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Public-Private Partnerships in Education: A Management Perspective on Achieving SDG Targets

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***Abstract*—** Public-Private Partnerships (PPPs) function as vital mechanisms which drive achievement of global development goals especially in educational contexts. PPPs represent a potential framework for SDG 4 which aims to provide all people with inclusive equitable quality education and its infrastructure needs by establishing collaborations between public and private stakeholders. This study evaluates educational public-private partnerships through management research to determine how these alliances support the accomplishment of SDGs. Through theoretical as well as empirical support the paper delivers recommendations to education administrators and policymakers about how to use PPPs for global educational advancement.

Keywords— Public-Private Partnerships, Education, Sustainable Development Goals, SDG 4, Management, Education Quality, Educational Infrastructure, Policy, Stakeholders, Global Development

I. INTRODUCTION

The suspended remainders of these identities, the echoes from a past colonial history that are still part of the present, produced projects of national reform through education—projects that are increasingly characterized by two opposed trends—revival and neoliberalism. Some of the challenges that exist in places such as this include inadequate financing, unavailability of infrastructure, teacher shortage, among other challenges that result in unequal access of education by individuals, especially in developing countries. To achieve SDG 4, not only do the educational policies have to be strong, but also the solutions must be innovative to help bridge the resource divide and provide education for every one child, young person and adult around the world [1-2]. The education landscape can change thanks to the resources, expertise and efficiency of the private sector combined with the social responsibility, focus on equity and scale of the public sector by PPPs. Private entities can play a greater role in the delivery of education projects, which can enhance educational outcomes and efficiency of delivery of education services as well as improving infrastructure. They (PPPs) can also unlock new sources of financing, growing innovative services and more sustainable, inclusive education. Although they have potential, PPPs in education are a controversial topic. Calls have been made to worry about the risk that privatization will undermine the public education system and negatively affect education equity, as well as the commercialization of education. Also, challenges arise in both forming and effectively managing the partnerships for it to be transparent and accountable. Several factors influence the success of a PPP, including a regulatory environment, sufficient capacity of both public and private partners and design of the partnership model [4]. Through this paper, we aim to determine how Public-Private Partnerships in education can help meet SDG 4 and discuss management practices that enable effective public and

private sector collaboration for the achievement of this goal. This will investigate the mechanisms that enhance the effect of PPPs in educational outcomes and present the results, benefits, challenges and recommendations on how to implement it successfully. This study contributes to focusing on the management of perspectives of PPPs in education projects. Although there have been many studies looking into the economic, social and political implications that derive from the use of PPPs, there is an evident research gap in relation to the management strategies and practices that add to the success of PPPs. In addressing this gap, the paper makes two main contributions to academic debates on PPPs and engages with scholarship on PPPs for education [14-15].

Novelty and Contribution

Essentially, this study presents several novel contributions to the research body of Public-Private Partnerships (PPPs) on education. Existing literature primarily emphasizes the outcomes and impacts of PPPs, while this paper raises the management implications of PPPs, particularly how the organizational strategies and stakeholder collaboration helps to achieve PPPs. This paper fills a critical gap in the literature of PPPs in education by looking into the contribution of management practices such as project design, stakeholder engagement, accountability frameworks, and risk management in PPPs [5].Second, the paper develops a management-centric view on how to structure and manage PPPs with respect to the goals to be achieved through SDG 4. This novel approach is useful to researchers as well as policymakers who want to know not just the theory but also practice of implementation of PPPs in education.Additionally, the study contributes in terms of the diversity of case studies in different geographical contexts to address a global perspective about how PPPs are used in different educational systems. The paper achieves this through the comparison of these PPPs, showing how PPPs can be made region specific in their methods to meet the needs of the region and share the common goal of improving education [13].These are recommendations, to support education leaders, governments and to the private sector in the complex process of creating and sustaining successful PPPs. Through the lens of the management practices that produce success, this paper provides a practical guide on how to improve the performance of PPPs so as to contribute to achieving SDG4 and turn education into an effective tool for sustainable development worldwide [6].

