5-20-2024

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Recommended Citation

Merhi, M.I., Ahluwalia, P. The Role of E-participation, Human Capital, and Corruption-Free on Environmental Performance. Inf Syst Front (2024). https://doi.org/10.1007/s10796-024-10493-y

Information Systems Frontiers
https://doi.org/10.1007/s10796-024-10493-y

The Role of E-participation, Human Capital, and Corruption-Free on Environmental Performance

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Accepted: 19 April 2024

Abstract
There are many concerns at the global level about environmental performance. The United Nations has created a framework for measuring national development goals that enable environmental sustainability. This paper examines the relationships between technological and social factors as enablers of environmental performance and draws from technological determinism and human agency paradigms. It fills an important gap in the literature by empirically examining the hypothesized relationships. The specific examined factors are online service (maturity and quality), IT infrastructure, e-participation, corruption-free, and human capital. Environmental performance is the dependent variable. These factors are relevant to ten of the seventeen goals that the United Nations set in their SDG framework. The hypotheses are tested and validated using secondary data collected by reputable global institutions and PLS-SEM analytical procedures. The results indicate that technology can enable environmental performance directly and indirectly through e-participation. We also found that e-participation influences corruption-free and human capital that positively impact environmental performance. This paper provides significant implications for research and practice.

Keywords Environmental performance · Human capital · Corruption · E-participation

1 Introduction

There are increasing concerns about environmental sustainability among the research and scientific community, policymakers, and people in general. The increased urgency to evaluate environmental performance is reflected in the growth of literature, world forum discussions, and policies focused on environmental sustainability in recent years (Akande et al., 2019; Alraja et al., 2022; Janowski, 2016; Silal & Saha, 2021). Among the most notable recently developed artifacts is the framework developed by the United Nations (UN) for countries to achieve long-term environmental sustainability (United Nations, 2022). The UN has provided this framework for measuring progress through multiple Sustainable Development Goals (SDGs), which directly or indirectly enable environmental sustainability, comprising seventeen goals and 169 targets. Researchers in the Information Systems (IS) community have also aligned their efforts towards this important research area and have called for research that explores sustainable social development and practices that have become environmentally unsustainable (Walsham et al., 2007; Watson et al., 2021). This paper answers these calls by assessing the IS-centric macro-level factors that impact environmental performance. The factors examined in this paper impact ten of the seventeen goals included in the UN framework. Human capital is relevant to SDG 3: Good Health and Well-being and SDG 4: Quality Education. E-participation and Corruption-free are related to SDG 16: Peace, justice, and strong institutions. Telecommunication infrastructure and online service are relevant to SDG 9: Industry, Innovation, and Infrastructure. The Environmental Performance Index (EPI) is relevant to SDG 6: Clean Water and Sanitation, SDG 7: Affordable and Clean Energy, SDG 12: Responsible Consumption and

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Published online: 20 May 2024

Production, SDG 13: Climate Action, SDG 14: Life Below Water, and SGD 15: Life on Land.

The environmental performance index (EPI) has been selected as the main indicator of environmental sustainability in this study for several reasons. The EPI was first published in 2002 and has become the primary source of information regarding environmental performance, enabling the ranking of 180 countries on eleven performance indicators (Wolf et al., 2022). Secondly, many studies have incorporated the EPI into their research, further validating its applicability (Chakrabartty, 2018; Pimonenko et al., 2018; Rawal, 2019). Finally, the EPI continuously adapts to global proceedings, technology advancements, and political improvements to remain relevant in an ever-evolving global landscape.

Technological advancements have enabled governments to make investments in technologies and transform their interactions with the public from face-to-face to digital. There are many advantages to this digital transformation such as improving engagement and participation of the citizens in decision-making (Bertot et al., 2016; Merhi, 2023; Sharma et al., 2022), increasing trust (Pappas et al., 2023), fighting corruption (Addo & Avgerou, 2020; Das & Das, 2022), increasing human capital, and increasing sustainable development (Alraja et al., 2022; Dabbous & Tarhini, 2021; Estevez & Janowski, 2013; He et al., 2017).

In this research, we explore the role of corruption-free and human capital on environmental performance. Not many papers have examined the impact of digital transformation and ICT on environmental performance. Research has shown that corruption impacts various dimensions of human development and environmental sustainability factors including the health infrastructure due to poor management, increases infant mortality rates, increases income, health, and education inequalities, and deters environmental sustainability through the increase in CO2 emissions (Biswas et al., 2012; Gani, 2012; Gupta et al., 2002; Hassaballa, 2015; Ortega et al., 2016). To our knowledge, no study has yet examined the impact of corruption-free and human capital on environmental performance. Research has also not explored the role of technological factors, namely online service maturity, IT infrastructure, and e-participation in environmental performance. As mentioned earlier governments are implementing digital technologies to increase engagement, improve human development, and fight corruption. Using the conflicted relationship between technological determinism and the human agency paradigm, we investigate the role of technology as an antecedent to corruption and human capital. Our goal is to examine the indirect effect that technology can play in improving the environmental performance of nations. Based on this, we aim to answer the following research question:

- Does technology improve environmental performance through corruption-free mitigation and greater human capital?

We expect this research to help both scholars and practitioners. For researchers, this paper presents and assesses new relationships that have not been explored. The research model combines technological and social factors, thus bridging the IS literature to other areas. This paper also helps practitioners make informed decisions to fight corruption, enhance human capital, and improve environmental performance. The research model is very relevant for practitioners because it does not only focus on technology itself. It shows that technology can have a big role in society.

The remainder of this paper is organized as follows. First, we present background and a brief literature review of the important factors followed by the research model and the research hypotheses. Then, we discuss the methodology followed by the quantitative data analysis techniques used to test the hypotheses. Next, we discuss the findings, their implications for practice and research, and the limitations of the paper along with future research opportunities. Finally, we conclude.

2 Background and Literature Review

2.1 Environmental Sustainability and Performance

Environmental sustainability has been defined "as the development that meets the needs of the current without compromising the needs of future generations to meet their own needs" (WCED, 1987). This definition taps into the economic, social, and environmental dimensions of any system that may be evaluated for environmental performance. The emergent need for actions for environmental sustainability has brought into focus balancing short-term and long-term objectives and looking beyond the current return on investment or other related financial metrics. The implementation of sustainable practices is crucial in addressing environmental issues, and information systems play a vital role in this endeavor (Melville, 2010; Seidel et al., 2013; Watson et al., 2010). These systems offer significant capabilities such as automation, decision-making, sense-making, knowledge creation, and innovation (Butler, 2011; Dao et al., 2011; Seidel et al., 2017). These capabilities are essential for designing and implementing sustainable processes.

