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AN OVERVIEW OF LAND ACCOUNTING TRENDS, ENCOMPASSING PAST, PRESENT, AND FUTURE PERSPECTIVES, BASED ON ENGLISH-LANGUAGE ARTICLES IN THE WEB OF SCIENCE DATABASE LAST DECADE

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Abstract

This review explores the past, current, and future trends of land accounting by analyzing papers indexed in the Scopus database published in English between 2013 and 2024. Land accounting, which involves systematically measuring, recording, and analyzing land use, land cover, and land-related resources, is crucial for managing land resources sustainably. This review synthesizes findings from a range of studies, highlighting significant advancements, challenges, and evolving methodologies in land accounting. The analysis identifies key trends in the use of remote sensing technologies, Geographic Information Systems (GIS), and spatial data analytics, which have enhanced land accounting practices. It also examines the growing importance of environmental sustainability, land degradation monitoring, and policy implications. Finally, the review outlines emerging trends, such as the integration of land accounting with climate change adaptation strategies, and offers suggestions for future research directions.

Keywords: *Land Accounting, Land Resource Management, Geographic Information Systems (GIS), Remote Sensing, Digital Land Mapping, Land Data Analysis, Land Valuation, Land Information Systems (LIS).*

Introduction. Land is one of the most valuable and finite natural resources, supporting various socio-economic activities, including agriculture, urban development, and conservation. As the global population continues to grow, the demand for land intensifies, necessitating effective and sustainable management. Land accounting has emerged as a critical tool in this context, offering a systematic approach to track, assess, and manage land resources. Over the past few decades, technological advancements and a growing understanding of environmental concerns have significantly influenced the evolution of land accounting practices. This paper reviews the past, current, and future trends in land accounting, focusing on papers published in English between 2013 and 2024 that are indexed in the Scopus database. The objective is to provide a comprehensive overview of the key developments in this field, assess the methodologies employed, and identify potential gaps and opportunities for future research. By analyzing a wide range of studies, this review aims to contribute to the ongoing discourse on land resource management, providing valuable insights for researchers, policymakers, and practitioners alike. The review also seeks to highlight how land accounting intersects with broader global issues such as environmental sustainability, urbanization, and climate change adaptation.

2. Methods

A Global Library of Advanced Land Quantitative Methods for 2013-2024 in Scopus. We first searched for "Land Quantitative Accounting" as a keyword in the article title, abstract, and keywords section and found 36,985 published papers within the above-mentioned time period. During the skimming process, we found that most of the papers were not entirely devoted to land quantitative accounting. Then, the following filters were used as a search strategy.) and (limit-to (language, "English")) and research disciplines were selected. Through this refinement, we finally captured the papers from 2013-2024 and converted them into CSV and RIS extensions. VOSviewer citations 1.6.18 software is used to analyze bibliographic aggregation, topics, co-authorship, co-occurrence, citation, and co-citation.

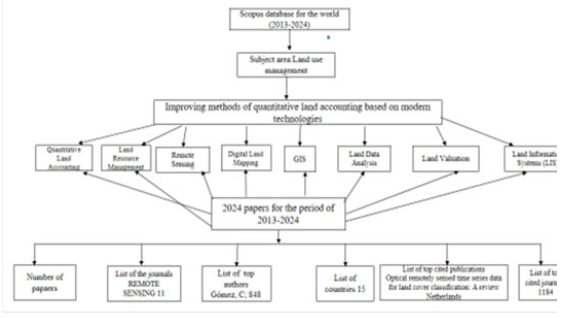


Figure 1. Flowchart of the methodology

The causes why we use the methods mentioned earlier are due to SCOPUS as a well-known database that collects authoritative literature from all over the world, especially in the case of land use management. English is a universal language, therefore, the literature in English is more standard and meaningful than literature in other languages.

3. Results and discussion

3.1. Published papers on improving methods of quantitative land accounting

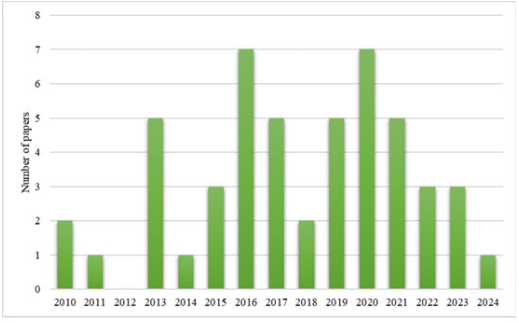


Figure 2. Number of papers on LA (land accounting) by the year of publication in the world

The graph shows the growth of the number of articles published in the field of LA over the years. Especially in the last decade, there has been a rapid increase. This indicator indicates the importance of the field and the increasing demand for research. This trend proves that the importance of environmental and land resource management is increasing year by year. The development of modern technologies (for example, remote sensing and GIS) has stimulated an increase in research. In addition, climate change and efficient use of resources have become topical issues.

