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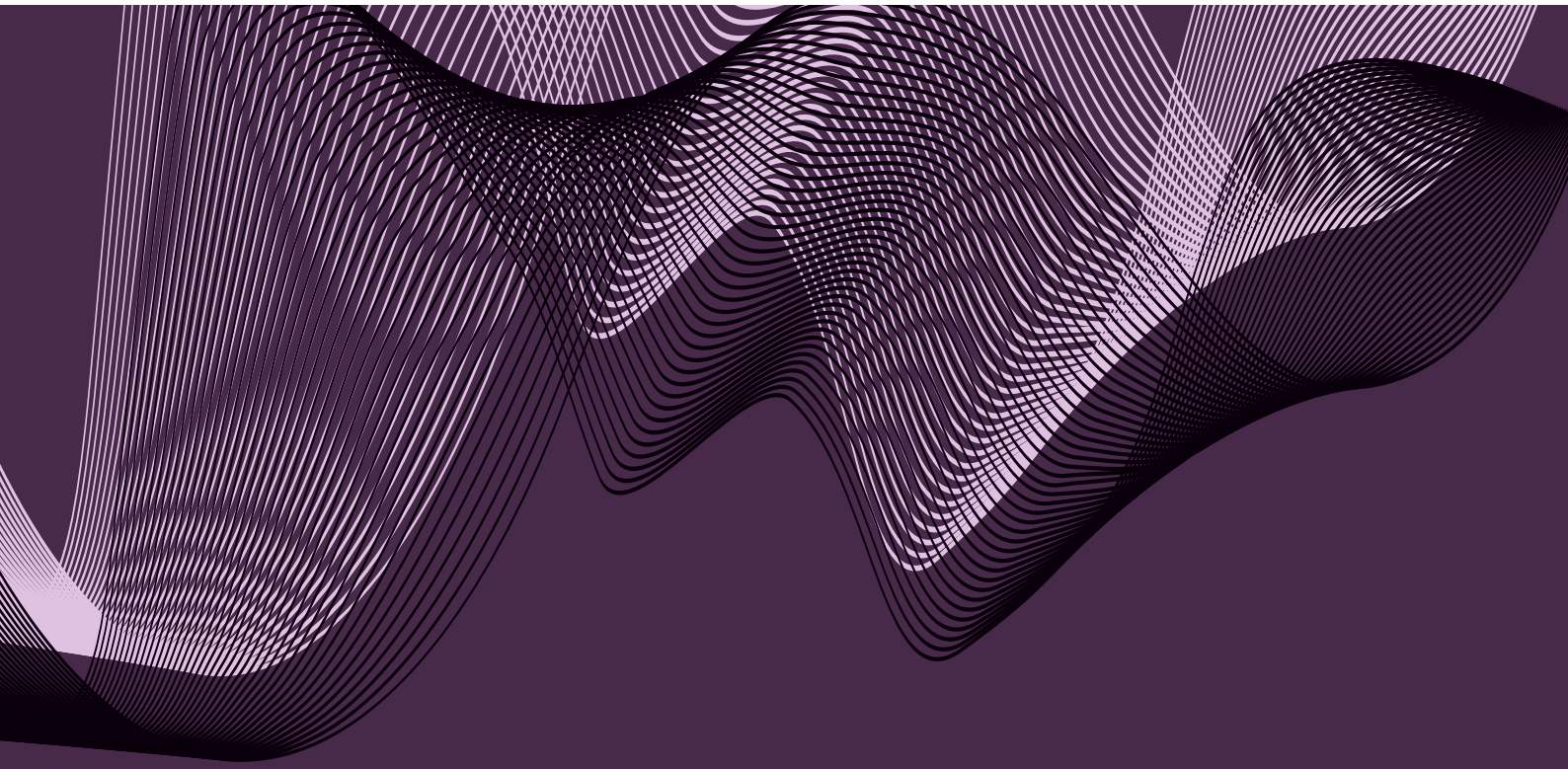

DIGITAL MATURITY AND SUSTAINABILITY

Unpacking the Interrelationships between the Global Digitalization Index and Human Development

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Acknowledgements

Huawei are thanked for their role in supporting this work and providing the detailed data for analysis.

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Suggested citation

Stuart, J., Raghunath, P. & Guariso, D. 2025. Digital Maturity and Sustainability: Unpacking the Interactions between the Global Digitalization Index and Human Development. White paper. Macau, UNU. https://doi.org/10.17605/OSF.IO/E9GVF

© UNU, 2025
ISBN: 978-92-808-9166-9

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OCTOBER 2025

Executive Summary

Sustainable development and digital transformation are the two most important mega-trends shaping the current global social, economic and environmental landscape. Understanding the nexus of these domains provides a promising approach to tackling global challenges, such as achieving the United Nations Sustainable Development Goals (SDGs), promoting economic prosperity, and enhancing equity for all. To understand how countries can achieve or balance digital sustainability, the current state of national-level digital maturity and its interrelations with indicators of sustainable development must be assessed by:

1) Outlining the interactions between sustainable development and digital transformation at the national level,
2) Introducing the Global Digitalization Index (GDI) as an effective metric for measuring digital maturity, and
3) Analysing the interrelations between GDI and various sustainable development indicators, extending beyond solely economic growth.

Correlation analyses were conducted to evaluate the association of GDI (as well as its four pillars) with three groups of indicators: overall human development, peace and governance, and wellbeing and environment. The results show that the GDI is strongly associated with multidimensional sustainable development indicators, indicating that digital development is closely linked to national investments in social development. This suggests that well-defined and sound governance frameworks provide a solid foundation for supporting digital economy growth. However, the GDI showed weaker connections with inclusivity, political participation, peace, and environmental quality. Furthermore, most countries categorised as "Frontrunners" in the GDI exhibited firm commitments to coordinated, government-driven actions towards cybersecurity and were grouped into a cluster of countries with the highest levels of inclusivity and positive environmental outcomes. Thus, digital maturity can be viewed as a crucial aspect of national-level sustainable development initiatives, extending beyond solely wealth.

This whitepaper demonstrates a positive association between digital transformation and sustainable development in many countries, especially among higher-income economies. Further research is required to understand the pathways towards digital maturity and sustainability in less developed contexts. Such research should ensure equitable access to digital technologies, address associated risks, and prioritise human rights, inclusivity, and security. When considered alongside other human development indicators, the Global Digitalization Index (GDI) can inform more targeted strategies to realise the potential of the digital economy globally.

Digital Maturity and Sustainability:

Unpacking the Interrelationships between the Global Digitalization Index and Human Development

Sustainable Development and Digital Maturity

Sustainable development and digital transformation are two of the most important mega-trends shaping our modern global social, economic, and environmental landscape. The nexus between these areas is considered the most promising way to address global challenges, including achieving United Nations Sustainable Development Goals (SDGs), fostering economic prosperity, and creating a more equitable future for everyone (Gouvea et al., 2018; Sachs et al., 2019; Seele & Lock, 2017). The interlinked processes of sustainable development and digital transformation are often described as "twin transitions," highlighting their simultaneous progress and mutual reinforcement, as well as potential adverse interactions. Notably, levels of digital transformation at the national level have been shown to correlate positively with higher human development and environmental sustainability, promoting beneficial interactions between these aspects (Del Río Castro et al., 2021; Gouvea et al., 2018; Sachs et al., 2019). However, a growing body of research also points to the environmental and social costs of digitisation of data and digitalisation of services, as well as the increasing need for digital infrastructure as part of digital transformation (Bran et al., 2024; Brevini, 2024).

While understanding the interactions between these trends holds immense strategic importance on global, regional, and national levels, digital and sustainable transformations are often studied separately due to the complex nature of each concept and the subtle interrelations between digital transformation and sustainable development. Nonetheless, integrating these two shifts is essential to fully understand their synergies and boost the overall effectiveness and impact of related efforts (Muench et al., 2022). The importance of the interrelationships between digital transformation and sustainable development is emphasised by the United Nations (UN) in its pursuit of achieving the 2030 Agenda. The SDG Digital Acceleration Agenda stresses the importance of understanding how nations can effectively utilise digital technologies to support diverse development goals. The Agenda also highlights key challenges, including inconsistent terminology, unclear definitions, a lack of suitable national-level metrics, and the complex relationships between digital transformation, sustainability, and economic development (ITU & UNDP, 2023). To bridge these gaps and lay the groundwork for future research and action, this whitepaper aims to achieve **three primary objectives**:

1. Outline the interactions between sustainable development and digital transformation at the national level.
2. Introduce the Global Digitalization Index (GDI) as a metric for measuring digital maturity.
3. Explore the connections between GDI and various sustainable development indicators beyond economic aspects of development.

Unpacking the Sustainable and the Digital

Contemporary understandings of the term sustainability follow the definition provided by the UN's Brundtland Commission: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 41). This definition argues that successful development is measured not only by economic wealth but also by social and environmental factors (Delgosha et al., 2020). The United Nations' 2030 Agenda, which includes 17 SDGs and 169 targets within five pillars (planet, people, peace, prosperity, partnerships), was designed to be comprehensive, inclusive, and universally applicable across three key areas of sustainable development: economic, social, and environmental (Biermann et al., 2017). Although the SDGs were adopted in 2015 by 191 member states, progress towards them has been slow, uneven, and hindered by increased global conflict, as well as the COVID-19 pandemic (Sachs et al., 2019; UN, 2024). **As of 2024, the world is clearly off target for meeting the 2030 Agenda, with only 17% of SDGs on track, and no country has yet fully achieved the goals. Even highly developed economies face significant challenges. Consequently, deep and urgent transformations are necessary to accelerate progress.**

Some argue that the concept of sustainable development, while aspirational and idealistic, is an oxymoron due to the

often mutually exclusive nature of different development types (i.e., pursuing one SDG can sometimes hinder progress on others), and the global emphasis on growth rather than balance (Linnerud et al., 2021; Spaiser et al., 2017). However, the advent of innovative technologies, systems, and devices, along with the rise of computational power and the development of advanced data management and processing systems (e.g., AI, blockchain, cloud computing, robotics, extended reality), presents new opportunities to promote sustainability while managing risks and overcoming barriers. As suggested by Nambisan et al. (2017), digital technologies are a vital resource for achieving individual, national, or global goals; therefore, the key challenge is how to leverage these technologies effectively to enhance efforts towards sustainable development. In fact, their analysis of the synergies and trade-offs among SDGs highlights the role of digital innovation in creating a "virtuous cycle of SDG progress" (pp. 7-11) that reduces tensions between different SDGs and promotes comprehensive achievement of the goals.

