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Bibliometric analysis of the impact of environmental degradation on women and the importance of women's representationY.A. Pratama¹, M.Y.A. Kadir^{1*}, A. Rivaldi¹, I.C. Mulya², S. Amirah³, M. Iqhrammullah⁴¹ Faculty of Law, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia² Department of Obstetrics and Gynaecology, Monash University, Melbourne, Victoria 3168, Australia³ Faculty of Medicine, Universitas Indonesia, Jakarta 40115, Indonesia⁴ Postgraduate Program of Public Health, Universitas Muhammadiyah Aceh, Banda Aceh 23123, Indonesia

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ABSTRACT

BACKGROUND AND OBJECTIVES: Climate change and pollution present severe threats to the environment and human well-being. Women are disproportionately affected by health challenges, including reproduction, cardiovascular, and neurological challenges. To address this issue, gender-inclusive environmental policies must be implemented. This aspect is particularly important with a setback observed in the environmental management regulations in Indonesia, where the government ratified the Omnibus Law on Job Creation, which removes the stringent licensing process for environmentally impactful activities. This situation highlights government negligence, emphasizing the urgent necessity for enhanced women's participation in the legislature. This study has two objectives. First, evidence of environmental impact on women's health is subject for evaluation. Second, this study aims to highlight the urgent need for increased women's participation in environmental policy-making and legislative processes.

METHODS: This study used bibliometric analysis, examining metadata from published literature indexed in the Scopus database. The search, conducted on 10 January 2024, utilized the keywords "Women" AND "Environment" and their synonyms, covering records from 1909 to 2024. Bibliometric analysis was conducted using Biblioshiny, with network and density visualization performed using VOSviewer. The participation of women in decision-making was analyzed based on their number of seats in Parliament and a literature survey. The selection of frequently occurring keywords and clusters of keyword co-occurrence was carried out independently by two independent reviewers.

FINDINGS: The bibliometric analysis included metadata from 3770 records, revealing an exponential increase in trends from 2000 to 2020. Keyword co-occurrence analysis identified eight research topic clusters focused on the environmental impact on women's health. Thereafter, the co-occurring keywords were utilized to trace the evolution of study themes, resulting in the identification of four main themes with well-established scientific evidence: (1) air pollution impact on pregnancy and its outcome, (2) pollution impact on women's hormones, (3) environmental impact in urban settings, and (4) heavy metal pollution. Indonesia has never achieved 30 percent women representation in Parliament, highlighting the unsatisfactory participation of women in legislative elections. The underrepresentation of women directly impacts the insufficient attention to their well-being throughout the policy-making.

CONCLUSION: The environment significantly influences women's health, potentially making the population markedly vulnerable owing to societal roles and hormonal factors. To address this issue, a crucial step is actively involving women in policy-making, particularly through a reserved seat concept in Parliament. This approach, applicable globally, acknowledges the widespread impact of environmental issues on women across countries.

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INTRODUCTION

The increasing presence of climate change and pollution poses growing threats to the environment and, consequently, to human well-being (Yang et al., 2023; Frimawaty et al., 2023). The recent COVID-19 pandemic provided an opportunity to experience clean air owing to widespread lockdowns and mobility restrictions. However, this situation came with the downside of an escalation in municipal and medical wastes, exacerbating environmental issues (Chiari et al., 2022; Otorin et al., 2022). Deterioration of the environment has been reported to affect multiple health conditions, such as the cardiovascular system (Mensah et al., 2023), genetic machinery (Ahmed et al., 2023), neurological fitness (Lee et al., 2023), and mental well-being (Cuijpers et al., 2023). Various social groups experience the detrimental impact of these factors differently, with women being more susceptible to disadvantages than men (Bai et al., 2020; Giorgis-Allemand et al., 2020). This situation is attributed to the fact that women have physiological systems that are more susceptible to external factors, including pregnancy and menstruation (Bai et al., 2020; Giorgis-Allemand et al., 2020). In the wake of many countries realizing the importance of environmental protection (Liang et al., 2022), Indonesia is seeing a drawback in its policy-making (Mahardika, 2021). Although the Indonesian government ratified the Omnibus Law on Job Creation to attract foreign investments, the consequence is that it lost its legal basis to impose a lawful stringent assessment on environmental impact derived from business (Mahardika, 2021). In the academic and environmental activist circles, the Omnibus Law has been subject to scrutiny, notably attributed to the paucity of prior scholarly investigations (Sulaiman, 2023). The enactment of the Omnibus Law, notwithstanding widespread societal opposition, unequivocally positions the government as being negligent to the community's well-being. Shortcomings in policy formulation can be primarily attributed to the consistent underrepresentation of women in the Indonesian legislature, perpetuated by marginalization and a patriarchal culture (Aspinall et al., 2021). Women, as crucial stakeholders, play a pivotal role in shaping comprehensive policies and legislation. However, the insufficient representation of women in Indonesia's legislative body hinders balanced discussions on environmental issues owing

