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Article

Analysis of research on the SDGs: The relationship between climate change, poverty and inequality.

María del Carmen Pérez-Peña [1], Mercedes Jiménez-García [1], Jose Ruiz- Chico *[1] and Antonio Rafael Peña- Sánchez [1]

[1] INDESS (University Institute for Sustainable Social Development), Department of General Economy, Faculty of Social Sciences and Communication. University of Cadiz, Avda. de la Universidad, 4-11406 Jerez de la Frontera, Spain; carmen.perezpena@uca.es (M.C.-P.); mercedes.jimenezgarcia@uca.es (M.J.-G.); jose.ruizchico@uca.es (J.R.-C.); rafael.pena@uca.es (A.R.P.-S.).

* Correspondence: jose.ruizchico@uca.es (J.R.-C.)

Abstract: Since its adoption in September 2015, the 2030 Agenda has laid the foundations for a model of shared prosperity for a sustainable world. We are going through a complicated pandemic that shows profound inequalities affecting our economies, health, and quality of life. For this reason, our aim in this work is to make known the state of the art of scientific research related to inequality, poverty, and climate change and to propose lines of improvement that can contribute to achieving 3 of the 17 SDGs (End poverty-SDG 1-, Reduce inequality-SDG 10-, and Climate action -SDG 13-), proposed in the 2030 Agenda. To do so, we have used a systematic literature review methodology. The results show that poverty, inequality and climate change is a subject that has been little studied and articulated by researchers, with significant differences between the different areas studied. Topics related to sustainability and economics are those with the highest number of publications (51.7%). The rest are distributed among the 12 existing departments. Another relevant finding is that the effects of climate change are more pressing for more vulnerable populations, including impoverished women from rural areas and children from underdeveloped countries. This is a gender and social inequality that has been little addressed in climate change studies. Food security and energy poverty is another under-exploited aspect in this area. According to the results obtained in this work, we consider that the circular economy could improve these indicators, constituting a line of future research. Thus, one of its main objectives is to eliminate negative externalities, specifically existing social inequalities within the current linear economy model.

Keywords: Food security, agriculture, health, Sustainable Development Goals, 2030 agenda, gender studies.

1. Introduction

The 2030 Agenda sets out 17 goals with 169 inclusive and indivisible targets covering the economic, social and environmental spheres whose main purpose is to provide healthy livelihoods, free from poverty and hunger in healthy and safe environments. They will successfully combat the threats of climate change with sustainable production pat-terns and efficient and effective economies [1]. These 17 goals include ending poverty (SDG 1), reducing inequalities (SDG 10) and climate action (SDG 13) [2].

Extreme poverty has most often been associated with rural areas [3]. Globally, 78% of people living in extreme poverty live in such an environment and depend on agriculture for their livelihoods [4]. In 2018, 4 out of 5 people affected by poverty lived in these rural areas, with children and women being the main protagonists. The areas most affected by this situation remain concentrated in Southern Africa and India [5,6]. However, due to the Covid-19 pandemic, extreme poverty is spreading to overcrowded urban centres, affecting a population that depends on informal and manufacturing services for its livelihood. In the face of this paradigm shift, extreme poverty

will reach more than 150 million people in 2021, who will have to subsist on less than $1.90 a day [7].

There is a direct relationship between poverty and inequality [8, 9]. The latter has increased in recent years [10] because of the effects of the current pandemic and climate change [11]. Social vulnerability is closely related to the climate threat, and the stance of governments is critical to curbing inequalities [12]. The impacts of climate change will be most severe and immediate for billions of poor people, especially those whose livelihoods are based on agriculture and subsistence activities and are directly dependent on weather patterns [13, 14]. Women, youth, the elderly, ethnic and racial minorities, indigenous and rural populations in underdeveloped and developing countries are the most affected by these effects [15].

Solutions are urgently needed to mitigate climate change, end poverty and reduce inequality. Against this backdrop, the circular economy could be one of the elements contributing to solve this problem. The circular economy concept proposes a paradigm shift from the current linear economy model based on non-renewable resources to prioritise sustainability and resource renewal [16]. Based on three pillars (reduce, reuse and recycle), this model makes it possible to continue doing business in a way that supports society's economic growth and environmental and social sustainability [17], as well as reducing negative externalities and curbing social inequality [16].

