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Evaluating ICT development: Indicators, digital progress, and societal impact for sustainable development

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ABSTRACT

Measuring the progress of Information and Communication Technology (ICT) is important for achieving sustainable development. Various methods and indices have been created to evaluate the level of digitalization in a society or country. ICT indicators and indices involve choosing and weighing factors such as the accessibility, efficiency, and impact of ICT development. This study used the PRISMA method to select and review eighteen previous studies, focusing on the ICT development indicators they used and assessing their effects on society. It identified many indicators, with access, usage, and ICT skills being the most common. By examining these indicators, the study has gained insights into how to measure digital progress, assess the digital divide, create strategic policies, and evaluate the influence of ICT on human and social capital. The study concludes that the development and selection of ICT indicators should be broadened beyond the current framework to improve the effectiveness and relevance of ICT development goals.

1. Introduction

Over the past few decades, there has been a significant focus on the development of Information and Communication Technology (ICT) as a means of advancing global society. Research has proven that ICT development has played a vital role in developing countries by creating livelihood opportunities (Perumal et al., 2023; Makoza and Chigona, 2012; Khalid et al., 2019; Naivinit, 2009), allowing citizens to access a greater volume of information and consequently to make better and more appropriate decision making in less time plus providing a competitive advantage (Kerras et al. 2020). ICT contains a complex and heterogeneous mix of items, applications, and services used to produce, distribute, process, and transform information, and ICT has been recognized as playing a crucial role in a country's economic development (Khalid et al., 2019). ICT has become an integral element of our lives and an indispensable technology in global and government strategies (Torkayesh and Torkayesh, 2021).

In the current context of the post-COVID-19 pandemic, ICT has become a vital tool for maintaining societal order amidst movement restrictions (Yang et al., 2020). This includes various technologies such as the internet, platforms, networks, telephones, digital applications, databases, and their underlying infrastructure. As the pandemic continues to impact our daily lives, it is unlikely that we will return to a pre-COVID-19 state, and a new strategy is needed to address the ongoing challenges posed by the epidemic (WEF, 2021). The COVID-19 pandemic has highlighted the importance of ICT and the need for its continued development as it has become an essential part of many aspects of our lives and has revolutionized many fields and sectors. The concept of a "new normal" demonstrates that ICT has become both advantageous and practical and has digitalized our way of life (Saeed et al., 2022). Furthermore, technology has played a significant role in post-COVID-19 eras by connecting people and creating opportunities.

The increasing significance of digital technologies and infrastructures in daily life has placed digital strategies at the center of policy agendas for a post-COVID-19 era to develop resilience and overcome digital disparities (OECD, 2020; Marston et al., 2020). Transformation and innovation in the digital realm

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are crucial nowadays (OECD, 2020). ICT has become a tool for achieving Sustainable Development Goals (SDGs) and an essential component for enhancing community and national prosperity. Research demonstrates that there is a correlation between technologies, sustainable development, and socio-economic issues in a world that is rapidly changing (Khalid et al., 2019), and ICT has demonstrated positive impacts on creating sustainability in three dimensions: economic, social, and environmental. The development of ICT has far-reaching social impacts, including education, work, consumption, health, community and family, creation and innovation, participatory governance, contemporary organizations, social entrepreneurs, political activism, social integration, and peace and security. The values of the digital revolution positively impact most of the human environment and continue to generate possibilities and opportunities in society. However, the digital divide remains a significant issue, with substantial disparities across individuals, groups, regions, and nations in terms of access to and utilization of ICTs (ITU, 2023; Srinuan and Bohlin, 2011).

The rapid and continuous progress of ICT, along with the constantly evolving technological advancements, cultural values, and political perspectives, presents significant challenges in identifying the societal impacts of ICT (Beroggi et al., 2005). Given the dynamic nature of the human environment, it is crucial to understand the intersection of technology use with human development and living standards. As such, identifying the most critical indicators that should be prioritized in measuring the effects and influence of ICT development on society is of utmost importance. The measurement of ICT development is essential for evaluating the effectiveness and efficiency of ICT strategies and outcomes. These indicators serve as the core of evaluation, identifying, refining, and approving ICT strategies, implementation, and outcomes (Whyte, 2000). They are also necessary for setting policy priorities, evaluating progress toward objectives, and benchmarking results to provide relevant information about projects, countries, or regions (Mahan, 2007).