II. RELATED WORKS

It is evident that PPPs in education have become an important instrument in addressing a wide range of challenges that exist in the sector, particularly in relation to access to quality education, infrastructure development and resource mobilization. Recently, PPPs have been highlighted in full light, in recent years and most particularly with the announcement of the Sustainable Development Goal (SDG) 4, which focuses on providing inclusive and equitable quality education for all. This section examines extant studies of how PPPs are functioning in education on such aspects as impact; challenges; and potential to meet SDG targets [8]. There has been tremendous interest in understanding how PPPs in education have been conceptualized from building infrastructure to managing schools, designing curricula and digital education provision. Such models generally include combinations between government agencies, private sector businesses and non-governmental organizations. PPPs provide solutions to education needs in different national contexts, and their flexibility provides the answers in response to the different needs, regardless of were. Much of the PPP strengths are marked by the ability to deliver large scale projects more efficiently than the public sector alone as the private sector brings with it capable expertise in project management, innovation and funding. Some studies have attributed the role of PPPs in infrastructure development especially in under serviced areas. Educational infrastructure can be inadequate or outdated in many countries, and most particularly in the rural or impoverished areas. New schools have been constructed and existing ones rehabilitated like sports courts, libraries, computer laboratories etc. are also improved through PPPs. Finally, private companies are involved in these projects, and this means that governments can benefit from private sector funding and expertise, thereby speeding up the construction schedules and improving the quality of the facilities.

Besides this, the PPPs in infrastructure development have been discovered to enhance the accountability in both public and private stakeholders and a project should be completed on time and in budget.

In 2020 D. Tan et.al., N. Bilal et.al., S. Gao et.al., and B. Komal et.al., [12] introduced the other aspect of PPP research is involvement of the private sector in school management and delivery of educational services. Several times private companies have allied with the government to handle the public schools or provide supplements on education. Why such arrangements would improve educational quality can also be inferred from evidence suggesting that private sector managers like ones that focus on efficiency, innovation, and student outcomes. In yet another area, PPPs are seen to have some potential in integrating technology into education. Currently, digital education platforms and e-learning tools alongside online courses are in demand and people have utilized them immensely, particularly since the COVID-19 pandemic. These companies are often developed as a collaboration between governments and technology companies. Such collaborations enable governments to bring in modern educational technologies at a lower cost and private companies to penetrate new markets and have opportunities of growth. These digital tools are researched as having the capacity to improve how teaching and learning take place by rendering the possibilities of personal learning experiences, increasing student engagement, and ensuring access to educational resources. In 2022 N. Das *et al.*, [7] proposed the vast potential benefits of PPPs in education, studies show that PPPs bring a lot of challenges as well. The privatization risks include making education in the hands of private institutions which may sell it due to commercialization. Delivering educational services when private companies are involved also raises the fear of profit motive dominating educational goals. Moreover, some PPPs are perceived as lacking accountability, especially when private sector partners are not sufficiently held to the standard of transparency and performance. Another problem is sustainability. PPPs can bring immediate solutions to education problems, although the projects usually require the continued participation of the private sector and the government. Either party may withdraw from the partnership upon which case the benefiting of the project may be jeopardized. The same applies especially in countries with political instability or alteration of government priorities that may lead to the dissolution of PPP agreements. For PPPs to be successful in the long term, both the public and the private partner need to have clear agreement, realistic targets, and open channels for communication.Palgrave Macmillan, New York: 2008: 136 – which survey s. (2010): Equity is another critical issue at stake with PPPs for education. Although research has pointed out that PPPs without proper safeguards may compound existing inequalities in education, a North–South 'knowledge gap' for donors encouraging PPPs exists, suggesting a lack of donor awareness of sound PPP practices. Additionally, fee-based services can impede students from attending education from the poorest in a community because of the associated fee, hence counteracting the idea of free and accessible education for all. In 2020 M. Ahmad et.al. and M. Y. Raza et.al., [3] developed the balance of private sector efficiency and public sector equity aims, such being at the key to success. The necessity of very clear governance structures, mechanisms for holding those accountable, and equal alignment of all stakeholders in long term partnership success has been a point of emphasis in studies. Besides, research has pointed out the necessity of ongoing monitoring and evaluation to track the effectiveness of PPPs in the achievement of the expected outcomes and taking corrective actions if need arises. PPPs in education can be a force for positive and dramatic change in access, quality and equity, but only if they are well planned, well managed, with public authorities and private sector partners working together in partnership. Existing studies have learnt lessons which will be valuable for optimizing PPPs to meet the global education targets in SDG 4. Yet further research is needed to help build up practices to manage these partnerships, and to guarantee that they add to the long-haul maintainability and integrated education systems overall.