Under this approach, this work aims to know the state of the art of scientific research related to poverty, inequality, and climate change, and to propose lines of improvement that can contribute to achieving 3 of the 17 SDGs (End poverty -SDG 1-, Reduce inequality -SDG 10-, and Climate action -SDG 13-), proposed in the 2030 Agenda.

2. Materials and Methods

We have carried out a systematic literature review (SLR) to conduct this study. We have chosen this method because it synthesises the available evidence that summarises the in-formation on a particular topic [18]. It is characterised by being systematic, critical, rigor-ous, specific and reproducible [19,20]. We have followed different phases to carry it out [19, 21], as detailed below:

- Phase 1: Identification of the research questions

In this phase, we have posed these research questions (RQ) to achieve the objectives:

RQ1: What are the main papers that study poverty, climate change and social inequality?

RQ2: In which journals are these papers published?

RQ3: What has been the evolution of these papers over time?

RQ4: Which countries, universities and areas of knowledge show a more significant concern for this type of research?

RQ5: Who are the most productive authors?

RQ6: What research topics are you addressing in the field of poverty, climate change, and social inequality?

- Phase 2: Search strategy

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To carry out this stage, we have considered the search terms of the information to be dealt with [22]. To do this, we used the main concepts referred to in this research, recognising the different forms of writing, and synonyms and abbreviations [19]. In addition, the quality standards of the Prisma statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) were used to include the relevant items and ensure the internal consistency of the systematic review [23].

We have chosen two of the most relevant academic databases for the information search process: Web of Science (WoS) and Scopus. They mainly collect scientific research products because of their multidisciplinary and international nature. Both are identified with an impact factor in their publications: Journal Citation Report (JCR) for WoS and SCImago Journal Rank (SJR) for Scopus [24].

The algorithm used in both databases was "poverty", "climate change", "inequality" with AND as the Boolean operator. The study period covers the period from 1999, when the first publication appears according to the search parameters used, until 2020.

As a result of the search, we obtained 720 papers, which were filtered according to the inclusion and exclusion criteria (table 1). For this purpose, we retrieved scientific articles with a publication date between 1999 and 2020 [25], published in English. To meet the quality criteria of the literature, we searched for articles published in scientific journals [26], and those referring to primary studies [27], obtaining 480 contributions (279 from WoS and 201 from Scopus). We exported these documents to the Endnote database to continue applying the inclusion and exclusion criteria [28] as indicated in table 1.

Table 1. Inclusion and Exclusion Criteria.

Inclusion	Exclusion
Period: 1999-2020	Duplicates
Language: English	Not related to the topic "Poverty, Inequality and Climate Change" [21]
Primary Works [27]	Restricted access to full text [29]
Articles in scientific journals [26]	Unquoted articles [30]

Once we have defined the inclusion and exclusion criteria, the next step is the selection of articles. For this, we have followed several stages (Figure 1).

