Library Progress International
Vol.44 No. 3, Jul-Dec 2024: P. 14519-14536

Print version ISSN 0970 1052
Online version ISSN 2320 317X

Original Article

Available online at www.bpasjournals.com

Understanding The Impact Of Financial Incentives On The Adoption Of Solar Photovoltaic (Spv) Water Pumping Systems In Haryana's Agricultural Sector: A Bibliometric Analysis And Review

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How to cite this article: Mohan Kumar, Manju Dagar, Swaricha Johri, Himani Gupta, Ritu Malik (2024) Understanding The Impact Of Financial Incentives On The Adoption Of Solar Photovoltaic (Spv) Water Pumping Systems In Haryana's Agricultural Sector: A Bibliometric Analysis And Review. *Library Progress International,* 44(3), 14519-14536.

ABSTRACT

Many advanced and emerging countries are strategizing to shift towards renewable energy technologies to fulfill the increasing electricity requirements of their populations and enhance the efficiency of their power grids. This bibliometric review aims to comprehensively understand and visually represent research perspectives on renewable energy's contribution to sustainable development, utilizing Scopus data spanning from 1978 to 2023. A total of 392 Scopus articles were chosen and analyzed using a qualitative methodology. The study utilizes innovative visualization techniques, such as Citation Network Analysis, Global Citation Score, and Co-Occurrence Networks of Keywords, to visually represent the scientific structure of the Solar Photovoltaic Water Pumping System. The survey indicates that the research on Solar photovoltaic water pumping systems has been increasing since 2012, with an average of 21.60 citations per document. The aim and findings of the study are to improve understanding of the content and structure of the influence of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems in India's agricultural sector, as well as its representation in the literature. In contrast to the recent advancements in integrating solar photovoltaic water system information, the current study showcases a higher degree of meticulousness in terms of the approach and databases employed.

Keywords: Solar photovoltaic, pumping system, financial incentive, bibliometric analysis, renewable energy.

Introduction

Energy: In emerging nations, the infrastructure of the electricity grid is unable to keep up with the growing need for electricity for water pumping (Mantri et al., 2020). The increasing global energy demand motivates government officials and lawmakers to promote clean energy sources such as solar, biomass, wind, and geothermal (Nikolaidis & Poullikkas, 2022). Traditional energy sources, particularly fossil fuels, are currently the leading cause of climate change and have major environmental consequences (Yalew et al., 2020). Excessive dependence on fossil fuels will not only result in environmental degradation, such as greenhouse gas emissions but also in global warming. Energy is a crucial factor and a necessary component for economic growth. It is also essential for enhancing and preserving the quality of life (Estoque et al., 2019; Magazzino et al., 2020). The results of earlier studies on the energy markets demonstrated that the threat to energy security is growing (Zhu et al., 2022). According to the 2013 World Energy Resources Survey report, approximately 1.2 billion people cannot access electricity. This is one of the world's most pressing problems (Ludwig et al., 2022). Therefore, many countries (both developed and developing) are planning to transition to renewable energy technologies to meet the growing population's electricity demand and improve the utility grid (Barbar et al., 2021). The solar PV system is the most frequently used renewable energy technology for a variety of reasons (Sahoo, 2016).

Renewable Energy: As the world's energy demand rises, non-renewable energy sources like coal, oil, and gas become more expensive. Fossil fuel use negatively influences the atmosphere, and globally, fossil fuel consumption in producing electric power accounts for 37.5% of annual CO2 emissions (Sims et al., 2003). The need for alternative energy sources is growing to meet the rapidly rising global energy demands, and the greenhouse gases released by fossil fuels lead to global warming and climate change (Rosen, 2021; Valipour et al., 2020; Yildiz & Yılmaz, 2020). The demand for new renewable energy arises from pollution-related environmental concerns and rising fuel prices. Photovoltaic (PV) solar panels could be an essential part of the solution to this issue because they are environmentally friendly and generate electricity from environmentally friendly solar power (Chaichan et al., 2015). According to a recent study, irrigation uses over 70% of the freshwater that is available to us globally. 90% of the water resources available in underdeveloped countries are used for irrigation, compared to 60% in developed countries (Adeyemi et al., 2017). In India's irrigation infrastructure, electric and diesel pump sets predominate. There are approximately 30 million pump sets in India (21 million electric and 9 million diesel), which account for approximately 20% and 12% of the country's total electricity and diesel consumption, respectively (Shravanth Vasisht et al., 2016).

The population is growing alarmingly in developing nations like Bangladesh, China, and India. The rising population further emphasizes the necessity of increasing food production. The agricultural industry is continuously modernized to fulfil these growing food demands(Rubio-Aliaga et al., 2016). By 2050, the demand for food grains in India is predicted to rise from 278 MT to 450 MT(Vohra & Franklin, 2021) (M. Kumar et al., 2024; Pankaj et al., 2023). Agriculture in developing nations like India depends heavily on rainfall, so the national government and local governments have taken several initiatives to increase the amount of ground and surface water available for agriculture all year. These measures include rainwater harvesting, building check dams across rivers, and maintaining lakes and ponds. In the majority of locations, water is supplied to fields via pumps (Kumar & Kandpal, 2007). Water pumping is essential in agriculture because a timely and sufficient water supply increases crop yield. For agricultural activities, the majority of producers rely on groundwater (Sarkar &