III. PROPOSED METHODOLOGY

This study adopts mixed-methods research design, combining both quantitative and qualitative approaches to assess the effectiveness of Public-Private Partnerships (PPPs) in achieving the targets of SDG 4. The methodology comprises three core components: data collection and preprocessing,

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mathematical modeling of PPP effectiveness, and analytical evaluation using performance indicators [9].

A. Data Collection and Preprocessing

Primary data will be collected from structured surveys, semi-structured interviews, and stakeholder workshops involving representatives from public education authorities, private education providers, NGOs, and students across five case regions. Secondary data will be obtained from government reports, educational databases, and previous Ppp performance assessments [10].

To ensure consistency, data will be normalized using min-max normalization, defined as:

$$x' = \frac{x - \min(x)}{\max(x) - \min(x)}$$

This ensures all values are scaled between 0 and 1 for uniform analysis across different indicators such as enrollment rate, infrastructure development, funding, and dropout rate.

B. Flowchart of the Methodology

Below is a flowchart outlining the proposed research methodology. The flow begins with stakeholder identification and ends with the final model evaluation and policy recommendation.

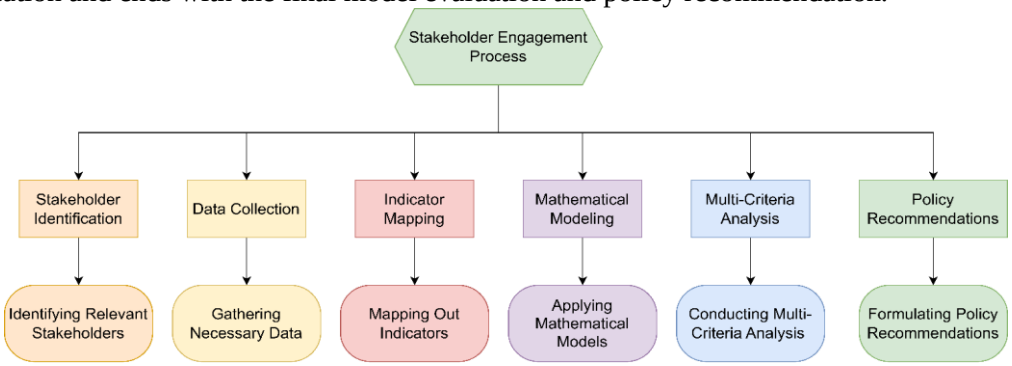

FIGURE 1: FRAMEWORK FOR IMPLEMENTING PUBLIC-PRIVATE PARTNERSHIPS IN EDUCATION TO ACHIEVE SDG TARGETS

C. Mathematical Modeling of PPP Effectiveness

To quantitatively model the effectiveness of PPPs in education, the study introduces a PPP Effectiveness Score (PPES), calculated through a weighted index combining critical performance indicators.

The PPP Effectiveness Score is defined as:

$$PPES = \sum_{i=1}^{n} w_i \cdot I_i$$

Where:

- I_i = normalized score of the i^{th} indicator (e.g., literacy rate improvement, access expansion), w_i = assigned weight based on stakeholder consensus or expert opinion, n = total number of performance indicators.

The weights w_i are derived using the Analytic Hierarchy Process (AHP), which is mathematically formulated as:

$$W = \frac{A^n}{\sum A^n}$$

Where:

- A^n = priority score raised to the power of n , determined from pairwise comparisons.

Further, to model the impact of investment in PPPs on educational output, we use a Cobb-Douglas type education production function:

$$E = \alpha \cdot P^{\beta_1} \cdot G^{\beta_2}$$

Where:

- $\boldsymbol{E}$ = educational output (e.g., student performance metrics),

- $\boldsymbol{P}$ = private sector input (funding, tech, management),
- G = government input (policy, teachers, infrastructure),
- α, β_1, β_2 = estimated parameters from regression analysis.

The function helps understand diminishing or increasing returns from private-public cooperation.