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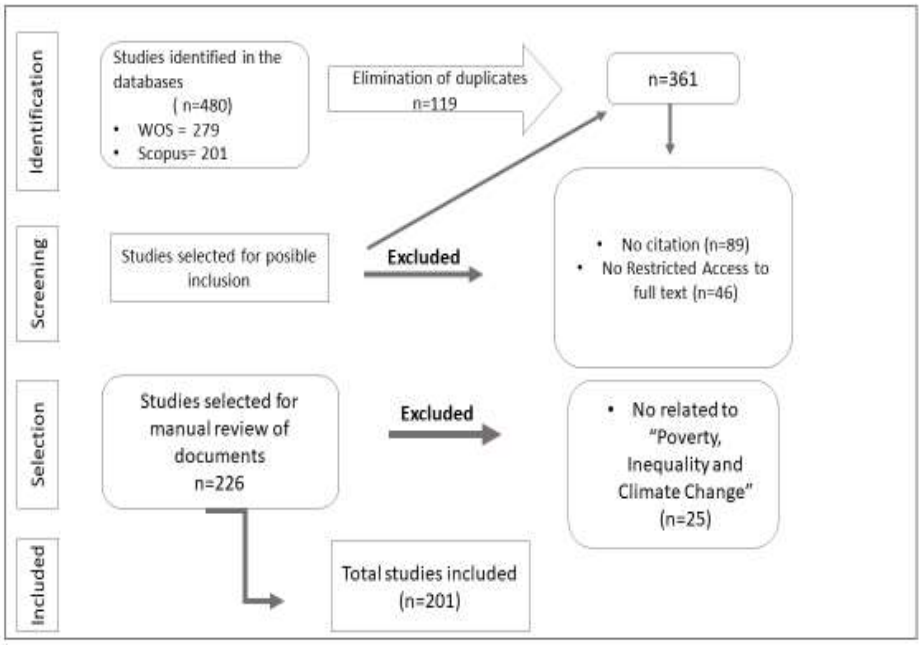

Figure 1. Flow chart of study selection process based on the PRISMA statement.

As shown in Figure 1, in the first stage, we identified 480 articles, and we exported them to Endnote to eliminate duplicates (n=119). In the second stage, we excluded all those articles that do not have restricted access to full text (n=46) [29], and those that do not have any citations (n=89). This is a determining aspect of their relevance as a significant indicator of influence [30]. In the third and final stage, we manually analysed the title, abstract and keywords of the 226 resulting articles. We discarded all research whose analysis does not focus on poverty, climate change and inequality [21] (n=25). We also carried out a complete reading of the articles, focusing mainly on their conclusions to meet the objectives pursued in this paper.

From this process, we have obtained 201 articles for review, and detailed reading that corresponds to the questions and objectives set out in this research.

3. Results

We have analysed the articles obtained, taking into account the following parameters: year, scientific journal, country and university, area of knowledge, methodology, author and number of citations, the result of previous research and main limitations related to the subject studied.

3.1. Number of Publications per Year

As shown in Figure 2, the number of publications related to poverty, climate change and social inequality began to increase from 2011 onwards, with 2018 being the year with the highest scientific output. Among the reasons that aroused academic interest in the topic in question were the concerns of the UN committee of scientists about the increase in extreme phenomena - rising sea levels, the decline of ice in the Arctic, the increase in global warming of the planet by 1ºC due to the emission of greenhouse gases - and the increase in inequality and poverty at a worldwide level.

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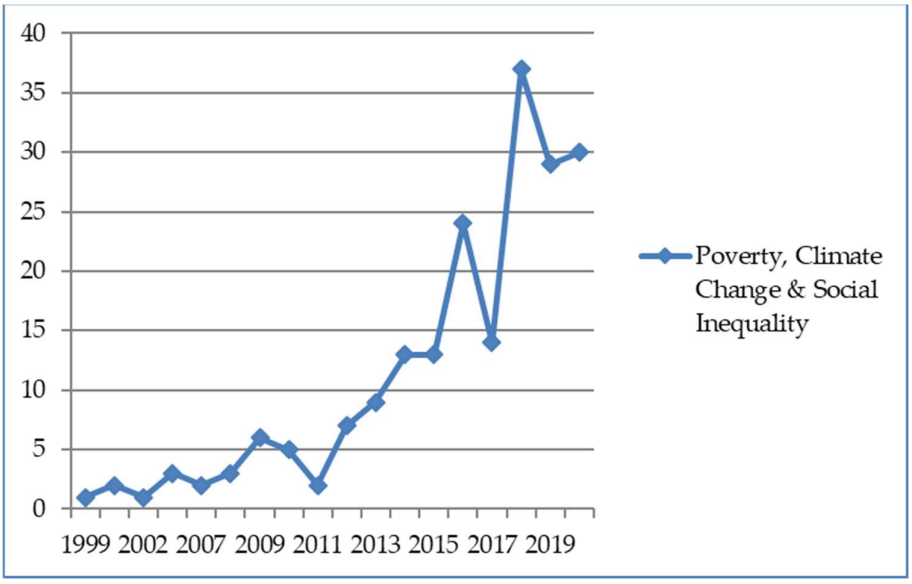

Figure 2. Number of publications per year on Poverty, Climate change and Social Inequality.