The research on environmental sustainability from an IS perspective is relatively nascent even though Melville (2010) proposed a framework for conducting IS research in this important area. The IS discipline has a unique opportunity to contribute to this giant problem facing human

society because it can investigate the technological, organizational, and social aspects of the problem (Watson et al., 2021). A review of the IS literature shows a range of studies, from innovating design science artifacts to proposing operational research models. Problems concerning IS and environmental sustainability include social, environmental, and behavioral dimensions. Accordingly, the units of analysis may include individuals, organizations, and social units of various granularity. This includes dealing with micro and macro-level factors and their interrelationships. Coleman (1986) has proposed a macro-micro-macro relations model for what he calls methodological individualism doctrine. The model posits that individual behaviors, beliefs, and perceptions (micro) are shaped by social structures in which individuals are situated (macro), and collective actions of individuals in turn shape the social systems or changes (macro). This model has been used widely, including in IS research. For example, Melville (2010) extended this model to include organizational factors and named it the belief-action-outcome (BAO) framework for conducting IS research on sustainability.

2.2 E-Participation

The E-participation concept is based on participation by citizens and other stakeholders in their governance processes using Information Communication Technologies (ICTs). The term is made up of two components, the "e" part and "participation." Participation of stakeholders in the governance of a social unit is known to be one of the essential elements of democracy and predates the emergence of ICT, however, the widespread diffusion of Internet-based technologies makes e-participation a very promising element of democratic processes. Naturally, this has generated significant interest in the research community in the last two decades. The evidence of the attractiveness and relevance of e-participation is reflected in the fact that there are dedicated academic conferences and journals focused exclusively on e-participation.

Interestingly, there is no universal definition of e-participation. According to Alrashedi et al. (2015), e-participation engages citizens in government decision-making, planning, and governance using ICT (Gronlund, 2001; Millard, 2009). In a review of the literature on e-participation, Wirtz et al. (2018) find five different definitions of e-participation. OECD defines e-participation as active participation in which citizens engage in defining the process and content of policymaking through a partnership with the government (OECD, 2011). Macintosh and Whyte (2006) focus on broadening and deepening the participation of citizens by making use of ICTs. Saebo et al. (2008) emphasize on extension and transformation of participation in "societal, democratic, and consultative processes mediated by ICT technologies." The definition put forward by the United Nations includes three elements, namely consultation, information, and decision-making. Thus, citizens are provided with information, they can take part in deliberations, and influence decision-making. The definition of the European Commission is similar to that of the United Nations as it emphasizes the ICT technologies making it easy for the citizens to engage in politics and policymaking.

Because of its multi-disciplinary character, researchers across disciplines have studied e-participation - from Political Science to IS. An important goal of e-participation is to create an ongoing dialogue between citizens and the government (Ahangama, 2023; Charalabidis & Koussouris, 2012; White, 2015). A review of the e-participation literature shows that e-participation received a push because of the widespread deployment of the Internet (Saebo et al., 2008). In terms of the relationship between ICT and e-participation, the findings did not always converge. For example, (Ergazakis et al., 2011; Themistocleous et al., 2012; Kamal, 2009) suggest that the deployment of effective ICT infrastructure was a significant antecedent of e-participation. On the other hand, setting up web-based ICTs as one-way delivery of information did not affect e-participation (Saebo et al., 2008). Other factors that drive e-participation have been examined. For example, technical competence has been found to have a positive effect on e-participation (Medaglia, 2012). A significant body of research shows that technology by itself may not drive e-participation and that trust in government and institutions, responsiveness, competence, engagement, commitment, security, and accessibility have been found to influence e-participation (Medaglia, 2012). Tambouris et al. (2007) assert that citizens' trust in political institutions, lack of commitment by the government to engage with citizens using ICTs, and lack of infrastructure act as barriers to e-participation.

Another stream of research in e-participation has examined the role of different types of ICTs such as discussion forums, social networks, electronic voting, blogs, websites, and group DSS (Saebo et al., 2008). In recent years, the widespread adoption of social media technologies has enabled even greater possibilities of citizen engagement in democratic processes (Saebo et al., 2009; Dini et al., 2018; Wahid & Saebo, 2015; Charalabidis & Loukis, 2011). Social media has enabled two types of e-participation, government-initiated, and citizen-initiated.

2.3 Human Capital

The concept of human capital is prolifically used in entrepreneurial research and reflects the knowledge and skills that a person brings to perform certain tasks. Accordingly, human

capital has been used to predict entrepreneurial outcomes. Wordnet defines the word "capital" as something synonymous with an asset. Deriving from this definition, human capital can be defined as the measure of the human capacity to generate or contribute to positive outcomes. This concept has been extended to the macro level where human capital reflects the competence that citizens possess to contribute to a country's national output. Researchers have investigated the relationship between human capital and environmental performance. Huang et al. (2022) examined the relationship between the human capital index and carbon emissions and found a significant association. However, it may be difficult to generalize the findings of this paper because the sample comprised merely seven countries, all members of G7. Human capital was also found to influence the absorptive capacity of organizations which reflects an organization's ability to learn. However, this paper mainly focused on the organization as the unit of analysis, and the count of skilled workers, i.e., engineers and R&D employees were used to measure human capital (Perez et al., 2019). Ikazaki (2014) provides an analytical treatment of human capital and corruption and their impact on the environment. This study is based on the premise that corruption affects growth and the environment. Corruption relaxes the standards, therefore affecting environmental performance and long-term growth. For example, corruption increases pollution because governments accept donations and award permits as a 'quid pro quo' that may be detrimental to environmental performance. According to Lucas (1988), human capital is the most important factor for achieving long-term growth. Many studies equate human capital to R&D and Innovation.

The Agency theory posits that agents give primacy to self-interests. In corrupt societies, agents tend to profiteer at the cost of social goals and outcomes such as environmental performance and long-term goals. The agents invest in political capital to affect income distribution but not increase productivity (Ehrlich & Lui, 1999). Corruption leads to a nexus between low-skilled managers, capitalists, and government thereby causing delays in changes in efficient structures. Harnani et al. (2022) assert that the relevance of human capital can be estimated by the fact that many drivers of economic growth did not seem to have any effect in many countries because of inadequate human capital. Harnani et al. (2022) examined the literature on human capital and reported factors that affect human capital and reported that human capital is intimately linked to environmental improvement and that human capital may be increased by using new technology. However, because of the absence of a universal definition of human capital, the construct has been measured in different ways in the literature. Many studies conceptualized human capital by the number of hours of work or quantity of workforce.