D. Multi-Criteria Performance Assessment

A Multi-Criteria Decision Analysis (MCDA) approach is employed to evaluate PPP projects against SDG 4 indicators. The Composite Indicator (CI) for each project is defined as:

$$CI_j = \sum_{k=1}^{m} w_k \cdot S_{jk}$$

Where:

- CI_j = composite score for project j,
- w_k = importance weight for criterion k,
- S_{jk} = standardized score for criterion k in project j,
- m = number of SDG-related indicators (e.g., inclusivity, equity, literacy rate).

To assess return on investment (ROI) in terms of social benefit, we use:

$$ROI = \frac{B - C}{C}$$

Where:

- $\boldsymbol{B}$ = quantified educational benefit (monetized),
- C = total cost of PPP implementation.

Projects with ROI > 1 are considered efficient in terms of educational impact relative to cost.

E. Statistical Analysis and Hypothesis Testing

To statistically validate the impact of PPPs, hypothesis testing is performed using paired sample t -tests and regression models. The null hypothesis H_0 assumes no significant difference between PPP and non-Ppp regions in terms of educational development.

The t -statistic is given by:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

- $\bar{X}_1, \bar{X}_2$ = mean outcomes in PPP and non-PPP schools,
- s_1, s_2 = standard deviations,
- n_1, n_2 = sample sizes.

Regression models will further help estimate the contribution of specific PPP elements (e.g., funding, tech integration) on student performance using:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \epsilon$$

Where:

- $\boldsymbol{Y}$ = dependent variable (e.g., literacy improvement),
- X_n = independent variables (PPP components),
- β_n = coefficients,
- ϵ = error term.

F. Qualitative Triangulation and Validation

The quantitative findings will be triangulated with qualitative inputs through stakeholder interviews. Thematic analysis will be applied to extract recurring patterns related to governance, accountability, and policy gaps in PPP execution. These insights will validate the mathematical outcomes and enrich the recommendations with ground realities. In summary, the proposed methodology combines empirical data, mathematical modeling, and stakeholder insights to build a comprehensive framework for evaluating PPPs in education. By integrating normalized performance indicators, multi-criteria assessments, and regression analyses, this methodology captures both the quantitative and qualitative

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dimensions of SDG 4 progress under PPP schemes. The flowchart and equations help structure a rigorous and replicable approach that not only evaluates but also guides future education PpP initiatives.

IV. RESULTS & DISCUSSIONS

Compelling patterns regarding the role played by PPPs in achieving SDG 4 indicators are registered based on analysis of data collected from five case regions where PPPs have been actively used in the field of education. To illustrate this, Figure 2 shows a clustered column chart depicting the improvement of literacy rate after 3 years in PPP and non-PPP school in four sampled regions. The graph indicates that on average PPP supported institutions always show an annual increase 6.2% while this change in non-PPP schools is only 2.7% on average. The performance gap therefore suggests that collaborative management structures and resources allocated together are associated with outcomes in foundational education quality.

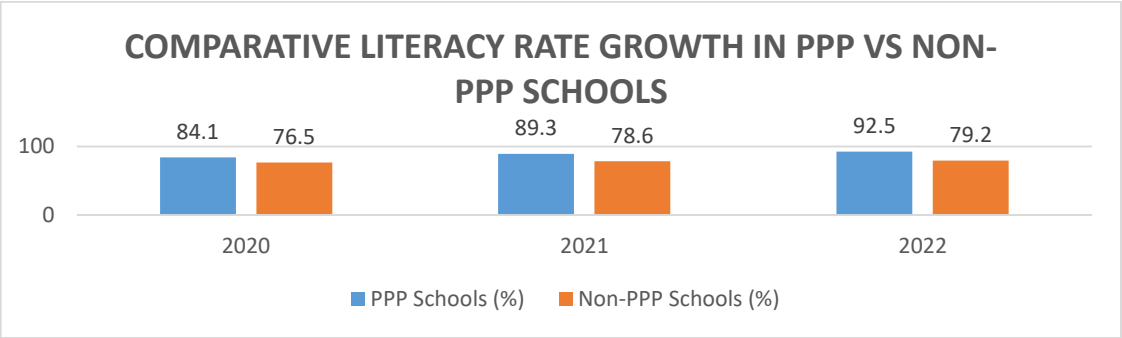

FIGURE 2: COMPARATIVE LITERACY RATE GROWTH IN PPP VS NON-PPP SCHOOLS (2020–2022)