Digital Transformation and Digital Maturity

There is no doubt that increased accessibility to ICTs, internet connectivity, mobile technologies, and the growth of digital infrastructure have transformed our world. **Currently, 5.35 billion people have internet access, and with an additional 175,000 new online users each day, this number is expected to increase to 7.9 billion by 2029 (ITU, 2023)**. As of 2024, approximately 66% of the world's population was connected and could generate, store, copy, and access millions of terabytes of data. Such trends are elements of digital transformation, which has been defined as a change "that is triggered and shaped by the widespread diffusion of digital technologies" (Hanelt et al., 2021, p. 2) but also as a "process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019, p. 1). Both definitions emphasise the critical importance of change following digital technology introduction into an existing system, but Vial (2019) goes further by suggesting that such change should be characterised by its intention for progress.

Applying this definition of digital transformation inevitably means that digitalization, or the change, enhancement and improvement of processes due to the introduction, adoption, application, and utilisation of digital technology, is currently occurring (Gradillas & Thomas, 2023). This process differs from digitization which refers to the conversion of information from analogue form to digital and machine-readable format, with a digital artifact as an outcome of this process, but it should be noted that digitization is a key part of digitalization (Nambisan et al., 2017; Yoo et al., 2010). According to the Organisation for Economic Co-operation and Development (OECD, 2019), digital transformation affects economies and societies in three primary ways: scale, scope, and speed; changes in ownership, assets, and economic value; and impacts on relationships, markets, and ecosystems. To achieve positive outcomes, digital transformation requires the recipients of digital technology to be ready to take advantage of them. In turn, this is labelled digital readiness, whereby entities (i.e., organisations or countries) can fully utilise the opportunities presented by digitalization and undergo digital transformation in ways that promote economic, social, and environmental development. **Digital maturity is the distinguishing characteristic of entities that have successfully undergone sustainable digital transformation**.

According to the UN, digital maturity is a broad metric describing the extent to which digital technologies have been integrated into varied areas of activity in a country, such as its economy, business operations, social policies, service systems, and research landscape (ITU & UNDP, 2023). However, digital maturity can also be understood as an entity's ability to respond and adapt to a rapidly evolving digital ecosystem. Brodny and Tutak (2023) extend this definition to describe "a measure of the state (stage) of development of a company, economy of a given country, or a group of countries, in the implementation and use of digital technologies to achieve their objectives". To date, the concept of digital maturity has mainly been studied in organisational contexts where it has been observed that businesses mature through a process of adopting and implementing digital transformation initiatives, eventually enabling them to fully utilise the opportunities offered by digital environments and technologies to meet their goals (Calabrese et al., 2022; Gökalp & Martinez, 2022). Haryanti et al. (2024) identify a culture of employee readiness for technology adoption, along with continuous improvement as key features of digital maturity in their review of the research. Notably, even amid continuous change and innovation, digitally mature entities tend to have higher levels of digital readiness because the integration of ICTs into work processes enhances employees' knowledge, skills, and abilities, while also fostering the development of policies to guide technology uptake and cybersecurity, as well as strategic productivity goals aligned to innovation.

Digital maturity at the organisational and national levels share key characteristics. Digitally mature countries typically exhibit high levels of digital adoption and competitiveness, as well as a strong openness to digital transformation across public organisations, private enterprises, and social systems. The adoption of Industry 4.0 technologies, such as artificial

intelligence (AI) and Internet of Things (IoT) devices, is a primary indicator of national digital maturity (Brodny & Tutak, 2023; Calabrese et al., 2022). These countries foster the development of advanced digital skills, which are essential for overcoming challenges associated with digital transformation and for establishing adaptive, innovative ecosystems (Kutnjak et al., 2020). In such environments, digital sustainability—defined as activities that advance sustainable development goals through the creative use of electronic data technologies—can be effectively realised (George et al., 2021, p. 1000).

As previously noted, achieving sustainable development can generate tensions between conflicting goals and needs; however, **digital sustainability has the potential to unify the twin transitions, fostering positive societal and environmental changes**. For instance, investments in technology for scientific discovery can accelerate a shift towards sustainability, resulting in value and knowledge creation and supporting virtuous cycles of progress (Kroll et al., 2019). The UN strongly supports these arguments as part of the Global Digital Compact (GDC), which emphasises that the level of digital maturity at the national level is likely to be strongly and positively associated with sustainable development, extending beyond just economic metrics.

The Global Digital Compact and Digital Maturity

The Pact for the Future is an initiative led by the UN (and adopted by member states in September 2024) aimed at addressing the lack of progress on SDGs and establishing a comprehensive framework to guide international cooperation and policy-making. The GDC is a component of this broader initiative that not only focuses on ensuring that digital technologies are inclusive, safe and beneficial for all, but also addresses issues such as digital inequality, data privacy, cybersecurity, and AI ethics, as well as global digital cooperation, regulation and human rights in the cyberspace.

The GDC outlines a series of key objectives, principles, commitments and actions that can support digital maturity and facilitate SDGs achievement, such as:

i. **Accessibility and affordability of connection:** Referring to Universal connectivity and affordable digital access from global to local levels. The GDC commits to ensuring affordable broadband access for all, regardless of background, especially in remote areas, and supports resilient, safe digital infrastructure like open-source software, data, and AI. It also emphasises digital literacy, upskilling, and training as key to national digital development (Ostmeier & Strobel, 2022). Accessibility and affordability across all backgrounds are essential for digital maturity.

ii. **Human rights:** The GDC commits to upholding international human rights law in cyberspace, aiming to protect individuals, especially children, from violence, abuse, and discrimination. It encourages technology companies to implement human rights due diligence and impact assessments to prevent bias and reduce hate speech on social media. The GDC suggests that digital maturity is dependent on governance efforts to ensure digital trust and safety at the same time as enabling integrity and democratic provision of information. Therefore, while digital integration through physical technology infrastructures is essential, these cannot be said to be mature if the technology is not ethical, or if it has adverse impacts. As such, digital maturity is considered to be strongly interrelated with safe and secure digital ecosystems whereby people of all backgrounds can thrive, which boosts digital activity and integration.

iii. **Gender equality:** Ensuring digital technologies benefit everyone is essential, with a focus on gender equality and empowerment. This involves addressing divides in access, skills, and leadership and working to eliminate gender-based violence. The GDC emphasises that true digital maturity requires fair access to safe digital connectivity for all. A nation cannot be digitally mature if systemic barriers prevent a significant portion of its population from safely and meaningfully engaging with technology.

iv. **Environmental sustainability:** Minimising the negative environmental impacts of digital technologies and promoting digital sustainability, particularly in digital infrastructure and AI, is vital. Some digital infrastructures are resource-intensive, disproportionately affecting vulnerable and marginalised groups. To achieve digital maturity, it is essential to integrate technological infrastructure with sustainable practices, managing socio-ecological implications through multi-stakeholder consultation and incorporating the ethics of care in the development and maintenance of these systems.

v. **Cybersecurity:** A cornerstone of the GDC concerns data privacy, security and interoperability as essential elements for effective data use in early warning systems, crisis prevention, and disaster risk resilience. It underscores the need for data exchanges, standards, audits, and safeguards for cross-border data flows, alongside an increased focus on data protection and broader access to data. Cybersecurity is regarded as vital for digital maturity, enabling successful digital transformations while minimising negative impacts and biases. The GDC highlights the role of digital technologies in achieving SDGs and encourages nations to enhance

their digital maturity for sustainable economic, social, and environmental transformations.

The GDC highlights the importance of digital technologies in achieving the SDGs and outlines ways in which nations can develop the necessary levels of digital maturity to ensure that transformations are sustainable across the economic, social, and environmental spheres. For instance, the GDC provides recommendations on investing in skill-building initiatives to foster cultures of innovation and entrepreneurship, while ensuring an inclusive and accessible digital economy. Furthermore, supporting open access to high-computing infrastructure and high-quality data sharing, as well as investing in digital safety and trust-building, is essential. This includes ensuring that the design and deployment of new technologies do not perpetuate existing biases or inequalities.

Assessing National-Level Digital Maturity: The Global Digitalization Index (GDI)

The literature review has established digital maturity as critical for aligning digital transformation with SDGs. Therefore, measuring the degree of digital maturity at a national level can showcase best practices and identify areas for improvement. There are, however, few appropriate digital readiness indicators that enable such assessment at a national level, including the Network Readiness Index (NRI), the Digital Economy and Society Index (DESI), the International Digital Connectivity Readiness Index, and the Digital Readiness Index. All these indices aim to assess a country's readiness for the digital economy; however, some are overly narrow (e.g., focusing solely on connectivity) or have only been evaluated in certain regions (e.g., Europe), and none of them specifically measure maturity. Nevertheless, the Global Digitalization Index (GDI) measures the maturity of a country's ICT industry by factoring in a broad range of indicators related to connectivity, digital infrastructure, investments in green energy and policy to quantify the value of each country's digital economy and its impact on the broader national economy. It is proposed that the GDI can also serve as an indicator of digital sustainability or the impact of the ICT industry on social and environmental development.

The GDI is a collaboration between Huawei and the International Data Corporation (IDC), providing a comprehensive measure of national digital maturity. Although first released in 2024, it was developed as an extension of the Global Connectivity Index (GCI), which was compiled from 2014 to 2020. The GDI assesses levels of investment in and utilisation of digital infrastructure among 77 countries (representing 80% of the global population and 93% of the GDP) across four pillars: Ubiquitous Connectivity (UC), Digital Foundation (DF), Green Energy (GE), and Policy & Ecosystem (P&E). It is based on the concept that the core drivers of a digital economy are Supply and Demand, with Supply comprising the entire ICT development and digital transformation chain, which facilitates Demand driven by technology adoption. For example, to enable Ubiquitous Connectivity, the supply of digital infrastructure such as 5G and mobile broadband must be available to stimulate demand for broadband and mobile data subscriptions. The GDI encompasses countries across the digital maturity spectrum: Frontrunners (digitally advanced nations), Adopters (countries rapidly progressing in digital development), and Starters (those at early stages of ICT infrastructure development). This index provides valuable insights into each country's strengths, weaknesses, and potential opportunities, enabling the development of strategic roadmaps towards digital maturity. Initial analyses of the GDI suggest a strong correlation between digital maturity and economic growth, as well as AI readiness, particularly among Frontrunners (Huawei & IDC, 2024). These findings underscore the importance of digital maturity levels in leveraging innovative technology solutions to capitalise on economic opportunities in an increasingly digital world.

