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Social Rural Energy, Solar Energy, and Sustainable Rural Research Trends in Asia and Indonesia

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Abstract

Electricity is a vital energy source required by both commercial and non-commercial entities. Global progress towards achieving sustainable energy goals remains insufficient in terms of pace. An examination of titles within reputable international publication databases such as SCOPUS.COM indicates a substantial rise in research focused on social rural sustainability since the year 2000. Despite

the increasing recognition of research and publications worldwide, there are currently no researchers from Indonesia contributing to these endeavours. Indonesia's contribution to social rural sustainable research is relatively limited in comparison to other Asian countries, including India, China, Japan, and Iran, which have larger rural populations. Indonesia's universities, namely Brawijaya University, Universitas Sebelas Maret, Universitas Jenderal Soedirman, and Universitas Islam Negeri Syarif Hidayatullah Jakarta, make significant contributions to social, rural, and sustainable research. However, it is worth noting that despite the growth of research on social rural energy since 1982, there has been no contribution from researchers in Indonesia. Similarly, research on social solar energy has been expanding since 1970, but there is still no involvement from Indonesian researchers. Indonesia should prioritise increased support for research on social solar energy and research on social rural energy in order to effectively progress towards sustainable energy objectives.

Keywords: Solar energy, rural development, social rural energy, Review, Indonesia,

Introduction

Energy serves as the fundamental catalyst for life and all biological activities on Earth. The evolution of energy systems throughout history can be traced to the discovery of fire, enabling humans to capture and control diverse energy sources. The implementation of new technological systems is necessary for enhancing control over daily life and improving overall comfort (Ould Amrouche et al., 2016). Procuring energy poses challenges owing to the scarcity of energy sources and the soaring demand for fuel. Nevertheless, the utilization of energy sources adversely affects the environment. Renewable energy emerges as a potential remedy to this issue, with its importance heightened by the escalating fuel prices (Tripathi et al., 2016), posing a global environmental hazard.

The utilisation and availability of clean energy are significant challenges that should be acknowledged. Approximately 2 billion individuals worldwide rely on conventional sources of energy. However, it is worth noting that over 1 billion individuals lack access to clean energy (Akinbami et al., 2021). Therefore, prioritizing universal access to modern energy sources holds paramount importance. Numerous environmentally sustainable and renewable energy alternatives, including hydro, wind, and solar energy, are available. These sources play a crucial role in providing user-friendly energy solutions for rural and remote areas. These regions are currently experiencing electricity-related challenges, which are causing significant hardships for the residents residing in these

areas. The provision of electricity is recognized as an essential human right (Akinbami et al., 2021). Previous research has consistently demonstrated a substantial association between human development and the availability of resources.

Ensuring universal access to electricity is crucial for economic development. The provision of electricity in rural areas offers several advantages, such as reducing carbon dioxide emissions, providing access to heat and light, enabling the use of electricity for cooking, and addressing health concerns (Akinbami et al., 2021; Strielkowski et al., 2021). Scholars have proposed that the improvement of health and education conditions is contingent upon the provision of an adequate energy supply. In rural areas, particularly within the health and education sectors, individuals rely on candles and oil for lighting purposes.

Research has indicated that the utilisation of oil for the purpose of lighting can contribute to environmental pollution. It also has a propensity to generate various mental disorders among the general population. Both adults and children can be at risk of fatality. Students in rural areas face challenges in studying at night due to the lack of available energy resources beyond evening hours. The government's allocation of energy-related resources in rural areas is anticipated to significantly boost student performance. The socioeconomic conditions of rural populations will experience improvement (Saif-Ur-Rehman et al., 2017).

Globally, the energy sector is shifting from fossil fuels to renewables, primarily motivated by climate change (Kabeyi & Olanrewaju, 2022). Abnormal weather patterns affecting the global population stem from human activities, including the emission of greenhouse gases from vehicle and factory combustion of fossil fuel. These gases are released into the atmosphere. Climate change may potentially necessitate the relocation of rural populations due to anticipated increases in temperature and the occurrence of flooding.

