Evolution of Green Finance: A Bibliometric Approach

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Abstract

A Comprehensive study of Green Finance publications along with Bibliometric analysis was carried out in this work to follow the evolution and growth trajectory of Green Finance since last 31Years from Year 1990 to 2020. It comprises of study of 9998 research papers, letters published in any journal, books and documents on Green Finance. The keywords used to search were Green Finance and Climate Finance. The published output analysis showed that Green Finance as a research area and subject has very rapidly increased over last 5-10 years. The annual paper production in 2000-2010 was about 5.36 times 1990-1999 decade. Based on this study, a demarcation can be set on Climate conscious Finance studies previous to year 2000 and post year 2000. This study also proposes a general definition of Green Finance free from any biases. The analytical results also provide several key indexes.

Keywords: *Green Finance; Bibliometric; Research trend; Finance*

I. Introduction

Green Finance is an emerging branch in Finance. A clear definition till now has not been provided by or agreed upon unanimously by Economists and world institutions. However various researchers, institutions and countries have come up with a working definition. An interesting variation of it is that some institutions instead of defining Green Finance have come up with alternative to use the term sustainable financial system. Their tools and mechanisms however remain same. According to UNEP, A financial system that involves creation of values and helps in transacting financial assets in such a way that real wealth can be used to serve the needs of an environmentally sustainable and inclusive economy over longer period of time is termed as sustainable financial system [10]. There are various other definitions given by Green Finance Study Group of G20 [6], according to which, Green financing is financing to promote the use of technology such that it reduces pollution. As stated by OECD, it is financing aimed at achieving economic growth while at the same time reducing pollution at large and improving efficiency in waste management and usage of natural resources [7]. (Höhne et. al. 2012) has given similar definition for Green Finance while also including pollution control and mitigating climate change [8].

People's Bank of China views Green finance as policy that refers to a series of policy and institutional arrangements for attracting private capital into green industries like environmental protection, energy conservation etc. through financial services. It appears that this definition is somewhat based on justifying any kind of investment as Green Investments as it lacks any quantifying criteria inclusive in it. While various other authors (Zadek and Flynn, 2013) [13] and organizations (Pricewaterhouse Coopers Consultants, 2013) [12] makes it a point to include land

acquisition and project preparation costs, which may not be significant but has ability to create financing challenges after monitoring and risk management.

Germany assesses Green finance as a judicious approach to include the financial sector in the process of transforming towards an economy having low-carbon footprint and also being resource efficient. While as far as adaptation due to challenges caused by climate change is concerned, European Banking Federation takes a more inclusive view and states that Green finance is not limited to only environmental aspects or Climate change-related aspects thus opening prospects for Green Insurance policies and Green bonds [5]. As much as these definitions differ, they share some common features like financing capital for a wider and more sustainable purpose, benefitting the environment or to reduce harm to it and to some extent managing risk and framing policies and infrastructure to viably sustain the environment.

In summary, green finance can be considered as a superset of the self-sustaining financial system approach to meet the challenges owing to climate change and transition towards a low-carbon society. It can be said that any financial investment that funds activities viz. policy making, insurances/Risk solutions, Bonds or other commercial activities etc. having significantly lower adverse impact than the status-quo being carried out or bearing positive impact on environment shall be called Green Finance.

This study hereby proposes a Green Financial system. It is an ecosystem of interdependent financial units working together to create a sustainable economy and meet environmental challenges concurrently. Figure 1.1 shows various interdependent financial units of Green Financial system.