to the limited number and also because elected individuals predominantly emerge from elite circles and fail to adequately represent women from marginalized communities (Aspinall et al., 2021). Accordingly, women's active participation must be ensured, especially given Indonesia's ratification of the Convention on the Elimination of All Forms of Discrimination Against Women (CEDAW). In this research, a bibliometric analysis was conducted to discern the extent to which evidence has been established regarding the impact of environmental degradation on women's health. Although previous studies have reported bibliometric findings on health impact (Dhital and Rupakheti, 2019; Kolsky et al., 2023; Sweileh, 2020), there exists a notable absence of a specific focus on women. The utilization of bibliometric data, coupled with an in-depth literature study, is poised to furnish robust evidence of the environmental repercussions on women's health. Subsequently, the findings of this study are used to urge increased women's participation in policy-making, particularly those pertinent to environmental management. Furthermore, this study analyzed women's participation in the legislature and provided a recommendation to improve their condition. If scientific evidence is found conclusively endorsing the severe impact of environmental degradation, in accordance with CEDAW, then the Indonesian government should ensure protection to this group, particularly by providing access to participate in policy-making. This study is the first to conduct a bibliometric analysis of the environmental impact on women's health and to discuss women's participatory roles in legislative processes. The objectives of this study are twofold. First, this study aimed to evaluate the establishment of scientific evidence of the environmental impact on women's health by means of bibliometric analysis. Second, the current study aimed to qualitatively analyze women's participation in environmental policy-making and propose a suitable recommendation. The study was carried out in Banda Aceh, Indonesia, by analyzing metadata and information from published literature in 2024.

MATERIALS AND METHODS

Study design

Bibliometric analysis was conducted to obtain the established and trending study on the impact of environmental degradation on women. Thereafter, in-

depth literature search was performed in accordance with the themes suggested by the bibliometric review (Sulphrey *et al.*, 2024). The effect of certain parameters was investigated through epidemiological studies, critical review of epidemiological studies, and/or systematic review. Only studies reporting evidence satisfying the Bradford Hill criteria will be used, as suggested previously (Nowinski *et al.*, 2022). Evidence would be flagged weak if not supported by epidemiological studies. Participation of women in decision-making was analyzed based on their number of seats in Parliament. Moreover, women's participation was analyzed through literature surveys. Given that the environmental issue is handled by the Commission IV of the Indonesian Parliament, the number of occupied seats by women in the commission was also observed.

Data collection

Metadata of published literature were retrieved from the Scopus database (Nouri, 2022) on 10 January 2024. The number of seats in Parliament occupied by women from 1950 to 2024 was collected from Indonesia's Central Agency of Statistics (BPS). The number of women occupying seats in the Commission IV was obtained from the Indonesian Parliament official website (Wahyudi *et al.*, 2023).

Search strategy

The publication records were identified on the Scopus database by using the following keyword combination: "TITLE ((women OR woman OR female* OR menopaus* OR pregnan* OR cervic*) AND (environment OR pollut* OR contaminat* OR contaminant* OR (endocrine AND disruptor*) OR (green AND space*) OR (heavy AND metal*) AND NOT (animal OR dolphins OR "in vitro")))." The keywords were used in the respective truncated forms of each word. AND and OR are the Boolean operators used to form the combination of keywords. The search was performed for records indexed from 1909 to 2024, when the earliest publication was checked to ensure relevance. The earliest publication year was determined by the year of the first relevant study published and indexed.

Bibliometric analysis

Bibliometric analysis was conducted on Biblioshiny package (an R studio package for bibliometric

analysis) run on R studio version 2023.12.0. The comma separated value (csv) file was uploaded to the software. The analysis was run for the keyword co-occurrence collaboration map and evolution of themes. The keyword co-occurrence analysis using network and density visualization was performed on VOSviewer version 1.6.19 (a software tool for constructing and visualizing bibliometric networks). The same csv file was uploaded to the desktop software, and visualization was constructed based on 11 minimum total link strength (TLS) of author keywords. TLS is calculated based on the number of publications where the two keywords are co-occurring together. On the basis of TLS, predominant keywords were selected and used to translate the theme of each cluster.

RESULTS AND DISCUSSION

Trends and collaboration patterns

A total of 3770 studies were included in the bibliometric analysis. The annual number of publications on themes related to environmental impact on women's health is presented in Fig. 1. The number of publications reached over 250 in the last three years (2021–2023). The exponential increase was observed within 2000–2020, suggesting that the themes receive considerable attention from the research community. The earliest publication on the correlation between environmental quality and women's health was first recorded in 1910.

The number of publications is relatively higher compared with other themes, such as pharmaceutical (Zulkifli *et al.*, 2023) or environmental (Iqhrammullah *et al.*, 2023a; Puspita *et al.*, 2022). Nonetheless, the number is not as high as the COVID-19 pandemic-related fields (Ginting *et al.*, 2023). Compared with monkeypox, the number of publication has never reached 50 documents annually since its first publication in 1962 until 2022, when the outbreak became an international public health concern (Sofyantoro *et al.*, 2022). In this present study, collaboration among researchers from different countries was well-established, as indicated by the red lines in the collaboration map (Fig. 2). Although the US produced relatively more related papers, researchers from other countries show similar productivity in this topic (Fig. 2). Unlike other research topics, the publication was mostly concentrated to certain countries (Ahmad and Chiari,