The World Bank has undertaken a major project to define and report measures of human capital across countries (World Bank, 2018). The human capital index has been designed to measure the amount of human capital a child would attain at the age of 18. This project involved countries in identifying national priorities and identifying barriers preventing countries from reaching their goals. According to the World Bank (2018), the Human Capital index is comprised of 3 components, survival, quality and quality of education until the age of 18, and health. Survival measures whether a child would reach the age of 5 when her formal education can begin. In other words, this is a measure of the under-5 mortality rate. Quantity of education adjusted for quality till the age of 18. The quality is adjusted by comparing results from international achievement tests taken by citizens across countries. Health measures the (1) stunting of children under age 5, and (2) health outcomes a child born would face as an adult – the proportion of 15-year-olds who will survive till age 60. The components are combined in the Human Capital index to reflect worker productivity. It is important to distinguish between health outcomes and human capital because human capital is a combination of the ability to work hard, cognitive ability, and health.

2.4 Corruption

Corruption reflects the abuse of entrusted power for political gain. Corruption is defined as the "abuse of public power or authority for private benefit" (Anokhin & Schulze, 2009). Examples of corruption include bribery, clientelism, embezzlement, lobbying, and patronage (Merhi, 2022). Corruption leads to a lack of trust between governments and their citizens which hinders the effective delivery of public services (Damania et al., 2004). Many countries around the world face high levels of perceived corruption and there is a widely held belief that corrupt practices are one of the biggest impediments to the overall public good. Transparency International publishes a yearly Corruption Perception Index (CPI), which is a widely used indicator of corruption worldwide (ourworldindata.org). Based on this index, significant differences exist among the countries. Denmark, Finland, Sweden, New Zealand, and the Netherlands are the least corrupt countries whereas South Sudan, Sudan, Afghanistan, North Korea, and Somalia are considered to have the highest level of corruption in the world. The countries with low CPI are plagued by untrustworthy and badly functioning public institutions (transparency.org) and negative government effectiveness index (GEI) whereas the countries with high CPI exhibit positive GEI. On the other hand, less corrupt countries tend to have higher degrees of information about public expenditure and stronger standards

when it comes to integrity for public officials (transparency.org).

Research has shown that corruption can impact health and education spending because of the misallocation of funds (Gupta, 2000) resulting in poor education and health levels in the countries (Ferraz et al., 2012; Ortega et al., 2016). The corruption and mismanagement of the spending in the health infrastructure lead to high infant mortality rates due to the lack of equipment and required supplies (Hu & Mendoza, 2013; Ortega et al., 2016). Similarly, it has been shown that, in general, corruption can also impact environmental sustainability although with inconsistent results. Some researchers have found corruption to deter environmental sustainability directly through CO2 emission (Gani, 2012; Hassaballa, 2015; Ortega et al., 2016), while others have found an indirect effect of corruption on CO2 (Bae et al., 2017; Cole, 2007). Interestingly, Arminen and Menegaki (2019) found no significant effect. Thus, it is critical to examine the role of corruption in environmental performance.

3 Theoretical Framework

This section explains the theoretical reasoning underlying different hypotheses examined in the present paper.

This paper is inspired by the dialectic relationship between technological determinism and human agency paradigms to explain the interaction of technology and social structures to bring about social change (Boudreau & Robey, 2005). Technological determinism is premised on the dogma that technology's attributes are capable and instrumental in effecting social changes. Technology plays an active role in enabling social changes by limiting choices, monitoring human actions, providing rules that guide action, and by other means (Huber, 1990; Jones et al., 1999). Accordingly, ICT infrastructure, online service, and e-participation are the technological instruments that can influence human capital, corruption, and environmental performance. The human agency doctrine believes that technology by itself is incapable of effecting changes because humans are free to interpret and use the technology the way they want to use it. If they regard that using the technology does not serve their interests, human agents will most likely refrain from using it or even undermine its overall use. Human agency theory negates the proposition that technology by itself can effect social change and asserts that it is the principal driver of social change. According to human agency theorists, there is an absence of direct causality between technology and patterns of social change. To affirm the validity of their doctrine, the proponents of human agency theory put forward numerous examples of the failure of technologies to achieve the outcome intentions of their designers.

A considerable body of literature points to the interaction between technological determinism and human agency doctrines that drive social change. According to Boudreau and Robey (2005), technology and human agency factors operate in a dialectic manner, and it is the interaction of the social milieu of the users with the technology that determines the outcomes of technology use. For example, the proponents of the dialectic approach suggest that the outcome achieved using technology by a user is a result of not only the technological characteristics and possibilities but also the user's temporal and situational environment at the time of use and this technology-user-milieu set is a dynamic entity.

3.1 Human Capital and Environmental Performance

It has been reported that human capital is an important driver of environmental and at an aggregate level can shift social actions towards environmental performance. However, empirical research to validate this relationship is scant. The U.N. Conference on Environment and Development in 1992 declared that sustained development is predicated on the development of human capacity. They specifically pointed out many parts of the world where this capacity was acutely lacking and called for urgent action and bringing this area under the national policy agenda (IJES, 2005). This (IJES, 2005) report specifically examines the role of education in enhancing human capacity and in turn sustainable development. The Agenda 21 adopted by the 1992 U.N. Conference stated that education, an important component of human capital, impacts virtually all areas of environmentally sustainable development. The International Conference on Environment and Society identified education as the "driving force" for meeting all challenges of the future. Many other international, regional, and national meetings have emphasized the critical role of human capital in achieving environmental performance (IJES, 2005). McKenzie-Mohr (2011) acknowledges that information and knowledge are important drivers of sustainable development but other factors such as self-profits are relevant as well. They assess the role of community campaigns in advancing the sustainability goal. Based on this, we hypothesize:

Hypothesis 1: Human Capital is positively associated with the environmental performance of a country.

3.2 Corruption and its Impact on Human Capital and Environmental Performance

Many studies have shown that corruption has a deleterious effect on sustained environmental performance such as CO2 emissions (e.g., Biswas et al., 2012; Gani, 2012; Gupta et al., 2002, Hassaballa, 2015; Ortega et al., 2016) and education and health levels in a country (Ferraz et al., 2012; Ortega et al., 2016). Special interests and profiteers are often able to get away with environmentally harmful projects by bribing political leaders and others holding decision-making power and by circumventing rules and regulations. It is reasonable to expect that a citizenship body that has a higher level of human capital would be less susceptible to corrupt practices as compared to societies with lesser levels of human capital. The mismanagement of resources and corruption are causing high infant mortality rates and a decrease in the quality of education due to the lack of equipment and required supplies (Hu & Mendoza, 2013; Ortega et al., 2016). Therefore, we postulate:

Hypothesis 2a: Corruption-free is positively associated with human capital.

