HEIs, Latin America Circular Economy

Subjects: Others | Engineering, Environmental | Green & Sustainable Science & Technology

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HEIs (Higher Education Institutions) are main actors in the economic development and innovative potential of regions, but now and an increasing number of additional roles are expected. HEIs, as institutional actors, are enablers of social, economic, and cultural development, and sustainability. HEIs can foster collaboration between actors and catalyze public awareness and engagement in CE practices.

circular economy | Latin America | higher education institutions | industrial ecology | developing countries | bibliometric analysis | systematic review

1. Introduction

The Circular economy (CE) arises as a concept that may support sustainable development at various levels (industrial/manufacturing, business, consumption, and social) [1][2][3][4][5][6][7][8][9][10][11][12] and is in line with other sustainability strategies, which contributed to its meaning [13][9][11][12][14][15], and has gained great momentum during the last years [3][4][7][16][17].

The research in the concept is intense, and it is derived mostly from experiences in developed countries from the Global North. Due to their industrialization, these countries have passed take-back laws that aim to reduce the toxicity of materials, increase the availability of recyclable materials and prevent pollution [18]. As a result, the CE concept has been considered to promote efficient production and sustainable consumption [19]. In fact, CE has already influenced policies in large global economies, such as China, Japan, the United Kingdom, and the European Union [15][16]. However, while ambitious and committed efforts towards CE were reported in these regions, the path that emerging economies are taking has not yet been properly researched [20]. For countries that rely on different activities such as agriculture, fossil fuel, and mineral extraction, specifically Latin American countries (LA countries), CE requires a different roadmap. The COVID-19 pandemic in Latin America revealed significant shortcomings in the linear economy; the vulnerability of global value chains, the depletion of natural resources, and the exacerbation of social inequalities. The CE shows great potential if inclusive development is promoted in these regions [2][21]. The coordination and engagement of multiple stakeholders are relevant for a CE transition. However, CE is not only a “technological and business-oriented issue, social and institutional contexts matter” [22]. Achieving circular economic development in Latin American countries requires transparent, robust, and accountable institutions. It was proven that institutions have a strong bearing on the capacity of governments in Latin America to achieve economic development [23].

Higher education institutions (HEIs) represent the type of institution in LA countries which has an essential roles not only for research but also for the unity of different actors such as government, industry, and civil society [24]. The intellectual capital is the value of intangible assets of HEIs, such as scholars' knowledge and expertise, and it is relevant for any effort towards CE [25][26]. HEIs are considered main actors which aid all relevant efforts towards sustainable development [8][27][28][29]. Additionally, they are expected to play an essential role in the global sustainability agenda of these decades [30][31]. The engagement of HEIs in developing countries poses unique challenges [32][33], as HEIs are able to address regional and cultural differences when importing sustainability solutions from developed regions [34] and have a unique opportunity to harness the benefits of local circular practices, which are commonly performed in Latin American countries by people out of necessity [18]. While defining the role of HEIs regarding CE, there should be caution with "one-size-fits-all" approaches, and there may already be some degree of embeddedness of HEIs in local social issues, which should be understood as well [35].

The role of other stakeholders was already addressed by reviewing the literature. There are CE reviews about policies [17][36], business models [37], industry [38], and supply chain [39]. However, there is a lack of research on the role of HEIs in the pursuit for a CE in Latin American countries, even though these are main stakeholders for CE. Thus, a route for HEIs' involvement in CE does not exist in the region. The present study addresses this gap by providing an analysis of literature under a bibliometric systematic and narrative approach. This research aims to define the role of HEIs for the transition to CE in Latin American countries and poses an opportunity to contribute to the CE body of knowledge from a Latin American , Global South perspective by answering the following main research question: what is the role of HEIs in the transition to a CE in Latin American countries?

2. Activities Related to Circular Economy Keywords Involving HEIs in Latin American Countries

Figure 1 provides insights from the results of Search 1 [40][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66][67][68][69][70][71][72][73][74][75][76][77][78][79][80][81][82][83][84][85][86][87][88][89][90][91]. **Figure 1** presents the number of articles by CE keyword, year, country, journal, and affiliation. This information allows scholars to understand how activities, considered "circular" to some degree, were addressed without considering the current CE concept. **Figure 1**a shows the CE keywords and the number of articles with topics related to each keyword. Those with more results are associated mainly with waste management (recycling, collection, and reuse) and energy (renewable and biogas). The number of articles on related CE activities has increased in the last years; 77% were published after 2015, and 30% only in 2020, as shown in **Figure 1**b. This shows the increasing trend in topics related to CE in LA countries where HEIs are involved. It is important to note that most of these studies do not address the CE concept as understood in this article but address topics related to CE keywords.

