

Article

Forestry Research in the Middle East: A Bibliometric Analysis

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Abstract: Research trends in the field of forestry have experienced a significant evolution in recent years. However, there has been little use of bibliometric analyses to assess academic organizations and individual researchers in this field of science. This study investigates the progress of forestry research in Iran, Israel, and Turkey based on a bibliometric analysis of 2482 documents published between 2005 and 2019 and indexed in the Web of Science (WoS) scientific information platform. The countries were analyzed and compared in terms of the number of documents, the number of citations, the mean number of citations per document, the h-index, the share of funded articles, and several other metrics. A complete keyword network with graphical visualization and cluster analysis was also used for depicting the most frequent keywords used by the authors from these three countries. The results showed that the number of publications on forestry research grew steadily during the study period. Turkey, with 1529 documents, was the most active in publishing research in the field of forestry, followed by Iran (726 documents) and Israel (219 documents). Turkey's publications received 11,220 citations with a cooperation coefficient (CC) of 0.587 that revealed a strong relationship between international collaboration with the USA, Germany, and Italy, and the number of citations, such that the articles with co-authors affiliated to foreign institutions were cited far more often than the articles with Turkish authorship. Although Iran (CC = 0.680) and Israel (CC = 0.706) recorded more activities in international collaboration than Turkey, their publications received much lower citations (Iran's citations = 4433, Israel's citations = 3939). Israel had 136 articles (62%) that received research funding, followed by Turkey and Iran with 604 (39%) and 284 (38%) articles. Nine out of the ten most popular journals among Israeli researchers were ranked as quartiles 1 and 2 in the forestry category, whereas Iranian and Turkish researchers mostly published in fewer journals ranked as quartiles 1 and 2. The most frequent keywords (i.e., topics) were species, condition, forest, and tree. Insights provided here can help balance research activities towards publishing more informed and effective scientific articles.

Keywords: scientific production; activity index; cooperation network; co-words network



Citation: Fazeli-Varzaneh, M.; Bettinger, P.; Ghaderi-Azad, E.; Kozak, M.; Mafi-Gholami, D.; Jaafari, A. Forestry Research in the Middle East: A Bibliometric Analysis. *Sustainability* **2021**, *13*, 8261. <https://doi.org/10.3390/su13158261>

Academic Editor: Pablo Peri

Received: 1 July 2021

Accepted: 21 July 2021

Published: 23 July 2021

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1. Introduction

Forests are complex ecosystems that encompass many types of life forms. They constitute perhaps the most important renewable resource, with not only human, but also many animal and plant species almost fully depending on the efficiency of forests, at the very least in terms of their oxygen-producing machinery. Forests affect the environment and climate and their various aspects, such as temperature and rainfall patterns [1,2] or

fauna and flora biodiversity [3,4], all of which depend on forest biodiversity, health, and sustainability. Our understanding of forests and what they provide to society is thus crucial [5]. For various reasons, including human activity, we are witnessing global climate change [6], which adversely affects sustainable development [7,8].

One aspect reflecting a human approach to forests and the critical meanings of management, afforestation, and deforestation for future generations is forestry research. A bibliometric study of such research can provide us with a general map of this field, with information about the most important research topics, whether and how particular topics are related, who works with whom, how the field has been evolving [9,10], and which topics might have been neglected and thus may need more attention. Providing various quantitative data about research in a particular field, bibliometric studies have been used to evaluate the performance of countries, institutions, and researchers [11–14]. Institutions and policymakers can use these studies to plan science development in their countries [15,16].

Bibliometric analysis is the act of investigating scholarly output using information such as publication counts and citation rates, and is viewed as a subset of a group of techniques aimed at analyzing science and scholarship, or scientometric [17]. Bibliometric analysis is an established method for assessing the quantitative output of published works [18,19]. For example, publication production trends have been used for forestry-related ranking purposes [20,21]. Publication counts are reflective of the volume of work completed, and have been used as an indicator of productivity for over two centuries [18]. The number of published works on a subject or by a researcher can infer the importance of the subject or researcher [20]. For individual papers, individual researchers, and journals, citation counts reflect the significance of published works [22], as a citation count reports how many times other published works have acknowledged their contributions. Decades ago, this type of analysis was tedious, however, today a database of publications serves as the basis for these investigations, even though issues of incompleteness and biases may arise [23]. Through an examination of research production through published works contained in a database, one may be able to describe trends in research areas and the productivity of individual researchers or research groups [23].

Quite a few bibliometric studies have focused on forestry and related topics, with some of them dealing with particular subjects of forestry research. For example, Gambella et al. [24] focused on forestry research that involved unmanned aerial vehicles (UAVs) using information available through the Web of Science (WoS) and Scopus during the period 2004–2015. Pautasso [25] reviewed research related to forest health and concluded that a comprehensive scientometric approach, one that does not focus on particular journals but considers all articles from any sources if only they are related to the topic studied for a wide view of a topic, was preferable than merely examining articles published in journals directly related to a discipline. Alexandre-Benavent et al. [26] investigated trends in scientific research on climate change in subject areas related to agriculture and forestry during the period 2005–2014, based on data from the WoS database, and found that more than 50% of articles in this field had been published in the last three years (2012–2014). The U.S. Department of Agriculture (USDA), the Chinese Academy of Sciences, and the Institut National de la Recherche Agronomique (INRA, France) also seemed to be the most active institutions in this field. The most frequent keywords in the work by Alexandre-Benavent et al. [27] were CO₂, adaptation, model, temperature, and impact, and the USA, China, Canada, Australia, Germany, and the UK took central positions in the collaboration network. Alexandre-Benavent et al. [26] also analyzed 2051 publications during the period 1954–2015, and found that research on deforestation has been significantly influenced by work in other disciplines, such as environmental science, botany, plant science, ecology, and agronomy. Aznar-Sánchez et al. [28] analyzed global scientific production in forest ecosystem services during the period 1998–2017 and showed that the number of research articles in this field had been increasing, especially in recent years, given the extensive international collaboration among the USA, China, UK, Germany, and Brazil.

Several bibliometric studies have also examined the importance of individual forestry researchers. For example, Chirici [13] compared the information available from WoS and Scopus in terms of the scientific production of Italian forestry researchers. Song and Zhao [29] analyzed global forest ecology research during the period 2002–2011, using the WoS database and identified the USA, Canada, and Germany as the most productive countries. Bullock and Lawler [30] analyzed Canadian forestry researchers publishing in specialized journals using simple indicators, such as publication year, the number of authors, journal names, and citation counts. Giannetti et al. [31] analyzed Italian forestry researchers and compared their performance with scientists from countries that were most productive in terms of forestry research (the USA, the UK, China, Germany, and France).

Several bibliometric studies have further examined several aspects of forestry journals. Some of these have provided ratings and lists of the most important journals in this field [32–35]. Some studies examined bibliometric indices such as the numbers of documents, the numbers of citations, top authors and journals, active organizations, national, and international collaboration networks. For example, Uribe-Toril et al. [36] studied papers published in *Forests* and highlighted the state-of-the-art of forestry as an interdisciplinary area. Huang et al. [37] examined the trend of global research in forest carbon sequestration, and suggested that research in this field is in the growth stage, with *Forest Ecology and Management* being the journal that published the most articles in this field. Fazeli-Varzaneh [38] analyzed 376 published works related to the Hyrcanian forests in terms of citations, collaboration networks, productive organizations, productive authors, and the journals that published the most articles on the topic.

In keeping with this line of research, this study aimed to map forestry research trends for the period between 1988 and 2017 in Middle East countries. We intentionally restricted our study to a comparison between Turkey, Iran, and Israel, and removed the other Middle East countries from the analysis. Turkey and Iran have significant forest resources compared to the other Middle East countries. Israel does not, but it stands out in terms of its scientific output of forest research, despite its small forest resource. The other Middle East countries play a negligible role in forestry research and have small areas covered by forest. Our bibliometric analysis was guided by the following research questions:

- (1) What are the main scopes of forestry research in Iran, Israel, and Turkey?
- (2) How was the trend of forestry documents publication during the period 2005–2019?
- (3) How do these countries collaborate with other countries?
- (4) How many citations do these countries receive per document?
- (5) Which researchers and institutions had the most influence on the progress of forestry research in their country?

