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Water Security under Climate Change and Land Use/Land Cover Changes in Brazil: A Comprehensive Bibliometric Analysis

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Abstract

Background: Studies on water security, climate change, land use, and land cover changes are, therefore, carried out all over the world, including in Brazil, where a growing body of related literature has been published in various scientific journals. On the one hand, performance analysis and science mapping are two main procedures in bibliometric analysis. They can conveniently show an important quantitative perspective to quickly learn the state, characteristics, and trends of research topics by providing robust indicators to reveal the dynamic mechanics hidden behind the number. The data of research publications on "water security (WS)", "climate change (CC)" and "land use and land cover changes (LULC)" are all of them linked to "Brazil", from the Web of Science Core Collection database and Scopus dataset were collected between 1990-2019. As well as, a critical review of the Brazilian National Water Security Plan (PNSH), aims to examine different approaches to water security under climate change and land use/land cover changes, and water governance in the context of the PNSH. Our results highlighted that research on CC and LULC has increased sharply over the past decade, while the WS concept starts to appear in 2014. Summarized information on retrieved WS, CC, LULC studies, such as yearly publications timeline, most popular publication platforms, salient keywords analysis, hot topics, cooperation level, and top-cited articles. That analysis provided the clues to discover the current research emphases and mapping trends of research topics. High rates of deforestation due to the expansion of agricultural lands, the water-food-energy nexus, strongly promoted climate change and land use/land cover changes research. However, the simultaneous effect of the two stressors on water resources is not often comprehensively investigated. As well as, the environmental consequences of these transformations are still poorly assessed but are strongly needed to support future planning and management of water resources, to mitigate these impacts.

Keywords: Literature review • Research trend mapping • Climate change • Water resources management

Introduction

Water security brings together concepts related to water characterizing the interactions between water conditions, ecosystem functioning and societal needs [1]. Thus, water security consists of having access to water in acceptable quantity and quality for health, livelihoods, ecosystems, and production, coupled with an acceptable level of water-related risks to people, environments and economies [2]. Similarly, it is intrinsically associated with society's ability to adapt to extreme events and especially to better predict periods of scarcity [3].

The concept of water security has evolved significantly since it emerged in the 1990s [4]. Nonetheless, interdisciplinary water security research faces considerable challenges given the complexity of analyzing interrelationships between vulnerability, risk, and resilience across scales, sectors, and disciplines [5]. Despite the water security research challenges found that more regions of the world are being studied, and a greater variety of spatial scales [6].

A comprehensive study was conducted through a systematic analysis of articles, book and book chapters published between 2010-2015 on how water security is considered, articulated, and operationalized in place-based studies at a global scale [6].

Likewise, on a global scale, was conducted a worldwide synthesis of water security considering human and biodiversity perspective [7]. And they found that nearly 80% (4.8 billion) of the world's population lives in areas where either incident human water security or biodiversity threat exceeds the 75th percentile

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[7]. This exposition to high levels of threat to water security is expected to be exacerbated by climate change which, driven by rising temperatures and changes in precipitation patterns, may altered frequency of extreme events [8-10]. A systematic review and comparative approach can complement earlier research and reveal new lessons about the application of water security around the world [6]. However, applications of this type of study on a regional scale are also necessary, since achieving water security requires coordinating actors within the context of overarching water-related standards and targets which may be optimally designed and set by higher orders of government [5]. Thus, this paper seeks to make a conceptual contribution by an extensive and updated bibliometric analysis of published literature to identify different approaches to water security in Brazil.

In addition to the published literature, we evaluate the Brazilian National Security Plan (PNSH), recently launched in 2019. The PNSH defines solutions to the quantitative water security challenge, in the short-term up to 2035. Most of the solutions pointed out by the PNSH are related to the implementation of infrastructures such as dams, water conduction infrastructure, and water bypasses (adductors and channels). In the PNSH, traditional approaches to dealing with water security have widely depended on building large scale infrastructure. Responses to meet these demands of security are often pursued through large infrastructures, which are argued by critical geographers as depoliticized measures because of its potential to hide socio-political complexities behind technical solutions [11].

Different than review articles that outline some specific aspects, this paper conducted an updated bibliometric analysis of water security literature considering increasing uncertainties caused by global socio-natural changes, published in English between 1990 and 2019. The analysis was carried out with the software R 3.6.2. Using an adaptation of the source code provided by the Network Analysis Interface for Literature Studies (NAILS) project and bibliometric-biblioshiny package [12]. The R-tool allowed a comprehensive science mapping analysis, elucidating the dynamics and publication trends, identifying gaps and suggest directions (to researchers and policymakers) for effective decision-making and formulation of new research proposals. Further, we investigated different approaches of water security and water governance in the context of the PNSH, to explore the role of governance processes and structures in the shaping of water security. Considering that the appropriate (and continuing) responsibility of states should be a central question in the debate over the place, that adaptive and multi-level governance should play in addressing water security [5].

Methodology

Bibliometric analysis

In the next section, we described the bibliometric and biblioshiny method, the software R, and the databases. We choose the search engine Web of Sciences (WoS), considering the advantages of being a central source of information due to its comprehensiveness and high-quality records [13]. Besides, the WoS is a typical scientific review platform, it has a reliable indexing technology that minimizes "indexer effect", and is well accepted among scientific communities [14]. The WoS is the only bibliographic database that normalizes the cited references for each article record across the whole collection [15]. According to the Journal Citation Report (JCR), it indexes 11,877 journals across 236 WoS subject categories in 2019. From this total, 283 journals were added to the JCR for the first time.

We searched the literature in English available between 1990 and 2019, using the following strings "water security", "climate change" and "land use and land cover changes", all of them linked to the word "Brazil". We do not include publications of project reports, meeting abstracts, and legal documents because are not peer-reviewed scientific papers. The only exception was the Brazilian National Water Security Plan (PNSH), as we believe a critical analysis is necessary since climate change analyzes are implicit. We also searched Scopus database (titles, abstracts, and keywords) from 1990-2019, using the same strings, aiming to evaluate that our sample retrieved from Web of Science database was representative of the existing literature.

