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Measuring the Role of Technology and Information Systems in Achieving the Sustainable Development Goals in Middle Eastern Countries

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Abstract: This study examines how the contribution of technology and information systems to the Sustainable Development Goals (SDGs) in Middle Eastern countries is measured across different evidence systems. Rather than estimating a new country-level regression, the study compares three measurement layers: composite digital-government indices, absolute ICT indicators, and published econometric estimates linking ICT variables with sustainability outcomes. The analysis maps these layers to SDG 16 (institutions), SDG 9 (infrastructure), SDG 5 (gender equality), and SDG 13 (climate action), and compares the direction of reported environmental effects across studies. The results show a substantial digital-government gap between GCC countries and the remaining Arab countries, a persistent gap between network coverage and actual internet use, and a gender disparity in internet use. Environmental findings are the least stable because the sign of the relationship changes with the ICT variable, time horizon, estimator, and environmental proxy. The study therefore argues that relative indices, absolute ICT statistics, and econometric elasticities should not be combined into a single digital-contribution score. A measurement protocol that keeps these layers separate is proposed as a more transparent basis for assessing digitalization and achieve the SDGs.

Keywords: Digital technologies; Information systems, Sustainable Development Goals, MENA, e-government, ICT, environmental sustainability, measurement.

I. INTRODUCTION

Governments around the Middle East are increasingly making digital technologies and information systems the main drivers of development. All share the view that this can help them get closer to their economic, social, and environmental objectives. However, even this cheerfulness is insufficient, as there is still no accepted method for determining the effectiveness of the digital integration and using information systems in regard to sustainable development in the region.

How can the contribution of digital technologies to sustainable development be measured when the underlying indicators are compiled by different organizations using incompatible methodologies? The question is an eminently practical one. Middle Eastern countries have invested sums in digital infrastructure comparable to the budgets of entire industries, yet published estimates of the returns diverge to the point of opposite signs. According to the International Telecommunication Union, the share of internet users in the Arab States reached 70% by 2024, against a global average of 68% [9]. In the 2024 edition of the E-Government Development Index (EGDI), Saudi Arabia ranked 6th out of 193 states and the United Arab Emirates 11th, with a score of 0.9533 [8].

In this article, the approaches that have been applied to quantify the linkage between information systems and Sustainable Development Goals (SDGs) in the region are systematized and the areas where these linkages fail are identified. It is not yet another fallback regression of ICT on CO_2. The object of the study is the measuring devices themselves, namely the instruments used, the measures they actually record and the ways the same digital variable can be beneficial for one measure of sustainability and detrimental for another [4; 16].

II. REVIEW OF PRIOR SEARCH

The first section of this work examines the "digital dividend" hypothesis in public administration .Dhawi used data from 15 countries in the Middle East and North Africa region for the period 2003–2018 to study the impact of e-government development on combating corruption and government effectiveness. He found that it had a positive impact on both, although its direct impact on composite indicators of sustainable

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development was negative [1]. The result is counter-intuitive: digitalization without parallel public-sector reform does not translate into measurable outcome indicators.

The second section is the econometrics of the ICT–environment nexus. Saad and Boussi, drawing on a sample of 10 MENA countries for 2001–2022 and a Pooled Mean Group estimator, established that ICT reduces CO_2 emissions in the long run while simultaneously increasing both the ecological footprint and aggregate greenhouse gas volumes [2]. Ebaidalla and Abusin obtained a similarly bifurcated result for the Gulf States, where the significance of the effect is conditioned by the level of globalization [5].

The third group of studies is institutional in nature. Ghazal Masri and El-Fadel demonstrate that, in the absence of a regulatory framework, digital innovation does not align automatically with the SDG agenda and requires dedicated governance mechanisms [4]. The World Bank review of the Gulf Cooperation Council (GCC) states records extreme heterogeneity of digital maturity within a single sub region [10].

III. RESEARCH METHODOLOGY

3.1 Study scope and analytical design

The study follows a comparative secondary-analysis design. It does not re-estimate the econometric models reported in the literature; it extracts and compares the measurement logic, variables, direction of effects, geographical coverage, periods, and estimation approaches reported by the cited studies.