Ghosh, 2017). About 20.3% of India's electricity is used for agriculture. Pumping water for extensive agricultural activities typically uses diesel generators or power from grids. Further development of these approaches suffers from rising fossil fuel prices, CO2 emissions, and inadequate electric infrastructure in remote, rural, and arid areas. However, the practicality of solar water pumping depends on the climate, crop type, level and accessibility of groundwater, government financial incentives, the accessibility of conventional electric grid electricity, and its price (Kelley et al., 2010). Solar energy for water pumping is a possible alternative to current electricity- and diesel-based pumping systems since it may be used to increase water pumping capacity for agricultural and community water supplies (Chandel et al., 2015). Developing nations like India have taken numerous steps to promote PV installations. India has a mission statement stating that 100 GW of PV will be deployed by 2025. As a potential claim for PV generation, solar water pumping applications are crucial to this goal (Elgendy et al., 2016). In the last 20 years, photovoltaic (PV) water pumps have become a popular way to use solar energy (Firatoglu & Yesilata, 2004). A World Bank study says that as of 1993, 10,000 PV water pumping systems had been put in place around the world. By 1998, there were more than 60,000 of these (Short & Oldach, 2003). PV water pumping systems have been thought of as a good way to get water to remote places since most country people live in sunny tropical or subtropical areas. PV systems are especially useful in places where it is not possible to connect to the grid. Even in places where it would be possible to link to a grid, utilities have found that using PV pumps is more cost-effective than extending and maintaining the grid (Kou et al., 1998). Water is the most important resource for sustainable agriculture because the quality and quantity of food produced depend on its timely availability and efficient utilization. Pumping and moving water for crop irrigation requires a lot of energy. Global food production is seriously threatened by the shrinking and depletion of natural water and energy resources (Panwar et al., 2011). Climate change puts the world's ability to produce food at risk, particularly in vulnerable poor nations (Misselhorn et al., 2012). For future agricultural production, energy and water availability will be restricted due to climate change (Wada et al., 2013). Therefore, water and energy conservation are of the highest priority. Various water pumping systems use both electricity and diesel fuel to operate the pump. However, this type of energy source has many disadvantages, including environmental degradation, low dependability, high fossil fuel prices, low efficiency, and high maintenance costs (Errouha et al., 2020; Hammoumi et al., 2018; B. Liu et al., 2021). Therefore, it is necessary to use a viable and suitable alternative energy source to power water extraction systems. Utilizing renewable energy sources is the most effective method for overcoming the disadvantages above. Various renewable energy sources, such as solar, wind, and biomass, can convey water (Gopal et al., 2013). Solar photovoltaic technology is the most desirable and appropriate because it is pure, abundant, and noise-free (Meunier et al., 2019).

Nevertheless, recent research has emphasized the necessity for more comprehensive investigations, despite the growing number of studies assessing the influence of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems. This study analyzes the implementation of solar photovoltaic (SPV) water pumping systems, considering their historical, current, and future implications. The analysis utilizes bibliometric methods, relying on secondary data obtained from the Scopus database. The article clearly outlines various crucial aspects related to the implementation of solar photovoltaic (SPV) water pumping systems. It covers the current trends and potential areas for future research in this field.

The research questions of the study are enumerated below.
RQ1. What is the prevailing trend in terms of publishing and citation patterns within the field

of adoption of solar photovoltaic (SPV) water pumping systems?
RQ2. Which academic journals are known for publishing a significant number of articles on research in the domain of solar photovoltaic (SPV) water pumping systems?
RQ3. Which scholarly articles gained the most substantial influence in terms of citation count?
RQ4. What is the prevailing trend in the collaborative efforts of authors of different countries in publishing within the field of solar photovoltaic (SPV) water pumping systems?
RQ5. What are the potential future research trends within the field of solar photovoltaic (SPV) water pumping systems?

To examine these questions, the current investigation employed an extensive literature survey and bibliometric analysis.

The main aim of this paper is to examine various limitations that have been identified in previous research, intending to provide a valuable contribution to the broader field of solar photovoltaic (SPV) water pumping systems. This research involved a comprehensive analysis of relevant academic sources to gain knowledge, followed by a meticulous examination of the collected data. To evaluate the advancements that have been made in the field of reverse migration research between the years 1978 and 2023, a comprehensive scientific investigation was carried out. A large number of pertinent indicators were utilized in the process of conducting the evaluation. These indicators included the annual publication trend along with citation patterns, the countries that are the most prolific, the productivity of authors, the research articles that are the most cited, the prevalent motor and emergent themes, and the inter-country collaboration among countries for publication. This study utilized the Scopus database to obtain bibliographic data on solar photovoltaic (SPV) water pumping systems. This study demonstrates a greater level of comprehensiveness in comparison to prior research, thereby decreasing the probability of overlooking any noteworthy contributions to the subject matter. The duration of previous research has shown considerable variation, depending on the particular subject being studied and the objectives of the study.

2 Research Methodology

2.1 Materials and Methods

The bibliometric study offers a thorough perspective on the current literature, aiding in the comprehension of the fundamental concepts and facilitating the identification of future trends in the field (Nasir et al., 2021). This advancement contributes to the progression of theories and the creation of novel models (Khan et al., 2022; M. Kumar et al., 2023, 2024; Pankaj et al., 2023) The current study utilized bibliometric, network, and content analysis techniques to examine papers on understanding the impact of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems in Haryana's agricultural sector to address the research questions. The text emphasizes the importance of understanding the impact of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems in Haryana's agricultural sector. Bibliometric and Scientometric analyses were conducted using the new R-package, bibliometric R-tool, and VOSviewer software. The software was also employed for data modification, graphical representation, and tabulation of scientific information.

The analysis adhered to a three-step methodology. During stage 1, bibliometric analysis is performed to measure the quantitative aspects of the published data. This practice facilitates comprehension of the prevailing patterns in the literature about the subject being investigated. During stage 2, a network analysis was performed to determine the homogeneous areas within the research. This strategy involves a comprehensive analysis of several topics, mapping out publications, and making predictions about trends and crucial spots. During stage 3, a content analysis was conducted to identify the blind spots and hot areas in the research. This analysis

provides valuable insights for future research directions to researchers. The VOSviewer software was utilized for network and content analysis because of its superior graphical presentation structure, which is both user-friendly and easily comprehensible.