3.2. Publications by Scientific Journals

Table 2 shows the breakdown of publications by journals, referring to those that have published more than 2 papers on the subject studied during the period 1999-2020, and their percentage of the total 201 definitive papers.

Table 2. Contributions per journals

Name of the Journal	No. of Publications	%
Sustainability	8	3.98%
World Development	7	3.48%
Climatic Change	5	2.48%
Global Environmental Change-Human and Policy Dimensions	5	2.48
Environmental Science & Policy	4	1.99%
Science of the Total Environment	4	1.99%
Climate policy	3	1.49%
GeoJournal	3	1.49%
Habitat International	3	1.49%

We can see in Table 2 that 18 journals concentrate 36 articles (2 per journal), and in 123 journals only 1 article has been published in each of them. This shows no specialisation or high concentration in one or several journals, as the maximum number of publications in one journal was 8 over the period analysed.

3.3. Publications by Country and University

Table 3 lists the countries that have contributed 10 or more publications on the topic of poverty, inequality and climate change and the universities that have published 2 or more articles on it.

Table 3. Publications by country and University.

Countries	No. of Publications	%	University

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UK	50	24.87	University of London[6] University of Leeds [5] University of Southampton[4] University of Sussex[4] University of Harvard[4] University of Oxford [3] University of Western [2] University of Lancaster [2] University of Cardiff [2] University of East Anglia[2] University of the West of England[2] University of Dundee[2]
USA	36	17.91	University of Washington [7] University of California [3] University of Maryland [3] University of Cornell[2] University of Michigan[2] University of New York[2]
Australia	17	8.45	University of Canberra[3] Australian National University [2] University of Quensland[2] Charles Sturt University [2]
Germany	12	5.97	University of Berlin[3] University of Bonn[2] Technische Universität Dresden [2]
Australia	17	8.45	University of Canberra[3] Australian National University [2] University of Quensland[2] Charles Sturt University [2]
Germany	12	5.97	University of Berlin[3] University of Bonn[2] Technische Universität Dresden [2]

89.97% of the countries have contributed with less than 10 publications, with Nor-way, Italy, Sweden, India and China being the most productive within this ranking (with more than 5 publications and less than 10), and Argentina, Colombia, France, Kenya, Russia, and Switzerland, Ghana, Czech Republic, Mexico, Malaysia, Nigeria, Pakistan, Egypt and the Philippines, the least, with only 1 publication.

10.03% of the countries contribute with more than 10 publications. The United Kingdom and the USA make the most significant differences with the rest of the countries in Table 3 Thailand, USA, and the Netherlands.

3.4. Publications by Field of Knowledge

In table 4, we see the most prolific areas of knowledge. We have identified 14 different areas or departments dealing with climate change, poverty and social inequality. It is

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worth noting that the areas of Sustainability and Economics are the ones with the highest number of publications (51.7%), the rest being distributed among the 12 existing departments. The great interest shown in these areas is mainly due to the knowledge of the effects of climate change on the most vulnerable populations, mainly in underdeveloped countries such as India or South Africa, whose main livelihood is agriculture. Heavy rains, hurricanes or droughts make it increasingly difficult for the rural poor to eat, which is a relevant factor for food security and consequently a higher level of inequality [31; 32].

Table 4. Publications by field of knowledge

Field of Knowledge	No. of Publications	%
Sustainability	60	29.85
Economics	44	21.89
Geography	27	13.43
Health	25	12.44
Agriculture	8	3.98
Development and Planning	8	3.98
Psychology	7	3.48
Sociology	6	2.99
Engineering	5	2.49
Biology	3	1.49
Education	3	1.49
Social anthropology	2	1.00
Law	2	1.00
Political science	1	0.5

3.5. Type of Study

Academic research divides work into two main areas. On the one hand, there are empirical research studies (related to evidence from questionnaires, experiments or case studies) and, on the other, documentary research (which mainly includes contributions related to literature reviews and conceptual documentation) [33].

