SIXTY YEARS OF TROPICAL FORESTRY SCIENCE AT GADJAH MADA UNIVERSITY: A SCOPUS-BASED BIBLIOMETRIC STUDY

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SIXTY YEARS OF TROPICAL FORESTRY SCIENCE AT GADJAH MADA UNIVERSITY: A SCOPUS-BASED BIBLIOMETRIC STUDY. This Study undertakes a comprehensive bibliometric analysis to explore the research trends in the Scopus publications affiliated with the Faculty of Forestry at Gadjah Mada University (FF-UGM) in the generation of knowledge in tropical forestry. A total of 725 publications affiliated with FF-UGM were mined from the Scopus database and analyzed using VOSviewer and CiteSpace. The findings indicate a steady growth in the number of research publications and therefore, the cumulative count of 5,409 citations amounts to an average of 7.5 citations per publication. Furthermore, FF-UGM has engaged collaborations with researchers from all continents, with Japan exhibiting the highest network power through 112 collaborations. In relation to the sources of funding, a total of 518 articles has been granted financial assistance from 159 donors on a global scale, with 133 publications being self-sponsored by UGM. The Burst analysis, further, reveals emerging research frontiers to be explored further in future study including deforestation, catchments, agroforestry, and sustainable development. Thematic clustering indicates five big areas with high interdisciplinary approach to forest management, policy, product innovation, silviculture, and biodiversity conservation. The present bibliometric analysis proves that the FF-UGM is also changing its areas of interest into sustainable tropical forest ecosystems and serves as a source of both science and policy-related studies.

Keywords: Research trends, Faculty of Forestry, Gadjah Mada University, Scopus, tropical forestry

ENAM PULUH TAHUN ILMU KEHUTANAN TROPIS DI UNIVERSITAS GADJAH MADA: STUDI BIBLIOMETRIK BERBASIS SCOPUS. *Studi ini melakukan analisis bibliometrik komprehensif untuk mengeksplorasi tren penelitian dalam publikasi Scopus yang berafiliasi dengan Fakultas Kehutanan Universitas Gadjah Mada (FF-UGM) dalam menghasilkan pengetahuan di bidang kehutanan tropis. Sebanyak 725 publikasi yang berafiliasi dengan FF-UGM ditelusuri dari database Scopus dan kemudian dianalisis menggunakan VOSviewer dan CiteSpace. Temuan tersebut menunjukkan pertumbuhan yang stabil dalam jumlah publikasi penelitian dan oleh karena itu, jumlah kumulatif 5.409 sitasi setara dengan rata-rata 7,5 sitasi per publikasi. Selain itu, FF-UGM telah berkolaborasi dengan peneliti dari semua benua, dengan Jepang menunjukkan kekuatan jaringan tertinggi melalui 112 kolaborasi. Terkait dengan sumber pendanaan, total 518 artikel telah mendapat bantuan keuangan dari 159 donor secara global, dengan 133 publikasi dibiayai sendiri oleh UGM. Analisis Burst lebih lanjut mengungkapkan bidang penelitian baru yang perlu dieksplorasi lebih lanjut dalam studi mendatang, termasuk deforestasi, daerah aliran sungai, agroforestri, dan pembangunan berkelanjutan. Pengelompokan tematik menunjukkan lima area besar dengan pendekatan interdisipliner yang tinggi terhadap pengelolaan hutan, kebijakan, inovasi produk, silvikultur, dan konservasi keanekaragaman hayati. Analisis bibliometrik ini membuktikan bahwa FF-UGM juga mengubah area minatnya menjadi ekosistem hutan tropis berkelanjutan dan berfungsi sebagai sumber studi yang berkaitan dengan sains dan kebijakan.*

Kata kunci: Tren penelitian, Fakultas kehutanan, Universitas Gadjah Mada, Scopus, Kehutanan tropis

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I. INTRODUCTION

The major aim of tropical forestry studies is to achieve sustainable forest management and sustainable development (Poorter et al., 2021). This involves the need to understand the intricate ecological regimes within the tropical forest, and how to respond to such issues as deforestation by maintaining sustainable land use practices, equitable sharing of economic gains, and protection of biodiversity. As it is discussed in the study by Elliott et al. (2023), a combination of field research, remote sensing, and modeling is important in the study of tropical forests. This interdisciplinary way is important in enlightening the policies and taking up measures that are very vital to the conservation of these invaluable ecosystems. It also provides the long-term sustainability of the tropical forests besides fulfilling the needs of the locals.

In the era of the fast development of science, the evaluation of academic outputs created in academic institutions has gained significant value, and bibliometric studies have become a crucial part of this evaluation (Tomaszewski, 2023). Established in 1949, Gadjah Mada University is widely recognized as one of the oldest institutions of higher education in Indonesia. A separation process within the Faculty of Agriculture was accomplished in the year 1963 leading to the creation of the Faculty of Forestry at Gadjah Mada University (FF-UGM). The FF-UGM has four distinct departments, devoted to the fields of forest resource conservation, forest management, silviculture, and forest product technology. The departments mentioned above work together to achieve synergistic development of their common goal of pushing the limits of knowledge, technology, and efficient management of tropical forest ecosystems.

During the six decades of its existence, the FF-UGM has gained a lot of credit concerning its fearless pursuit of high standards of achievement. According to the UGM annual report (2021) highlights the substantial contribution of the FF-UGM in promoting progress in the fields of forestry and environmental sciences. It has recognized the growing importance of learning the emerging trends in research and the resultant implication that has followed. The relevance of the problem to the field of academia has been extended to include policymakers, high-profile academics and numerous stakeholders fully involved in the complex areas of forestry and environmental conservation to develop a sustainable development. (Stupnisky et al., 2019).

Numerous studies have been undertaken on a global scale to investigate the academic publications of institutions, organizations, and specific disciplines. The studies use several well-known sources including, such as Scopus, Web of Science (WOS), Elsevier, Science Direct, EBSCO, JSTOR, and ProQuest, among others (Shi et al., 2021). This study uses Scopus as a popular and widely used citation resource that consists of a database of abstracts of peer-reviewed academic literature (Vengadesh et al., 2023).

Bibliometric studies, based on data from extensive databases, have become a necessary method of determining the qualitative and quantitative output and impact of a specific topic or research center on the basis of analyzing publications (Hakim et al., 2022). It is done through defining key research areas and themes, monitoring citation patterns, and acknowledging the international collaborative activities (Klapka & Slaby, 2018). Given the prominent status of FF-UGM within the academic landscape of Indonesia, there is a strong need to subject it to comprehensive scrutiny in order to clarify its academic achievements and its contribution to the overall scientific community.

The purpose of this bibliometric research is to analyze the research products of FF-UGM in Scopus data, by developing a thorough review of the scientific impact of the faculty. This was done by carefully scrutinizing scholarly publications, citations, patterns of authorship, and the extent of international collaborations.