The current bibliometric analysis conducted a comprehensive search across diverse repositories to investigate the impact of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems in the agriculture sector's literature. Information was obtained using the Scopus database. The following research query was designed to obtain the necessary information "TITLE-ABS-KEY ((("Photovoltaic" OR "Solar energy") AND ("Solar water pump" OR "Water pumping system" OR "Photovoltaic pumping system"))) AND PUBYEAR > 1978 AND PUBYEAR < 2023 AND (LIMIT-TO (SUBJAREA, "ENGI") OR LIMIT-TO (SUBJAREA, "ENER") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "AGRI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (AFFILCOUNTRY, "India")). The query was executed on January 22, 2022, yielding 563 results published between 1978 and 2023. The data underwent a cleaning process that involved the removal of irrelevant, off-topic duplicates and incomplete documents. Ultimately, the procedure culminated in a total of 392 eligible documents that were deemed suitable for the final analysis.

3 Data analysis

3.1 Annual scientific production

To explore Research Question 1, we analyze the development of scholarly articles related to solar photovoltaic (SPV) water pumping systems. The examination is conducted every year within the designated timeframe, as illustrated in Table 1. This study involves a comprehensive analysis of academic articles on solar photovoltaic (SPV) water pumping systems that have been published over the past forty-five years. The research progress on this subject was notably very slow during the first decades (1978 to 1987). In contrast, there has been a significant increase in academic attention since the second decade, leading to a substantial growth of over 39 publications in the third decade, 48 in the fourth decade, and a total of 196 research articles published from 2018 to 2023. From 1978 to 2023, there has been a significant rise in the number of published articles, ranging from 3 research articles to 392 articles.

This section presents fundamental details regarding the extracted bibliometric data. The analysis of publication trends during the observed period encompassed various significant indicators, such as core sources, publications, authors, countries, institutions, citations, and keywords. Figure 2 illustrates the yearly scientific output of the publications that were considered in the analysis. The data illustrates a consistent upward trajectory over the course of several years, emphasizing the growing importance of the subject in more recent times. The data reveals a significant rise in the aforementioned figure over the past decade, indicating a growing recognition among researchers and professionals regarding the significance of financial incentives in driving the adoption of solar photovoltaic (SPV) water pumping systems within Haryana's agricultural sector. Since 2008, there has been a significant increase in the rate of studies conducted in the field of solar photovoltaic (SPV) water pumping systems. On average, each document in this field receives 21.60 citations. Based on the yearly scientific production scale, the articles produced in this area have a growth rate of 6.76 percent. Additionally, it demonstrates the progression of article publications per year over time.

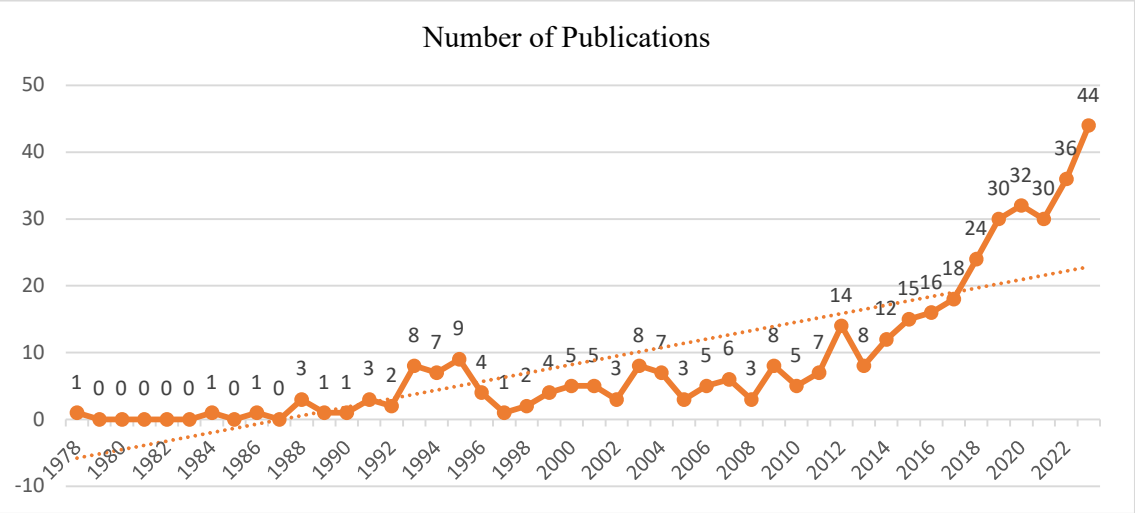
Table 1: Decade-wise scientific production of research articles on financial incentives on the

adoption of solar photovoltaic (SPV) water pumping systems.

	First decade	Second decade	Third decade	Fourth decade	Fifth decade	Consolidated
Timespan	1978-1987	1988-1997	1998-2007	2008-2017	2018-2023	1978-2023
Sources	3	18	19	50	69	128
Total documents	3	39	48	106	152	392
Authors	3	71	91	236	460	888
Annual growth rate	0	11.49	12.98%	22.03%	10.67%	6.76%
Authors of single-author doc	3	7	6	15	7	39
International Co-Authorship	0%	7.69%	14.58%	19.81%	26.32%	19.64%
Author's keywords (DE)	3	48	82	337	507	935
Average citations per doc	13.67%	11.41	61.69	30.65%	10.27	21.60

Source: Authors' development using Biblioshiny in conjunction with R-Studio.

Figure 2: Annual scientific production of research articles.