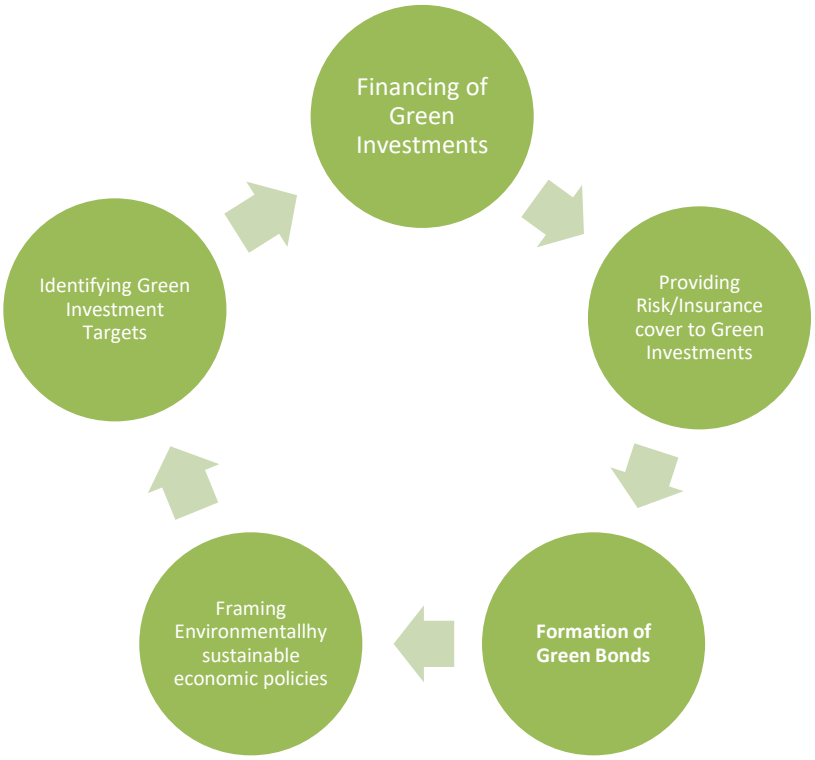

Fig.1.1: Green Financial System

Thus we may define Green Finance as a superset of Green financial system. A positive outcome of this definition is that it allows us to visualize and observe Green Finance in its entirety.

A Bibliometric analysis is also carried out to observe the trends in Green Finance. This method is a common tool applied in many disciplines of science and engineering (Almind & Ingwersen, 1997) [1]; (Cronin, 2001) [4]. It can provide us interesting facts and statistics. It has been extensively used to evaluate the origins of terms, medicinal literature survey, scientific achievements quantifying data for rankings, and faculty evaluation (Chu Keong, 2003) [3]. (Le Minor and Dostatni, 1991) has listed publications utilising Science Citation Index (SCI) to develop a tool for helping in Institute's decision making [9].

II. Materials and Methods

For the purpose of this study Bibliometric data openly available via Google Scholar has been used. The data specifications are listed in table 2.1.

Table 2.1: Summary of Data

Time Period(Years)	1990-2020
Number of years	31
Total Number of Papers	10374
Number of Papers used for this study	9997
Indexes Used	h_index, g_index, hc_index, hI_index, hI_Norm, AWCR, AWCRpA, AW_Index, e_index, hm_Index.

The Bibliometric data comprises of (Cites, Authors, Title, Year, Source, Publisher, ECC, Cites per year, Cites per Author, Age, Abstract, Author count, h_index, g_index, hc_index, hI_index, hI_Norm, AWCR, AWCRpA, AW_Index, e_index, hm_Index) of all publications published during 1990–2020. Data was analyzed using 'Publish or Perish' software. The total number of papers related to Green Finance research in the Google Scholar database published between 1990 and 2020 was 10374. Out of these 9997 were used for carrying out this study. The remaining was left due to insufficient citation and publication year data. Year 2020 is ongoing hence data is taken only for publications available up to March, 30, 2020.

III. Results and Discussion

Table 3.1: **CY:** Cites per year, **CP:** Cites per paper, **CA:** Cites per Author, **PA:** Papers per author, **AP:** Authors per paper, **hI_annual:** hI Index annual