The use of fossil fuels not only poses detrimental effects on the surrounding environment but also has adverse impacts on human health. Based on projections, the global population is expected to witness a growth of approximately 2 billion individuals, reaching a total of 10 billion by the year 2057. An anticipated rise in the global demand for all fossil fuels in the coming years, as highlighted by Ramakrishna (2021), underscores the pressing need for additional energy resources. These resources are deemed essential in addressing

urbanization challenges and supporting the transition of individuals from rural to urban areas by providing essential energy-related amenities (Natividad & Benalcazar, 2023).

Electricity is a crucial form of energy that is essential for the operations of both commercial and non-commercial entities. Numerous industries rely heavily on the uninterrupted provision of electrical energy. The sectors include transportation (airport, harbour, and train station), agriculture (food crops, horticulture, and crops), livestock, forestry, and fishery. The unreliable electricity supply motivates individuals to fulfil their energy requirements by generating their own electricity through the utilisation of personal power plants (Petrović-Ranđelović et al., 2020). To facilitate progress in various energy-consuming sectors, such as households, transportation, industries, commerce, and agriculture, it is crucial to ensure a harmonious and sustainable balance between energy demand and the availability of energy resources. The analysis of energy supply and demand is crucial in determining the contribution of each energy source to various activities. Therefore, it is essential to prioritise the availability of energy sources (Al-Hamamre et al., 2017).

Countries worldwide are actively working towards achieving the goal of sustainable energy. However, the pace of this advancement is insufficient. If the current rate of growth for organisations persists, over 600 million individuals will remain without access to modern electricity (Kumar. J & Majid, 2020). However, it is projected that by 2030, over two billion individuals worldwide will continue to rely on fossil fuels as their primary source of energy. Renewable energy sources have the capacity to meet 30% of the electricity demand. Nevertheless, a notable challenge resides in the integration of renewable energy sources into the transportation and heating sectors (Aghahosseini et al., 2018). In developing countries, renewable energy sources are undergoing an annual growth rate of 10%. However, the extent of their utilization remains substantial. Global investment inflows into green energy have decreased, emphasizing the imperative to boost investments in renewable energy and expedite electrification to meet the projected energy demand by 2030 (Aghahosseini et al., 2018).

The adoption of renewable energy sources in the electrical sector is experiencing substantial growth, yet its application in the transportation and healthcare industries remains limited. As of 2020, global utilization of renewable energy represented around

19% of total energy consumption, indicating a roughly 2% increase over the past five years. Notably, there has been a 16% rise in the utilization of renewable energy according to the assessment by Holechek et al. (2022), and the 2020 report. Conventional utilization of these resources is estimated to be approximately one-third.

However, the growth rate of modern renewable resources is currently sluggish. The utilisation of modern renewable sources has increased by approximately 2.5% over a five-year period from 2015 to 2020, resulting in a rise from 10% to 12.5%. Nevertheless, there has been marginal progress in both the heating and transportation sectors during the preceding decade. The demand for renewable energy has exceeded its supply, highlighting the imperative for sustained policy momentum to fulfill global sustainable energy requirements (Le & Sarkodie, 2020). Energy conservation is necessary across all sectors and requires mobilising people and raising awareness to encourage increased investment in this area. The allocation of this investment is specifically required in developing nations (Gabriel, 2016).

The population residing in Indonesia is currently confronted with significant challenges pertaining to health and unemployment. Big cities such as Jakarta are currently grappling with health and unemployment challenges. Health-related institutions require energy to provide support to individuals who unable to afford healthcare facilities face challenges. In Indonesia, rural communities are resorting to the use of diesel-powered generators to fulfil their energy requirements (Wahyuni, 2022). The use of diesel fuel is associated with significant environmental pollution, posing substantial risks to human health and the ecosystem. One potential solution that has been mentioned in limited studies is the implementation of decentralised renewable energy systems. These systems are designed to offer accessible electricity to remote areas. Decentralized renewable energy stands as a sustainable, cost-efficient, and environmentally friendly energy source (Torra, 2019). It is also in line with the renewable energy source utilisation vision of Indonesia 2025 (Reyseliani & Purwanto, 2021). Some studies have recommended using centralised energy sources, as it is very challenging to use decentralised energy sources in rural areas of Indonesia.