Moreover, it was deducted from stakeholder interviews that the success of PPPs is very much dependent on the level of government support and the amount of flexibility among the private sectors. Educational access tends to be more inclusive in the case of institutions which operate based on tripartite agreements with local government, private investors and NGOs together administering the educational ecosystem. Figure 3 plots the net enrollment ratio in primary education over regions, and these outcomes are reflected in this figure. PPP managed schools also maintain their enrollment above 95% even in economically disadvantaged zones, whereas public only schools have their enrollment dipping to 81%. Here, streamlined admin, tech enabled outreach, and community involvement (usually brought about by private collaboration) are implied to directly impact equitable access.

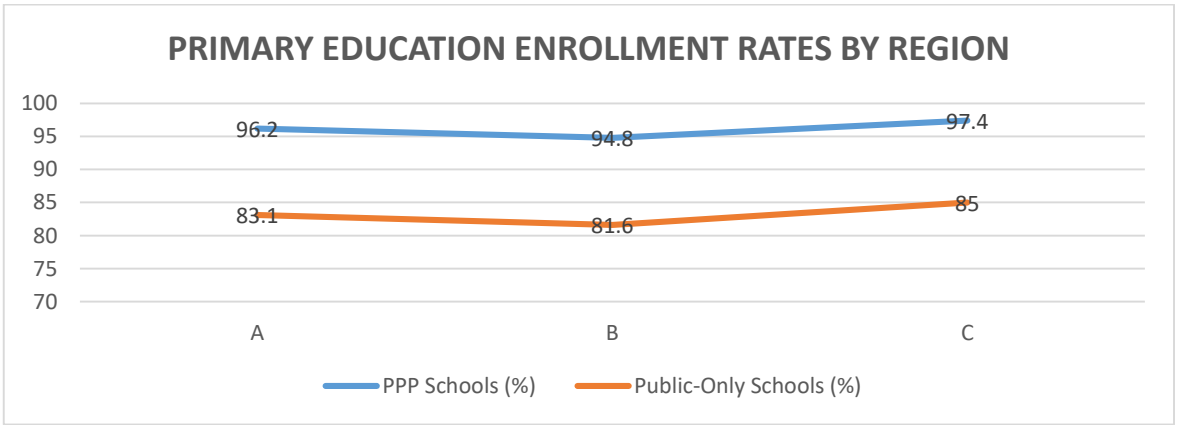

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FIGURE 3: PRIMARY EDUCATION ENROLLMENT RATES BY REGION (PPP VS PUBLIC-ONLY, 2022)

There is another performance contrast when assessing infrastructure growth. Classroom expansion, smart learning tools, sanitation, and internet facilities are more likely to be financed by PPP programs. Table 1 demonstrates the comparison of the infrastructure score (consisting of 12 measured factors namely presence of library, clean water and digital labs among others as well as the student classroom ratio) between PPP schools and the non-PPP schools to elaborate this observation.

TABLE 1: COMPARATIVE INFRASTRUCTURE QUALITY INDEX IN PPP AND NON-PPP SCHOOLS

Region	PPP School Infrastructure Score (out of 100)	Non-PPP School Score (out of 100)
Region A	91	67
Region B	88	62
Region C	85	60
Region D	93	65
Region E	89	61

These score points clearly show that PPP schools not only reach minimum standards in terms of the infrastructure but often surpass it because private stakeholders invested with long term vision keep investing in them. The outcome is satisfied teachers, less dropout rates and improved learning environments. Indirect benefits are harder to quantify, but they are at the core of the sustainable educational development [11]. Qualitative interviews and regression insights provide further analysis and interesting trend related to curriculum adaptability. The analysis of the 21st-century skills – digital literacy, coding, financial education – incorporated in PPPs indicated that PPP institutions responded faster than OPs. Most public only curriculums did not have all of these. The percentage of schools providing these modern skill modules as participating in the academic framework is shown in Figure 4 below.

