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ORIGINAL

Management conservation of ecosystem services based on artificial intelligence: a analysis of citations in Scopus

Gestión sostenible de los servicios ecosistémicos basada en la inteligencia artificial: un análisis de citaciones en Scopus

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ABSTRACT

Technological development has allowed a global advance of artificial intelligence (AI), which is used as an advanced tool for the conservation of ecosystem services in order to achieve planetary sustainability. The objective of the article was to analyze the conservation of ecosystem services focused on the application of artificial intelligence based on bibliometric research. The Scopus database was used as a direct source of research. Using the 2020 prism methodology, 69 articles were quantified, considered from the year 2020 to 2025, with a notable growth of study from the year 2022 to 2024, obtaining in 2024 the maximum point with a total of 31 publications, of which environmental science is the most studied with 24 % and the country in which more research is generated is the United States with 15,84 %, followed by Italy with 14,85 %. Most of the studies involving ecosystem services seek to generate a green solution for the preservation of natural resources that provide great benefits and contribute to human wellbeing.

Keywords: Ecosystem Services; Artificial Intelligence; Sustainable Development; Environmental Managemen.

RESUMEN

El desarrollo tecnológico ha permitido un avance global de la inteligencia artificial (IA), la cual es empleada como herramienta de avanzada para la conservación de los servicios ecosistémicos en miras de alcanzar la sostenibilidad planetaria. El objetivo del artículo fue analizar la conservación de los servicios ecosistémicos enfocados en la aplicación de la inteligencia artificial a partir de una investigación bibliométrica. Se empleó la base de datos Scopus como fuente directa de indagación. Mediante la metodología prisma 2020 se cuantificaron 69 artículos, considerados desde el año 2020 al 2025, con un notable crecimiento de estudio desde el año 2022 al 2024, obteniendo en el 2024 el punto máximo con un total de 31 publicaciones, de los cuales la ciencia medio ambiental es la más estudiada con un 24 % y el país en el que se genera más investigaciones es en Estados Unidos con 15,84 %, seguido de Italia con un 14,85 %. Los estudios en su gran mayoría que involucran servicios ecosistémicos buscan generar una solución verde para la preservación de los recursos naturales que brindan grandes beneficios y contribuyen al bienestar humano.

Palabras clave: Servicios Ecosistémicos; Inteligencia Artificial; Desarrollo Sostenible; Gestión Ambiental.

INTRODUCTION

In recent decades, anthropic activities have generated irreversible environmental damage, causing the degradation of natural resources,[1] through deforestation, erosion, desertification, loss of biodiversity, and climate change.[2,3,4,5,6,7] Therefore, a sector with great potential to address this environmental problem is the sustainable preservation of ecosystem services (ES) with the applicability of artificial intelligence (AI).[8,9]

On the other hand, nature's contributions to people (NPC) are classified into provisioning, support or maintenance, regulating, and cultural services.[10,11,12,13,14,15,16] Thus, conservation planning and protection of (ES) can be significantly enhanced through the applicability of (AI),[17] as it facilitates the analysis of large amounts of data from nature, such as making accurate forecasts through predictions of environmental modifications and the consequences induced by human activities in altering biodiversity.[18,19,20]

There are several ways in which AI is currently applied in favor of the care of the ES, starting with the identification of alterations in fragile ecosystems that can predict the effects of forest fires, the greenhouse effect, global warming, climate change, unplanned agricultural expansion or abandonment, absence of wetlands, marine heat waves, loss of glaciers, abrupt development in rural areas, illegal mining among others, to anticipate environmental disturbance, modeling its impact and durability of environmental degradation.[21,21,22,23,24,25,26,27,28] This action enriches informed decision-making on sustainable resource management by government agencies for implementing sustainable policies and action on socio-environmental issues.[29,30,31,32] Real-time monitoring of environmental conditions is possible with the help of drones, spatial planning, neural networks, satellite imagery, geospatial data, and sensors, which use AI to collect information about the state of ES; however, AI algorithms can assess how protected areas are currently functioning and propose efficient ways of care to preserve ES and their biodiversity, this means that it can consider habitat restoration, non-native species control, rehabilitation, regeneration, and water management, urban growth planning, strategic afforestation, emission reduction, forestry, biodiversity, strengthening connectivity in nature, neutralization as carbon storage and adaptation to climate change through ES conservation.[33,34,35,36,37,38,39,40,41,42,43]

