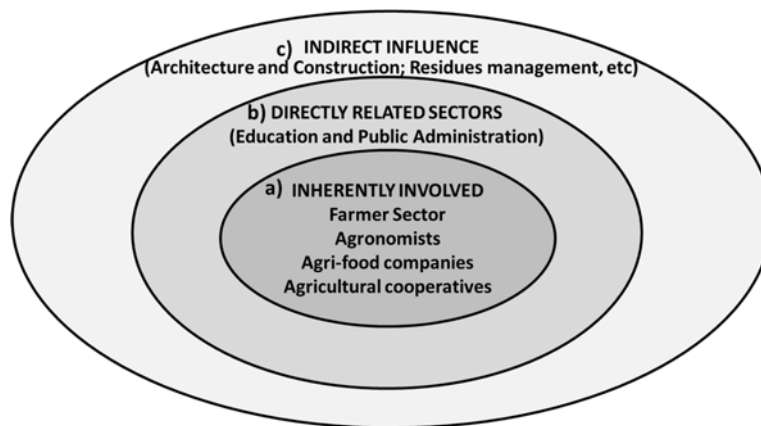
## **2. Material and Methods**

### **2.1. Survey Planning and Design**

In order to better address the objectives of this study, concerning (a) the level of awareness, (b) the current situation and (c) the expectations regarding the transition towards a circular economy approach within agricultural related sectors of Argentina, based on the results of an opinion and perception/awareness survey, the following steps have been planned: (i) type of survey; (ii) sectors of Argentina's agriculture to be addressed and criteria for selecting them; (iii) categories and topics within each category to be inquired about; (iv) survey structure and clear elaboration of the questions; and (v) conduction of pilot surveys to validate the questionnaire. In particular, with reference to the above:

(i) An anonymous online survey was decided, instead of face-to-face interviews. This seemed to be the most suitable tool, due to the implemented COVID-19 lockdown. This consultation instrument has advantages and disadvantages. Among the first ones, it is possible to mention the low cost, less effort to administer, the feasibility of being completed in a time and space convenient for the respondent, and the perceived sense of internet as an anonymous medium. Among the disadvantages, the most debated topic is the sample bias, typical of internet surveys since nowadays the respondents are overwhelmed by excess of opinion demands or unwanted surveys arriving into their inboxes. Moreover, the mass sending of invitations can be considered an invasion of the privacy of the recipients (Siva Durga Prasad Nayak and Narayan, 2019, Rocco and Oliari, 2007). These disadvantages, among others such as the difficulties to daily internet access, mainly in some agricultural area, drive to a low contribution from the target population. Responses rates are generally low and vary considerably (Vehovar and Manfreda, 2017), being usually less than 10% of the invitations (Rocco and Oliari, 2007). Moreover, according to Siva Durga Prasad Nayak and Narayan (2019) experience, online survey yielded a poor response rate. Despite the mentioned disadvantages, due to the context, authors think that the advantages are strong enough to suggest the online anonymous survey as the tool to reach the objectives of this work.

(ii) The Authors' criteria for selecting the sectors of Argentina's agriculture to be included in the survey were based primarily on: a) persons that are inherently involved in agricultural activities such as agricultural engineers, veterinarians and biologists (from now on, Agronomists), Farmers, Agrifood companies and Agricultural Cooperatives, b) persons that can have a direct influence on agriculture by incorporating educational programs as University Researchers and Professors, and persons that may facilitate official formalities such as people that belong to the Public Administration (from now on, Administration). Then, as an additional focus, authors added a third group of potential respondents, c) which involves others persons with an indirect influence to agricultural aspects and infrastructures such as Environmental Associations, Residues Management as well as Architecture, and Construction (e.g. roads, barns, machinery). These sectors are indirectly related to agriculture by designing buildings, barns, mills or other installations required to operate, to managing residues or logistics and to promoting environmental health). All the selected sectors are relevant because of their role in adopting criteria for promoting CE within agricultural activities, to identify and understand the limitations, as well as to help implementing actions and policies.



**Figure 2:** Selected sectors related to Agriculture to include in the survey.

(iii) The list of categories and topics to be explored in the questionnaire was shaped by the Authors after four working meetings, based on their specific professional expertise (agriculture, statistics, industrial engineering, economy and sociological studies) with published research papers about agriculture, qualitative questionnaires, and survey methods (van Langen et al., 2021; Vassillo et al., 2019; Hornsby et al., 2017; Rótolo et al., 2015a, Rótolo et al., 2015b). Therefore, categories, its topics and questions firstly originate from the authors' expertise about the agro-sector and secondly from literature search (Table B1 in the Appendix). Table 1 shows a general description of the selected categories and topics to be addressed in the survey. Details about the selected categories, topics, questions and reasons for the question selection can be found in Table B2 of the Appendix.



**Table 1:** Overview of the selected categories/topics to be inquired about within the survey.

Categories	Topics	Reason for selection
Baseline or starting point	<ul style="list-style-type: none"><li>• Concept;</li><li>• Current Stage</li></ul>	These questions intend to know the level of awareness regarding to CE concept (van Langen et al., 2021). The Authors of this study were interested to know how integral the respondents perceived the concept (Iacovidou, et al., 2021, OECD, 2020), as well as to know how the respondent of different sectors perceived the current stage of CE transitioning (Case et al., 2017; van Langen et al., 2021)
Implementation	<ul style="list-style-type: none"><li>• Reasons for implementing it,</li><li>• Aspects or actions to focus on,</li><li>• Advantages of its advancement</li><li>• Drivers (tools/attitude) required</li></ul>	The input and fuel costs and probably shortage, as well as the relevant nature of agriculture in production and trade (shown by own calculations stated in Section 1.1 of the manuscript based on INDEC 2021, MAGyP, 2021, FAOSTAT 2021, Calzada and Treboux, 2019) drive to a need of an agricultural management change. Therefore, it is important to improve processes for the environment, the economy and competitiveness. Thus, questioning withing these topics Authors started to deepen into the features of CE approach to have a general picture of the respondents' awareness and the more perceived aspects to where to focus further actions and studies regarding to implementation
Barriers	<ul style="list-style-type: none"><li>• Reasons that may discourage/frustrate transitions;</li><li>• Obstacles that can be found</li></ul>	Frustration refers to a feeling, the feeling of disappointment for the inability to satisfy a need or want, the feeling of finding it difficult to overcome. Obstacles (objects or facts) interfere with achieving a goal (Garcia Roda 2019; Marguc et al., 2010; RAE Dictionary; Oxford dictionary). Obstacles refer mainly to objects or factors (Marguc et al., 2010; RAE Dictionary; Oxford dictionary). Authors of this study were interested in knowing which factors respondents perceived as "obstacles", which of them are perceived as a motive of frustration or discouragement that might drive to not intend transformation.
Governance	<ul style="list-style-type: none"><li>• Tools to implement</li><li>• Investments</li><li>• Key persons</li></ul>	These topics aim to elucidate the way the respondents perceived they could drive transformation towards a CE (van Langen et al, 2021), the main areas where to invest, key persons to initiate the transformation, and the tools to implement to start the transformation in those production models that are already functioning.

(iv) The questionnaire was structured according to three parts as follows:

- A) Part (A): respondents' demographic characteristics such as age, gender, working area, education level, area of education and job position.
- B) Part (B): region where respondents develop their activities that involve different aspects leading to circularity and their relation with different dimensions of sustainable development. This part covers the categories and its topics mentioned in Table 1:
  - a. *Baseline to start CE*: the notion of circular economy and its current situation (two questions),
  - b. *Implementation of the CE approach*: reasons for its success, aspects on which to focus, advantages of its advancement and drivers (tools/attitude) required (four questions),

- c. *Barriers to implementation*: motive that discourage/frustrate transitions and obstacles that can be found (two questions),
- d. *Governance for facilitating the transition*: areas of investment, key actors and tools/behavior required to accelerate or initiate the change within ongoing production models (three questions), and
- e. Selection of the *specific sector* in which the respondent operates. Respondents could only choose one sector among the options offered (Figure 1), which directly addresses the corresponding part C of the survey.