Some of the published evidence and research used in the study covers the period 2020-2026, while the main data series extends from 2003 to 2024..The analysis focuses on the description of each measurement tool, the number of sustainable development goals (SDGs) that can be reasonably answered by the tool, and if the results are robust when the ICT or sustainability indicator is varied. The analytical process follows five steps: (1) identification of relevant measurement sources and published estimates; (2) classification of evidence in terms of composite, sectoral and inferential layers; (3) linkage between each layer and SDGs that are covered by the available measurement indicators; (4) comparison of trends and magnitude of reported impacts across studies, estimates, periods, and environmental indicators; and (5) synthesis of the evidence of impact of measurement and the development of a practical protocol for reporting. Given that this study is a structured synthesis and not a systematic review, it is important to note that the literature referenced should be considered as the evidence base used in this paper, and not as a comprehensive list of literature on ICT and the SDGs in the MENA region.

The study is designed as a structured secondary analysis of measurement systems rather than as a new country-level regression. The unit of analysis is the measurement apparatus as such: composite indices, sectoral ICT statistics and published econometric elasticities that claim to quantify the contribution of information systems to individual SDGs in Middle Eastern countries. The time window is 2020–2026 for the literature base and 2003–2024 for the data series.

Three tasks follow from this design. First, the instruments in use are classified into three layers and described operationally (Figure 3). Second, each layer is mapped onto a short list of SDGs for which the region publishes usable indicators: SDG 16 (institutions), SDG 9 (infrastructure), SDG 5 (gender parity) and SDG 13 (climate). Third, the signs and magnitudes recorded in the econometric work of the second layer are compared across estimators and environmental proxies in order to locate the points at which the apparatus yields opposite conclusions from one and the same family of ICT variables.

3.2 Data and measurement logic

Measurement rests on three layers that are not interchangeable. The EGDI combines the Online Services Index (OSI), the Telecommunication Infrastructure Index (TII) and the Human Capital Index (HCI), and ranks countries relative to one another [8]. ITU sectoral statistics record network coverage, user shares and the gender gap in absolute terms [9; 20]. Econometric elasticities treat ICT as a repressor and sustainability as either CO_2 or the ecological footprint [2; 6; 11–14].

Table 1: Data sources and measurement dimensions used in the study

Measurement rule: an index rank, an absolute coverage percentage, and an econometric elasticity are different statistical objects. They are therefore compared qualitatively and diagnostically, rather than mathematically aggregated into one score.

Evidence layer	Main source(s)	Main measures	Measurement role
Layer A — Composite	UN E-Government Survey; World Bank GovTech	EGDI, OSI, TII, HCI, GTMI	Relative digital-government position
Layer B —	ITU digital-development	coverage, internet use,	Absolute access and

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Sectoral	statistics	gender gap	usage levels
Layer C — Inferential	Published MENA/GCC econometric studies	ICT variables; CO_2; ecological footprint	Estimated associations/elasticities

A methodological limitation of the first layer is hardly mentioned in the context of the EGDI: it is a measure of a country's rank, not its absolute level of development. Saudi Arabia's climb from rank 31 last year to rank 6 this year is partly due to the progress made by the Kingdom while other countries either stagnated or declined. The country's EGDI value in 2024 stands at 0.9602; the UAE records 0.9533, with TII = 1.0000 and a human capital index of 0.9436 [8].