Several studies have examined the utilisation of energy sources in rural regions of Indonesia. The non-commercial energy consumption in Indonesia is significantly

elevated (Cahyani et al., 2022). There is an escalating emphasis on advocating the adoption of alternative energy sources to address the rising energy demands of individuals. The principal goal of this initiative is to diminish people's dependence on petroleum-related products. To effectively address the energy needs of rural areas, it is crucial to thoroughly analyse and comprehend the specific challenges faced by communities in various rural regions (Rahman et al., 2021). The mitigation of water and forest damage can be achieved through the implementation of various pilot projects, such as utilising agricultural waste and dung as alternative energy sources. One viable option for utilising alternative energy sources is biogas energy. However, there exist economic limitations that hinder its widespread adoption (Omer, 2017). The aim of this study is to perform a literature analysis focusing on Social Rural Energy, Solar Energy, and Sustainable Rural Development within the distinct context of Indonesia and Asia.

Literature Review

Solar Energy and Intensity of Global primary energy

In literature, global primary energy is defined as the ratio of Gross Domestic Product (GDP) in terms of energy supply to total energy consumption, reflecting the relationship between total energy consumption and economic productivity. The global consumption of energy has been experiencing a significant and rapid increase since 2022 (Ahmad & Zhang, 2020). However, it is crucial to note that there is a requirement for an annual increase of 3.4% in energy resources to fulfil the growing energy demand.

Solar energy is widely acknowledged as a substantial and essential source of clean energy. Biomass is considered a significant sustainable energy source for generating electricity without contributing to global warming or toxic pollution (Shahsavari & Akbari, 2018). Solar energy has a significantly lower negative impact on the environment compared to fossil energy, particularly in terms of the use of harmful materials, water consumption, and land utilisation, this can lead to detrimental effects on both the environment and human health. Hassanien et al. (2016)

conducted a study to investigate the factors that contribute to the adoption of solar energy for electricity usage in sectors such as agriculture. This study identified key variables essential for improving the utilization of solar energy-generated electricity in the agricultural sector. Factors contributing to awareness creation in the agriculture sector encompass support requirements and physiological needs, attitude requirements, technology cost equipment, educational requirements, and political requirements (Hatamifard et al., 2023).

Pandey et al. (2020) conducted a study that examined the utilisation of electricity and identified factors that contribute to its improvement. The study findings indicate a statistically significant and positive relationship between policy making, organisational factors, research factors, educational factors, social cultural factors, economic factors, and the adoption of solar energy in the agriculture sector. Current research indicates that strategically installing solar panels in specific locations holds the potential to optimize the utilization of solar energy. According to Jaeger-Erben et al. (2021), there is a high likelihood of increased adoption of solar energy. It is undeniable that solar energy can significantly contribute to the reduction of carbon emissions.

However, it is necessary to prioritise the development of technology and allocate substantial investments towards the solar energy sector to streamline and expedite progress. Advancements in technological performance, complemented by policy support and decreased costs, have facilitated the integration of solar energy as a feasible alternative to fossil fuels in the energy sector. However, despite the rapid expansion of solar energy, its complete potential remains underutilized. The primary investigation revolves around the factors contributing to the limited adoption of solar energy on a substantial scale up to this point (Shakeel & Rajala, 2020).

Sustainable Rural

In recent decades, the installation of energy infrastructure in rural areas has presented significant challenges. Nevertheless, it is imperative to recognize the considerable potential of deploying renewable energy infrastructure in rural regions. The strategic relocation of renewable energy facilities to rural areas carries substantial

significance, as there exists a robust correlation between the development of rural areas and the adoption of renewable energy sources (Irfan et al., 2019). Consequently, nations are currently engaged in policy development efforts aimed at implementing solar energy and other renewable sources in rural regions.