Further research is essential to explore the relationships between the GDI and other development indicators, including those related to SDGs. This is especially relevant given the focus on digital sustainability shared by the GDI and the GDC. Notably, the GDC aims to use digital technology for the benefit of all, ensuring universal internet access, secure online spaces, and effective AI governance, while the GDI measures and encourages digital progress necessary to achieve these goals. Both initiatives aim to bridge the digital divide and promote sustainable development by enhancing digital capabilities. Consequently, investigating whether GDI-measured digital maturity correlates with broader sustainable development indicators, as outlined in the GDC, can help clarify the links between digital development and sustainability, identify best practices, and determine areas that need attention.

Research Aims

The research aims to explore the interrelations between the GDI and its four pillars, using a wide range of indicators, including those related to aspects of human development beyond economic growth, as guided by the factors outlined in the GDC. The goal is to demonstrate how the GDI can be used, alongside other country-level measures, to foster a comprehensive understanding of human development in the digital age. From a theoretical standpoint, this study expands current knowledge

of sustainability and digital transformation by examining the relationship between national levels of digital maturity and broad metrics of sustainable development. From a practical perspective, this research can help to clarify the strengths, weaknesses, and growth opportunities across countries with varying levels of digital maturity, supporting more effective policymaking.

Data Analysis

To examine the interrelations between GDI and sustainable development, a series of indicators were selected representing three overarching thematic areas: (1) overall human development including the Human Development Index, the SDG Index, and the Global Gender Gap Index; (2) governance including three of the Worldwide Governance Indicators, Rule of Law, Political Stability, and Voice and Accountability, as well as the Human Freedom Index and the Global Peace Index; and (3) wellbeing and environment including the three sub-factors of the Social Progress Index (SPI): Wellbeing, Opportunity, and Basic Needs, as well as Subjective Wellbeing and Air Quality.

Additionally, the interrelations between the GDI and the Global Cybersecurity Index were also examined. Details of each indicator are provided in Appendix 1.

The data analysis consisted of four main stages. In the first stage, the correlations between the overall GDI and each set of indicators were assessed and Pearson correlation coefficients calculated.[1] The strongest associations within each of the themes were then graphed in scatter plots coded by region and income category. The second stage of the analysis paralleled the first but instead of the overall score, the associations between the four GDI pillars and the sustainable development indicators were explored and the strongest associations graphed. The third stage of data analysis explored the associations between the GDI clusters (Frontrunners, Adopters, and Starters) and tiers of the Global Cybersecurity Index (Building, Evolving, Establishing, Advancing, Role-Modelling). In the fourth and final stage, a k-means cluster analysis was undertaken to examine the clustering of the sustainable development indicators with the weakest relationship to the GDI and then an examination of the overlap between the GDI clusters and the emergent sustainable development clusters was completed.

Overall Human Development		**Governance**		**Wellbeing & Environment**	
	GDI		GDI		GDI
HDI	0 85	**WGI – Rule of law**	0.85	**SPI – Well-being**	0.82
SDG Index	0.68	**Human Freedom Index**	0.63	**SPI – Opportunity**	0.75
Gender Gap	0.50	**WGI – Political Stability**	0.62	**Happiness**	0.70
		WGI – Voice and Accountability	0.59	**SPI – Basic Needs**	0.68
		Global Peace Index	0.53	**Air Quality**	0.42

Table 1: Correlation analysis: GDI (overall score)

Stage 1. GDI Interrelations with Sustainable Development

Table 1 illustrates the correlation coefficients between the overall GDI and each of the sustainable development indicators grouped by theme.[2] Results show positive interrelations between digital maturity and all selected indicators.[3] Strong correlations are evident between GDI and HDI (ρ=0.85), WGI Rule of Law (ρ=0.85) and SPI – Wellbeing (ρ=0.82), all of which are aggregate measures reflecting living standards along the dimensions of health, education, and safety. Moderate interrelations are observed between GDI and the metrics related to freedom, happiness, and equal opportunities, whereas weak relationships were found with measures of inclusivity (Gender Gap, ρ=0.50) and political participation (WGI Voice and Accountability, ρ=0.59) as well as peace (Global Peace Index, ρ=0.53) and environment (Air Quality, ρ=0.42).

Following the correlation analysis, visualisations of the relationship between the GDI and indicators with the strongest interrelations were then undertaken through scatter plots: HDI (Figure 1), WGI – Rule of Law (Figure 2), and SPI – Wellbeing (Figure 3).[4]

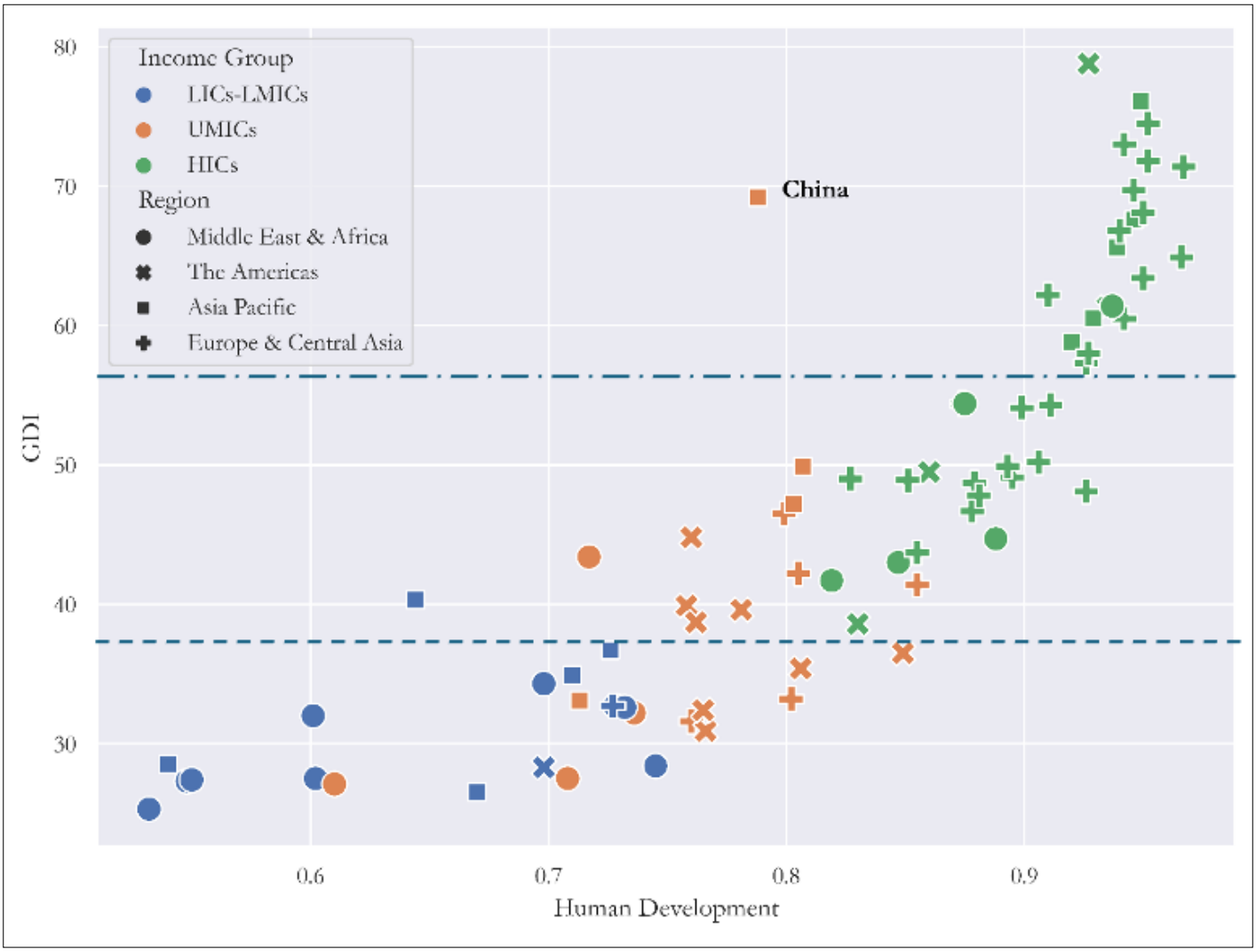

Figure 1. Scatter Plot: GDI and HDI

There is a clear and positive relationship between the GDI and HDI such that the higher a country's digital maturity, the higher its ratings on human development. The HDI is an aggregate score that includes dimensions of health, education and gross national income (i.e., standard of living), making it a critical metric for sustainable development. This strong association supports the idea that levels of digital maturity are closely tied to national engagement in digital sustainability activities. The results also show that higher-income countries (HICs) from Europe and Central Asia tend to cluster at the top right (i.e., high values on both indicators), whereas lower-income (LICs) and lower-middle-income countries (LMICs) from the Middle East and Africa mostly cluster at the bottom left (i.e., low values for both indicators). Figure 1 indicates that the interrelation between GDI and HDI is negligible in many Frontrunners countries (above the upper dashed line) due to a ceiling effect on the HDI, except in China, where the GDI is high, but income levels are lower than other Frontrunners and this is reflected in the HDI score. There is a more apparent association between GDI Adopters (above the lower dashed line) and Starters with the HDI. The Adopters include a diverse group of HICs and UMICs where GDI levels are strongly linked to human development, and there is room for improvement in both. The only exception to this is India, which has relatively high levels of digital maturity, but low levels of HDI. The Starters show a similar association, but there is greater variation in levels of HDI and less variation in levels of GDI.