We divided our dataset into three, one for each concept searched: Water Security (WS); Climate Change (CC); and Land use and Land cover (LULC). We downloaded the full record and cited references (including 74 variables). The three sets of records (WS, CC and LULC bodies of literature) were considered as an individual concept, where a corpus is defined in text mining as a collection of text, generally in the form of several document.

The analysis was performed applying the software R 3.6.2, using an adaptation of the source code provided by the Network Analysis Interface for Literature Studies (NAILS) project [16,17]. This was used worldwide for important scientific publications dealing with all types of research, for example, sustainability hydrology, psychology, public health and finance [18-26].

The individual string (i.e. WS, CC, and LULC) were analyzed based on Latent Dirichlet Allocation (LDA) and supported by the NAILS code with LDAvis 0.3.3 package in R [25,26,28]. Witch includes a list of salient keyword terms associated with the overall corpus; and six topics maximum, with associated topic-specific keywords. The full description of the Latent Dirichlet allocation (LDA) method is detailed by D'Amato and collators [29].

The NAILS code also present the specificity keyword and the distance between topics on a scatter plot, calculated using Jensen-Shannon divergence, which approximates the semantic relationship between topics based on multidimensional scaling (MDS) [28]. This allows the level of similarity or distance between investigated objects to be visualized [29]. Also, the specificity of the keyword is calculated as the ratio of the frequency of the keyword in a certain topic to the overall keyword frequency in the overall corpus, given a weight parameter λ ($0 \leq \lambda \leq 1$) [30]. Where decreasing of the λ weight parameter values reveals topic-specific while increasing of the λ weight parameter values reveals keywords that are common to the entire corpus.

As suggested by, based on the recommendation of, for a better definition of non-usual keywords, we adopted the $\boldsymbol{\lambda}$ of 0.75. The meaning of each emerging topic and the inter-topic distance was analyzed, based on the given salient keywords [28,29]. For each concept, we programmed the model to highlight (up to six) topics characterized by a set of keywords, that can be generic to the entire corpus, or specific to one or a few topics. The model provides the option to identify the keywords that are specific to certain topics.

Bibliometrics data processing and analysis

The bibliometric-biblioshiny package, an R-tool for comprehensive science mapping analysis [31]. The Authors developed this tool for accurate publication data processing such as: file conversion; term extraction; duplicate matching and merging; descriptive analysis; matrix building; and similarity normalization. We imported data into RStudio, converted to a bibliographic data frame, and normalized for duplicate marching [32].

For bibliometric analysis, we used a descriptive statistical method based on the information delivered from the Web of Science records. The records include number of publications per year; most popular publication platforms; main information; most relevant authors; correlated author country; network collaboration; collaboration country; and treemaps. Data were analyzed for descriptive output, citation analysis, authors' h-index and scientific productivity using the relevant functions of the bibliometric R-package. Bibliometric networks (e.g., citation, author, network collaboration, author keyword, and Keywords-Plus networks) and bibliographic coupling (co-citation and keyword co-occurrences) were computed.

Observations, Validity, Reliability and Limitations

There were some limitations related to the bibliometric survey adopted in this study. The limitations include the exclusions of some types of documents (e.g., project reports, meeting abstracts, and legal documents), articles published in non-English Language (e.g. in Chinese and Portuguese), and the use of only two databases (WoS and Scopus). As suggested by previous studies, we decided however not to use ancillary search terms (i.e. synonyms), to guarantee a balanced search strategy and comparability of the datasets.

The Latent Dirichlet allocation (LDA) process adds another limitation. Some words in LDA analysis are common, for this reason can disturb the final

analysis even with $\lambda = 0.75$ [23]. In these cases, the researcher (base on his expertise) can decide the application for each term. Hence, we highlighted enough topics within each concept to uncover internal variability. Thus, we did not have an excessive number of topics, which could create noise and hamper comparability among concepts. To ensure a successful analysis of the data, the text material was pre-processed through tokenization and stemming [23,34].

Results and Discussion

In this section, the results are presented and discussed. The bibliometric analysis, of water security under climate and land use/land cover changes examined Brazilian research trends between 1990 and 2019. The analysis was based on data retrieved from Web of Science and Scopus, two of the most important worldwide scientific databases.

In total, the Climate Change (CC) literature body is the largest, 2759 publications. The Land use/land cover changes (LULC) follows with 708 and Water Security (WS) is the smallest corpus with 32 entries. The total was 3499 published scientific papers within the survey period, and their attributes are summarized in Table 1.

The studies involved 12,859 authors, with 0.296, 0.273 and 0.268 article per author for WS, CC and LULC respectively, as presented in Table 2. (3.38, 3.66, 3,74 authors per article for WS, CC, and LULC). If we look at co-authors per article the numbers for WS, CC, and LULC are 3.59, 4.84 and 5.22 commonly. The collaboration index of 3.62, 3.92, 3.91 for WS, CC and LULC. Except for 3 (WS), 252 (CC) and 38 (LULC) authors publishing solo, the rest of the authors were involved in multi-author articles. The recorded average citations per article during the study period highlighted that for WS concept (6.312) the citations were much lower than CC (20.32) and LULC (25.87) concepts. This is due to the lack of influential papers and the smaller number of publications within the WS concept.

Cooperation level and top-cited articles

It is well known that coauthorship is the most formal and widely used indicator of national and international collaboration. Scientific network collaboration through co-authored papers is an indicator of value to measure the development of certain concept [28]. For instance, analyzing the socio-environmental implications of the changes now underway in the global water cycle in support of science-informed policy [33]. It requires interdisciplinary, collaborative research, transcending "broad" versus "narrow" and "academic" versus "applied" distinctions. Even such research strategies currently face substantial barriers, including in disciplinary biases, funding constraints, and institutionalized incentives for tenure and promotion [29]. In this context, biblioshiny analysis outputs, were used in this study to measure the degree of cooperation in the field. It can be seen from Table 1 that the cooperation of land use and land cover research is on the rise at the author level in the recent decade. With an average of 5.22 co-authors/paper and an average degree of 3.96 of collaboration index. This indicates a potentially closer relationship among the authors within the same domain and a greater opportunity for collaboration along, with the rapid increase in scientific research output in this research area. While, the cooperation of water security and climate change researches are still needed. These facts can be noted in Figure 1, which show the number of published documents by researchers from other countries (even in single or multiple country publication). Although the focus of this article was only articles developed in and by Brazilian researchers, our results highlighted documents with at least one coauthor from different country, for multi-author articles (Figure 2-4).