Furthermore, this study also identifies emerging research trends and areas of expertise, with an investment in the 60-year legacy of FF-UGM as an autonomous faculty within Gadjah Mada University.

The understanding of the complex research dynamics in the FF-UGM is important because it is not only essential to the clarification of academic objectives, but also to the creation of research-based policies and sustainable practices in scientific disciplines forestry and environmental science. With this investigation going on, it can possibly fill the existing gap in the field of bibliometrics and give priceless information on the current state of research in this prestigious institution.

II. MATERIAL AND METHOD

A. Data Collection

The affiliated publication records at FF-UGM were downloaded from Scopus, a leading abstract and citation database popular in the scientific community. A strict data mining process was followed in order to guarantee the accuracy and quality of the selected documents. The first step consisted of conducting a thorough search using specific keywords associated with FF-UGM: [AFFIL (faculty AND of AND forestry) OR AFFIL (fakultas AND kehutanan) AND AFFIL (universitas AND gadjah AND mada) OR AFFIL (university AND gadjah AND mada) OR AFFIL (gadjah AND mada)]. This involved different spellings of the name of the institution both in the English and Indonesian languages, to capture all the possible spellings of the institution. There was no time limitation to capture all publications affiliated with FF-UGM from its inception until September 2023.

We then further reduced our scope of interest to four major types of documents that include conference papers and scientific articles, book chapters, and reviews. The usage of this classification system allowed including a wide variety of materials and promoted the deep knowledge of the subject in question. Language consistency was also another criterion which was taken into consideration when selecting the document. Only publications that were written mostly in English were included in order to bring about clarity and ease the further analysis.

After applying these strict selection criteria, we were able to come up with a final dataset comprising 725 publications. The following overall analysis performed in this paper is based on this dataset.

B. Methods

Two of the most prominent bibliometric analysis tools were tapped in this research. The first tool, CiteSpace, is widely recognized as a leading software application with a specific purpose to analyze literature data in details. CiteSpace is a software that is specifically developed for the purpose of investigating the organization and distribution of scientific knowledge (Chen & Song, 2019). It makes use of scientific metrology, information visualization and data analysis methods. Researchers are provided with the ability to create a wide range of knowledge graphs, which serve as visual depictions of the complex network of citations found inside academic literature (Chen, 2014; 2020) In this study, we employed CiteSpace 6.2.R4 (64-bit) Basic version.

The second tool engaged in this study is VOSviewer, a software application developed using the Java programming language. VOSviewer is a flexible tool that can be used to build and visualize network-based maps. It simplifies the process of exploration and analysis of these maps, which helps to gain a better insight into the intricate interrelations inherent in the dataset (van Eck & Waltman, 2023). In this study, VOSviewer 1.6.19 with Java 1.8.0_371 was deployed for the purpose of conducting our investigation.

The utilization of advanced analysis instruments has contributed to the acquisition of useful insights and have also enabled the generation of clear visual representations that explain the scientific literature landscape of FF-UGM.

III. RESULT AND DISCUSSION

A. Result

Overview of FF-UGM Research Outputs

Publication and Citation Quantities

Figure 1 shows the temporal trend of annual publication volume and cumulative citations of the Faculty of Forestry at Gadjah Mada University (FF-UGM) since its inception. The dataset obtained from Scopus includes a total of 725 publications and can be divided into 532 articles, 161 conference papers, 18 book chapters, and 14 reviews.

The publications of FF-UGM in the Scopus database have exhibited a steady and continuous growth since its inception in 1963. The initial publication affiliated to FF-UGM in Scopus dates back to 1988 and was followed by another publication in 1997. However, it was only in 2003 that the research production of FF-UGM began to exhibit a consistent upward trend, ultimately culminating in a pinnacle of 131 articles in 2022. As of September 15, 2023, the date of data mining, the FF-UGM portfolio comprises a cumulative count of 725 research articles. The observed surge in publications implies the possible increase in the number of existing resources, including financial, technological, and human resources, as well as improvement in the knowledge and abilities of the faculty. A combination of this factor helps in motivation of FF-UGM in attaining its aspirations of becoming a nationally renowned internationally recognized institution in the field of tropical forestry. The venture is guided by the principles of Pancasila and devoted towards developing the well-being of the country.

This review singles out two landmark events in the history of the research publications of FF-UGM. In 2016, FF-UGM achieved the significant milestone of surpassing 20 annual publications for the first time. In 2020, FF-UGM accomplished a significant achievement by exceeding a total of 120 publications within a single year. Before 2016, the annual publication count of FF-UGM constantly stayed below 20. The publications have grown by a great margin of 64.3% within the period between 2016 and 2020 with 34 publications in 2016, and 124 publications in 2020. This growth accounted for 45% of the total 725 publications that were recorded since 1988.

Cumulative trends in frequency of citation with time are also shown in figure 1. Between 1988 and 2023, the works of FF-UGM had a total of 5,409 citations in the cumulative years. The average number of citations per year is 154, which corresponds approximately to 7.5 citations per publication. Remarkably, the number of citations to the publications of FF-

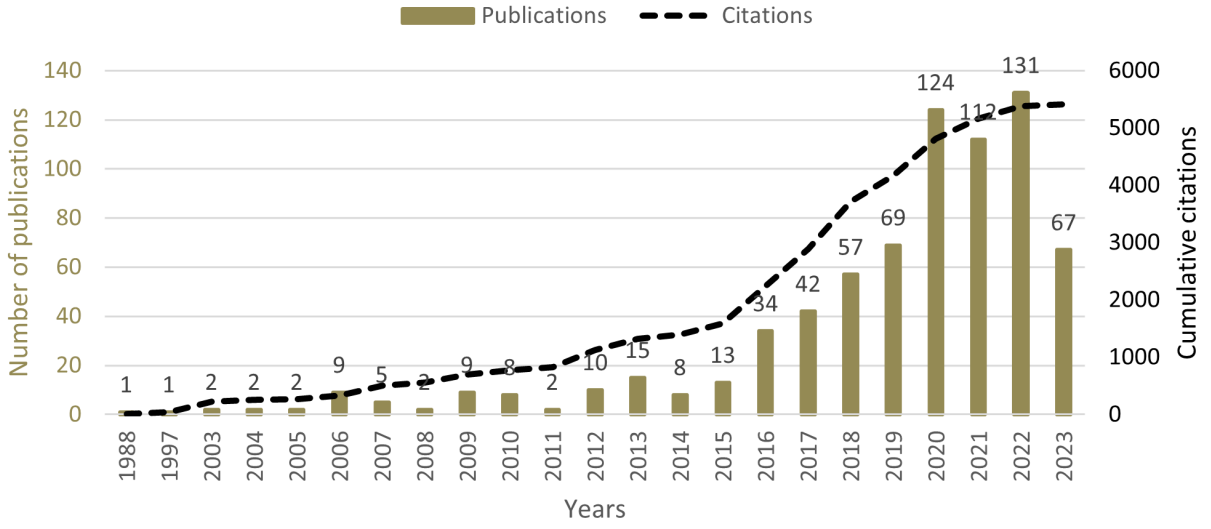

Figure 1. Evolution of Scopus' Publications and Citations Affiliated with FF-UGM

UGM also increased significantly throughout the years 2016-2020. The mean annual amount of volume of citation was 643. Furthermore, our analysis has revealed a strong positive connection of 0.53 between the number of published works and the number of citations received. The correlation witnessed shows that the self-citation among the researchers of FF-UGM is of high nature. This means that their natural quality and influence of their respective publications might have very minimal influence on the chances of receiving citations.