Ongoing scholarly debates, discussions, and research have been conducted to explore the most appropriate approaches for measuring the societal effects of ICT. Studies done previously have utilized different approaches to select and employ ICT indicators (Whyte, 2000; Borjigin et al., 2016; Solomon and Klyton, 2020; Machova and Lnenicka, 2015; Binsfeld et al., 2017). Moreover, several global organizations, including the United Nations Development Programme (UNDP), the International Telecommunication Union (ITU), the World Bank, and the Economist Intelligence Unit (EIU) have produced sets of ICT indicators. These models include the Digital Access Index, Digital Opportunity Index, E-Readiness Index, ICT index, Index of ICT Diffusion, Index of Knowledge Societies, Info states, Knowledge-Economy Index, Networked Readiness Index, and Technology Achievement Index, among others (Mahan, 2007). The selection of appropriate indicators to evaluate ICT development is crucial in addressing the concerns of the digital divide and designing a future strategy for ICT development.

The literature also highlights the concern that today's excellent indicators may become irrelevant soon due to rapid technological development and the adoption and impact of innovation (Beroggi et al., 2005). Therefore, to achieve the intended outcome of empowering individuals and improving living conditions, it is necessary to consider and align the qualities of individuals and society with society's needs. Besides, ICT indicators must evaluate the system's performance and its effects to establish a relationship between project objectives, key concepts, and data collection (Whyte, 2000). These indicators play a critical role in ensuring that ICT development meets societal needs and its implementation contributes to its intended outcomes. Furthermore, ICT indicators enable a better understanding of the system's performance and impact, providing a basis for policy decisions and future developments that are both relevant and responsive to the ever-changing ICT landscape.

Understanding the significance of ICT impacts on the human environment requires a study of studies establishing indicators for measuring ICT development. In a worldwide context, various ICT indicators have been used to examine technology accessibility and consumption levels among societies and nations. This systematic review, therefore, poses the following two questions: 1) Which ICT indicators do the previous studies use to measure the development of ICT on a societal or global scale? and 2) What are the social implications of these indicators? Understanding the answers to these questions is crucial to comprehending the evaluation process and the selection of indicators. The aim of this study is to conduct a literature review and identify the various types of indicators used in previous research studies. Additionally, this review seeks to understand the social implications associated with using these indicators. The overarching goal of this review is to enhance our understanding of the field of ICT development and to develop a systematic and methodical approach to evaluating ICT development.

2. Materials and methods

A systematic literature review is characterized as a thorough, structured, transparent, and referenced review method (Higgins et al., 2019), as well as a protocol-driven and systematically executed review of the literature (Nightingale, 2009). A systematic literature review has been acknowledged as a best practice for providing relevant recommendations for an agenda for future refinement (Rojon et al., 2021). Besides, a systematic literature evaluation was done to ensure that a current and comprehensive understanding of relevant research evidence can inform decisions affecting the lives of people

(Chandler et al., 2019; Diansyah et al., 2021). Okoli (2015) suggested eight steps for doing a systematic literature review: i) identify the purpose, ii) develop a procedure and train the team, iii) apply practical screen, iv) search for literature, v) extract data, vi) assess quality, vii) synthesize research, and viii) write the review. The study uses Preferred Reporting Items for Systematic Evaluation and Meta-analysis (PRISMA) to present a comprehensive literature review. PRISMA is a publication standard extensively used in medicine and public health, but it is also applicable to other fields, such as the social sciences, because it facilitates the formulation of straightforward research questions and enables systematic literature searches. PRISMA comprises 27 items that can be followed in the construction of a systematic literature review (Moher et al., 2009). Identification, screening, and eligibility were the organizational tactics used to organize the literature search process. Fig. 1 illustrates the flow and provides a summary of the systematic literature review for this study.