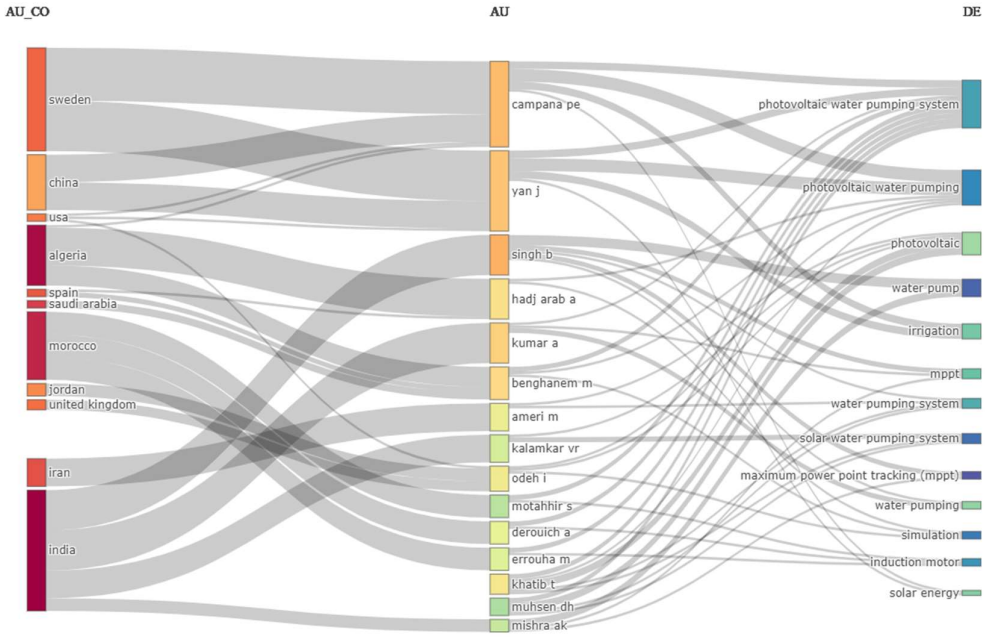


Source: Authors' development using Biblioshiny in conjunction with R-Studio.

3.2 Three-field plot:

Figure 3 is derived by using the renowned Sankey diagrams (Riehmann et al., 2005) that illustrate a three-field plot representing the country of the authors, the authors' names, and the authors' keywords. The size of the boxes is directly proportional to the frequency of occurrences of the items. This dataset allows us to analyze the countries "Sweden", "India", "Morocco", "Algeria", and "China" that have published the highest number of articles in the selected research field. The researchers "Campana Pe" and "Yan J" specialize in "Photovoltaic water pumping systems". On the other hand, "Singh b" and "Muhsen dh" focus on "Water pump" research. Lastly, "Campana Pe" and "Errouh M" have a research interest in "Solar energy" and "Induction motor". An examination of keywords by country reveals that Sweden and China have shown significant acceptance of the term "Photovoltaic water pumping system," whereas "Iran" and "India" have demonstrated acceptance of the keywords "Water pump" and "Solar water pumping system."

Figure 3: Three-field plot for publication of research articles using Authors' countries and keywords.



Source: Authors' development using Biblioshiny in conjunction with R-Studio.

3.3 Top Most prolific Journals

Noticeable variations are observed in the top 10 journals that make the most significant contributions. The journal "Renewable Energy" (CiteScore 16.1) has been identified as the most productive in its field, having contributed 32 research articles in the integrated domain since its publication starting date in this domain since 1991. The publisher of this journal is “Elsevier”. The journal "Solar Energy" (CiteScore 13.1) is ranked as the second most productive journal, having published a total of 30 articles. The journal is published by the publisher "Elsevier" since 1957 for the incorporated domain. The journal "Energy Conversion and Management" has a CiteScore of 19.1 and an h-index of 16. It is ranked third among other journals based on the number of articles published, with a total of 24 articles published since 1988. The publisher of this journal is "Elsevier". The journals "Energies" (CiteScore 5.5) with an h-index of 6, "Applied Energy" (CiteScore 21.1) with an h-index of 11, "International Journal of Renewable Energy Research" (CiteScore 3.1) with an h-index of 6, and "IET Renewable Power Generation" (CiteScore 7.1) with an h-index of 6 are ranked fourth, fifth, sixth, and seventh, respectively. These journals have published 13, 12, 9, and 8 articles. The journal "Energy" has a CiteScore of 14.9 and an h-index of 6. It has been published by Elsevier since 1999. The journal "Energy Sources, Part A: Recovery, Utilization and Environmental Effects" has a CiteScore of 4.7 and an h-index of 3. It has been published by Taylor and Francis since 2011. Both journals are ranked eighth and ninth, respectively, based on the number of articles published, with each journal having published 7 articles. The journal "International Journal of Sustainable Energy" has a CiteScore of 4.9 and an h-index of 3. It is ranked in the top tenth position among other journals. The journal has published 6 research articles in relevant domains and is published by publishers "Taylor and Francis".

Table 2: Most prolific journals of the incorporated domain.

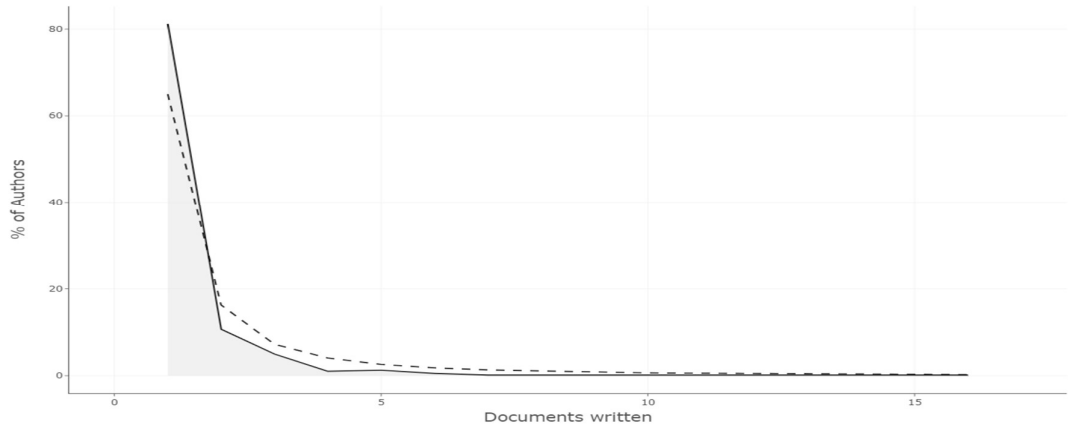
Sources	Publisher	Articles	TC	h_index	Scopus CiteScore	PY_start
Renewable Energy	Elsevier	32	1218	19	16.1	1991
Solar Energy	Elsevier	30	1423	21	13.1	1957
Energy Conversion and Management	Elsevier	24	1021	16	19.1	1988
Energies	MDPI	13	140	6	5.5	2018
Applied Energy	Elsevier	12	545	11	21.1	1994
International Journal of Renewable Energy Research	International Journal of Renewable Energy Research	9	65	6	3.1	2014
IET Renewable Power Generation	Wiley-Blackwell	8	207	6	7.1	2016
Energy	Elsevier	7	247	6	14.9	1999
Energy Sources, Part A: Recovery, Utilization and Environmental Effects	Taylor & Francis	7	39	3	4.7	2011
International Journal of Sustainable Energy	Taylor & Francis	6	79	3	4.9	2019