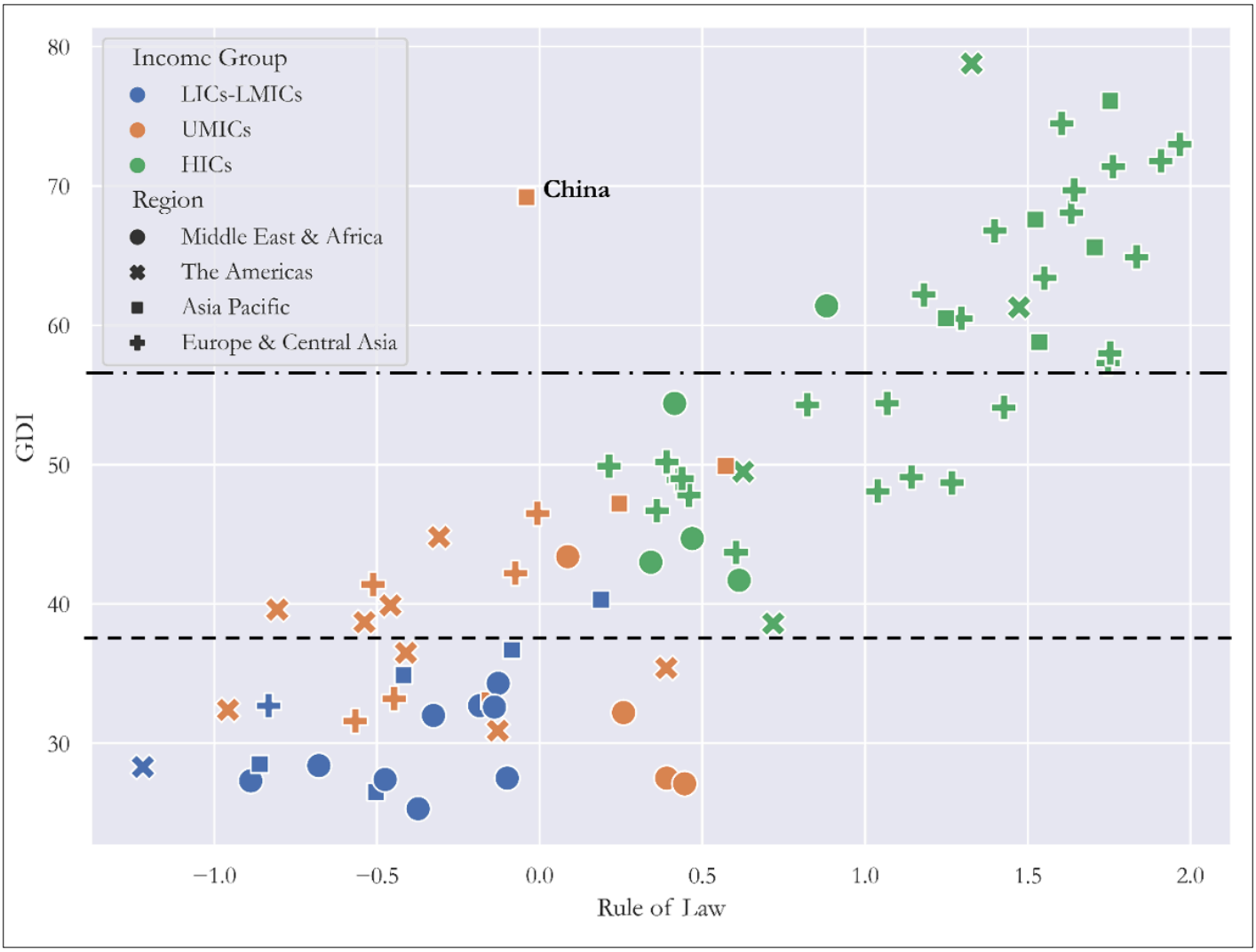

Figure 2. Scatter Plot: GDI and Rule of Law

The Rule of Law is a dimension of the Worldwide Governance Indicators that assesses the levels of confidence in and upholding of social safety and stability (including policing, contracts, property rights and levels of crime). Similar to HDI, there is a clear and positive relationship between the GDI and Rule of Law such that the higher the levels of digital maturity of a country, the higher the ratings on safety. The results also parallel the findings that HICs cluster at the top right (i.e., high values on both indicators), while LICs and LMICs cluster at the bottom left (i.e., low values for both indicators). The figure shows that the Rule of Law score is near or above 0 for most Frontrunners or Adopters countries (above the dashed lines),[5] compared to below 0 for Starters countries. The clear association between GDI and Rule of Law indicates that good governance and safety tend to go hand in hand with levels of digital maturity.

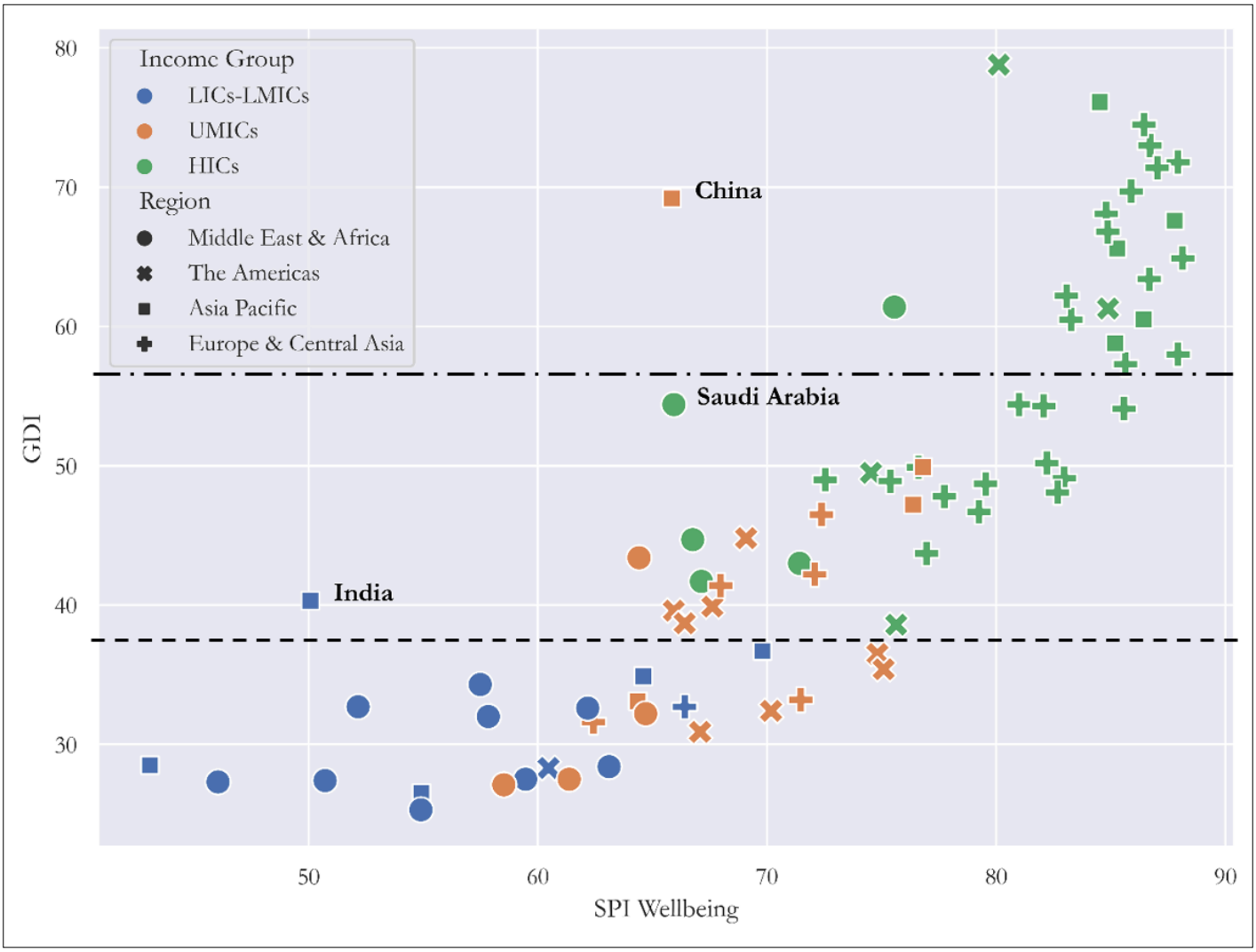

Figure 3. Scatter Plot: GDI and SPI – Wellbeing

The Social Progress Index – Wellbeing is a composite score including basic education, health, environmental quality, and information access, making it a vital metric for sustainable development that is separate from economic indicators. Consistent with previous results, findings show a strong positive correlation between the GDI and SPI – Wellbeing, indicating that countries with higher levels of digital maturity tend to have higher human development ratings. This robust link supports the idea that digital maturity levels are connected to national engagement in various digital sustainability activities. Similar to the association with HDI for Frontrunners countries (above the upper dashed line), the relationship between GDI and Wellbeing becomes negligible due to a ceiling effect, except in China and the UAE, where high GDI scores do not correspond to equally high Wellbeing levels. Among Adopters countries, India and Saudi Arabia display a similar pattern, with lower levels of SPI – Wellbeing than expected based on their digital maturity. Conversely, among Starters countries, a significant variation in SPI –Wellbeing appears to be tied to income levels and geographical region.