Thus, of the 201 articles analysed, 60.19% were classified as empirical studies and 39.81% as documentary studies (Figure 3).

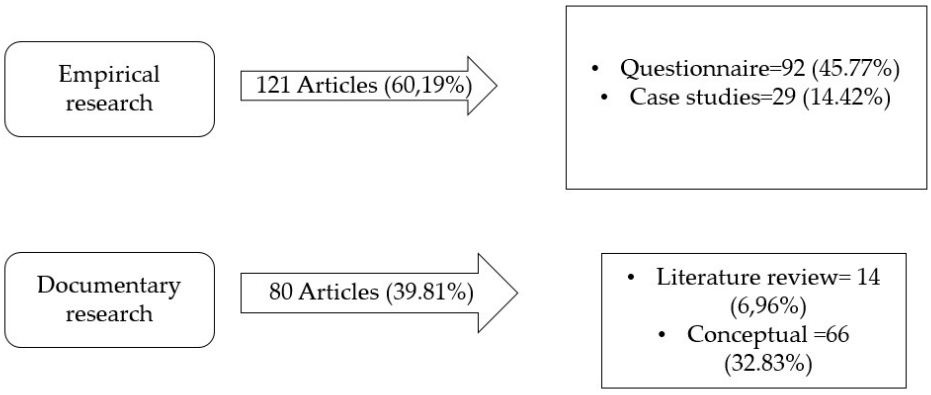

Figure 3. Type of study.

As shown in figure 3, the questionnaire is the study technique chosen by the vast majority of authors [34]. These questionnaires have taken centre stage in numerous scientific experiments, as the analysis of 201 articles shows, whether in the form of an interview or a

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survey. Focus groups have been the most widely used qualitative research technique, and various statistical models of regression, multivariate, polarisation, clustering and multi-sectoral, among others, have been used to process them [35].

On the other hand, we should note that the case studies have focused on developing or underdeveloped countries such as Mozambique, Kenya, Rwanda and Bangladesh, where the population is characterised by high levels of poverty and inequality, which make them more vulnerable to the adversities of climate change.

3.6. Publications by Author and Relevance of Articles

This section lists the authors who are actively involved in research on poverty, cli-mate change and inequality. A total of 528 authors have participated in 201 articles in this systematic review during the period analysed, and 7 of them have alluded to the circular economy. The most productive researcher in the subject analysed was A. Jerneck, who participated in 4 papers, followed by J.A. Silva, with 3 publications. Of the remaining researchers, 28 have contributed 2 articles and 498 have only contributed 1 paper, representing 94.31% of the total.

On the other hand, classifying the articles by their relevance, according to the number of citations received [30], we can say that a total of 6,008 citations are obtained from 201 articles retrieved in this systematic review of the literature, of which 61.19% (123 papers) have only received between 1 and 10 citations, 41 papers have been cited between 11 and 20 times, representing 20.39%. With more than 21 citations, 37 articles have been collected, reaching 18.94%.

10 articles have received more than 100 citations, 2 of them published in the journal Climate change (Table 5). Adger was the most cited author, receiving 1,340 citations for his two published papers.

Table 5. Most Cited Publications.

Authors	Year	Title	Journal	No. of Citations
Kelly, P. M.;Adger, W. N.	2000	Theory and practice in assessing vulnerability to climate change and facilitating adaptation	Climatic Change	775
Adger, W. N	1999	Social vulnerability to climate change and extremes in coastal Vietnam	World Development	565
Arora-Jonsson, S.	2011	Virtue and vulnerability: Discourses on women, gender and climate change	Global Environmental Change-Human and Policy Dimensions	296
McMichael, A.	2000	The urban environment and health in a world of increasing globalization: issues for developing countries	Bulletin of the World Health Organization	257