The subject categories of publications

Within the realm of subject categorization in academic publications, it becomes evident that research conducted at FF-UGM has exhibited a tendency to surpass disciplinary confines throughout the course of the last three and a half decades. This has resulted in the generation of academic materials that cover a broad spectrum of 23 distinct subject areas. Figure 2 s a detailed description of the different subject areas that will be covered in this scholarly undertaking. One of the prominent areas of the corpus is Agricultural and Biological Sciences as it is a substantial part, containing 413 publications, which constitute 29.3% of the entire corpus.

In addition, it can be noted that the discipline of Environmental Science has a notable presence, accounting for 345 papers (24.5%). Immediately after this is the group of Biochemistry, Genetics, and Molecular Biology which adds up to 142 publications 142 publications (10.1%). The field of Earth and Planetary Sciences is also a substantial entity with 140 papers (9.9%). The other important fields of interest include Social Science, accounting for 7.0% of the total, Material Science with a contribution of 4.5%, Engineering with a share of 3.4%, Economics, Econometrics, and Finance collectively representing 2.0%, Energy making up 1.5%, and Chemical Engineering contributing 1.3%. Furthermore, it is worth mentioning that there exists a significant presence within the wider scope of 'other topic fields,' which makes a contribution of 6.5% to the entire body of scholarly work.

This spread in the wide fields of study provides invaluable information in the multidisciplinary approach needed to overcome the multifaceted challenge of the four departments of the faculty, namely: Conservation of Forest Resources, Forest Management, Silviculture, and Forest

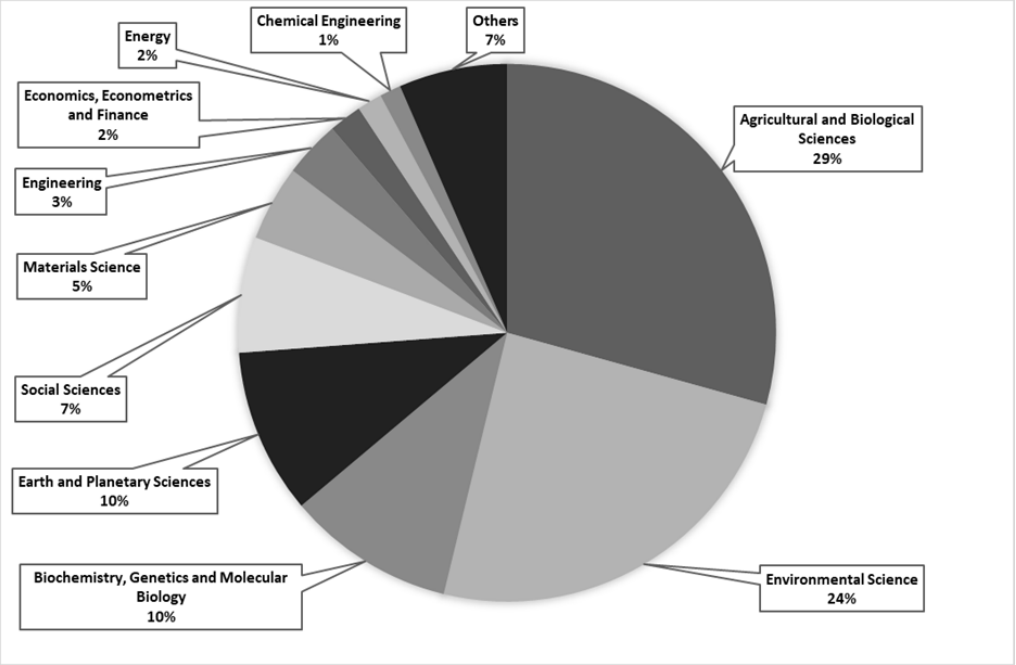

Figure 2. Subject area of FF-UGM's research outputs.

Product Technology. The collective attempts to derive the ecological and biological dynamics of depletion of tropical forests are indicated by the vast amount of literature in the fields of agricultural and biological sciences, as well as environmental science. Furthermore, the active involvement in the field of earth and planetary sciences indicates a growing fascination with exploring the ecological consequences and dynamics of earth's systems that are associated with the decline of tropical forests.

Furthermore, the role of Social Science in the situation indicates that the socio-economic and political nature, the intricate connection of human activity with forest management are considered, and the implications of these issues on human well-being can be observed. It's essential to emphasize that the quantity of publications in each subject area serves as a reflection of research volume and is not necessarily an indicator of research quality or impact.

Most cited publications

Within the pool of 725 publications affiliated to FF-UGM, a noteworthy 541 (75%), have garnered at least one citation by September 2023. It is worth noting that 189 publications or 26% of them have surpassed average citation of 7.5 with a minimum of 8 citation. Moreover, an even smaller number of 68 publications, which constitute (9%), have been able to achieve a respectable minimum of 20 citations.

Table 1 provides the list of the most influential publications that are related to the FF-UGM within the Scopus database. These publications are characterized by their attainment of the highest citation counts (more than 50 citations).

