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A bibliometric analysis of the scientific production related to "zero hunger" as a sustainable development goal: trends of the pacific alliance towards 2030

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Abstract

Background: In 2015, The United Nations (UN) established 17 Sustainable Development Goals (SDGs) by 2030. In Latin America, the Pacific Alliance is integrated by Chile, Colombia, Peru, and Mexico, which the scientific activity is focused on the scientific production from research and academic institutions. In this study, the main goal was to analyze the scientific production (2015–2019) in the Pacific Alliance related to "zero hunger" as SDG. The bibliometric analysis of the scientific literature was carried out using the Scopus database with search terms related to zero hunger and validated by Elsevier. We analyzed the annual production of original articles, productive journals, leading institutions, funding agencies, authors, and the most influential original.

Results: Our results showed that the Pacific Alliance produced 2215 (81.0%) original articles, which is the fraction of non-excluded outputs with an annual growth rate of 12.62%, Mexico was the leading country, Nutrición Hospitalaria was the most active journal, and The Universidad Autónoma de Mexico was the leading institution and CONACYT as the leading funding institution.

Conclusion: As conclusion, the scientific production of the Pacific Alliance is showing positive substantial changes, which reflects the main research themes related to zero hunger, such as food security, sustainable agriculture, and malnutrition to achieve this SDG by 2030.

Keywords: VOSviewer, Bibliometric indicators, Science mapping analysis, Scientometric, Zero hunger, Sustainable development, Agriculture

Background

The Sustainable Development Goals (SDGs) were adopted by all United Nations (UN) Member States in November 2015 as a global agenda to end poverty, protect the planet, and ensure that all people enjoy peace and welfare by 2030 [1]. As of January 2016, SDGs replaced the Millennium Development Goals (MDGs), which nowadays are conformed by 17 SDGs and 169 targets, focusing on environmental, economic, and social sustainability [2]. However, SDGs are not only focused on developing countries, because the agenda towards 2030 covers all countries and sectors of the society [2].

SDG 2 called "zero hunger" has specific targets mainly environmental problems such as biodiversity, agricultural productivity, and sustainable production systems together with the serious consequences of climate

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change, the elimination of hunger and malnutrition, as well as the control of micronutrient deficiencies in different age groups and the socioeconomic factors involved that encompass farmers and commercial markets leading to a very in-depth investigation of them [4].

Zero hunger as SDG seems to be promised with ending all forms of undernourishment by 2030 and ensure that all people, especially children, have access to sufficient and nutritious food throughout next few years [3]. Several tasks have been involved by the UN to achieve this goal by 2030 such as promoting sustainable agricultural practices to obtain better crops, these activities must be practiced such as cover crops, crop rotation, permaculture, soil enrichment, natural pest predators, bio-intensive integrated pest management, polyculture farming, and others [4]. It is known that hunger and undernourishment remain as the main barrier for the development in many countries as a direct consequence of environmental degradation, drought, loss of biodiversity, and a growth of urban cities [5].

According to the UN, in the world, more than 90 million children under the age of 5 are dangerously underweight, being the malnutrition and food insecurity as the leading causes in all regions of Africa, as well as in South America [3, 6]. In 2018, famine affected 42.5 million people in Latin America and the Caribbean, according to the new joint UN report [9]. In fact, in South America lives the majority (68%) of undernourished people from Latin America and this observed increase in recent years is due to the economic slowdown experienced by Latin America countries. On the other hand, the Food and Agriculture Organization (FAO) revealed that undernourishment in 2018 had a prevalence of 6.1% in Central America and 5.5% in South America, respectively [10]. However, numerous efforts of each country try to stop the undernourishment and according to the Global Hunger Index (GHI) Chile is the country that has had a better index from 2000 to 2020 followed by Peru, Colombia, and Mexico, respectively [3].

On the other hand, the Pacific Alliance (PA) is a regional integration initiative, which was announced in Lima (Peru) on April 28, 2011, through the Lima Declaration made up of four member countries: Chile, Colombia, Mexico, and Peru, four countries in the incorporation process, four associated countries, and more than 40 observer countries on four continents [7]. PA presents four main axes as vision being: more integrated, more global, more connected, and more citizen. The last vision englobes to achieve the SDGs and ensure that the benefits of the PA reach all citizens, contributing to overcoming inequality and poverty, and have a sustainable agenda with joint projects for the adaptation and mitigation to the effects of climate change and energy clean, among others [7].

Bibliometrics as an instrumental discipline provides different types of indicators that allow us to know the trends and regularities of scientific activity. Its use is important to evaluate disciplines, institutions, journals, and other scientific aggregates, the results of which are useful both for decision-making and for the generation of new knowledge [8]. As antecedents to this investigation, bibliometric analysis of the second SDG has not been reported in the literature since 2015, which was the official launch year of the SDGs. In a recently published bibliometric report for the region of the Americas, European region, and the Western Pacific region, the SDG 13 (climate action) was the most researched field [9]. As regards international collaborations in the scientific literature based on 17 SDGs, the United Kingdom was linked especially with the United States and Brazil, Canada, India, Mexico, and Switzerland [10]. Therefore, analyses of this type seek to know the participation of countries in research on a topic, observe where the capacities are found, create, and strengthen alliances and carry out projects together.

On the other hand, governments need ideas, and alternative plans to decrease indicators related to famine and poverty, but unfortunately, a global review of the literature finds that most researchers have had wrong priorities [3]. Otherwise, researchers and academics are key players in this context and government authorities should take actions and decisions based on the results and recommendations of its researchers to achieve the SDGs in coming years [3]. According to Taşkın et al. [11], they indicated that the number of publications and citations will increase each year unless there is a change in research evaluation systems.

Therefore, we hypothesize that the scientific production of the original articles (2015–2019) related to "hunger zero" will reflect the investigations and trends in the Pacific Alliance to achieve the second SDG by 2030. Several research questions guided the review.

> RQ 1. What is the overall volume, growth rate of published documents across Pacific Alliance countries in "zero hunger" between 2015 and 2019 year?
> RQ 2. What journals, funding institutions, organizations or institutions, authors have had the greatest influence on "zero hunger" research?
> RQ 3. What is the most frequently studied topics in recent years in the "zero hunger" literature?
> RQ 4. What is the state-of-the-art underlying theory and "zero hunger" research?

