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Artificial Intelligence and Poverty Alleviation: A Review

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Research-in-progress

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Abstract

Artificial intelligence (AI) is a term attracting significant attention from both research as well as practice. AI is a constantly evolving frontier of emerging computing capabilities and technologies including but not limited to autonomous vehicles, natural language processing, robots, and virtual agents. The impact of AI has been examined in various business as well as non-business contexts, including the achievement of the sustainable development goals (SDGs) proposed by the United Nations. However, due to the mixed findings of various studies, the exact nature of AI on specific SDGs is not clear. We combine quantitative and qualitative reviews of the extant academic literature to examine the impact of AI on an important SDG – alleviation of poverty. This study has multiple potential contributions – we identify the key trends in the extant research in this domain and also open up the black box of intermediate mechanisms through which AI affects poverty alleviation.

Keywords Artificial intelligence, poverty, sustainable development goals, bibliometric review

1 Introduction

Many economic, ecological, and societal challenges in the current world require urgent action, leading the United Nations (UN) to frame the 2030 Agenda and the underlying 17 Sustainable Development Goals (SDGs) (Schoorman et al. 2021). The various stakeholders agree on the critical role that information and communication technology (ICT) in general (Venkatesh et al. 2020), and artificial intelligence (AI) in particular (Tomašev et al. 2020), can play in helping the world achieve these SDGs. Sustainability can be understood as the development processes which can meet the needs of the present while not compromising the ability of future generations (Schoorman et al. 2021).

AI can be defined as the ability of machines to perform human-like cognitive tasks, including the automation of physical processes such as manipulating and moving objects, sensing, perceiving, problem solving, decision making, and innovation (Benbya et al. 2020). AI offers three key benefits – (a) automation of repetitive tasks, (b) revelation of insights from vast amounts of unstructured data, and (c) integration of distributed resources to help solve highly complex problems (Nishant et al. 2020). AI is considered to be a continuously evolving frontier of emerging computing capabilities, with current AI technologies such as robots, autonomous vehicles, and natural language processing, finding application in various problem domains (Berente et al. 2021). The application of AI in the achievement of SDGs is termed as AI for Social Good (AI4SG) (Cowls et al. 2021). Recently, scholars have reviewed the application of AI in the achievement of SDGs (Schoorman et al. 2021; Vinuesa et al. 2020) and have found mixed results as far as the relationship between AI and SDGs is concerned. Further, extant research also notes some key challenges as far as AI for sustainability is concerned – (a) overreliance on historical data in machine learning models, (b) uncertain human behavioural responses to AI interventions, (c) cybersecurity-related risks, (d) adverse impacts of AI applications, and (e) difficulties in measuring effects of interventions (Nishant et al. 2020).

Thus, there is a need for more research about whether and how exactly AI can help achieve SDGs and consequently help solve problems with global implications. A recent literature review (Schoorman et al. 2021) finds that one of the blind spots of the current research on AI for sustainability has been the SDG-1, that is *no poverty*. In this paper, we focus on SDG-1, and the role that AI can play in alleviation of poverty and related issues. While there is some extant literature discussing the role of AI in poverty alleviation (Bennington-Castro 2017; Jean et al. 2016), a comprehensive understanding of the same is missing (Vinuesa et al. 2020). Further, a systematic and comprehensive review of the role played by AI in alleviating poverty is missing, despite the importance and relevance of this topic for both academic research as well as managerial practice and policy formulation. We formulate the following research questions to drive this paper:

- *What are the main themes of research on AI and poverty alleviation?*
- *What are the intermediate mechanisms through which AI can help in poverty alleviation?*

To address these questions, we conduct a systematic review of the academic literature pertaining to AI and poverty alleviation in order to expand our current understanding of this topic. Further, we seek to lay a foundation for future research in this domain by identifying gaps in the current literature and providing a comprehensive research agenda. We conduct a bibliometric study to examine how artificial intelligence is helping to alleviate poverty as this area is of emerging interest in current world. The structure of the paper is as follows. We describe the method, data gathering and analysis procedure in the next section. The findings of the bibliometric study are then provided, defining the most important journals, organisations, and authors. We also take note of the research clusters identified, the keyword analysis, co-citation networks, and the conceptual structure of the literature. The content analysis of the publications is then combined with bibliographic approaches to establish two study categories. On the basis of the earlier findings, we conclude by outlining potential avenues for further research in the use of AI in poverty alleviation.