These issues are important to society, as the exchange of knowledge, experiences, ideas, and models for sustainable forest management is guided in part by research activity.

2. Materials and Methods

2.1. Forests of the Middle East

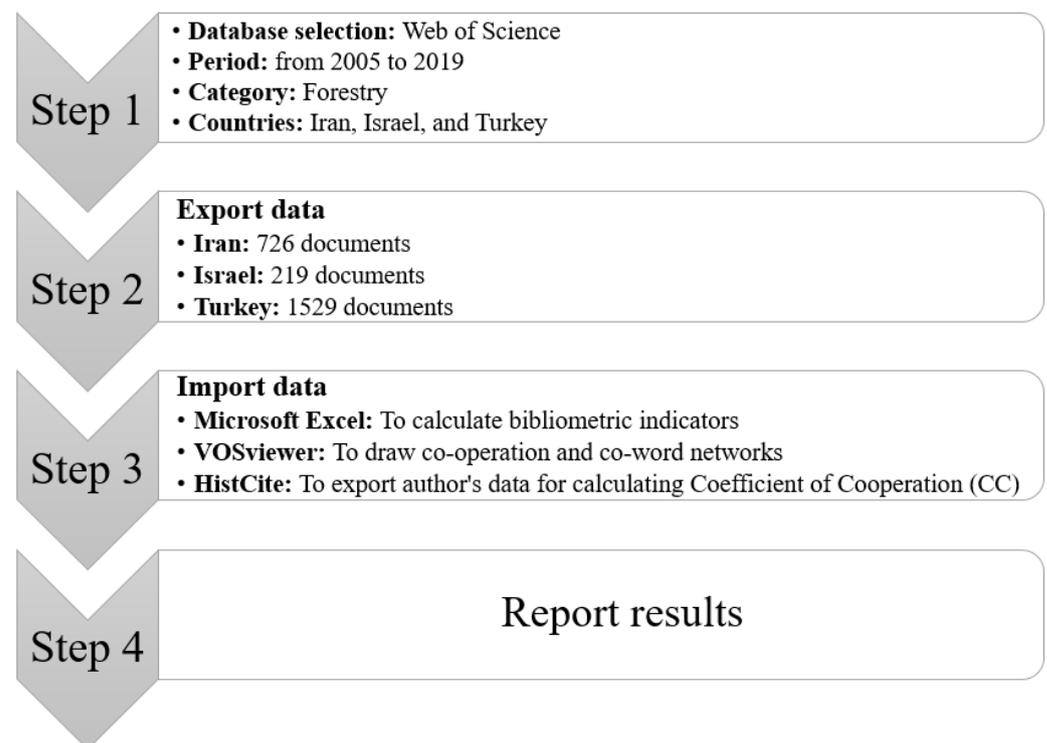
As part of the Global Forest Resources Assessment (FRA) project, the FAO has been collecting and analyzing data on world's forest areas since 1946 at intervals of 5–10 years. The reports include essential information for understanding the extent of forest resources, their condition, management, and uses across the world, with the exception for small islands and land states where no information is provided. The latest of these reports, FRA 2020, examines the status of and trends in forest resources in 236 countries and territories during a 10-year period (1990–2020). Turkey and Iran rank as the first countries in the Middle East in terms of forest area (Table 1).

2.2. Analysis Procedure

A four-step procedure (Figure 1) was followed in this study for the bibliometric analysis of published works in forestry by researchers from Iran, Israel, and Turkey.

Table 1. Forest area in the Middle East countries.

| Country | Total Land Area (1000 ha) | Forest Area (1000 ha) |
|----------------------|---------------------------|-----------------------|
| Bahrain | 77 | 1 |
| Cyprus | 924 | 173 |
| Egypt | 99,545 | 45 |
| Iran | 162,876 | 10,752 |
| Iraq | 43,413 | 825 |
| Israel | 2164 | 140 |
| Jordan | 8878 | 98 |
| Kuwait | 1782 | 6 |
| Lebanon | 1023 | 143 |
| Oman | 30,950 | 3 |
| Palestine | 602 | 10 |
| Qatar | 1616 | 0 |
| Saudi Arabia | 214,969 | 977 |
| Syria | 18,363 | 522 |
| Turkey | 76,963 | 22,220 |
| United Arab Emirates | 7102 | 317 |
| Yemen | 52,797 | 549 |

**Figure 1.** Methodological steps of the bibliometric analysis adopted in this study.

2.2.1. Data

The data used in this study were obtained from the WoS database. The WoS scientific information platform is a comprehensive, multidisciplinary database that preserves quality-controlled data on the titles, authors, abstracts, keywords, references, and citations of works constituting the scientific literature. The WoS database contains over 74.8 million records of published works from as far back in time as 1900. These records originate from over 21,100 peer-reviewed journals and thousands of books, reports, and conference proceedings. The WoS is among the most widely used database for scientometric analyses, given its data quality and straightforward search process that allows for filtering the search results using various bibliographic parameters [36]. In this study, we collected data concerning Iranian,

Israeli, and Turkish forestry research during the period 2005–2019 from the WoS database. The search strategy for each country was as follows:

$$WC = (\text{Forestry}) \text{ AND } CU = (\text{Iran}) \text{ AND } PY = (2005\text{--}2019) \quad (1)$$

$$WC = (\text{Forestry}) \text{ AND } CU = (\text{Israel}) \text{ AND } PY = (2005\text{--}2019) \quad (2)$$

$$WC = (\text{Forestry}) \text{ AND } CU = (\text{Turkey}) \text{ AND } PY = (2005\text{--}2019) \quad (3)$$

where WC is the WoS category, CU is the country/region, and PY is the year of publication.

Therefore, the keywords were “forestry”, the country of interest, and the publication year of interest to this study. These queries identified 1529, 726, and 219 documents for Turkey, Iran, and Israel, respectively. The results of the three countries only had eight documents in common.

2.2.2. Methods

For scientometric analysis, we used the following indices.

1. Coefficient of cooperation (CC). This index presents a value indicating the ratio of collaboration between two groups of researchers. As the CC approaches 1, one should find more multi-author articles in the sample collected, and articles with greater numbers of co-authors, both representative of a high level of cooperation. The closer the CC value is to zero, the stronger the trend is towards single-authored articles. To calculate CC, we used the following formula [39]:

$$CC = 1 - \sum_{j=1}^k \frac{n_j}{jn} \quad (4)$$

where j is the number of authors of articles, k represents the maximum number of authors in one article among all the articles included in the analysis (in our analysis, $k = 36$ for Iran, $k = 10$ for Israel, and $k = 176$ for Turkey), n_j is the number of articles in the analyzed set published by j authors, and n is the total number of articles in the analyzed dataset.

2. h-index. Proposed by Hirsch [40], the h-index joins the productivity and the citation impact of the publications of a scientist or a country. In the WoS database, the data related to h-index is provided in the citation report section. In developing the h-index, the publications of interest are sorted in descending order of their associated citation count and subsequently ranked. Then, the maximum rank of these publications (the h-index) is determined based on the location of a publication in the sorted list where the associated citation count is equal to or greater than the publication’s rank [41].

3. Relative specialization index (RSI). This indicator represents the level of scientific activity of a country in a field relative to global scientific activity in the same field. RSI takes values from -1 to 1 , with a negative value indicating that a country’s scientific activity is worse than the global average in the field. Its positive value indicates that a country’s scientific activity is better than the global average in the field [42]. RSI is calculated by

$$RSI_{ij} = \frac{AI_{ij} - 1}{AI_{ij} + 1} \quad (5)$$

where AI_{ij} is the activity index, an indicator used for systematic comparisons of countries in a given subject. AI was first introduced by Frame [43] and improved by Schubert and Braun [44] and Schubert et al. [45]. The index indicates the relative research efforts of different countries in different subfields or branches of the discipline, and thus it represents the emphasis of a country in a particular branch [46]:

$$AI_{ij} = \frac{n_{ij}/n_i}{n_{.j}/n_{..}} = \frac{n_{ij}n_{..}}{n_i n_{.j}} \quad (6)$$

where n_{ij} is the number of documents published in the i th field affiliated to the j th country, n_i is the number of documents published in the i th field in the world, $n_{.j}$ is the total number of documents affiliated to the j th country, and $n_{..}$ is the total number of documents for the whole world.