Table 1. Top publications affiliated with FF-UGM

No	Authors and year of publication	Title	Journal	TC
Department of Silviculture				
1	Jones D. T., Susilo F. X., Bignell D. E., Hardiwinoto S., Gillison A. N., & Eggleton P. (2003)	Termite assemblage collapse along a land-use intensification gradient in lowland central Sumatra, Indonesia	Journal of Applied Ecology	179
2	Beukema H., Danielsen F., Vincent G., Hardiwinoto S., & Van Andel J. (2007)	Plant and bird diversity in rubber agroforests in the lowlands of Sumatra, Indonesia	Agroforestry Systems	110
3	Harwood C. E., Hardiyanto E. B., & Yong W. C. (2015)	Genetic improvement of tropical acacias: achievements and challenges	Southern Forest	40
4	Begum S., Kudo K., Rahman M. H., Nakaba S., Yamagishi Y., Nabeshima E., Nugroho W. D., Oribe Y., Kitin P., Jin H.-O., & Funada R. (2018)	Climate change and the regulation of wood formation in trees by temperature	Trees - Structure and Function	62
Department of Forest Management				
1	Maryudi A., Devkota R. R., Schusser C., Yufanyi C., Salla M., Aurenhammer H., Rotchanaphatharawit R., & Krott M. (2012)	Back to basics: Considerations in evaluating the outcomes of community forestry	Forest Policy and Economics	137
2	Sahide M. A. K., Supratman S., Maryudi A., Kim Y.-S., & Giessen L. (2016)	Decentralization Policy as Recentralization Strategy: Forest Management Units and Community Forestry in Indonesia	International Forestry Review	95
3	Prabowo D., Maryudi A., & Imron M. A. (2017)	Conversion of forests into oil palm plantations in West Kalimantan, Indonesia: Insights from actors' power and its dynamics	Forest Policy and Economics	61
4	Maryudi A., Citraningtyas E. R., Purwanto R. H., Sadono R., Suryanto P., Riyanto S., & Siswoko B. D. (2016)	The emerging power of peasant farmers in the tenurial conflicts over the uses of state forestland in Central Java, Indonesia	Forest Policy and Economics	42
Departement of Forest Resource Conservation				
1	Marhaento H., Booij M. J., & Hoekstra A. Y. (2018)	Hydrological response to future land-use changes and climate change in a tropical catchment	Hydrological Sciences Journal	86
2	Nijman V., Langgeng A., Birot H., Imron M. A., & Nekaris K. A. I. (2018)	Wildlife trade, captive breeding, and the imminent extinction of a songbird	Global Ecology and Conservation	42

No	Authors and year of publication	Title	Journal	TC
3	Pudyatmoko, S. (2017)	Free-ranging livestock influence species richness, occupancy, and daily behavior of wild mammalian species in Baluran National Park, Indonesia	Mammalian Biology	35
Departement of Forest Product Technology				
1	Schollaen K., Heinrich I., Neuwirth B., Krusic P. J., D'Arrigo R. D., Karyanto O., & Helle G. (2013)	Multiple tree-ring chronologies (ring width, δ13C and δ18O) reveal dry and rainy season signals of rainfall in Indonesia	Quaternary Science Reviews	74
2	Nugroho W. D., Marsoem S. N., Yasue K., Fujiwara T., Nakajima T., Hayakawa M., Nakaba S., Yamagishi Y., Jin H.-O., Kubo, T., & Funada R. (2012)	Radial variations in the anatomical characteristics and density of the wood of *Acacia mangium* of five different provenances in Indonesia	Journal of Wood Science	47
3	Widyorini R., Nugraha P. A., Rahman M. Z. A., & Prayitno T. A. (2016)	Bonding ability of a new adhesive composed of citric acid-sucrose for particleboard	BioResources	40
4	Lukmandaru G., & Takahashi K. (2009)	Radial distribution of quinones in plantation teak (*Tectona grandis* L.f.)	Annals of Forest Science	38

TC: total citation counts of each publication

Collaboration and Networking Analysis

Country Networking

The research publications affiliated with FF-UGM on Scopus have exhibited collaboration with scholars from a wide array of backgrounds, encompassing 80 nations across all continents. Figure 3, which shows a distribution map, is the global coverage of FF-UGM collaborative research activity.

The collaborative network that was created between countries that are involved in FF-UGM research publications is visually described in figure 4. This figure includes only nations that have collaborated in at least five publications. In this context, every country is depicted as a node, wherein the size of each node is directly proportional to the quantity of publications attributed to that country. The thickness of the lines linking nodes represents the degree of strength of the co-authorship links among these countries. The countries are categorized into four distinct clusters, distinguished by different colors.

Table 2 provides a comprehensive breakdown of each country and cluster (a group of similar countries occurring closely together), encompassing a range of key metrics. These metrics include the number of publications (P), the percentage of country publications