We presented a highlight of the most cited publications and the most productive authors for each field. For WS concept, the work of, was the most cited paper. For land use and land cover changes research field, the work driven by was the top cited paper [30,31]. In climate change research field, the work performed dealing about increasing energy use, climate change, and carbon dioxide emissions from fossil fuels, was the most cited papers (more than 2000 citations) [32].

There are also other high-impact articles, although they are not the most cited. For instance, water security by applying the Blue and Green Water-Footprint for human activities, was assessed [33]. For climate change, updated simulations of energy use and greenhouse gas emissions, also, assessment of climate projections over South America [34-36]. While, the multiplicities and interdisciplinarities of political ecologies, policies, politics scientific approaches and technologies that have moderated forest conversion and shaped Amazonia's was outlined [37]. The output of 24 climate change models, also a dynamic vegetation model to determine the likelihood and causes of land use and land cover changes, was analyzed [38].

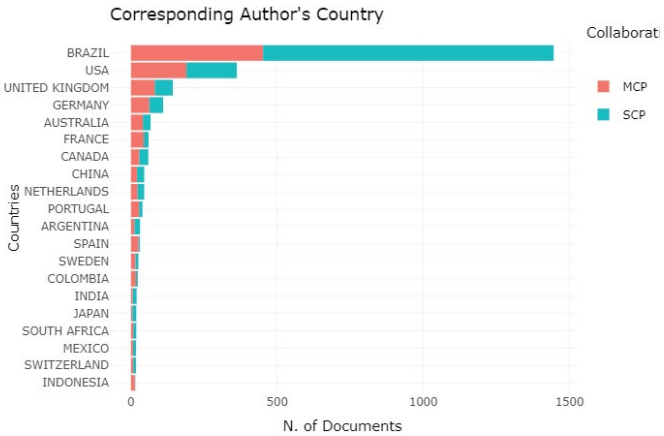
In Figure 2 and Figure 3, we present respectively, publications timeline

Table 1. A summary of the bibliometric analysis, including search engines, strings, dataset size and type of analysis.

Search engine	Strings searched	Dataset size	Analysis
Web of Science	Water Security (WS)	32	Temporal distribution of publications; most popular publication platforms; salient keywords, main information, most relevant authors, correlated author country, network collaboration, collaboration country, tree maps, emerging topics (LDA).
	Climate Change (CC)	2759	
	Land Use/Land Cover (LULC)	708	

Table 2. Summary information on retrieved WS, CC, LULC studies, between 1990–2019.

Descriptions	Counts and rates		
	WS	CC	LULC
No. of articles	32	2759	708
No. of authors	108	10106	2645
Involved in single-author articles	3	252	38
Involved in multi-author articles	105	9887	2620
Articles/author	0.296	0.273	0.268
Authors/article	3.38	3.66	3.74
Author appearances	115	13351	3699
Co-authors/article	3.59	4.84	5.22
Collaboration index (CI)	3.62	3.94	3.96
Average no. of citations/article	6.312	20.32	25.87
Study source (journals)	27	956	285
Keywords-Plus (ID)	135	6084	1794
Author's keywords (DE)	121	6809	1797



Note: MCP - Multiple Countries Publication and SCP - Single Country Publication. MCP indicates, for each country, the number of documents in which there is at least one co-author from a different country. MCP measures the international collaboration intensity of a country.

Figure 1. Authors' countries of published papers on the theme WS, CC and LULC, related to Brazil.

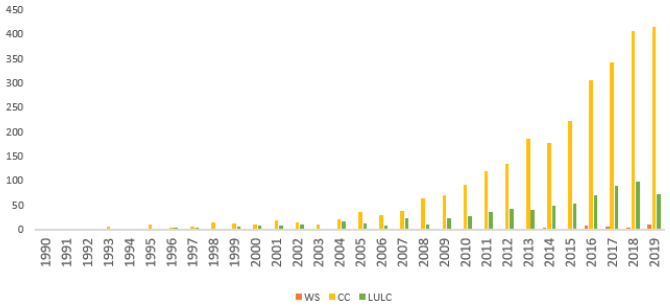


Figure 2. Publication trends for WS, CC and LULC literature between 1990–2019.

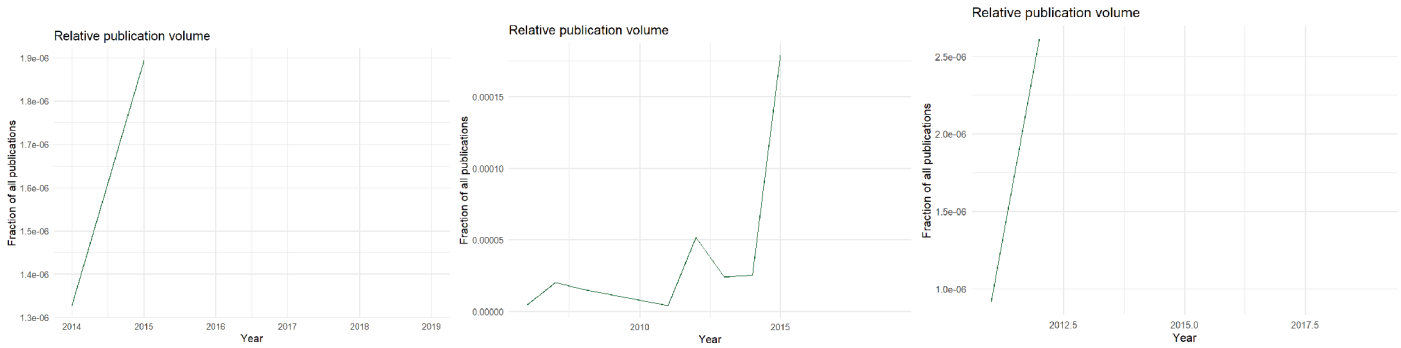


Figure 3. The relative publication volume related to WS (a), CC (b) and LULC (c), as found in the Web of Science Core Collection.

and relative publication volume related to water security, climate change and land use/land cover changes concepts, between 1990-2019.