Hypothesis 2b: Corruption-free is positively associated with the environmental performance of a country.

3.3 E-participation and its Impact on Human Capital and Corruption-Free

The stakeholder theory provides a lens through which the relationship between e-participation, corruption, and human capital can be examined. Freeman et al. (2010) in their initial explication of stakeholder theory espoused the argument that social entities or organizations need to meet their goals by "balancing the conflicting claims" of their various stakeholders. The term stakeholder has been defined in several ways in the literature, ranging from a very restrictive to a very expansive view. In the context of e-participation, citizens, social organizations, special interest groups, and business and lobbying organizations are all stakeholders. When applied to e-participation, the stakeholder theory changes the paradigm of policy-making and decision-making processes by shifting the focus from those who hold political powers to a wider range of stakeholders.

E-participation improves citizens' ability to have a say in decision-making processes, enabling access to consequential persons in authority, and reducing information asymmetry, all factors consequential to corruption opportunities (Nam, 2018). The agency theory provides the lens through which risk sharing between principals and agents can be explained (Eisenhardt, 1989). The Agency theory assumes agents to be driven by self-interest and self-serving motivations. If the agents believed that their actions were not visible, then they are likely to act in their self-interest which may not align with the interest of the principal. Thus, agency theory provides a mechanism of a contract between the principal and the agent by way of which risk sharing can be calibrated. We suggest that by having greater citizen participation, the principal-agent-contract conditions promote lower corruption. With increased emphasis on sustainability and green computing, citizens' participation is vital to achieving short and long-term success. In addition, sharing information, which is one of the characteristics of e-participation, about health and education issues, increases awareness, and provides a means for citizens to gain more knowledge. The high levels of awareness increase the education and health levels in the country. Therefore, e-participation can significantly impact corrupt practices and also human capital. Based on this, we hypothesize:

Hypothesis 3a: E-participation is positively associated with human capital.

Hypothesis 3 E-participation is positively associated with corruption free.

3.4 Online Service and E-participation

Gulati et al. (2014) found that the telecom competition index is a predictor of e-participation. The quality and spread of ICT infrastructure and the maturity, i.e., the sophistication of online services are significant drivers of e-participation. With a high level of diffusion in the enabling technologies, democratic countries can deepen and broaden the participation of citizens in consultative and decision-making processes of the government. The maturity and reach of Internet technologies facilitate the analysis of task performance and overcome personal and situational resources/constraints (Ahluwalia & Merhi, 2020). Reliable internet connections can ease the concerns about whether online transactions can be completed successfully and that they are not frequently interrupted in the middle of commercial transactions. A sense of assurance about the security of the internet channel contributes to increased confidence that the action (online transaction) can be completed safely. Research shows that low levels of ICT diffusion can limit awareness about online

services and e-participation (Molla & Licker, 2005). Based on the foregoing, we can posit the following hypothesis:

Hypothesis 4: Online service maturity and quality is positively associated with e-participation.

3.5 Telecommunication Infrastructure and its Impact on Environmental Performance and Online Service

Implementation of an efficient and reliable ICTs infrastructure is an essential driver of achieving efficient online services (Okoli et al., 2010; Zwick & Dholakia, 2008). A robust and reliable telecommunication infrastructure is essential for creating and offering innovative online services. For the same reason, a lack of telecommunication infrastructure is known to act as a barrier to the development of new online services (Kaba et al., 2009). Online service depends on the quality and effectiveness of Internet and mobile phone communications (Zwick & Dholakia, 2008) and computers (Elen et al., 2010). Higher broadband penetration, low Internet prices, and good-quality network connections are likely to facilitate online service. The ubiquitous availability of Internet access, reliable network connections, affordable prices, and implementation of adequate security protocols in the network and web technologies are fundamental drivers of online service.

When updating and upgrading their infrastructure, countries need to become less dependent on hardware and software consumption. Telecommunication infrastructure causes e-waste, energy consumption, and carbon emissions, among many other environmental issues. By investing in green infrastructure, countries can deliver a quality online service while helping the sustainability of the environment. Thus, one can expect that telecommunication impacts both online service and environmental performance. Based on this, we hypothesize that:

Hypothesis 5a: Infrastructure is positively associated with the environmental performance of a country.

Hypothesis 5b: Infrastructure is positively associated with online service.

We used GDP and population density as control variables since they were found to have an impact on environmental performance (Kumar et al., 2019; Lee &Theil, 2017). Figure 1 depicts the research model and the hypotheses.

4 Methodology

4.1 Data

The focus of this paper is at the country level. Thus, the unit of observation is the country. We used secondary data to empirically assess the hypotheses presented in the research model for two reasons. First, secondary data are most suitable to answer the research questions. Second, because of the difficulty of collecting macro-level data due to the lack of resources. The data we used are collected by credible international organizations that are known for their integrity. These organizations are Transparency International;