The population in other Asian countries is widely distributed. Installing power grids becomes challenging in this scenario. The cost of developing infrastructure in remote areas is high (Come Zebra et al., 2021). The cost of installation increases significantly when multiple grids need to be installed in rural areas. Hence, there is a necessity for the implementation of efficient methods to electrify rural areas due to their geographically isolated locations and scattered population. The incorporation of renewable energy sources can contribute to delivering high-quality electricity, eliminating the necessity for the establishment of multiple grids for electrification purposes (Strielkowski et al., 2021). Rural areas harbor substantial potential for renewable energy development, contingent upon the implementation of suitable technologies and policies. The expansiveness of rural areas provides favorable conditions for deploying renewable energy infrastructure, encompassing photovoltaic, biomass, and wind power generation (Gao et al., 2019). Thus, it is prudent to employ strategies for renewable energy development by comprehending available resources, engaging in systematic planning, assessing the potential for renewable energy, and considering the existing technical and economic conditions of rural areas at a national level (Xin et al., 2022).

Hybrid power generation refers to the integration of small-scale, non-conventional, and renewable energy sources. Research has indicated that it has the capacity to address issues pertaining to renewable energy generation and contribute to environmental sustainability (El-houari et al., 2020). Renewable energy significantly alleviates poverty, positively impacting economic development in regions. It enables farmers to attain energy self-sufficiency, fostering economic growth and creating employment opportunities, particularly through initiatives involving rural electricians (Djanibekov & Gaur, 2018). Advancements in renewable energy technology, such as energy-efficient stoves, diminish reliance on high-energy cooking equipment and reduce losses during harvesting (Mehetre et al., 2017). Diversified

renewable energy sources have the potential to diminish dependence on natural resources for energy.

Advantage of Renewable Energy Technologies

The adoption of renewable technology has positively affected the lives of ordinary individuals. The overall health of individuals has been enhanced due to the improved combustion of biomass. The decision-making process should prioritise the reduction of smog-related problems, such as conjunctivitis and respiratory diseases (Ghorani-Azam et al., 2016). The utilisation of advanced technologies in cooking has the potential to yield various health advantages. Renewable energy offers a highly convenient and straightforward means of cooking food and boiling water. Women and children can allocate their time towards activities that bring them pleasure, engage in productive work, and pursue educational endeavours.

By granting individuals residing in rural areas access to renewable electricity, they can allocate their time towards domestic activities. Electric water pumps can be utilised to efficiently access cleaner water with minimal manual labour. Renewable energy sources can be utilised to provide electrical energy for refrigeration and the safe operation of medical equipment in rural medical centres (Khogali et al., 2022). The provision of electricity in rural areas enables access to radio and television, thereby indirectly enhancing the knowledge of individuals. Electric lighting provides a sense of comfort, safety, and security within residential environments.

The utilisation of electricity derived from renewable sources enables individuals residing in a particular area to allocate more time towards health and education-related activities. While there are various advantages associated with the utilisation of modern power, such as aiding local communities and enhancing operational efficiency within organizations, Renewable technology can significantly contribute to the development of regional economies. Renewable energy can also be used to effectively manage local industries. Renewable technology enables the execution of various productive tasks (Ishaq et al., 2022).

The tasks involve the utilisation of milling machines and the harnessing of wind energy for water pumping and other productive mechanisms. The presence of

energy androids has the potential to enhance agricultural processing and related industries in rural regions. According to Baumüller (2022), the employment prospects for young individuals in rural areas will be enhanced consequently. The utilisation of modern energy in both urban and rural areas enables businesses to effectively preserve and process food. Storage facilities can be constructed in rural areas to safeguard perishable commodities (Adeyeye, 2017). Moreover, it is feasible to offer telecommunications services and deliver up-to-date weather forecasts to farmers and fishermen. Renewable energy can be utilised to facilitate the development of modernised infrastructure in key sectors (Adeyeye, 2017; Nkiaka et al., 2019).

Barriers in Renewable Energy Technologies

Numerous challenges are linked to resource utilization in rural areas, including the unreliable supply and substantial infrastructure investment required for renewable energy sources, which positively impact the Earth's climate (Malik et al., 2019). The promotion of renewable energy initiatives in rural regions is significantly influenced by economic poverty. Additional factors contributing to the issue include inadequate technological advancements, vulnerable natural habitats, and limited public awareness(Mboumboue & Njomo, 2016). Furthermore, there are several additional challenges that need to be considered, such as the number of individuals residing in a household, geographical constraints, the financial implications of energy consumption, and the progress of infrastructure development in rural regions of Asia.