2 Research Methodology

Our objective is to characterise the field's progress and pinpoint its trends, obstacles, and future prospects. We do bibliometric and content analysis to achieve this. The study is less prone to judgement bias and the peculiarities of the reviewers that are represented in qualitative reviews thanks to the bibliometric method, which entails the collection of a lot of bibliographic data (Vogel and Güttel 2013; Zupic and Čater 2015). Using the Bibliometrix package in R and the VOSviewer software, as well as other methods, we attempt to discover the research clusters, how they have developed temporally, and the implications for future research. This paper reviews the relevant academic literature using a

combination of quantitative and qualitative methods. Specifically, we conduct bibliometric analysis (bibliographic coupling, citation and historiographic citation analysis, keyword co-occurrence, and conceptual theme mapping) along with a thematic content analysis.

2.1 Creating the corpus of relevant academic literature

To collect the relevant corpus of academic publications, we used the Scopus database since it has the broadest coverage compared to other databases such as Web of Science (WoS). We used a combination of keywords to create the search query that was used on the Scopus database to retrieve the relevant academic output. Our inclusion criteria included the following – (a) only English language publications, (b) only journal articles and conference papers, and (c) only papers that were returned based on running our search query on the combination of title, abstract, and keywords. The following combination of keywords was used to extract the relevant papers:

> TITLE-ABS-KEY ("artificial intelligence" OR "intelligent systems" OR "AI" OR "machine learning" OR "robot" OR "automation" OR "big data" OR "neural network*" OR "text mining" OR "natural language processing" OR "data mining" OR "soft computing" OR "fuzzylogic" OR "biometrics" OR "geotagging" OR "wearable*" OR "IoT" O R "internet of things" OR "Artificial neural network" OR "case-based reasoning" OR "cognitive computing" OR "cognitive science" OR "computer vision OR "data science" OR "deep learning" OR "expert system" OR "fuzzy linguistic modelling" OR "genetic algorithm" OR "image recognition" OR "k-means" OR "knowledge-based system" OR "logic programming" OR "machine vision" OR "neural network" OR "pattern recognition" OR "recommender system" OR "semantic network" OR "speech recognition" OR "support vector machine" OR "SVM" OR "text mining" OR "algorithms" OR "decision support system" OR "business intelligence" OR "business analytics" "unsupervised learning" OR "supervised learning" OR "reinforcement learning" OR "computer vision" OR "natural language processing" OR nlp OR "self learning" OR "transfer learning" OR "logic programming" OR "Responsible AI") AND TITLE-ABS-KEY ("poverty* alleviation" OR "reduce* poverty" OR "poverty reduction" OR "poverty elimination" OR "poverty mitigate*" OR "poverty eradicate*" OR "energy poverty" OR "energy shortage" OR "energy access" OR "fuel poverty" OR "energy vulnerability" OR "energy deprivation") AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English"))

The preliminary search led to the identification of 991 articles, after which the title and abstract of each of these articles was studied to decide on their relevance for this study. In cases where a reading of the abstract was not sufficient to take the inclusion / exclusion decision, the entire manuscript was studied. The areas like Mathematics, Physics and Astronomy, Medicine, Biochemistry, Genetics and Molecular Biology, Chemical Engineering, Chemistry, Arts and Humanities, Neuroscience, Immunology and Microbiology, Psychology, Health Profession, Nursing, Pharmacology, Toxicology and Pharmaceutics, Veterinary, which were less related to AI and poverty were first separated out and their abstracts and the full papers (if abstract lacked sufficient information) were examined. Related areas like Engineering, Computer, Science, Energy, Environmental Science, Social Sciences, Earth and Planetary Sciences, Decision Sciences, Business, Management and Accounting, Materials Science, Agricultural and Biological Sciences, Economics, Econometrics and Finance were reviewed for abstracts and if the abstract lacked sufficient details to confirm these requirements, we reviewed the entire manuscript to double-check it. None of the papers were out right disqualified and all papers were thoroughly examined before disqualifying. After this procedure, we had 205 studies left over for bibliometric evaluation. Out of the 205 articles 31.7% were conference papers and the rest of the articles were from journals.