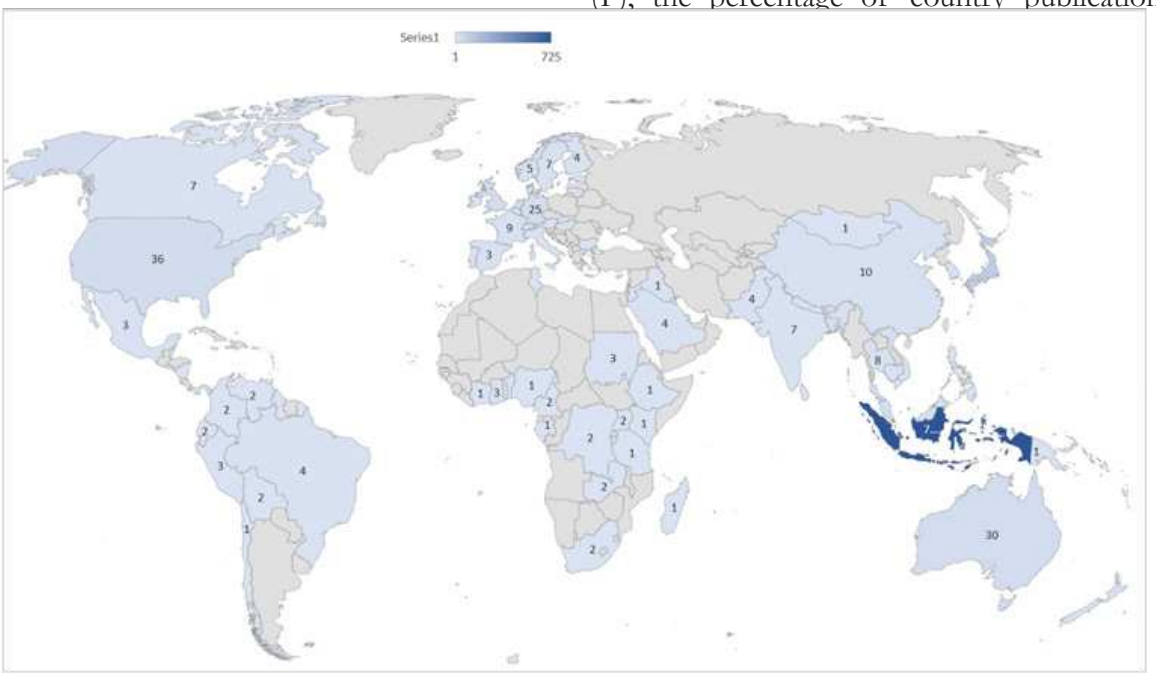

Figure 3. Distribution map of the countries' collaboration in FF-UGM research

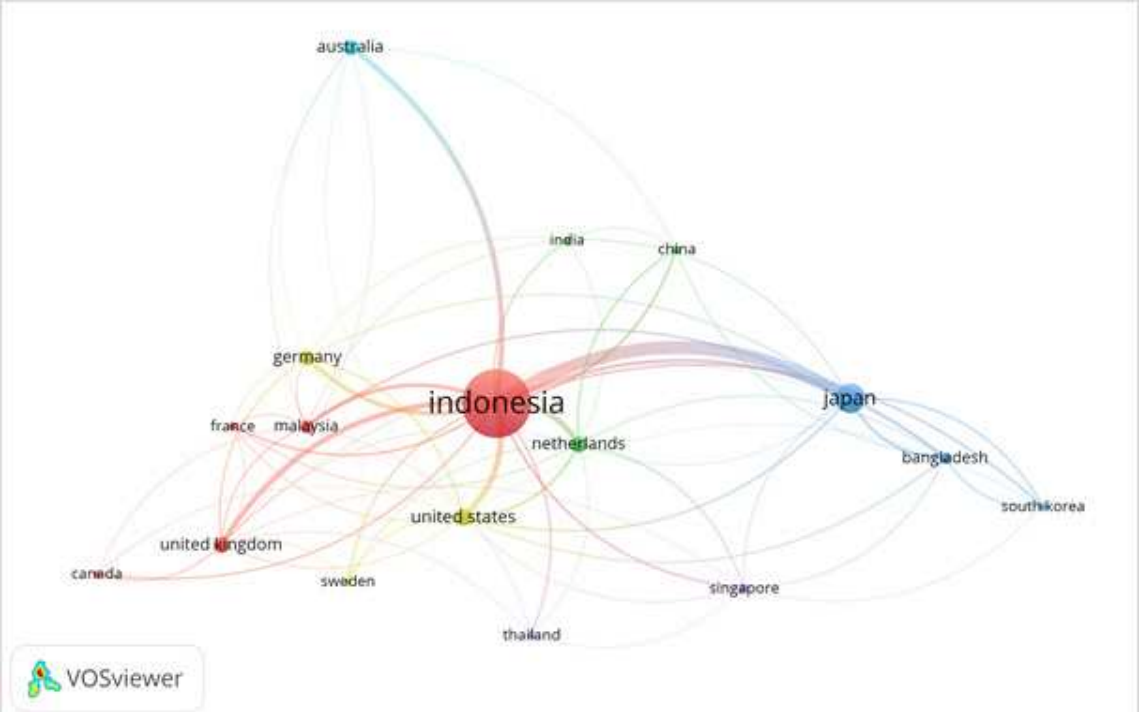

Figure 4. Distribution map of the countries' collaboration in FF-UGM research

relative to the total of 725 research outputs (%725), total citations (TC), average citations per publication (TC/P), normalized citation (N.C), the count of links with other countries, the cumulative strength of these links (TLS), and the corresponding cluster number.

Naturally, Indonesia leads in the number of publications (725) because all publications are affiliated with FF-UGM. Japan appears as the first partner country with collaboration on 112 publications and the percentage of total contributions (15%), indicating its significant involvement in this field, working together with FF-UGM. However, when considering publication impact, Japan, the United States, Germany, and the United Kingdom emerge as highly efficient, with a relatively high total citation count (TC) higher than 600. The countries such as Singapore, India and South Korea have moderate figures on publications and have more average citation per publication (TC/P), which also reflects the quality and impact of their studies. This wide range of contributions by various countries highlights how the world is interested and working together in the field of tropical forestry research and each country delivers individual and valuable inputs towards the discipline.

Table 2. List of countries sharing at least 5 common publications with the FF-UGM

Country	P	%725	TC	TC/P	N.C	Links	TLS	Cluster
Indonesia	725	100	5140	7.14	718.70	16	331	1
Japan	112	15.2	1071	9.74	101.37	10	148	3
United States	34	4.7	711	20.91	73.21	12	72	4
Australia	30	4.0	563	20.11	39.87	6	33	5
Netherlands	28	3.9	575	20.54	55.10	11	56	2
United Kingdom	28	3.9	607	21.68	86.03	12	47	1
Germany	23	3.2	671	29.17	51.59	9	42	4
Malaysia	18	2.5	353	19.61	18.57	9	36	1
Bangladesh	13	1.8	227	17.46	20.67	7	39	3
Singapore	9	1.2	321	35.67	32.47	8	22	3

Country	P	%725	TC	TC/P	N.C	Links	TLS	Cluster
China	8	1.1	50	6.25	10.84	5	17	2
France	7	1.0	128	18.28	5.68	6	15	1
South Korea	7	1.0	211	30.14	11.35	5	20	3
Thailand	6	0.8	44	7.33	9.51	5	10	3
Canada	5	0.7	56	11.2	4.33	4	10	1
India	5	0.7	174	34.8	7.47	6	10	2
Sweden	5	0.7	112	22.4	13.95	5	12	4

P: number of publications of a country related to coauthorship with FF-UGM researchers. %/725: percentage of the country's publications out of a total of 725 FF-UGM's publications. TC: total citations of a country. TC/P: average citations per publication of a country. N.C: normalized number of citations received by a country. TLS: total link strength of a country.

The network of collaborative partnerships among institutions

Our list of 752 publications has 159 places of collaboration with the FF-UGM. Table 3 shows a summary of the institutions that have been very productive in terms of coauthoring at least 21 works in partnership with FF-UGM. It is interesting to note that among the top nine mentioned institutions only academic institutions of Indonesia and Japan were listed and this shows that FF-UGM is national based and has good ties with Japanese universities. In terms of scientific collaboration, it is noteworthy that Institut Pertanian Bogor (IPB) University has become the leading institution as it has been involved in 36 collaborations with FF-UGM. The Tokyo University of Agriculture and Technology has actively participated in 31 collaboration initiatives with FF-UGM.

Table 3. Top prolific collaborative institutions

Institution	P	Country
IPB University	36	Indonesia
Tokyo University of Agriculture and Technology	31	Japan
Institut Teknologi Bandung	30	Indonesia
Badan Riset dan Inovasi Nasional	26	Indonesia
Universitas Airlangga	25	Indonesia
Hasanuddin University	24	Indonesia
Forestry and Forest Products Research Institute	23	Japan
Kyoto University	21	Japan
Universitas Sumatera Utara	21	Indonesia

P: number of publications of each institution coauthored with FF-UGM researchers

Source of Research Funding

Among the 725 articles that were examined, a notable portion of 518 publications (71%), have received funding from a wide-ranging group of 159 donors from several continents. These sponsors encompass a diverse range of categories, including universities (such as UGM, Hasanuddin University, University of Western Australia, IPB University, King Saud University, Kyushu University, among others), Indonesian Ministries (such as the Ministry of Education, Culture, Sports, Science and Technology; Ministry of Environment and Forestry (KLHK); Ministry of Finance; Ministry of Foreign affairs), Foreign Ministries (Ministry of Science and Technology, Taiwan; Ministry of the Environment, Japan; Ministry of Higher Education, Egypt), foreign country development agencies (including the United States Agency for International Development, Norwegian Agency for Development Cooperation, Australian Agency for International Development), international organizations (such as the European Research Council, International Fund for Agricultural Development, UNDP, UNESCO, CGIAR, WWF), and grants awarded through competitive selection processes (such as the Mohamed bin Zayed Species Conservation Fund, Leverhulme Trust, Arcus Foundation, Forest Conservation Fund). Table 4 presents a comprehensive overview of the leading 20 funding institutions for FF-UGM research, together with their corresponding countries of origin.