C) Part (C): related specifically to each sector in which the respondent operates and has 3-6 questions each, which deepen the same categories and topics already explained.

Only one survey questionnaire was created, organized according to the three parts above, in which the last one (Part C) should be completed after selecting the sector (e) in part B. This decision was adopted to avoid misleading due to the distribution strategy used (explained in Section 2.2.), where one respondent, for example, could be Agronomist, Farmer and Professor/Teacher. By using only one survey with the three parts, the respondent can select the sector where he/she is best identified.

(v) The questions were elaborated by the authors and other colleagues from Project ProCEedS (Promoting Circular Economy in the Food Supply Chain, N° 823967-H2020-MSCA-RISE-2018) after on-line meeting as well as e-mail rounds for improving their clarity and comprehensiveness. These questions were first tested on a control group formed by thirty (30) international researchers (from Europe, Asia, Latin America and Africa), as reported in Van Langen et al. (2021). Then, after a careful translation into Spanish and adaptation to the Argentina context, new rounds of on-line meetings to check clarity were carried out. After this, another pilot survey was performed within the Oliveros Agricultural Experimental Station of National Institute of Agricultural Technology (INTA-EEA Oliveros), where Agronomists, Researchers, Professors and Administrators as well as Farmers and Agrifood companies connected to INTA-EEA Oliveros were contacted in order to evaluate the questions again. These thirteen (13) persons were not further included in the survey. This step allowed to clarify and improved the questionnaire and be ready for the respondents of the survey.

Additionally, a workshop to share the results of the survey with respondents was considered and scheduled. When the respondents answered the questionnaire, they were asked to state if they were willing to participate in the survey report by leaving their email for further contact. This workshop was organized as a virtual meeting via the institutional (INTA) Zoom Platform. The activities

related to presenting the results, chat interaction and management of technical issues of the workshop were distributed among the authors and INTA communications colleagues.

## **2.2. Data Collection and Analysis Method**

A Google Form in Spanish (Appendix A, provides an English translation), was used to collect the answers. The heading of the form includes the title and a brief explanatory text listing the institutions that were participating on it, the rationale of the survey, and the time needed.

The survey was made accessible online for a period of forty days (March and April 2021) and was sent to a considerable number of stakeholders, by means of the “Snowball sampling technique”: we sent the questionnaire to groups of key stakeholders and asked them to share it with their collaboration contacts potentially interested to be involved in it. In so doing, the snowball technique may provide a large number of respondents, by taking advantage of the existing links among stakeholders. This sampling technique is generally applied by researchers to identify potential subjects in studies where they are hard to locate (Wohlin et al., 2022; Naderifar et al., 2017; Farquharson, 2005), as it was during the time of the present research, where a strong lockout was established because of the SarsCov2 pandemic. The starting point of this technique consists of identifying groups of key stakeholders and ask them to spread the survey to all their contacts that might be interested in being involved. The nature of this technique is a non-probability sampling and, therefore, it cannot be considered for a representative sample or in any case for statistical studies. However, this sampling technique can be extensively used for conducting qualitative research, when there are too strong difficulties in accessing the target population. Therefore, the distribution channels used were those offered by institutional and organizations contact lists, mainly via e-mail and WhatsApp. The number of recipients was estimated according to the report made by the persons in charge of these contact lists.

The questionnaire was sent to Agronomists (about 3395 recipients); Farmers (about 2274); Teachers and Professors (about 1688); Administrators (about 1017); Agri-food companies (no information)<sup>3</sup>. These recipients were reached through: a) the Communications Department of the National Institute of Agricultural Technology (INTA); b) the Academic Secretaries of selected Universities and Faculties, such as the National Technological University of Mendoza (UTN) and, specifically, the Faculties of Agronomy, Architecture, Civil Engineering and Economics of the National University

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<sup>3</sup> Agri-food companies have been contacted via several different patterns (Agrifood Chamber of Commerce of Rosario, Academic Secretaries, internal INTA list of collaborating Companies, Conference lists, personal contacts) and it was impossible to determine the full number of recipients (which was, however, sufficiently high, considering the number of responses received).

of Rosario (UNR); and c) Agri-food Chambers of Commerce in Rosario<sup>4</sup> and personal contacts. Even though it was not possible to get information about the survey's recipients of Agri-food companies, authors decided to keep the sector in the study due to its exploratory character and the relevance of the agroindustry sector in Argentina economy.

The survey gathered 620 respondents from the nine selected sectors. However, five of these sectors, inherently (a) and directly (b) related to agriculture (Figure 2), accounted for 86% of the total. These five sectors included more than 50 respondents each, accounting for n=534, and had a sample share higher than 10% each (Table 2). Therefore, along the sections the Authors will only refer to those highly responded sectors (Agronomists, Farmers, Education, Administration and Agrifood). Agricultural cooperatives, an important actor in the agricultural system, could not be included in this project given that the number of respondents was lower than the established cut-off criteria, which calls for further and deeper understanding of this sector in a future study.

**Table 2:** Number of respondents per selected sector as shown in Figure 2.

Selected sector	Total sample respondents	Total selected sectors
	N°	%
Agronomists	199	37.3
Farmers	149	27.9
Education	69	12.9
Public administration	59	11.0
Agri-food companies	58	10.9
<b>Sub-total</b>	<b>534</b>	
Engineers, architects	26	4.19
Residues management	24	3.87
Environmental associations	18	2.90
Cooperatives	17	2.74
<b>Total</b>	<b>620</b>	

Therefore, an exploratory and descriptive research design was implemented based on the opinion polls about the knowledge of circular economy in the target population. This design was chosen as a first approximation of empirical research about respondents' perceptions on ideas and conceptions of circular economy in sectors related to agriculture in Argentina. It was a rough estimation to identify the "intermediate variables or initiating causes" such as opinions, and perceptions, that intervene in the intentions and cognitions of the subjects (Tolman, in Bleger 2006, pp 146-147). Since the survey was conducted online, in an unusual contextual situation as was previously defined, Authors considered that the information collected is close enough to identify the perception factor as a component element of the complex behavior system. The information collected was

<sup>4</sup> Rosario is the most relevant harbor in the country for exporting raw matter and industrialized products related to agriculture, raking second in the world. Available at: <https://www.bcr.com.ar/es/mercados/investigacion-y-desarrollo/informativo-semanal/noticias-informativo-semanal/el-gran-2>. Last retrieved on Dec. 2021.

automatically saved in an Excel spreadsheet. After debugging, coding and cleaning the data, a descriptive statistics parameter was carried out for the analysis. Given that some of the questions can be given qualitative responses and that respondents were allowed to choose more than one response, the sum of the percentages of responses may exceed 100%.

Further, a Multiple Correspondence Analysis (MCA) was also applied. Correspondence Analysis is a technique that allows to explore graphical associations among category variables. The aim is to summarize a big amount of data into a smaller number of dimensions, losing as little information as possible. For the sake of clarity, generally in the case of a contingency table with only two category variables, the Correspondence Analysis consists of summarizing the information displayed in rows and columns in a way that it can be projected over a reduced space allowing the row and column coordinates to be represented simultaneously, showing the relationship between them. Instead, the Multiple Correspondence Analysis (MCA) is an extension of the above mentioned case, where the number of category variables is greater than two, hence the contingency tables are multidimensional (Greenacre, M.J., 1984). As a follow up of MCA, Authors have shown and explained in more details the similarities and differences that respondents' sectors had on some specific categories and topics (Table 6). Final results are exhibited in graphs and tables in Section 3.

### **3. Results**

The responses' rate of the five sectors were between 4-6.5% (i.e.: Agronomists 5.9%, Farmers 6.5%, Administration 5.8%, Education 4%). These figures are in accordance with Rocco and Oliari, (2007) who referred as usual answers to a percentage lower than 10%, but are lower than Case et. al (2017) and Van Langen et al. (2022). However, Case et al. (2017) had obtained a response rate of 28% in a survey addressed to a specifically defined sector and topic: the use of organic wastes as fertilizers. In a like manner, Van Langen et al. (2022) obtained a response rate of 68%, 27% and 26% to the three groups analyzed (researchers, economists and administrators respectively), whose participants were specifically selected as experts on circular economy (which may explain such high rates). The results shown in this paper allow to obtain a sufficiently reliable respondent's overview about concepts and aspects of circular economy, according to the Authors' focus, namely exploring CE awareness and perceptions by stakeholders.