Source: Authors' development using Biblioshiny in conjunction with R-Studio. (TC: Total Citations, PY: Publication Year).

3.4 Lotka Law

In the specific field of assessing the influence of financial incentives on the acceptance of solar photovoltaic (SPV) water pumping systems, a total of 656 authors from various countries have each contributed one article. A total of 86 authors has each contributed two articles, while an additional 40 authors have each contributed three research articles. Furthermore, there are eight authors who have each contributed four research articles, and another 10 authors who have each contributed five research articles.

Figure 4: Authors' contribution using Lotka's law



Source: Authors' development using Biblioshiny in conjunction with R-Studio.

Finally, another four authors have made a significant contribution by each authoring six research articles. Table 3 shows that three authors have individually published 7, 8, and 9 research articles. Two researchers, who have individually published 16 research articles each, were discovered to be affiliated with the incorporated domain.

Table 3: Authors' collaboration using Lotka Law

Documents written	Number of Authors	Proportion of Authors
1	656	0.812
2	86	0.106
3	40	0.05
4	8	0.01
5	10	0.012
6	4	0.005
7	1	0.001
9	1	0.001
10	1	0.001
16	2	0.001

Source: Authors' development using Biblioshiny (R-Studio).

3.5 Top most cited research articles of the incorporated domain

Table 4 depicts the 15 most widely referenced documents in the current bibliometric study within the included domain. The research article titled “Theoretical and experimental analyses of photovoltaic systems with voltage and current-based maximum power-point tracking” published by (Masoum et al., 2002) in the journal “IEEE Transactions on Energy Conversion” has been the most cited article (760) in the domain followed by the article titled “Improving the effectiveness of a photovoltaic water pumping system by spraying water over the front of photovoltaic cells”, which is published by (Abdolzadeh & Ameri, 2009) in the journal of “Renewable Energy” has been globally cited 243 times. “Design optimization of photovoltaic powered water pumping systems”, published by (Ghoneim, 2006) in the journal “Energy Conversion and Management” received 180 citations, while the article titled “Loss-of-load probability of photovoltaic water pumping systems”, which is published by (Hadj Arab et al., 2004) in the journal “Solar Energy” has received 166 citations globally. The research article titled "A method for estimating the long-term performance of direct-coupled PV pumping systems" by Kou et al. (1998) in the journal "Solar Energy" has received a total of 162 citations. In comparison, the research paper titled "Optimal sizing of a photovoltaic pumping system with water tank storage using LPSP concept" by Bakelli et al. (2011) in the journal "Solar Energy" has received a total of 157 citations. The research article titled "Modelling Photovoltaic Water Pumping Systems and Evaluation of their CO2 Emissions Mitigation Potential" by (Ould-Amrouche et al., 2010) in the journal "Applied Energy" is ranked fifteenth in terms of citations within its domain, with a total of 101 citations.

3.6 Co-occurrence of author’s keywords and Countries.

The present study analyzed seven distinct clusters by examining the centrality of various keywords' betweenness and closeness. The authors reviewed the main ywords, considering a threshold of seven occurrences and fifty maximum representative articles. The quantification of centrality degree refers to the process of counting the number of relational connections that a document or research constituent has within a network, as explained by (Donthu *et al.,* 2021). The terms "Photovoltaic", "Water pumping", "Solar energy", "MPPT",

Table 4: Most cited research articles in the Solar Photovoltaic (SPV) water pumping system domain.

Authors	Title	Sources	Total Citations	TC per Year	Normalized TC
(Masoum et al., 2002)	Theoretical and experimental analyses of photovoltaic systems with voltage and current-based maximum power-point tracking	IEEE Transactions on Energy Conversion	760	34.55	2.95
(Abdolzadeh & Ameri, 2009)	Improving the effectiveness of a photovoltaic water pumping system by spraying water over the front of photovoltaic cells	Renewable Energy	243	16.20	4.25
(Ghoneim, 2006)	Design optimization of photovoltaic powered water pumping systems	Energy Conversion and Management	180	10.00	2.15
(Hadj Arab et al., 2004)	Loss-of-load probability of photovoltaic water pumping systems	Solar Energy	166	8.30	1.88
(Kou et al., 1998)	A method for estimating the long-term performance of direct-coupled PV pumping systems	Solar Energy	162	6.23	1.66
(Bakelli et al., 2011)	Optimal sizing of photovoltaic pumping system with water tank storage using LPSP concept	Solar Energy	157	12.08	3.17
(Kolhe et al., 2004)	Performance analysis of a directly coupled photovoltaic water-pumping system	Energy Conversion and Management	154	7.70	1.74
(Campana et al., 2013)	Dynamic modelling of a PV pumping system with special consideration on water demand	Applied Energy	134	12.18	3.21
(Campana et al., 2015)	Economic optimization of photovoltaic water pumping systems for irrigation	Energy Conversion and Management	122	13.56	3.73
(Mokeddem et al., 2011)	Performance of a directly-coupled PV water pumping system	Energy Conversion and Management	114	8.77	2.30
(R. Kumar & Singh, 2017)	Single Stage Solar PV Fed Brushless DC Motor Driven Water Pump	IEEE Journal of Emerging and Selected Topics in Power Electronics	111	15.86	3.96
(Benlarbi et al., 2004)	A fuzzy global efficiency optimization of a photovoltaic water pumping system	Solar Energy	106	5.30	1.20
(Hamidat et al., 2003)	Small-scale irrigation with photovoltaic water pumping system in Sahara regions	Renewable Energy	105	5.00	2.31
(Chandel et al., 2015)	Degradation analysis of 28 year field exposed mono-c-Si photovoltaic modules of a direct coupled solar water pumping system in western Himalayan region of India	Renewable Energy	103	11.44	3.15
(Ould-Amrouche et al., 2010)	Modelling photovoltaic water pumping systems and evaluation of their CO2 emissions mitigation potential	Applied Energy	101	7.21	2.67