2.2 Conducting the bibliometric analysis

We used both *Bibliometrix* (an R-based software package) and *VOS Viewer* to conduct the bibliometric analysis in order to identify the overall intellectual structure of this research field (Donthu et al. 2021; Zupic and Čater 2015). While numerous software programmes, including CiteSpace, VOSViewer, Bibexcel, SciMAT, CitNetExplorer, and others, can be used to do bibliometric analysis, most of them are labour-intensive and unable to support researchers in completing the necessary workflow for analysing literature. In contrast, Bibliometrix, a recently created R-environment based software package, is more flexible and incorporates the graphical features of several bibliometric tools. Vos Viewer was also used for some parts of the analysis along with R as it provides useful visualisations and also generates some of the networks which cannot be generated in R software. First, a metrological study of publications,

journals, researchers, institutions, and countries in the is carried out. Second, content analysis, and thematic analysis which combines keyword and citation analysis, were employed to identify the hot issues, thematic evolutions, and focus areas of AI in poverty research from, in order to examine the intellectual structure.

We used citation analysis to indicate the journals, papers, organisations, and authors that were the most pertinent, and co-citation analysis to illustrate how the material was connected. In addition, as a supplement to the study, we used keyword co-occurrence, a conceptual theme map, three fields plot and thematic evolution to confirm the historical evolution of the citations and the intellectual structure of the field.

2.3 Conducting the manual content analysis

Following the bibliometric analysis, we also did a manual evaluation of the content in their identified corpus of literature by applying the thematic analysis method (Braun and Clarke 2006). Thematic analysis broadly comprises six phases – (a) familiarization with the data, (b) generation of initial codes, (c) search for themes, (d) review of the themes, (e) definition and naming of the themes, and (f) production of the research report (Braun and Clarke 2006; Nowell et al. 2017). We familiarized ourselves with the collected corpus of papers through repeated readings and looked for patterns and meanings that were explicit in the data. Then, we generated initial codes from the collected papers and organized the codes into meaningful groups based on the convergence in their meanings. Further, we combined the set of initial codes to arrive at a set of themes.

3 Findings and Analysis

3.1 Findings of the bibliometric analysis

The bibliographic coupling analysis, keyword co-occurrence, and conceptual theme map were first used to understand the historical evolution of the citations and the intellectual structure of the field. The final corpus of 205 articles had 688 authors, and 156 sources associated. Interest in this

research is rapidly increasing, evidenced by an average yearly growth rate of 19.84 %. The research in this domain has gathered pace especially after 2017.

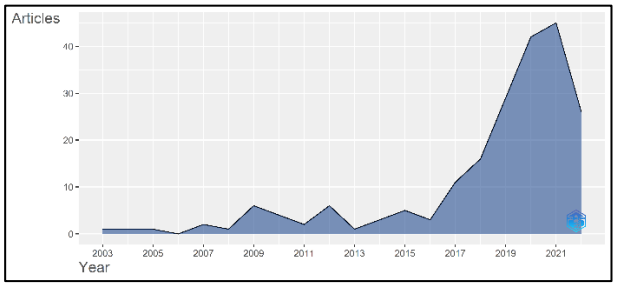

Figure 1: Annual scientific production in the domain

The bibliometric citation analysis then revealed the most pertinent journals, papers, relevant organizations, and influential scholars working in this domain. For example, the three most significant schools producing research in this domain were found to be – (a) The China University of Geosciences, (b) University of Science and Technology of China, and (c) The Uppsala University. One interesting observation was that a significant number of organizations conducting research in this domain belong to developing and emerging economies. Analysing the keyword frequency, we found that *big data*, *agriculture*, and *agricultural robots* were some of the most frequently occurring keywords.