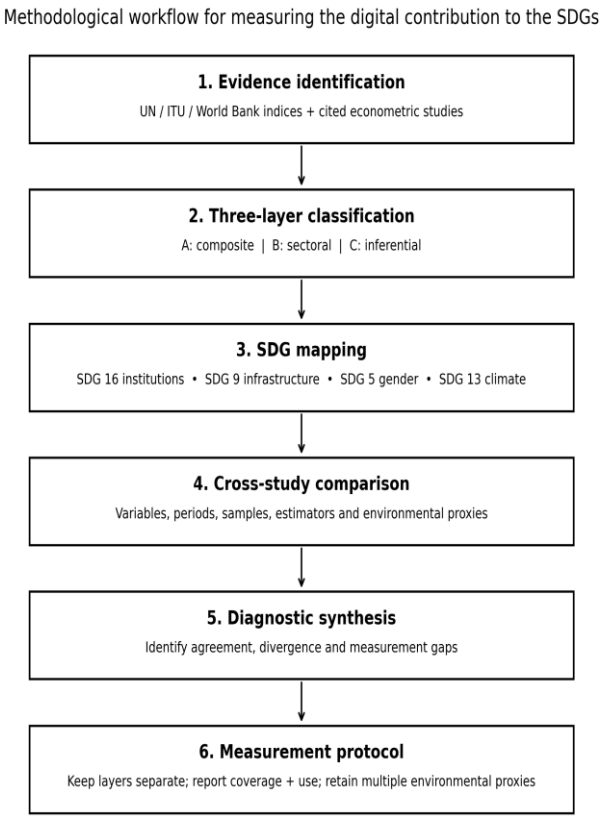

Figure 1: Methodological workflow for the comparative secondary analysis

IV. EXPERIMENTAL RESULTS

The gap between the sub regions of the Middle Eastern space can be measured exactly. The overall average EGDI for the six GCC countries stood at 0.88 in 2024, while the other Arab states had an average EGDI of 0.49, after removing the weights, which is equivalent to more than 39% of the spread of the entire scale [8]. The rank of countries in the Arab world, from top to bottom, according to the rankings: Saudi Arabia (6th worldwide), the UAE (11th), Bahrain (18th), Oman (41st) and Qatar (53rd) at one end, Sudan (178th) and Yemen (185th) at the other [8].

Table 2: Digital government indices of Middle Eastern countries, 2024

Country	EGDI 2024	World rank	TII (infrastructure)
Saudi Arabia	0.9602	6	0.9650
UAE	0.9533	11	1.0000
Bahrain	0.8987	18	0.9300
Oman	0.8102	41	0.8500
Qatar	0.7895	53	0.8700
GCC average	0.8800	-	0.9230
Other Arab countries	0.4900	-	-
Sudan	-	178	-
Yemen	-	185	-

Throughout the Survey, it is important to note that TII = 1.0000 is only recorded in the UAE, the only country in the Survey to have the maximum value of TII [8]. The infrastructure part of the index has reached a saturation point, which makes the service quality and the human capital part more important as they are located outside the sphere of the infrastructure.

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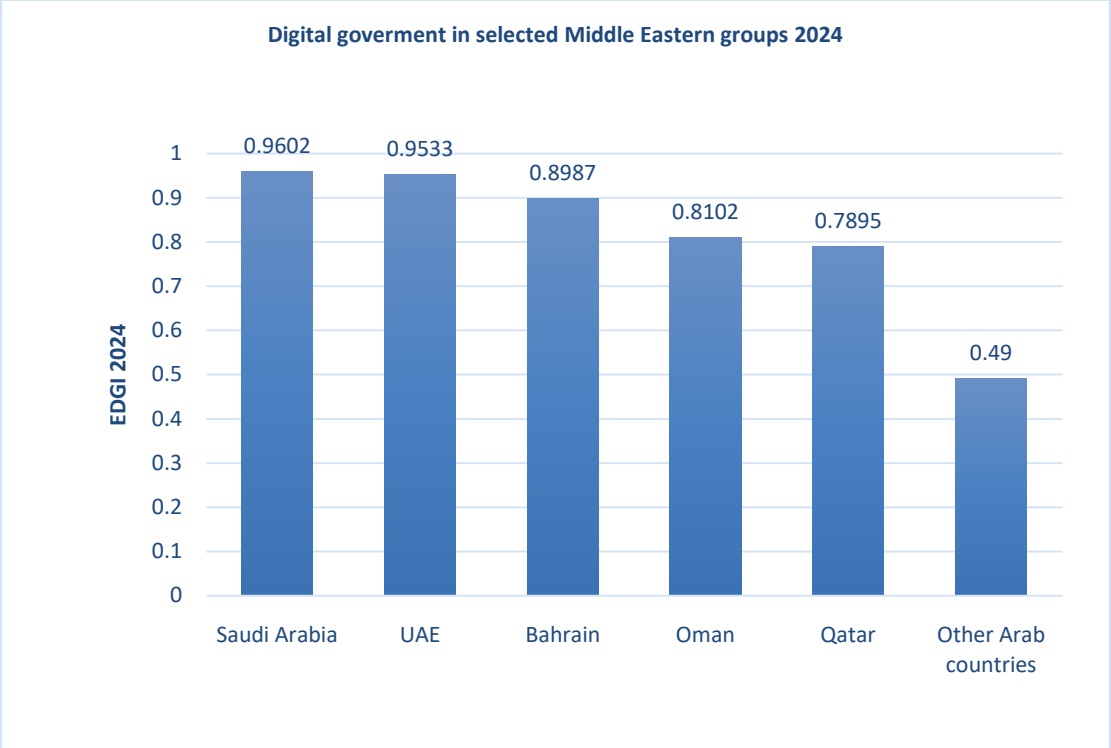