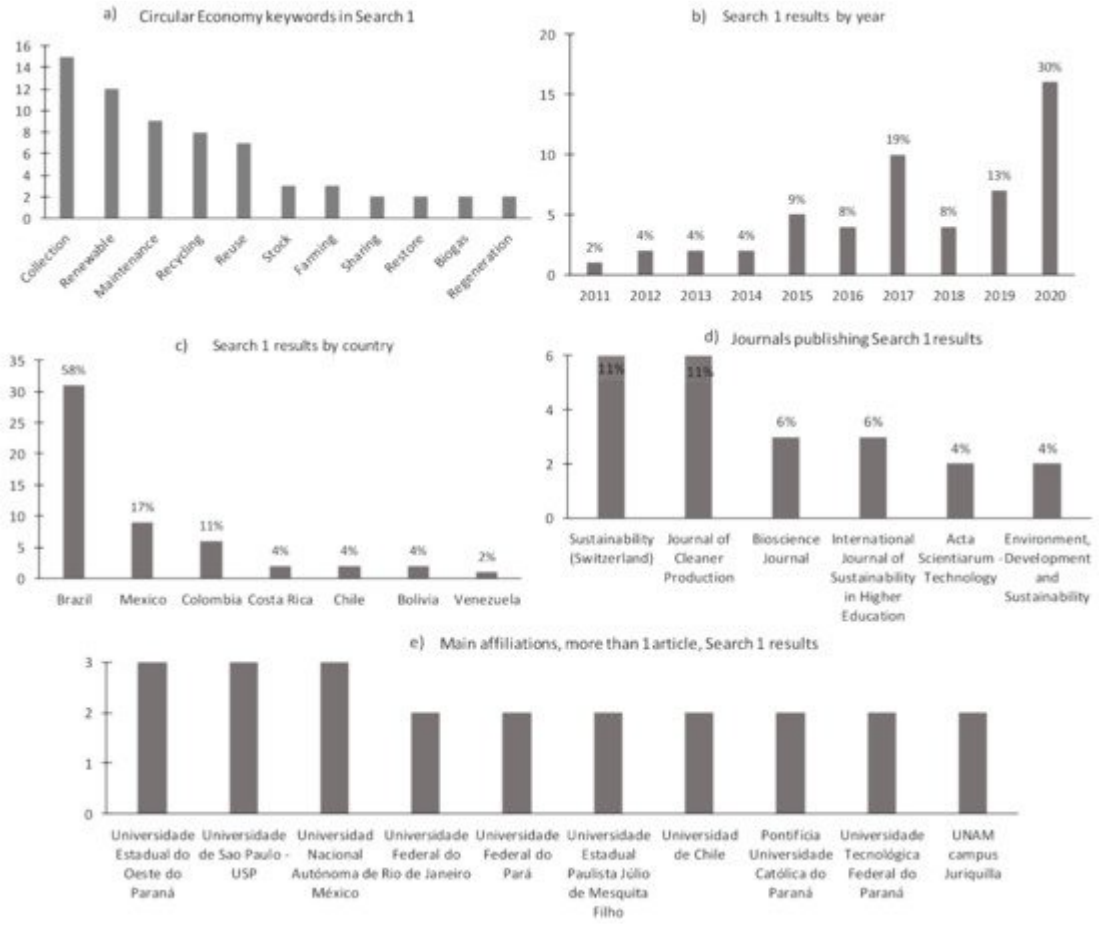

Figure 1. Results for Search 1.

Brazil is the main contributor to Search 1 results (58%), followed by Mexico (17%) and Colombia (6%). These three countries sum up 87% of the articles (**Figure 1**c).

Sustainability (Switzerland) and *Journal of Cleaner Production* are the journals with most articles, each with 11% of the articles (**Figure 1**d), and Brazilian universities are the main contributors, as expected given the fact that Brazil is the country which contributed with more than half of the articles. A Chilean and a Mexican university count more than one publication each (**Figure 1**e).