To assist in the data analysis and calculate the scientometric indicators, we used the HistCite software and the lattice package [47] of R.

4. Collaboration and co-word networks. From the WoS database, we downloaded a plain text file with all the data and imported it into VOSviewer software [48] that enabled us to graph co-authorship networks independently for each country. These types of networks are commonly used to visualize publication distribution and collaboration networks among people, organizations, and countries [49]. The resulting networks show countries that had at least ten co-authorships with the countries investigated in this study. A particular node's size indicates the number of collaborations (common articles) between the country of interest and the country represented by the node. Co-word networks are similar to the co-authorship networks, the only difference being node sizes, here representing the frequency of the co-occurrences of the corresponding pairs of words.

In addition to aforementioned indices, we analyzed and compared the three countries in terms of the number of citations and authors, citations per document, document per author, h-index, number of funding agencies, number of documents receiving funding, and total number of funds received.

3. Results and Discussion

Turkish researchers published more articles (1529) than Iranian (726) and Israeli (219) researchers, with a greater number of citations (11,220), authors (5625), and document per author (0.271) than the other two countries (Table 2). In terms of *RSI*, Turkey (0.111) demonstrated better scientific activity compared to Iran (−0.189) and Israel (−0.491). It should be kept in mind that, however, *RSI* employs numbers of articles, so it is not normalized. Thus, the obvious reason behind this result can be the number of researchers working in the forest area in the three countries. There are almost exactly half as many Iranian researchers (2828) than there are Turkish researchers (5625), and the number of Israeli researchers was even lower. Therefore, it is not surprising that a two-fold larger group of researchers published more work during the study period. If we examine the average researcher publication rate during the study period, Iranian researchers with 0.26 articles per author, and Israeli researchers with 0.19 articles per author, come off only slightly worse than Turkish researchers with 0.27 documents per author. However, Israeli publications had the highest average number of citations per document (17.99), the highest average number of citations per author (3.59), and the highest h-index (34) of the three countries. Israel also had the highest *CC* (0.706), followed by Iran (0.680) and Turkey (0.587). In terms of funding and its related indices, researchers from Turkey performed better than those from Iran and Israel, although researchers from Israel had the highest ratio of funded articles (62%) compared to Iran (38%) and Turkey (39%).

Further examination shows that the high *CPD* value of Turkey's cooperative works with China, Canada, and Switzerland was due to Allen et al. [50] who published "A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests". This article has received a large number of citations ($n = 2866$) and has thus positively influenced the *CPD*. A review of the three countries' international collaboration networks also indicated that neither of the three countries existed in another cooperation network, while we expected the opposite because of the geographical proximity of the three countries.

For all three countries, scientific production has steadily increased since 2005 (Figure 2), although Turkey has shown an atypical performance in recent years, with a high peak of documents published in 2016 and then a regress to the mean in the following years. This atypical peak draws attention, which is why we analyzed where it might have come from. To do so, we checked the numbers of journals in which Turkish authors published

during the study period, but we did not find any explanation here. Thus, we looked into the most frequent journals among them, which were *Kastamonu University Journal of Forestry Faculty* and *Journal of the Faculty of Forestry-Istanbul University*—and this is where we found the explanation (Figure 3). While the first among them did not show any change, the last two did: these two journals, both published in Turkish, were recently indexed to WoS (*Kastamonu University Journal of Forestry Faculty*, starting in 2015 and the *Journal of the Faculty of Forestry-Istanbul University* in 2016). Both of these journals published a lot of papers in 2016 and 2017. In 2018, the former published much fewer articles, and the latter was terminated.

Table 2. WoS statistics for the forestry articles published during the period 2005–2019 by Iran, Israel, and Turkey.

| Index | Iran | Israel | Turkey |
|-------------------------------------------------|--------|--------|--------|
| Number of documents | 726 | 219 | 1529 |
| Number of citations | 4433 | 3939 | 11,220 |
| Number of authors | 2828 | 1097 | 5625 |
| Citations per document | 6.11 | 17.99 | 7.34 |
| Documents per author | 0.256 | 0.199 | 0.271 |
| Citations per author | 1.56 | 3.59 | 1.99 |
| H-index | 23 | 34 | 31 |
| Relative specialization index (RSI) in forestry | −0.189 | −0.491 | 0.111 |
| Cooperation coefficient (CC) | 0.680 | 0.706 | 0.587 |
| Number of funding agencies | 274 | 234 | 375 |
| Total funds * | 870 | 353 | 881 |
| Documents received funding | 284 | 136 | 604 |
| Ratio of funded articles (%) | 38 | 62 | 39 |

* Some of the articles received funds from more than one source, so the number of “Total funds” is higher than the number of “Documents received funding”.

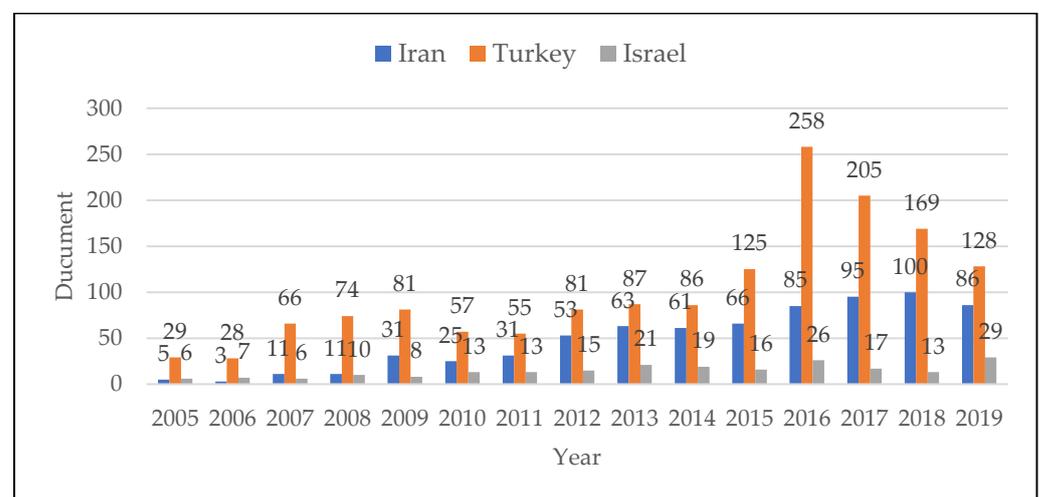


Figure 2. Number of forestry documents per year during the period 2005–2019.

During the period 2005–2007, no article reviewed received funds (Figure 4), or perhaps none reported this information. Iran and Turkey had similar shares of funded articles (with some minor differences usually in favor of Turkey). Israel, however, stands out in this context, since—except for 2008 and 2010—its share of funded articles was the highest among the three countries and exceeded 50%. We can see an interesting phenomenon in 2016 and 2017, when Turkey’s share dropped, a phenomenon possibly related to the *Kastamonu University Journal of Forestry Faculty* and the *Journal of the Faculty of Forestry-Istanbul University*, which—as discussed above—published many articles of low quality, so further research was less likely to receive funding. While we have no proof of this being

the case, these two years stand out in various analyses, suggesting that the two journals did have an influence on various indicators for Turkey's output in forestry research.