Figure 2: EGDI 2024: comparative profile of countries in the region

Note: The values are taken from the UN E-Government Survey 2024 [8]. The author has calculated the mean for the GCC as an unweighted arithmetic average of the six countries.

This size renders any single regional average as an unreliable gauge: a mean average over 19 states will mask top and bottom performers and will create a skewed picture for academic judgments and policy decisions. The same warning is implicit in the GovTech series: the average may rise while the distance between group A and group D widens [19].

Links to individual goals can be traced along three lines that differ both in the direction of the effect and in its measurability. For ease of comparison they are consolidated in summary Table 3.

Table 3: Correspondence between measurement layers and the Sustainable Development Goals

SDG	Layer A (EGDI/GTMI)	Layer B (ITU – absolute level)	Layer C (econometrics)
SDG 16 (institutions)	EGDI: SA 6th, UAE 11th; negative aggregate effect [1]	Not directly applicable	Control of corruption ↑; direct effect on SDGs ↓ [1]
SDG 9 (infrastructure)	UAE TII = 1.000 (maximum)	90% coverage but only 70% users: a 20 p.p. gap	Insufficient sector-level research
SDG 5 (gender)	Absent from the EGDI	Men 75%, women 64%; parity 0.86 vs 0.94 (world)	Not identified in panel studies
SDG 13 (climate)	Absent from the EGDI	Absent from ITU data	Unstable: CO_2 ↓ and ↑; ecological footprint ↑

SDG 16 - institutions and e-government. E-government behaves predictably: an improvement in control of corruption is confirmed on a panel of 15 countries [1]. Country-level mapping for Saudi Arabia likewise treats e-government maturity as a contribution to institutional and service-related goals, although this mapping is descriptive rather than causal [15].

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At the same time, OECD public-governance monitoring in MENA records accelerated portal construction alongside weak progress on SDG 16 in a number of non-GCC administrations [16]: digitalization transforms the social contract - who is protected, who participates and on which platforms - without automatically generating the institutional outcomes the Goals require [18].

SDG 9 - infrastructure and innovation. Coverage serves as the principal indicator: more than 90% of the population of the Arab States lives within reach of mobile networks, yet only 70% actually use the internet [9; 20]. The 20-percentage-point gap between coverage and usage is not an infrastructure problem but a socio-economic one - devices, skills and content relevance.

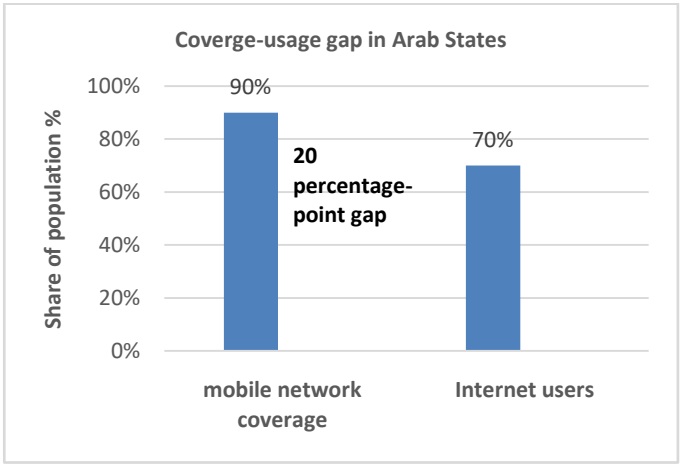

Figure 3: Coverage–usage gap in the Arab States: Networks reach versus actual internet use