3.2 Journals on LA (land accounting)

Scientists use various journals around the world to publish their research.

Table 1 List of the top journals in the world on LA (land accounting)

Scopus Source Title	Number of papers
REMOTE SENSING	11
REMOTE SENSING OF ENVIRONMENT	11
INTERNATIONAL JOURNAL OF REMOTE SENSING	6
INTERNATIONAL JOURNAL OF APPLIED EARTH OBSERVATION AND GEOINFORMATION	5
LAND	3
IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING	2
ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	2
SCIENCE OF THE TOTAL ENVIRONMENT	2
CANADIAN JOURNAL OF REMOTE SENSING	1
LAND DEGRADATION & DEVELOPMENT	1

This table lists the leading scientific journals that have published the most articles in the field of land assessment. The journals are ranked by the number of articles.

Remote sensing and remote sensing of environment are the most popular journals with 11 articles each and are attracting attention in the field. They cover topics that are widely used in Land Assessment (LA). international journal of remote sensing and international journal of applied and geoinformation are well established in this field. These journals are the most popular platforms for publishing LA software and modern technologies. Remote sensing of the environment and remote sensing of the environment have left others behind with their high-quality scientific articles.

3.3 Top authors in the world on LA (land accounting)

There is no doubt that authors play a major role in the development of a particular field of research in any region of the world. By analyzing the authors with the most publications, this section provides insight into the research contributions of individuals. Table 2 shows the top 15 authors who have published articles on land resource quantification in the last decade. According to statistics, Gómez, C; (14) is the most cited researcher. Eklundh, L. is cited 848 times in each work. Woodcock, CE (87) Friedl, MA (73) v a Herold, M (75). has the most publications and has a high H-index, expanding its position as a leading expert in land resource quantification.

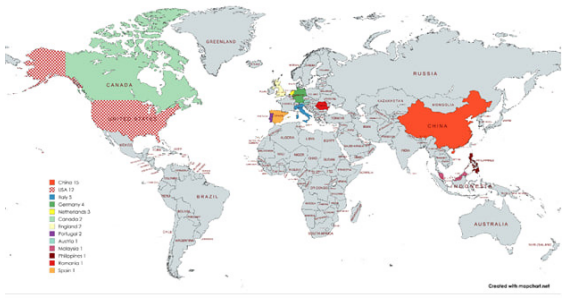
This information helps to evaluate the contributions of researchers in the field of LA.

Table 2 List of top productive authors in research on LA

No.	Author	Sum of times cited	H- index	Total citations	Citing articles
1	Gómez, C;	1644	14	848	1534
2	Eklundh, L	9834	45	269	7035
3	Zhu, Z;	12961	39	196	8240
4	Griffiths, P;	4349	30	179	3365
5	Potapov, P;	23570	57	162	17734
6	Woodcock, CE;	31467	87	149	20571
7	Feng, M;	16472	59	101	10378
8	Liu, L.;	855	16	96	725
9	Albergel, C;	8303	37	79	5838
10	Friedl, MA	26500	73	77	18809
11	Ahmed, Oumer S	763	15	75	678
12	Stehman, SV	24972	65	68	18220
13	Liu, B.	530	12	63	444
14	Rufin, P;	572	12	60	499
15	Herold, M	23143	75	56	17301

3.4 List of the top 10 countries in the world in terms of LA

The internationalization of a region can be measured by the number of countries participating in research activities on a particular topic. In total, more than 100 countries collaborated on the quantitative accounting of Earth's resources in the world from 2013 to 2024. Figure 3 shows the geographical location of the top 10 countries that participated in publishing at least 45 or more publications. By a large margin, China dominates this indicator with 15 research papers, followed by the USA 12, Italy 5, Germany 4, Netherlands 3.