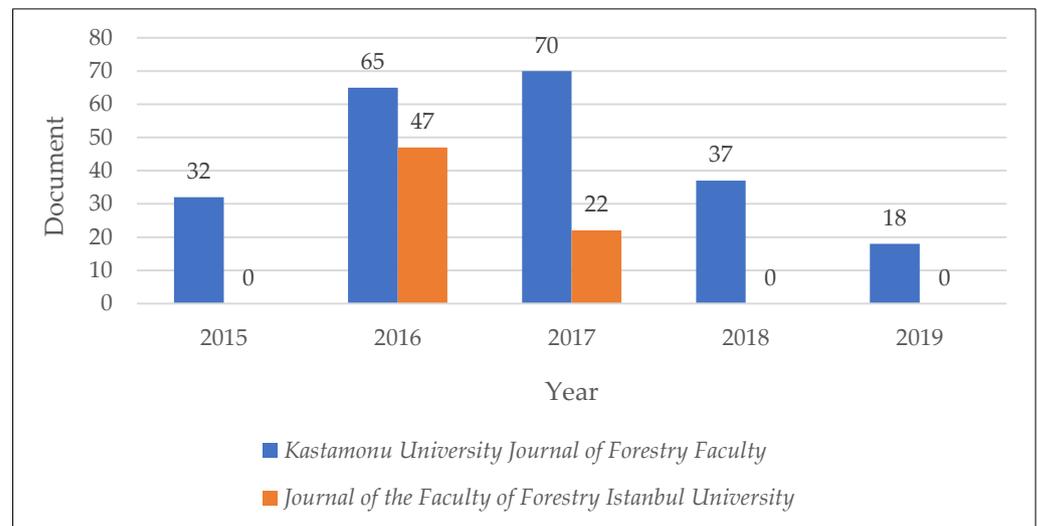


Figure 3. The number of documents published by two Turkish journals from 2005 to 2019.

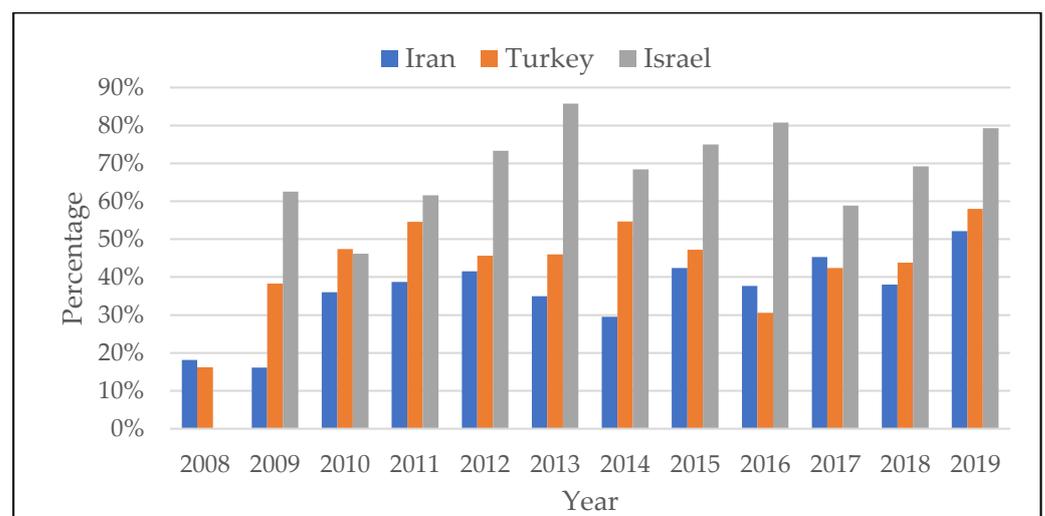


Figure 4. Percentage of forestry funded articles per year during the period 2005–2019. Notice that during the period 2005–2007, no article received funds.

Israeli researchers published slightly more often their forestry articles in collaboration with researchers affiliated with foreign institutions (48.45%) than Iranian researchers (46.4%) and much more than Turkish ones (22.73%). Citation analysis, however, showed that the international collaboration was more effective for Israel as the CPD for articles resulting from international collaboration was 19.8 and for the other articles, this was 16.5. Turkey's CPD for international collaboration articles was 17.8 while for the other articles only 5.4. Iranian articles did not show such a discrepancy, with a CPD of 7.7 for collaborative articles and 6.7 for the other ones.

Figure 5 shows Iran's international collaboration network with countries with at least 10 co-authorships. Researchers from the USA (91 joint articles) were the most frequent cooperators for Iranian scientists, followed by those from Germany (63) and Italy (36). However, in terms of citations per document (CPD), co-authorship with France (CPD = 12.96), Japan (CPD = 12.4), and Australia (CPD = 10.52) led to the topmost CPD.

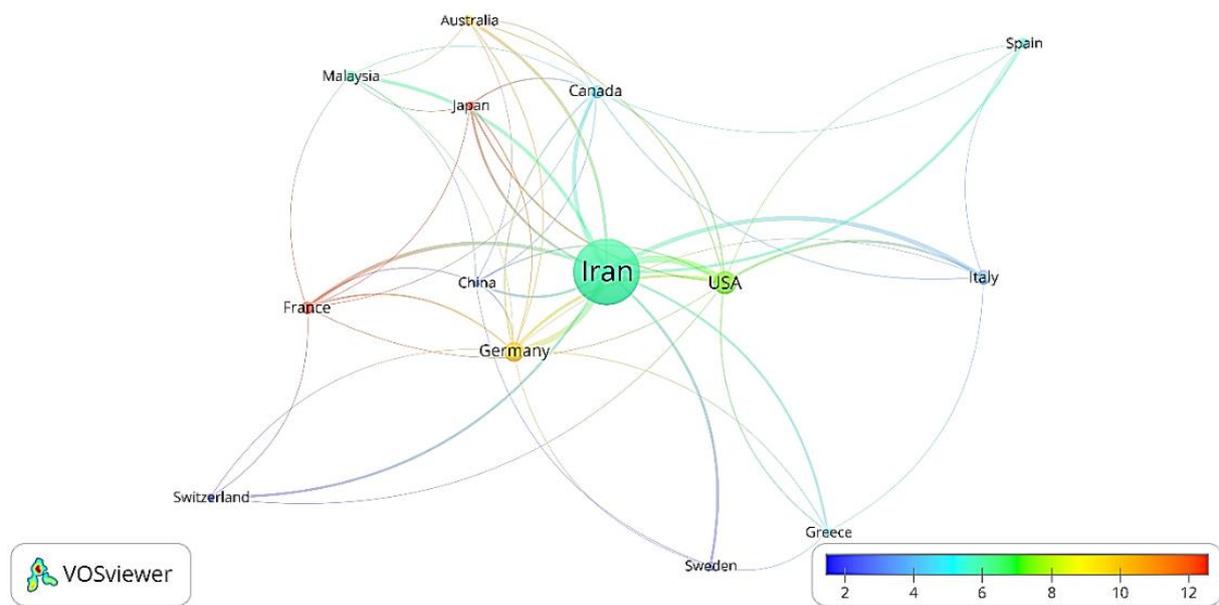


Figure 5. Iran's international collaboration network in the field of forestry during the period 2005–2019. Colors indicate the number citations per document.

The cooperation of Turkish scientists (Figure 6) showed a similar trend. Researchers from the USA were also the most frequent collaborators for Turkish scientists (139), followed by those from Germany (39), Italy (26), and Spain (26). In terms of per-document citations, the most fruitful cooperation of Turkish scientists was that with China (CPD = 288.6), Canada (CPD = 207.78), and Switzerland (CPD = 205.53). We can notice a huge difference in CPDs from collaboration, with Iran's values being over 20 times smaller than Turkey's.