Materials and methods

Search strategy and inclusion/exclusion criteria

This study was a cross-sectional descriptive analysis of scientific production from the Pacific Alliance related to "zero hunger" literature as SDG of the United Nations. Therefore, the Scopus database was used as a primary source of information. Scopus is widely used in bibliometric studies because it includes a wide range of indexed journals across all fields of scientific literature [12]. The current study was carried out on December 23rd, 2020, and all data analysis, including citation analysis, was carried out on the same day.

The search strategy for "zero hunger"- related literature was carried out based on search terms detailed in the pre-generated queries of Scopus Data Base, and it is stated as: (TITLE-ABS-KEY (({land tenure rights} OR (smallholder AND (farm OR forestry OR pastoral OR agriculture OR fishery OR {food producer} OR {food producers})) OR malnourish* OR malnutrition OR undernourish* OR {undernutrition} OR {agricultural production} OR {agricultural productivity} OR {agricultural practices} OR {agricultural management} OR {food production} OR {food productivity} OR {food security} OR {food insecurity} OR {land right} OR {land rights} OR {land reform} OR {land reforms} OR {resilient agricultural practices} OR (agriculture AND potassium) OR fertilizers OR {food nutrition improvement} OR {hidden hunger} OR {genetically modified food} OR (gmo AND food) OR {agroforestry practices} OR {agroforestry management} OR {agricultural innovation} OR ({food security} AND {genetic diversity}) OR ({food market} AND (restriction OR tariff OR access OR {north south divide} OR {development governance})) OR {food governance} OR {food supply chain} OR {food value chain} OR {food commodity market} AND NOT {disease})))) AND (AFFILCOUNTRY (peru OR colombia OR chile OR mexico)) AND (LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015)). The meaning and the methodology for using these terms can be consulted and reviewed at https://data.mendeley.com/datasets/87txkw7khs/1 as well as in our Additional file 1. We took this model of search query, which is freely available on Mendeley (https://data.mendeley.com/datasets/87txkw7khs/1). These search terms were updated on November 26, 2020, as it is detailed in the Scopus database [13].

Accordingly, we conducted a literature search for the years 2015–2019. The documents were limited to original articles with at least one affiliation author of the Pacific Alliance countries such as: Mexico, Colombia, Chile, and Peru, without language restriction (Fig. 1). In this bibliometric analysis, only are included original articles, because it reflects the actual research in each country and has probably received some funding from national or international agencies [14], and additionally, the original articles are taken as primary information to make decisions regarding any problem local or global [15].

Bibliometric indicators

The information retrieved from the Scopus database included:

- Annual production of original articles of the Pacific Alliance countries related to "zero hunger",
- More productive journals,
- Leading institutions, countries, funding agencies, H index of authors, and the most influential original articles cited between 2015 and 2019,
- H index Scopus: a bibliometric indicator that measures the productivity and the impact of the published work of a scientist or academic. Also is defined as the number of papers with citation number higher or equal to h,
- Quartile: position of journals in a category based on SJR values,
- SJR (Scimago Journal Rank): indicator that measures the quality of Scopus journals. One journal transfers prestige to another for the fact of citing it, journals that receive citations from those better positioned, increase the SJR values.

Statistical treatment

Data in Scopus were exported to Excel software for tabulation or mapping and VOSviewer program for mapping purposes [16]. Mapping was made for the most frequently encountered terms in titles/abstracts of the retrieved documents, and the final number of terms was obtained by removing irrelevant terms [17] and for countries with a minimum contribution of 20 documents to visualize international research collaboration in SDG 2.

Results

Volume and annual growth of publications by documentary typology

The search query found 2734 documents of the Pacific Alliance countries between 2015 and 2019. Most citable documents were research articles ($n=2215$; 81.0%) followed by review articles ($n=204$; 7.5%) and book chapters ($n=132$; 4.8%). In the followings analysis, all results were based on the original articles.

The average percentage of the annual growth rate of original articles showed in Fig. 2 was 12.62%. The number of original articles showed an active increasing in 2016,