This section is organized by presenting the survey results, i.e., Subsection 1- Demographic characterization, Subsection 2- Overview of transitioning towards a Circular Economy at a regional level, Subsection 3- Specific features within each selected sector for the transition to a CE (sectoral level), Subsection 4- Similarities and differences among specific topics of selected categories both

in the region and within each sector and, finally, Subsection 5 shows the outputs from the results shared with the respondents during the workshop.

### 3.1. Demographic Characterization of the Consulted Participants

Approximately 76% of the consulted individuals belong to specifically agricultural areas, being Agrarian Sciences the most represented fields (55%). The remaining 24% belong to closely related agricultural sectors, such as Education (who mainly teach at bachelor degree or higher) and Public Administration. Respondent’s belonging to exclusively Pampas region accounted for 66% (Table 3), being Buenos Aires and Santa Fe the provinces most represented (52%). The prevailing age of the respondents were between 40-50 years old. Regarding education levels, 87% have bachelor or higher degrees, where 24% have a master and 16% a doctorate. Employee (including teachers, professionals, researchers from different national institutes and universities) is the job most represented (66%), while entrepreneurs or independent job accounted for 16%. (Table B3 in the Appendix).

**Table 3:** Number of respondents per selected sector and province, at national level as well as in the most representative provinces (Pampas region and Province of Mendoza).

Selected sector	Sample respondents N°	%	Respondents of selected provinces (Pampas region and Mendoza province) <sup>(1)</sup> N°	Respondents’ sectors of selected provinces %
Agronomists	199	37.3	143	71.86
Farmers	149	27.9	108	71.81
Education	69	12.9	57	82.61
Public administration	59	11.0	49	83.05
Agri-food companies	58	10.9	47	81.03
Total	534	100	404	

Note: (1) Selected provinces are: those that integrate Pampas region (Ref. 2, page footnote in Section 1), and Mendoza, which is the province that contribute with the highest percentage outside Pampas region. Mendoza contributed with 8.7% of 404 respondents.

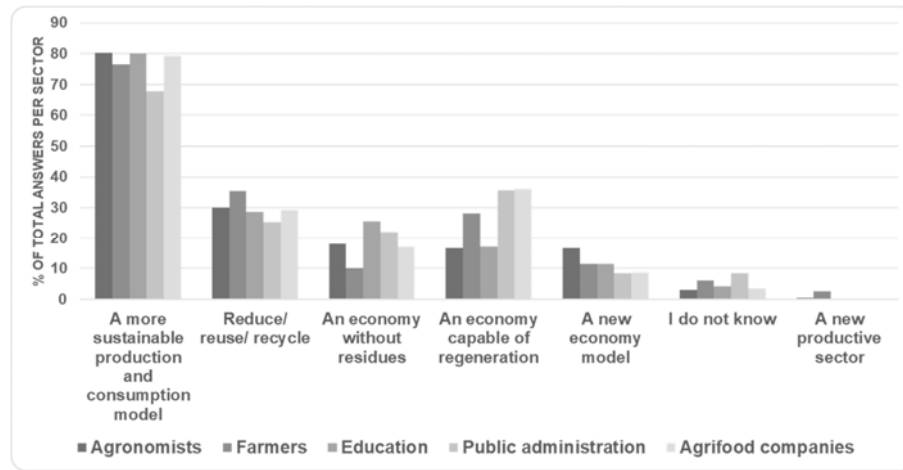
### 3.2. Overview on the Transition Towards Circular Economy at Regional Level

This overview corresponds to the respondents’ opinions about Part B of the questionnaire and it is organized according to the aspects considered and listed in Section 2.1. A summary of these aspects and the workshop outputs are also presented.

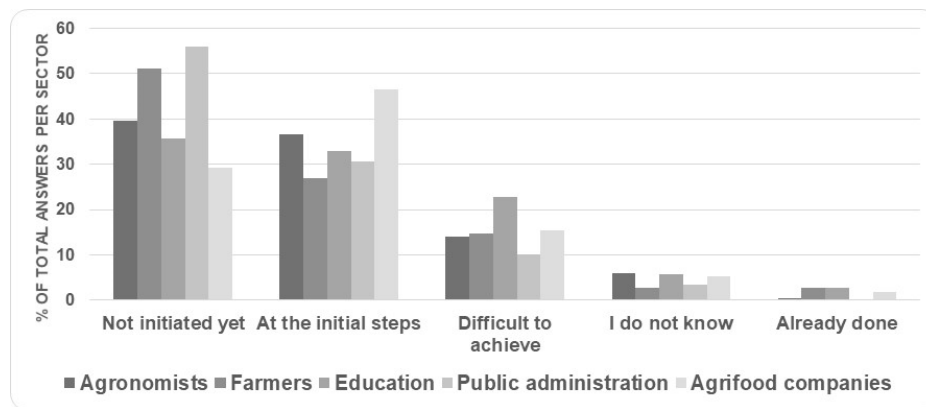
#### 3.2.1. The starting point

Respondents from all sectors, when answering about their concept of circular economy, chose “A More Sustainable Production and Consumption Model” (Figure 3). However, they had differences when answering about the stage of the transformation from linear to circular (Figure 4), distributing

their preferences mainly within two main groups of the available options, “Not yet initiated” and, “In the initial steps”.



**Figure 3:** Respondents' opinion about “what is circular economy for you?” (max. two replies allowed).



**Figure 4:** Respondents' opinion about “At what stage is the transformation process from a linear to a circular economy model?” (only one reply allowed).

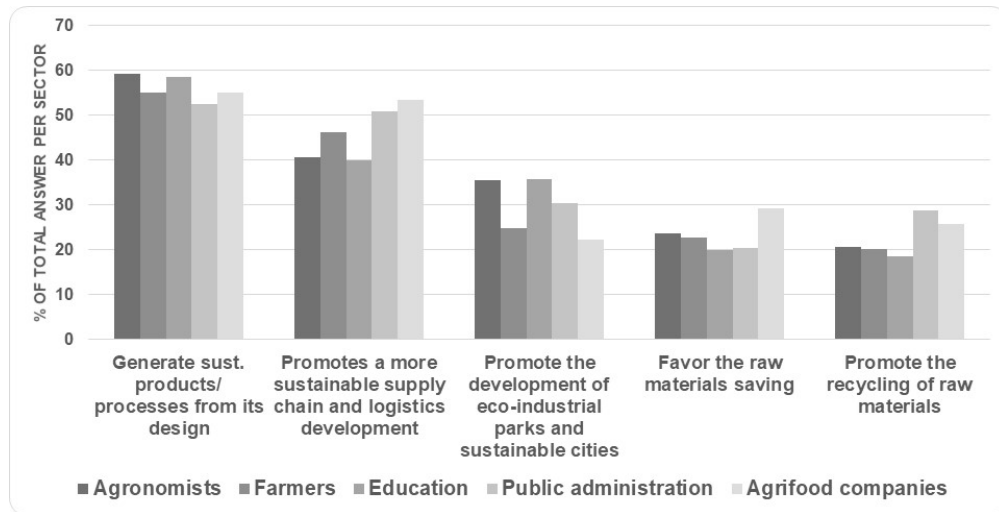
The most frequent response in Figure 3, “A More Sustainable Production and Consumption Model”, was usually accompanied by another because the question admitted up to two response options. Therefore, for inquiring deeper, and for knowing how the concept of CE and the stage of transformation related together and with the education level, a multiple correspondence analysis (MCA) was performed (Figure C1 and Table C1, in the Appendix). The biplot revealed that, 64% of the respondents who think that the CE, in addition to being “A More Sustainable Production and Consumption Model” is “A New Model of Economy”, hold a PhD or Master degree. These groups also perceived that the transformation is at its initial steps. While, holders of Specialization Bachelor and Post High School Studies have selected “A More Sustainable Production and Consumption Model” coupled with “An Economy Cable of Regeneration” and they sensed similarly that transformation has not started yet as well as it is difficult to achieve.