Source: Authors' development using Biblioshiny in conjunction with R-Studio. (TC: Total citations)

"Irrigation", "Photovoltaic water pumping system", and "Water pumping system" are prominently displayed in Figure 5. In the same manners, Figure 18 illustrates the bibliometric coupling among countries. The countries that produced the highest number of research articles in collaboration with other countries in the field of assessing the influence of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems are India, the United Kingdom, Algeria, the United States of America, and Morocco. This also signifies the interconnection among the United States, Iran, Palestine, Iraq, and Oman. India maintains strong diplomatic ties with Egypt, while Saudi Arabia and Tunisia share a close proximity, indicating a significant level of interconnectedness between these nations.

Figure 5: Co-occurrence of authors' keywords

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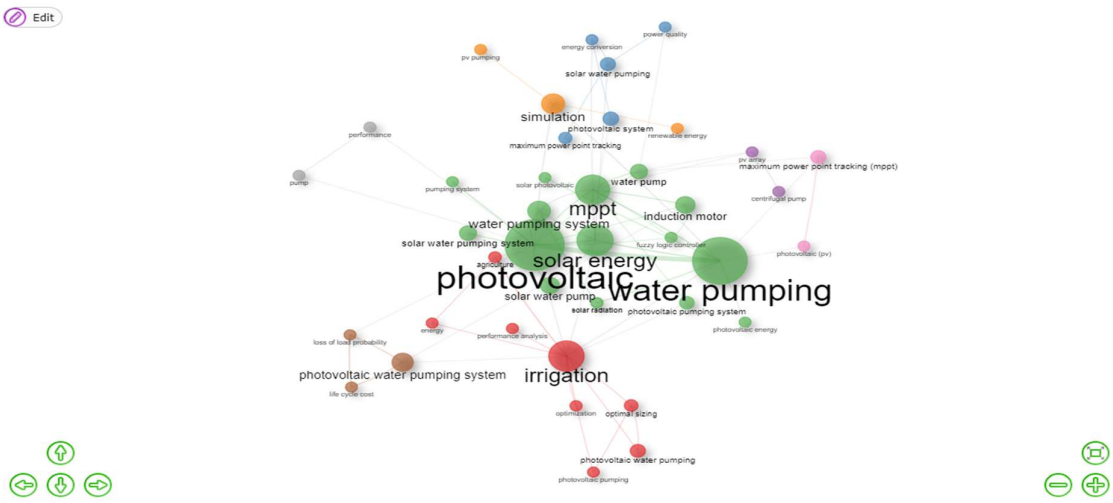
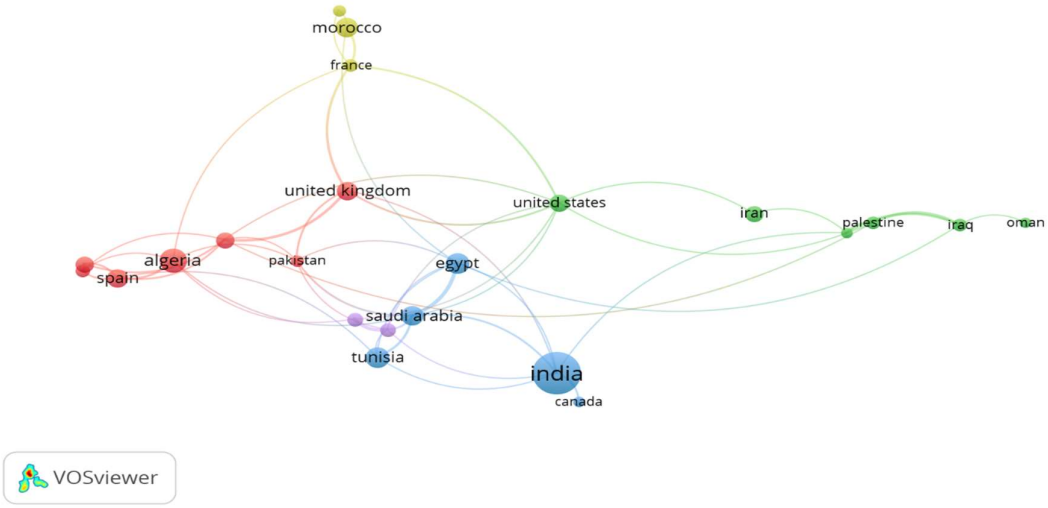


Source: Authors' development using Biblioshiny (R-Studio).

Figure 6: Countries collaboration.