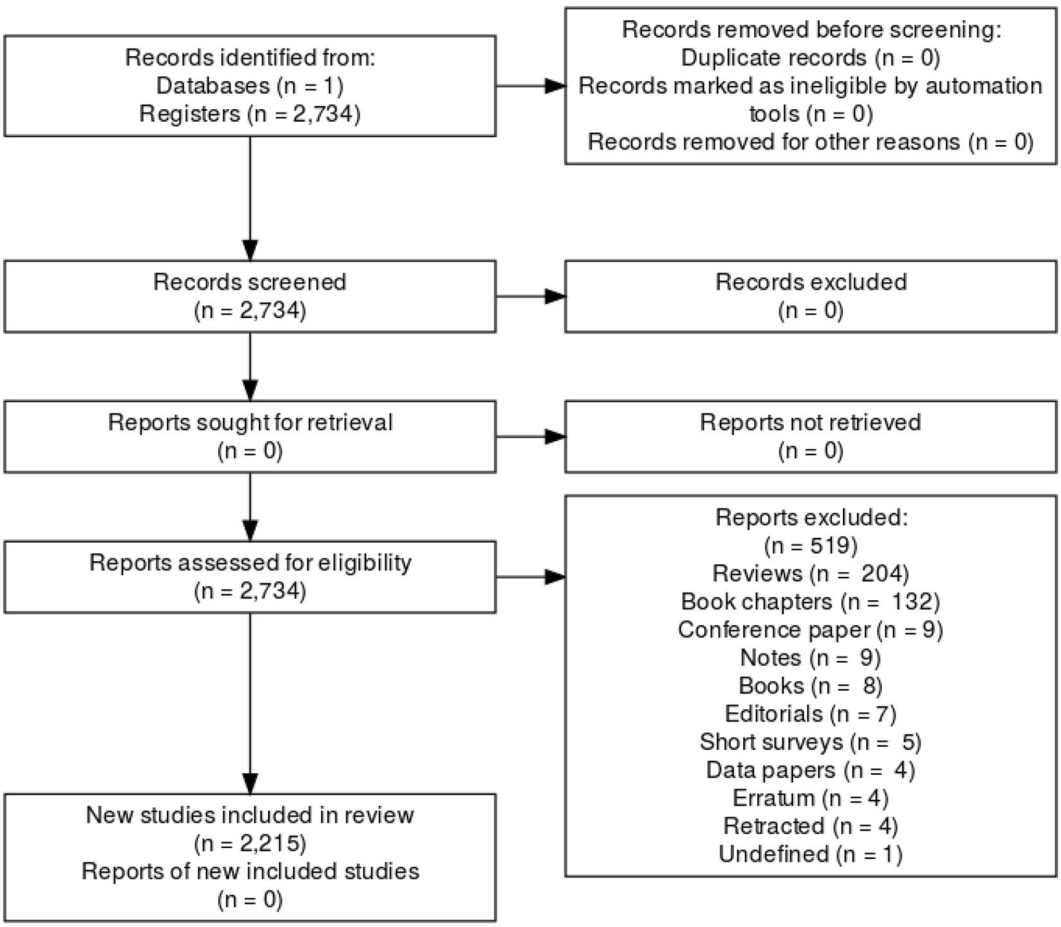

Fig. 1 Flowchart of "zero hunger" research inclusion process

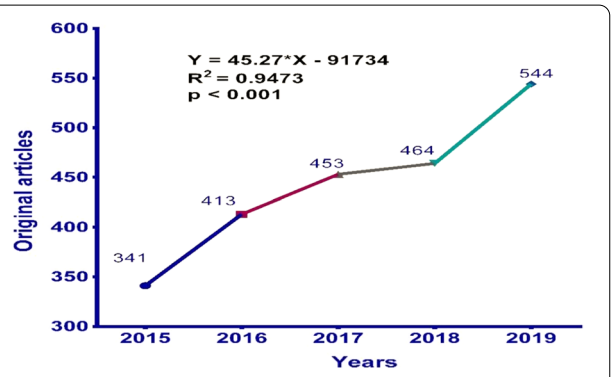

Fig. 2 The annual production of original articles published between 2015 and 2019 by the member countries of the Pacific Alliance

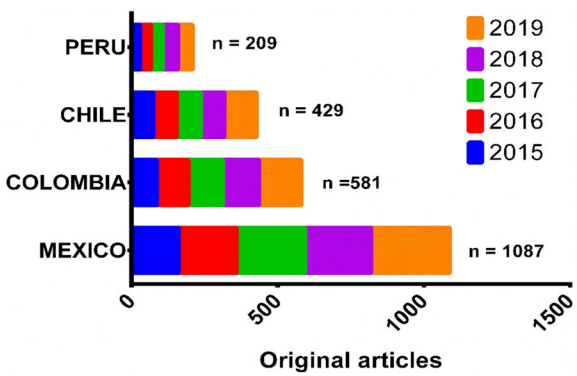

Fig. 3 The total production of original articles published between 2015 and 2019

which had the best annual growth rate with 21.11%. The two major languages of the publications were English ($n = 1813$; 81.85%) and Spanish ($n = 441$; 19.9%). In Fig. 3, it is observed that Mexico is the leading country in producing original articles related to "hunger zero", followed by Colombia, Chile, and Peru.

Top ten active authors

As is indicated in Table 1, Rahut Dil Bahadur, researcher of the Centro Internacional de Mejoramiento de Maiz y Trigo, from Mexico (2014–2020) was the most active author ($n=27$; 1.22%) in the number of "zero hunger"-linked publications. Furthermore, eight authors belong to this institution followed by two authors from the Centro Internacional de Agricultura Tropical (Colombia), one author of the University of Talca (Chile), and The Pontificia Universidad Católica del Peru, respectively.

Top ten active institutions/organizations

The Universidad Autónoma de Mexico, a public university ranked first ($n=177$; 7.99%) in the number of "zero hunger"-related publications followed by the Centro Internacional de Mejoramiento de Maiz y Trigo ($n=146$; 6.59%) and Centro Internacional de Agricultura Tropical from Colombia ($n=136$; 6.14%). Four Mexican and Chilean institutions conform the top ten institutions in Table 2, and two out of ten are private institutions such as the Pontificia Universidad Católica de Chile

Table 1 Top ten active authors in publishing zero hunger-related literature (2015–2019)

Rank	Author	Affiliation	Frequency	% ($N=2215$)	H index*	Times cited*
1	Rahut, Dil Bahadur	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2014–2020)	27	1.22	17	117
2	Erenstein, Olaf	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2015–2020)	26	1.17	24	2191
3a	Govaerts, Bram	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2005–2021)	13	0.59	34	4128
3b	Läderach, Peter Roman	Centro Internacional de Agricultura Tropical, Cali, Colombia (2010–2020) International Center for Tropical Agriculture CIAT, Hanoi, Viet Nam (2017–2020)	13	0.59	23	1876
3c	Shamah-Levy, Teresa	Instituto Nacional de Salud Pública de México, Cuernavaca, Mexico (2000–2020)	13	0.59	33	10,466
6a	Challinor, Andrew J	Centro Internacional de Agricultura Tropical, Cali, Colombia (2013–2019) University of Leeds, Leeds, United Kingdom (2008–2020)	12	0.54	46	8633
6b	Hellin, Jon	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2006–2019) International Rice Research Institute, Makati, Philippines (2018–2020)	12	0.54	25	2078
8a	Mottaleb, Khondoker Abdul	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2016–2020) International Rice Research Institute, Makati, Philippines (2012–2015)	11	0.50	15	413
8b	Stirling, Clare Maeve	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2014–2020) International Maize and Wheat Improvement Center CIMMYT, London, United Kingdom (2014–2017) World Agroforestry Centre, Nairobi, Kenya (2019–2020)	11	0.50	23	1176
10a	Bravo-Ureta, Boris E	Universidad de Talca, Talca, Chile (1995–2019) University of Connecticut, Storrs, United States (1991–2020)	10	0.50	21	1537
10b	Ramirez-Villegas, Julian	Centro Internacional de Agricultura Tropical, Cali, Colombia (2009–2020) University of Leeds, Leeds, United Kingdom (2012–2020) CGIAR Research Program on Climate Change, Cali, Colombia (2013–2020)	10	0.50	25	2406
10c	Sonder, Kai	Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico City, Mexico (2012–2020)	10	0.50	16	874
10d	Vázquez-Rowe, Ian	Pontificia Universidad Catolica del Peru, Lima, Peru (2014–2021) Universidad de Santiago de Compostela, Santiago de Compostela, Spain (2010–2018) Luxembourg Institute of Science and Technology, Esch-sur-Alzette, Luxembourg 2013–2015)	10	0.50	28	2246

In ranking, two or more equally active authors were given similar ranks and one position in the rank was skipped