### 3.2.2. Implementation

This section looks at inquiring about the feasibilities to implement criteria of CE approach. Therefore, to deepen the inquire about the transformation process towards a CE, features as reasons, advantages, aspects or actions to focus and drivers were addressed.

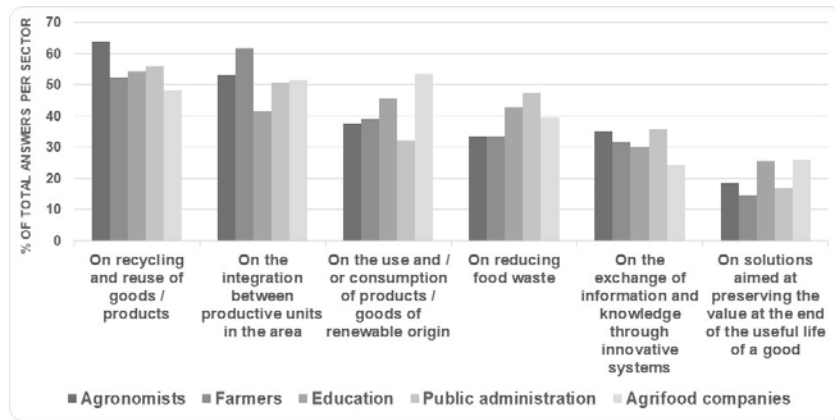
In order to answer about the reasons for implementing CE, specifically “Why would circular economy implementation be successful?”, with slight differences among the participating sectors, respondents focused on two reasons, oriented to increase sustainability, one was, “creating sustainable products/processes from its design”, and the other, “promoting a more sustainable supply chain and logistics development” (Figure 5). These reasons are reinforced by the advantages the respondents selected for implementing it, namely “emission reduction” (46-62%) and “waste reduction” (39-47%). Education, was the exception, since they have chosen as advantage the “new job opportunities” (56%).

However, when respondents have to choose the aspects, they would focus on to implement CE (Figure 6), the sectors opinions were more distributed among options, being mainly grouped among “recycling and reuse of goods/products” and “integration between productive units in the area”.

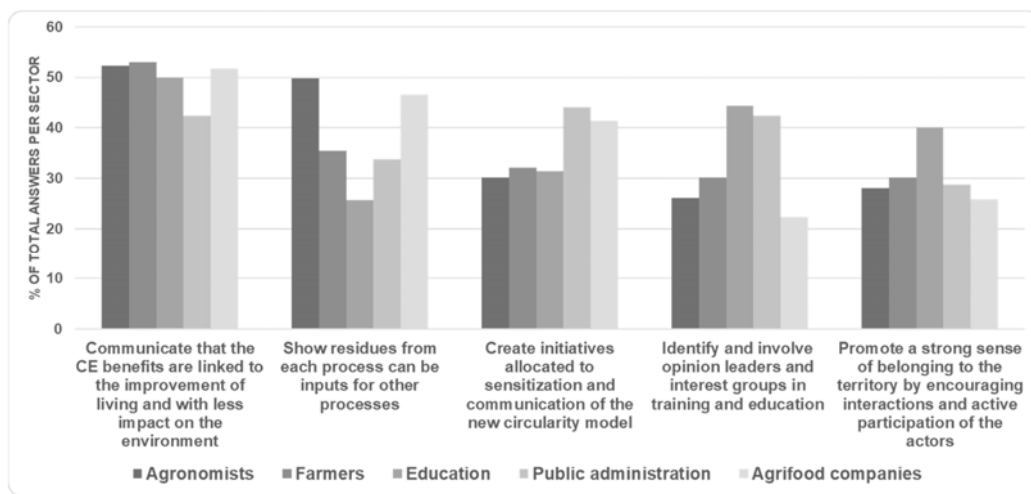


**Figure 5:** Respondents’ opinion about “why would the CE implementation be successful”? (max. two replies allowed).





**Figure 6:** Respondents' opinions about "what aspects would you focus on the implementation of CE?" (max. three replies allowed).



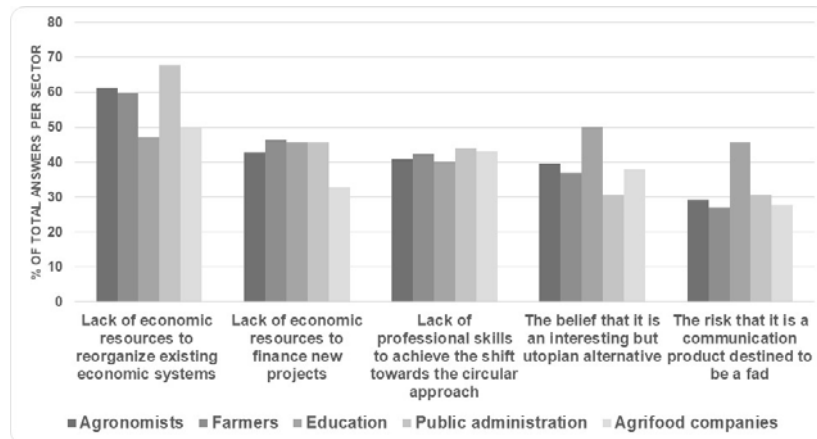
**Figure 7:** Respondents' opinions about "Which are the tools/attitudes that consider indispensable to drive the actors change?" (max. two replies allowed).

When surveyors were asked about needed tools/attitudes to drive the actors change, the general choice was "communication that CE benefits are linked to the improvement of living conditions", The other options were differently selected by the respondents of the sectors (Figure 7).

### 3.2.3. Limitations

Inquiring about barriers, it was addressed those that can be obstacles (an object or fact that prevent progress) and frustrations (a feeling that can discourage or prevent from continuing the initiative) (Table 1). Therefore, asking for the obstacles, with slight differences among the participating sectors, the respondents mainly focused on two options, the "lack of adequate policies/legislation", and the "lack of awareness about the environmental problem" (within a frequency range of 40-53%). While, when asking about causes that might frustrate/discourage the transition to circular

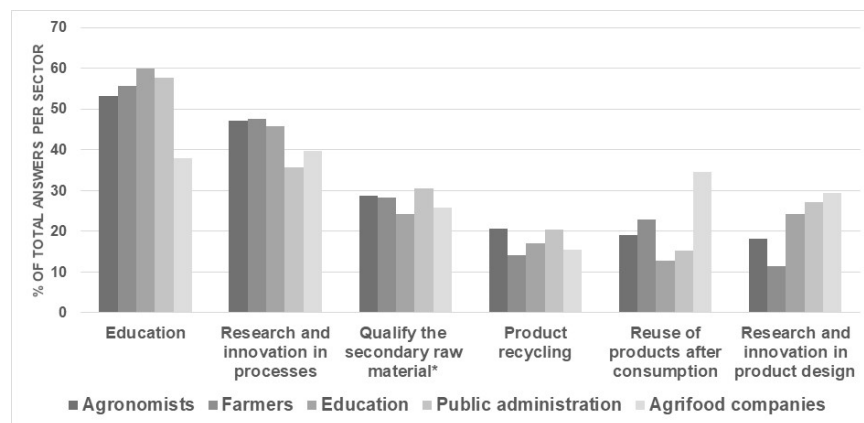
economy, the “lack of economic resources to reorganize existing economic systems” was the most chosen (Figure 8)



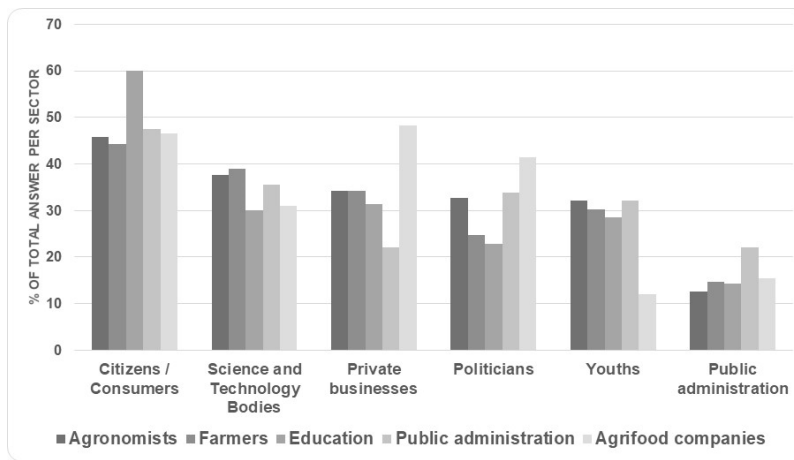
**Figure 8:** Respondents’ opinions about “What motive can frustrate/discourage the transition to CE? (max. three replies allowed).