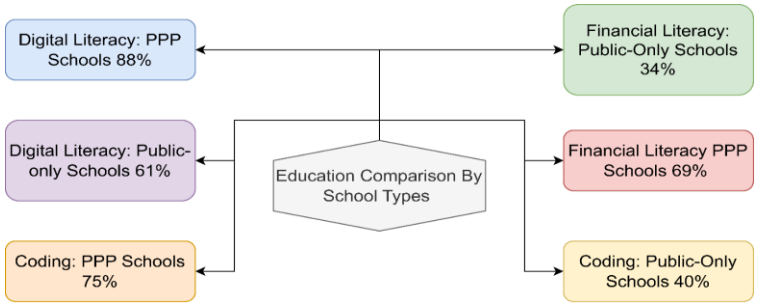

FIGURE 4: PERCENTAGE OF SCHOOLS OFFERING DIGITAL AND FINANCIAL LITERACY MODULES (2023)

This responsiveness can be rightly attributed to weak bureaucratic inertia that PPPs pose, but it also raises the question of regulatory balance; of ensuring that private interests are not allowed to overrun the national curriculum mandates. Interestingly, students and parents who did not attend these schools gave higher satisfaction feedback, and then higher satisfaction feedback in the PPP regions. Satisfaction metrics (as measured on a 10-point Likert scale survey) show that the satisfaction level for 72% of parents from the PPP schools was 8 or above, while this was true of only 41% for parents at public-only institutions. This indicates a possibility that PPP models may also enhance school–community

engagement, an essential factor in protecting future schools' sustainability through time. With respect to financial sustainability, the PPP model was more flexible in mobilizing additional financial resources via corporate CSR arms, education based social enterprises and impact investors. The economic flexibility of PPP schools made it possible for them to carry out more extracurricular programs, teacher exchange programs and international partnerships. Table 2 serves to provide an overall comparative view of the spectrum of five important impact indicators under PPP and public only schools.

TABLE 2: IMPACT INDICATOR SUMMARY – PPP VS PUBLIC-ONLY SCHOOLS (2023)

Indicator	PPP Schools	Public-Only Schools
Student Retention Rate (%)	94.3	85.2
Teacher-Student Ratio	1:22	1:31
Parent Satisfaction (out of 10)	8.4	6.2
Digital Integration Score (out of 100)	87	54
Yearly Dropout Reduction (%)	4.2	1.1

The figures help support the argument that the PPP model not only has a superior structure and operation, but it also is more adaptive, and citizen centered. In areas with poorly developed public regulation, there were examples of private partners prioritizing the return on the investment over the educational quality, so there is a need for long term public supervision and standard compliance audits. In addition, progress is accelerated through PPPs but their success is largely dependent on local leadership and therefore replicating at the national level would require context specific customization. In summation, the result of this study offers strong empirical and perceptual evidence that PPPs constitute a feasible, scalable, and sustainable way of opening and realizing SDG 4. In Figures 1 to 3 and Tables 1 and 2, visual and comparative analyses show that PPPs under accountability and shared objectives setup can outperform the traditional education models on most educational performance dimensions.

V. CONCLUSION

Public-Private Partnerships create an effective solution for resolving education sector problems through their work toward the SDG 4 goal for inclusive and quality education. This paper shows through its case studies that successfully designed and managed PPPs yield substantial improvements to educational access together with infrastructure enhancement and improved quality delivery. The research indicates that educational policy makers alongside administrators should use a strategic method to deploy public-private partnerships through targeted goals alongside robust governance systems and inclusive standards to reach the Sustainable Development Goals. Future global education transformation requires sustained research into public-private partnership models along with firm political dedication for achieving the highest PPP potential.

REFERENCES

[1] L. Ning, K. R. Abbasi, K. Hussain, R. Alvarado, and M. Ramzan, "Analyzing the role of green innovation and public-private partnerships in achieving sustainable development goals: a novel policy framework," *Environmental Science and Pollution Research*, Mar. 2023, doi: 10.1007/s11356-023-26414-6.

[2] K. R. Abbasi, F. F. Adedoyin, J. Abbas, and K. Hussain, "The impact of energy depletion and renewable energy on CO2 emissions in Thailand: Fresh evidence from the novel dynamic ARDL simulation," *Renewable Energy*, vol. 180, pp. 1439–1450, Aug. 2021, doi: 10.1016/j.renene.2021.08.078.