Thus, AI provides valuable resources for the sustainable preservation of ES, such as the creation of strategic ecological restoration plans for the benefit of marine and terrestrial ecosystems[44,45,46] as well as modeling the impact of various anthropogenic actions in line with the regenerative economy and the advance of Industry 4.0.[47,48,49,50] However, its implementation must be done responsibly and ethically, considering the technology's economic, social, and environmental impacts.[51,52,53] Therefore, the study aims to analyze the sustainable conservation of ecosystem services focused on applying artificial intelligence using the Scopus database as a direct source of bibliometric research.

METHOD

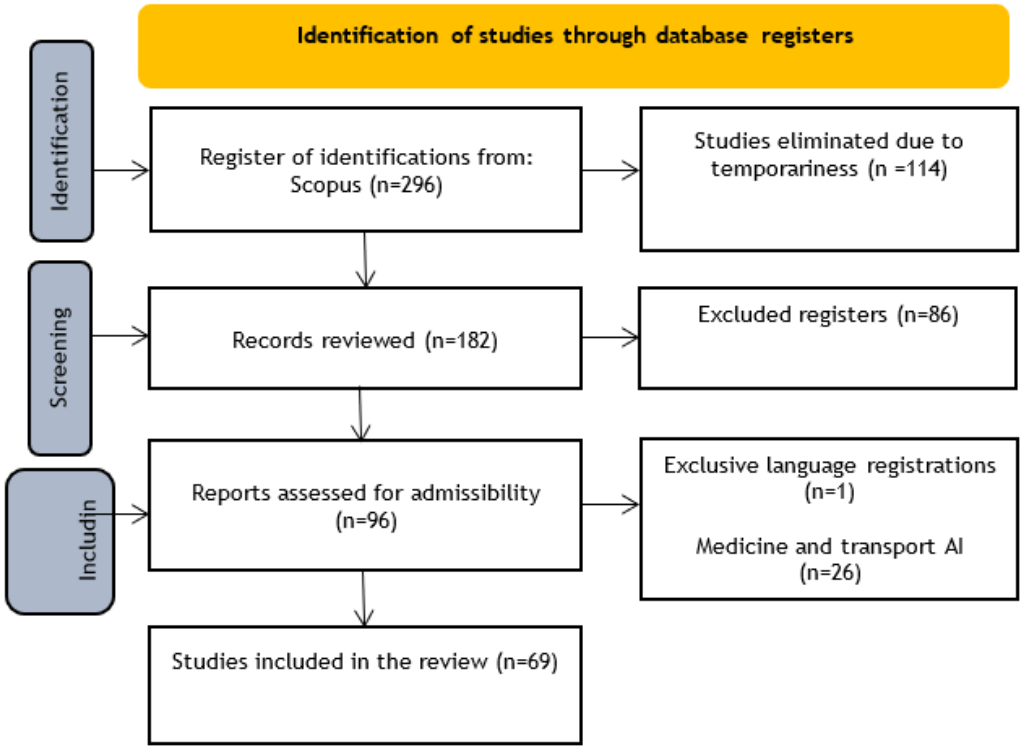

Figura 1. Diagrama de flujo PRISMA 2020

A bibliometric study was carried out to analyze the sustainable management of ecosystem services through artificial intelligence. The Scopus database was used for this purpose,[54] and the Prism 2020 methodology[55] 296 documents were initially identified. The timeframe for the research was 2020 - 2025, considering the keywords: 'ecosystem services,' 'artificial intelligence,' 'sustainable development,' and 'environmental management.' One hundred eighty-two documents were obtained; subsequently, files that are not articles were excluded, giving a result of 96 files, with language restrictions reduced to a total of 95 articles; after a review, studies concerning medicine and transport were discarded that although they use AI as a source of study respecting the ES do not pose environmental solutions being reduced to 69 articles which are included for the analysis. This procedure is detailed in figure 1 prism method.