2.1. Identification

Identification is the process of locating relevant research articles with the appropriate keywords based on research questions. This systematic review is restricted to searching, revealing, and analyzing Web of Science publications. It has been asserted that the Web of Science database is the world's most trusted publisher-independent global citation database with the most influential research engine, providing the best publishing and citation data for confident discovery, access, and evaluation. Web of Science in 2021 also asserted that all articles are all-cited references from every journal that has been indexed and impacted, thereby creating the most comprehensive and complete citation network to facilitate confident discovery and reliable evaluation across multiple disciplines and fields. In addition, this database contains articles from 5,000 fully open access, hybrid, and subscription journals from across the world.

In this review study, two keywords and their synonyms were used to refine the search. First, the keywords were <social indicator> AND <ICT development> used for searching in the Web of Science database, generating 419 publications. Second, the search was refined topic in 3 types of keyword synonyms, which were <social> OR <civil> OR <communal>, <indicator> OR <index>, and <development> OR <advancement> OR <Evolution> OR <improvement>. The search resulted in 144 publications. Table 1 illustrates the steps of the search in the identification step.

2.2. Screening

In this step, a list of possibly relevant articles has been analyzed for content that corresponds to predefined research questions based on the criteria and checklist established for this study. The study has been filtered by article type and language for each of the 144 publications. There is no restriction on the publishing year. The database's cataloged publications range from 2002 to 2023. The sorting was performed using the search feature of the Web of Science database, allowing the study to be limited to research papers as the type of publication, and the articles must be written in English. There are 36 publications that were eliminated from the record because of screening; 35 publications were conferences, review papers, and book chapters, and three publications were not written in English. The study has selected only English and research articles to ensure quality and avoid misunderstanding by referring to other languages. The remaining 106 papers were evaluated for the third and final step, eligibility. Table 2 displays the inclusion criteria for published searches.

Table 1: The search strings

Database	Search strings
Web of Science	Topic: (social indicator AND ICT development) Refined by: Topic: (social OR civil OR communal), (indicator OR index), and (development OR advancement OR evolution OR improvement)

Table 2: Criteria of search inclusion

Inclusion criteria	Type
Year of publication	No restriction
Type of publication	Research article/journal
Publication language	English
Publication focus	Index or indicator of ICT development

2.3. Eligibility

The selected 106 publications have been evaluated according to the eligibility criteria. Eligibility is the third step, during which the study will examine the keyword and abstract to determine content-based inclusion or exclusion (Hiebl, 2023). The method entails examining the article's title, keywords, and abstract, as well as scanning or reading a few articles, if necessary, to determine if their content is pertinent to the study's research questions. There were 84 papers that were removed because their topic was unrelated to the study issues. Articles on green development, energy development, corporate reputation management, cryptocurrency, gig economy, tourism industry development, oral health, transformation stress, corporate social responsibility, environmental degradation, predicting preterm birth, predictive model for suicide, clean energy, general practitioners, social media, multidomain intervention, food processing, health care, carbon dioxide emission, environmental sustainability index, spatial information, insomnia symptoms, tourism, gender study, photosynthetic, human development, smoking prevalence, plot-based

detection, health management, economy formation, violence, risk evaluation, and public networks are excluded. After the qualification process, only 22 articles remain for quality appraisal.