Figure 2 shows the author keywords co-occurrences (minimum three occurrences) for selected articles of Search 1 (53 articles). The most occurring author keywords are: “sustainable development”, “sustainability”, “Brazil”, “recycling”, and “waste management.” Other keywords with high occurrence are related to water and energy: “wastewater”, and “renewable energy.” This figure identifies that the most researched topics in these articles are related to waste management and energy efficiency and that the HEIs involved are mainly from Brazil.

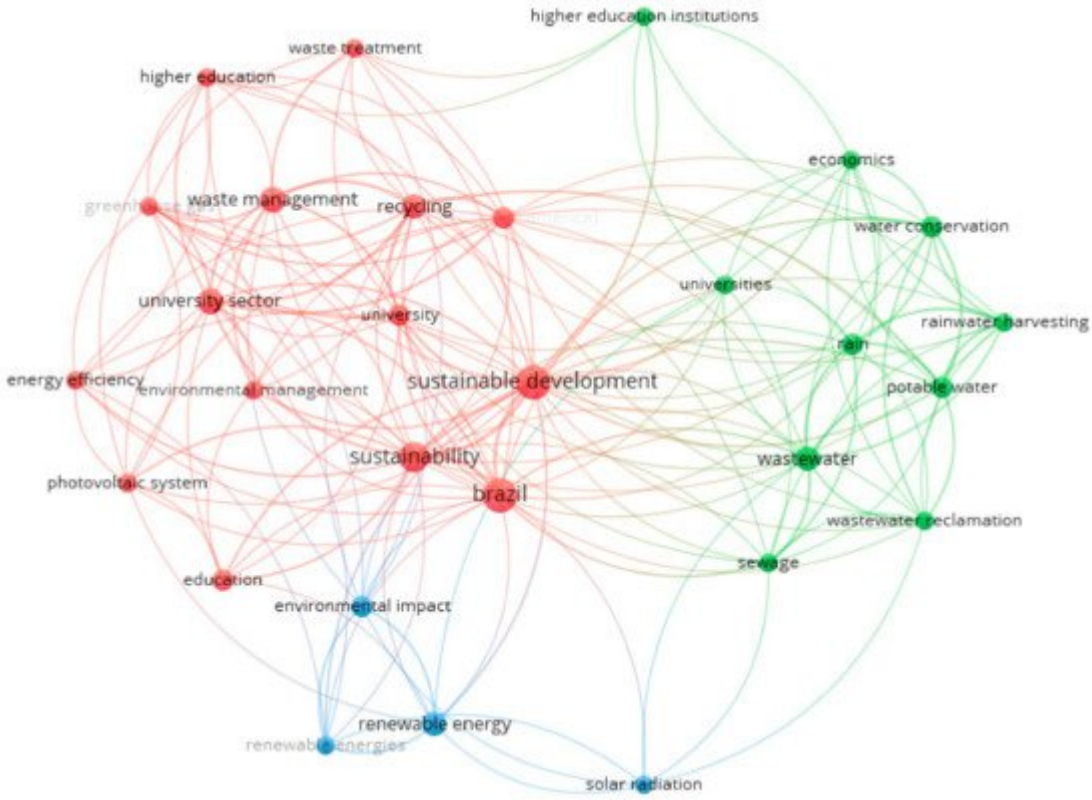

Figure 2. Author keywords co-occurrence for Search 1 results. Minimum three occurrences.

3. Circular Economy Research in Latin American Countries and the Extent of Higher Education Institutions' Involvement

The following articles were selected from Search 2: [20][21][39][92][93][94][95][96][97][98][99][100][101][102][103][104][105][106][107][108][109][110][111][112][113][114][115][116][117][118][119][120][121][122][123][124][125][126][127][128][129][130][131][132][133][134][135][136][137][138][139][140][141][142][143][144][145][146][147][148][149][150][151][152][153][154][155][156][157][158][159][160][161][162][163][164][165][166][167][168][169][170][171][172][173][174][175][176][177][178]. **Figure 3** presents insights into this set of results, including articles by year, country, journal, affiliations, and authors, and also presents which of these articles were related to HEIs. These articles refer to the current CE concept. **Figure 3**a shows the distribution per year. No articles were found before 2016. Publications in the last two years (2019 and 2020) count for almost 80% of the results, while articles from 2020 represent half of them. This shows how novel the CE research is in the region is, and how publications show a growing trend. However, from 90 articles, only four (4%) involved case studies related to HEI campuses, food waste-to-energy [99], waste management strategies [150], collection of recyclable waste [124], and community engagement [139].