*According to author Scopus profile

Table 2 Top ten active institutions/organizations in publishing zero hunger-related literature (2015–2019)

Rank	Institutions/organizations	Country	*n*	% (*N* = 2215)	PositionQS 2019	THE-World University Ranking (SDGs)[a]	Zero hunger ranking[b]
1	Universidad Nacional Autónoma de México	Mexico	177	7.99	113	201–300	101–200
2	Centro Internacional de Mejoramiento de Maiz y Trigo	Mexico	146	6.59	n.d	n.d	n.d
3	Centro Internacional de Agricultura Tropical	Colombia	136	6.14	n.d	n.d	n.d
4	Universidad Nacional de Colombia	Colombia	74	3.34	275	n.d	n.d
5	Universidad de Chile	Chile	69	3.12	208	n.d	n.d
6	Universidad de Concepcion	Chile	59	2.66	651–700	101–200	n.d
7a	Instituto Politécnico Nacional	Mexico	55	2.48	651–700	201–300	n.d
7b	Colegio de Postgraduados	Mexico	55	2.48	n.d	n.d	n.d
9a	Universidad de la Frontera	Chile	50	2.26	n.d	n.d	n.d
9b	Pontificia Universidad Católica de Chile	Chile	50	2.26	132	58	101–200

[a] The Times Higher Education University Impact Rankings are the only global performance tables that assess universities against the United Nations' Sustainable Development Goals (SDGs): Impact Rankings 2019

[b] Impact Rankings 2020: zero hunger; available at: https://www.timeshighereducation.com/rankings/impact/2020/zero-hunger#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/undefined

and Centro Internacional de Agricultura Tropical from Colombia. Otherwise, 6 institutions have the category of universities.

Peru does not have a representative institution in this top table, but its main institution in publishing is the International Center of Potato (Lima, Peru) (Material Supplementary: Table 1).

Top ten leading journals

The Nutrición Hospitalaria, a multidisciplinary journal ranked first ($n = 48$; 2.17%) in the number of "zero hunger"-linked publications followed by Sustainability ($n = 38$; 1.72%) and Agriculture Ecosystems and Environment ($n = 27$; 1.22%). Eight of the top ten active journals were from Europe and two were from Latin America (Table 3). Five journals were Q1 and only one journal did have any classification in the Scimago Journal Rank. The main journal that had a major cites per document was Agriculture Ecosystems and Environment which is Q1, while the lowest journal with cites per document was Agrociencia which is Q3.

Top ten funding institutions

As is shown in Table 4, of the retrieved publications, 1123 (50.69% of 2215) original articles declared receiving funding to carry out the investigation. The most active funding sponsor was CONACYT, Mexico ($n = 161$; 14.34% of the Mexican total production). The other funding institutions more representative of each country were FONDECYT, Chile ($n = 66$; 6.07% of the Chilean total production), COLCIENCIAS, Colombia ($n = 30$; 2.76% of the Colombian total production), and Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica (CONCYTEC, Peru) only funded 3 original articles with 1.44% of its total production ($n = 209$, Fig. 2) and 0.27% of the total production ($n = 1123$, Table 4).

Top ten influential original articles

Table 5 shows the work of Asseng S, et al. [18] titled "Rising temperatures reduce global wheat production", which was the most influential article with 111.5 cites per year and published in Nature Climate Change with Q1 and high impact factor. Furthermore, all publications had more than three authors with any external author who does not belong to the Pacific Alliance. In general, all publications had at least one foreign authors and more than five authors per document.

Research themes in zero hunger-related literature

Mapping the most frequent terms in title/abstract fields of documents in the zero hunger-related literature with a minimum occurrence of 30 gave 129 terms distributed in three clusters representing three main research themes, which we only selected the 100 first terms. According to Fig. 4, the first cluster (green) included 22 terms and focused on the following topics arranged alphabetically and being more representative: Adolescent, anthropometry, body mass index, calor intake, diet, food intake, nutrition, malnutrition, nutritional status, obesity, overweight, pregnancy, pre-school child, prevalence, and poverty. The second cluster (Blue) included 28 items and focused on the following topics arranged alphabetically and more representative: animal, bacterium, biomass, chemistry, fertilizer, genetics, metabolism, microbiology, nutrient, nitrogen, and soil. The third cluster (red) included 35 items and focused on the following topics

Table 3 Top ten active journals in publishing the zero hunger-related literature (2015–2019)

Rank	Journal	Editorial	n	% (N = 2215)	TC	CPD	Language	Impact factor[a] (2019)	SJR 2019	Quarti[b] (2019)
1	Nutricion Hospitalaria	Aran Ediciones, SL (Spain)	48	2.17	159	3.31	Spanish	0.888	0.259	Q3
2	Sustainability (Switzerland)	MDPI	38	1.72	254	6.68	English	2.576	0.589	Q2
3	Agriculture ecosystems and environment	Elsevier	27	1.22	623	23.07	English	4.241	1.719	Q1
4	Plos One	Public library science	24	1.08	193	8.04	English	2.740	1.023	Q1
5	Agricultural systems	Elsevier	23	1.04	396	17.21	English	4.212	1.505	Q1
5b	Terra latinoamericana	Mexican Society of Soil Science (SMCS) Mexico	23	1.04	30	1.30	Multi language	n.d	n.d	n.d
7a	Agrociencia	Colegio de Postgraduados de Mexico (Mexico)	21	0.95	17	0.81	Multi language	0.346	0.181	Q3
7b	Journal of cleaner production	Elsevier	21	0.95	417	19.85	English	7.246	1.886	Q1
9a	Chemical engineering transactions	Italian Association of Chemical Engineering—AIDIC	20	0.90	42	2.1	English	n.d	0.316	Q3
9b	Frontiers in plant science	Frontier	20	0.90	254	12.7	English	4.402	1.691	Q1

In ranking, two equally active journals were given similar ranks and one position in the rank was skipped

n.d no determined, *TC* total cites, *CPD* cites per document

[a] According to journal citation reports

[b] Scimago journal rank

Table 4 Top ten active funding institutions in publishing the zero hunger-related literature (2015–2019)