### 3.2.4. Governance

In relation to governance issues, three aspects were focused on: investments, key agents and tools or behaviors to implement. Respondents have seen that the “education” and the “research and innovation processes” as the main areas to invest (Figure 9) in concordance with one of the options selected (“lack of professionals skills”) as a cause that can frustrate the transition towards CE (Figure 8). “Consumers/Citizens”, that involves all society, were chosen as key subject capable to speed the transition towards CE (Figure 10).



**Figure 9:** Respondents’ opinion about “Which areas should investments facilitate the transition from a linear to a circular economy?” (max. two replies allowed). (\*) secondary material: materials that, after use, can be repeatedly availed as raw material for other process.



**Figure 10:** Respondents' opinions about "Who are the key subjects capable of accelerating the transition towards CE" (max. two replies allowed).

When the participants were asked for "What tools / behaviors could be necessary to start the transition to CE in the production models already functioning?", with some differences among sectors five options were selected in a range frequency of 38-48%. In general, they think necessary a concrete commitment from different actors of the society, as well as an "incentive system" and "financial support"

### 3.2.5. Most frequent features raised by the respondents at regional level (Part B)

In order to have a general picture of the respondents' opinion about the categories and topics selected, this section aims to only summarize the results already presented. Since there are differences among sectors within options along the topics of each category, Table 2 only shows those that group, in general, the higher frequencies.

**Table 4:** Relevant features of respondents' opinion about the identified categories. Part B of the questionnaire.

Categories	Topics	Most frequently selected opinions
Starting point	Concept	A more sustainable and production model
	Stage	<ul style="list-style-type: none"> <li>Not initiated yet</li> <li>At the initial steps</li> </ul>
Implementation	Reason	<ul style="list-style-type: none"> <li>Generate sustainable products/processes from its design</li> <li>Promotes a more sustainable supply chain and logistics developments</li> </ul>
	Advantages	<ul style="list-style-type: none"> <li>Reduction of emissions and environmental impacts</li> <li>Waste reduction</li> </ul>
	Focus	<ul style="list-style-type: none"> <li>On recycling and reuse of goods/products</li> <li>On integration between productive units in the area</li> </ul>
	Drivers	<ul style="list-style-type: none"> <li>Communicate that the benefits of CE are linked to the improvement of living conditions in the context of the region and to the perspective of a future with less impact on the environment.</li> </ul>
Barriers	Obstacles	<ul style="list-style-type: none"> <li>Lack of adequate policies/legislation</li> </ul>

Categories	Topics	Most frequently selected opinions
Governance	Discouragements	<ul style="list-style-type: none"> <li>Lack of awareness about the environmental problem</li> <li>Lack of economic resources to reorganize, in a circular way, existing economic systems</li> </ul>
	Investments	<ul style="list-style-type: none"> <li>Education</li> <li>Research and innovation in processes</li> </ul>
	Key agents	Citizens- consumers
	Tools/behaviors	<ul style="list-style-type: none"> <li>A concrete commitment from entrepreneurs, political sector and consumers</li> <li>Incentive system and financial support</li> </ul>

### 3.3. Specific Features of the Transition Towards a CE Within Each Selected Agricultural Sector

In order to obtain a deeper insight of the opinion and perceptions within each selected sector (Part C of the survey), very few questions were specifically directed to each of them. Some specificities have come out when focusing on some topics within selected categories.

**Table 5:** Options with the highest frequencies within each sector according to specific topics of the categories selected.

Category (Topic) / Sector	Agronomists	Farmers	Education	Public Administration	Agri-food companies
<b>Baseline (Stage of transition) - one reply</b>	36% perceived that the transformation has partially initiated, 26% perceived that it is not enough	35% perceived that has not initiated 26% perceived equally that is at its initial steps and partially initiated	(a)	41% perceived that the transformation has been initiated	38% perceived that the transformation is initiated 35% perceived that it is not initiated yet
<b>Implementation (Strategy/Aspects to focus)- two replies</b>	67 % To promote agro-industrial symbiosis	46 % Promote mechanisms to integrate, small/medium-scale enterprises in circular processes	45% Organization of specific projects for different age groups	46 % Disseminate more and more the principles of circularity to the public 36% to promote waste separation	35% Existence of a recovery system <sup>(b)</sup> 31% Monitoring residues and emissions <sup>(b)</sup>
<b>Barriers -three replies, except for Agrifood sector that it was two</b>	65 % Lack of adequate knowledge on the subject	71 % Lack of political/economic incentives 63 % Lack of adequate knowledge on the subject	54% Lack of teacher training	19 % Lack of coordination between all the responsible bodies for achieving a CE	22 % perceived Lack of technology 22% perceived also financial impediments

Note: Authors have chosen to ask more specific questions such as for Education: (a) “Why would the introduction of environmental education and circular economy principles be essential?” (max. two replies); and for Agrifood companies: (b) “Which practices have been implemented by the company towards circularity and input reduction?” (max. three replies). More details in Appendix D.

Except for Public Administration, the rest of the sectors, with light differences, in general strengthened the sense that the transformation stage has initiated. For starting to implement circular criteria, Agronomists and Farmers pointed the opinion of focusing on productive units' integration, while Education and Administration, have their specific action to focus. The limitation options within all the sectors are mainly concentrated in the lack of knowledge/training. Relevant is the option perceived with the higher frequency in Administration, which is the coordination between bodies related to CE and Agrifood companies that has featured the lack of technology and financial support.

### **3.4. Similarities and Differences Related to Specific Categories (Topics) related to implementing CE Approach (at Regional and Sectoral Levels)**

As shown in Table 5, specific questions within sectors focused in general only on three categories: baseline to start (stage of transition), implementation (aspects to focus), and barriers (limitations). Therefore, this Section highlights similarities or differences centered in these categories among sectors' respondents according to their regional or sectoral point of view (Table 6).

Agronomists, Farmers, Agri-food companies and Public Administration respondents provided similar regional points of view about the integration of productive units and recycling as strategies or aspects to focus on for the implementation of CE. These sectors also agreed on the limitations. However, respondents from Education sector only focused on recycling as an aspect to address for implementing CE, and even though they share some limitations with other sectors, they also pointed out that CE is a utopic, very difficult to achieve, approach.

Moreover, some features raised at regional level coincide with respondents' opinions regarding their specific sectors such as: need to focus on the integrations of productive units/agro-industrial symbiosis as well as the claim for incentives and the lack of knowledge (Farmers and Agronomists). Nevertheless, regarding to the stage of transition, there were differences in the respondents' point of view at both regional level and specific sector.

While it is highly recommended to address specific sectors in further studies, it is possible that by addressing some of these coincidences at regional level, also the respondents' point of view raised within their own sectors may be better understood. Section 4 will point out some of these issues.

**Table 6:** Answers centered on selected categories and topics among sectors' respondents according their regional or sectorial point of view.