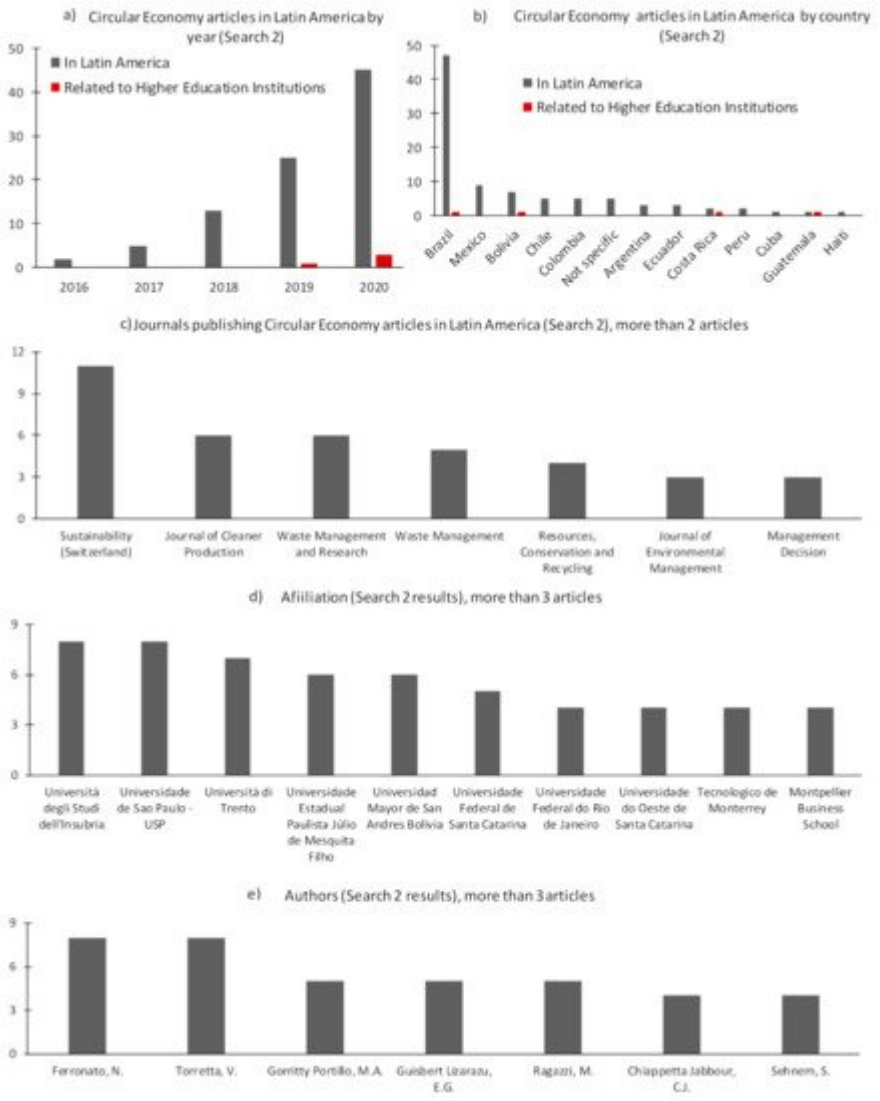

Figure 3. Results for Search 2.

Half of the results (52%) in Search 2 are from Brazil, as **Figure 3**b shows, which is remarkable compared with the second country on the list, Mexico, with approximately 10% of the publications. These are followed by Bolivia (8%), where the authors with more publications (See **Figure 3**e) have been working with topics related to waste management [125][126][129][145]. Brazil, Mexico, Bolivia, Chile, and Colombia sum up 80% of the results.

The journals with more publications are *Sustainability* (Switzerland) (12%), *Journal of Cleaner Production* (7%), *Waste Management and Research* (7%), and *Waste Management* (6%). The rest counted for 4% or less of the results (**Figure 3**c).

Figure 3d shows the affiliations with more than three articles, and **Figure 3**e shows the authors with more than three articles. Most occurring affiliations include Italian HEIs, which correspond to the top two most occurring authors. The most occurring authors hold co-authorship in some articles [123][125][126][127][129][164]. Most top affiliations are Brazilian HEIs, but there is also a Bolivian and a Mexican HEI.