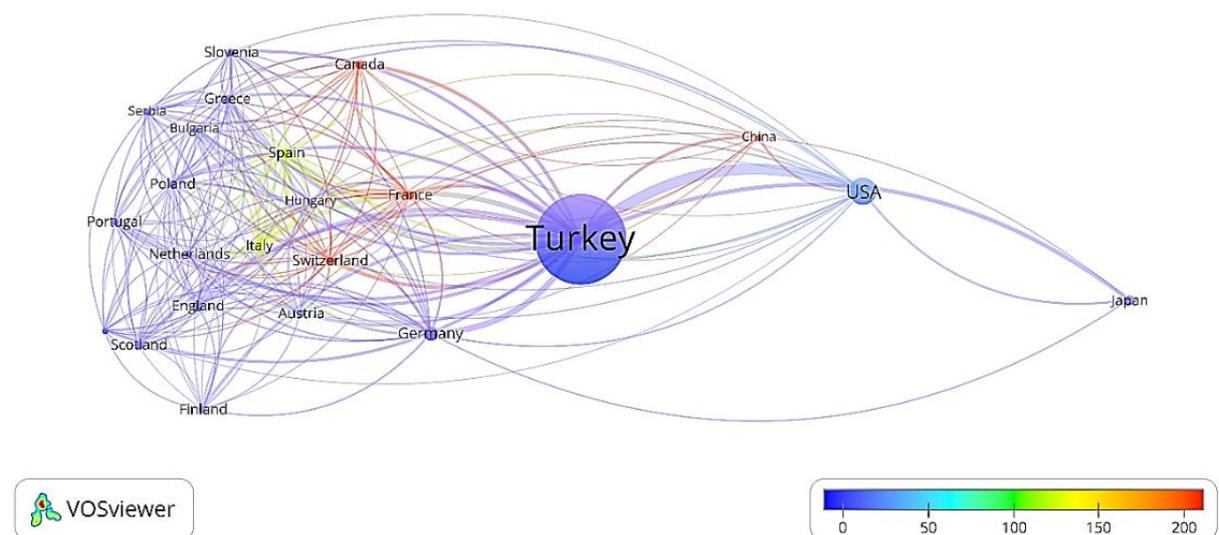


Figure 6. Turkey's international collaboration network in the field of forestry during the period 2005–2019. Colors indicate the number citations per document.

Researchers from 17 countries had at least three shared publications with Israeli researchers (Figure 7). As was the case for the two other countries, researchers from the USA were also the most frequent collaborators for Israeli researchers (43), followed by Germany (16), and Italy (12). In terms of CPD, the most effective turned out to be co-authorship with authors affiliated to Sweden (CPD = 35.33), Germany (CPD = 34.43), and Switzerland (CPD = 32.9).

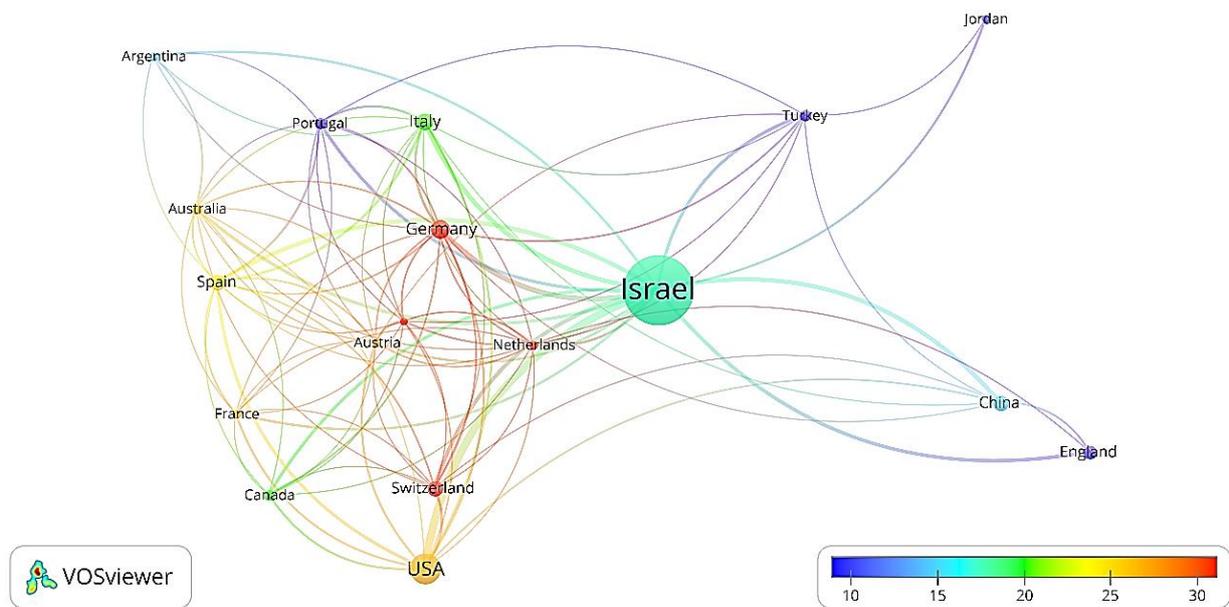


Figure 7. Israel's international collaboration network in the field of forestry during the period 2005–2019. Colors indicate the number of citations per document.

According to the results, Iran, Israel, and Turkey had the most collaboration with the USA and Germany, which are known as pioneering countries in the field of forestry [27–29].

The analysis of findings shows that a higher number of collaborations does not necessarily lead to a higher CPD. As shown in Figure 5, Iran has the most collaboration with the USA while co-authorship with French researchers has led to a greater CPD. The same is true for Turkey, which has the highest collaboration with the USA, but co-authorship with Chinese researchers has led to a greater CPD. Additionally, the same is true for Israel, which also has the highest cooperation with the USA, however, co-authorship with Swedish researchers led to a greater CPD.

Table 3 presents the journals in which Iranian, Turkish, and Israeli authors published the most during the study period. We see much more variation in the output of Iranian and Israeli authors than those of Turkish authors, who published a lot in the *Turkish Journal of Forestry and Agriculture* and *Kastamonu University Journal of Forestry Faculty*. In addition, only Turkish authors tend to frequently publish in their own national journals (the two mentioned above, in addition to the *Journal of the Faculty of Forestry-Istanbul University*), while both Iranian and Israeli authors published more frequently in international journals, probably because they do not have national forestry journals indexed in WoS.

Table 3. Most popular journals among Iranian, Israeli, and Turkish forestry researchers during the period 2005–2019.

| Country | Rank | Journal | Publisher Country | Language | No. of Articles | Share of Articles That Received Funding (%) | Journal's Quartile (in the Forestry Category) | Impact Factor (2019) |
|---------|------|----------------------------------------------------|-------------------|------------------|-----------------|---------------------------------------------|-----------------------------------------------|----------------------|
| Iran | 1 | <i>Journal of Forestry Research</i> | China | English | 93 | 42.1 | Q2 | 1.689 |
| | 2 | <i>Turkish Journal of Agriculture and Forestry</i> | Turkey | English | 63 | 33.3 | Q2 | 1.660 |
| | 3 | <i>European Journal of Wood and Wood Products</i> | USA | English/German | 54 | 32.7 | Q3 | 1.542 |
| | 4 | <i>Forest Pathology</i> | USA | English | 31 | 55.9 | Q3 | 1.196 |
| | 5 | <i>Trees Structure and Function</i> | Germany | English | 31 | 61.3 | Q2 | 2.125 |
| | 6 | <i>Croatian Journal of Forest Engineering</i> | Croatia | English/Croatian | 27 | 33.3 | Q1 | 2.500 |
| | 7 | <i>European Journal of Forest Research</i> | USA | English | 25 | 44.0 | Q1 | 2.451 |
| | 8 | <i>iforest</i> | Italy | English | 24 | 34.6 | Q2 | 1.683 |
| | 9 | <i>Forest Ecology and Management</i> | Netherlands | English | 20 | 65.0 | Q1 | 3.170 |
| | 10 | <i>Urban Forestry and Urban Greening</i> | Germany | English | 20 | 25.0 | Q1 | 4.021 |

Table 3. Cont.