SDG 5 - gender equality. Here the picture is considerably harsher: in 2024, 75% of men were online against 64% of women, the gender parity index stood at 0.86 versus a world average of 0.94, and no improvement has been recorded over the past five years [9; 20]. This is the only SDG block considered here for which neither the EGDI nor the econometric literature offers a corrective mechanism - the indicator exists solely within the ITU sectoral layer.

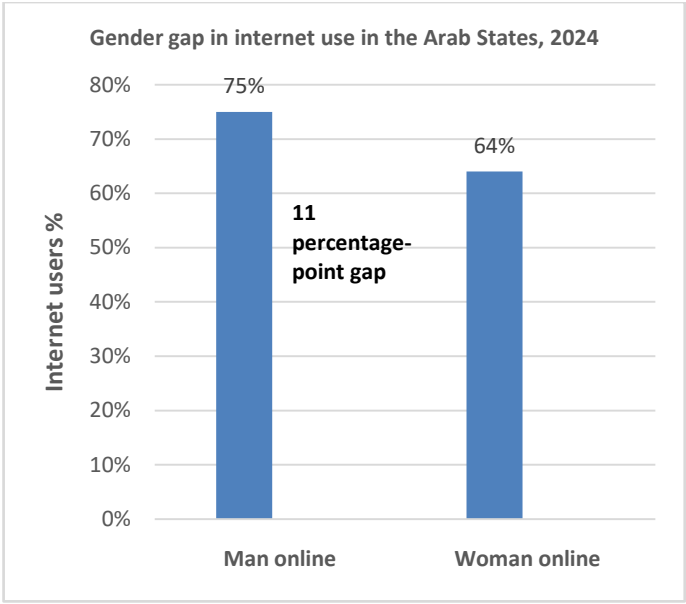

Figure 4: Internet use, Arab States, Gender gap, 2024. Source: ITU [9; 20]

Of all the SDGs assessed, the environmental block gave the lowest stability of the estimates. This discrepancy comes in part from the diversity of samples and estimators, and in large part from the fact that the ecological footprint includes resource consumption of data centres and equipment manufacturing, while CO_2 only measures the energy circuit.

Table 4: Econometric estimates of the impact of ICT on environmental indicators in MENA countries

Authors	Sample / period	Method	Effect on CO_2	Effect on ecological footprint
Saad & Boussi (2025)	10 countries, 2001–2022	PMG	↓ decrease	↑ increase
Charfeddine & Kahia (2021/2025)	15–17 countries, 2003–2022	ARDL-PMG	↓ decrease	↑ depends on the proxy
Appiah-Otoo & Chen (2024)	13 countries, 1995–2018	STIRPAT	↑ increase	n/a
Ebaidalla & Abusin (2022)	6 GCC countries	FMOLS	↑ without globalisation	n/a
Zohra (2025)	17 countries, 2003–2021	ARDL-PMG	↓↑ in the short run	↓↑ non-linear
Abid (2026)	14 countries, 1995–2023	DOLS	n/a	↓ decrease
Jahanger & Usman (2023)	BRI countries, 1995–2019	FMOLS	↓ broadband	↑ mobile
Rahman & Ferdaous (2024)	MENA, 1998–2019	PVAR	↑ increase	n/a

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Table 5: Sign matrix of ICT effects on sustainability indicators (literature review)

ICT variable	CO_2 (short run)	CO_2 (long run)	Ecological footprint
Mobile telephony	↑	↑/↓	↑
Internet users	↓	↓	↑
Broadband internet	↓	↓	↓/↑
ICT services exports	n/a	↓	↓
EGDI (e-government)	-	↓	n/a

The same ICT variable reduces CO_2 in Saad and Boussi and increases ecological footprint [2]. In the earlier samples, and in specifications that lump ICT trade together with ICT use, the first-order effect - more devices, more traffic, more electricity in a fossil-based energy system - is the dominant one [11; 13].