Table 4. Funding institutions supporting FF-UGM's research.

	Institution	P	Country/Territory
1	Universitas Gadjah Mada	133	Indonesia
2	Ministry of Education, Culture, Sports, Science and Technology	69	Indonesia
3	Japan Society for the Promotion of Science	26	Japan
4	Lembaga Pengelola Dana Pendidikan	14	Indonesia
5	Australian Centre for International Agricultural Research	13	Australia
6	Ministry of Environment and Forestry	11	Indonesia
7	Direktorat Jenderal Pendidikan Tinggi	9	Indonesia
8	Ministry of Finance	9	Indonesia
9	Japan Student Services Organization	7	Japan
10	United States Agency for International Development	7	USA
11	Cleveland Zoological Society	6	USA
12	Institut Teknologi Bandung	6	Indonesia
13	Margot Marsh Biodiversity Foundation	6	USA
14	National Geographic Society	5	USA
15	Universitas Airlangga	5	Indonesia
16	Wellcome Trust	5	UK
17	Columbus Zoo and Aquarium	4	USA
18	Direktoratet for Utviklingssamarbeid	4	Norway
19	Disney Worldwide Conservation Fund	4	USA
20	European Commission / European Research Council	4	Europe

P: number of publications sponsored by each funding institution

It is interesting to note that, the Indonesian institutions lead in the number of publications among the top 20 sponsors. It is worth mentioning that the Gadjah Mada University (UGM) has self-funded a total of 133 publications. This observation highlights the importance of developing nations investing in the promotion of research projects by them, consistent with previous research (Nanda et al., 2021; Sills & Sanganyado, 2021). This way, they are able to solve problems that are applicable to their situation and minimize chances of being subjected to influence of the research priorities and interests of countries that fund the research.

FF-UGM's Research Themes Analysis

Keyworks evolution

Figure 5 Figure 5 offers clues concerning the historical evolution of the research interests of FF-UGM, which is presented in the form of a word cloud created due to the presence of terms used in its publications. The given picture shows the correlation between the size of words and the rate of their occurrence in which the bigger words will be used to reflect the bigger frequency.

Before 2009, the primary research focus of FF-UGM was centered on many aspects including Acacia plantation study in Southeast Asia, Eurasia, and Indonesia. Additionally, investigations pertaining to plant growth, density, species genetic identification using DNA analysis, and forest management were conducted (Kurinobu et al., 2006). Between 2009 and 2013, a trend of the investigation of silviculture with the focus on cultivation of Eucalyptus as a primary species of interest can be observed. During this time, there was a notable surge in research conducted in the fields of wood products and biodiversity protection. Furthermore, following the 13th Conference of the Parties (COP) in Bali and the creation of the REDD mechanism, FF-UGM also engaged in research activities related to the forest biomass and its carbon sequestration potential (Wirabuana et al., 2020).

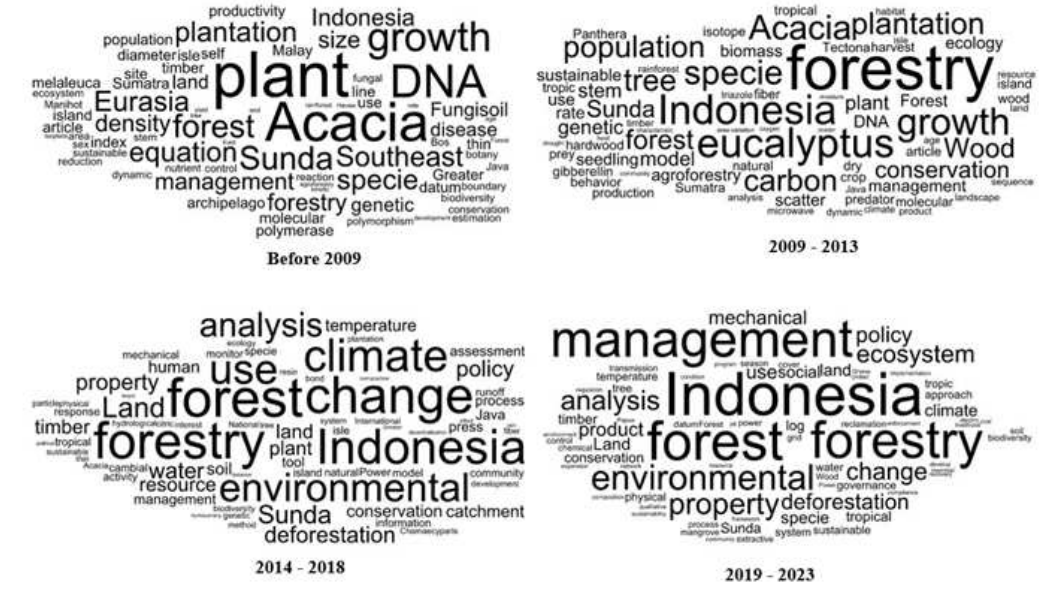

Figure 5. Temporal Dynamics of FF-UGM Research Keywords

Before 2009, the primary research focus of FF-UGM was centered on many aspects including Acacia plantation study in Southeast Asia, Eurasia, and Indonesia. Additionally, investigations pertaining to plant growth, density, species genetic identification using DNA analysis, and forest management were conducted (Kurinobu et al., 2006). Between 2009 and 2013, a trend of the investigation of silviculture with the focus on cultivation of Eucalyptus as a primary species of interest can be observed. During this time, there was a notable surge in research conducted in the fields of wood products and biodiversity protection. Furthermore, following the 13th Conference of the Parties (COP) in Bali and the creation of the REDD mechanism, FF-UGM also engaged in research activities related to the forest biomass and its carbon sequestration potential (Wirabuana et al., 2020).

In the years 2014 to 2018, much attention in the FF-UGM community was strongly concerned with the issue of climate change. It included the in-depth analysis of the land use change and deforestation along with the respective impacts on environmental sustainability. These impacts touched on a variety of dimensions, including temperature, the qualities of soil, water resources, and water catchment (Marhaento et al., 2018). Following the year 2018, there was a notable movement in the predominant research issues within the FF-UGM community towards the sustainable management of the environment. This entailed policy analysis (Rahayu et al., 2023) while exploring non-wood product qualities as potential alternatives to wood in the field of building (Sucipto et al., 2020).