As presented in Figure 2 and Figure 3 we found that CC and LULC starts to appear in the 1993's and 1995's, and 2014's for WS. This reveals that these concepts were becoming interesting for researchers. The number of published academic papers is an important indicator to measure the development trend of certain scientific research [35]. The number of research articles on CC and LULC increased non-linearly from 2006 and followed an exponential growth curve with time. Although both concepts have been concretely popularized in 2015.

As displayed in Figure 2, only CC and LULC fields have grown exponentially in the last decades. This suggests that research on water security has not been of broad interest in the past 24 years, likely due to discontinuation of WS-related research by certain authors and absence of a water security policy. In Brazil, the water security concept was introduced in 2014 [40].

There has also been a notable growth of the CC literature in 2013, probably indirectly fueled by national and global policy developments in this area, such as the 2012 UN Climate Change Conference (Rio+20).

On the other hand, the expansion of agricultural lands has shaped Brazilian Cerrado landscapes in recent decades. However, the environmental consequences of these transformations are still poorly [41], representing a gap and opportunity for LULC research. In addition, document analysis requires statistical on their origins, i.e., the key journals in the research field. Regarding the publication platforms of the three concepts, WS is generally published in "environmental hydrology"- oriented journals, namely, water resources research, agricultural water management and science (Figure 4a). The figure 4b shows that CC research is more often published in climate change science journals, while LULC research occurs in a mixed set of journals, often dedicated to land use policy, environmental sector-oriented journals, such as sustainability and agriculture (Figure 4c). It means that, WS, CC and LULC research papers are published in numerous journals, i.e., the publication

platforms exhibit a wide range and reflect the intra and inter-diversity of the concepts.

As far as the impact factors of these journals are concerned, most of those selected journals have an impact factor over 1, indicating their dominating academic influence.

In Figure 5 we present Word TreeMaps for WS, CC and LULC, delivered from Scopus. Each one displays large amounts of hierarchically structured (tree-structured) data. And, each branch of the tree is given a rectangle, which is then tiled with smaller rectangles representing sub-branches, which are proportional to a specified dimension of the words.

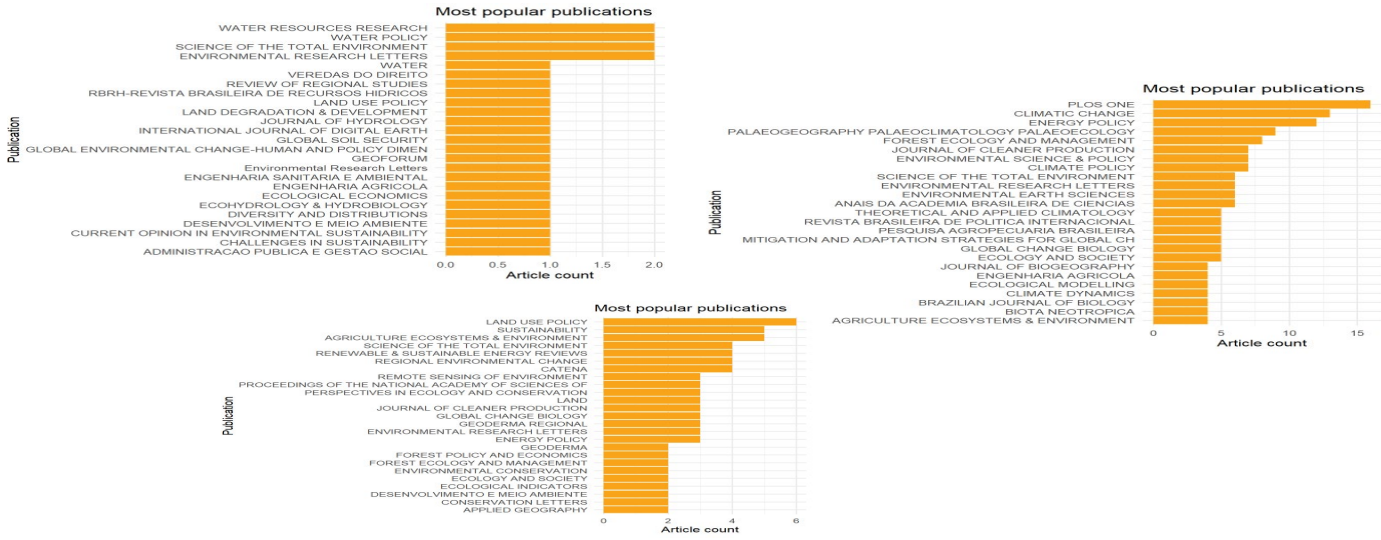


Figure 4. Most popular publications platforms for WS (a), CC (b) and LULC (c) concepts.