	Category (Topic) / Sector	Within the Sector (Part C of the survey)			At Region (Part B of the survey)		
		Baseline (Stage of transition)	Implementation (Strategy/Aspects to focus)	Barriers	Baseline (Stage of transition)	Implementation (Strategy/Aspects to focus)	Barriers
Sectors inherently related to agriculture (a), Figure 2	<b>Agronomists</b>	It has been partially initiated	Promote agro-industrial symbiosis and mechanisms of enterprises	Lack of adequate knowledge on the subject	equally not initiated and at its initial steps		
	<b>Farmers</b>	At its initial steps and also that has not been initiated	integration into circular processes	Lack of political/economic incentives and knowledge on the subject	not initiated yet	Equally on recycling and on integration of productive units	* Lack of adequate policies * Lack of awareness about the env problem * Lack of economic resources to reorganize in a circular way existing economic system
	<b>Agri-food companies</b>	Equally initiated and not initiated yet	* Existence of a waste, by-product and raw material recovery system * Monitoring of energy, water and pollutant emissions	Lack of technology as well as financial impediments	at its initial steps		
Sectors directly related to agriculture (b), Figure 2	<b>Education</b>	* Teach people to respect nature and preserve the biodiversity * Raise awareness of tomorrow's citizens on the fundamental issue of environmental protection	Organization of specific projects for different age groups	Lack of teacher training	Equally not initiated and at its initial steps	On recycling	* Lack of adequate policies * Lack of awareness about the env problem * The believe that is an interesting but utopian alternative
	<b>Public Administration</b>	Has been initiated	Disseminate the principles of circularity to the public	Lack of coordination between all the responsible bodies for achieving a CE	Not initiated yet	Iqualy on recycling and on integration of productive units	* Lack of adequate policies * Lack of awareness about the env problem * Lack of economic resources to reorganize in a circular way existing economic system

Note: Education: the topic of starting point was replaced by other question as explained in Table 5. Here we have only indicated it answers

### **3.5 Workshop Outputs**

A workshop was organized in order to share the results gathered in the survey. At the moment of the workshop, 25% of the respondents that expressed their will to know the results previous to publication participated. It is necessary to highlight that the survey was carried out seven months before they received the invitation to participate in the workshop.

The respondents' comments at the end of the presentation showed that they agree the subject is at an initial stage and it is a baseline to identify the knowledge and expectations that exist on this topic. In addition, it was recognized that there is still work to be done to create citizen awareness, train professionals, pass new legislation and promote financing linked to this issue.

Even though it was clear that the cooperative sector, specifically agriculture cooperatives, will be addressed in the near future, the comments mentioned this sector as being a key actor to advance circular economy in the region. Particularly, because they work with small and medium farmers in different aspects of circularity.

It was mentioned that the agreement of all sectors on the concept of circular economy facilitates the articulations between them, as well as the development and implementation of public policies. In relation to the latter, they could be aimed at generating resources for research, education and awareness or for the implementation of specific processes. Regarding this point, a concern was expressed about certain current actions from the legislative area that appear as a "patch to linear economy". For this reason, the results of the survey will be taken as a reference to communicate these concerns to legislators, so that they can make future consultations on what type of resources are necessary to raise awareness and promote the circular economy paradigm. Regarding this issue, the need to pass new laws that contemplate the use of effluents in intensive livestock activities explicitly appears.

The participants agree that this paradigm shift must be carried out by society as a whole.

As a general conclusion of the meeting, the idea of beginning to establish the paradigm of circular economy arises strongly and therefore, the generation and transmission of knowledge is key.

## **4. Discussion**

According to the information gathered during this study, interesting outcomes and conclusions can be drawn, which are described below as follows: Section 4.1, discuss the lessons learned from the results in the frame of other studies or experiences; Section 4.2 mentions, some indicators, derived from the results, for monitoring transition towards CE; Section 4.3 alludes to policies, priorities and perspectives; and Section 4.4 refers to the limits of the study and future research.

#### 4.1. Perception and awareness of the transition towards CE. Learned lessons

The five agricultural selected sectors present a similar demographic characterization, since the questionnaire was mainly responded by employees with a high academic level in the area of Agricultural Sciences, mainly residents of the Pampas region of Argentina. This is an area characterized by its linear agricultural production practices, that reduce biodiversity and cause soil erosion among other environmental degradations (Andrade, 2017), as well as social inequity (INDEC, 2021).

The connections between some of the selected categories and specific topics, detailed in Section 2.1 and Table B2 of the Appendix, can envisage the feasibility of future actions, just as to strengthen the education, communication and/or policies on needed concepts. Therefore, they are discussed linking them, when it was possible, in the following paragraphs.

Respondents who had perceived that the concept of CE is “A more Sustainable Production and Consumption Model” together with, “a New Economy Model” hold a PhD and a Master degree. Surveyed that had answered “An Economy Capable of Regenerating” had a Specialization, Bachelor and Post high Schools Studies (Figure 3 and Table C1 in the Appendix). These answers showed an integral point of view as a starting point of a systemic approach, where the integration among many actors and their actions have to contribute to a system design towards circularity patterns (Iacovidou, et al., 2021, OECD, 2020). The association between education level and the concept about CE has been also highlighted by van Langen et al. (2021) and Liu et al. (2009). This interaction of the perceived concept of CE approach with the education level strengthen the foundation for training programs and its implementation.

Moreover, this perception also showed to be relevant for the respondents of the selected sectors since new courses on the subject were claimed when responding about the need of investments (Figure 9). The Argentinean Ministry of Science and Technology have launched the “Introduction to Bioeconomy” course<sup>5</sup> in 2017 and a specific program<sup>6</sup> has been also implemented at the University of Buenos Aires. Even though bioeconomy and circular economy are conceptually linked and complementary in policies strategies (De Schoenmakere et al., 2018), and bioeconomy has a pivotal role in the circular economy strategy (EBCD<sup>7</sup> 2021), they need specific academic programs. Therefore, the systemic approach offered by the circular economy from the design of

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<sup>5</sup> Introduction to bioeconomy course, Available at: <http://www.cursobioeconomia.mincyt.gob.ar/curso-virtual-introduccion-a-la-bioeconomia-argentina/>- last retrieved on July 2021.

<sup>6</sup> Bioeconomy program, Available at: <https://www.agro.uba.ar/bioeconomia/cursos-capacitacion/>- Last retrieved on July 2021.

<sup>7</sup> EBCD intergroup. The role of the bioeconomy in circular economy Available at: (<https://ebcd.org/role-bioeconomy-circular-economy/>) Last retrieved July 2021.



products and process to the residues needs to be implemented at all education levels in order to include its principles and criteria as part of the everyday life of citizens.

It is also worth noticing that respondents' concept about CE is in line with the most selected options about both: a) the reason for implementing CE, which are "Generation of Sustainable Products or Processes from its Design" and "Promotion of a More Sustainable Supply Chain and Logistics Development" (Figure 5), and b) the key subjects capable to drive transition, which are the citizen/consumers (Figure 10). Moreover, the involvement of whole society (Figure 10) added to this conceptual choice of CE (Figure 3), which is linked with the reasons for implementing CE (Figure 5), embrace the dimensions of sustainable development, and it is in agreement with what it was supported by Schroeder et al. (2018), who have linked CE practices with SDGs.

In general, most of respondents perceive that the level of transformation towards CE is not initiated yet or it is at the initial steps (Figure 4). The perception of Agri-food sector is more inclined towards the option of a transition that is making its initial steps, probably because their regional view is specifically focused on the industrial process and coincides with their sector view.

Actually, some of the regional industries have already initiated their transition towards circularity such as Solamb<sup>8</sup>, Adecoagro<sup>9</sup>, ACA<sup>10</sup>, Monje Agricultural Cooperative<sup>11</sup>, as it is also shown in the study realized by CEADS (2019) on certain companies. This choice is also linked with their perception that themselves are key actors to initiate the transition (Figure 10), and that the concrete commitment of entrepreneurs is required for achieving it.

The main driver perceived as relevant to implement CE (Figure 7), was "To Communicate that CE Benefit are Linked to Living Conditions Improvements and Reduction of Environmental Impacts". Bargiolo et al. (2022) also mentioned the importance of space creation for communication and information sharing, which is also a target of SDGs (Schroeder et al., 2018). However, as advantages (Figure 4), respondents focused mainly on the environment, since they have chosen "The Reduction of Emission and Environmental Impacts" in first place, followed by "Waste Reduction". These choices are coherent with EMF (2022) principles: "Design out of Waste and Pollutions". However, the Education Sector, a different perception was found. They mostly pointed out the option of "New Job Creation", a comprehensible selection in a moment in which unemployment rose in Argentina (UNjobs, 2022; INDEC, 2021).