Year	Papers	Citations	Duration	CY	CP	CA	PA	AP	hI_annual
1990 to 1999	999	79594	31	736.71	123.89	90413.43	803.76	1.52	0.84
2000 to 2006	995	200705	20	10035.25	201.71	117816.3	715.02	1.78	8.7
2007 to 2009	992	93301	13	7177	94.05	51329.34	713.59	1.81	8.38
2010 to 2012	993	93116	10	9311.6	93.77	50900.08	689.16	1.88	10.8
2013 to 2014	976	57700	7	8242.86	59.12	32200.62	625.7	2.08	12
2015 to 2015	520	12030	5	2406	23.13	7298.17	313.23	2.21	8
2016 to 2016	988	19258	4	4814.5	19.49	11817.69	614.55	2.17	9.75
2017 to 2017	994	16097	3	5365.67	16.19	10115.34	618.28	2.2	11.33
2018 to 2018	991	8940	2	4470	9.02	4108.23	585.62	2.34	11.5
2019 to 2019	976	5103	1	5103	5.23	2939.66	556.86	2.39	21
2020 to 2020	949	1597	1	1597	1.68	847.92	511.91	2.52	12

The scientific output between 1990 and 2020 is given in Table 3.1. The number of papers/publications, the no. of citations related to Green Finance research has increased substantially. Only 310 papers related to Green Finance were published during 1990-1999 while post 2000, in next 5 years alone more than 631 i.e. twice the number of research papers in half of the previous time were published. Figure 3.1 shows the growth trajectory of publications related to Green Finance.

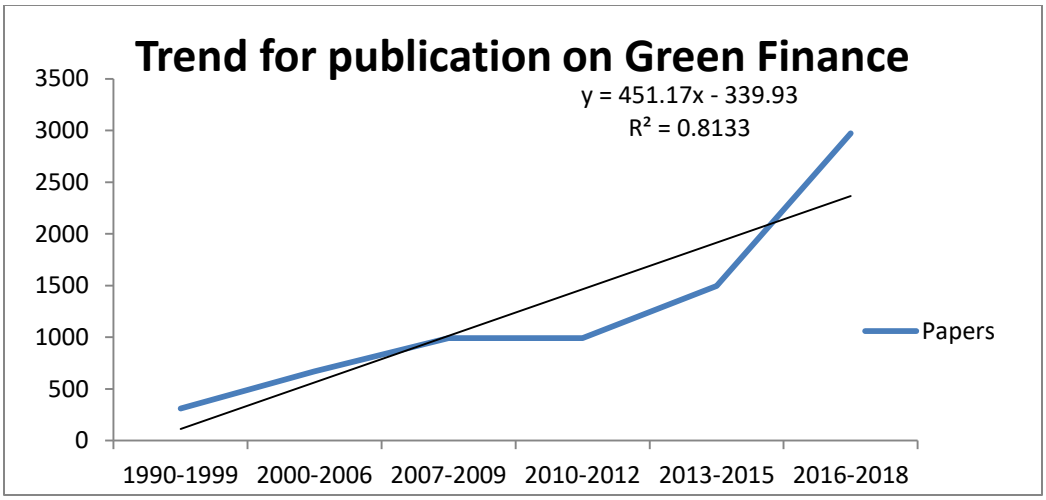

Fig 3.1: Trend for publications on Green Finance.

It is to be noted that year 2020 is still going and till March, 30, 2020 alone 949 publications have been made. The numbers are only bound to go upwards in remaining 9 months. The number of publication raised 2.07 fold from period 2001-2006 to 2007-2012. The number of publications based on the above linear model for the year 2020 is expected to be around 2600-3000.