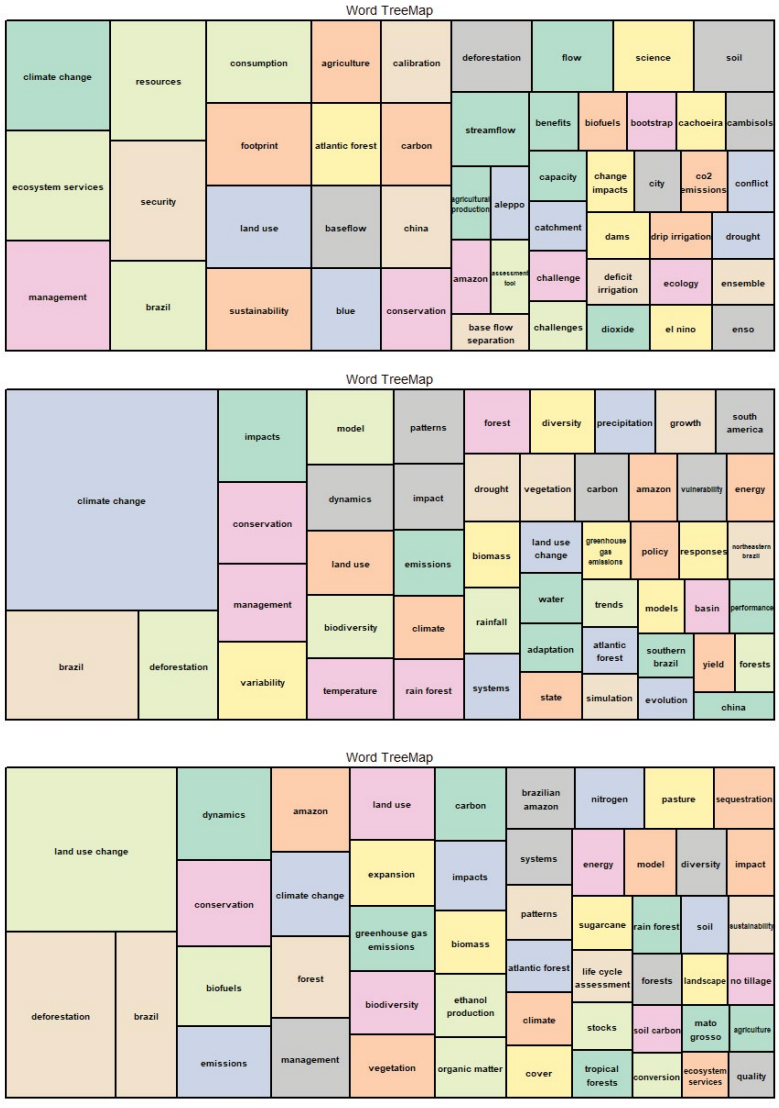


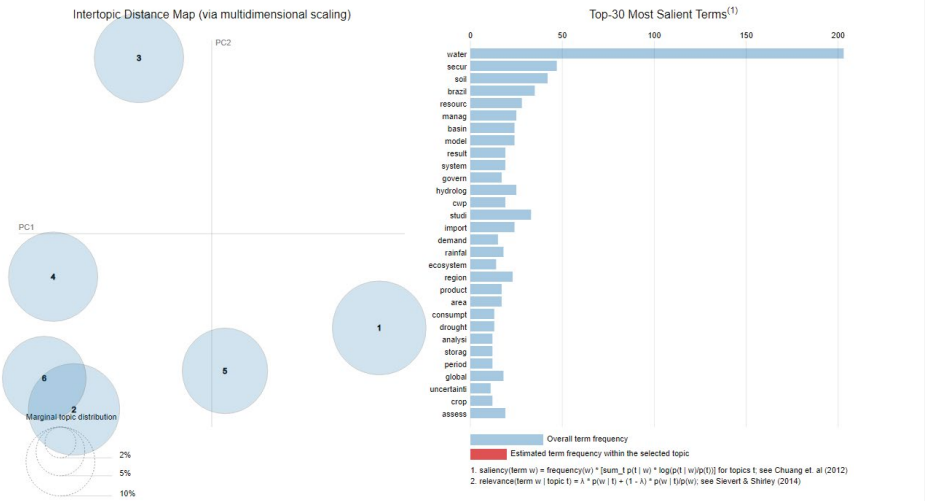
Figure 5. Word Tree Map for WS, CC and LULC concepts delivered from Scopus.

For the WS concept the most frequent words were climate change, ecosystem services, management, resources, security, and Brazil, meaning that they are searched in the same magnitude. Other word as consumption, footprint, land use and sustainability, followed as treated in the medium magnitude. While, words like conflict, drought, ecology, CO_2 emission, impact challenge, drip irrigation, have low magnitude. Although future researches are expected to focus on the impacts of CO_2 emissions and drought. Climate change is the only word that appears frequently in this research topic, which is on the rise, while, words like impacts, conservation, management, variability, are searched in the same dimension as the words model, dynamics, land use, biodiversity, temperature. This means future researches focused on climate vulnerability responses at a basin scale, mainly in northeastern Brazil region [42-46]. For LULC research, the words soil, sustainability, impact, rain forest, conservation, ecosystem services, life cycle assessment, and diversity, are the ones that need special attention in future researches.

Salient keywords analysis and hot topics

As a research field develops, the researchers will converge at certain important directions or conduct intensive studies at the different levels, reflecting the maturity of the subject [35]. However, the analysis of salient keyword terms and topics reveals that CC and LULC literature are more homogeneous than WS. Thus, in our analysis, we clear up the salient keywords and hot topics, to better understanding the development of the latest advances in each, aiming to track the research trends. Salient keywords associated with the WS literature include, for instance, water security, soil, resources, management, basin, model, system, government, and hydrology, identify research on hydrological modeling for integrated water resources management towards better water security (Figure 4). And salient keywords associated with the CC literature, includes forest, specie, distribution, deforest, Amazon, development, climate, model, water, region, temperature, emission, change, carbon, system, product, increase, soil, land, scenarios, energy, future, distribution, and policy (Figure 5). These salient key words identify researches related to the importance of deforestation, precipitation change, and temperature sensitivity in determining the future distributions and diversity of Amazonian plant species. While salient keywords associated with the LULC literature, includes soil, product, change, forest, water, sugarcane, climate, model, land, deforestation, agriculture, region, expansion, emission, increase, soybeans, stock, ecosystem, loss, development, impact, and crop (Figure 6). Which highlights research topics on how spatial patterns on agricultural expansion determines impacts on biodiversity. It is important to highlight that, the majority of the studies were developed along the following biomes, Amazon, Atlantic Forest (for WS and CC researches), Cerrado and Caatinga (for LULC researches), presenting a gap and a research opportunity for Pantanal and Pampa biomes.