The country-level data for Oman introduces another division in the environmental block, as the digital economy is correlated with smaller climate impacts in the long run, but greater freshwater consumption, which is expected for an energy-intensive country with extensive digital infrastructure, such as Oman [17].

The consequence is that regional reports based on a single indicator (CO_2 only or ecological footprint only) overestimate the environmental benefits of digitalization systematically. It should not be treated as a handy analytical tool to average the two proxies into one 'eco-green' score.

The first possibility scenario. But if the disparity between the 0.88 and 0.49 remains, then the average scores in regions will lose their usefulness as it hides leaders and laggards. A change to a cluster-based approach (GCC, conflict-affected countries and the middle group) would be more methodologically justifiable.

The second case relates to institutions. Dhaoui [1] recorded a negative sign which has not been challenged by later research but qualified: the effect comes into existence only if there is a functional system of public governance, as Ghazal Masri and El-Fadel assert [4]. Without such a system, investments in portals bring a corresponding rise in the rankings of the index without any improvement in the value of services.

The third challenge is in measuring AI. Although AI is already included in the national programs of Saudi Arabia and the UAE, and is just starting to show up in GovTech maturity factors [8; 19], the EGDI and ITU statistics do not yet have a sub-index for the generative models. Interestingly, Riyadh's ranking is in the top three of 193 cities in the local ranking of online services, whereas Saudi Arabia's is 6th of 193 in the country ranking [8]. This highlights the clustering of digital capacity in capital cities. The study has its own limitations, which follow from its design. Elasticities are taken as published; differences in country lists, ICT proxies and lag structures have not been homogenized. Unweighted regional averages give small conflict-affected states the same voice as Saudi Arabia - defensible for a critique of measurement, but misleading as an aggregate of welfare. Primary administrative data from government agencies were not obtained.

Figures 1, 3, and 4 make the main descriptive results visually comparable, while Figure 2 highlights the instability of environmental findings across ICT measures and environmental proxies.

V. DISCUSSION

This finding indicates that there is no one size fits all indicator or measurement strategy to capture the link between digitalization and sustainable development in Middle Eastern countries. The impacts of ICT, however, vary considerably as can be seen in Figure 2, across the range of different environmental indicators. For example, several studies show that the use of the internet and the development of the broadband is associated with CO_2 reductions, while the same development of the internet and broadband could be associated with an increase in ecological footprint. This difference reflects the fact that the assessment of the contribution of ICTs to sustainability can be greatly influenced by the use of different environmental indicators. The difference is considerable because CO_2 emissions and ecological footprint are two different indicators of environmental stress. A CO_2 reduction does not always mean a reduction of the overall environmental impact of digitalization. The components of building digital infrastructure are electricity, electronic equipment, data centers, network expansion and device manufacturing. Therefore if only CO_2 is assessed, the environmental assessment may show positive environmental impacts, but not see the other environmental and resource pressures. The results reveal also that the effect of ICT is not equal for all technologies. The pattern of mobile telephony and the Internet as compared to broadband is different as can be seen in figure 2.In some studies, for example, CO_2 is abated in the broadband, while others don't make the link between broadband and ecological footprint. This means that ICT is not a universal or global sustainability variable. Research at the empirical level needs to differentiate between various types of digital