The co-citation analysis network comprised 19 nodes in total, and five separate clusters (each representing a different sub-domain) were formed. The red and blue clusters use AI and machine learning (ML) algorithms in conjunction with remote sensing and satellite imagery to analyse the spatial data and identify regions most affected by poverty. The orange cluster comprises the articles that are related to the role of AI in dealing with fuel poverty. The green cluster comprises articles related to policies formulated for tackling poverty while the articles in the violet cluster are concerned with multidimensional poverty measurement.

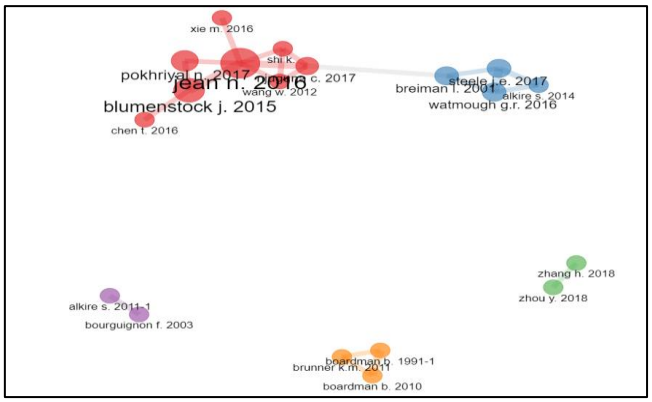

Figure 2: Co-citation analysis network

The keyword co-occurrence network and its analysis revealed findings that were correlated with the findings of the co-citation analysis. The maximum number of co-occurrences were set to a threshold of 5 and76 of them met threshold. Four clusters are shown by the network as shown in Figure 3. Most of the relevant terms are split between the 2 major clusters. These two major clusters are connected to those found in earlier analysis. Several terms related to Ai and poverty alleviation may be found in Blue and green clusters. These clusters include words related to artificial intelligence and its sub domains like “machine learning”, “big data” etc. Therefore, we can say these clusters focus on AI related methods for poverty alleviation. Along with words related to AI and its sub domain blue and green clusters also include words like “poverty alleviation”,” fuel poverty” and several other phrases related to poverty and poverty alleviation. Phrases related to economy are included in red cluster, including "agriculture," "rural areas," and "developing country". Terms in yellow cluster is varied as it is connected to all other clusters.