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<sup>8</sup> SOLAMB: biogas for energy and compost Available at: <http://www.solamb.com.ar/website> - Last retrieved on July 2021

<sup>9</sup> ADECOAGRO: grains, ethanol, biogas energy, rice mill - Available at: <https://www.adecoagro.com/index.html> - Last retrieved on July 2021

<sup>10</sup> ACA: plastic recycling service - Available at: [https://www.acacoop.com.ar/planta\\_de\\_recupero.html](https://www.acacoop.com.ar/planta_de_recupero.html) - Last retrieved on July 2021

<sup>11</sup> Monje Agricultural cooperative: grains, methyl-oil, animal feed, biogas - Available at: <http://www.coopmonje.com.ar/> - Last retrieved on July 2021

Regarding to the aspects to focus on for implementing CE in the region (Figure 6), we found a diversity of options, being “Recycling/Reuse” and “The Integration between Productive Units” the favorite ones. While there is slight differences, Agronomists, Education and Administration focus on “Recycling/Reuse”. This choice implies that at the time to implement practices, they focused on a concrete action, even though they have a broader view about the concept of CE approach (Figure 3). Even though this selection is in line with what suggested Gaustad et al (2018), a broader scope also needs to be contemplated at the time of implementation to contribute to the integral approach of CE, i.e. considering both an efficient use of resources during the raw materials extraction and manufacturing, and a prolonged permanence in the economy before being discarded (Hahladakis et al, 2020). This idea also reinforces the need of providing and spreading deeper information (communication and education as stated before) about the circular economy strategies, its multidimensional scope (social, environmental and economic), their application in the different sectors of the economy and the benefits that each of them provide in a context of sustainable production and consumption. Farmers and Agrifood companies somewhat are more inclined towards the option “Integration between Productive Units”, and Agrifood sector towards “The Use and/or Consumption of Products of Renewable Design”.

The analysis, that condense the respondents’ answers regarding the barriers to the advance of CE, show a close agreement with the study done by van Langen et al. (2021), where respondents, all experts in CE, have also seen as limitation, among others, “Low Awareness and Know-how” and “Lack of Policies/Regulations”. It was also found agreement with the study from Ghisellini and Ulgiati (2020) who mention the lack of support (financial and political) to promote investments in CE. This information is complemented with the answers about a concrete commitment of entrepreneurs/political sector/consumers, as well as incentives and financials’ support as required tools/behaviors to initiate transition and to adopt circular models.

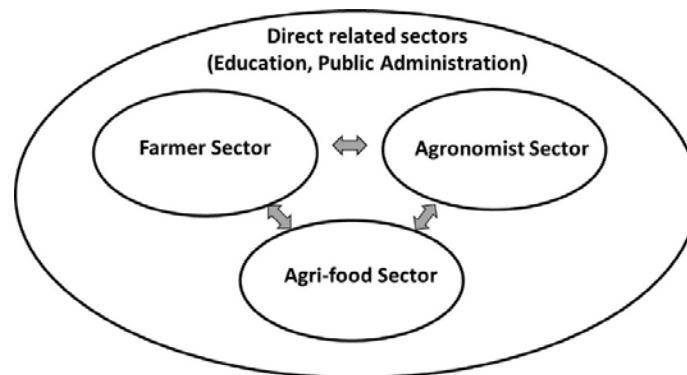
Interesting is also to notice that respondents’ opinion within their specific sectors, in some cases, are in line with the regional view over the same criteria (Table 5). Agronomists within their sector, gave more weigh to promote agro-industrial symbiosis, in concordance with the idea of their opinion at regional level where they have chosen to focus on recycling and re-use of goods and products (Figure 6). Farmers, kept perceiving to strength integration between productive units both, within the sector and at regional level.

Much of the identified aspects are implying a solid idea regarding to the foundations of the circular economy approach, where all social actors have a role (Iacovidou, et al., 2021). This is an important understanding, in a country where the agricultural sector occupies a relevant position in the economic engine, since the CE approach involves the three dimensions of sustainable development

(Shoroeder, et al 2018; Rodriguez-Antón et al., 2021; ODS Agenda 2030 Argentina, 2019; SIDA, 2015). These coincidences of perceptions constitute a good starting point for the design of national and/ or regional programs and policies as well as the selection of indicators for monitoring progress. Inspired examples and support frameworks can be found at Circular Economy Coalition for LAC (2022), I.C.I.S. (2021), EU (2020).

#### 4.2. Suggested Indicators for Monitoring the Transition Towards a Circular Mechanism Approach

Based on the baseline established by the results of this study, it is possible to propose a set of indicators to start monitoring it as contribution for a CE plan, inspired on OECD (2020), EU (2021) and Iacovidou et al. (2021). OECD (2020) classified the indicators in five categories (a- economy and business, b- environment, c- governance, d- infrastructure and technology, and e- jobs) with sub-categories within each. Also, the EU (2021) suggested several indicators that can directly and indirectly contribute to assess CE and finally, Iacovidou et al. (2021) provide a system approach designed to understand the way resource recovery systems operate and to promote deep transformational change. Since a system approach is implicit in the circular economy perspective, addressing some of the CE aspects already assessed might influence others and contribute decision-makers build integrated actions considering levels of influence, (Figure 11 highlights the interaction between sectors).



**Figure 11:** Interaction between sectors of the selected system.

**Table 7:** Selected indicators extracted from this survey, to monitor progresses in the explored sectors. Explanation of their relevance.

Suggested actions	indicators	Sectors impacted	Driven agents	Explanation
Increase/Promote new Courses and Postgrads related to circular and system approach-	<ul style="list-style-type: none"> <li>•N° of courses</li> <li>•N° of students' specialists, or willing to</li> </ul>	Farmer Agronomists Agri-food Education	<ul style="list-style-type: none"> <li>• Agronomists that sit at Universities and</li> </ul>	This was an action mentioned by most of the respondents. Addressing it could help to increase the number of

<b>Suggested actions</b>	<b>indicators</b>	<b>Sectors impacted</b>	<b>Driven agents</b>	<b>Explanation</b>
faculty curricula modification and strength those already in offer <i>(Related to investments on Table 2)</i>	implement criteria of CE approach	Administration	research institutions	professionals related to this topic, as well as increasing skills, awareness and research topics. Many post-degree programs are already on: Erasmus Mundus Master's Degree Program in Circular Economy <sup>12</sup> ; Master Program in CE, LUT University, Finland <sup>13</sup> ; courses such as: CE -University of Amsterdam <sup>14</sup> ; EMF <sup>15</sup> ; Applied CE, Harvard University <sup>16</sup> , courses at CIEC <sup>17</sup> . In Argentina a postgrads course started in 2021 in National University of Córdoba
Increases communication strategies about CE approach and CE practices or criteria <i>(Related to drivers on Table 2)</i>	<ul style="list-style-type: none"> <li>•Nº of citizens aware about CE approach</li> <li>•Nº of CE practices or criteria applied within certain entrepreneurs</li> </ul>	Farmer Agronomists Agri-food Education Administration Society	<ul style="list-style-type: none"> <li>• Agronomists that sit at Universities and research institutions</li> <li>• Independent Agronomists</li> <li>• Communication Professional</li> <li>• Diverse diffusion media</li> </ul>	This is other issue raised in the survey and is a way to illustrate citizens (mentioned as key agent for transformation) about responsibilities/involvement and networking related to consumption, production and disposals
Promote integration units/processes within defined farm developments (farmers or food companies) and area <i>(Related to practices/focus on Table 2)</i>	<ul style="list-style-type: none"> <li>•Nº of select integrated processes within selected developments to keep records</li> <li>•Nº of selected integrated units within a certain area to keep record</li> </ul>	Farmers Agri-food Society	<ul style="list-style-type: none"> <li>• Agronomists in general</li> </ul>	These actions, might be addressing some limitations selected by respondents, and might define aspects to focus within the region/enterprise as well as increase or promote networking

Note: Agronomists, include agricultural engineers, veterinarians and biologists; they are key persons that may occupy different positions within society, such as Professors/Researchers, Farmers, Consultant/Advisor.