Rank	Funding institutions	Country	N	% (*N* = 1123)	TC	CPD
1	Consejo Nacional de Ciencia y Tecnología (CONACYT)	Mexico	161	14.34	885	5.5
2	Fondo Nacional de Desarrollo Científico y Tecnológico (FONDECYT)	Chile	66	5.88	626	9.48
3	Comisión Nacional de Investigación Científica y Tecnológica (CONICYT)	Chile	53	4.72	317	6.0
4	United States Agency for International Development (USAID)	USA	40	3.56	528	13.2
5a	Bill and Melinda Gates Foundation	USA	36	3.21	586	16.3
5b	National Science Foundation (NSF)	USA	36	3.21	436	12.1
7a	Departamento Administrativo de Ciencia Tecnología e Innovación (COLCIENCIAS)	Colombia	30	2.67	140	4.7
7b	Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)	Brazil	26	2.32	517	19.9
9	European Commission (EC)	UE member states	24	2.14	500	20.8
10	National Institutes of Health (NIHs)	USA	20	1.78	413	20.7

In ranking, two equally active funding institutions were given similar ranks and one position in the rank was skipped. Funded total documents = 1123 (year: 2015–2019). Since January 1, 2020: the Agencia Nacional de Investigación y Desarrollo (ANID) is CONICYT's legal successor. COLCIENCIAS officially ceased to function on December 5, 2019, when the Ministry of Science, Technology and Innovation (MINCIENCIAS) was created

TC total cites, *CPD* cites per document

Table 5 Top ten influential original articles in publishing zero hunger-related literature (2015–2019)

Rank	Authors	Title	Year	Journal	JIF	TC	TC/year
1	Asseng S, et al. [18]	Rising temperatures reduce global wheat production	2015	Nature climate change	20.893	669	111.5
2	Anderson I, et al. [19]	Indigenous and tribal peoples' health (The Lancet–Lowitja Institute Global Collaboration): a population study	2016	Lancet	60.390	317	63.4
3	Béné C, et al. [20]	Contribution of Fisheries and Aquaculture to Food Security and Poverty Reduction: Assessing the Current Evidence	2016	World development	3.869	232	46.4
4	Béné C, et al. [21]	Feeding 9 billion by 2050 – Putting fish back on the menu	2015	Food security	2.095	219	36.5
5	Estel S, et al. [22]	Mapping farmland abandonment and recultivation across Europe using MODIS NDVI time series	2015	Remote sensing of environment	9.085	182	30.3
6	Garibaldi LA, et al. [23]	Mutually beneficial pollinator diversity and crop yield outcomes in small and large farms	2016	Science	41.846	165	33.0
7	Liu B, et al. [24]	Similar estimates of temperature impacts on global wheat yield by three independent methods	2016	Nature climate change	20.893	156	31.2
8	Marrugo-Negrete J, et al. [25]	Assessment of heavy metal pollution, spatial distribution and origin in agricultural soils along the Sinú River Basin, Colombia	2017	Environmental research	5.715	147	36.75
9	Cuellar-Bermudez SP, et al. [26]	Photosynthetic bioenergy utilizing CO_2: An approach on flue gases utilization for third generation biofuels	2015	Journal of cleaner production	7.246	144	24.0
10	Powlson DS, et al. [27]	Does conservation agriculture deliver climate change mitigation through soil carbon sequestration in tropical agro-ecosystems?	2016	Agriculture, ecosystems and environment	4.241	132	26.4

Total documents = 2215 (year: 2015–2019)

JIF journal impact factor (Journal Citation Reports: 2019)

TC total cites

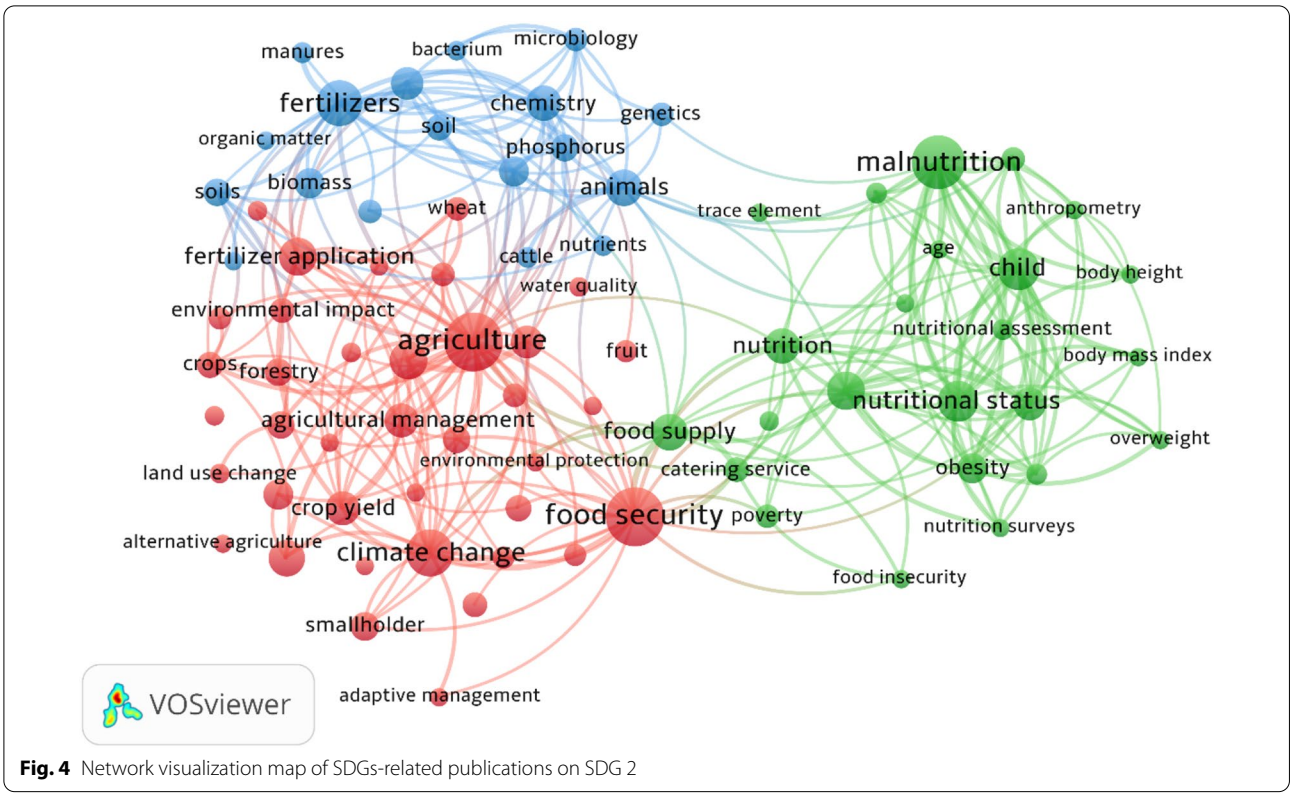

Fig. 4 Network visualization map of SDGs-related publications on SDG 2

arranged alphabetically and more representative: Agriculture, biodiversity, climate change, crops yield, crops, fertilizer application, food security, food supply, sustainable development, and water quality. Additionally, these terms were correlated with the FAO indicator of SDG-2 in order to establish any relationship between the thematic focused on three indicators as is shown in Table 6. In addition, the top term repetitions were: Agriculture, food security, climate change, fertilizer, child, nutritional status, and malnutrition.