Stage 2. GDI Pillars Interrelations with Sustainable Development

Table 2 illustrates the correlation coefficients between the GDI pillars and each of the sustainable development indicators grouped by theme.[6] Results show positive interrelations between digital maturity and all selected indicators[7], however, some of the pillars have stronger interrelations with sustainable development indicators than others. Ubiquitous Connectivity (UC) had very similar results to the overall GDI with strong association found for HDI (ρ=0.85), Rule of Law (ρ=0.79), and SPI – Wellbeing (ρ=0.79), but also a stronger relationship with SPI – Basic Needs (ρ=0.76) than the overall measure. In contrast, UC had the weakest association of all indicators with inclusivity (Gender Gap, ρ=0.32) and environment (Air Quality, ρ=0.23) as well as moderate relationships with political participation, peace and freedom. Digital Foundation (DF) also had strong interrelations with HDI, Rule of Law and SPI – Wellbeing, but additionally, a strong correlation was also evidenced with SPI – Opportunity (ρ=0.71). In contrast, DF had weaker interrelations with peace (Global Peace Index, ρ=0.46) and environment (Air Quality, ρ=0.42). Green Energy (GE), as distinct from the other pillars, did not have as strong interrelations with the sustainable development indicators, with moderate correlations found for the SDG Index (ρ=0.53) and the SPI – Opportunity (ρ=0.51), but weak correlations with the other measures. Policy and Ecosystem (P&E), however, was strongly associated with HDI (ρ=0.82), Rule of Law (ρ=0.83), SPI – Well-being (ρ=0.81) and SPI – Opportunity (ρ=0.78). Furthermore, P&E had moderate correlations with indicators of freedom and peace as well as the highest interrelations with inclusivity (Gender Gap, ρ = 0.52, Voice and Accountability, ρ = 0.65) and environment (Air Quality, ρ = 0.47). Alongside the correlations analyses, scatter plots were created for GDI pillars (see Figures 4 – 7); but, to maintain simplicity, the analysis focuses solely on their relationship with the HDI, as this provides an overarching measure of sustainable development. The disaggregation of the GDI enables a clearer understanding of pillar-specific trends. For instance, UC (Figure 4) shows a strong positive linear relationship with the HDI (similar to the aggregate GDI). However, there are also some outliers, such as Argentina, which have relatively low digital maturity but high human development levels. On the UC pillar, the UAE ranks highest and Nigeria the lowest. A similar positive linear relationship was found for Policy & Ecosystem with HDI (Figure 5), with Bangladesh and the United States at the bottom and top of this pillar, respectively. However, both countries are outliers, with the United States scoring higher and Bangladesh scoring lower in P&E than expected based on their HDI scores. In contrast, the relationship between Digital Foundation shows a curvilinear pattern, with many countries scoring extremely high in human development but displaying heterogeneous outcomes for the GDI component.

Overall Human Development					Governance					Wellbeing & Environment				
	UC	DF	GE	P&E		UC	DF	GE	P&E		UC	DF	GE	P&E
HDI	0.85	0.75	0.41	0.82	Rule of Law	0.79	0.78	0.47	0.83	Social Progress - Wellbeing	0.79	0.74	0.44	0.81
SDGs Index	0.62	0.59	0.53	0.67	Human Freedom Index	0.49	0.59	0.40	0.67	Social Progress – Opportunity	0.62	0.71	0.51	0.78
Gender Gap	0.32	0.50	0.45	0.52	Political Stability	0.63	0.55	0.30	0.59	Happiness	0.69	0.62	0.39	0.67
					Voice and Accountability	0.42	0.56	0.43	0.65	Social Progress – Basic Needs	0.76	0.55	0.35	0.61
					Global Peace Index	0.56	0.46	0.34	0.47	Air Quality	0.23	0.42	0.35	0.47

UC = Ubiquitous Connectivity, DF = Digital Foundation, GE = Green Energy, P&E = Policy and Ecosystem

Table 2. Correlations

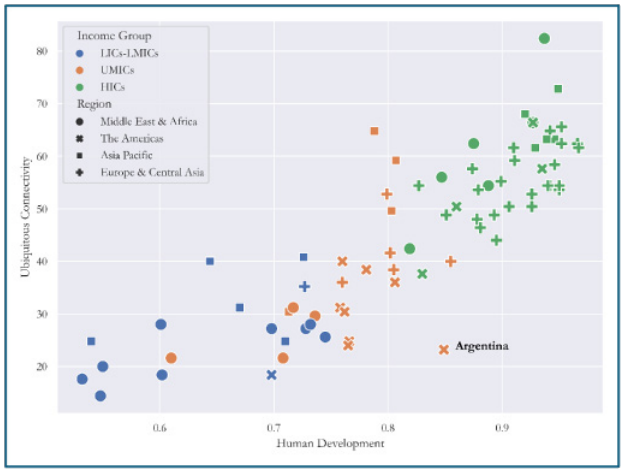

Figure 4. Scatter Plot: UC and HDI

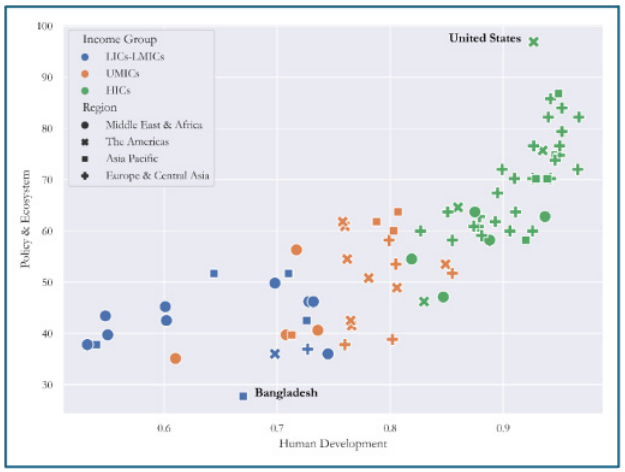

Figure 5. Scatter Plot: P&E and HDI

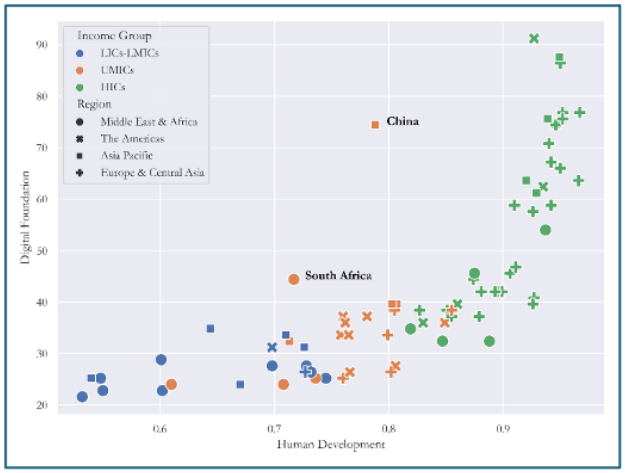

Figure 6. Scatter Plot: DF and HDI

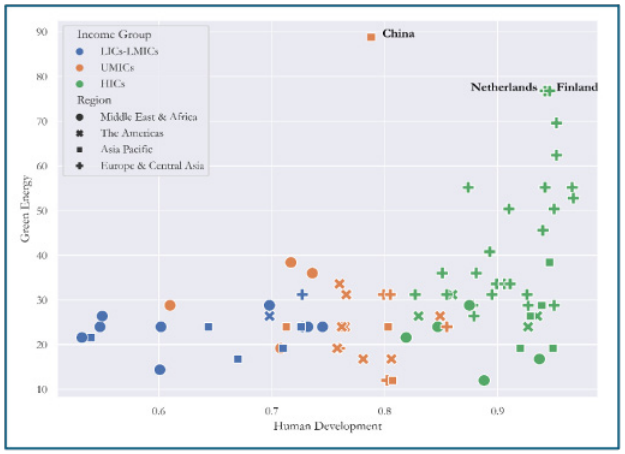

Figure 7. Scatter Plot: GE and HDI

Finally, we observe a flat relationship between Green Energy and HDI (which matches the low correlation reported in Table 2). From Figure 7, we see that most of the countries score between 10 and 40 on this GDI pillar, covering the entire spectrum of HDI values.

Stage 3. GDI clusters and the Global Cybersecurity Index Tiers

To investigate the relationship between cybersecurity and the GDI, a Sankey diagram (Figure 8) displays overlaps between GDI clusters and the Global Cybersecurity Index tiers (GCI; Evolving, Establishing, Advancing, and Role-modelling).[8] The GDI categorises 22 countries as Frontrunners or those at the forefront of digitalization. As expected, most Frontrunners countries (73%; n = 16) are also categorised as Role-modelling, thus demonstrating a strong commitment to coordinated and government-driven actions towards cybersecurity. Out of the remaining Frontrunners countries, 23% exhibited an Advanced tier of cybersecurity and only one (New Zealand) was categorised as Establishing. However, there was evidence for much more variance across the Adopters and Starters countries such that a large proportion were considered to be at Role-modelling (50% and 40% respectively) even though they were not in the most mature GDI cluster. As expected, however, the less digitally mature a country is, the less likely it is to demonstrate high cybersecurity levels. Yet, there are some key areas where countries excel in one but not in the other, highlighting a potential gap in governance or preparedness.

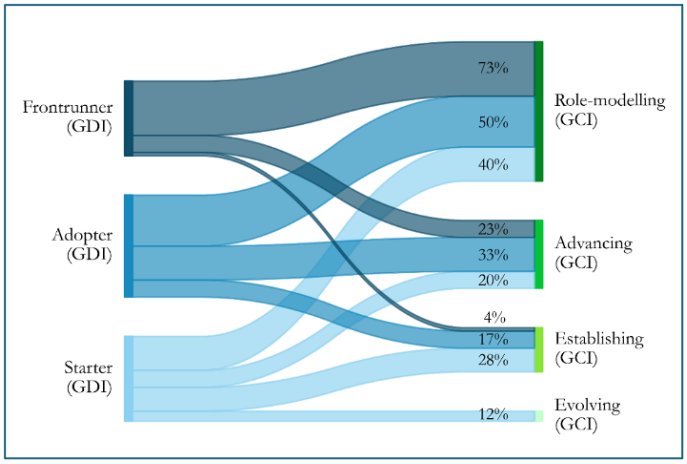

Figure 8. Sankey Diagram: GDI Clusters & GCI Tiers

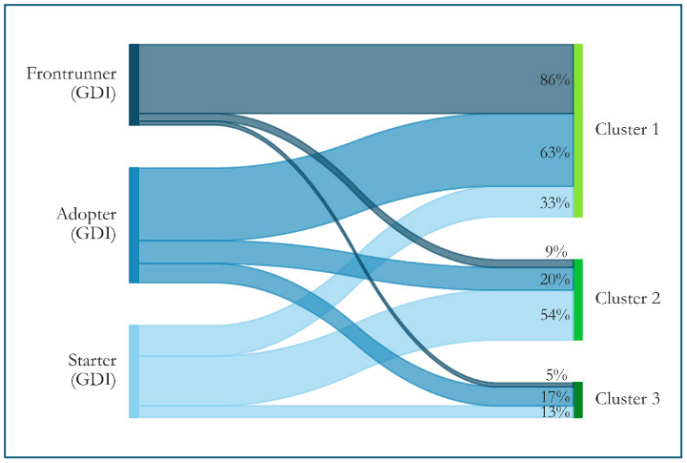

Figure 9. Sankey Diagram: GDI & K-means Clusters

Stage 4. GDI clusters and the K-means clusters

In the final stage of the analysis, emergent clusters were identified based on indicators that showed the weakest association with the GDI in each macro theme, to uncover a non-trivial categorisation that could further describe the overlap between digital maturity and the indicators. The measures selected for inclusion in the cluster analysis are the Gender Gap (Overall Human Development), the Global Peace Index (Governance), and Air Quality (Well-being & Environment). Clusters are inferred by K-means[9] and three groups were distinguished. The first is characterised by joint high values in all three variables (Cluster 1). The second displays middle values across the indicators or a combination of high and low values for two of the variables (Cluster 2). In the third set, countries tend to score low in all indicators (Cluster 3). Figure 9 shows the Sankey diagram between the GDI clusters and the inferred clusters of development. Most Frontrunners and Adopters are categorised into Cluster 1 (86% and 63% respectively), including a substantial number of Starters (33%), such as Algeria, Argentina, Costa Rica, Dominican Republic, Ecuador, Indonesia, Kazakhstan, and Namibia. These countries tended to score high on Gender Gap and/or Air Quality. There is also a small number of Frontrunners that belong to either Cluster 2 or 3. Notably, China and the Republic of Korea belong to Cluster 2 due to low values in both Gender Gap and Air Quality, while the UAE is the only Frontrunner that is categorised into Cluster 3 due to low scores on Air Quality.