Women's representation in environmental management

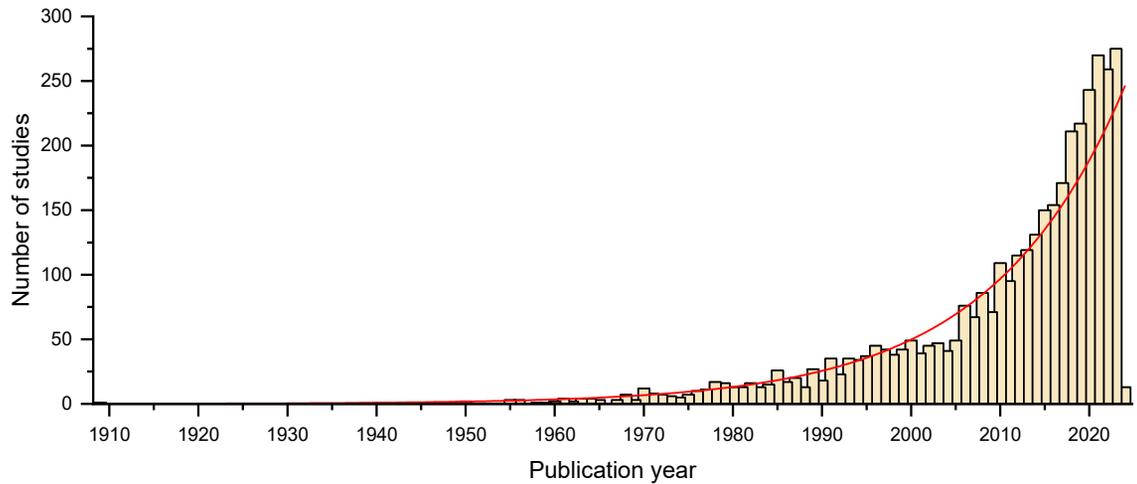


Fig. 1: Annual number of studies with themes related to environmental impact on women's health. Constructed in accordance with the suggestion of a previous study (Iqhrammullah *et al.*, 2023a)

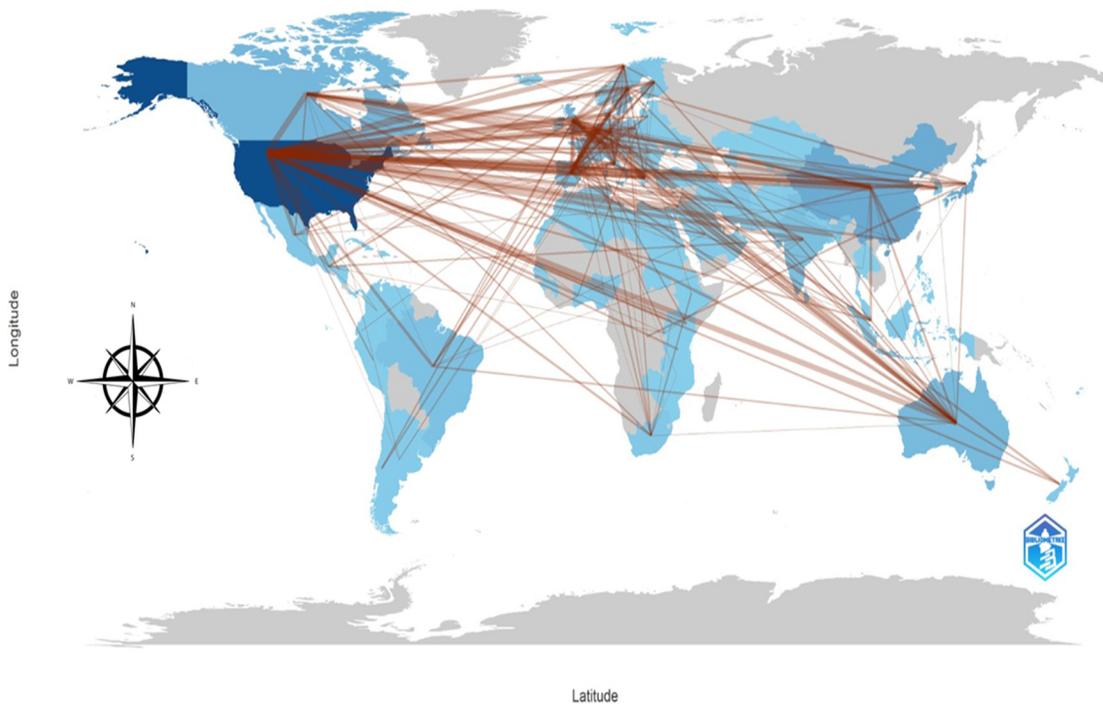


Fig. 2: Schematic diagram of the collaboration among countries in conducting research on the impact of environmental quality on women's health. Constructed based on bibliometric data from the Scopus database using Biblioshiny as suggested by a previous study (Ginting *et al.*, 2023)

2023; Ginting *et al.*, 2023). Findings from the present and previous studies suggest that articles with theme of environmental impact on women's health have been popularly published by many researchers and became one of the important topics. The reason

why the annual publication quantity is not as high as that of COVID-19 or monkeypox disease is that the problem has yet to emerge as an emergency topic. Conducting research on the topic would help avoid the problem progressing into a public health

emergency but accommodating policy-making is more critical (Maffei et al., 2020).

Clusters of the study themes

The network visualization of keywords co-occurrence could suggest how well a certain research topic has been established. The network visualization for the association of environmental quality and women’s health is presented in Fig. 3. The network visualization was constructed by removing the keywords, “women” and “women’s health.” The reason is that the analysis was evidently conducted to understand the impact on women’s health. Hence, the keywords’ presence would obscure the real network co-occurrence of the study themes. The keyword, “biomass” was removed because it is meaningless to the objective of the present study. The settings were also applied for density visualization, constructed to observe the most trending or popular keywords among scientific publications. The same strategy of this keyword selection has been used in previous studies (Ginting et al., 2023; Iqhrammullah et al., 2023b). The network visualization suggests the presence of eight research theme clusters indicated by different colors (Fig. 3a and Table 1). Cluster I is indicated by red, and the connected keywords suggest the research theme of “women reproduction and prenatal health.” Cluster II, indicated by blue and extremely close to Cluster I, belongs to the research theme “pregnancy outcome.” Among the keywords