Figure 4 shows the author keyword co-occurrence (keywords occurring at least four times) from Search 2 results. “circular economy” is the most occurring keyword, as these articles directly address the current CE concept. Besides that, the most occurring keywords are: “sustainable development”, “waste management”, “recycling”, “Brazil”, “sustainability”, “human”, and “municipal solid waste”. This evidences that approaches related to waste management are at the core of CE research in LA countries and that Brazil is the main contributor.

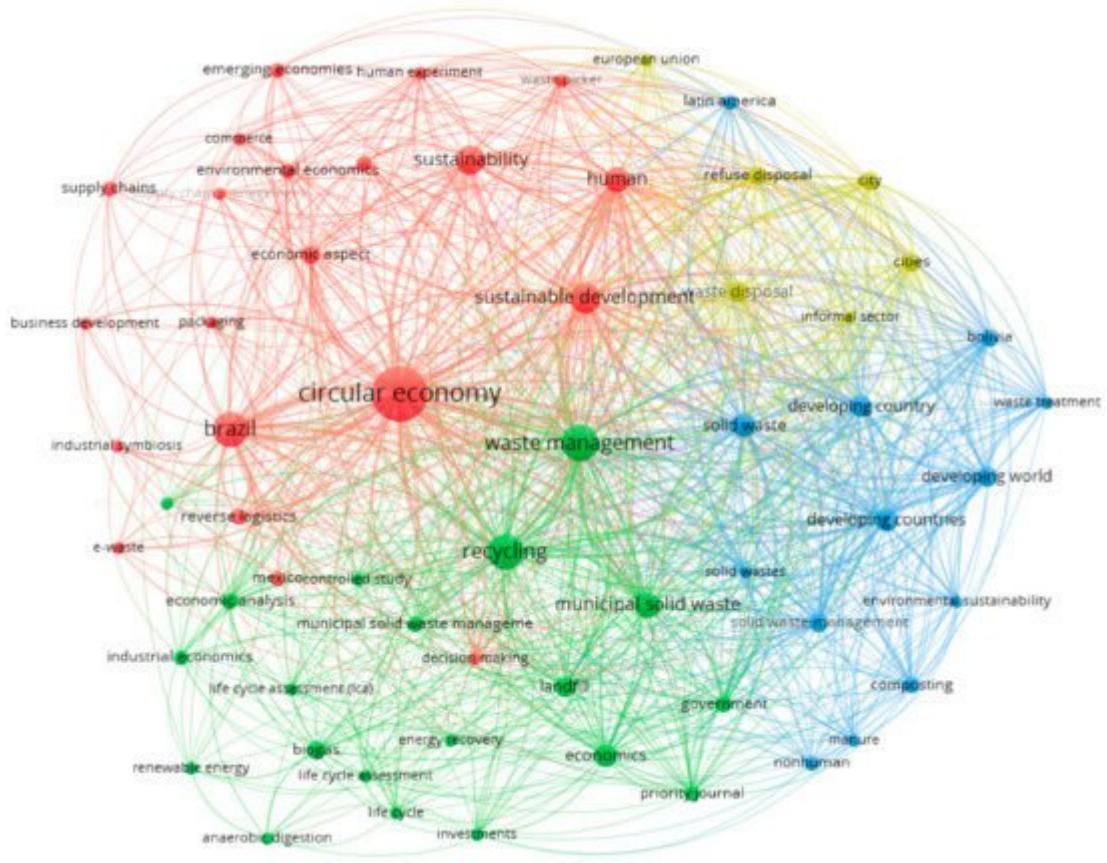

Figure 4. Author keywords co-occurrence in Search 2. Minimum 4 occurrences.

4.6. Circular Economy and Higher Education Institutions

International commitments, such as the 2030 Agenda and the Sustainable Development Goals, exert pressure to improve the engagement level of HEIs in some areas of sustainability action (energy efficiency and renewable energy), which may be related to CE [179]. The importance of HEIs for sustainability challenges has been highlighted by national and international frameworks [180].