When we analyzed the specific topics of each term, we notice how the peculiarities of the large areas organize the way and direction of research over the years (Table 3). A deeper analysis of the individual topics within each concept is provided in Table 4 and in Figures 6-8 clearly detailed by specific



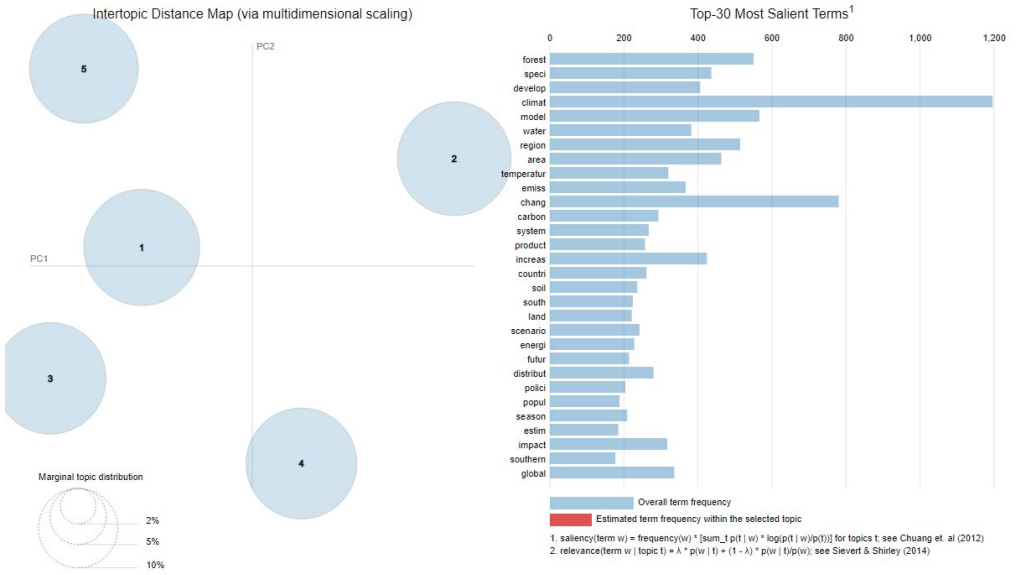
Note (1): in the bottom-right part of the figure, the numbers 1. And 2. (saliency and relevance) do not refer to the numbers of the circles in the scatterplot on the left part of the figure; the estimated term frequency (represented in red) isn't shown in this figure. (For interpretation of the references to color in this figure legend, the reader is referred to the online version of this manuscript.).

Note (2): the topics are visualized as circle areas. So, the circle size represents the proportion of each topic within the corpus; the number in the circle represents the topic number.

Figure 6. Top 30 salient keywords in WS (water security) literature and inter-topic distance. The figures show: a. The most salient keyword terms found in the articles dealing respectively with WS (right part of the figure). The semantic distance between the six topics (16), based on co-occurrence of words (left part of the figure).

Table 3. Six main topics emerging in WS, CC, LULC concepts.

Topic	Water Security (WS)	Climate Change (CC)	Land Use/Land Cover (LULC)
1	Rainfall and human activity impacts, on soil conservation for agriculture.	Models of temperature and precipitation variability on climate change predictions.	Impacts of regional future climate change scenarios in Amazon basin due land use and land cover changes.
2	Evaluating water conservation and reuse sources.	Sustainable development policies under climate change scenarios.	Increased emissions as a result of agricultural lands expansion.
3	Reservoirs water conservation and management strategies under water stress	Forest loss and fragmentation and its implications for habitat and species conservation in the Amazon.	Regional climate change projections
4	Hydrological models for assessing uncertainties.	Assessment and estimation of the impacts of carbon emissions.	Policies for support environmental ecosystems conservation
5	Ecosystem services management challenges in watersheds.	Assessment of climate change over South America.	
6	Government actions for water security under droughts scenarios.		



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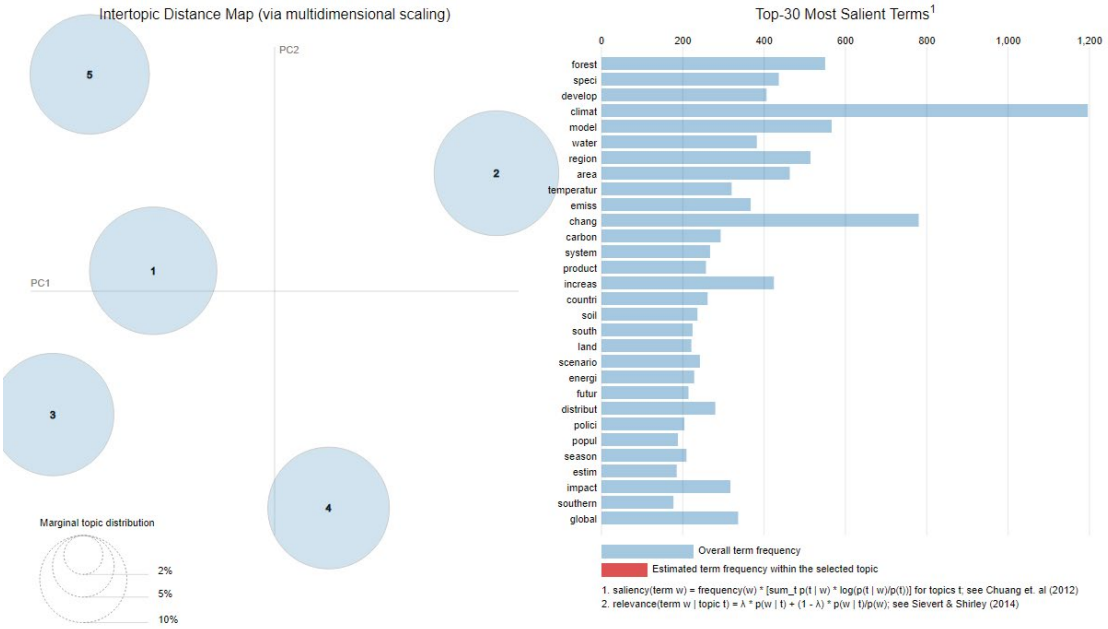
Note (2): the topics are visualized as circle areas. So, the circle size represents the proportion of each topic within the corpus; the number in the circle represents the topic number.

Figure 7. Top 30 salient keywords in CC (climate change) literature and inter-topic distance. The figures show: a.The most salient keyword terms found in the articles dealing respectively with CC (right part of the figure); and b. he semantic distance between the five topics (15), based on co-occurrence of words (left part of the figure).