| Country | Rank | Journal | Publisher Country | Language | No. of Articles | Share of Articles That Received Funding (%) | Journal's Quartile (in the Forestry Category) | Impact Factor (2019) |
|---------|------|---------------------------------------------------------------|-------------------|-------------------------|-----------------|---------------------------------------------|-----------------------------------------------|----------------------|
| Israel | 1 | <i>Agricultural and Forest Meteorology</i> | Netherlands | English | 40 | 65 | Q1 | 4.651 |
| | 2 | <i>Tree Physiology</i> | England | English | 26 | 69.24 | Q1 | 3.655 |
| | 3 | <i>Forest Ecology and Management</i> | Netherlands | English | 20 | 60 | Q1 | 3.170 |
| | 4 | <i>Journal of Vegetation Science</i> | USA | English | 16 | 43.75 | Q1 | 2.698 |
| | 5 | <i>Plant Ecology</i> | Netherlands | English | 15 | 73.34 | Q3 | 1.509 |
| | 6 | <i>International Journal of Wildland Fire</i> | Australia | English | 9 | 55.56 | Q1 | 2.627 |
| | 7 | <i>Tree Genetics Genomes</i> | Germany | English | 9 | 88.89 | Q2 | 2.081 |
| | 8 | <i>Trees Structure and Function</i> | Germany | English | 7 | 42.86 | Q2 | 2.125 |
| | 9 | <i>Annals of Forest Science</i> | France | English | 6 | 83.34 | Q2 | 2.033 |
| | 10 | <i>Applied Vegetation Science</i> | USA | English | 6 | 83.34 | Q1 | 2.574 |
| Turkey | 1 | <i>Turkish Journal of Agriculture and Forestry</i> | Turkey | English | 534 | 49.8 | Q2 | 1.660 |
| | 2 | <i>Kastamonu University Journal of Forestry Faculty</i> | Turkey | English/Turkish/Spanish | 222 | 17.7 | - * | - |
| | 3 | <i>Journal of the Faculty of Forestry-Istanbul University</i> | Turkey | English/Turkish | 69 | 11.6 | - | - |
| | 4 | <i>Forest Products Journal</i> | USA | English | 46 | 13.0 | Q4 | 0.802 |
| | 5 | <i>Journal of Forestry Research</i> | China | English | 37 | 57.9 | Q2 | 1.689 |
| | 6 | <i>European Journal of Wood and Wood Products</i> | USA | English/German | 36 | 33.3 | Q3 | 1.542 |
| | 7 | <i>Sumarski List</i> | Croatia | Different language | 35 | 43.2 | Q4 | 0.451 |
| | 8 | <i>Forest Pathology</i> | USA | Croatian/English | 34 | 67.6 | Q3 | 1.196 |
| | 9 | <i>iforest</i> | Italy | English | 29 | 51.7 | Q2 | 1.683 |
| | 10 | <i>Forestist</i> | Turkey | English | 27 | 51.9 | - | - |

* A journal not indexed in either Journal Citation Reports (so having no IF) or SCOPUS (so having no quartile).

Based on the Scopus journal quartile ranking that measures journal credibility, Israeli authors published more articles in Q1 and Q2 journals than authors from the other two countries (Figure 8).

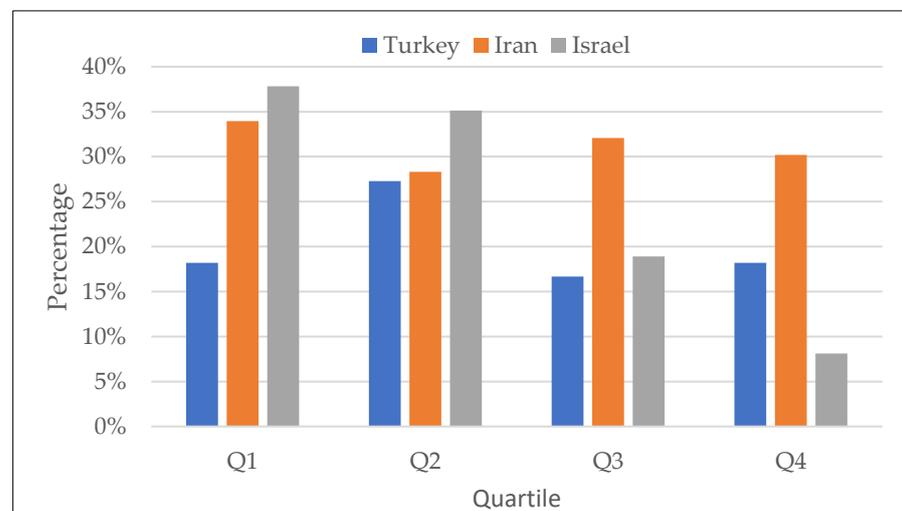


Figure 8. The share of forestry articles in journals by the journals' SCOPUS quartile in which Iranian, Israeli, and Turkish authors published during the period 2005–2019.

In all three countries, it is difficult to point out clear scientific leaders. This is because different institutions scored best in various indices. While the institutions that published the most documents received the most citations (University of Tehran in Iran, Istanbul University in Turkey, and the Volcani Institute of Agricultural Research in Israel) (Table 4), in terms of citations per document, different institutions scored better (Shahid Rajae Teacher Training University in Iran, Suleyman Demirel University in Turkey, and the Weizmann Institute of Science in Israel). In terms of *RSI*, other institutions showed the best performance. These included the Sari Agricultural Sciences Natural Resources University in Iran, Kastamonu University in Turkey, and the Jewish National Fund in Israel.

Table 4. Top ten most active Iranian, Israeli, and Turkish institutions in the field of forestry during the period 2005–2019.

| Country | Rank | Institute | No. of Documents | No. of Citations | CPD | Funded Articles (%) | RSI |
|---------|------|------------------------------------------------------------------|------------------|------------------|-------|---------------------|--------|
| Iran | 1 | University of Tehran | 204 | 1229 | 6.02 | 34.18 | 0.355 |
| | 2 | Tarbiat Modares University | 112 | 834 | 7.45 | 35.90 | 0.379 |
| | 3 | Islamic Azad University | 105 | 590 | 5.62 | 32.11 | −0.270 |
| | 4 | University of Guilan | 73 | 265 | 3.63 | 29.73 | 0.640 |
| | 5 | Shahid Rajaee Teacher Training University | 40 | 386 | 9.65 | 43.91 | 0.791 |
| | 6 | Gorgan University of Agricultural Sciences and Natural Resources | 31 | 131 | 4.23 | 36.37 | 0.792 |
| | 7 | Sari Agricultural Sciences Natural Resources University | 27 | 97 | 3.59 | 37.94 | 0.864 |
| | 8 | University of Tabriz | 27 | 167 | 6.19 | 25.93 | −0.025 |
| | 9 | University of Kurdistan | 23 | 99 | 4.3 | 47.83 | 0.550 |
| | 10 | University of Mohaghegh Ardabili | 23 | 49 | 2.13 | 21.74 | 0.536 |
| Israel | 1 | Volcani Institute of Agricultural Research | 77 | 1493 | 19.39 | 70.13 | 0.765 |
| | 2 | Ben Gurion University | 61 | 994 | 16.29 | 67.22 | −0.138 |
| | 3 | Hebrew University of Jerusalem | 53 | 905 | 17.07 | 60.38 | −0.401 |
| | 4 | University of Haifa | 36 | 444 | 12.33 | 58.34 | −0.023 |
| | 5 | Weizmann Institute of Science | 26 | 875 | 33.65 | 76.93 | −0.350 |
| | 6 | Tel Aviv University | 16 | 181 | 11.31 | 43.75 | −0.830 |
| | 7 | Technion Israel Institute of Technology | 13 | 344 | 26.46 | 61.54 | −0.756 |
| | 8 | Agricultural Research Organization | 12 | 144 | 12 | 83.34 | 0.127 |
| | 9 | Jewish National Fund | 7 | 76 | 10.85 | 85.72 | 0.993 |
| | 10 | Academic and Technology College of Tel-Hai | 7 | 39 | 5.57 | 57.15 | 0.465 |
| Turkey | 1 | Istanbul University | 218 | 1287 | 5.9 | 38.47 | 0.465 |
| | 2 | Karadeniz Teknik University | 174 | 921 | 5.29 | 30.56 | 0.761 |
| | 3 | Suleyman Demirel University | 121 | 817 | 6.75 | 45.91 | 0.709 |
| | 4 | Kastamonu University | 118 | 321 | 2.72 | 20.50 | 0.945 |
| | 5 | Cukurova University | 91 | 597 | 6.56 | 58.70 | 0.532 |
| | 6 | Duzce University | 89 | 425 | 4.78 | 42.23 | 0.821 |
| | 7 | Ministry of Food Agriculture Livestock Turkey | 86 | 510 | 5.93 | 54.03 | 0.828 |
| | 8 | Bartın University | 84 | 364 | 4.33 | 21.43 | 0.936 |
| | 9 | Kahramanmaraş Sutcu Imam University | 74 | 431 | 5.82 | 36.12 | 0.775 |
| | 10 | Cankiri Karatekin University | 72 | 284 | 3.94 | 39.48 | 0.919 |

With 35 documents indexed in WoS, the most productive Iranian forestry researcher was Hamid Reza Taghiyari, followed by Ramin Naghdi (24 articles) and Mehrdad Nikooy (21 articles) (Table 5). Hamid Reza Taghiyari had the greatest CPD (10.7), followed by Akbar Najafi (10.4), and Pedram Attarod (8.4).