Over the last two decades, the interest in higher education for sustainable development has increased among scholars [30]. HEIs are main actors in the economic development and innovative potential of regions, but now and an increasing number of additional roles are expected [181][182][183]. HEIs, as institutional actors, are enablers of social, economic, and cultural development [33][34][182][184][185][186][187][188], and sustainability [180][189][190][191]. HEIs can foster collaboration between actors and catalyze public awareness and engagement in CE practices [192]. A main contribution of HEIs is the generation of human capital, which understands the need to pursue sustainable

development and is very important to drive the implementation of CE [10][107][193]. It was shown that the intellectual capital of HEIs influences directly and positively in such initiatives [26][27]. The role of HEIs in developing countries should be addressed adequately given the specific context where it operates [184]. It is clear that all HEIs are now expected to engage actively in national and regional development, both in developed and developing countries; however, the way that HEIs should engage should be agreed [33].

The role of HEIs has evolved. Now sustainable development and outreach ("third mission" contributing to socio-economic development) compromises are expected by society (stakeholders, civil society, governments, and industry) [32][35][194]. HEIs may promote action towards sustainability by internal operative and cultural changes and by their triple function: teaching, researching, and community engagement [9][28]. Regional HEIs can engage closely with local communities, providing the region with a self-developing capacity, thus obtaining mutually beneficial outcomes [29]. HEIs outreach can be addressed by building collaboration channels with local actors (communities, planners, government bodies, NGOs) and fostering student participation in engagement and professional projects [31]. Thus, HEIs can tackle circular behaviors already established in the local communities (which may be disregarded by current CE theory), gather them as a local knowledge body, and merge them with outside knowledge on CE business models. HEIs have a unique opportunity to harness the benefits of the local circular practices commonly performed in developing countries by people out of necessity, not by choice [18].

There are various ways in which HEIs relate to regional development, which depend on the characteristics of the region [188]. If the role of HEIs regarding CE in Latin American countries is to be defined, simultaneously occurring challenges should be acknowledged, such as massification, globalization, marketization, digitalization [28], and now even adaptation to the COVID Pandemic, [195]. To cope with these increasingly complex demands, HEIs should be integrative and networked (University 4.0) [28].

4. Addressing the Role of Higher Education Institutions for the Transition to a Circular Economy in Latin American Countries

Table 1 sums the factors that aid in defining the role of HEIs for the transition to a CE in Latin American countries. The way HEIs engage in developed regions may not be suitable to less developed regions, given poorer infrastructure and technology conditions [196], different cultural traits, and institutional constraints, which may hinder the catalytic role of HEIs in developing countries [33]. There are different types of HEIs (research, entrepreneurial, and engaged), and thus different roles and engagement modes for each type [182]. In the least developed regions, research-oriented HEIs may be the only link to the global scientific knowledge network, playing a central role in fostering development in such areas [184]. These institutions allow knowledge and technology transfer from the Global North, where CE is gaining great momentum [197].

Developing countries face some unique challenges and require some unique elements regarding HEIs, especially research-oriented ones (when compared with developed countries): creation and retention of a scientific

community, research relevance to society and industry, cultural and social development and critique, formation of a new generation of scholars and technicians, research in national languages [184].

Furthermore, practical efforts of HEIs do not occur in isolation but require the engagement of other actors and stakeholders and benefit from participating in formal and informal networks [29][187][197]. There must exist an absorptive capacity in the region to incorporate novel knowledge into society [33].

CE implementation requires both top-down and bottom-up approaches [15]. However, initiatives on campus may go beyond. Brinkhurst et al. [198] suggested considering “faculty and staff” as the “institutional middle”, whose leadership roles are critically important to change behaviors towards sustainability.

Table 1. Factors that aid to define the role of higher education institutions for circular economy in Latin American countries.

Factors Which Aid to Define the Role of HEIs for the Implementation of CE in Latin American Countries	Implications for the Role of HEIs
Factors relating to the rest of CE stakeholders in developing countries: - The distrust of governments [199], which are drivers for CE in the Global North and in China [17][200]; - The characteristic barriers in developing countries for innovation activities perceived by firms [201]; - The lack, or low reports, of non-governmental organizations promoting CE in Latin American [98]; - The lack of inclusion of informal practitioners of circular activities already existent in Latin American countries in CE discourse [20][145][202]; - Less environmental literacy on the consumer side (citizens) [203][204][205]; - Actors demonstrate a lack of awareness of the benefits of CE solutions [94]. - The inclusion of small producers in CE discourse and practice should be promoted [206]; -	HEIs: - Are expected to become cultural change agents for sustainable development, and their role may be greater than the rest of stakeholders in this endeavor [27]; - Are main promoters of innovation in developing regions [208]; - Can aid decisionmakers and governments in defining the CE policy and agenda; - Should contribute to the environmental literacy of members (staff, students, faculty), citizens; - Can reach informal practitioners of circular activities and small producers through community engagement and outreach activities; - May mediate between actors with differing attitudes towards CE. This role should be studied. -