The uneven distribution of various types of renewable energy installations is negatively affecting the long-term benefits of utilising this form of energy. In modern technology industries, there is a significant reliance on resources such as firewood, straw, and coal. Ineffectively harnessing renewable energy sources may lead to a return to outdated technologies. Individual failure to adopt renewable energy can be ascribed to factors like high service costs, equipment malfunctions, and a lack of technical expertise. Additionally, the use of hydropower facilities may negatively impact agriculture by utilizing irrigation water and occupying farmland, with considerable construction costs associated with their development (Patnaik et al., 2022).

Promoting renewable energy in Indonesia

Significant effort is necessary to implement renewable energy installations, including in Indonesia, during the current year. Most countries in East Asia are situated on islands. Installing these facilities is challenging in this condition (Burke et al., 2019). Consequently, these nations are dependent on diesel-powered generators to meet their power requirements. Over 97% of households in Indonesia are engaged in various activities. The provision of activities throughout Indonesia is challenging due to the presence of dense jungles and numerous islands. The installation expenses for renewable energy in remote areas are significantly high, resulting in the prevalent use of diesel-powered generators. The unpredictable nature of wind and solar energy has posed significant challenges to their practical utilisation. Furthermore, the exorbitant expenses associated with equipment such as energy storage liquids and batteries have posed significant challenges in the utilisation of these energy sources (Hassan et al., 2023). Therefore, the high costs associated with the purchase, installation, and maintenance of renewable energy equipment act as a deterrent to its widespread adoption.

Only a limited number of renewable energy sources have been able to consistently provide a reliable energy supply. Biomass and hydro-geothermal are among the energy sources that possess the capacity to offer reliable and consistent energy supplies. Ensuring consistent access to electricity is crucial for the advancement of rural areas. It is imperative to address the obstacles hindering the widespread adoption of renewable energy in order to achieve affordable electricity prices (Wahono et al., 2021).

Methodology

This study is grounded in a comprehensive review of existing literature. Subsequently, these articles are scrutinised to assess the prevailing pattern pertaining to solar energy and other forms of renewable energy in Asia, specifically focusing on Indonesia. This study delved into the latest advancements in renewable energy research, conducting a comprehensive literature review to thoroughly assess the costs

and benefits associated with the utilization of these energy sources. This study utilised the Scopus database to analyse research articles. A comprehensive analysis was conducted on all articles with the title "Solar Energy" that were published after the year 2000. This study examined the publication count of articles by country from the year 2000 onwards. In addition to analysing the database, the researcher also considered the document type and funding source in their study.

Data analysis

Through a thorough literature review of past articles retrieved from Scopus databases, an analysis was performed on data related to renewable energy sources, with a specific focus on solar energy. Notably, there has been a discernible rise in the number of studies addressing this subject in recent decades. However, despite its significance, no studies on this topic have been conducted from Indonesia. Indonesia's contribution to solar and renewable energy is relatively modest compared to other Asian countries like Thailand, Iran, India, and China, which boast larger populations.