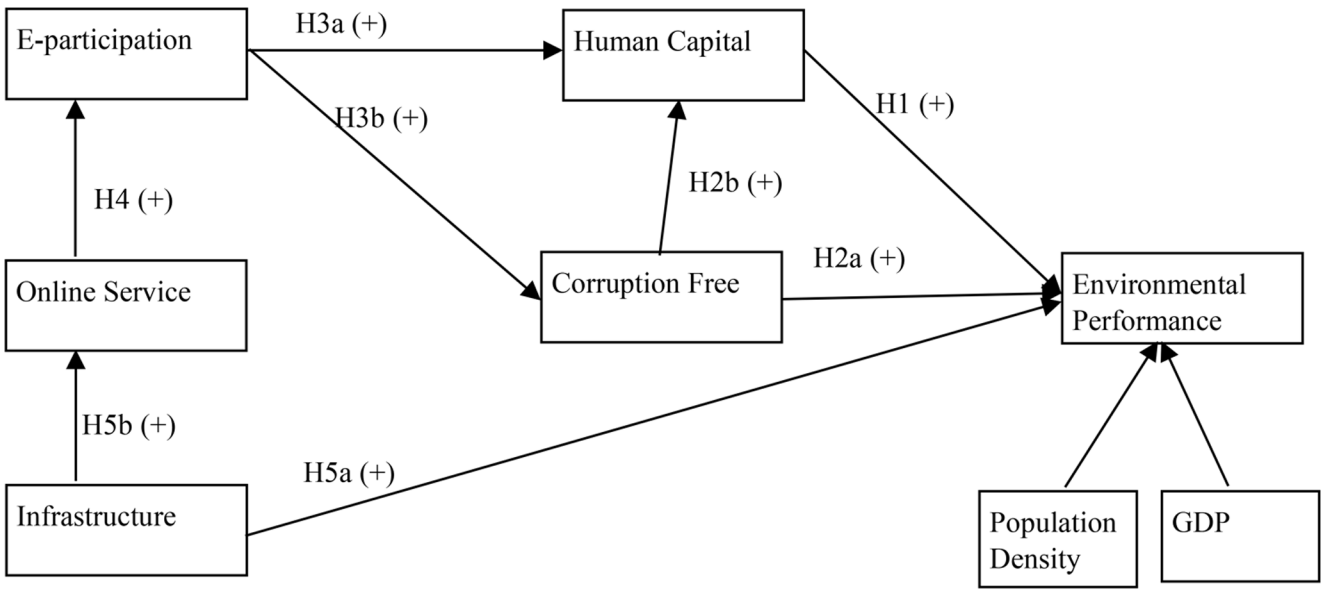

Fig. 1 Research model

the United Nations; the World Bank; and the Yale Center for Environmental Law & Policy and The Center for International Earth Science Information Network. The data on our dependent variable (Environmental Performance) are only available for 180 countries. Due to missing data on other factors, we eliminated one observation (Sao Tome and Principe). The final sample size used in this paper is 179 countries. The data on environmental performance are from 2022 and the rest are from 2021. The usage of lagged data sufficiently addresses any endogeneity concern because of potential reverse causality (Huang et al., 2018).

4.2 Measures/Factors

The environmental performance index (EPI) (Wolf et al., 2022) is the dependent variable. This index is calculated and published by the Yale Center for Environmental Law & Policy and The Center for International Earth Science Information Network at Columbia University in collaboration with the World Economic Forum. The EPI is a composite index covering important topics of sustainability such as climate change mitigation, air quality, sanitation & drinking water, heavy metals, waste management, biodiversity & habitat, ecosystem services, fisheries, acid rain, agriculture, and water resources. It ranges from 0 to 100 where low values indicate poor environmental performance and 100 excellent environmental performance. The EPI has been used in previous papers (e.g., Kumar et al., 2019; Silal & Saha, 2021).

The corruption perception index measures the citizens' perceptions of how corrupt the public sector is in a country. It ranges from 0 to 100 where 0 is very corrupt and 100 is free of corruption.

The human capital index measures the knowledge, skills, and health that people accumulate over their lives. This index is based on three pillars survival, school, and health. It ranges from 0 to 1, where 1 indicates that the maximum potential is reached.

The e-participation index (EPI) is published by the United Nations. It measures the extent to which citizens are engaged and collaborate with their governments. The index is composed of three main pillars (1) facilitating the provision of information by governments to citizens (e-information sharing), (2) interaction and engagement of the government with the citizens (e-consultation), and (3) engagement in decision-making processes (e-decision making). It ranges from 0 to 1, where higher values indicate better EPI levels. Studies have used the EPI as a measure of e-participation at the country level (e.g., Silal & Saha, 2021).

The online service measures the level of sophistication of the online presence a nation has. The level of sophistication is measured using four stages, from basic information to highly engaged systems. This index ranges from 0 to 1 where a high value indicates high levels of the four stages.

The telecommunication infrastructure index is published by the United Nations. It is the average of six key infrastructure indicators. These indicators are the number of computers per capita, number of internet users per capita, number of telephone lines per capita, number of people using the internet, number of mobile phones per capita, and number of households with a TV. This index ranges from 0 to 1, where higher values indicate a very good infrastructure level.

Table 1 includes the factors, definitions, the entity that collected the data, and direct links to the datasets.

5 Analysis and Results

5.1 Descriptive Statistics

We analyzed the data using SmartPLS 3.0 software. We first executed descriptive analysis to learn about the data disparity and to check for the normality assumption (the shape of the distribution). Table 2 includes the results of the descriptive analysis. The results indicate that overall, the countries are below the average level on the environmental performance index, about average on corruption, and above average on all other factors. Based on the standard deviation, there are wide disparities among the countries on corruption and the environmental performance index. Finally, the data are normally distributed based on kurtosis and skewness measures.

We then conducted a correlation analysis to gain knowledge about the strength and the direction of the relationships between and among the variables. The results are presented in Table 3. The coefficients of correlation indicate that there are positive moderate to strong relationships among the variables. The positive relationships are in line with the hypotheses we postulated, although not indicating causal relationships. We also assessed the potential of multicollinearity using the Variance Inflation Factor (VIF) and found that all the VIFs ranged from 1.0 to 3.54 and did not pass the threshold of 4.0 (Fox, 2019). Thus, we can conclude that multicollinearity does not appear to be a concern in this paper.

5.2 Reliability and Validity of Data

Although many researchers have used the measures of this paper in their analysis, it is worth mentioning facts about the reliability and validity of the data. As mentioned earlier, all the variables are drawn from reputable international organizations. These organizations follow rigorous procedures in

Table 1 Factors and their sources

Factor	Definition	Source
Environmental Performance (EPI)	The EPI provides a summary of the state of sustainability around the world. Using 40 performance indicators across 11 issue categories, the EPI measures the climate change performance, environmental health, and ecosystem vitality of each country.	Wolf et al. (2022)
Corruption	The corruption index measures perceived levels of public sector corruption in countries and territories around the world. The results are given on a scale of 0 (highly corrupt) to 100 (very clean).	Transparency International (2021)
Human Capital (HCI)	The HCI combines indicators of health and education into a measure of the human capital that a child born today can expect to obtain by her 18th birthday, given the risks of poor education and health that prevail in the country where she lives. The HCI is measured in units of productivity relative to a benchmark of complete education and full health and ranges from 0 to 1.	World Bank (2021)
E-participation	E-Participation is a multifaceted framework, composed of three core components, i.e., e-information, e-consultation, and e-decision-making. • E-information: Enabling participation by providing citizens with public information and access to information without or upon demand. • E-consultation: Engaging citizens in contributions to and deliberation on public policies and services. • E-decision-making: Empowering citizens through the co-design of policy options and co-production of service components and delivery modalities.	United Nations (2021)
Online Service	The Online Service index measures the evolution of e-government services (smart services) in terms of availability, quality, connectivity, and diversity of channels and the use by the citizens of these services.	United Nations (2021)
Telecommunication Infrastructure (TII)	The TII is a composite weighted average index of six primary infrastructural indicators. These indicators define a country's ICT infrastructure capacity. The indicators are PCs per 1000 persons; Internet users per 1000 persons; Telephone Lines per 1000 persons; Online population; Mobile phones per 1000 persons; and TV per 1000 persons.	United Nations (2021)
GDP Per Capita	Gross Domestic Product (GDP) per capita shows a nation's GDP divided by its population.	World Bank (2021)
Population Density	Population density shows the number of people per Km^2 of land area.	World Bank (2021)

data collection and analysis to ensure that the measures and the data are valid and reliable.