3.5 Top institutions on LA in the world

In general, institutions are ranked based on the quality of the papers published by their researchers. Between 2013 and 2024, 160 different institutions collaborated to publish 3,547 papers in the field of LA. To identify the most influential and productive institutions in the field of LA, we analyzed the publications of the 15 best institutions. As shown in Figure 4, five of the 15 institutions are from China, four from the United States, and three from France, Switzerland, the Netherlands, and Germany. China leads the way with 3,729 and the United States with 1,373 papers, indicating that countries are strategically focusing on resource management and environmental monitoring in the field of LA. European countries, including France, Germany, and Switzerland, maintain

their leading positions in basic research.



Figure 4. List of top institutions on LA

3.5 Top cited papers on LA

There is a correlation between the number of citations and the quality and novelty of land accounting research. The table shows the fifteen most cited articles. A total of 22,426 citations were given to 2,010 publications in this field. Among them, 15 articles were cited 2961 times, which is 13.2% of the total citations. Among these 15 articles, the USA leads with 9 contributions, which is 60% of the total volume. Switzerland and the Netherlands each have two contributions, each accounting for 13.3%. The United Kingdom and China each account for 6.7%. These figures reflect the level of interest and contribution of different countries to the field of research. These papers cover innovative topics such as land cover mapping, improvements in remote sensing technologies, and land condition monitoring, all of which have significantly contributed to the development of land accounting research.

This table highlights the most cited research articles in the field of Land Assessment (LA). The provided metrics include:

Title: The name of the research publication.

Journal: The journal where the article was published.

Corresponding Author(s): Primary authors responsible for the article.

Country: The country of affiliation of the authors.

PY (Publication Year): The year the article was published.

TC (Total Citations): The total number of citations received.

3.6 Top cited journals on LA

The diagram shows the number of citations for various journals in the field of remote sensing and land accounting research. The total number of citations across all journals is 3,898. Below is a detailed analysis of the citation distribution and percentage for each journal: Remote Sensing Of Environment leads the list with 1,184 citations, accounting for 30.4% of the total citations, ISPRS Journal Of Photogrammetry And Remote Sensing follows with 857 citations, representing 22.0% of the total, Remote Sensing has 384 citations, contributing 9.9% to the overall citation count, International Journal Of Remote Sensing has 190 citations, making up 4.9% of the total citations, International Journal Of Applied Earth Observation and Geoinformation comes next with 144 citations, or 3.7% of the total, IEEE Transactions On Geoscience And Remote Sensing has 105 citations, contributing 2.7%, Canadian Journal Of Remote Sensing follows with 75 citations, representing 1.9% of the total, IEEE Journal Of Selected Topics In Earth Observation And Remote Sensing has 45 citations, accounting for 1.2% of the total, Land contributes 38 citations, or 1.0%, Science Of The Total Environment has 20 citations, representing 0.5% of the total.

This breakdown clearly shows that Remote Sensing Of Environment and ISPRS Journal Of Photogrammetry And Remote Sensing are the dominant journals in this field, with nearly half of the total citations coming from these two sources. The remaining journals represent a smaller share of the citations but still contribute to the broader research landscape.

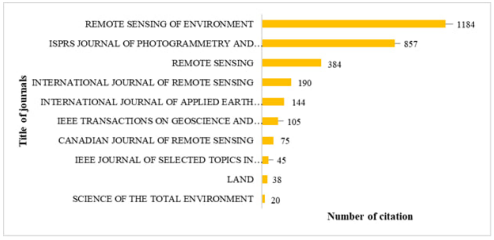


Figure 5 List of top cited journals on LA

In recent years, the field of land cover classification and monitoring has seen significant advancements due to the increasing use of optical remotely sensed time series data. Several studies have contributed to improving the methods and tools for land cover monitoring through satellite imagery, which has led to enhanced capabilities for detecting land disturbances, monitoring urbanization, and assessing environmental changes.

White and Wulder's (2016) review in the ISPRS Journal of Photogrammetry and Remote Sensing focused on optical remotely sensed time series data for land cover classification, providing valuable insights into the evolving methodologies for classifying land cover types from multi-temporal imagery. Their work highlighted the growing importance of utilizing long-term satellite datasets, which can track changes in land cover over time with high accuracy.

Similarly, in 2020, Gray et al. conducted a study published in Remote Sensing of Environment on continental-scale land surface phenology using harmonized Landsat 8 and Sentinel-2 imagery. This study not only provided a comprehensive analysis of land surface phenology but also stressed the importance of integrating data from different sensors to improve monitoring and understanding of seasonal land surface changes. This work complements Zhang et al. (2020), who developed a framework for continuous monitoring of land disturbance using Landsat time series, emphasizing the critical role of consistent satellite observations in tracking long-term land changes, particularly in the face of urbanization and agricultural expansion.