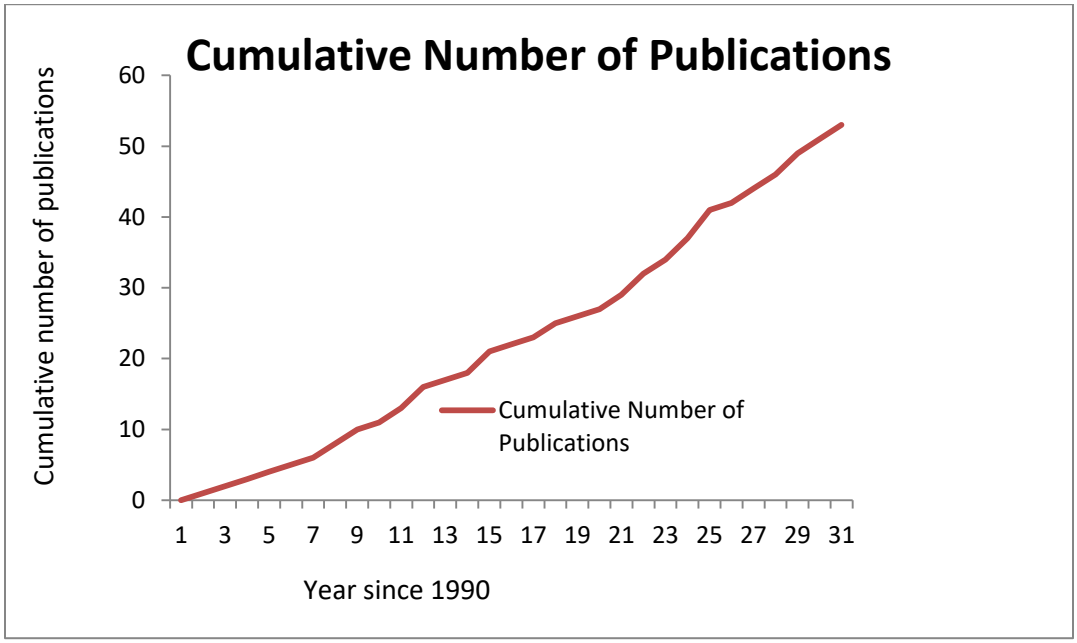

Fig 3.2: Cumulative number of publications by year.

From Figure 3.2 it can be seen that cumulative number of citations has risen with time taken as number of years since publication.

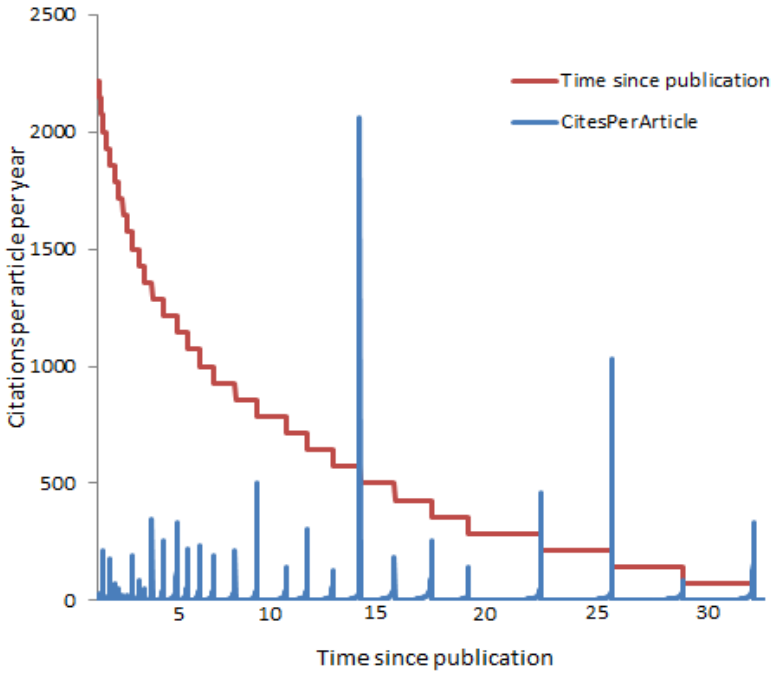

Fig 3.3: Citation per publication per year corresponding to time since publication.

Figure 3.3 shows the number of citations per article per year plotted corresponding to the time since their publication. It can be inferred that citations for an article have increased with age of article. The earlier published articles have higher citation rate than the recent ones. This is in conjunction with the finding that number of citations for a single article is highly correlated with time duration after its publication (Chiu & Ho, 2005) [2], (Marx & Cardona, 2003) [11]. Various indexes used to rate the research articles have also been calculated and analyzed. Table 3.1 summarizes the h_index, g_index, hc_index, hI_Index, hI Normalized, Age-weighted citation rate, Age-weighted citation rate per Author, e_index, modified h_index and citations. A common trend is observable in these indexes.