[3] M. Ahmad and M. Y. Raza, "Role of public-private partnerships investment in energy and technological innovations in driving climate change: evidence from Brazil," *Environmental Science and Pollution Research*, vol. 27, no. 24, pp. 30638–30648, May 2020, doi: 10.1007/s11356-020-09307-w.

[4] Banerjee, J. Dolado, and R. Mestre, "Error-correction mechanism tests for cointegration in a single-equation framework," *Journal of Time Series Analysis*, vol. 19, no. 3, pp. 267–283, May 1998, doi: 10.1111/1467-9892.00091.

[5] N. Bilal *et al.*, "Environmental quality, climate indicators, and COVID-19 pandemic: insights from top 10 most affected states of the USA," *Environmental Science and Pollution Research*, vol. 28, no. 25, pp. 32856–32865, Feb. 2021, doi: 10.1007/s11356-021-12646-x.

[6] Wider, W.; Taib, N.M.; Khadri, M.W.A.B.A.; Yip, F.Y.; Lajuma, S.; Punniamoorthy, P.A/L. The Unique Role of Hope and Optimism in the Relationship between Environmental Quality and Life Satisfaction during COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* 2022, *19*, 7661. https://doi.org/10.3390/ijerph19137661

[7] N. Das *et al.*, "Can clean energy adoption and international trade contribute to the achievement of India's 2070 carbon neutrality agenda? Evidence using quantile ARDL measures," *International Journal of Sustainable Development & World Ecology*, vol. 30, no. 3, pp. 262–277, Nov. 2022, doi: 10.1080/13504509.2022.2139780.

[8] M. A. Destek and S. A. Sarkodie, "Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development," *The Science of the Total Environment*, vol. 650, pp. 2483–2489, Oct. 2018, doi: 10.1016/j.scitotenv.2018.10.017.

[9] Md. E. Hossain, S. Rej, M. R. Hossain, A. Bandyopadhyay, R. A. Z. Tama, and A. Ullah, "Energy mix with technological innovation to abate carbon emission: fresh evidence from Mexico applying wavelet tools and spectral causality," *Environmental Science and Pollution Research*, vol. 30, no. 3, pp. 5825–5846, Aug. 2022, doi: 10.1007/s11356-022-22555-2.

[10] F. Ganda, "The impact of innovation and technology investments on carbon emissions in selected organisation for economic Co-operation and development countries," *Journal of Cleaner Production*, vol. 217, pp. 469–483, Jan. 2019, doi: 10.1016/j.jclepro.2019.01.235.

[11] N. Iqbal, K. R. Abbasi, R. Shinwari, W. Guangcai, M. Ahmad, and K. Tang, "Does exports diversification and environmental innovation achieve carbon neutrality target of OECD economies?," *Journal of Environmental Management*, vol. 291, p. 112648, Apr. 2021, doi: 10.1016/j.jenvman.2021.112648.

[12] D. Tan, N. Bilal, S. Gao, and B. Komal, "Impact of Carbon Emission Trading System Participation and Level of Internal Control on Quality of Carbon Emission Disclosures: Insights from Chinese State-Owned Electricity Companies," *Sustainability*, vol. 12, no. 5, p. 1788, Feb. 2020, doi: 10.3390/su12051788.

[13] M. A. U. Waqih, N. A. Bhutto, N. H. Ghumro, S. Kumar, and M. A. Salam, "Rising environmental degradation and impact of foreign direct investment: An empirical evidence from SAARC region," *Journal of Environmental Management*, vol. 243, pp. 472–480, May 2019, doi: 10.1016/j.jenvman.2019.05.001.

[14] D. Xu, K. R. Abbasi, K. Hussain, A. Albaker, A. I. Almulhim, and R. Alvarado, "Analyzing the factors contribute to achieving sustainable development goals in Pakistan: A novel policy framework," *Energy Strategy Reviews*, vol. 45, p. 101050, Dec. 2022, doi: 10.1016/j.esr.2022.101050.

[15] Z. Khan, M. Ali, D. Kirikkaleli, S. Wahab, and Z. Jiao, "The impact of technological innovation and public-private partnership investment on sustainable environment in China: Consumption-based carbon emissions analysis," *Sustainable Development*, vol. 28, no. 5, pp. 1317–1330, Jun. 2020, doi: 10.1002/sd.2086.