Another notable contribution to the field came from Hostert et al. (2010), who focused on mapping megacity growth with multi-sensor data. Their study, published in Remote Sensing of Environment, showed how integrating data from different remote sensing

platforms can provide a detailed view of urban growth, a critical factor for land use planning and environmental monitoring.

Moreover, Hansen et al. (2020) in their work on Landsat Analysis Ready Data for Global Land Cover and Land Cover Change Mapping presented an innovative approach to utilizing readily available Landsat data for global land cover mapping. Their study addressed the increasing need for standardized datasets that allow for seamless and large-scale land cover change monitoring, which has become crucial in global environmental assessments.

Loveland et al. (2020), in their article Transitioning from change detection to monitoring with remote sensing: A paradigm shift, discussed the shift in remote sensing applications from traditional change detection towards ongoing monitoring. This shift aligns with the broader trend in land cover studies, where long-term and continuous monitoring has become more critical than ever before for understanding and managing environmental changes.

The importance of improving the consistency and accuracy of land cover maps was also highlighted by Huang et al. (2013) in Remote Sensing of Environment. Their study, Global Surface Reflectance Products from Landsat: Assessment Using Coincident MODIS Observations, evaluated the consistency of different satellite products and the potential to combine them for more accurate land cover classifications, thus enhancing the quality of remote sensing data for global land cover mapping.

In addition to these studies, Hong et al. (2013) proposed a visible and shortwave infrared drought index for monitoring soil and vegetation moisture in their work published in International Journal of Remote Sensing. Their research emphasized the role of optical remote sensing in drought monitoring, a critical factor in assessing land productivity and managing natural resources.

The challenges of consistent mapping of land cover dynamics were addressed by Abercrombie et al. (2016) in their work on improving multitemporal land cover maps using a Hidden Markov Model, published in IEEE Transactions on Geoscience and Remote Sensing. This methodology allowed for better handling of temporal changes, which is essential for monitoring annual land cover dynamics.

Franklin et al. (2015), in their work on large-area mapping of annual land cover dynamics using Landsat time series, explored the potential of multitemporal change detection to create annual land cover maps over large areas. This method is valuable for monitoring both natural and human-induced changes in land cover at a global scale.

Dorigo et al. (2013) contributed to the understanding of soil moisture dynamics through satellite Earth observation. Their study, Monitoring Multi-Decadal Satellite Earth Observation of Soil Moisture Products, emphasized the importance of soil moisture products for understanding land surface processes and improving agricultural practices, as well as informing climate models.

In operational national monitoring programs, Pengra et al. (2020) examined the consistency of land cover reference data. Their work, published in Remote Sensing of Environment, provides crucial insights into the accuracy of land cover mapping products and the importance of quality control in large-scale land monitoring initiatives.

In terms of flood monitoring, Wan et al. (2019) leveraged CYGNSS data to monitor flood inundation during typhoon and extreme precipitation events in China. Their research, published in Remote Sensing, underlines the importance of integrating different types of satellite data for disaster management and mitigation strategies.

Müller et al. (2015) explored land use intensity trajectories in Amazonian pastures derived from Landsat time series, focusing on land use dynamics in sensitive ecosystems. Their study, published in the International Journal of Applied Earth Observation and Geoinformation, highlighted the role of remote sensing in tracking land use changes and its implications for biodiversity and land management in the Amazon.

Finally, Hüttich et al. (2011) assessed the effects of temporal compositing and varying observation periods for large-area land-cover mapping in semi-arid ecosystems. Their research, published in Remote Sensing of Environment, illustrated the challenges of mapping land cover changes in arid regions and the need for precise timing of satellite observations to account for the unique environmental conditions in these areas.

In summary, these diverse studies demonstrate the significant advances in the application of remote sensing for land cover monitoring and environmental management. From tracking urban growth and agricultural changes to monitoring droughts, floods, and soil moisture, the integration of various remote sensing technologies continues to play a crucial role in understanding and addressing global environmental challenges. The combined efforts of researchers like White, Wulder, Gray, Hansen, and many others underscore the interdisciplinary nature of land cover and environmental monitoring, which remains critical for sustainable land management and policy development in the coming years.