Table 5. Top ten most productive Turkish, Iranian, and Israeli authors in the field of forestry during the period 2005–2019.

| Country | Rank | Author | No. of Documents | No. of Citations | CPD |
|---------|------|---------------------------|------------------|------------------|------|
| Iran | 1 | Hamid Reza Taghiyari | 35 | 376 | 10.7 |
| | 2 | Ramin Naghdi | 24 | 90 | 3.8 |
| | 3 | Mehrdad Nikooy | 21 | 72 | 3.4 |
| | 4 | Kambiz Pourtahmasi | 20 | 142 | 7.1 |
| | 5 | Ahmad Solgi | 17 | 75 | 4.4 |
| | 6 | Seyed Mohsen Hosseini | 16 | 78 | 4.9 |
| | 7 | Pedram Attarod | 14 | 117 | 8.4 |
| | 8 | Ghanbar Ebrahimi | 14 | 85 | 6.1 |
| | 9 | Soleiman Mohammadi Limaee | 14 | 49 | 3.5 |
| | 10 | Akbar Najafi | 14 | 146 | 10.4 |

Table 5. Cont.

| Country | Rank | Author | No. of Documents | No. of Citations | CPD |
|---------|------|-----------------------------|------------------|------------------|------|
| Israel | 1 | Shabtai Cohen | 20 | 608 | 30.4 |
| | 2 | Dan Yakir | 18 | 721 | 40.1 |
| | 3 | Yagil Osem | 17 | 217 | 12.8 |
| | 4 | Avi Perevolotsky | 14 | 224 | 16.0 |
| | 5 | Tamir Klein | 12 | 338 | 28.2 |
| | 6 | Yossi Moshe | 11 | 128 | 11.6 |
| | 7 | Eyal Rotenberg | 11 | 456 | 41.5 |
| | 8 | Nurit Agam | 10 | 337 | 33.7 |
| | 9 | Yohay Carmel | 8 | 257 | 32.1 |
| | 10 | Jaime Kigel | 8 | 145 | 18.1 |
| Turkey | 1 | Nadir Ayrilmis | 28 | 371 | 13.3 |
| | 2 | Abdullah E. Akay | 26 | 129 | 5.0 |
| | 3 | Ramazan Ozcelik | 26 | 218 | 8.4 |
| | 4 | Emin Zeki Baskent | 25 | 157 | 6.3 |
| | 5 | Yusuf Ziya Erdil | 19 | 129 | 6.8 |
| | 6 | Ender Makineci | 19 | 68 | 3.6 |
| | 7 | Asko Lehtijarvi | 17 | 88 | 5.2 |
| | 8 | Unal Akkemik | 16 | 61 | 3.8 |
| | 9 | Hatice T. Dogmus-Lehtijarvi | 16 | 177 | 11.1 |
| | 10 | Ali Kasal | 16 | 128 | 8.0 |

In Israel, the three most productive authors were Shabtai Cohen (20 articles), Dan Yakir (18 articles), and Yagil Osem (17 articles). The greatest CPD belonged to Eyal Rotenberg (41.5), followed by Dan Yakir (40.1), and Nurit Agam (33.7). What strikes attention is that Israeli authors were much more often cited than Iranian and Turkish authors (Table 4), an observation suggesting that the quality of Israeli forestry research can be higher than that of the other countries.

In Turkey, the three most productive authors were Nadir Ayrilmis (28 articles), Abdullah E. Akay (26 articles), and Ramazan Ozcelik (26 articles). As was the case in Iran, the most productive author—Nadir Ayrilmis—was also among the three most cited (CPD of 13.3), followed by Hatice T. Dogmus-Lehtijarvi (11.1), and Ramazan Ozcelik (CPD of 8.4).

We might perhaps check whether these most productive Turkish authors were not so productive because of having published in either *Kastamonu University Journal of Forestry Faculty* or *Journal of the Faculty of Forestry-Istanbul University*, two Turkish journals that were added to WoS in 2016, and as so many journals were, only to be removed shortly after. The most productive author, Nadir Ayrilmis, published only one of his 28 articles in this journal (in *Kastamonu University Journal of Forestry Faculty*). Ramazan Ozcelik published only two articles in *Journal of the Faculty of Forestry-Istanbul University*, but Abdullah E. Akay quite a few more: four articles in *Journal of the Faculty of Forestry-Istanbul University* and two in *Kastamonu University Journal of Forestry Faculty*. Altogether, the top ten Turkish authors published 135 journals (some of them in collaboration), only six of which were in *Kastamonu University Journal of Forestry Faculty* and three in *Journal of the Faculty of Forestry-Istanbul University*.

Figures 9–11 illustrate maps of forestry co-words in scientific articles affiliated to Iranian, Israeli, and Turkish institutions, respectively. Four clusters of keywords were observed (Table 6), those within one cluster are tightly related to each other and loosely related to others in other clusters. In the case of Iran (Figure 9), the red cluster contains 33 words that occurred a total of 2342 times. The three words that had the most repetition in this group are: Iranian (270), species (204), tree (204). The green cluster contains 22 words that occurred 1204 times, and wood (113), density (111), treatment (108) had the most repetition. The blue cluster contained 19 words that were repeated 867 times in these scientific productions, and soil (104), change (100), impact (81) had the most repetition.

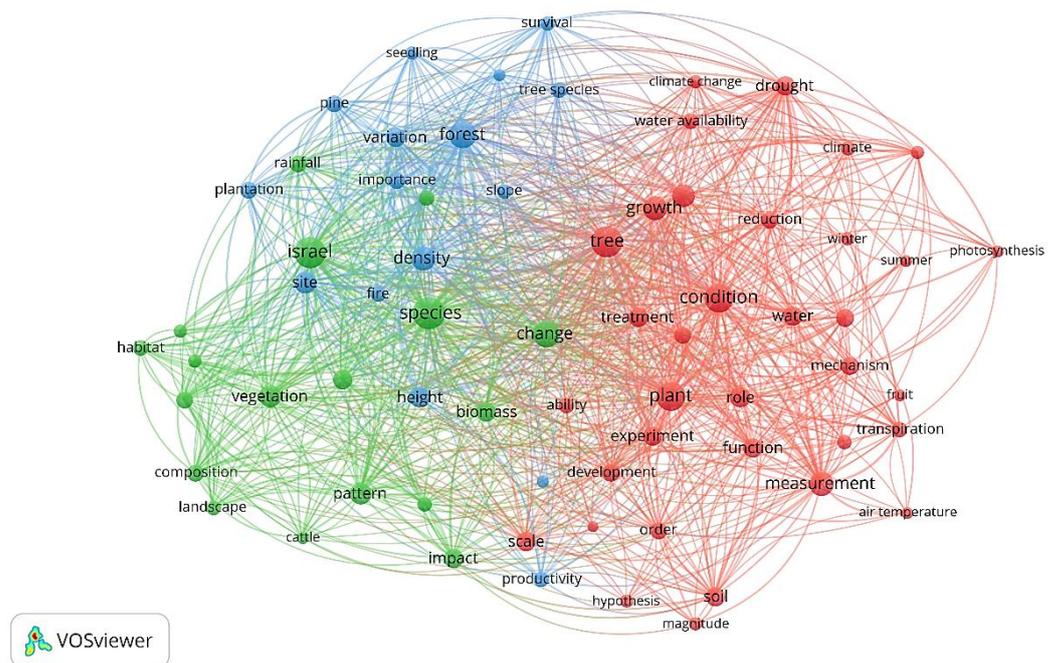


Figure 11. Cluster analysis map of the most used keywords in at least 20 articles published by Israeli researchers during the period 2005–2019. Colors indicate the cluster in which each keyword was related the most. Lines represent the co-occurrence link strength among terms.