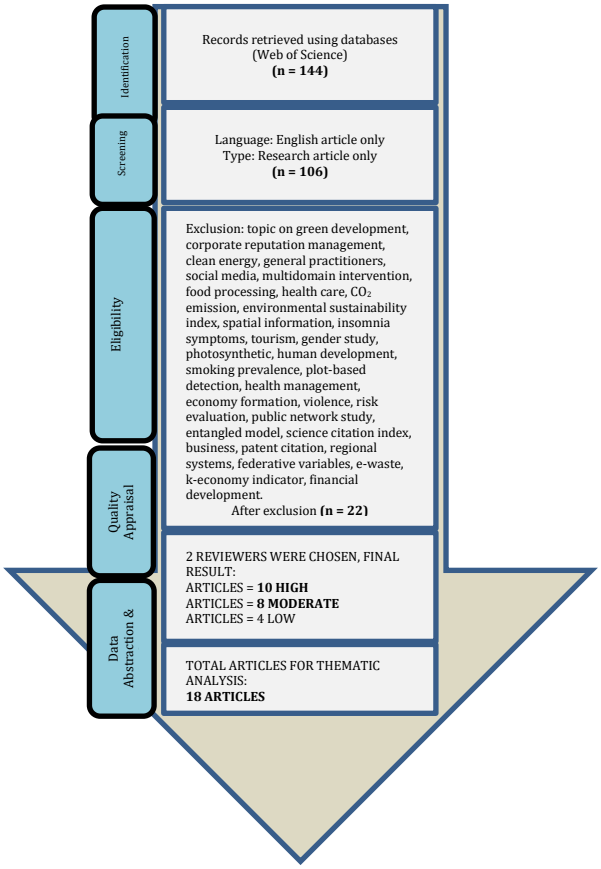

Fig. 1: The flow diagram

2.4. Quality appraisal

The 22 selected articles were provided to two experts for quality appraisal. The experts have categorized the papers into three categories based on their quality: high, moderate, and low. Only items with high and moderate ratings have been examined (Abas et al., 2022). Quality appraisal in a systematic review is necessary to exclude low-quality articles and include only high and moderate-quality articles. The quality appraisal ensures the quality of the contained analysis and evidence and eliminates methodological bias (Pieper et al., 2014). The evaluation of the publications was based on the research questions and techniques. Ten articles have been ranked as high, eight as moderate, and four as low by the experts. Therefore, only eighteen articles qualified for review. The low ranking of the articles is due to their diverse research scopes, which include research on the e-government index, key performance indicators for contact center system development, trans-oriented development, and the sustainability of urban development.

2.5. Data abstraction and analysis

In this study review, eighteen papers were spatially and temporally analyzed to establish the location and year of their publication. The study next analyzed the indicator employed by the selected papers to quantify ICT development on a societal or global scale. The study then utilized thematic analysis to identify and categorize the data from the chosen publications. Thematic analysis is a qualitative method for analyzing classification, presenting themes that link to the data in depth, and addressing a variety of subjects revealed through interpretations. Examining one by one the extracted findings from the eighteen selected publications, the investigation identifies similarities to set as a single data set. After a thorough review, related facts were grouped together to form the theme. During this process, four major topics were developed: i) digital development measurement, ii) digital divide gap quantification, iii) strategic planning and development strategy, and iv) measuring human and social capital. All themes developed are relevant to the study questions.

3. Results

3.1. Temporal and spatial analysis of the selected articles

Before discussing the key findings, this study will first provide an overview of the context within the eighteen selected publications for this systematic literature review. As shown in Fig. 2, the distribution of relevant articles over the years is notable. A single article was identified for each of the years 2011, 2012, 2016, 2017, and 2020, with two articles added in 2015. The article search was unrestricted by publication date, and no relevant articles were found before 2011. Additionally, there were no reviewed publications from 2013–2014 or 2018–2019. However, starting from 2021 through 2023, there was an increase in publications relevant to the review's focus. Fig. 2 illustrates this trend, showing that three articles were selected from each of 2021 and 2022, while five were included from 2023.

Next, spatial analysis of the selected literature reveals that thirteen papers undertake comparative examinations of ICT development across multiple nations. Correspondingly, five articles adopt a narrower focus, confining their investigations to a single country (Fig. 3). These countries under analysis in single-country studies are Japan, China, Spain, Luxembourg, and Romania. Furthermore, within the subset of single-country studies, three articles engage in comparative analyses between regions, while two articles concentrate on specific study areas within a country. Fig. 4 illustrates the distribution of publications conducting both comparative and non-comparative research across nations and regions.

Based on the outcomes derived from both the temporal and spatial analyses, this investigation has unveiled a paucity of scholarly inquiries into the ICT indicators pertaining to social development. ICT research has adapted to the current context, given the importance of ICT use and access during the

COVID-19 pandemic, and ICT development has become a component of the instruments for achieving the SDGs. Hence, comparative studies are becoming increasingly common.