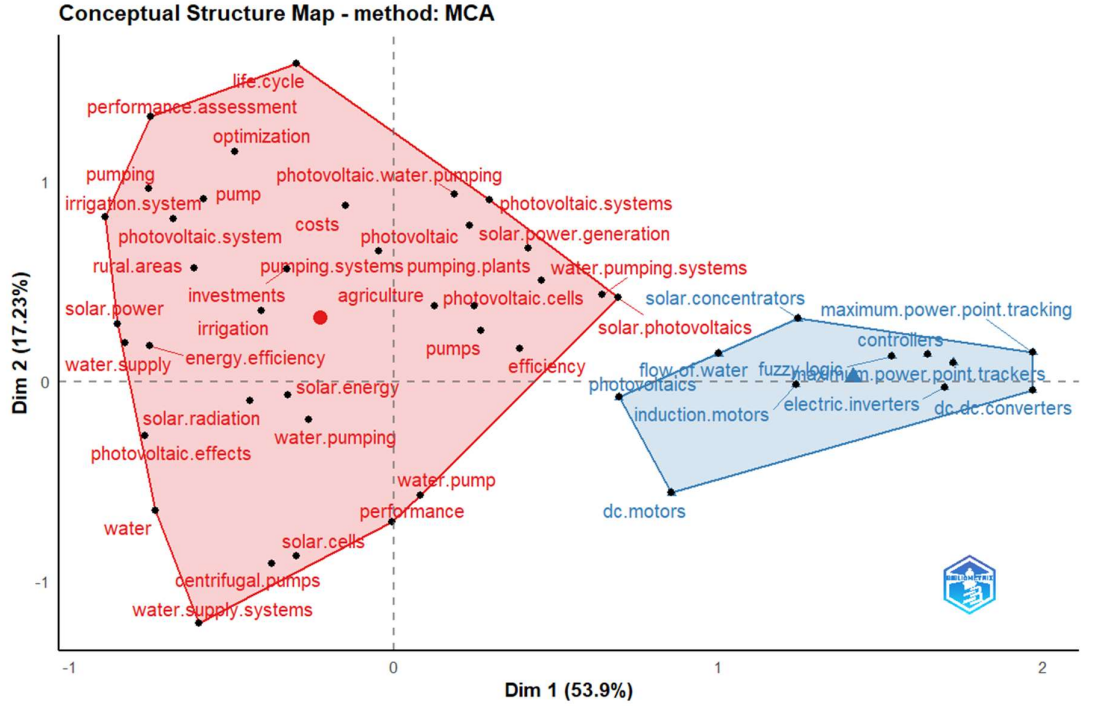
Source: Authors' development using VOSviewer.

3.7 Conceptual structure map using Multiple Correspondence Analysis method

The conceptual structure mapping seeks to determine the level of clustering density displayed by the topics studied over a period of time. Figure 7 depicts the clustering of red corner themes, with a prominent focus on intellectual domains such as "Solar energy", "Photovoltaic cells", "Photovoltaic water pumping system", "Pumping irrigation system", "Solar cell", "Photovoltaic system", "Solar power", and "Solar power generation". These clusters demonstrate a notable level of compactness, suggesting a robust interconnection and concentration of these intellectual pursuits. This observation indicates that these specific

domains have attracted significant attention from the academic community and are expected to continue being a prominent area of investigation in the future regarding the influence of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems. These clusters demonstrate a notable level of density, suggesting a robust interconnection and concentration of these intellectual endeavors. This observation indicates that these specific domains have been attracting attention in the academic community and are likely to continue being a significant area of investigation in the future regarding the impact of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems. As we move on to the next cluster, it becomes clear that new areas such as "Solar Concentrators", "Maximum power point tracking controllers", "Flow of water photovoltaic", Fuzzy logic", "Electric inverters", "Induction Motors", and "DC converters" are emerging and are being acknowledged as having a lower level of focus compared to the previous cluster. This suggests that the aforementioned fields are receiving a diminished amount of attention in comparison to their predecessors.

Figure 7: Conceptual structure map of Solar Photovoltaic (SPV) Water Pumping Systems.



Source: Authors' development using R-4.1.0.

4. Discussion

4.1 Theoretical contributions

The paper's findings highlight a growing number of scholarly articles that delve into the topic of evaluating the influence of financial incentives on the uptake of solar photovoltaic (SPV) water pumping systems in the field of business and management. After examining publications from 1978 to 2023, it became evident that the rate of publication growth experienced a significant slowdown over the course of the period. There was a significant increase in the number of publications starting from the year 2008. Regarding the mentioned journals, it is unsurprising that the majority of the publications have been distributed through prestigious journals that are focused on Solar Photovoltaic (SPV) and solar energy. The "Renewable Energy" journal holds a prominent position, with the "Solar Energy" journal

following closely behind among Solar Photovoltaic (SPV) and solar energy publications. The academic investigation into the impact of financial incentives on the adoption of solar photovoltaic (SPV) water pumping systems has reached a commendable level of complexity, especially in India, Sweden, the United States of America, and the United Kingdom. In these countries, a sincere dedication to acquiring knowledge and comprehension has driven this research forward. The results suggest that India, Egypt, and Saudi Arabia are leading in terms of collaborative efforts at both the national and institutional levels. At the country level, the United Kingdom, Algeria, and Spain are also emerging as frontrunners. When selecting keywords, it is common to analyze the authors' use of terms such as solar photovoltaic (SPV) water pumping systems, financial incentives, photovoltaic, water pumping, solar energy, and solar pumping system. The conducted Conceptual structure map suggests that potential areas of investigation regarding factors affecting Solar Photovoltaic (SPV) Water Pumping Systems include "Solar energy", "Photovoltaic cells", "Photovoltaic water pumping systems", "Pumping irrigation systems", "Solar cell", "Photovoltaic system", "Solar power", and "Solar power generation". These subjects may be fruitful for further scholarly exploration.

As a result, the study has effectively answered the five research questions:

RQ1. What is the prevailing trend in terms of publishing and citation patterns within the field of adoption of solar photovoltaic (SPV) water pumping systems?

RQ2. Which academic journals are known for publishing a significant number of articles on research in the domain of solar photovoltaic (SPV) water pumping systems?

RQ3. Which scholarly articles gained the most substantial influence in terms of citation count?

RQ4. What is the prevailing trend in the collaborative efforts of authors of different countries in publishing within the field of solar photovoltaic (SPV) water pumping systems?

RQ5. What are the potential future research trends within the field of solar photovoltaic (SPV) water pumping systems?

The findings of this study exceed the existing literature on the factors that determine the influence of financial incentives on the adoption rate of solar photovoltaic (SPV) water pumping systems, particularly in Haryana.