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infrastructure, connectivity and/or digital services instead of just a single indicator of ICTs. The institutional results are quite different. The findings from this study indicate that the positive relationship between digital government and institutional outcomes (e.g., government effectiveness, control of corruption) is fairly robust. However, if the e-government infrastructure is improved or online service is provided, it does not necessarily result in equal results in sustainable-development outcomes. Digitalisation has a bit better chance of success when this is accompanied by elements of institutional capacity, governance reforms and mechanisms that link technological investments to improved public services. The other major finding was in the difference between infrastructure and the use of technology. The high rates of network coverage are contrasted with lower rates of people using the internet in the Arab States. However, this coverage–usage gap suggests that infrastructure is not enough to show digital inclusion. If the infrastructure is affordable, it has digital skills or if there is some relevance of content and socioeconomic conditions, infrastructure can be converted into meaningful use. Hence, separately coverage and use shall be reported for SDG related assessments. The gender dimension is a part of this argument. The lack of a gender parity in the use of Internet implies a possible over-estimation of inequalities among population groups when using overall digital-development indicators. A country can have a high overall level of digitalization without the important groups having a high level of digitalization. Thus, indicators need to be disaggregated not based on general digital-government or infrastructure indicators, but to measure the contribution of ICT to SDG 5. The three levels of measurement can be used to account for the apparent paradoxical results. The composite indices (EGDI) are used to measure how a country does as compared to other countries, the ITU indicators are used to measure absolute levels of access and use, and the econometric studies estimate relationships between ICT variables and sustainability outcomes. The following instruments are not always comparable instruments for measuring the same digital contribution, because they question in different ways. The evidence thus support the use of a multi-level measurement approach. The first level indicators can be used to measure the national maturity of digital government. For level 2, sectoral indicators will be required for measuring actual access, usage and inclusion. Econometric evidence is the third type of evidence that tries to answer the question of whether digitalization is associated with a change in specific sustainability outcomes. Digital-development rankings that are separated from the digital and sustainability scores do not pose the same risk of using a high score on digital development as a proxy for sustainability improvement. Overall, the results indicate that the role information systems play in the SDGs is not consistently positive. Digital technologies can help to reinforce institutions and increase access to services, but context, population group and technology examined determine environmental and social impacts. The significant take-home message is methodological: future assessments should not rely on a single ‘digital contribution' metric but instead include a multi-dimensional set of metrics that reflects variations between digital maturity, actual use, and inclusion and sustainable outcomes.

The results indicate that the role of information systems in the SDGs is not necessarily positive, but depends on the situation. While digital technologies can improve institutions and increase access to services, their environment and social impacts vary by the technology, indicator, institutional structure and population group assessed. The key takeaway is thus the method to be used in future evaluations, which should not rely on a single aggregate “digital contribution” measure, but rather a multidimensional series of indicators which can capture the differences between digital maturity and actual use, inclusion and sustainability outcomes.

VI. CONCLUSIONS

This study explored the measurement of contribution of information systems and digital technologies to SDGs (Sustainable Development Goals) in Middle Eastern countries. The analysis reveals that the reported contribution of digitalization is very dependent on the indicator and the measurement approach. The indices of sustainable development shown in the images are composite digital-government indices, sectoral information on ICTs, and econometric estimates, respectively, and should not be treated as identical measures of sustainable development. The results suggest that the strongest and most direct link between digitalization and institutional development is with e-government, government effectiveness and control of corruption. The impacts of ICT on the environment are more ambiguous, however. The reviewed studies show inconsistent findings with regard to the direction of the association on the basis of the geographical sample, environmental indicator, estimation method and the ICT variable. In particular, the reduction of CO_2 emissions does not mean that the overall ecological footprint of digitalization is reduced .The study also identifies key inequalities within the regional digital-development averages. The significant disparity between the GCC countries and the rest of the Arab region reveals the extent of variation in digital maturity across the region. Likewise, the gap between network coverage and actual

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Internet use, as well as the continuing gender disparity in Internet use demonstrates that infrastructure alone is not a sufficient measure of digital inclusion. The multidimensional approach should be followed in the measurement of digitalization and its role in achieving the SDGs based on these findings. Digital-government maturity, infrastructure coverage, use of digital government, gender inclusion, institutional outcomes, and environmental impact are four dimensions that should be reported separately but interconnected. Assessing environmental impacts should also rely on multiple indicators and not on CO_2 emissions alone, as these are not a full proxy for the environmental impacts of digital technologies. The study thus concludes that there is no one reliable measure of the overall contribution of the "digital" to the SDGs in the region. Further progress towards informing the assessment would be made through the use of separate measurement layers, disaggregated indicators, and through more focus on differences between countries and between population groups. Future research should create more uniform regional data, integrate new technologies like artificial intelligence into official digital-development indicators and advance indicators of the energy and material footprint of digital infrastructure. These enhancements would offer a better foundation to assess the extent to which digital transformation is advancing technological progress and also measurable and inclusive sustainable development.

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