Emerging and Prospective Area of Research Focus: Keywords with Burst

Burst keywords refer to terms that undergo a rapid increase in their usage frequency. To detect and make special interest such sudden rises in activity, researchers apply an extremely effective methodology of analysis known as burst detection. The methodology outlined by Chen (2014) is essential towards identifying the keywords that will draw significant attention to the keywords of the relevant scholarly communities in a given time frame. The keywords are of great relevance since they serve as significant pointers of research venturing and draw predictions on the direction of research to come. Figure 6 displays a combination of the top 17 bursting keywords that have been detected using the CiteSpace tool. This presentation provides an overview of the

power and duration of the occurrences being discussed. This period is shown as a graph and the blue line illustrates the period. Besides, the red line on the graph shows the start and end times of each burst keyword (Chen, 2014).

The year 2003 had a notable surge in research activity focused on the principal term "Acacia mangium". During the period from 2006 to 2012, there were notable changes in the research emphasis, as seen by the emergence of "biomass," "Tectona grandis," "rainforest," and "Falcataria moluccana" as major and actively studied subjects.

The research interests have shifted significantly with a new set of keywords ever since 2015. Such terms include "runoff," "deforestation," "catchments," "agroforestry system," "sustainable development," and "agricultural robots," have become major fields of concern. One should admit that these issues remain open to be researched more and they demand additional research efforts. Thus, they act as promising fields of future research undertakings.

Word Occurrence

The clustering analysis of publication titles and abstracts, as depicted in Figure 7, has identified five primary clusters of research themes that correspond to the four departments of FF-UGM.

Top 17 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2003 - 2022
acacia	2003	5.85	2003	2018	
eurasia	2004	5.44	2004	2010	
asia	2004	5.44	2004	2010	
southeast asia	2004	5.19	2004	2014	
acacia mangium	2003	4.45	2003	2018	
biomass	2006	3.57	2006	2018	
malay archipelago	2005	3.06	2005	2010	
tectona grandis	2008	4.81	2008	2018	
rainforest	2007	3.92	2007	2018	
falcataria moluccana	2007	3.17	2007	2010	
fibers	2012	3.13	2012	2018	
runoff	2017	3.71	2017	2022	
deforestation	2015	3.67	2015	2022	
catchments	2017	3.32	2017	2022	
agroforestry system	2019	4.42	2019	2022	
sustainable development	2016	4.03	2019	2022	
agricultural robots	2020	3.65	2020	2022	

Figure 6. Keywords with bursts within FF-UGM Scopus publications

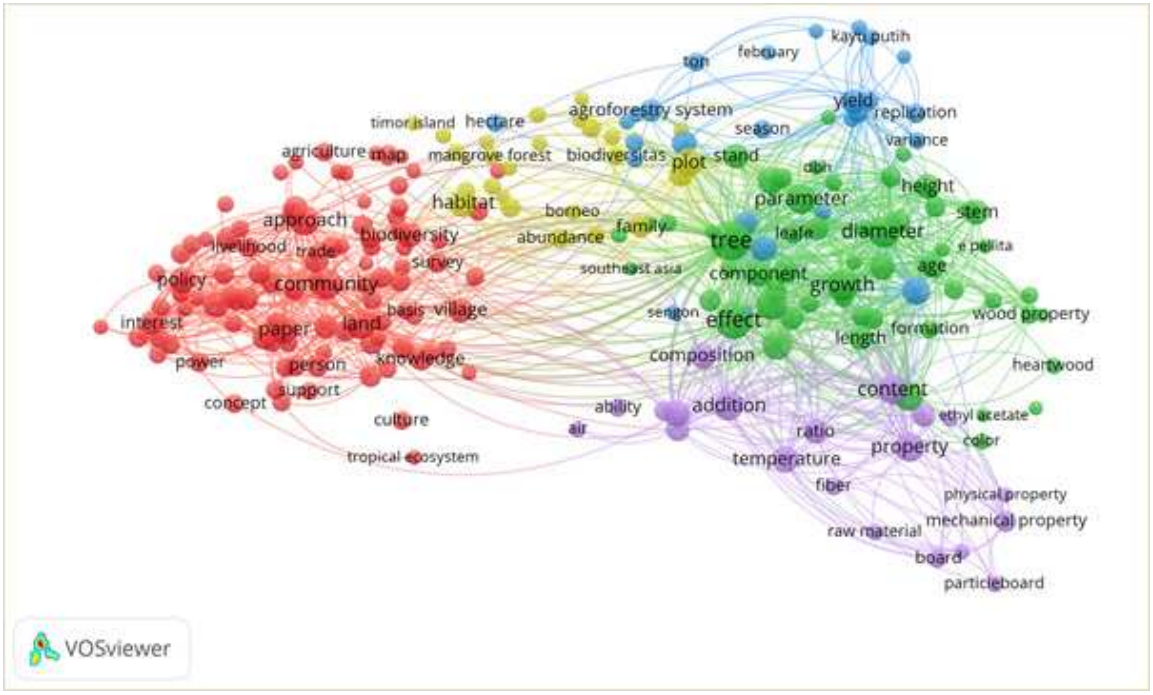

Figure 7. Visualization of the keywords' co-occurring clustering in FF-UGM research

B. Discussion

The research themes of FF-UGM naturally cut across the four departments of the faculty. The first and second clusters are associated with the Department of Forest Management of the FF-UGM. The first cluster under red color includes such words as "policy," "interest," "community," "land," "approach," "livelihood," "village," "power," "interview," "survey," "local community," "government," "farmer," "dynamic," "importance," and "challenge." The abovementioned terms comprise the most common questions and procedures that are frequently applied to the area of forest policy research which implies the set of guidelines and regulations according to which practices regarding the forest management are regulated. The establishment of the Research Center for Forest Policy and History Studies, known as "SEBIJAK Institute", is a response to the notable progress made in the field of forest policy and governance studies. This initiative is dedicated to the overall analysis of various subjects, including policy and power networks, governance, land tenure and access, community-based forest management, land use policy and politics, environmental justice, verification of legality, and sustainable forestry. Moreover, it is actively interested in developing new approaches that will improve the sphere of forest policy and governance studies.

The research center has conducted power network analysis of different stakeholders in forest management who include rural communities (Permadi et al., 2018), governmental agencies (Parera et al., 2022), and non-governmental organizations (Rahayu et al., 2023) within its activities; each has its own interests and viewpoints. Relative to land tenure and access, the research center has discovered a number of things that explain the low motivation of the local communities with the policy. These considerations provide an insight into particular barriers related to the approaches to access and the benefits that the local populations obtain due to the rights granted to them (Ragandhi et al., 2021). Additionally, researchers have noted that state institutions have a very important role to play in the forest tenure reform process (Rodd et al., 2022). They have also emphasized the need to develop appropriate land use policies

and politics to have sustainable forest resource management (Nurprabowo et al., 2021).