4.2 Practical contributions

Although this manuscript is primarily intended for the scientific community, it is important to acknowledge that the findings also have practical implications. The academic interest in studying the impact of financial incentives on the adoption rate of solar photovoltaic (SPV) water pumping systems has significantly grown in recent years. This study aims to enhance comprehension of the determinants that govern the impact of financial incentives on the rate at which solar photovoltaic (SPV) water pumping systems are adopted. It has considerable practical value in providing information for decision-making in different situations. Within the context of the current framework, which places an emphasis on the growing significance of understanding the factors that influence the adoption rate of solar photovoltaic (SPV) water pumping systems, particularly in Haryana across a wide range of industries (including Agriculture and Manufacturing), such knowledge has the potential to improve the overall effectiveness of efforts to implement SPV water systems. In addition, it is important to point out that the subject matter and the subsequent development of it could be improved by a robust collaboration between academics and executives working within organizations. In the realm of business and management, participating in these activities has the potential to improve our understanding of the factors that influence the adoption rate of solar photovoltaic (SPV) water pumping systems. These factors include financial incentives. Furthermore, working together with other people will increase the likelihood of coming up with solutions that are regarded as valuable and influential. Identifying eminent scholars and influential academic publications in the field of Solar photovoltaic water pumping systems can

be a valuable asset for practitioners and researchers, assisting them in finding reliable and relevant sources of knowledge. Engaging in partnerships with renowned specialists and sharing research results through reputable academic publications can greatly enhance the visibility and impact of their scholarly pursuits. The findings highlight the dominant role of India, Sweden, the United States, and the United Kingdom in SPV initiatives and the examination of factors that impact these endeavors. This phenomenon offers abundant prospects for researchers from various nations to collaborate with these esteemed countries and institutions, thereby promoting the exchange of knowledge and facilitating joint research endeavors. The study demonstrates the relevance of using performance analysis and science mapping methodologies to enhance our understanding of how financial incentives affect the adoption of SPV water pumping systems in this field. Practitioners and researchers can adopt these approaches to gain a comprehensive understanding of the development and patterns within the research field. This can enhance the formulation of effective strategies and protocols. This has the potential to promote the spread of priceless knowledge and profound understanding, thus facilitating societal progress, creativity, and the resolution of intricate problems.

5. Conclusion

Renewable energy (RE), as an uncontaminated source, is crucial in the present era due to the fact that utilizing conventional energy sources results in the release of CO2 emissions and exacerbates the problem of global warming (Seetharaman et al., 2019). There is a great deal of untapped potential in solar energy, which is one of the renewable energy sources. Previous research on the topic of rooftop solar energy adoption primarily concentrated on the adoption of rooftop solar energy systems by households or households in general, as well as other applications of solar energy technology (such as solar water heaters, solar pumps, solar lamps, solar lights, and so on) globally (Fathimah et al., 2020; Memon et al., 2020). Because of this, there is a dearth of research that investigates the perspectives of non-residential customers regarding solar photovoltaic technology (Reindl & Palm, 2021). Although there have been a few studies that have examined the techno-economic feasibility of non-residential RSPV systems, there is a paucity of studies in this field from the perspective of social science (Kumar Singh et al., 2022; Sharma et al., 2012). Hence, this study made a distinct contribution to the existing research by examining the influence of financial incentives on the rate at which solar photovoltaic water pumping systems are adopted, particularly in the context of Haryana and taking into account the post-usage experience of rooftop solar photovoltaic systems.

Significant insights can be derived from our current comprehension of the complex patterns demonstrated by entrepreneurial life cycles. Certain individuals sustain long-term success, while others do not, primarily because they fail to embrace the latest technological advancements in their respective fields (Mohan & Malhan, 2021; Martin & Sunley, 2011). The discourse surrounding the efficient utilization of financial incentives to promote the adoption of solar photovoltaic water pumping systems has emerged as a prominent subject in the field. Data were gathered from the Scopus database spanning the years 1978 to 2023. The findings reveal that the publication source with the highest number of citations is "Renewable Energy" with a total of 1218 citations, followed by the journal "Solar Energy" which has the highest number of citations at 1423. India is the most dedicated country when it comes to publishing research articles in the field of the SPV domain. The research article titled "Theoretical and experimental analyses of photovoltaic systems with voltage and current-based maximum power-point tracking" authored by (Masoum et al., 2002) and published in the journal "IEEE Transaction" has garnered the highest number of citations, with a total of 760. It is closely followed by the research article titled "Improving the effectiveness of a photovoltaic water pumping system by spraying water over the front of photovoltaic cells" authored by (Abdolzadeh & Ameri, 2009) and published in the journal "Renewable Energy". It is evident from the existing literature that the gradual implementation of financial incentives significantly

contributes to the higher adoption rate of solar photovoltaic water pumping systems, particularly in the context of Haryana.

6. Study Implications

The study results shed light on the importance of financial incentives in improving the acceptance and efficiency of solar photovoltaic water pumping systems for irrigation. The study provides multiple conceptual and managerial contributions to the field. This schematic research contributes to the future prominence of environmentally friendly and economically efficient energy sources and practices. It can aid governments, policymakers, scholars, international organizations, and other stakeholders in utilizing advanced technological tools to implement precise, dependable, and cost-efficient power-generating projects. The implementation of solar photovoltaic (SPV) water pumping systems in Haryana's agricultural sector, motivated by financial incentives, has the capacity to enhance economic empowerment and foster rural development. The adoption of sustainable and cost-effective solar photovoltaic (SPV) technologies by farmers in Haryana could potentially lead to a favourable improvement in their economic prosperity. By decreasing reliance on conventional energy sources and alleviating the economic strain linked to traditional water pumping systems, farmers may achieve higher income and financial security. Consequently, this economic empowerment can result in enhancements across multiple facets of rural existence. Farmers possess the resources necessary to allocate funds towards education, healthcare, and other vital services for both themselves and their families. Rural communities may experience an improvement in their overall standard of living, which will contribute to the broader socio-economic development of the region

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