Note (1): in the bottom-right part of the figure, the numbers 1. And 2. (Saliency and relevance) don't refer to the numbers of the circles in the scatterplot on the left part of the figure; the estimated term frequency (represented in red) isn't shown in this figure. (For interpretation of the references to color in this figure legend, the reader is referred to the online version of this manuscript.).

Note (2): the topics are visualized as circle areas. So, the circle size represents the proportion of each topic within the corpus; the number in the circle represents the topic number.

Figure 8. Top 30 salient keywords in LULC (land use and land cover) literature and inter-topic distance. The figures show: a. the most salient keyword terms found in the articles dealing respectively with LULC (right part of the figure); and b. The semantic distance between the four topics (14), based on co-occurrence of words (left part of the figure).

salient keywords in figures 9-11 included in the appendices) witch are print-screens of the results from the LDA analysis performed in this study, and the general results can be best explored interactively through the following website: https://rpubs.com/challenge

For the emerging topics presented in Table 3, it can be noted for WS that topics 1 and 4 are more related than topics 2, 3 and 5. Some researches align with these topics, such as, the determination and quantification of hydrological and erosive phenomena in two chosen vineyards, during diverse seasons and under different management conditions (before, during and after vintage), in Germany [43]. This suggests the need for more research (e.g.: comprehensive water security index) considering the water security concept presented in Brazilian National Water Security Plan (PNSH), upgrading or updating a blue/green water-based accounting framework for assessment of water security developed in Brazil [40]. Besides incorporating in this plan, regional impacts,

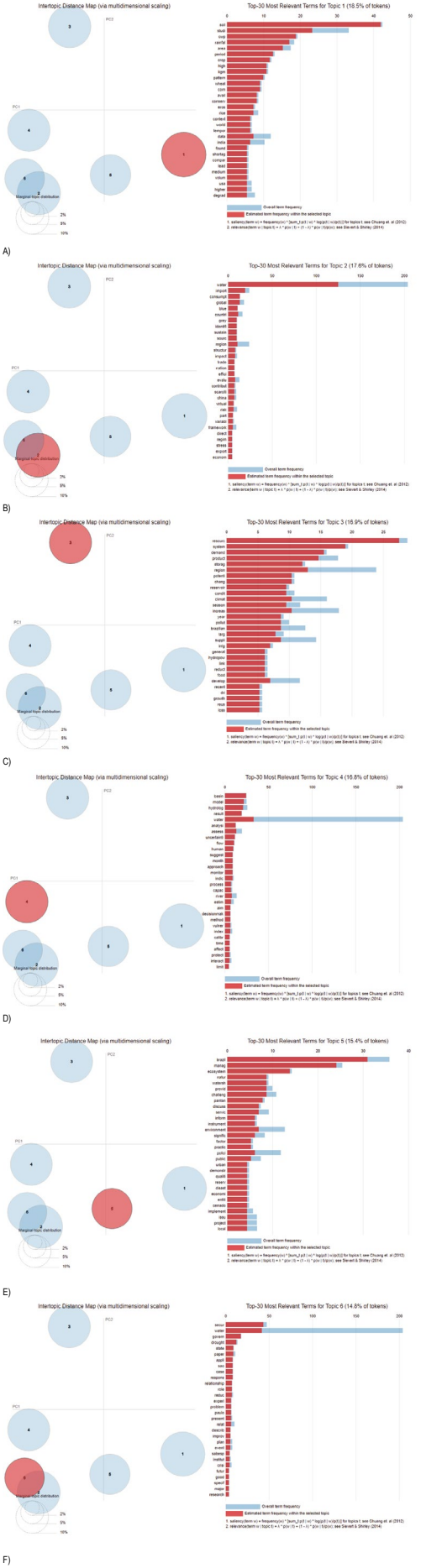


Figure 9. Water security report.

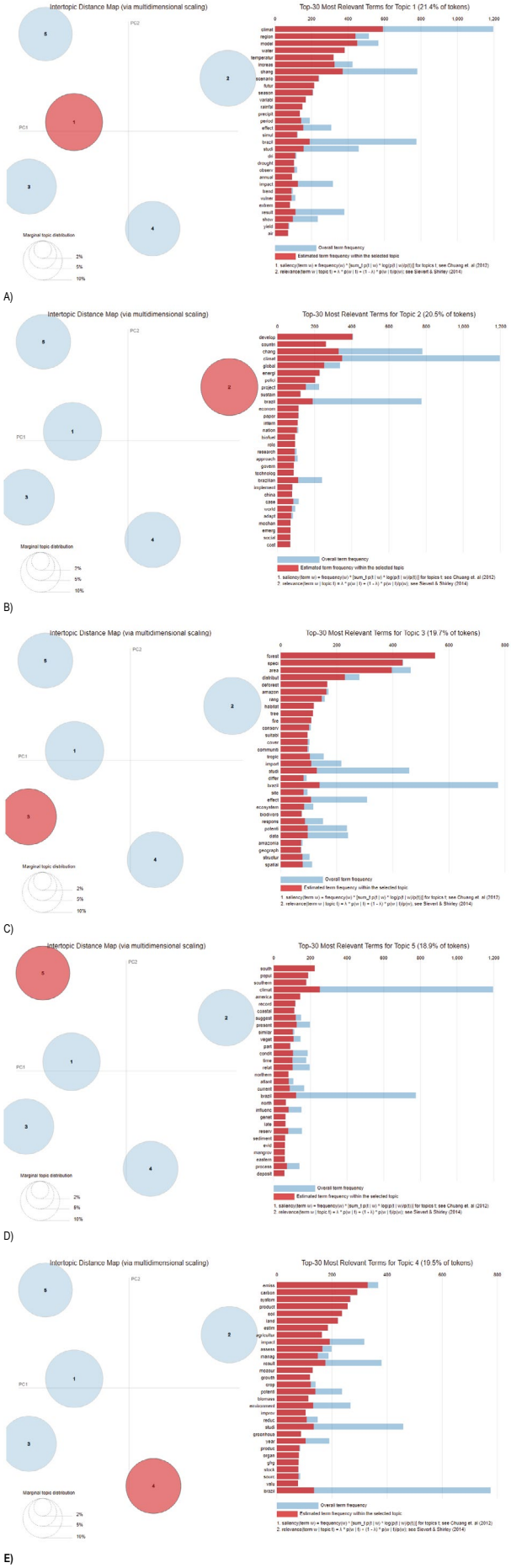
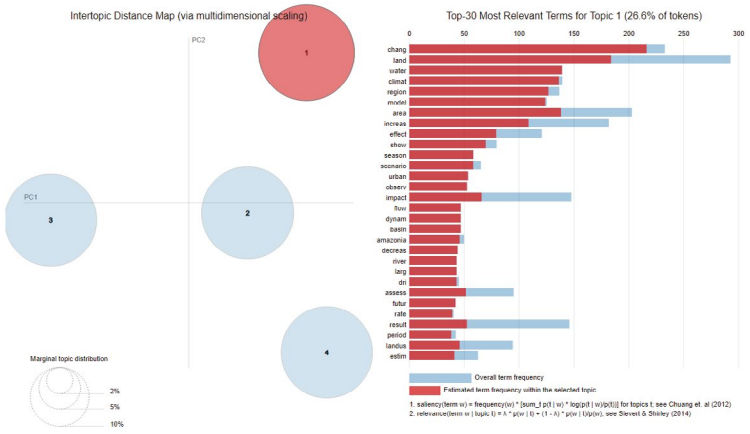
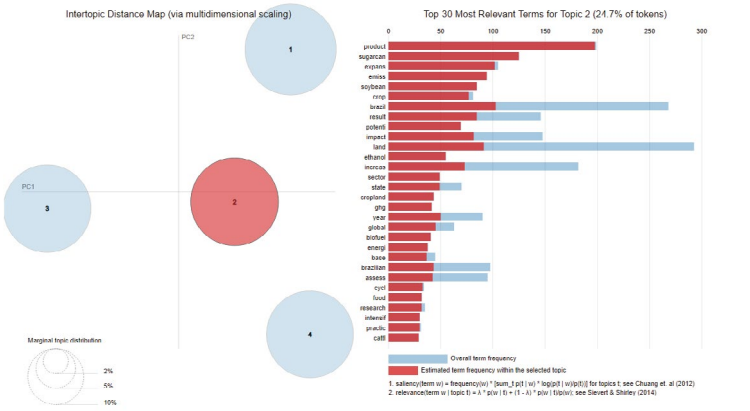