Table 3.1: **h:** h_index, **g:** g_index, **hc:** hc_index, **hI:** hI_Index, **hI_Norm:** hI Normalized, **AWCR:** Age-weighted citation rate, **AWCRpA:** Age-weighted citation rate per Author, **AW-index**, **e:** e_index, **hm:** modified h_index

Years	Citations	Duration	h	g	hc	hI	hI_Norm	AWCR	AW	AWCRpA	E	hm
1990-1999	79594	31	166	338	57	95.02	141	4356.85	66.01	3125.73	261.14	142.59
2000-2006	200705	20	220	442	114	105.22	174	12128.2	110.13	7118.56	348.85	161.23
2007-2009	93301	13	148	292	87	64.61	109	7745.63	88.01	4259.22	225.31	105.8
2010-2012	93116	10	136	286	85	63.13	108	10548.8	102.71	5668.49	220.04	109.22
2013-2014	57700	7	119	205	91	50.04	84	8943.45	94.57	4955.69	141.17	90.28
2015-2015	12030	5	55	89	49	24.01	40	2405	49.04	1458.77	58.64	42.63
2016-2016	19258	4	60	108	60	26.47	39	4813.5	69.38	2953.94	76.11	46.9
2017-2017	16097	3	47	101	58	17.67	34	5364.66	73.24	3371.2	77.21	37.73
2018-2018	8940	2	39	55	62	12.57	23	4470	66.86	2054.12	31.84	28.85
2019-2019	5103	1	28	53	64	13.07	21	5097	71.39	2935.76	38.18	24
2020-2020	1597	1	15	31	36	7.26	12	1592	39.9	843.67	23.32	12.75

When plotted against each other over number of years, all the indexes show a similar trend. As usual “Individual h_index” is lower than “h_index” for similar paper and “Individual h_normalized” is even lower. This can be observed in figure 3.4. Another interesting finding however turns out to be over calculation to a very high degree of “g_index” than “h_index” for same object. The “AW_index” behaves normally and linger lower than all, for older publications while interestingly it gives higher evaluation to recent publications. The “modified h_index” is slightly less than “h_index”. The “e_index” kind of averages between “g” and “h” index.