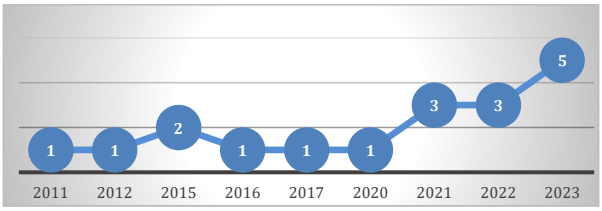

Fig. 2: Temporal distribution analysis

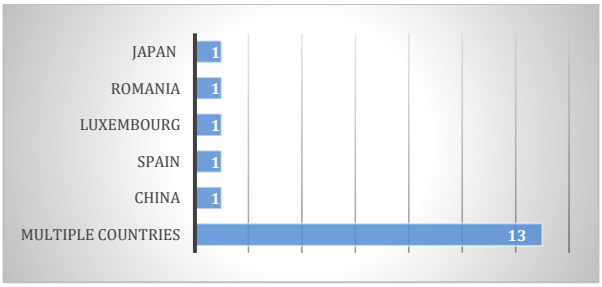

Fig. 3: Spatial distribution analysis of the selected articles

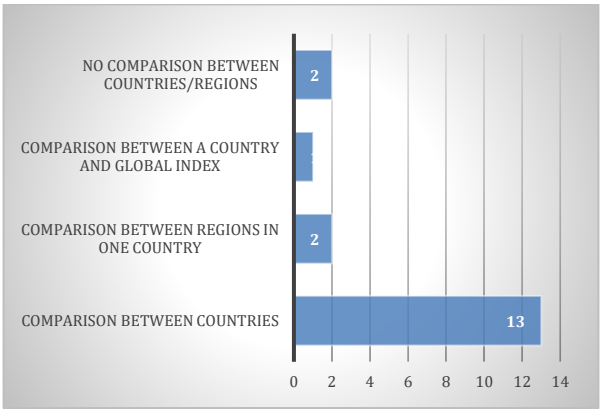

Fig. 4: Comparison and non-comparison research

The primary objective underpinning comparative research employing ICT indicators as a metric lies in assessing the extent of a nation's or society's digitalization. Such comparative endeavors are instrumental in evaluating ICT progress and formulating strategic frameworks for systematic ICT expansion. It is widely posited that such endeavors hold promise in catalyzing economic growth and fostering societal well-being.

3.2. ICT indicators of the selected articles

The present investigation analyzed and examined the ICT indicators employed by researchers across eighteen selected publications to address their respective research inquiries and accomplish their research objectives. As presented in Fig. 5, the preeminent and widely adopted ICT indicator is the ICT Development Index, a metric established by the International Telecommunication Union. Following closely, the Internet Penetration Index emerged as a secondary ICT measurement indicator, featured in five studies. Subsequently, three studies utilized various indicators, including the Mobile Cellular Subscriptions and the Network Readiness Index, as ICT measurement metrics.

As previously stated, the ICT Development Index stands out as the most widely used index. This indicator serves to assess the advancement of ICT across diverse nations and concurrently monitors the global digital divide, thereby serving as a comprehensive gauge of the Information Society (Miranda and Lima, 2012). The ICT Development Index is comprised of three major components, namely access, use, and skills, with respective weights of 40%, 40%, and 20%, and a total of 11 indicators (Miranda and Lima, 2012; Novo-Corti and Barreiro-Gen, 2015; Hincu et al., 2011; Abbasabadi and Soleimani, 2021; Gerpott and Ahmadi, 2015; Perez- Martínez-Cerdá et al., 2018). The three sub-index components include i) ICT readiness and infrastructure access in the access sub-index; ii) ICT intensity and use in the use component sub-index; and iii) ICT capability or skills, including literacy and gross secondary and tertiary enrolment in the skills component sub-index (Hincu et al., 2011). Abbasabadi and Soleimani (2021) have categorized the three sub-index components into three stages. Stage 1 is ICT readiness, which reflects the extent of ICT availability and networked infrastructure. Stage 2 is ICT intensity, which shows the level of ICT infrastructure used in a society, and Stage 3 is ICT impact, which reflects results or outcomes taking IT use skills with efficiency and effectiveness into account.