Table 6 The most frequent terms in zero hunger-related literature and its relationship with FAO indicators

	SDG-2 indicators according to the FAO [28]	Terms
1	Prevalence of undernourishment	Nutritional status, overweight, obesity, child, body index weight, pregnancy
2	Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)	Food insecurity, Food security, Food supply, catering service, poverty
3	Volume of production per labor unit by classes of farming/pastoral/forestry enterprise size	Forestry, land use change, small holder
4	Average income of small-scale food producers, by sex and indigenous status	Forestry, alternative agriculture, anthropometry, poverty, pregnancy, age, child, land use
5	Proportion of agricultural area under productive and sustainable agriculture	Adaptative management, sustainable agriculture, fertilizers, water quality, nutrients
6	Conservation of plant genetic resources for food and agriculture	Genetics, chemistry, soil, sustainable agriculture, biomass, microbiology
7	Conservation of animal genetic resources for food and agriculture	Animals, genetics, cattle, sustainable agriculture
8	Proportion of local breeds, classified as being at risk, not-at-risk, or unknown level of risk of extinction	Environmental protection, climate change, *Zea mays*, maize, wheat, fruits, crops field
9	The agriculture orientation index for government expenditures	Nutrition surveys, Environmental impact, alternative agriculture, adaptive management
10	Indicator of (food) price anomalies	No terms

In Fig. 5A, we can visualize that the tendency of research terms is focused on food security and food supply in last year as well as the use of fertilizers and environmental impact. In the density visualization (Fig. 5B), it is noted that other terms such as Agriculture, food security, fertilizer, genetic, adolescent,

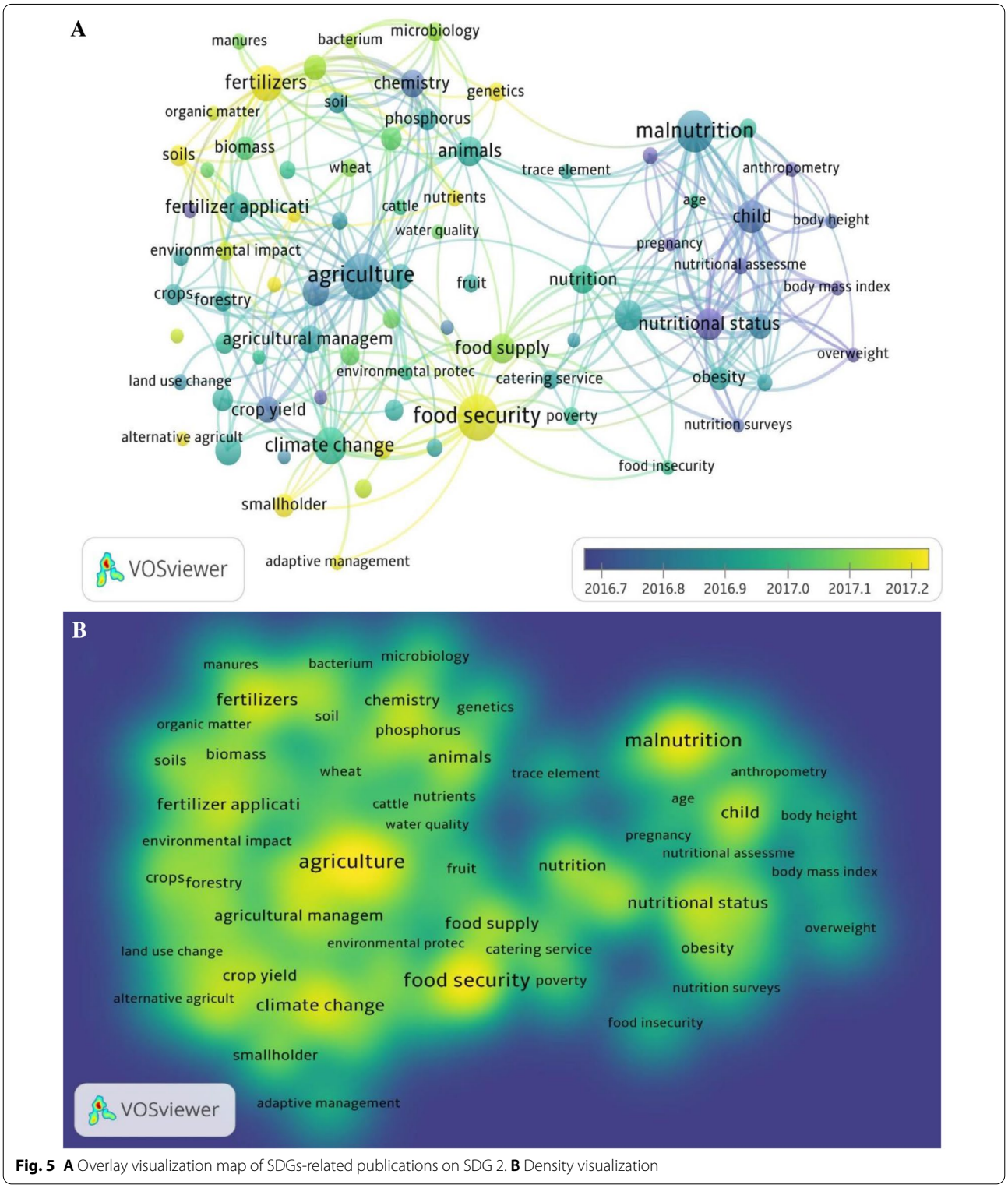

Fig. 5 **A** Overlay visualization map of SDGs-related publications on SDG 2. **B** Density visualization

malnutrition, nutritional status, wheat, and obesity are the main central themes in the Pacific Alliance.