Two large institutions (Yale and Columbia) in collaboration with the World Economic Forum collect data on the environmental performance index. The majority of the indicators (e.g., CO2, tree loss, waste management) used in calculating the index are standard in all countries. These indicators follow well-established scientific procedures. Thus, increasing the validity and reliability of the data.

Transparency International collects data on corruption from at least three data sources drawn from 13 different surveys and assessments. The data sources are in their turn collected by the World Bank and the World Economic Forum. They also use several steps to calculate the index. The fact that the data are collected from several sources and several steps are used in the calculation increases the validity and reliability of the data.

The measures on e-participation, online service, and telecommunication infrastructure are collected by the United Nations using a comprehensive survey. The questionnaire is regularly revised to capture the updated trends in technology, e-government, etc. To improve the validity of the data, the UN back-translates the questionnaire into six different languages. The survey items capture the delivery of information to citizens, the development status of telecommunication infrastructure, and the inherent human capital. The websites of governmental entities are examined in a well-standardized form set by a team of experts hired by the United Nations. This team gets trained regularly to ensure consistency and high-quality data.

5.3 Hypotheses Testing

Finally, we used Partial Least Square (PLS) to empirically examine the causal relationships and the research hypotheses. Hair et al. (2017) recommend that it is best to use PLS-SEM when the data are secondary/archival, particularly single-item measures, and when the research objective is just to explain the relationships between exogenous and endogenous constructs. Both cases apply to this study. For this reason, we used SmartPLS. The results are displayed in Fig. 2. The standardized coefficients of the relationships are included on top of the arrows. The coefficients of determination (R^2) are included next to the endogenous variable (environmental performance, human capital, corruption, e-participation, and online service). The results indicate that human capital, corruption, and infrastructure accounted for 55% of the variance in environmental performance. All the hypotheses are supported by the data at the 0.0001 significance level except 5a (infrastructure impacts environmental performance) which is significant at 0.05 level). Of the

Table 2 Descriptive statistics

Factors	Mean	Median	Min	Max	St. dev	Kurtosis	Skewness
EPI	43.028	41.900	18.900	77.900	12.284	0.039	0.581
Corruption	49.264	48.08	1.920	100	28.194	-1.147	0.140
Human Capital	0.695	0.741	0.130	1	0.188	-0.106	-0.749
E-participation	0.591	0.595	0	1	0.252	-0.988	-0.186
Online Service	0.585	0.612	0.012	1	0.240	-0.862	-0.284
Infrastructure	0.555	0.579	0	0.998	0.251	-0.948	-0.235

Table 3 Correlation matrix

Factors	EPI	Corruption	Human Capital	E-participation	Online Service
Corruption	0.659				
Human Capital	0.649	0.620			
E-participation	0.496	0.559	0.718		
Online Service	0.497	0.570	0.722	0.780	
Infrastructure	0.651	0.680	0.618	0.774	0.792

control variables, GDP significantly impacts environmental performance.

6 Discussions

Our results shed light on the relationship between technological factors and environmental performance. The results demonstrate that technology as an antecedent to e-participation plays an indirect nevertheless significant role in improving environmental performance. In general, we found that e-participation helps improve human capital and mitigate corruption. The results suggest that both corruption and human capital are significant factors impacting environmental performance and explain more than half of its variance. Thus, this paper demonstrates that technology can be part of the solution to environmental performance.

The findings show that human capital is positively associated with the environmental performance of a country (H1). To our knowledge, this is the first study that empirically assesses this relationship using data collected from 179 countries. Human capital is a critical factor in attaining long-term growth (Lucas, 1988), and thus, is very relevant for sustainability and environmental performance. Previous research has examined the role of human capital on carbon emissions using data collected from seven countries and found a significant association between the two (Huang et al., 2022). Our findings extend the findings of previous studies. The human capital index taps into survival, health, and education. Thus, to improve environmental performance, governments need to invest in the education and health sectors while making sure that the mortality rates of infants are the lowest possible.