Next, the research conducted by Bilan et al. (2023), Solomon and Klyton (2020), and Binsfeld et al. (2017) featured the utilization of the Networked Readiness Index as a metric to measure ICT development. The Networked Readiness Index is intended to address gaps in ICT development by encompassing the regulatory environment, access, usage, and diffusion of technology within society (Solomon and Klyton, 2020). This index not only captures the current state of ICT development but also measures the propensity of countries to exploit the opportunities offered by ICT, thereby providing insight into how ICT impacts the competitiveness of nations (Binsfeld et al., 2017). According to Solomon and Klyton (2020) and Binsfeld et al. (2017), this index is comprised of ten pillars and 53 indicators, organized into four sub-indices: environment, readiness, usage, and impact. The four sub-indices are further explicated as follows: i) the environment sub-index consists of indicators that measure general political, regulatory, business, and innovation; ii) the readiness sub-index consists of individuals, businesses, and government ICT infrastructure and digital content, such as the quality of education; iii) the usage sub-index measures ICT adoption, affordability, and skills by individuals, businesses, and the government, as well as the proportion of households that have internet access, use of social networks, the capacity for innovation and online government services; and iv) the impact sub-index captures the social and economic impacts of ICT.

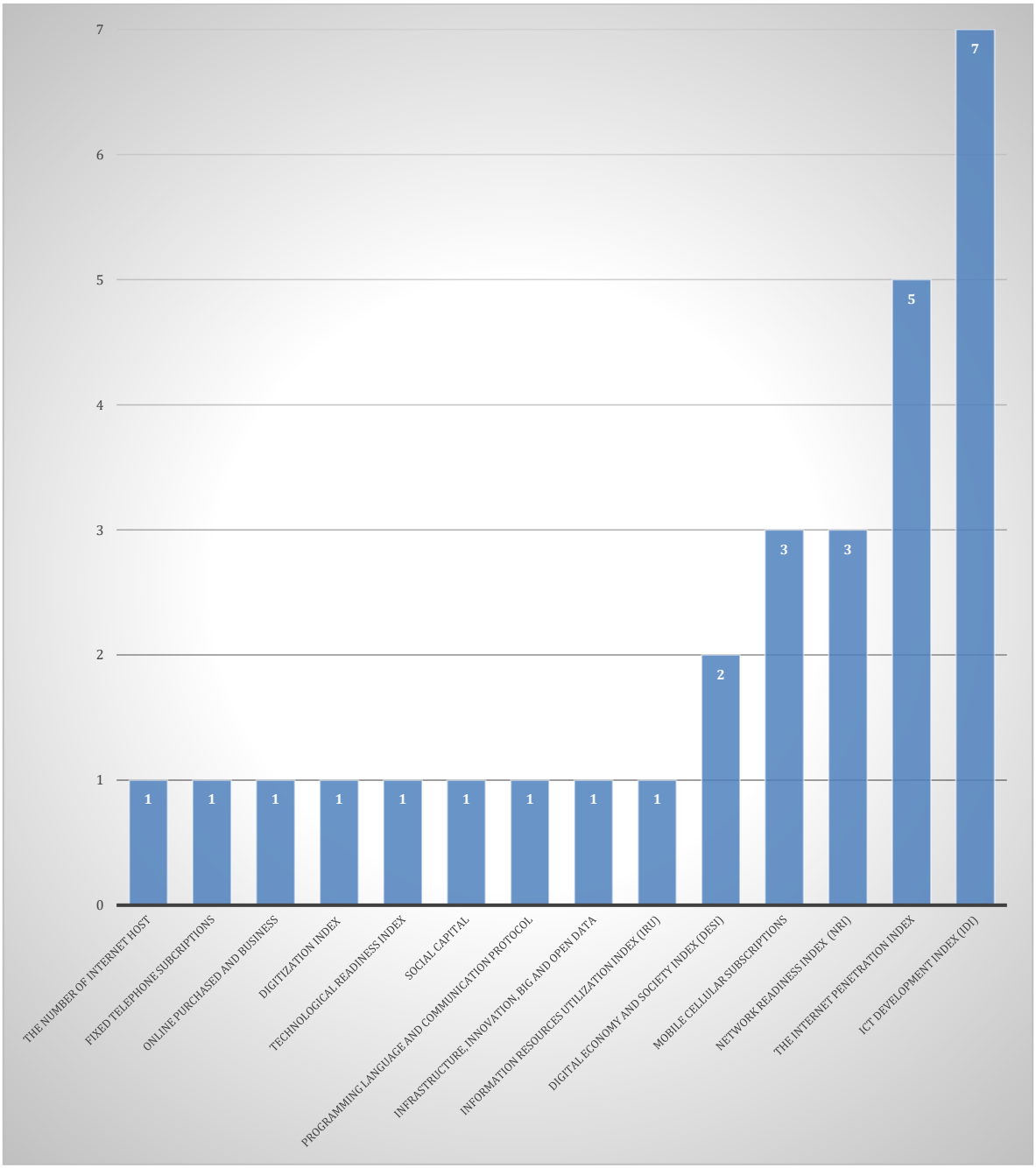

Fig. 5: ICT indicator used in the selected articles

In the research by Moldabekova et al. (2021) and Masoura and Malefaki (2023), the Digital Economy and Society Index (DESI) has been chosen as a key ICT indicator. The DESI captures digital readiness, constituting a critical prerequisite for the establishment of a digital economy. This index comprises five dimensions, each representing a facet of digital readiness: i) connectivity consists of internet infrastructure; ii) human capital consists of internet user skills; iii) use of internet services, which measures internet use and activities; iv) integration of digital technology, which evaluates business digitalization and e-commerce, and v) digital public services, which include e-government and e-health (Moldabekova et al., 2021). Concurrently, the Social Capital Indicator serves as a metric to gauge societal social capital, a dimension influenced by ICT development. According to Nakono and Washizu (2021), societies leveraging advanced technology exhibit higher social capital compared to those that do not, thereby indicating a positive relationship between ICT access and use and the social capital of a community. The social capital indicator employed in this study comprises 12 social variables, which combine three dimensions: trust, network, and norms, and two categories: bonding and bridging (Nakono and Washizu, 2021).