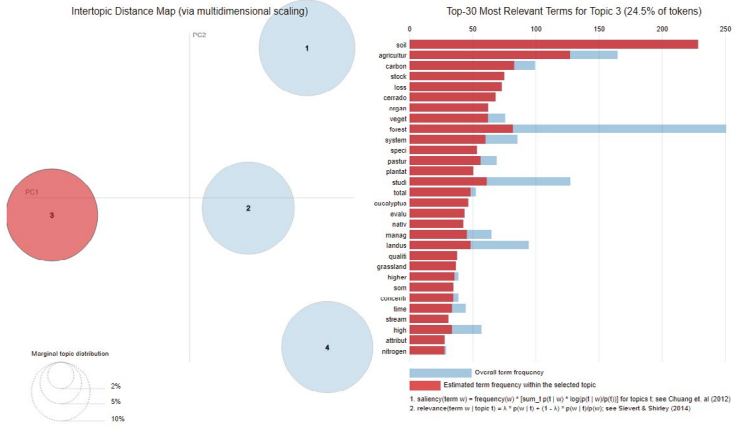
Figure 10. Climate change report.



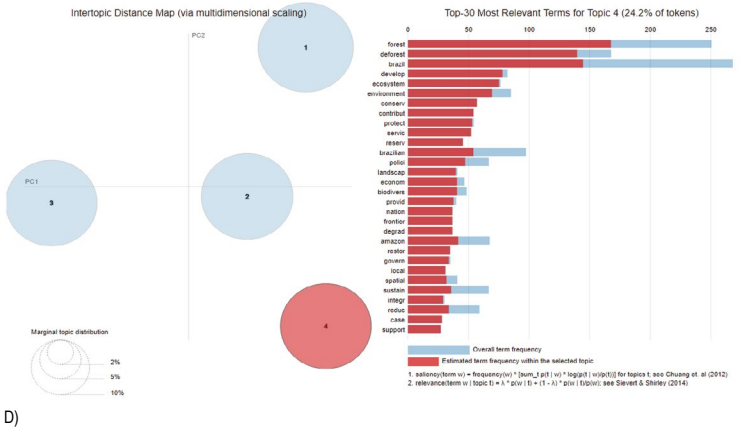
A)



B)



C)



D)

Figure 11. Land use and land cover changes report.

biome asymmetries and strategies be noted that topic 1, 4 and 5 are more related than topic 2 and 3. Some researches align with these hot topics [36].

Conclusion

An overview of the research on water security under climate change, land use and land cover change were presented with the summarized information, such as, yearly publications timeline, most popular journals, co-authored papers, collaboration index (CI), top cited publications and an average number of citations per article, hot topics, the most studied biomes and salient keywords. The analysis of this information has been proved to be an effective approach for discovering hotspots and research trends. It reveals that previous studies were mainly focused on climate change and land use and land cover changes, while water security it is still a research topic of recent interest. Based on cooperation level and co-authored paper analysis performed in this study, the Brazil-USA has been most closely correlated in the cooperative web system.

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Conflicts of Interest

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.

Appendix

As we mentioned in section 3.2, figures. 9(a-f), 10(a-e) and 11(a-d) included in the appendix are print-screens of the results from the LDA analysis used in the study, which can be explored interactively online through the following website: https://rpubs.com/challenge/.

Note that each (Figure includes 4-6) diagrams for WS, CC and LULC concepts, respectively. One for every topic identified in the corpus. The scatterplot on the left side of each diagram represents the linguistic distance among the six topics identified in the corpus, and the topics are represented in the scatterplot as circles; the circles' size indicates the topic's marginal distribution.

As an example, the first scatterplot in figure. 9a highlights the position of topic 1 within WS literature (note, the circle numbered 1 is highlighted in red). On the right side of the scatterplot, the most salient keywords for topic 1 are listed.

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