<sup>12</sup> Erasmus Mundus master degree programme on CE: Available at: <https://www.jointdegree.eu/en/circle-erasmus-mundus-international-masters-programme-on-circular-economy/>. Last retrieved on April 2022.

<sup>13</sup> Master Programme in CE-Lut Univerity, Finland: Available at: <https://www.lut.fi/web/en/admissions/masters-studies/msc-in-technology/environmental-technology/circular-economy>. Last retrieved on April 2022.

<sup>14</sup> CE course- University of Amsterdam: Available at: <https://www.uva.nl/en/programmes/open-programmes-iis/circular-economy/circular-economy.html>. Last retrieved on April 2022.

<sup>15</sup> EMF:Ellen Macarthur Foundation. Available at: <https://ellenmacarthurfoundation.org/resources/education-and-learning/circular-economy-courses>. Last retrieved on April 2022.

<sup>16</sup> Harvard University. Available at: <https://pll.harvard.edu/course/applied-circular-economics?delta=0>. Last retrieved on April 2022.

<sup>17</sup> CIEC: Centro de Innovación y Economía Circular. Available at: <https://ciecircular.com/ciec-en/>. Last retrieved on April 2022.

### 4.3. Policies, Priorities and Perspectives

The analysis of the answers provided by representatives of the different sectors shows a convergence of opinions towards some barriers that hinder the implementation of circularity strategies, as well as some common solutions.

In order to overcome the identified barriers in the previous Sections (3.2.3; 4.1 and Table 4) it is necessary to design and implement strategies aimed at the promotion and implementation of circular economy schemes. The responses given by the participants provide a general outline of different policies that were identified as influential for this purpose. Not surprisingly, finance and economic-related policies are among the most cited proposals, since the design and implementation of new processes, the incorporation of more advanced equipment, or the need to implement capacity building actions entails higher initial costs. In some cases, the low cost of virgin raw materials or the low quality of recycled material hampers the implementation of some circular economy strategies. The most frequently cited proposals can be synthesized as follows:

- Encouraging actions for the improvement of the financial viability of CE strategies, like e.g. provision of credit lines to circular projects, providing fiscal incentives for producers who incorporate circular economy initiatives.
- Encouraging the use of recycled material through legislation
- Improving the integration of livestock with agriculture and industry for enabling the implementation of circular economy strategies
- Supporting circular economy capacity by building actions aimed at training professionals, technicians and farmers.
- Promoting the on-site renewable energy generation on farms and industries

It's important to take into account that respondents pointed out that there is a lack of coordination between the bodies responsible for implementing circular economy, a lack of a homogeneous national approach and the lack of an area specifically dedicated to Circular Economy. From these responses a strong message is sent out: the proliferation of uncoordinated strategies, measures and policies may undermine the objective of facilitating the implementation of circularity strategies and of achieving the Nationally Determined Contributions submitted by Argentina to help meet the objectives of the Paris Agreement.

It is also worth mentioning that proposals similar to those collected in this work were found in the final documents of the project "Refining Hotspots Assessment in the Food and Beverage Processing Sector in Argentina and Shaping Action to Address them"

[/https://sites.google.com/view/clioporg/investigaci%C3%B3n/proyectos](https://sites.google.com/view/clioporg/investigaci%C3%B3n/proyectos)], and in the T20 Task Force 3 on Food Security and Sustainable Agriculture [[https://www.g20-insights.org/think\\_tanks/t20-argentina/](https://www.g20-insights.org/think_tanks/t20-argentina/)].

#### **4.4. Limits of the study and future research**

Some limitations of the present study need to be recognized. The present survey done to selected sectors related to agriculture, was mainly responded by employees with a high academic level in the area of Agricultural Sciences, mainly residents of the Pampas region of Argentina. Besides, the respondents' academic degree might represent biased answers. However, these limitations in this particular case, due to the distribution strategy adopted and the pandemic outbreak, contributed and ensured that answers about CE approach, which is an emerging issue in the country, were obtained. Moreover, the more knowledge the public targeted has, the more substantiated the answers and less responses on the type of "I don't know or I don't answer". Thus, since most of the questions have two and three options to select, some respondents, preferred not to complete all the options, while most of them completed all the questions in the different categories and its topics. Therefore, since this study was an exploratory first approximation to record the respondents' ideas and perception about CE, establishes a baseline about the approach towards a CE transition, providing a general overview. Therefore, allows to continue with further studies by focusing on specific sectors/aspects related to agriculture, within a certain area and with suggested on-site interviews, in order to deep towards the respondents' awareness and self-awareness about the circular economy process as they see, analyze and understand in the context of their region and/or sector. Moreover, they could be specifically addressed to individuals with different studies to confirm the present study results and deepen questions according the first sight provided by this study.

#### **5. Conclusion**

Living the current environmental, social and economic imbalances the productive-economic model that responds to a linear paradigm has led us to, it seems that the approach taken by circular economy needs to be implemented. However, it should not be forgotten that it is a system-dynamic oriented approach in permanent construction and improvement that must balance the three dimensions of sustainability. The objective of this exploratory paper was to identify the level of awareness, current situation and expectations of the transition towards a circular economy approach within five activity sectors of agriculture and related sectors in Argentina (Agronomists, Farmers, Agrifood companies, as well as those directly related to them, Education and Public Administration) based on opinion and perception/awareness in an online survey. While it is

necessary to expand the size of the sample of each sector, the present study lays the foundations and opens the way to future in-depth analytical and explanatory research to identify the actors' plurality of perspectives within a specific sector. This research focused on the concept, current situation, aspects for implementing CE approach, barriers and issues of governance for facilitating the transition towards a circular economy. Even though with some differences (sometimes minor ones), in general, most of the sectors coincided on the meaning, reasons, drivers and advantages of implementing CE, aspects to focus on, barriers, areas to invest in and key figures to lead the change. This study can lay the foundation for creating a framework for a specific national program involving actors of different sectors and where regional ones, key to the CE paradigm, can be backed. Another highlighted issue was the need of investing in education, designing programs that include the integral approach that circular economy involves within specific programs at different educative levels. The different participants in this project may have different roles in the road to a more circular economy, Farmers and Agrifood sectors are involved with the management of primary and processed products while Agronomists and members of the Education and Public Administration fields are usually a step back in contributing with know-how, innovation, paperwork and policies. In order to succeed in this endeavor all these sectors need to work in a coordinated framework. A coordination between the different national bodies which are related with the implementation of circular economy strategies in different sectors is imperative. In fact, Circular Economy calls for the integration of the different sectors of the economy, but the integration will be hampered if the actors and policymakers of the different compartments of the public administration do not relate to each other. The challenge is to find organized and progressive steps to build interactions, programs, actions and legislation to favor the integral (between sectors) and internal (within a sector) transition.

#### **CRedit authorship contribution statement**

**Gloria C. Rótolo:** Conceptualization, Methodology, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Funding acquisition, Project administration. **Chiara Vassillo:** Conceptualization, Survey design, Methodology. **Aranza A. Rodriguez:** Survey implementation, Workshop administration, Data curation. **Luciana Magnano:** Methodology, Data curation, Formal analysis, Writing – review & editing. **Marcelo Milo Vaccaro:** Methodology, Writing – original draft. **Barbara M. Civit:** Methodology, Writing – review & editing. **Melina S. Covacevich:** Workshop administration, Writing – original draft, Writing – review & editing. **Pablo A. Arena:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Sergio Ulgiati:** Conceptualization, Writing – review & editing, Supervision

## **Declaration of competing interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## **Acknowledgement**

Gloria C. Rótolo and Sergio Ulgiati acknowledge the funding from the European Commission via the Horizon 2020-MSCA-RISE-2018 Program, under Project N° 823967 named “Promoting circular economy in the supply chain” (ProCEedS). Chiara Vassillo acknowledges the funding from the European Commission’s research program Horizon 2020-SC5-2020-2 scheme, Grant Agreement 101003491 (JUST Transition to the Circular Economy project). The authors thank the editors and anonymous reviewers for their time and contributions to help improving the quality of the manuscript, as well as to the anonymous respondents for their predisposition on contributing with this project.

## **Appendices A, B, C and D. Supplementary data**

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