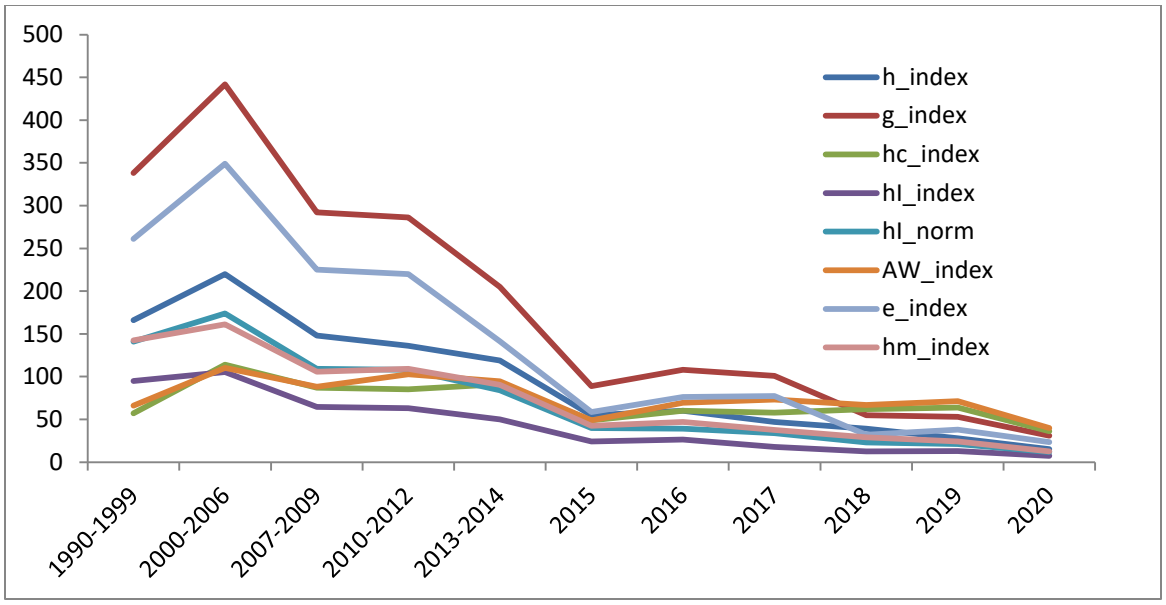

Fig3.4: Variation in index for similar publications

Figure 3.5 shows Age-weighted citation rate(AWCR) and Age-weighted citation rate per Author(AWCRpA) corresponding to publication in given years. The no. of citations in a year, AWCR and AWCRpA follows a similar trend however AWCRpA correcting the AWCR for number of authors in an article can be seen.

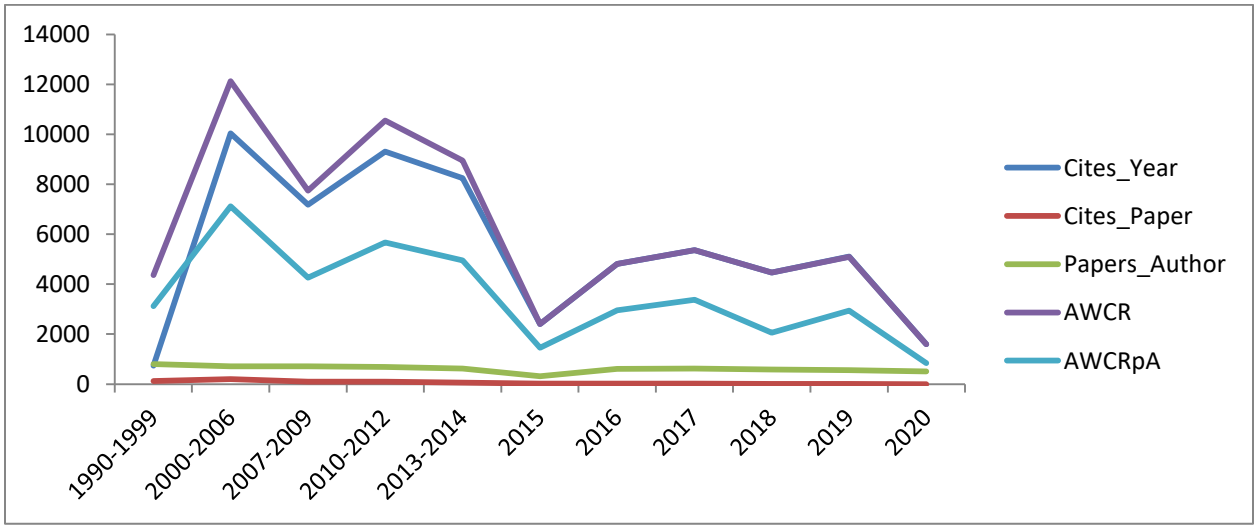

Fig3.5: Variation AWCR and AWCRpA for similar publications along with Cites per year, papers per author and cites per paper

IV. Conclusions

In this study we have calculated various indexes for rating research articles throughout the period for Green Finance related publications from 1990 to 2020. In total, 9997 articles, documents were used for analysis using Publish or Perish. There is a visible upward trend in the number of publications increasing steadily since last 10 years. Based on the linear model, the R^2 value was calculated as 0.81 and number of publications for year 2020 is expected to be between 2600-3000. This number will be 1.9 times the total no. of publications in 2019. Based on this study we conclude that Green Finance is an emerging trend.

This study proposes a bias free definition of "Green Finance" and terms it as "Any financial investment that funds activities viz. policy making, insurances/Risk solutions, Bonds or other commercial activities etc. having significantly lower adverse impact than the status-quo being carried out or bearing a constructive impact on environment shall be called Green Finance". Subsequently a Green Financial system is a cyclical ecosystem of interdependent units which together operates to create a sustainable economy and helps us in achieving the goal of minimal loss to environment or mitigating the effects of earlier Non-Environment friendly policies.

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