RESULTS

The research development showed a fluctuating trend, as seen in figure 2. From 2020 onwards, the interest in this type of study shows a total of 17 publications, whereas in 2021, research production experienced a reduction of 9 published articles; however, from 2022 to 2024, notable growth is evident, reaching its highest level in 2024 with a total of 31 academic publications, in addition, so far this year, three research studies have already been registered, which reflects a clear interest in the study of artificial intelligence applied to the sustainable conservation of ecosystem services.

Figure 2. Trend of publications in the Scopus database

On the other hand, 19 research studies were documented in different areas of knowledge, with environmental science standing out as the most studied, with 24 % of the total, which constitutes 42 scientific documents, followed by agricultural and biological sciences, with 28 articles representing 16 %. In contrast, 11 % corresponds to computer sciences with 19 academic publications, and the field of medicine, social sciences, and engineering with 8 % giving a combined value of 44 publications; the other areas present a smaller amount of studies, including business and decision sciences with 4 %, earth sciences 3 % and energy 2 % as can be seen in figure 3.

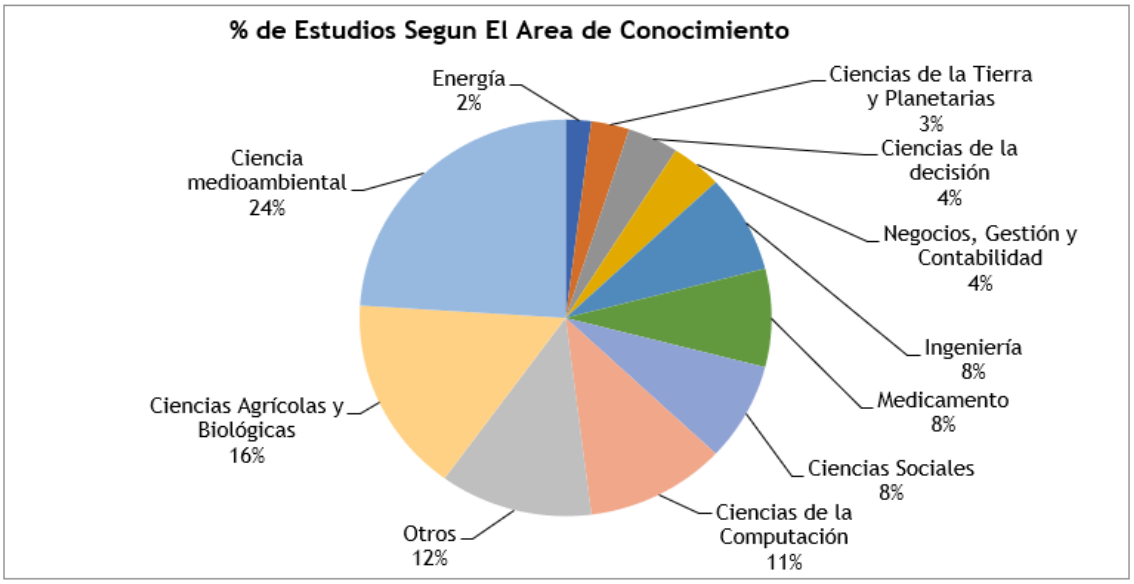

Figure 3. Percentage by study area

The correlation of co-authorship and countries was analyzed where 101 papers published in 15 countries were reflected with several three papers per author, as shown in figure 4, where 15,84 % of the papers are from the United States with 16 scientific papers, on the other hand, 14,85 % belong to Italy with 15 papers. For the present study, 5 clusters and 15 items were registered, which are divided by colors: cluster 1 with red color: United States, Italy, South Korea, United Kingdom, cluster 2 with green color: Finland, Germany, Sweden, Switzerland, cluster 3 with blue color: Australia, Canada, Norway, cluster 4 with yellow color: Spain, Netherlands, and cluster 5 with purple color: Czech Republic, Turkey, where the United States dominates the correlation. In addition, figure 5 shows that the United States and Italy have the highest number of publications in the field of HE with the applicability of AI.