Table 6. Keyword clustering and frequency.

| Country | Clusters | Color | Total Keywords | Total Occurrence of Keywords | Keyword |
|---------|----------|--------|----------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Iran | 1 | Red | 33 | 2342 | Iran (270), species (204), tree (204), forest (192), characteristic (110), northern Iran (89), variation (77), stand (76), structure (74), distribution (69), variable (66), Hyrcanian forest (62), site (62), size (62), tree species (61), height (57), role (57), diversity (56), oak (46), importance (42), beech (40), oriental beech (38), <i>Fagus orientalis</i> Lipsky (36), accuracy (34), season (34), breast height (32), north (32), conservation (31), stem (29), Zagros forest (27), rainfall (25), Caspian forest (24), dbh (24) |
| | 2 | Green | 22 | 1204 | wood (113), density (111), treatment (108), strength (77), temperature (75), increase (68), thickness (65), influence (63), water (58), weight (56), quality (55), specimen (48), water absorption (39), panel (37), decrease (36), resin (36), rupture (34), elasticity (29), physical property (27), reduction (27), g cm (21), moe (21) |
| | 3 | Blue | 19 | 867 | soil (104), change (100), impact (81), distance (59), slope (54), operation (52), combination (50), depth (50), cost (40), bulk density (35), damage (34), trail (33), road (32), ground (31), extent (23), skidder (23), soil sample (23), soil compaction (22), soil disturbance (21) |
| | 4 | Yellow | 13 | 727 | condition (135), growth (82), order (74), plant (68), concentration (61), seedling (48), root (45), experiment (43), interaction (40), leaf (37), seed (35), medium (32), ability (27) |

Table 6. Cont.

| Country | Clusters | Color | Total Keywords | Total Occurrence of Keywords | Keyword |
|---------|----------|--------|----------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Turkey | 1 | Red | 32 | 3357 | species (362), condition (305), characteristic (197), plant (173), quality (167), yield (165), concentration (143), soil (131), variation (130), cultivar (122), experiment (120), diversity (101), seed (97), genotype (88), season (80), combination (78), variety (76), selection (70), trait (70), root (67), black sea region (61), leaf (59), seedling (58), Europe (55), disease (54), interaction (54), marker (53), wheat (52), fruit (47), identification (43), isolate (41), family (38) |
| | 2 | Green | 29 | 3450 | Turkey (671), forest (283), production (204), change (195), development (167), order (161), activity (157), structure (157), management (138), impact (116), approach (110), distribution (108), environment (93), product (83), forestry (75), problem (73), solution (73), importance (69), map (64), forest ecosystem (58), aspect (54), productivity (54), survey (49), fire (48), basis (42), Istanbul (41), forest area (40), recent year (34), regard (33) |
| | 3 | Blue | 27 | 2360 | treatment (212), wood (185), test (146), temperature (145), increase (143), density (140), loss (114), performance (114), water (107), strength (94), size (92), resistance (84), influence (82), specimen (79), measurement (78), decrease (74), reduction (55), scots pine (55), thickness (52), panel (49), <i>Pinus sylvestris</i> (47), laboratory (39), mdf (39), elasticity (35), oriental beech (35), medium density fiberboard (34), <i>Fagus orientalis</i> Lipsky (31) |
| | 4 | Yellow | 10 | 1063 | tree (267), growth (152), stand (121), site (119), height (118), tree species (76), age (73), <i>Pinus brutia</i> (57), ability (44), breast height (36) |
| Israel | 1 | Red | 35 | 886 | tree (73), condition (60), plant (59), growth (41), measurement (41), season (39), role (32), experiment (29), drought (28), scale (27), water (27), function (26), soil (26), treatment (26), development (25), mechanism (25), temperature (24), increase (22), order (22), reduction (22), transpiration (19), water availability (19), ability (18), climate (16), leaf (16), climate change (14), magnitude (14), stomatal conductance (14), winter (14), hypothesis (13), fruit (12), air temperature (11), photosynthesis (11), summer (11), northern Israel (10) |
| | 2 | Green | 18 | 519 | species (78), Israel (73), change (53), pattern (33), vegetation (33), biomass (28), impact (26), interaction (26), species richness (21), composition (20), rainfall (20), habitat (19), Mediterranean (18), landscape (17), environmental condition (15), species composition (14), shrub (13), cattle (12) |
| | 3 | Blue | 16 | 384 | forest (55), density (44), site (35), height (31), variation (28), pine (22), importance (21), plantation (21), productivity (19), fire (18), tree species (18), slope (17), survival (17), seedling (14), establishment (12), influence (12) |

Figure 10 shows the co-words of Turkey that were repeated at least 30 times in forestry research during the period 2005–2019. These keywords were divided into four clusters: red, green, blue and yellow. The red cluster contains 32 words that were used 3357 times. Among these words' species (362), condition (305), characteristic (197) had the most occurrence. The green cluster also contains 29 words that were used 3450 times, and Turkey (671), forest (283), production (204) are more repetitive than the rest. The blue cluster has 27 words that were used 2360 times, and treatment (212), wood (185), test (146)

had the highest repetition. The yellow cluster also had 10 words with 1060 repetitions that tree (267), growth (152), and stand (121) had the most uses among them (Table 5).

Figure 11 shows the recurring co-words of Israeli scientific products in the field of forestry. The red cluster contains 35 keywords that occurred 886 times. The most repetitive words in this group are tree (73), condition (60), and plant (59). The green cluster has 18 words that occurred 519 times, and species (78), Israel (73), change (53) have been used more than the rest. The blue cluster also contains 16 keywords which occurred 384 times, and the three most common words in this group are forest (55), density (44), and site (35) (Table 6).

The “Diversity” in Iran and Turkey and the “Vegetation” in Iran are among the most frequent keywords that were previously identified as the most frequent keywords in global forest research by Song and Zhao [29]. In line with Aleixandre-Benavent et al. [27], “Temperature” was among the most frequently used keywords in Iran and Turkey. “Management”, one of the most frequent keywords in the Canadian forestry community research [30], was also among the most frequently used keywords in Iran and Turkey. The appearance of the “Hyrcanian forest” keyword in the co-words network of Iran could be due to the significance of this forested area for Iranian forestry researchers. Additionally, it is interesting that the University of Guilan, Gorgan University of Agricultural Sciences and Natural Resources, and Sari Agricultural Sciences Natural Resources University are three institutions located in the Hyrcanian forests, and obtained high *RSI* values in the forestry research, highlighting the importance of the Hyrcanian forests in Iranian forestry research.

4. Conclusions

We employed a bibliometric analysis with the objective of investigating and comparing Middle East countries in terms quantity and quality of forestry research. The bibliometric and bibliographic information presented in this study concentrated on the forestry documents published from 2005 to 2019 by researchers from Iran, Israel, and Turkey. We intentionally restricted our study to a comparison between three countries and removed the other Middle East countries from the analysis. While extending the research to all Middle East countries could unnecessarily increase the volume of the paper, an analysis with all Middle East countries provides marginally useful information because of the low contribution of these countries to the field of forestry. The analysis allowed for identifying the leading authors and institutions, the most widely used journals, and the most frequently used keywords (i.e., topics). The network of collaboration between these three countries and other countries revealed a significant level of international collaboration, where the triangle of the USA, Germany, and Italy was highlighted. Future research along these lines should investigate the influence of other disciplines such as socio-economics, environmental science, plant science, agronomy, ecology, and botany on the forestry discipline, as it would be interesting to examine the evolution of forestry research in the Middle East in relation to other fields of science. Insights provided by such analyses are useful both to advance research activities to an enhanced level and to reinforce international collaboration.

Author Contributions: Conceptualization: M.F.-V., E.G.-A., M.K. and A.J.; formal analysis: M.F.-V., E.G.-A. and M.K.; validation: M.F.-V., E.G.-A., M.K. and A.J.; supervision: A.J.; writing—original draft: M.F.-V., E.G.-A., M.K., D.M.-G. and A.J.; visualization: M.F.-V., E.G.-A. and M.K.; investigation: M.F.-V., E.G.-A., M.K., P.B. and A.J.; funding acquisition: A.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study will be available on interested request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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