Denton, F.	2002	Climate change vulnerability, impacts, and adaptation: Why does gender matter?	*Climatic change*	253
McMichael, A.; Friel, S.; Nyong, A.; Corvalan, C.	2008	Global environmental change and health: Impacts, inequalities, and the health sector	Bmj	182
Chakravarty, S.; Chikkatur, A.; de Coninck, H.; Pacala, S.; Socolow, R.; Tavoni, M.	2009	Sharing global CO2 emission reductions among one billion high emitters	Proceedings of the National Academy of Sciences of the United States of America	175
Gentle, P.; Maraseni, T.	2012	Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal	Environmental Science & Policy	166
Hirsch, P.; Adams, W.; Brosius, J. ; Zia, A.; Bariola, N.; Dammert, J.	2011	Acknowledging Conservation Trade-Offs and Embracing Complexity	Conservation Biology	154
Buhaug, H.; Urdal, H.	2013	An urbanization bomb? Population growth and social disorder in cities	Global Environmental Change-Human and Policy Dimensions	144

4. Discussion

In this section, we pose two fundamental questions for this research. The first one will answer the question of whether there is a relationship between inequality and climate change. The second one will examine the role of the circular economy as an element that can contribute to reducing inequality and the effects of climate change, and thus contribute to the achievement of the 3 SDGs set out in this work (End Poverty - SDG 1-, Reduce Inequality - SDG 10-, and Climate Action - SDG 13-).

To answer the first question, based on the results obtained in this research, we can affirm that there is a close relationship between climate change and inequality since climate-induced effects negatively impact health, gender, and income inequality, among others, as shown below.

In this work, we can see how health has a primordial role in the face of climate change, poverty and inequality, with 81.59% of the works analysed being related to this. Among the main problems related to the health of the most vulnerable people affected by this problem, it is worth mentioning those related to contaminated water, food insecurity, malnutrition and hunger [36]. The lack of water infrastructure means that this population has to drink water from rivers contaminated with microorganisms and chemicals, caus-ing severe diseases such as cholera, typhoid fever and hepatitis A, among others [37, 38]. On the other hand, climatic adversities prevent the harvesting of sufficient food to ensure access to healthy and wholesome food, causing food prices to rise and preventing consumption, as in indigenous people in Canada and

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rice farmers in the Philippines [37, 39, 40]. In addition, Aboriginal peoples living in remote areas face more significant challenges and climate vulnerability than urban populations due to their close ties to the land and more pronounced socio-economic-political marginalisation [41, 42]. Access to transport, whether public or private and road infrastructures hinders access to early medical care to prevent and cure such diseases [37, 43].

Concerning gender inequality, we highlight in this SLR that the role of women in climate change mitigation policies is not taken into account, as they are one of the most affected groups [44]. From a detailed reading of the 201 articles analysed, we can see that since the 1970s, women have not benefited equally from agricultural development programmes in underdeveloped countries [45]. This discrimination was due, on the one hand, to their attachment to the roles of mother and wife [46] and, on the other hand, to the existence of a global gender gap between vulnerabilities and access to resources, leading to a gender-differentiated capacity for climate adaptation, putting women and girls at a dis-advantage [47]. Moreover, as a consequence of this role, which is mainly associated with the performance of domestic tasks, we observe an increasing risk to their health [36]. Her role, characterised mainly by the assumption of household chores, means that they are largely the most affected by toxic diseases. Cooking over an open fire with solid fuels produces incomplete combustion. It causes severe respiratory diseases, which aggravate mortality among women and children in rural areas of Sub-Saharan Africa, Nigeria, Ethiopia, Malaysia, Mozambique, Bangladesh, and Kenya, among others [12, 44, 48, 49, 50].

Concerning income inequality, the two-way relationship between poverty and climate change [51] is presented in the articles analysed. On the one hand, we can recognise that the effects of climate change (droughts, floods, hurricanes, among others) will be more challenging in the most impoverished countries and in those whose economies are based on the primary sector, dependent on agriculture as the main activity. This is the case of those located in the southern tropics like sub-Saharan Africa, Kenya, Ethiopia or Bangladesh, and will affect low-income people, i.e. the poorest [52, 53]. On the other hand, a growth in poverty and income inequality increases CO2 emissions in these countries [54]. Insufficient economic resources highlight the constraints and capabilities of household resources that can reduce CO2 levels, such as the use of renewable wood cookers that improve the efficiency of charcoal consumption [36]. It is also worth noting that poor women, mainly those without access to adequate health care and decent housing, show greater vulnerability to flooding and are slower to recover than other women with higher incomes or any higher social class group [44].