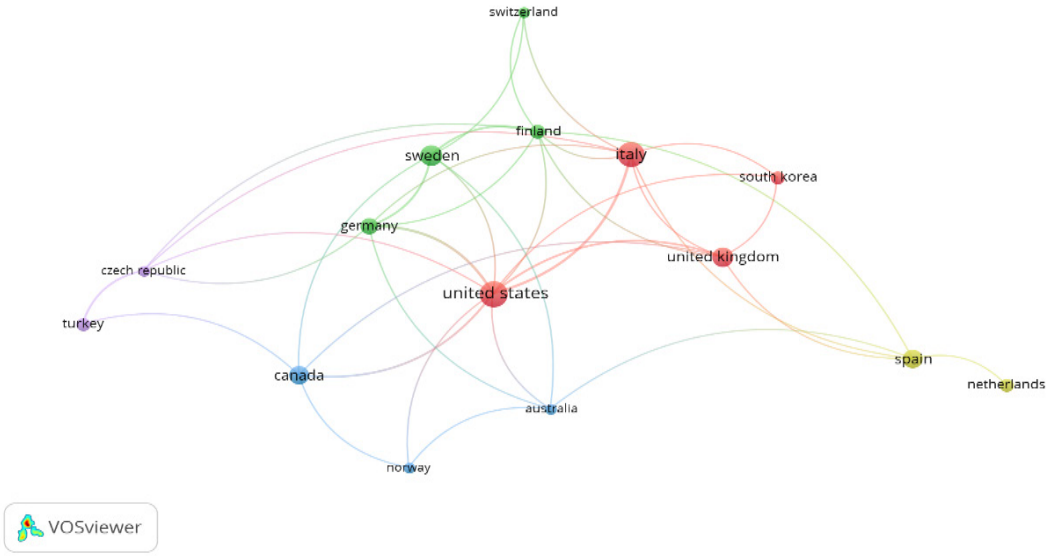

Figure 4. Correlation analysis of Co-authorship - Countries

Figure 5. Number of publications by country

Additionally, the relationship of co-occurrence with descriptors was evaluated by applying a minimum number of occurrences of a search term,[10] choosing the following keywords: Artificial intelligence, ecosystems, ecosystem service, and sustainable development, with several co-occurrence of 217 being the usual expression with 41,93 % corresponding to AI, on the other hand, ecosystem services reach 15,2 % of recurrence, exposing four items and 1 cluster as shown in figure 6.