Active countries and international research collaboration

In regard to the international research collaboration, Mexico (973) had the highest percentage of documents with international researchers followed by the Colombia (528), Chile (380), and Peru (192). Mapping research collaboration in the zero-hunger literature for active countries with at least 20 documents (Fig. 6). The strongest collaboration was between USA and Mexico (link strength = 163) followed by USA and Colombia (link strength = 106) and USA with Peru (link strength = 64). On the other hand, Chile had collaborations with Spain (link strength = 60) and USA (link strength = 69). However, as we can observe Peru and Chile are in the same cluster, while Colombia and Mexico lead other cluster, respectively. Three countries of the Pacific Alliance (Colombia, Chile, and Mexico) had very weak collaborations between them.

Data were included with a minimum of 20 "zero hunger"-related publications. Countries in the center with many connections had the highest research collaboration, while countries at the edge of the map had the least research collaboration.

Discussion

The fundamental principle of SDG-2 is to end hunger, achieve food security, sustainable agriculture, as well as improve nutrition, but this will not be achieved if political and economic changes are not adopted by 2030 [29]. However, the goals of zero hunger are not only focusing on the area of hunger reduction otherwise to include an environmental management, public health, and various associated socioeconomic factors such as adding value to agricultural products and to determine the origin of distortions in the price of these products [29].

Thus, we have that the author Rahut, Dil Bahadur from the Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico), is listed as the most productive researcher in the Pacific Alliance and the institution to which he belongs is committed to the SDG-2 whose politics are producing more with less, adding value to grain production, increasing resilience, improving ecosystem services, and promoting inclusion, but overall focusing on small, medium, and large farmers. On the other hand, the Universidad Autónoma de Mexico (UNAM) is consolidated as the most productive university institution which, in addition to leading in the ranking, is among the 200 universities in the world in the ranking of SDGs of the Times Higher Education. Furthermore, the most productive journal is *Nutrición Hospitalaria*, which has published topics related to malnutrition and its improvement, anemia, and nutritional requirements of women and girls. To all this, the most used search

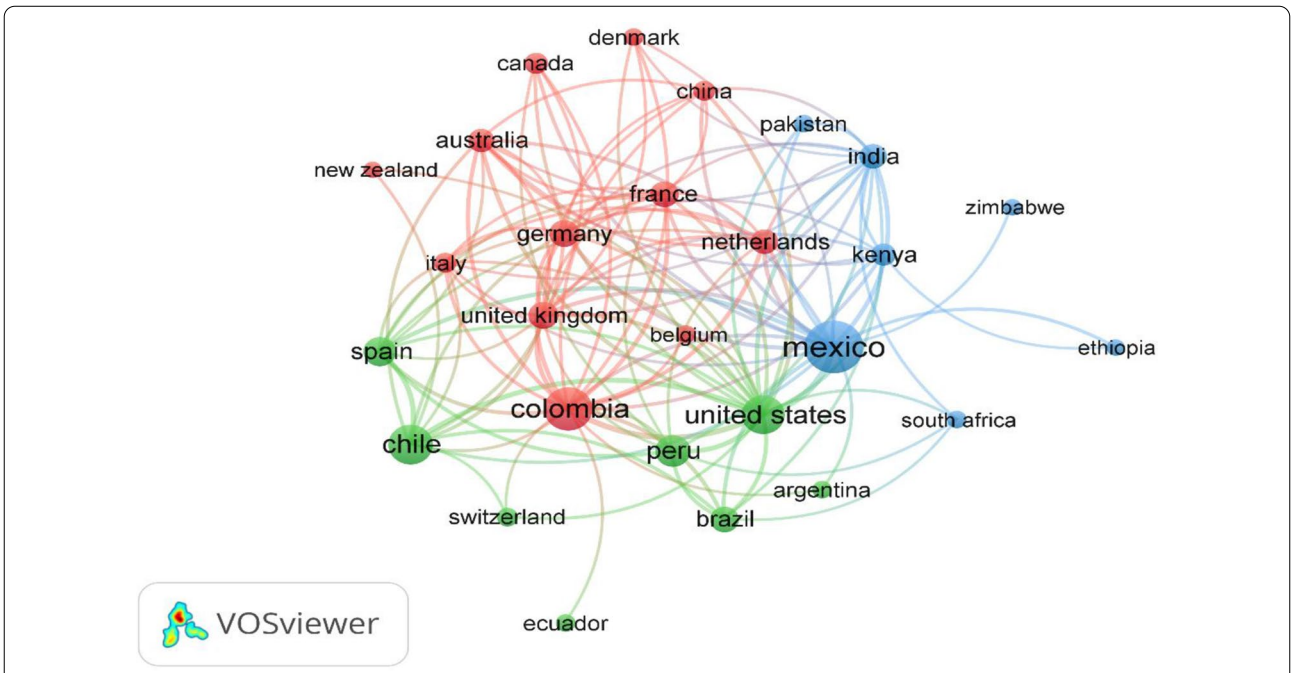

Fig. 6 Network visualization map of international research collaboration among countries

terms are closely linked to the FAO indicators according to the visualization maps, which allows us to infer that the aforementioned axes such as the environmental and socioeconomic are being carried out, as product of the investigations carried out by countries of the Pacific Alliance and its adopted public politics.

The scientific production in zero hunger of authors with at least one affiliation of the countries of the Pacific Alliance has shown a positive increase in the last 5 years, in a linear and growing way. This finding is similar to Sweileh, who carried out an analysis of the publications related to good health and well-being goal (2015–2019) [9]. According to our results, the institutions involved in the publication of these articles are usually research centers and universities, which have an important role as knowledge-generating entities in the agricultural and food area. Recently, a great number of academic institutions in the world have a plan to reduce the undernourishment with social programs [30], projects, and curricula guided to include the SDGs in some courses, [31]. For instance, the Universidad de Chile and the FAO established an agreement in 2019, to create the Forest Engineering School, technical support for the food processing industry with the Faculty of Agronomy, implementation of training programs in the Agricultural Sciences School, and others in the food security field [32].