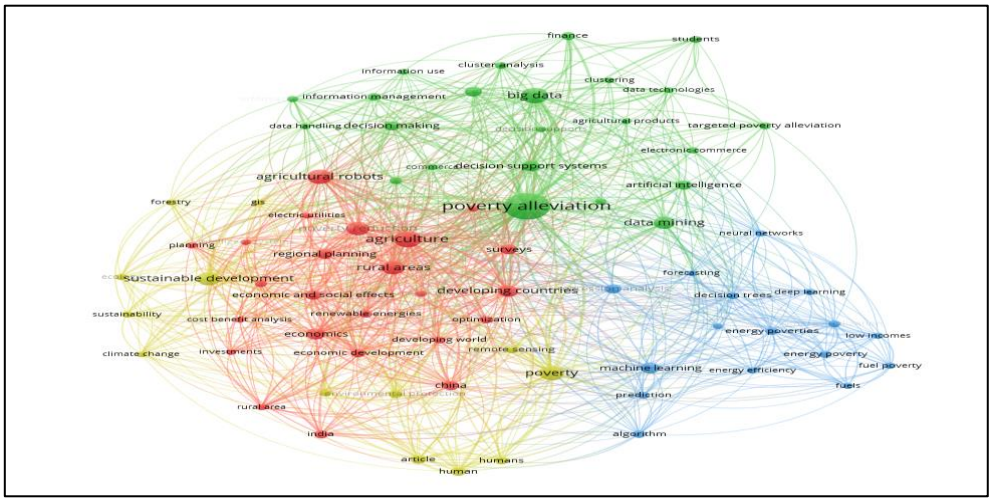

Figure 3: Keyword co-occurrence network

We also created a two-dimensional thematic map to identify the most important subject areas based on the keywords supplied by the authors of the various scholarly articles. The four quadrants of the thematic map comprise various subject areas based on their low-high values on the parameters of density and centrality. Thus, we find that the *common themes* (quadrant 1) are subjects related to poverty and sustainable development. The weakly established or developing themes (Quadrant 4) include regression and other statistical analyses of secondary data to identify the parts of a population which are most affected by poverty. Quadrants 2 and 3 are neither common nor developing topics, but lie somewhere in between. Here, we identified subject areas related to agriculture and optimization.

3.2 Findings of the manual content analysis

Finally, our thematic qualitative analysis of the articles revealed that AI technologies are found to have two types of impacts on poverty alleviation related issues – (a) direct, and (b) indirect. We found that

the direct impacts include – (a) technological solutions, and (b) formulation of acts and policies, while the indirect impacts include – (a) remote area development, (b) educational solutions, (c) agricultural solutions, and (d) energy and fuel related solutions.

Thus, we unpack the impact of AI on poverty alleviation in terms of two distinct aspects – direct effects (without any intermediary mechanisms) and indirect effects (characterised by the presence of intermediary mechanisms). In the case of the direct effects, AI acts as a technological solution that helps measure poverty and related aspects in a particular region, thus allowing for the formulation of appropriate policies and regulations to tackle poverty-related issues. On the other hand, AI also has the potential to address poverty-related issues by helping frame solutions in terms of developing remote areas, appropriate educational and agricultural interventions, and also by tackling issues related to energy and fuel.

4 Implications and Conclusion

The objective of this paper was to examine how the extant academic literature has studied the role of AI technology on issues related to poverty alleviation, which is one of the most critical sustainable development goals proposed by the United Nations. We used a combination of bibliometric analysis techniques and thematic analysis to examine the extant literature. We identified a number of themes and thrust areas in order to bring out the key areas that have been focused on so far, and the key areas which need more attention from academic research as well as managerial practice.

This study has shown that by increasing poor population's access to government, financial, educational, and health services, Artificial intelligence (AI) can help eliminate poverty (Cecchini and Scott 2003). Moreover, government efforts, legislative decisions, as well as the choices made by designers and users of AI in high-tech firms and sectors, will ultimately determine how AI will affect the world's poor. Also, while developing AI applications and putting them into practise, they must take the demands and interests of the poor into account. The societal effects of AI adoption will also be influenced by how government organisations adapt to these developments through legislation and social safety net initiatives. Finally, educational institutions need to prepare university students for a future of sustainable development, corporate social responsibility, and poverty alleviation which will have a significant influence in solving poverty related problems. These findings are in line with those in Goralski and Tan (2022).

This paper potentially makes a number of important contributions to theory and practice. First, while there is some research on the role of AI in helping achieve the SDGs, there is limited understanding on the impact of AI pertaining to specific SDGs. So, this study selects the first SDG (i.e., “no poverty”) and seeks to understand the role that AI can play in alleviating the same. Thus, we add to the current literatures on the value of emerging technologies of AI, which have utilized more commercial outcomes typically. Second, this study brings out the key role that technologies in general, and AI in particular, can play in helping achieve social good and sustainable outcomes, thus adding to our present understanding of the drivers of sustainable development. Third, we open the black box of AI for social good, by identifying specific direct and indirect mechanisms through which AI can help alleviate poverty and related issues. This can helpful for organizations in designing better action plans and policies while trying to leverage AI for social good, specifically poverty alleviation.

There are certain limitations of this research-in-progress paper. First, we are still in the process of analysing the extant literature using the thematic analysis method – thus the proposed conceptual framework may evolve further. Second, the use of more databases to collect the corpus of relevant literature could be explored, since our analysis is based solely on the Scopus database.

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