in Cluster II, “pregnancy” and “air pollution” have the highest TLS of 408 and 379, respectively. This result is consistent with the keywords’ appearance in the density visualization, in which the keywords, “pregnancy” and “air pollution” were highlighted in yellow, indicating these were mostly used in the included scientific articles (Fig. 3a). For Cluster III, studies reported the impact of urban environment on health issues among women, including obesity (TLS: 35), depression (TLS: 28), menopause (TLS: 25), aging (TLS: 14), cardiovascular disease (TLS: 14), and mental health (TLS: 14). Clusters IV and V were represented by dark yellow and cyan, respectively. Although the two clusters had different connected keywords, the two can be categorized into the same research theme of “air pollutions and the consequences to biological systems.” Such air pollutants as particulate matters (TLS: 121), nitrogen oxide (TLS: 62), and carbon monoxide (TLS: 40) were observed among the co-occurring keywords. In Cluster IV, the study focuses on biological systems, such as inflammation (TLS: 32) and oxidative stress (TLS: 39). For Cluster V, the focus was on disease or health parameters, such as body mass index (TLS: 15), blood pressure (TLS: 42), hypertension (TLS: 37), and preeclampsia (TLS: 41). Environmental impact on women’s hormonal system is depicted in Cluster VI, as indicated by the color purple. The cluster consists of estradiol (TLS: 17), progesterone (TLS: 16), and cortisol (TLS: 15) hormones as co-occurring keywords. Two health

Table 1: Study theme clusters based on keyword co-occurrence from studies on the environmental impact on women’s health

Clusters (Color)	Number of keywords	Predominant keywords	Translated research themes
I (red)	30	Pregnant women, prenatal exposure, persistent organic pollutant, endocrine disruption, reproduction, and ovary	Women reproduction and prenatal health
II (blue)	21	Pregnancy, air pollution, fetal growth, birth weight, and still birth	Pregnancy outcome
III (green)	21	Environment, built environment, physical activity, obesity, depression, menopause, cardiovascular disease, mental health, and aging	Impact of urban environment on women’s health
IV (dark yellow)	11	Carbon monoxide, indoor air pollution, inflammation, nitrogen oxide, particulate matter, and oxidative stress	Air pollution and the consequences to biological systems and health
V (cyan)	8	Ambient air pollution, blood pressure, body mass index, hypertension, and preeclampsia	
VI (purple)	9	Cortisol, progesterone, estradiol, stress, and postpartum depression	Impact on hormones
VII (orange)	6	Heavy metals, arsenic, cadmium, lead, mercury, and placenta	Adverse effects of heavy metal pollution
VIII (brown)	1	Traffic	Traffic-induced pollution

conditions constitute the cluster: stress (TLS: 20) and postpartum depression (TLS: 15). Heavy metal contaminants are fatally toxic to humans, and those are found in Cluster VII. The heavy metals are arsenic (TLS: 33), cadmium (TLS: 109), lead (TLS: 90), and mercury (TLS: 86). The keyword, “placenta” (TLS: 33), is interestingly found in this cluster. Lastly, Cluster VII comprises only a single keyword: “traffic” (TLS: 29). The formation of Cluster VII in the co-occurring keyword network suggests that researchers have focused on the impact of pollutant produce by motor vehicles on women’s health.

Co-occurring keywords were further used to analyze the evolution of research themes, in which the results are presented in Fig. 4. Findings from this analysis corroborate those obtained in the network visualization of co-occurring keywords. The study themes are divided into four quadrants, namely, niche, motor, emerging or declining, and basic themes. Themes in the right-hand quadrants (motor and basic themes) are already well established, suggesting strong scientific evidence. Given that the aim of this study is to observe the establishment of scientific evidence, the observation is focused on the right-hand quadrants. In general, the five clusters in the right-hand quadrants can be simplified into four main themes: (1) air pollution impact on pregnancy and its outcome, (2) pollution impact on women’s hormones, (3) environmental impact in urban

settings, and (4) heavy metal pollution. The four themes will be discussed in the following sections.

Air pollution impact on pregnancy and its outcomes

The impact of air pollution on pregnancy and its outcomes are indicated by the bibliometric analysis to have been well-evidenced by scientific investigation. Pregnancy is an exclusive health condition to women, in which ensuring maternal and prenatal health is a critical parameter of prosperity. A meta-analysis of 33 cohorts revealed that particulate matters are strongly associated with gestational hypertension and preeclampsia (Bai *et al.*, 2020). The risk of developing hypertension during pregnancy is also found to be significantly increased by exposure to particulate matters (Bai *et al.*, 2020). Exposure to particulate air pollution during pregnancy has been witnessed to affect birth weight and neonatal health (Steinle *et al.*, 2020). A study used a spatial approach and revealed the detrimental impact of air pollution on pregnancy outcomes (Luo *et al.*, 2021). The study reported that nitrogen dioxide exposure could significantly reduce fetal growth and development (Luo *et al.*, 2021). Particulate matter is found to be associated with reduced birth weight (Luo *et al.*, 2021). Furthermore, early air particulate exposure during pregnancy determines the prenatal risk of development stunting, which is simultaneously against the Indonesian national stunting prevention program as planned in