Synthesis of Findings

The data analysis reveals a strong association between the Global Digitalization Index (GDI) and indices of human development, wellbeing, and governance, particularly those reflecting social development factors such as population health, education, and public safety. These findings indicate that digital development is closely linked to national investments in social development, and that robust governance frameworks support digital economy growth. In contrast, the GDI shows weaker associations with measures of inclusivity, political participation, peace, and environmental quality. These latter measures represent structural and systemic factors that typically evolve over longer periods, whereas investments in information and communication technology (ICT) infrastructure and digital maturity tend to produce more immediate improvements in quality of life and economic prosperity.

Similar patterns emerged when analysing the four GDI pillars. Notably, ensuring widespread and stable connectivity was not strongly linked to gender equality and political freedom at the national level, but it is well recognised that progress in this pillar can generate positive effects on equal opportunities that may not yet be reflected in the overall indicators. Likewise, the Green Energy pillar showed the weakest connections with the other indicators included in this analysis. Nonetheless, increased investment in renewable energy has only recently started to be regarded as a key national priority, with many countries considered highly developed still lagging behind. In the long term, the Green Energy Pillar is likely to become an even more significant indicator of sustainable digital development, given the growing need for sustainable energy production. Currently, however, national investments in this area have not caught up with other facets of sustainable development. The cluster analysis supports these findings, showing that countries beginning to develop digital maturity (Adopters and Starters) tend to have lower levels of gender equality, peace, and air quality. Hence, it is crucial to explore how digital development can be harnessed to address these gaps as these countries progress in digital maturity.

An important finding is that GDI clusters do not always align with national cybersecurity levels. While frontrunner countries often have strong cybersecurity practices, there is significant variability among adopters and starters. Countries with lower digital maturity can benefit from developing protective measures before investing heavily in technology. Those already implementing such measures might be better positioned in the long term. Moreover, countries with high or moderate digital maturity but inadequate security measures face serious risks from advanced cyber threats. As critical infrastructure and essential services become more digitalized, vulnerabilities increase, potentially jeopardizing sustainable development. Thus, the relationship between digital maturity and cybersecurity is complex, and examining both indices provides a clearer picture of a country's progress toward secure ICT investments.

Overall, the GDI is linked to various indicators of sustainable development, especially those related to social progress and governance. However, it remains unclear which way the relationship flows — whether digital maturity drives sustainable development or vice versa. Further research is essential to examine how countries navigate the twin transitions, to better understand their pathways towards digital sustainability.

Conclusion

Digital transformation and sustainable development are key priority areas for the UN, especially with the adoption of the GDC that outlines the importance of technologies in accelerating progress towards achieving SDGs. Affordability and accessibility of the internet, human rights, gender equality, environmental sustainability and cybersecurity are all crucial areas where concepts of national-level digital maturity and sustainable development intersect. The GDI offers a timely and robust measure to evaluate whether innovation and technology investments connect with holistic economic, social and environmental progress across nations. However, additional dedicated efforts are needed to understand how the positive effects of digital maturity are achieved across different national levels of development and to clarify why, in some contexts, digital maturity does not align with sustainable development as expected.

Recent research from Delgosha et al. (2020) found that national-level relationships between sustainability and digital readiness are complex and variable, particularly in the least developed nations where levels of internet affordability, digital literacy, business and innovation environments, and investments in digital infrastructure are more vital for achieving sustainability than economic, political, and regulatory factors of ICTs. They suggest that countries with the lowest levels of sustainable development must enhance these elements of the digital ecosystem. Conversely, they propose that countries at mid-levels of development require investments in their political and regulatory environments and in business utilisation of ICTs to boost sustainability. Similarly, the findings of this white paper indicate that countries at different stages of the nexus between digital maturity and sustainable development are likely to prioritise different areas. In fact, Adopters and Starters on the GDI may need to focus on investments in digital innovation, with particular attention to gender inclusion, peace, environmental sustainability, and cybersecurity.

As suggested by Del Rio Castro et al. (2021), sustainability is both a means and an end, and it can be argued that digital transformation is similarly a process and a destination. These two transitions mutually promote each other in the most developed countries. Therefore, advanced research is needed to understand the trajectories towards digital maturity and sustainability in less developed contexts, ensuring everyone can benefit from digital technologies while addressing and mitigating associated risks, as well as prioritising human rights, inclusivity, and security.

Footnotes

1 The correlation is computed using Pearson's ρ. However, results do not qualitatively change if we employ Spearman's r.

2 The full correlation matrix is illustrated in Appendix 3.

3 For the purpose of interpretation, we use the following criteria: a correlation coefficient of <= 0.19 is regarded as very weak, 0.2-0.39 as weak, 0.40-0.59 as moderate, 0.60-0.79 as strong, and >= 0.8 as very strong.

4 In the figures, income group is depicted by colour and region by shape.

5 As this indicator is measured as an estimate on a normal distribution of all countries assessed, any score below 0 means that the country has less than average levels of Rule of Law and anything above 0 means greater than average levels of Rule of Law.

6 The full correlation matrix is illustrated in Appendix 3.

7 For the purpose of interpretation, we use the following criteria a correlation coefficient of <= 0.19 is regarded as very weak, 0.2-0.39 as weak, 0.40-0.59 as moderate, 0.60-0.79 as strong and >= 0.8 as very strong.

8 Note that while the GCI has five tiers, only four are represented here as the lowest level tier (Building) was not evident in this sample. The full table of categorisations is outlined in Appendix 4.

9 We set 3 as the number of clusters and initialize the algorithm by the K-means++ scheme, which tends to provide better results than random initialization. The optimal number of clusters is determined by the elbow method (see Figure 12 in Appendix 3).

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Appendices

Appendix 1 – Sustainable Development Indicators

1. Overall Human Development

Human Development Index (HDI)
The Human Development Index (HDI) is a composite measure created by the United Nations Development Programme (UNDP) to evaluate and rank countries based on social and economic development. Introduced in 1990, the HDI examines three essential aspects of human development: a long and healthy life, access to knowledge, and a decent standard of living. These aspects are assessed through four indicators: life expectancy at birth, mean years of schooling, expected years of schooling, and gross national income (GNI) per capita (PPP). The HDI is calculated as the geometric mean of normalised indices for each of the three dimensions, producing a score between 0 and 1, with higher scores representing better human development. The data for these indicators are collected from various sources, including the UN Department of Economic and Social Affairs (UN DESA), the UNESCO Institute for Statistics, and the World Bank.

Sustainable Development Goals (SDGs) Index
The Sustainable Development Goals (SDGs) Index, developed by the Sustainable Development Solutions Network (SDSN) and Bertelsmann Stiftung Foundation, is a comprehensive tool that tracks progress towards the 17 SDGs for all 193 UN member states. The 2024 SDG Index comprises 125 indicators, of which 98 are global indicators and 27 are additional indicators specified to OECD countries. Countries are rated on a scale of 0 to 100, with higher scores indicating greater progress towards the SDGs. The Index, published annually, highlights regional trends and gaps in SDGs achievement, especially between the global average and the world's poorest countries since 2015, when all UN member nations adopted SDGs.

Gender Gap
The Global Gender Gap Index (GGGI) is produced annually by the World Economic Forum (WEF) to measure gender disparities across countries. The Index evaluates gaps between men and women in four key areas: Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. These areas are assessed using 14 indicators sourced from organisations, such as the International Labour Organization (ILO), UNESCO, and national statistics offices. The Economic Participation and Opportunity sub-index includes 5 indicators, Educational Attainment has 4, Health and Survival comprises 2, and Political Empowerment uses 3 indicators. The GGGI calculates female-to-male ratios for each indicator, thereby focusing on gaps rather than absolute numbers. Scores range from 0 to 1, with higher scores nearer 1 indicating greater gender parity.

2. Peace and Governance

Political Stability
The Political Stability and Absence of Violence/Terrorism indicator is one of the six dimensions measured by the Worldwide Governance Indicators (WGI), produced by the World Bank. This indicator assesses perceptions of the likelihood of political instability and politically motivated violence, including terrorism, across over 200 countries and territories. It is derived from more than 30 data sources, including surveys of households and firms, as well as assessments by NGOs and commercial risk agencies. The scores range from approximately -2.5 to 2.5, with higher values indicating greater stability.

Rule of Law
Similarly, the Rule of Law indicator is another dimension measured by the World Bank's Worldwide Governance Indicators (WGI). This indicator assesses the extent to which societies adhere to legal frameworks by examining multiple aspects including judicial independence, property rights protection, contract enforcement, crime prevention, and institutional integrity. It evaluates the effectiveness of law enforcement, judicial systems, and regulatory mechanisms across over 200 countries, considering factors such as land tenure security, tax compliance, prosecutor independence, civilian control of security forces, and protection against political interference in legal processes. The scores range from approximately -2.5 to 2.5, with higher values reflecting a stronger Rule of Law.