Factors Which Aid to Define the Role of HEIs for the Implementation of CE in Latin American Countries	Implications for the Role of HEIs
The lack of suitability between CE solutions and the context [207]; - Actors with differing stances on CE [11]; - The lack of articulation among actors [92].	Given the eroded perception of government and institutions, and the characteristic barriers that firms face for innovating for CE in Latin American countries, HEIs may become the main drivers for the transition to CE in these regions, among other stakeholders. However, this role has been just marginally explored in recent literature on CE.
Factors related to characteritics of Latin American countries: - Lack of enabling social, institutional, and political conditions [33][207]; - High corruption rates [207][209]; - Informal circular activities already occurring out of necessity, and contributing importantly to sustainability. Actors related to these activities are usually part of vulnerable populations [18][21][100][127][136]; - High dependence on resource extraction [18]; - Different worldviews [210]; - Different ways of HEIs engagement [184]; - Consumer behavior with low environmental literacy [207]; - Lack of technological infrastructure [207].	HEIs: - May not address political problems and corruption rates, as it does not fit the expected HEIs mission. - Can harness the already existing knowledge, and know-how of informal organizations performing circular activities and merge it with state-of-the-art outcomes from developed regions [18], thus delivering an inclusive CE agenda; - Can promote innovation regarding the dependence on resource extraction; - Can engage (for CE) in different ways, depending on the context, thus reflecting different worldviews accordingly.
Factors related to the barriers to innovation in developing countries: - Knowledge barriers [211]; - Lack of training opportunities [100]; - Lack of circularity in HEIs curricula [10].	HEIs: - Can address these barriers directly by its teaching, research and outreach functions [10][212][181][213]; - Generate human capital [6][196] which allows society to address CE transition according to the context;

Factors Which Aid to Define the Role of HEIs for the Implementation of CE in Latin American Countries	Implications for the Role of HEIs
	- Generate external impacts from the individual's education, technology and productivity spillovers [214].
Factors related to circularity drivers in developing countries: - Know-how on circular activities already exist in developing countries (e.g., informal waste sorting) [18][202]; - Frugal innovation solutions allow for achieving circular products and inclusive energy use [101]; - Human capital is very important to handle CE transitions [107].	HEIs can help to integrate informal sectors in CE; education efforts can be expected from CE scholars and practitioners [12].
HEIs expected roles [35]: - Community engagement [191]; - Stakeholders synergies for innovation (HEIs, industry and government) [215]; - Local knowledge on circularity which can be harnessed by scholars and included in a CE framework [136]; - Collaboration with stakeholders and benefiters [216].	HEIs: - Are enablers of regional development in all aspects [34][186]; - Outreach requires collaboration channels with the rest of actors and promotes student participation in engagement and professional projects [31]; - Should be integrative and networked (University 4.0) [28].
CE theoretical gaps and limitations - Despite the relevance of decoupling economic growth from environmental degradation for developing countries, it is not clear if it can occur with the implementation of current CE discourses [217]. A lack of rigor on the understanding of thermodynamics principles which govern any phenomena occurring in the universe,	Research (fostered by HEIs): - Can influence CE meaning [1], thus acknowledging these gaps and avoiding overoptimistic discourses; - An "optimal circularity", or upper circularity, can be defined [219] from the assessing of local contextual factors;

Factors Which Aid to Define the Role of HEIs for the Implementation of CE in Latin American Countries	Implications for the Role of HEIs
including any form of economy, entail the risk to indulge in overoptimistic stance towards CE [8][218][219][220][221]; - Rebound effects of CE have not been thoroughly addressed by scholars [8][222][218].; - Lack of consensus among stakeholders about CE [223][221]; - CE discourse can include, or not, a human development component [224][203][2]; - The paths towards CE that emerging economies may be pursuing are poorly researched [20].	- Rebound effect of CE initiatives should be understood; - The relevance of the social side of CE should be considered; - Theoretical tools may aid in the practice of CE in Latin American countries: - HDI [2], SSE [224], inclusive economy framework [136], circular society framework [1].

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