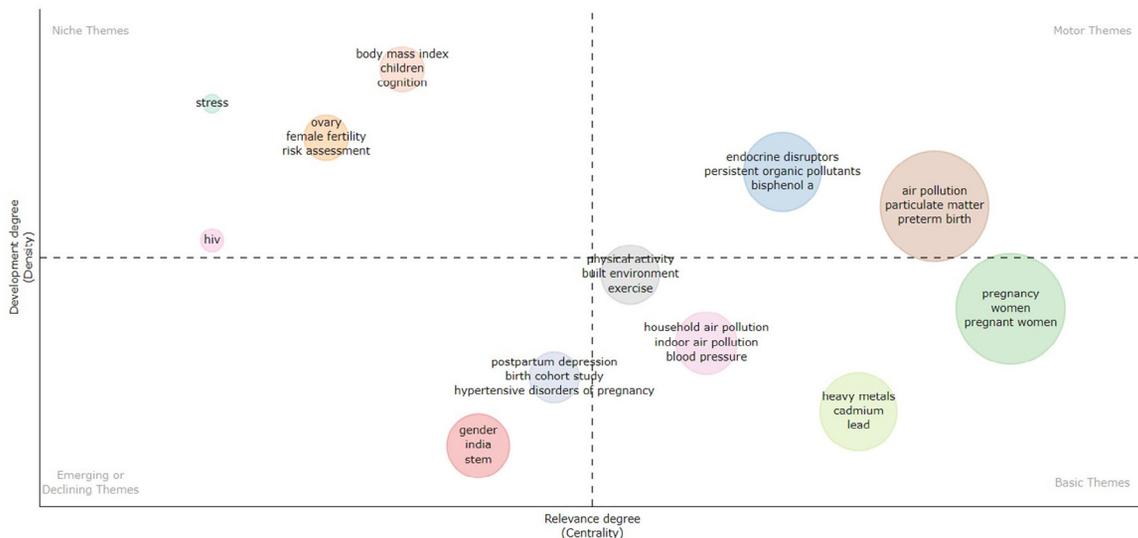


Fig. 4: Evolution of the research themes of environmental impact on women’s health based on the four quadrants. Constructed based on bibliometric data from the Scopus database using Biblioshiny, as suggested by a previous study (Ginting *et al.*, 2023)

the Indonesian National Medium-term Development Plan 2020–2024 (Pun *et al.*, 2021).

Pollution impact on women's hormones

Hormonal system imbalance among women is one of the research topics widely published according to the bibliometric herein. A study found that exposure to particulate matter during the early stage of pregnancy could elevate plasma progesterone level (Colicino *et al.*, 2022). A meta-analysis suggests that particulate matter and carbon dioxide are associated with shortened women's luteal phase, which is detrimental in optimizing oocyte quality (Merklinger-Gruchala *et al.*, 2017). Exposures to particulate matter and nitrogen dioxide are found to be associated with the alteration of menstrual cycle, especially the follicular phase (Giorgis-Allemand *et al.*, 2020). Pollution-induced menstrual cycle alteration is said to be characterized by dysregulation of the cortisol or other stress-related hormones (Giorgis-Allemand *et al.*, 2020). Air pollution is also responsible for the dysregulation of steroid hormones, such as 17 α -hydroxypregnenolone and androsterone, observed during the prenatal stages (Plusquin *et al.*, 2023). Pregnant women exposed to polycyclic aromatic hydrocarbon (combustion by-product pollutant) may experience dysregulations

of corticotrophin-releasing hormone, estriol, progesterone, and testosterone (Plusquin *et al.*, 2023). The reported findings underscore pollution's impact on the hormonal system, mainly women's reproductive hormones.

Environmental impact in urban settings

People living in urban areas are at risk of being exposed to air pollution owing to the high production of particulate matters from traffic and other intense anthropogenic activities (Liang and Gong, 2020). Studies have suggested that the presence of pollutants in urban areas could affect the health of women. For example, long-term exposure to nitrogen dioxide is found to be associated with cardiovascular health issues among women (Hart *et al.*, 2021). The incidence of atrial fibrillation is considerably prevalent among women living near roadways (Hart *et al.*, 2021). Higher risk of gaining preterm birth is found among those living in urban areas compared with those living in rural areas, where the condition is associated with exposure to particulate matters (Li *et al.*, 2020). Toxicity of air pollution also causes disruption to renal functions among women living in urban areas in China (Wang *et al.*, 2020). The situation is worrisome because most women living in urban areas are unaware of health risks caused by

Table 2: Health issues among women associated with poor environmental quality

Health issues	Etiology	Sources
Gestational hypertension	Particulate matter 10, Particulate matter 2.5	Bai <i>et al.</i> , 2020
Gestational diabetes mellitus	Sulfur dioxide	Bai <i>et al.</i> , 2020
Preeclampsia	Particulate matter 2.5	Bai <i>et al.</i> , 2020
Poor birth outcomes*	Particulate matter, nitrogen dioxide	Steinle <i>et al.</i> , 2020; Pun <i>et al.</i> , 2021
Reduced fetal growth	Nitrogen dioxide, particulate matter 2.5	Luo <i>et al.</i> , 2021
Hormones dysregulation	Particulate matter 2.5	Colicino <i>et al.</i> , 2022; Giorgis-Allemand <i>et al.</i> , 2020; Plusquin <i>et al.</i> , 2023; Plusquin <i>et al.</i> , 2023
Dysrupted menstrual cycle	Particulate matter 2.5, nitrogen dioxide	Giorgis-Allemand <i>et al.</i> , 2020; Merklinger-Gruchala <i>et al.</i> , 2017
Mental health issues	Particulate matter 2.5	Giorgis-Allemand <i>et al.</i> , 2020
Cardiovascular health	Particulate matter	Hart <i>et al.</i> , 2021
Dysrupted organ function	Air pollutants	Wang <i>et al.</i> , 2020; Pun <i>et al.</i> , 2021
Type 2 diabetes mellitus	Arsenic, cobalt, beryllium, chrome, copper, mercury, manganese, nickel, lead, zinc	Hendryx <i>et al.</i> , 2021
Reproduction problems	Cadmium, lead	Dutta <i>et al.</i> , 2022
Stillbirth	Cadmium, lead	Ren <i>et al.</i> , 2023
Nervous system and cognitive impairment	Cadmium, lead, mercury; Manganese, arsenic	Bauer <i>et al.</i> , 2020; Ruczaj and Brzóška, 2022

*As indicated by low birth weight and early neonatal health status

pollution, making individuals significantly vulnerable (Yang, 2020). As evidence has emerged on the effect of urban environment on women's health, public policies should be specifically formulated to address this issue to realize sustainable urban development.