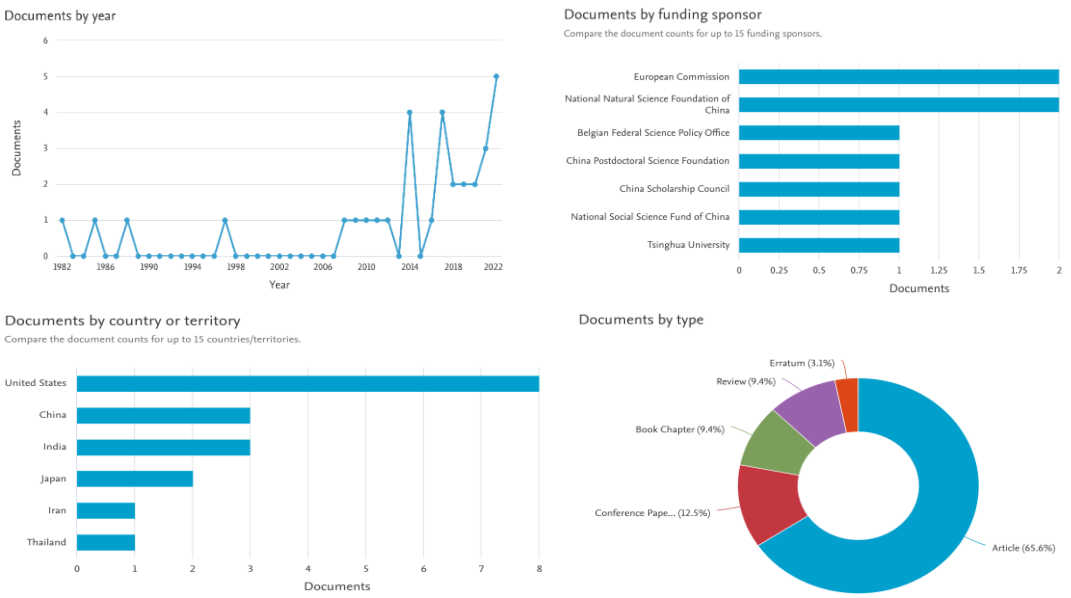

Figure 1. Article review from Scopus database on solar energy.

As depicted in Figure 2, the data illustrates a rise in the number of publications on the specified topic over the last five decades. However, there is a dearth of research conducted in the Indonesian region. This contribution is comparatively lower in comparison to countries such as Bangladesh, Malaysia, Japan, India, and China.