To answer the second question, we rely on the principles of circular economy. These principles are based on three premises. The first one is that the circular economy preserves and conserves natural capital because it selects resources efficiently and uses renewable resources. The second optimises resource yields by distributing products, components and materials with their maximum utility at all times in both technical and biological cycles, and the third is based on eliminating negative externalities [55]. This system could benefit the population, mainly the most vulnerable and impoverished who depend on agriculture for their livelihoods. In this work, we have shown how this group is one of the hardest hit by the adversities of climate change [56]. The introduction of a production sys-tem based on natural and renewable resources, waste decomposition, and the use of more efficient technology would increase production, employment, reduce poverty and inequality [55,57]. Therefore, better soil care can contribute to more significant equity and reduce CO2 emissions [12].

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Likewise, applying this circular economy model could eliminate negative externalities, and reduce damage to food, mobility, education, health, leisure and manage external factors such as land use, air and water noise pollution or the dumping of toxic substances. Controlling such externalities could curb inequality, as the different socio-economic impacts reflect a matrix of population inequality, whose structural axes are related to in-come, gender, health, race, education, and migration, territory, among others [58]. Inequality, social sustainability, vulnerability and the use of natural resources are closely linked to the effects of climate change in areas such as Asia, sub-Saharan Africa, Mozambique and Ghana, among others [59, 60, 61]. In the case of farmers occupying these territories, in-creased market interaction and commercialisation could cause them serious adaptation problems unless their access to the technical knowledge, inputs, land and natural resources needed for agricultural and non-farm activities is improved [62]. Unequal opportunities and differentiation, both socially between households and geographically be-tween villages, generate patterns of vulnerability [61].

With this work and considering the foundations on which the principles of the circular economy are based, we believe that this economic model constitutes an element that could contribute to reducing inequalities and mitigating the effects of climate change, and thus achieve the SDGs, as proposed in the 2030 agenda. From this research, a debate is open to highlight these premises.

5. Conclusions

As expected from the results analysed, in this systematic review of the literature, 201, concerning the topic of poverty, inequality a climate change, the largest number of publications are concentrated in the UK and the USA, with the rest of the countries remaining in second place, and that the areas related to the economy and sustainability are the ones that achieve the highest number of scientific publications (51.7%). This fact may be because most of the works analysed take into account the issue of social inequalities in the face of climate change threats. However, the policies aimed at mitigating CO2 emissions do not quantify the direct and indirect impacts on the most vulnerable populations [60], such as women (gender inequality), the poorest (income inequality) and the sick (health inequality), as reflected in this document. The effects of climate change have essential consequences on people's health, especially for the most vulnerable [58]. Analysing the interactions between climate change and health should feature prominently in studies related to environmental epidemiology and public health [63].

In addition to the shortcomings mentioned above, we should bear in mind that issues related to energy poverty and food insecurity are little dealt with in the articles studied in this review. About the first concept, only 10.95% of them pay attention to this issue, a phenomenon, energy poverty, that is present in the urban world [64] of European countries [65]. As for the second, 47.26% of the works analysed refer to food insecurity, which is not very relevant given the increase in hunger in the world, and the difficulty of obtaining food due to the effects of climate change, it would be advisable to carry out further research in this respect.

In short, a line of research remains open to working the interconnection between climate change, poverty and inequality and consider the role of the circular economy as an element that can contribute to ending poverty (SDG 1), reducing inequality (SDG 10) and enhancing climate action (SDG 13). To this end, in addition to considering the circular system as a possible way out of this problem, climate action policies that take into account the socio-economic aspects of the population should be considered [66]. Inclusive measures and policies that frame these three objectives together could be more beneficial to achieving the sustainable development goals [67]. Government corruption should also be assessed, as it is increasingly present in developing countries and prevents proper management to achieve these goals [68].

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