The second cluster, represented by the green color, includes the terms such as "tree," "parameters," "characteristics," "height," "density," "sample," and "site." Their usage can be mostly found in the analysis and description of the characteristics of forests, which are crucial in developing efficient forest management strategies (Harahap et al., 2022). The management of forests requires careful collection and analysis of information on various features of the forest ecosystem. This includes the overall and accurate acquisition of details of information about the tree species, forests density, age structure, biodiversity, soil structure, climatic factors and anthropic factors.

The Department of Forest Management has utilized many approaches, including field surveys, remote sensing technologies, such as satellite images (Musthofa et al., 2022), and ecological modeling (Wibowo et al., 2023), in order to assess forest resources. The obtained data is then analyzed extensively to be able to understand the multifaceted interrelationships of the forest ecosystems, identify trends, and project future changes over a given period (Budiadi et al., 2023). The interpretation of a large amount of data is conducted with the help of advanced analytical methods, such as Geographic Information Systems (GIS) and statistical modeling. These techniques enable forest managers to make well-informed decisions (Marhaento, 2022). Constant monitoring and analysis is more important to the adjustment of management techniques following shifting environment and other human activities and global trends. This will provide sustainable use and conservation of forest resources (Dimyati et al., 2023).

Furthermore, the Department conducted an investigation into community-based forest management by evaluating the outcomes of community forestry programs (Maryudi et al., 2012). Moreover, the department also looked into the aspect of community forestry in improving the livelihoods of local communities (Yokota et al., 2014). In addition, an extensive literature has been conducted to study and investigate the processes that influence the changes in forest biomass and carbon stock (Alam et al., 2022). In discussing the problem of climate change, one should focus on the potentially significant contribution of forests to the forest incentive systems such as REDD+ and the possibilities of stakeholders to participate in the process (Bong, Felker, & Maryudi, 2016).

These thematic clusters are indicative of the variety of research questions and methods required to study the management of forests and focus on the role of foreign actors specifically (Nanda et al., 2022). The network of interconnected concepts presented here supports the importance of the discussion on forest policy development and governance approaches.

The third cluster, depicted in the color purple includes terms like "wood," "raw material," "fiber," "mechanical properties," "board," and "physical properties." These phrases hold significant relevance within the Department of Forest Product Technology at FF-UGM, as they are geared towards furthering the careers of science and technology so as to handle and process the wood and non-timber forest products. The end product is to improve the livelihood of the entire humanity. The earlier research on this specific area has put a heavy emphasis on the examination of physical and mechanical characteristics of wood, in particular, regarding tension, strength, density, and elasticity (Ngadianto et al., 2020).

In addition, to alleviate the strain on wood resources, various non-timber forest products, including snake fruit fiber (Darmanto et al., 2017), bamboo (Marsoem et al., 2015), elephant dung fiber (Widyorini et al., 2018), and Kenaf Fiber-Epoxy (Setyayunita et al., 2022), have been investigated as potential alternatives to wood in the manufacturing of furniture. Moreover, the sphere of technology related to

the extraction and use of essential oils created by different species of forests also has been developed significantly (Umroni et al., 2021).

The fourth cluster, denoted in blue, encompasses terms like "plot," "cultivation," "soil," "experiment," "block," "replication," and "ton." The terms are widespread in terms of silviculture with the aim of scientific and technological advancement and the restoration of forests. This, on its part, helps to increase the productivity and benefits derived on the forest resources, which in the end benefits the welfare of the community. The study in the field of this specific issue involves a variety of factors related to the introduction of tree planting and ecosystem recovery (Nurjanto et al., 2023). Study of soil has paid attention to different issues including soil fertility, soil quality, soil properties, and how trees impact soil quality and composition (Sadono et al., 2021). Additionally, the occurrence of the terms "species kayu putih" and its corresponding scientific designation "*melaleuca cajuputi*" can be ascribed to the substantial research focus on this particular species conducted by the Department of Silviculture at FF-UGM (Suryanto et al., 2020). Several research investigates various agroforestry systems implemented throughout nations and emphasize their advantages and challenges of such systems to the sustainable forest management and the needs of the locals (Achmad et al., 2022).

The final cluster, represented in yellow, includes terms like "diversity," "composition," "habitat," "family," "abundance," "biodiversity," and "bird." The concepts mentioned above are often coupled with the Department of Biodiversity Conservation that is focused on scientific and technological advancement in the sphere of forest ecosystem conservation. The main goals of the department are preservation, protection, management and sustainable exploitation of forest resources with the purpose to provide their long-term sustainability as one of the main bases of life. These objectives align with the research priorities of the Forest Resource Conservation department at FF-UGM, as outlined by Poor et al. (2021). Research in the given area specifically puts the focus on the evaluation of the threat to biodiversity, such as logging and the expansion of agricultural land (Hemida et al., 2022) that have been known to cause habitat fragmentation. Moreover, academic research enlightened the importance of agroforestry (Ridho et al., 2023) in the preservation of biodiversity levels, and the essential role of the protected areas management (Meilani et al., 2019).

Limitations of the study

Although the given study provides an elaborate and in-depth analysis of trends and ideas, it is imperative to note that tendencies in the sector are subject to change and liable to significant changes in the future. Consequently, we anticipate variations in co-authorship and citation results, particularly as more recent articles are likely to accrue higher citation rates. It is reasonable to suppose that not all of the outstanding writers could be accurately missed by leading researchers when performing the citation analysis and research study. Additionally, it is important to note that this bibliometric study is limited to a single database Scopus. This will be used to enrich the future research efforts and to have a more holistic view of FF-UGM research patterns.

IV. CONCLUSION

In light of the foregoing discussion, it is clear that the Faculty of Forestry of Gadjah Mada University (FF-UGM) has significant strengths in a variety of key areas that lie within the scope of the forestry studies. It is important to note that, although the number of the outputs in terms of the number of publications and citations is promising given the recent trends, it is relatively small considering the amount of potential the university has in the roster of authors and talents. Furthermore, the selection of academic journals for publishing within research universities might provide insights into the influence of the conducted research. In

the specific setting, one can see that FF-UGM stands a considerable opportunity to raise the quality of its research activities and create a constituency within the worldly acknowledged and recognized academic journals. This will require a conscious effort in enhancing the standard of research which will culminate in a greater impact on publications. According to the burst analysis, it can be concluded that there are considerable possibilities to improve the research activities to increase the publication impact of FF-UGM. The quest to increase better research quality has a lot of potential in ensuring that FF-UGM would have more impact.

The implication of these findings has far reaching consequences in many fronts. To begin with, this research gives the researcher a comprehensive insight into the research patterns in the FF-UGM community, thus presenting workable advice to future research in this academic institution. In addition, the study extends to include viable implications of the study to most stakeholders. This assertion shows the importance of addressing the major issues and themes that emerge as pivotal factors towards attaining effective and sustainable forest management. Considering the findings expressed in this study, scholars and stakeholders could contribute immensely to the FF-UGM mission, not only with regard to enhancing knowledge, technology, and the management of tropical forest ecosystems.

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