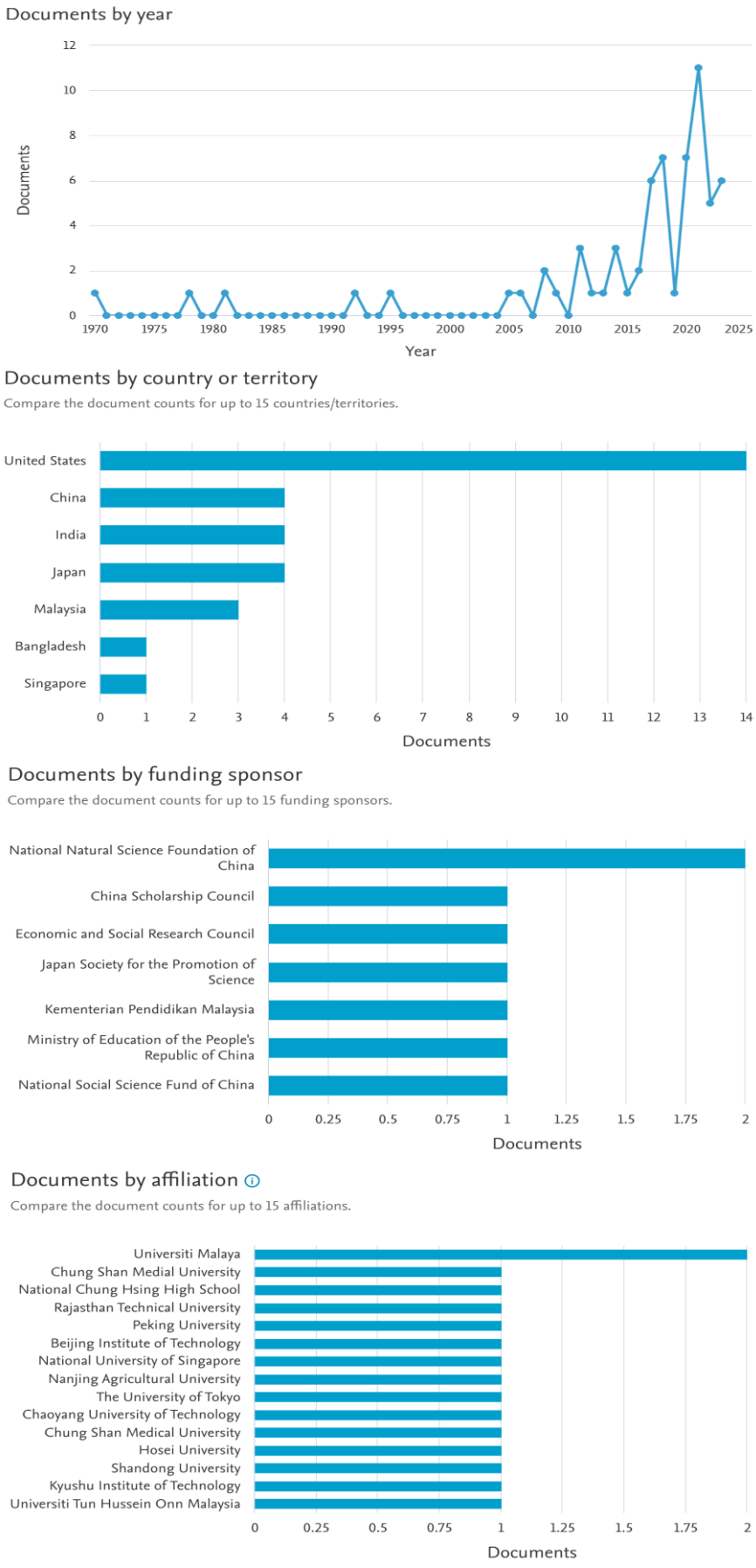

Figure 2. Articles reviewed regarding social solar energy.

Through a review of articles in the Scopus database focusing on resource sustainability, there has been a substantial increase in the number of publications since 2000. Notably, despite the growing publication output in other Asian countries, Indonesia has not contributed any publications to this topic. However, certain Indonesian universities, including Brawijaya University, Universitas Sebelas Maret, Universitas Jenderal Soedirman, and Universitas Islam Negeri Syarif Hidayatullah Jakarta, have made noteworthy contributions to research in the field of social rural sustainability.