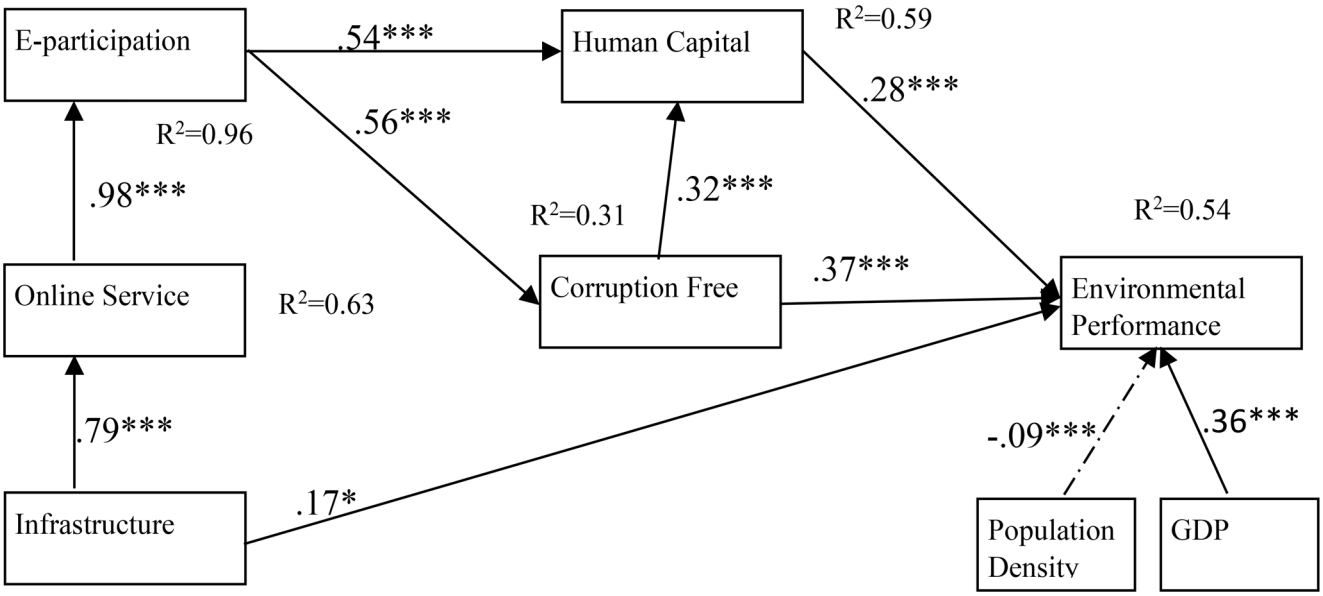

Fig. 2 Results. *Note**** significant at 0.01 level; * significant at 0.05 level; dashed not significant

The data indicate that countries that are low in corruption have better human capital (H2.a) and do better in environmental performance (H2b). Many countries face high levels of corruption thereby negatively affecting health, education, sustainability, and environmental performance. It is reported that in countries with high levels of corruption, individuals holding decision-making, or policy-making powers intend to accept gifts and bribery. In return, these people take actions that are detrimental to the health, education, and environment of citizens and society (Ikazaki, 2014). Researchers have shown that the misallocation and the mismanagement of spending in the health and education infrastructures, caused by corruption, negatively impact mortality rates and result in poor education (Gupta, 2000; Hu & Mendoza, 2013; Ferraz et al., 2012; Ortega et al., 2016). Most studies found a direct and positive effect of low corruption on environmental performance, (Gani, 2012; Hassaballa, 2015; Ortega et al., 2016, Bae et al., 2017; Cole, 2007). Our findings indicate that to improve human capital and environmental performance, countries need to invest more in practices that help them fight corruption.

This paper also investigates the role of e-participation as an antecedent of human capital and environmental performance. The stakeholder theory provides a lens through which the relationship role of e-participation, corruption, and human capital can be examined (Freeman et al., 2010). When applied to e-participation, the stakeholder theory changes the paradigm of policy-making and decision-making processes by changing the focus from those who hold political powers to a wider range of stakeholders. Governments around the globe are increasingly investing in technologies and creating digital-enabled processes such as e-government. That is because of the many advantages that can be achieved by using electronic processes such as convenience, efficiency, effectiveness, transparency, accountability, and diminishing corruption (Addo & Avgerou, 2020; Merhi & Ahluwalia, 2021). In addition to these advantages, governments can transform the way they interact with their citizens and encourage them to participate in the decision-making process (Choi &Song, 2020). Participation of stakeholders in the governance of a social unit is known to be one of the vital elements of democracy and precedes the emergence of ICTs, however, the widespread diffusion of Internet-based technologies makes e-participation a very promising element of democratic processes. The data indicate that e-participation is positively associated with human capital (H3.a) and corruption-free (H3.b). Researchers have found a significant relationship between e-participation and corruption (Merhi, 2022; Silal & Saha, 2021; Zheng, 2016). Our findings are in line with these previous studies. To our knowledge, this is the first paper that examines the relationship between e-participation and human capital. E-participation allows stakeholders to access more information related to health and education. It also allows them to raise concerns about these topics, thus improving human capital in the nation. Thus, governments need to continue investing in e-government systems and encourage e-participation to fight corruption and increase human capital.

We also found that online service is positively associated with e-participation (H4). To our knowledge, no study has empirically assessed this relationship. The diffusion of innovation theory affirms that the rates of diffusion are dependent on several factors including the characteristics of the adopters, the social network, the communication, and the characteristics of the innovation and the promoters (Rogers, 1962). Online service measures the level of sophistication of the online presence a nation has in terms of availability, quality, connectivity, and diversity of channels and the use by the citizens of these services. Our results indicate that by adopting sophisticated technologies, countries can expand the participation of stakeholders in consultative and decision-making processes of the government.

Our findings also indicate that telecommunication infrastructure is positively associated with environmental performance (H5.a) and is positively associated with the online services (H5.b) of a country. These relationships have also not been assessed at the macro level in settings related to the public sector. Researchers argued that the implementation of efficient and reliable telecommunication infrastructure is crucial for creating and offering online services, and a driver to achieve efficient online services (Okoli et al., 2010; Zwick & Dholakia, 2008). Therefore, a lack of telecommunication infrastructure can act as a barrier to the development of new online services (Kaba et al., 2009). That is because online services are contingent on the quality of the Internet, availability of low Internet prices, and high quality of network connections. In addition, green telecommunication infrastructure improves environmental performance. It was found that renewable energy impacts environmental performance (Khan et al., 2020). Thus, governments need to invest more in green telecommunication infrastructure especially those to improve their online service and environmental performance.

6.1 Implications for Research

The motivation for this study is to examine whether technical and social factors affect environmental performance and the relatively scarce existing literature on the topic. We examined the stated hypotheses in the research model by drawing from the secondary data published by reputable international organizations namely the United Nations, World Bank, Transparency International, and Yale Center for Environmental Law & Policy, and the Center for

International Earth Science Information Network. Our study contributes to the literature by assessing the interrelationships among e-participation, corruption, human capital, and their effect on environmental performance. First, we demonstrated the direct and indirect roles of technological factors in impacting environmental performance. The research model presented in this paper is grounded in a sound theoretical framework. We draw from the technological determinism and human agency paradigms to examine the enablers of environmental performance. Second, we validated the role of e-participation in improving sustainability. Previous research that examined e-participation focused on its role in promoting democracy, e-government success and implementation, and people's political efficacy (e.g., Yao & Xu, 2022). This paper shows that e-participation can also serve as a driver of improved sustainability and environmental performance. Third, by examining the antecedents of e-participation that have not been previously assessed in the literature, we find that online services and government-provided digital services enable stakeholders' participation. Fourth, this paper explores the role of human capital. The results show that human capital is a significant antecedent of environmental performance, thereby reinforcing various declarations of various bodies of the United Nations that have declared Human Capital to be a very important driver of long-lasting environmental performance. We also present two important factors impacting human capital: e-participation, and corruption mitigation. Finally, we validate the role of corruption mitigation in influencing environmental performance and human capital. In summary, our paper proposes and assesses a sound theoretical foundation demonstrating how technology and social factors impact environmental performance. We believe this paper adds to the rigor and generalizability of the findings of some of the previous studies by analytically assessing the hypothesized relationships using a relatively large sample size of 179 countries as compared to many of the existing papers at the macro/country level that included a sample size of only a few countries.