Heavy metal pollution

Heavy metal contamination of drinking water and food supplies have been witnessed, especially among low-middle income countries (Ahmad *et al.*, 2022; Nisah, 2022; Samimi and Nouri, 2023; Samimi, 2024). Among women, exposure to various heavy metals could increase the risk of developing type 2 diabetes mellitus (Hendryx *et al.*, 2021). Such heavy metals as cadmium and lead are also responsible for women's deteriorating reproductive health, including infertility (Dutta *et al.*, 2022). A cross-sectional study in Malaysia revealed that bioaccumulation of arsenic, mercury, and cadmium in seafood consumed by women in the area poses risk for cancer development (Jeevanaraj *et al.*, 2020). A laboratory experiment indicated that arsenic exposure could induce oxidative stress and chronic inflammation in the uterus of female rats (Irnawati *et al.*, 2023). Bioaccumulation of arsenic in women has been recorded, suggested by the presence of high concentration of metal in the hair and thought to be translocated by the surrounding arsenic-contaminated geothermal manifestations (Irnawati *et al.*, 2021). However, studies on the arsenic exposure to uterus health are limited to laboratory experiments (Irnawati *et al.*, 2023). Overall, environmental issues and women's health are strongly correlated because scientific evidence suggests that exposure to various contaminants could lead to the degradation of women's health. High concentrations of circulating lead or cadmium are associated with intrauterine fetal death, which is thought to involve hormonal dysregulation, insulin resistance, and hypovitaminosis (Ren *et al.*, 2023). In critical reviews of epidemiological studies, consistent scientific evidence suggests that women's nervous system is impaired when exposed to heavy metal pollutants (Bauer *et al.*, 2020; Ruczaj and Brzóška, 2022). A summary of women's health issues associated with environmental degradation is presented in Table 3.

Environmental policies and law in Indonesia

The impact of environmental degradation is

significant, particularly to women, urging the passage of laws that could promote the protection of this particular group as mandated by CEDAW. Given that Indonesia ratified the convention, the government should set policies and laws that could promote environmental protection as a mutually shared interest of society. In Indonesia, the legal basis for environmental management is based on the environmental management and protection law (UUPPLH). UUPPLH was once used as a legal guideline to perform the environmental impact assessment (EIA) covering the examination and analysis of environmental qualities caused by building construction, land clearing, industrial activities, or other human activities (Mahardika, 2021). The assessment was conducted to provide government licensure for entities conducting activities that can potentially impact the environment (Mahardika, 2021). The EIA document serves an environmental management function, including EIA, preventing pollution, environmental damage, and excessive exploitation of natural resources (Zahroh and Najicha, 2022). EIA also serves as an instrument for controlling the environmental impact of the plans of activities and projects on a project site scale (Tarigan, 2023). Since the approval of the Omnibus Law on Job Creation as a presidential decree, the assessment that requires obtaining the licensure has been significantly modified. First, Article 23, Paragraph 1 of the Omnibus Law states that EIA acts as the consideration factor and no longer acts as a requirement as previously provisioned in UUPPLH. Second, Article 26 of the Omnibus Law states that community participation will be adjusted according to government regulation. However, no specific regulation is referred to in the article and no government regulation has been formulated specifically accommodating the provision. Therefore, community participation is no longer mandatory in the absence of a government regulation. Third, criminal sanctions were imposed as a *primum remedium* for violating the UUPPLH licensure process, but administrative sanctions would be imposed instead through the Omnibus Law. Changes in the Omnibus Law were proposed as a means to simplify the licensure process, although eliminating the EIA requirement contradicts the goal of sustainable development. Environmental protection regulations have experienced a decline in the past decade and are contrary to the principles of

Table 3: Proportions of women and men in the Indonesian House of Representatives, 1955–2019 (Naqiyyah, 2021)

Periods	Women	Men
1950–1955*	9 (3.8%)	236 (96.2%)
1955–1960*	17 (6.3%)	272 (93.7%)
1956–1959*	25 (5.1%)	488 (94.9%)
1971–1977	36 (7.8%)	460 (92.2%)
1977–1982	29 (6.3%)	460 (93.7%)
1982–1987	39 (8.5%)	460 (91.5%)
1987–1992	65 (13%)	435 (87%)
1992–1997	62 (12.5%)	438 (87.5%)
1997–1999	54 (10.8%)	446 (89.2%)
1999–2004	46 (9%)	454 (91%)
2004–2009	65 (11.6%)	435 (87%)
2009–2014	101 (18%)	459 (82%)
2014–2019	97 (17.3%)	463 (82.7%)
2019–2024	118 (20.5%)	457 (79.5%)

*The representative members were not elected through public election.

anticipatory governance, contributing to Indonesia’s vulnerability to environmental degradation (Muiderman *et al.*, 2020).