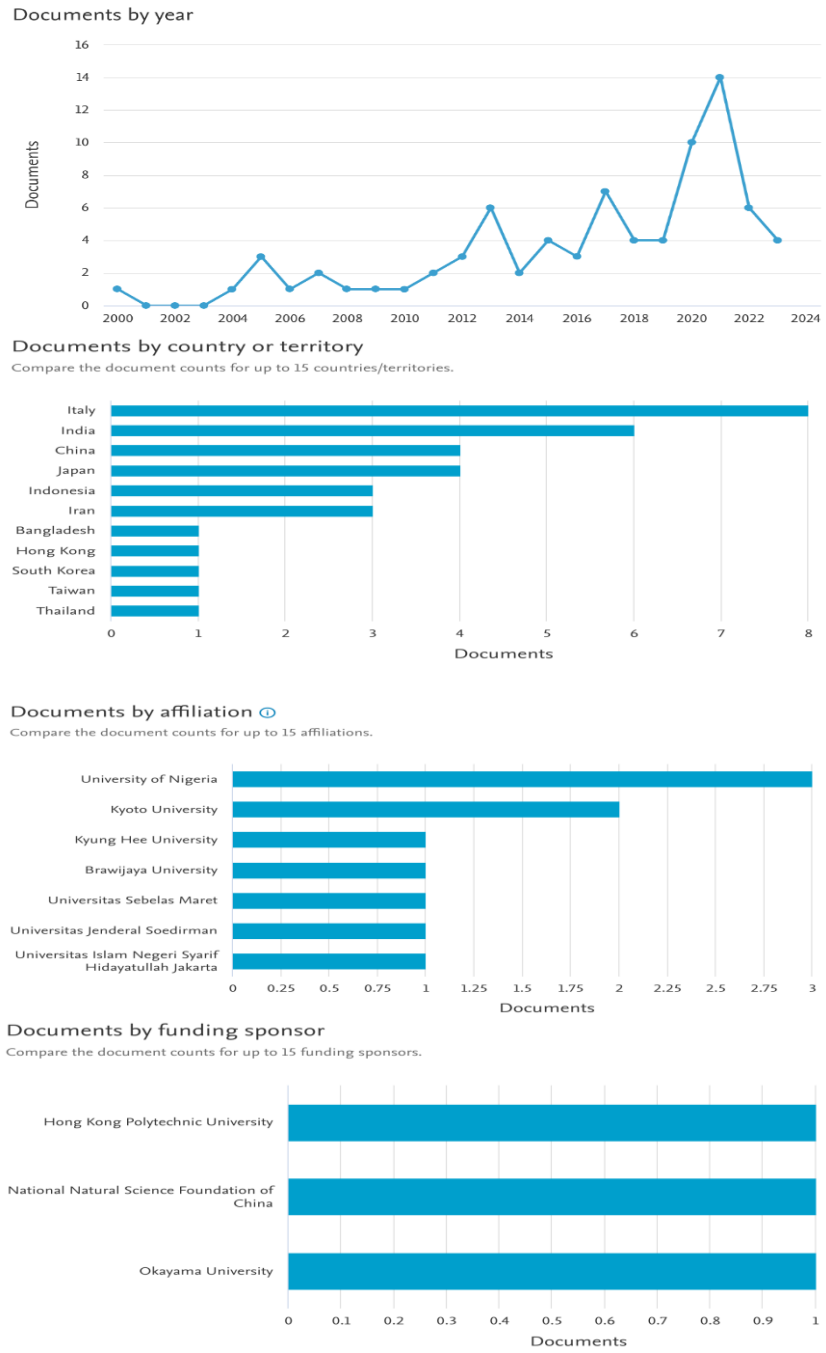

Figure 3. Articles reviewed regarding social rural sustainable.

Discussion

The aim of this study was to comprehensively analyse existing literature on renewable energy in Asia, emphasizing the specific context of Indonesia. The analysis reveals that a substantial majority of the global population resides in the continent of Asia, with Indonesia being one of the developing countries in this region. Asian nations are presently contending with challenges related to pollution and poverty, while urbanization poses a significant issue. These challenges are exacerbated by the use of expensive, non-renewable energy sources. The use of non-renewable energy sources is adversely affecting the climate, and waste generated from factories and vehicles contributes to various health issues. Additionally, the consumption of fossil fuels and the depletion of natural resources emerge as substantial contributors to pollution in Asia.

One potential solution to address this issue is the adoption of renewable energy sources like wind, solar power, and relevant technologies. Despite potential infrastructure costs, transitioning to solar-powered energy in Asian countries is crucial for long-term sustainability and public health improvement. To optimize time efficiency, clean and sustainable energy sources are imperative. Achieving this goal requires heightened public awareness about the importance of solar and other renewables for both the environment and human health. Comprehensive understanding of these resources is essential for all stakeholders. Effective time management influences the efficient utilization of time.

Conclusion, Limitation, and Implications

A comprehensive literature review since 2000 reveals a significant increase in studies on renewable energy over the past two decades. Notably, there is a dearth of research conducted in Indonesia compared to various other regions. Therefore, it is crucial to initiate further research endeavours following international standards, with Indonesia as the focal point. Indonesia's contribution to renewable energy consumption in rural areas is smaller than that of other Asian nations, such as India, China, Japan, and Iran, all of which have substantial rural populations. Among Indonesian universities, Brawijaya University, Universitas Sebelas Maret, Universitas

Jenderal Soedirman, and Universitas Islam Negeri Syarif Hidayatullah Jakarta have made significant contributions to social rural sustainable research.

Despite the expansion of research on social rural energy since 1982 and social solar energy since 1970, researchers in Indonesia have not made any contributions to these areas. It is essential for Indonesia to prioritize increased support for research on social solar energy and social rural energy to effectively contribute to achieving sustainable energy targets. However, this study has a few limitations. It utilized a systematic review methodology, and future studies may opt for an empirical research design to conduct a more thorough analysis. The current study also lacks a comprehensive discussion of technological factors, and future research could integrate technology-related variables into forthcoming studies.

This research is among the limited studies that have explored the role of solar energy in the context of Indonesia. Through a comprehensive literature review, the study evaluated the cost implications of implementing renewable energy sources in Indonesia. The study's findings bear significant managerial implications for decision-makers in Indonesia, offering insights that can be utilized to address poverty reduction and advocate for the adoption of environmentally friendly energy sources.

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