Voice and Accountability
The Worldwide Governance Indicators (WGI) also assess Voice and Accountability as one of the six dimensions. This indicator reflects perceptions of how well a country's citizens can participate in choosing their government, alongside freedom of expression, freedom of association, and a free media. As with other WGI measures, it includes data from over 200 countries and territories. Political rights, civil liberties, the integrity of electoral processes, media pluralism and press freedom are all attributes that are checked as part of this measurement. The scores range from approximately -2.5 to 2.5, with higher values indicating greater citizen participation in governance and stronger accountability mechanisms, providing insights into a nation's democratic health and civic freedoms.

Global Peace Index (GPI)
The Global Peace Index (GPI) is published by the Institute for Economics & Peace (IEP) and defines peace negatively as the absence of violence or fear of violence. The Index uses 23 qualitative and quantitative indicators to assess the peacefulness of 163 independent states and territories, covering 99.7% of the world's population. These indicators are organised into three key domains: Ongoing Domestic and International Conflict (6 indicators), Societal Safety and Security (11 indicators), and Militarisation (6 indicators). The data is collected and compiled by the Economist Intelligence Unit, with inputs from an international panel of peace experts. The indicators are weighted and combined into two sub-indices: internal peace (60% of a country's final score) and external peace (40% of the final score).

Human Freedom Index (HFI)
Published annually by the Cato Institute and the Fraser Institute, the Human Freedom Index (HFI) measures personal and economic freedoms across 165 countries and territories. The Index uses 86 distinct indicators from various reputable sources, including the World Justice Project, the United Nations, the World Bank, and others. These indicators are divided into 12 categories:

1. Rule of Law (4 indicators)

2. Security and Safety (2 indicators)

3. Movement (2 indicators)

4. Religion (2 indicators)

5. Association, Assembly, and Civil Society (4 indicators)

6. Expression and Information (5 indicators)

7. Relationships (4 indicators)

8. Size of Government (5 indicators)

9. Legal System and Property Rights (8 indicators)

10. Sound Money (4 indicators)

11. Freedom to Trade Internationally (4 indicators)

12. Regulation (4 indicators)

The HFI combines data from these categories to provide a comprehensive measure of human freedom, covering 98.8% of the world's population. Each country is scored on a scale from 0 to 10, with higher scores indicating greater freedom.

3. Well-being and Environment

Subjective Well-being
Subjective Well-being (SWB) measurement, as conceptualised by Ed Diener in 1984, encompasses three key components: frequent positive affect, infrequent negative affect, and cognitive evaluations such as life satisfaction. The OECD Guidelines on Measuring Subjective Well-being, published in 2013, further refined this approach by recommending a core set of measures including life

evaluation, affect, and eudaimonia. These indicators are derived from self-reported data collected through questionnaires and surveys. The most common measures include the Cantril ladder for life evaluation, the Positive and Negative Affect Schedule (PANAS) for emotional states, and various scales for assessing life satisfaction and sense of purpose. While there is no fixed number of indicators, the OECD recommends a core module of five key indicators for broad use in population surveys. It also comprises additional extended modules that cover various aspects of SWB, including domain satisfaction and experienced well-being.

Social Progress Index – Basic needs
The Social Progress Index (SPI), developed by the Social Progress Imperative, measures social and environmental outcomes across countries using 57 indicators grouped into 12 components within three dimensions. Basic Human Needs is one such dimensions, which includes four components: Nutrition and Medical Care, Water and Sanitation, Housing, and Safety. These components are assessed using specific indicators such as undernourishment, maternal and child mortality rates, access to improved water sources and sanitation facilities, access to electricity, household air pollution, and interpersonal violence. The SPI uniquely excludes economic variables, focusing solely on social and environmental factors to provide a comprehensive view of a society's well-being. Indicators are derived from various sources, including international organisations, national statistics offices, and academic institutions. The index uses a scale of 0 to 100, with higher scores indicating better social progress.

Social Progress Index – Wellbeing
Foundations of Well-being is a dimension of the Social Progress Index (SPI) and specifically addresses aspects of subjective well-being, including access to basic knowledge, information and communications, health and wellness, and environmental quality. These components are assessed using indicators such as access to schooling, press freedom, mobile phone subscriptions, life expectancy, quality of health services, and outdoor air pollution levels.

Social Progress Index – Opportunity
The Opportunity dimension of the Social Progress Index (SPI) attaches importance to the levels at which a country provides its residents with the opportunity to progress, by acquiring higher education, making life choices, exercising citizenship and contribution to social progress. It specifically assesses a country's provision for citizens' progress through higher education, personal freedom, and inclusiveness. This dimension includes indicators such as political rights, freedom of association, freedom to make life choices, absence of vulnerable employment, non-discrimination based on sexuality, access to advanced education, and research resources.

Air Quality
The Global Annual PM2.5 Grids dataset, developed by the Atmospheric Composition Analysis Group at Washington University in Saint Louis, provides comprehensive air quality measurements focusing on fine particulate matter (PM2.5) concentrations. PM2.5 refers to suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and can cause severe health damage. This dataset combines information from satellite observations, chemical transport models, and ground-based measurements to estimate global PM2.5 levels. The primary indicator is the annual average PM2.5 concentration, measured in micrograms per cubic meter ($\mu g/m^3$). The Sustainable Development Goal (SDG) 11 examines air pollution as the population-weighted mean annual concentration of PM2.5 for the urban population in a country, and the long-term objective for this indicator is a value of 6.3, as per the SDG Index website.

Cybersecurity
The Global Cybersecurity Index (GCI) was created by the International Telecommunication Union (ITU) in 2015 to assess the commitment of various countries to cybersecurity. The GCI evaluates 194 countries across five pillars: Legal, Technical, Organizational, Capacity Development, and Cooperation. These pillars are assessed using 25 indicators derived from diverse sources, including national cybersecurity strategies, computer incident response teams (CIRTs), and international cooperation efforts. Data collection employs a multi-stakeholder approach, leveraging questionnaires completed by country focal points, desk research, and expert validation. The GCI uses a scoring system from 0 to 100, with higher scores indicating stronger cybersecurity commitments.

Appendix 2 – Analyses' Assumptions and Limitations

The methods used rely on a set of assumptions that constrain the scope of the current analysis, therefore the main limitations of the analyses are outlined here. First, in the correlation analysis, Pearson's correlation coefficient, a measure that assesses only the strength of the linear relationship between two variables, is computed. However, the relationship between the variables of interest may not be linear. For instance, Figure 6 suggests that the relationship between the GDI pillar Digital Foundation and the HDI might be better represented as a curvilinear relationship. Despite this limitation, this approach provides a good first-order approximation of the relationship between two indicators. Notably, the correlations were also computed using Spearman's rank correlation coefficient, a more flexible metric capable of capturing non-linear relationships, and the results did not substantially change.

Secondly, in the initial part of the analysis, only bivariate interrelations are examined. This poses a limitation since the relationship between GDI and other indicators might vary when multiple factors are considered. Further analysis, such as multiple linear regression, could provide additional insights into multivariate relationships. However, it should be noted that the sample size (n = 77) for which GDI data is available, is relatively small and limits more sophisticated modelling options. This limitation is partially addressed in the final stage of our analysis, where country clusters are identified based on indicators from each macro theme (i.e., Gender Gap, Global Peace Index, and Air Quality). Nonetheless, while K-means is a commonly used and intuitive clustering method, it also has assumptions and limitations. For example, the analysis requires an a priori set of clusters to be defined (which were chosen in this study using the Elbow method). More importantly, the method assumes that clusters have equal variance, a spherical shape, and are roughly similar in size. Future analysis might assess alternative clustering techniques, such as hierarchical clustering or Gaussian Mixture Models. Finally, the current analysis could be further enriched by considering additional indicators within the macro-theme or narrowing focus to specific SDGs.