Women’s participation in Indonesian policy-making

As scientific evidence suggests that women suffer from the appalling impact of environmental degradation, their participation in formulating environmental management regulations is imperative. Unfortunately, women’s participation in legislative elections is still far from being satisfactory. According to General Election Commission data, women’s representation, as indicated by the number of occupied seats in the People’s Consultative Assembly of Indonesia, is still far from achieving the 30% percent (%) minimum quota, which has been achieved since the first general elections in 2004. Moreover, the BPS report in 2022 indicated that women occupied only 17.3% of the total House of Representatives seats in the 2014–2019 election period (Naqiyyah, 2021). The number increased significantly in 2019–2024, when women occupied 20.5% of the total seats (Naqiyyah, 2021). Nonetheless, achieving the 30% minimum quota for women persists as a challenge (Table 3). Environmental management policies are discussed in the Commission IV of the Consultative Assembly (Wahyudi *et al.*, 2023). The number of women representation is also low in the commission at only 23% of the total seats (12 out of 53 seats) (Wahyudi *et al.*, 2023). Underrepresentation of women in policy-making, especially in the legislative body, is limited by the low number of occupied seats and also various sociocultural aspects. Multiple studies

have suggested that women’s participation in the legislature is challenged by the existing patriarchal culture (Aspinall *et al.*, 2021). Opinions raised by women representative in Parliament, particularly policy-making, are often disregarded (Purwanti and Setiawan, 2020; Siahaan *et al.* 2024). In the society level, trust on women in engaging in “serious” issues, such as social welfare, budgeting and funding, and national defense, is low (Aspinall *et al.*, 2021; Siahaan *et al.* 2024). Collectively, social conditions only allow individuals with elite backgrounds to participate in political exercises and be entrusted with seats in Parliament (Aspinall *et al.*, 2021; Purwanti and Setiawan, 2020). The impact of environmental degradation, similar to many other issues, is more severe among the marginalized groups, including indigenous people and those living in poverty (Csevár, 2021). Representation from the marginalized group is essential to balance the discussion to realize comprehensive policies and laws formulation. Therefore, the lack of women’s participation in Indonesia’s policy-making process must be addressed.

Impact of low women representation

The underrepresentation of women in Parliament has significant consequences in terms of neglecting the specific needs and issues relevant to women in policy-making. When the number of women in legislative bodies is low, women’s voices reflecting diverse experiences and needs tend to be marginalized (Mahardika, 2021). With low women representation in Parliament, there is a risk of imbalance in discussions and decision-making

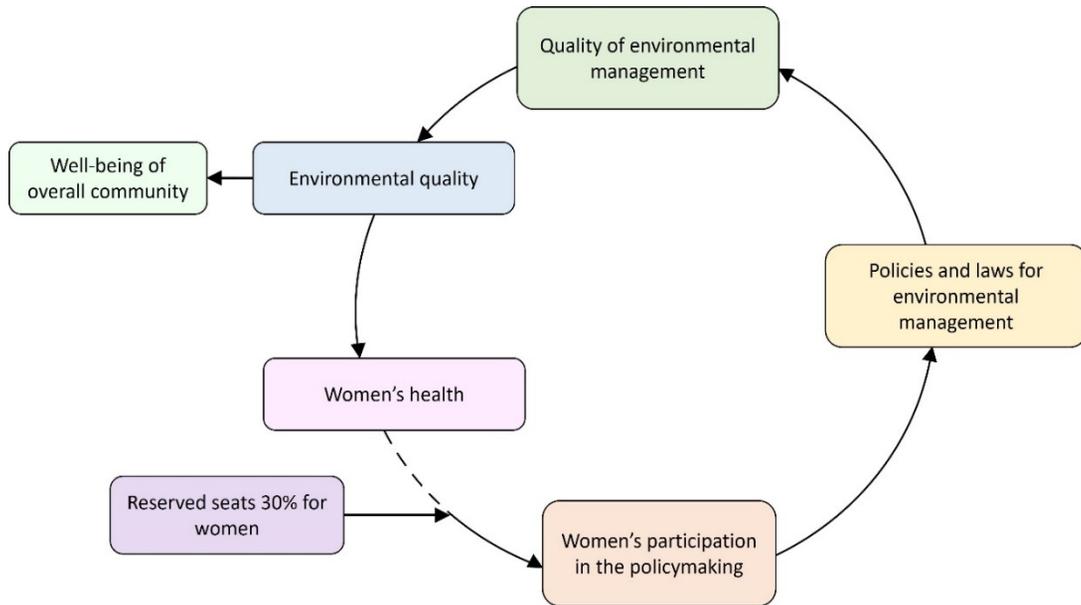


Fig. 5: Conceptual framework of environmental impact on the overall well-being of communities and women. Increasing women's participation in policy-making through the 30% reserved seats in Parliamnet could affect environmental management and consequently its quality. Given that the effects is significant on women, the importance of their representation and participation in policy-making is highlighted. However, the reserved seats are required, given the realization that equal participation for women in policy-making is nearly possible (indicated by the dashed line)

(Purwanti and Setiawan, 2020). Moreover, insufficient representation of women can result in lack of focus on gender policies. Such issues as reproductive health, gender-based violence, and equal employment may not receive sufficient consideration in policy formulation owing to the limited perspectives and experiences of women in Parliament (Mahardika, 2021; Purwanti and Setiawan, 2020). As evidenced by the bibliometric herein environmental impacts revolved around women reproduction and maternal health which are specific for women. In the case of underrepresentation, there is a change these issues received minimum considerations. Furthermore, low representation has been suggested to possibly lead to insufficient protection of women's rights. Protection of women's right is important, especially in the face of climate change because women often pay the price and receive violent treatment for the household economic decline as a consequence of environmental degradation (Csevár, 2021).