6.2 Implications for Practice

We believe that this paper makes very significant contributions toward practice. Firstly, the paper highlights the role of e-participation in promoting sustainability. In many democratically oriented countries, e-participation is being used to deepen and broaden the participation of citizens in decision-making and improve government performance. Countries around the globe are investing in digital services and e-government systems to increase transparency, accountability, efficiency, and effectiveness. The results of this paper show that e-participation can serve as a very useful channel for promoting environmental performance and sustainability. The results also reinforce the positive relationship between technological infrastructure and e-participation. Thus, environmental performance can be improved by strengthening technology and by deploying targeted e-participation towards sustainability. The United Nations needs to continue offering guidance and help for underdeveloped countries to invest and implement digital systems.

This paper suggests that human capital can also serve as a driver of long-term sustainability. The World Bank states that "*By improving their skills, health, knowledge, and resilience—their human capital—people can be more productive, flexible, and innovative. Human capital is a central driver of sustainable growth and poverty reduction*." (World Bank, 2018). This is the first paper that empirically examines the role of human capital on environmental performance. By investing more in human capital, the UN, World Bank, and government agencies can not only improve sustainable growth and poverty reduction but also improve environmental performance.

The debilitating influence of corruption on governmental performance in general is obvious and the existing literature points to various causes, effects, and remedies related to corruption. The Information Systems research has also investigated the causes and offered solutions to improve corruption performance. Technology and e-participation can help fight corruption since they increase transparency and traceability, and at the same time, reduce suspicious transactions. We examined the causality between corruption and environmental performance and found a significant relationship between them. Interestingly, the results also show that corruption can impact human capital and environmental performance.

The United Nations and other research organizations frequently publish important country-level data on many of the factors examined in this paper. The results show that all these factors influence environmental performance. Therefore, it may be very useful to create, measure, and publish environmental-performance indexed measures of e-participation, human capital, and corruption.

6.3 Limitations and Future Work Opportunities

Despite the significant contributions that this paper offers, it has a few limitations that need to be discussed. First, we used secondary data to assess the hypothesized relationships. The data we collected are from credible organizations that ensured the credibility and validity of their data; however, we were limited by the composition of the indices. For instance, the environmental performance index is composed of eleven categories. Future research might investigate specific categories and change the focus of their papers

from general to specific areas. Second, we are limited by the available data which limited the sample size. Third, the analysis is at the macro level and might not be relevant to micro-levels in the countries. Also, different regions and cultures might have specific factors that impact environmental performance. Thus, future research might investigate the impact of national culture on the relationships examined in this paper. Future research might also use different methods to collect primary data from a smaller number of countries and make comparisons. Finally, we used cross-sectional data. Future research might use longitudinal data and validate the results of the paper.

7 Conclusion

This paper investigates macro-level factors impacting environmental performance and contributes to both research and practice. The environmental factor index used in this study covers six of the seventeen goals set by the UN. We contribute to the literature by presenting and assessing a model that demonstrates how technological factors, human capital, and corruption impact environmental performance. The research model presented demonstrates the interaction and effects of technological and societal factors. It shows that both technological and societal factors impact environmental performance. This study assessed the role of human capital which covers two of the sustainable development goals that the United Nations set to improve sustainability. Extant literature has not investigated the role of human capital on environmental performance. These results of the paper also help practitioners and decision-makers in governments and the United Nations to understand the relationships between these factors. We explained the implications of the results in a previous section.

8 Appendix A: Countries Included in the Study

Afghanistan; Angola; Albania; United Arab Emirates; Argentina; Armenia; Samoa; Antigua and Barbuda; Australia; Austria; Azerbaijan; Burundi; Belgium; Benin; Burkina Faso; Bangladesh; Bulgaria; Bahrain; Bahamas; Bosnia and Herzegovina; Belarus; Belize; Bolivia; Brazil; Barbados; Brunei Darussalam; Bhutan; Botswana; Central African Republic; Canada; Switzerland; Chile; China; Côte d'Ivoire; Cameroon; Congo; Colombia; Comoros; Cape Verde; Costa Rica; Cuba; Cyprus; Czech Republic; Germany; Djibouti; Dominica; Denmark; Dominican Republic; Algeria; Ecuador; Egypt; Eritrea; Spain; Estonia; Ethiopia; Finland; Fiji; France; Micronesia; Gabon; United Kingdom; Georgia; Ghana; Guinea; Gambia; Guinea-Bissau; Equatorial Guinea; Greece; Grenada; Guatemala; Guyana; Honduras; Croatia; Haiti; Hungary; Indonesia; India; Ireland; Iran; Iraq; Iceland; Israel; Italy; Jamaica; Jordan; Japan; Kazakhstan; Kenya; Kyrgyz Republic; Cambodia; Kiribati; Korea; Kuwait; Lao; Lebanon; Liberia; St. Lucia; Sri Lanka; Lesotho; Lithuania; Luxembourg; Latvia; Morocco; Moldova; Madagascar; Maldives; Mexico; Marshall Islands; North Macedonia; Mali; Malta; Myanmar; Mongolia; Montenegro; Mozambique; Mauritania; Mauritius; Malawi; Malaysia; Namibia; Niger; Nigeria; Nicaragua; Netherlands; Norway; Nepal; New Zealand; Oman; Pakistan; Panama; Peru; Philippines; Papua New Guinea; Poland; Portugal; Paraguay; Qatar; Romania; Russian Federation; Rwanda; Samoa; Saudi Arabia; Sudan; Senegal; Singapore; Solomon Islands; Sierra Leone; El Salvador; Suriname; Slovakia; Slovenia; Sweden; Eswatini; Seychelles; Chad; Togo; Thailand; Tajikistan; Turkmenistan; Timor-Leste; Tonga; Trinidad and Tobago; Tunisia; Turkiye; Taiwan; Tanzania; Uganda; Ukraine; Uruguay; United States; Uzbekistan; St. Vincent and the Grenadines; Venezuela; Vietnam; Vanuatu; Serbia; South Africa; Zambia; Zimbabwe.

Acknowledgements Not applicable.

Funding Not applicable.

Data Availability The original data are publicly available.

Declarations

Conflict of Interest Not applicable.

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