Appendix 3 – Additional Analyses

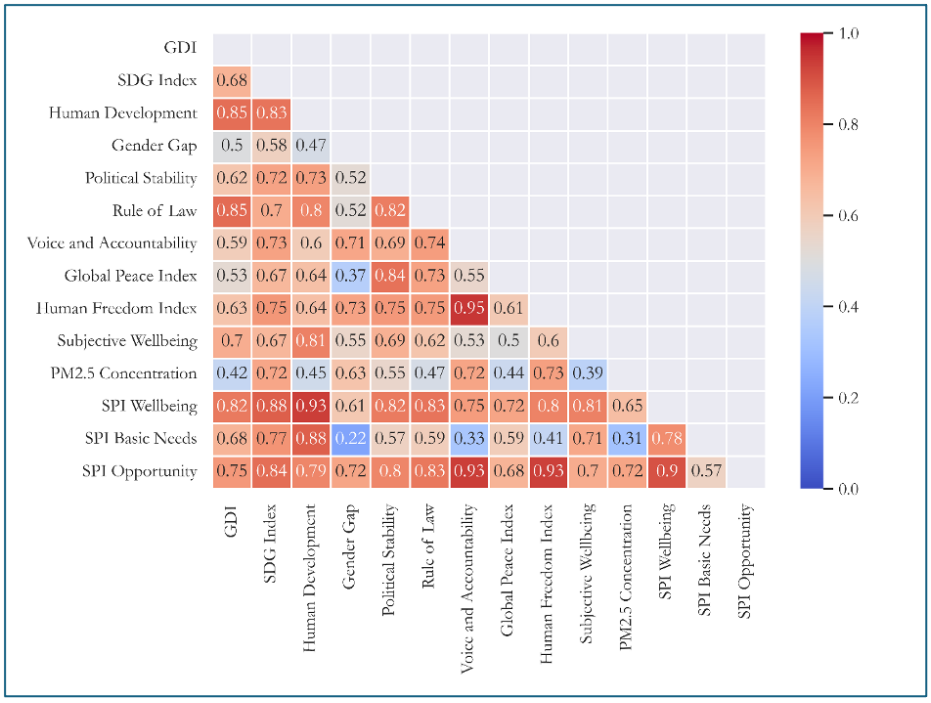

Figure 10. Correlation Matrix of GDI and all Indicators

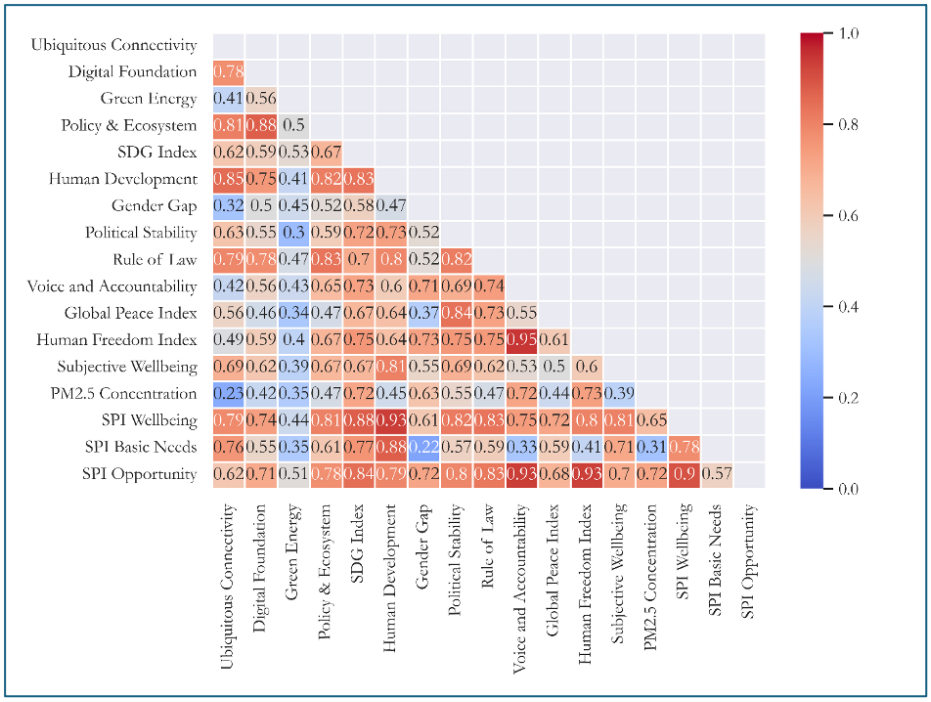

Figure 11. Correlation Matrix of GDI Pillars and all Indicators

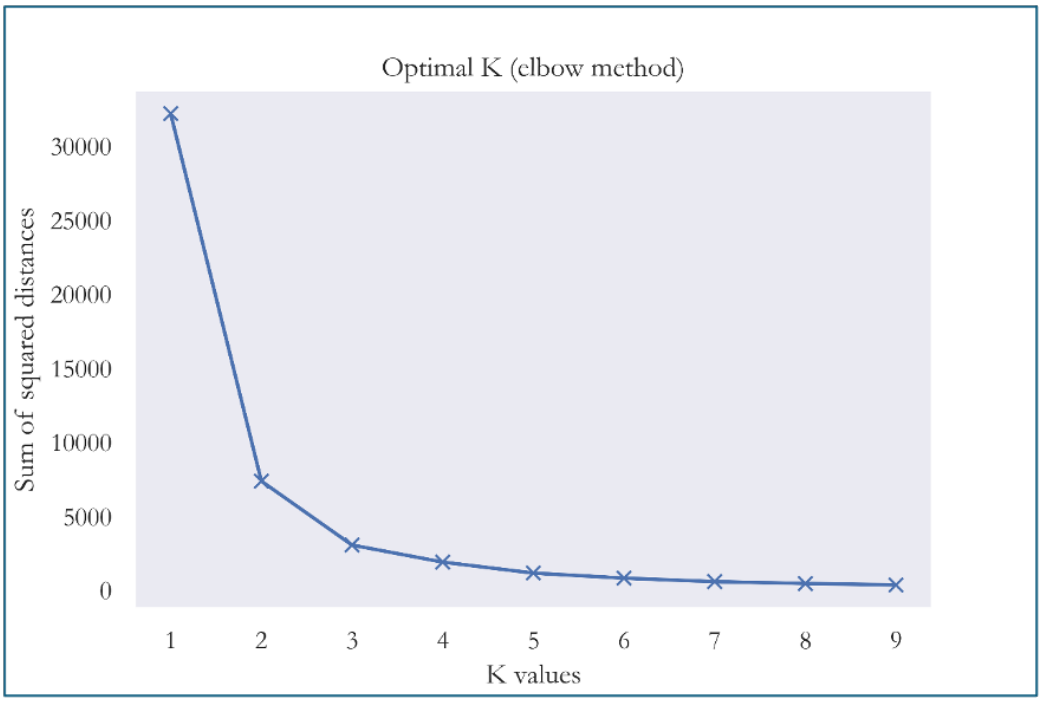

Figure 12. K-Means Cluster Optimal K Estimation

Appendix 4 – Clustering of Countries

Table 3: Clustering of countries by GDI, GCI, K-Means, region and income

Country	GDI Clusters	GCI Clusters	K-means Clusters	Region	Income Group
Australia	Frontrunner	**Role-modelling**	Cluster 1	**Asia Pacific**	HICs
Belgium	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Denmark	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Finland	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
France	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Germany	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Japan	Frontrunner	**Role-modelling**	Cluster 1	**Asia Pacific**	HICs
Netherlands	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Norway	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Singapore	Frontrunner	**Role-modelling**	Cluster 1	**Asia Pacific**	HICs
Sweden	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
United Kingdom	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
United States	Frontrunner	**Role-modelling**	Cluster 1	**The Americas**	HICs
Korea, Rep	Frontrunner	**Role-modelling**	Cluster 2	**Asia Pacific**	HICs
United Arab Emirates	Frontrunner	**Role-modelling**	Cluster 3	**Middle East & Africa**	HICs
Luxembourg	Frontrunner	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Austria	Frontrunner	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Canada	Frontrunner	**Advancing**	Cluster 1	**The Americas**	HICs
Ireland	Frontrunner	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Switzerland	Frontrunner	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
China	Frontrunner	**Advancing**	Cluster 2	**Asia Pacific**	UMICs
New Zealand	Frontrunner	**Establishing**	Cluster 1	**Asia Pacific**	HICs
Brazil	Adopter	**Role-modelling**	Cluster 1	**The Americas**	UMICs
Estonia	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Greece	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Italy	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Malaysia	Adopter	**Role-modelling**	Cluster 1	**Asia Pacific**	UMICs
Portugal	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Serbia	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	UMICs
Slovenia	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs

Country	GDI Clusters	GCI Clusters	K-means Clusters	Region	Income Group
Spain	Adopter	**Role-modelling**	Cluster 1	**Europe & Central Asia**	HICs
Thailand	Adopter	**Role-modelling**	Cluster 2	**Asia Pacific**	UMICs
Turkey	Adopter	**Role-modelling**	Cluster 2	**Europe & Central Asia**	UMICs
Bahrain	Adopter	**Role-modelling**	Cluster 3	**Middle East & Africa**	HICs
India	Adopter	**Role-modelling**	Cluster 3	**Asia Pacific**	LICs-LMICs
Oman	Adopter	**Role-modelling**	Cluster 3	**Middle East & Africa**	HICs
Saudi Arabia	Adopter	**Role-modelling**	Cluster 3	**Middle East & Africa**	HICs
Croatia	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Czech Republic	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Hungary	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Lithuania	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Mexico	Adopter	**Advancing**	Cluster 1	**The Americas**	UMICs
Poland	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Romania	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Slovakia	Adopter	**Advancing**	Cluster 1	**Europe & Central Asia**	HICs
Uruguay	Adopter	**Advancing**	Cluster 1	**The Americas**	HICs
South Africa	Adopter	**Advancing**	Cluster 2	**Middle East & Africa**	UMICs
Colombia	Adopter	**Establishing**	Cluster 1	**The Americas**	UMICs
Bulgaria	Adopter	**Establishing**	Cluster 2	**Europe & Central Asia**	UMICs
Chile	Adopter	**Establishing**	Cluster 2	**The Americas**	HICs
Peru	Adopter	**Establishing**	Cluster 2	**The Americas**	UMICs
Kuwait	Adopter	**Establishing**	Cluster 3	**Middle East & Africa**	HICs
Indonesia	Starter	**Role-modelling**	Cluster 1	**Asia Pacific**	UMICs
Egypt	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Ghana	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Jordan	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	UMICs
Kenya	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Morocco	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Tanzania	Starter	**Role-modelling**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Vietnam	Starter	**Role-modelling**	Cluster 2	**Asia Pacific**	LICs-LMICs
Bangladesh	Starter	**Role-modelling**	Cluster 3	**Asia Pacific**	LICs-LMICs
Pakistan	Starter	**Role-modelling**	Cluster 3	**Asia Pacific**	LICs-LMICs
Ecuador	Starter	**Advancing**	Cluster 1	**The Americas**	UMICs

Country	GDI Clusters	GCI Clusters	K-means Clusters	Region	Income Group
Kazakhstan	Starter	**Advancing**	Cluster 1	**Europe & Central Asia**	UMICs
Azerbaijan	Starter	**Advancing**	Cluster 2	**Europe & Central Asia**	UMICs
Philippines	Starter	**Advancing**	Cluster 2	**Asia Pacific**	LICs-LMICs
Uzbekistan	Starter	**Advancing**	Cluster 2	**Europe & Central Asia**	LICs-LMICs
Algeria	Starter	**Establishing**	Cluster 1	**Middle East & Africa**	LICs-LMICs
Costa Rica	Starter	**Establishing**	Cluster 1	**The Americas**	UMICs
Dominican Republic	Starter	**Establishing**	Cluster 1	**The Americas**	UMICs
Tunisia	Starter	**Establishing**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Uganda	Starter	**Establishing**	Cluster 2	**Middle East & Africa**	LICs-LMICs
Nigeria	Starter	**Establishing**	Cluster 3	**Middle East & Africa**	LICs-LMICs
Botswana	Starter	**Establishing**	Cluster 2	**Middle East & Africa**	UMICs
Argentina	Starter	**Evolving**	Cluster 1	**The Americas**	UMICs
Namibia	Starter	**Evolving**	Cluster 1	**Middle East & Africa**	UMICs
Bolivia	Starter	**Evolving**	Cluster 2	**The Americas**	LICs-LMICs