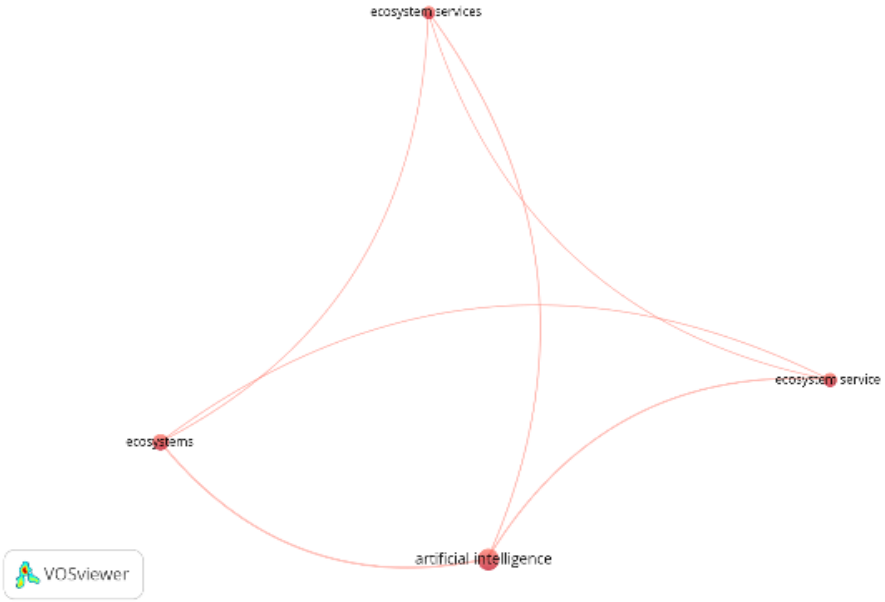

Figure 6. Correlation analysis with Co-occurrence and keywords

The interdependence cocitation study with author citations was applied to 20 author citations and 21 authors giving a total of 491 citations with 2 clusters, cluster 1 with 16 items: Bhattacharya P, Coro G, Costanza R, Kumar N. Li J, Li X, Liu Y, Lusch R, Tanwar S, Vargo S, Villa F, Wang J, Wang Y, Wirtz J, Zhang X, Zhang Y, and cluster 2 with five items: Baskent E, Borges J, Felton A, Mozgeris G, Seidl R. Standing out with 7,13 % is the author Vargo S with several 35 citations, as shown in figure 7.

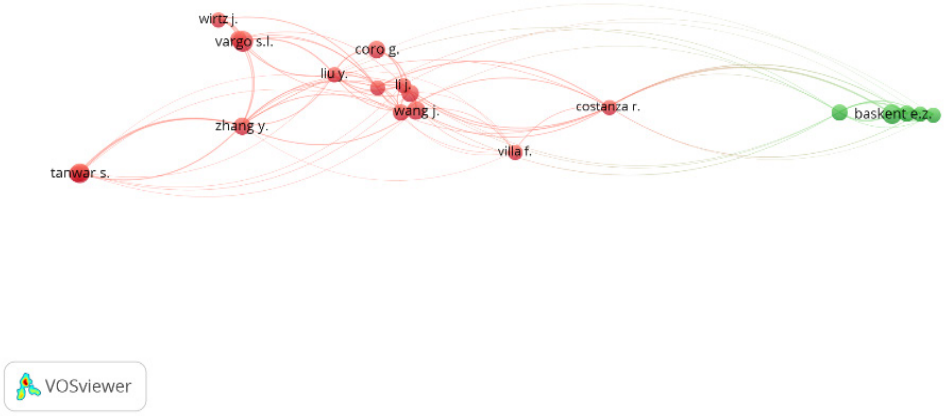

Figure 7. Correlation analysis of citations authors

DISCUSSION

According to the information available, ecosystem services indicate a major sustainability deficiency due to excessive consumption of natural resources, land degradation, and environmental changes, which increase carbon dioxide emissions, soil loss, water supply, and cultural values. Therefore, efficient forestry operations are essential for biodiversity and human well-being.[13,14,15,16,56,57,58,59,60,61,62] Implementing AI facilitates the manipulation of complex data analysis for a prior study of what is happening in an ecosystem to present a result of different environmental events in real time, promoting minimal consumption of green energy and aiding decision-making.[20,63,64,65,66,76,68] Mapping is widely used in previous research to restore these environmental services.[42,58,69,70,71] ES provides great benefits and advantages, which gives rise to the implementation of IA as a tool that generates support for the better use of natural resources.[16,72] When adopted by the community, it guarantees an optimal quality of life for all living beings, a sustainable economy, ecological education, and a socio-cultural balance.

CONCLUSION

Sustainable conservation of ecosystem services focused on the application of artificial intelligence was analyzed using the Scopus database as a direct source of bibliometric research. Studies involving ecosystem services generally seek to generate a green solution for the preservation of natural resources that provide great benefits to the community, promoting a sustainable economy and technological advancement with the great goal of environmental care.

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