Recommendation for women's underrepresentation

Given that the discussion on women's health related to environmental degradation is crucial

in policy-making, Indonesia should ensure their participation in the legislature. Therefore, reserving seats for women in Parliament is recommended to ensure fair and inclusive representation. Allocation of a specific percentage of seats for women (e.g., 30% of the total Parliament seats) may ensure that women's voices and issues will become an integral component of the decision-making process. This recommendation is crucial, given that the discussion of the Omnibus Law has been disadvantageous for women (Mahardika, 2021). The diversity of perspectives brought by women in Parliament reflects justice and also ensures that the needs and challenges faced by half the population receive sufficient attention. With reserved seats, a platform to address various issues, such as reproductive health, gender equality, the environment, education, and women's employment, can be provided (Mahardika, 2021; Purwanti and Setiawan, 2020). This step could be considered encouraging for women's participation in politics and addressing the gender representation imbalance. Thus, reserved seats in Parliament establish a more representative government and also strengthen a more inclusive and equal

society (Arora, 2022). Ultimately, concerns about diseases afflicting women caused by an unfavorable environment can be addressed, which would benefit them and also future generations (Matloob et al., 2021). A conceptual framework illustrating how the introduction of reserved seats for women could lead to the development of comprehensive policies and, consequently, enhance overall well-being is presented in Fig. 5. In the implementation stage, the minimum 30% seats in Parliament will be reserved for women who received the highest votes in public elections. Complementary activities to achieve include encouraging political parties to empower women candidates. Moreover, educational programs on politics could be implemented by the government to increase women's capacities as politicians and policy makers. The inclusion of women in legislative bodies has been shown to enhance the likelihood of environmental issues receiving legislative support, surpassing that of men representatives (Ramstetter and Habersack, 2019). Nevertheless, a mere numerical increase does not guarantee substantive representativeness (Hillman, 2017). Facilitating the participation of knowledgeable and skilled women from underprivileged groups may serve as the fundamental basis for achieving substantive representativeness (Hillman, 2017). In the worst-case scenario, reserved seats for women representation in the legislature, at the very least, provide a platform for this demographic to discuss pertinent issues.

Strengths and limitations

This study is the first to analyze the scientific evidence of the environmental impact on women's health by means of bibliometric analysis. The method is advantageous in observing research trends, especially when publication records reach the hundreds or thousands. In this research, 3770 studies are relevant to the consequences of environmental degradation on women's health. However, bibliometric analysis data could be biased by the presence of unwanted studies included in the analysis, often regarded as "noise" (Ginting et al., 2023). Nonetheless, the large quantity of included studies could overcome the noise effect. In addition, this study is the first to elaborate the role of women's representation in Parliament, which is worthy of consideration when discussing environmental issues. Unfortunately, representation and participation of women in policy-making were

merely assessed using the gender proportion of Parliament seats. Future research should conduct in-depth interviews on women occupying seats in Parliament or those who pursue careers in politics.

CONCLUSION

Findings of this study suggest that scientific evidence of the detrimental impact of environmental degradation on women's health has been well-established. The quality of the environment critically determines the overall well-being of communities, but the effects on women are more significant. Some negative environmental impact involve air, water, and soil pollutions, as well as exposure to hazardous chemicals. Exposure to an unhealthy environment can increase the risk of various diseases among women, including but not limited to cardiovascular impairment, neurodegenerative diseases, and mental health problems. Women exhibit heightened susceptibility to environmental impact, which is a predisposition attributed to familial and societal roles, particularly involving responsibilities for child welfare. In addition, hormonal influences further exacerbate the effects of environmental exposure on women. Women's reproductive system is mostly susceptible to poor environmental conditions and toxic contaminants, as indicated by the increased risk of unwanted pregnancy outcomes, pregnancy complications, and alteration of menstrual period. Undoubtedly, these diseases have an impact on the development of future generations, thereby necessitating strategic steps to address these issues. Despite scientific evidence suggesting the importance of maintaining a clean and protected environment, laws in Indonesia have caused setbacks in conservation effort. This situation is precipitated by the underrepresentation of women, who are crucial stakeholders in the policy-making process. In this study, the lack of women's representation is at least indicated by the low number of seats in the legislative body. Furthermore, access to political activities and Parliament seats is restricted to specific privileged groups, thereby worsening the issue of inadequate representation. One measure that can be pursued is the active involvement of women in policy-making, particularly by directly engaging Parliament members through the implementation of reserved seats for women. This initiative seeks to augment women's representation in advocating for all rights and needs

specific to women and can be incorporated into any country's regulations, especially in Indonesia. Without such measures, regulations prioritizing women's interests may prove challenging to enact, given the predominant male influence. Conversely, with elevated women's representation, regulations are likely to increasingly address women's needs, particularly issues related to environmental management. Hence, the reserved seats strategy is applicable in Indonesia also other countries, given the global impact on women of environmental issues. The intersection of environmental concerns and women's well-being is a global concern, necessitating heightened awareness in every country to ensure adequate attention to their representation and engagement in parliamentary policy-making. Indirectly, this measure serves as a manifestation of fostering a superior and healthy next generation, while mitigating gender discrimination, particularly among vulnerable groups, such as women.

AUTHOR CONTRIBUTIONS

M.Y.A. Kadir, the corresponding author, contributed in supervising study and manuscript preparation. Y.A. Pratama performed the investigation and original draft preparation. A. Rivaldi contributed in revising the manuscript and performed validation on the analysis. I.C. Mulya contributed in revising the manuscript and performed validation on the analysis. S. Amirah contributed in revising the manuscript and performed validation on the analysis. M. Iqhrammullah contributed in conceptualization, methodology, and revising the manuscript. All authors have read and agreed to the final version of the submitted manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission,

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ABBREVIATIONS

%	Percent
<i>Biblioshiny</i>	An R studio package for bibliometric analysis
<i>BPS</i>	Central Agency of Statistics
<i>CEDAW</i>	Convention on the Elimination of All Forms of Discrimination Against Women
<i>CSV</i>	Comma separated value
<i>Fig.</i>	Figure
<i>EIA</i>	Environmental impact assesment
<i>TLS</i>	Total link strength
<i>UUPPLH</i>	Environmental Management and Protection Law
<i>VOSviewer</i>	A software tool for constructing and visualizing bibliometric networks

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