4. Conclusions

The evolution of land accounting from 2013 to 2024 reveals an increasing sophistication in methods, technologies, and applications. While earlier research focused on the establishment of foundational concepts and technologies, the current trends show an emphasis on sustainability, ecosystem services, and governance. Looking to the future, land accounting is poised to play a key role in addressing global challenges such as climate change, resource management, and sustainable development through more integrated, transparent, and innovative approaches.

Table 2. Top Cited Publications in Land Assessment (LA)

№	Title	Journal	Corresponding author	Country	PY	TC
1	Optical remotely sensed time series data for land cover classification: A review	ISPRS JOURNAL OF PHOTOGRAMMETRY AND REMOTE SENSING	White, JC; Wulder, MA	Netherlands	2016	772
2	Continental-scale land surface phenology from harmonized Landsat 8 and Sentinel-2 imagery	REMOTE SENSING OF ENVIRONMENT	Gray, JM; Melaas, EK; Moon, M; Eklundh, L; Friedl, MA	USA	2020	255
3	Continuous monitoring of land disturbance based on Landsat time series	REMOTE SENSING OF ENVIRONMENT	Zhang, JX; Yang, ZQ; Aljaddani, AH; Cohen, WB; Qiu, S; Zhou, CL	USA	2020	174
4	Mapping megacity growth with multi-sensor data	REMOTE SENSING OF ENVIRONMENT	Hostert, P; Gruebner, O; van der Linden, S	USA	2010	159
5	Landsat Analysis Ready Data for Global Land Cover and Land Cover Change Mapping	REMOTE SENSING	Hansen, MC; Kommareddy, I; Kommareddy, A; Turubanova, S; Pickens, A; Adusei, B; Tyukavina, A; Ying, Q	Switzerland	2020	146
6	Transitioning from change detection to monitoring with remote sensing: A paradigm shift	REMOTE SENSING OF ENVIRONMENT	Loveland, TR; Herold, M; Bauer, ME	USA	2020	136
7	Global surface reflectance products from Landsat: Assessment using coincident MODIS observations	REMOTE SENSING OF ENVIRONMENT	Huang, CQ; Masek, JG; Vermote, EF; Gao, F; Narasimhan, R; Channan, S; Wolfe, RE; Townshend, JR	USA	2013	92
8	VSDI: a visible and shortwave infrared drought index for monitoring soil and vegetation moisture based on optical remote sensing	INTERNATIONAL JOURNAL OF REMOTE SENSING	Hong, Y; Qin, QM; Liu, L	UK	2013	86
9	Improving the Consistency of Multitemporal Land Cover Maps Using a Hidden Markov Model	IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	Abercrombie, SP;	USA	2016	73
10	Large Area Mapping of Annual Land Cover Dynamics Using Multitemporal Change Detection and Classification of Landsat Time Series Data	CANADIAN JOURNAL OF REMOTE SENSING	Franklin, SE;Wulder, MA; White, JC; Hermosilla, T; Coops, NC	USA	2015	70
11	Monitoring multi-decadal satellite earth observation of soil moisture products through land surface reanalyses	REMOTE SENSING OF ENVIRONMENT	Dorigo, W; Balsamo, G; Muñoz-Sabater, J; de Rosnay, P; Isaksen, L; Brocca, L; de Jeu, R; Wagner, W	USA	2013	69
12	Quality control and assessment of interpreter consistency of annual land cover reference data in an operational national monitoring program	REMOTE SENSING OF ENVIRONMENT	Pengra, BW; Horton, JA; Dockter, DJ; Schroeder, TA; Yang, ZQ; Cohen, WB; Healey, SP; Loveland, TR	USA	2020	65
13	Using CYGNSS Data to Monitor China's Flood Inundation during Typhoon and Extreme Precipitation Events in 2017	REMOTE SENSING	Wan, W;Zeng, ZY; Chen, X; Wu, GP; Xu, LW; Chen, XW; Hong, Y	Switzerland	2019	57
14	Land use intensity trajectories on Amazonian pastures derived from Landsat time series	INTERNATIONAL JOURNAL OF APPLIED EARTH OBSERVATION AND GEOINFORMATION	Müller, H; Pflugmacher, D; Hostert, P	Netherlands	2015	56
15	Assessing effects of temporal compositing and varying observation periods for large-area land-cover mapping in semi-arid ecosystems: Implications for global monitoring	REMOTE SENSING OF ENVIRONMENT	Hüttich, C; Wegmann, M; Cord, A; Strohbach, B; Schmullius, C; Dech, S	USA	2011	51

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