Likewise, the Pacific Alliance was created to promote the development among member countries in the commercial sector as well as common aspects such as reducing poverty and inequality, but there are some gaps that can slow down this progress, such as the investment in science and technology and political measures to achieve this goal [33]. On the other hand, within the Pacific Alliance, there is an inequality between its member countries such as Peru, which compared to Mexico, Chile, and Colombia have a greater number of ranked institutions [34] and better researcher and development spending [35]. As is observed, the highest production of articles comes from universities and specialized institutions in agriculture such as the Universidad Autónoma de Mexico and the Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico), respectively, which together other Latin American universities have established agreements and commitments with the FAO, focused on "zero hunger" and the scientific production of these institutions during the last 5 years allows us to understand the current trend of these countries towards 2030.

Additionally, the high proportion of international collaborations found and the consequent interinstitutional collaboration networks led by Mexican, Chilean, and Colombian institutions may partially explain these differences, in spite of having as main strategy internships and exchanges between students and professors in the Pacific Alliance. However, the scientific collaboration of Mexico reported in this study is similar to Meschede et al. [10], which Mexico had a strength link with USA and United Kingdom in the analysis of the global literature of the 17 SDGs. Likewise, it was observed that the most cited articles came from authors of the region with any external author from USA or Europe compared to those papers that only included local authors of the Pacific Alliance countries, and our finding is similar to the reports of Puuska et al. [36], which stated that papers published by the cooperation of authors from several organizations gather significantly more citations than papers authored by authors from one organization [37]. Furthermore, those with international collaboration have a greater impact than papers with national collaborations because of their greater quality and prestige [38].

Finally, the obvious interpretation for researchers in this area is that international cooperation will bring them publications with greater impact. However, it was also noted that according to the origin of funding institutions, the number of citations also varied, overall, institutions not belonging to the Pacific Alliance had a higher citation index than those produced with sponsors belonging to Pacific Alliance such as FONDECYT (Peru), COLCIENCIAS (Colombia), FINCYT (Mexico), FONDECYT (Chile), and CONACYT (Mexico). This could be explained according to the amount of money allocated per project, which was not considered in this research.

Thus, the most influential original article titled the "Rising temperatures reduce global wheat production" authored by Asseng S, et al. [18] was highly cited and had international collaboration with more than 20 authors as well as being published in a journal with high impact factor situated in Q1. It has been reported that the number of authors of a paper is correlated with the paper's impact, so that the more authors a paper has, the more probably it will be cited, as well as the presence of authors from different disciplines, highly cited authors, and high h-index values [39]. Additionally, this indicator takes the cites as a measure of the influence of the published articles. Articles with high citations are the most important for the generation of new knowledge and although it is a controversial metric, in fact when an article is cited denotes relevance in its field.

Thereby, it is highlighted that within the journals with the highest production of original articles, there is a good proportion of publications that are in quartile 3 (Q3) of Scopus, as Nutrición Hospitalaria, as the most widely used journal of dissemination by Pacific Alliance researchers. This journal open access covers the fields of nutrition and food sciences and publishes in English and Spanish [40]. Next, the journals preferred by the researchers to publish their findings

were Sustainability (Q2), Agriculture Ecosystem-items and Environment (Q1) and Terra Latinoamericana, a journal that was included in Scopus in 2016 and has not been yet established a Quartil according to the Scimago Journal Rank (SJR). This situation reflects some of the usual circumstances in Latin American research groups, who seek to send their manuscripts to the best ranked journals, but at the same time offer open access options and no publication costs. However, these difficulties do not affect the quality of the studies produced by Latin American researchers and many of them have been published in Q1 journals that offer affordable publication costs or those that can be accessed thanks to international cooperation. The leading authors in publishing "zero hunger"-related literature are academics or scientific specialist in the agricultural and food area, but with a lower number yet, the leading author only had 27 original articles, and perhaps, the interest in Latin America is focused on in other SDGs and according to Salvia et al., who reported that Latin America/Caribbean is focused on the SDGs such as 11(Sustainable cities and communities) and 13 (Climate action), with 50% and 39% of specialists in those areas, followed by SDG 4 (Quality education), with 29%, respectively [33].

In regard to the main themes developed during the 2015–2019, the universities and researcher institutions are focused on the food security and sustainable crops; additionally, the agriculture, environmental, climate change, and fertilizer, as well as fruits, wheat, and maize are the main products or crops, which the Pacific Alliance drives its funding and resources in laboratories and specialized experimental centers. However, efforts to reduce the malnutrition, overweight, and anemia are also being investigated, but between 2018 and 2019, food security and use of fertilizers are the new research fields related to zero hunger.

On the other hand, one of the greatest limitations of this study is that it only expresses what has been published in Scopus database of relevance to the regional scope in what corresponds to the Pacific Alliance, but that it does not encompass the entirety of the scientific production in these member countries of the Pacific Alliance, such as reviews, letters, and proceeding papers, among others. Likewise, the search for information does not include academic repositories and other databases such as Scielo or Latin American databases, so other types of production are not being considered, which could have a significant impact on this knowledge area, if it is considered that Latin America has a greater number of publications in Spanish language and free of article processing charges.

Conclusion

Given this, it is concluded that the scientific production on "zero hunger" of the Pacific Alliance with at least one author, which published between 2015 and 2019 in journals indexed in Scopus database, had a positive increase in last years, concentrated on specialized institutions in the agricultural area as well as ranked prestigious universities and this information is published in journals belong to Q1, Q2, and Q3; furthermore, highly cited documents come from funding agencies not belonging to the Pacific Alliance and at least one coauthor or leading author from the United Sates of Europe countries. As recommendation, it is necessary further work on the subject from a bibliometric perspective, expanding to other sources and information systems. This study allows to draw research policies and therefore improve public policies on the subject while serving as a guide to the conduct of new studies in SDGs. Indeed, we observed during the analysis gaps such as the case of Peru, which belongs to the Pacific Alliance, but its inclusion has not been possible to improve its production indicators either in collaboration within the region or its contribution to the achievement the second SDG according to investigations related to that. Nowadays, universities also are ranked according to its scientific production related to SDGs and this research could address if those recipient funds are used correctly.

Supplementary Information

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Additional file 1. Additional files of a bibliometric analysis of the scientific production related to "zero hunger" as a sustainable development goal: trends of the pacific alliance towards 2030.

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Authors' contributions

Conceptualization—OH-C; methodology—OH-C and GP-R; validation—VA-A and RAY-P; formal analysis—OH-C; investigation—RDH-Q and OG-C; writing–original draft preparation—OH-C; writing–review and editing—OH-C and OG-C. All authors have read and agreed to the published version of the manuscript. All authors have read and approved the final manuscript.

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Declarations

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Consent for publication
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Competing interests
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.

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