The study also incorporates the Information Resources Utilization Index as a societal metric for gauging ICT development. As explained by Borjigin et al. (2016), this indicator is structured with five distinct sub-indices, encompassing a cumulative total of nineteen indicators. The five sub-indexes are as follows: i) Content, which assesses the utilization of content resources through subscriptions of information resources such as newspapers,

magazines, books, TV programs, audio products, and technical contracts; ii) People, which gauges the utilization of human resources such as adult literacy rate, employment rate, and practitioners' rate; iii) Infrastructure, which measures the transferring, processing, or storing of content resources; iv) Facility, assessing the utilization of facility such as a platform for producing, processing or consuming content resources; and v) Fund, which consists of the utilization of financial resources to obtain content resources. Generally, this index focuses on the utilization of information resources and the consumption of information content facilitated through ICT access and usage.

Apart from the ICT Development Index, Abbasabadi and Soleimani's (2021) research utilized two additional indicators, namely the Technological Readiness Index and the Digitalisation Index. The Technology Readiness Index, as interpreted by Abbasabadi and Soleimani (2021), is one of the twelve indicators encompassed within the Global Competitiveness Index. This indicator comprises six components designed to measure various aspects of ICT: i) availability of the most advanced technology; ii) firm-level technology absorption; iii) foreign direct investment and technology transfer; iv) internet users; v) fixed-broadband internet subscriptions; and vi) internet bandwidth. Meanwhile, the Digitisation Index is a composite index that consolidates relevant indicators to provide a comprehensive overview of a country's digital performance, focusing on six dimensions: The dimensions are: i) infrastructure, ii) adoption by households, iii) adoption by businesses, iv) costs, v) regulation, and vi) content (Abbasabadi and Soleimani, 2021). Each of the six dimensions possesses its own indication. The lists of indicators are: i) infrastructure – incorporating indicators such as 3G or more mobile network coverage, international internet bandwidth and secure internet servers; ii) adoption by households – involving active mobile-broadband subscriptions, fixed broadband subscriptions, use of virtual social networks, households with the internet and individuals using the internet; iii) adoption by enterprises – including business to business internet use, business to consumer internet use and firm-level technology absorption; iv) cost – evaluating factors such as the affordability of fixed broadband internet tariffs and telephony competition; v) content – gauging online government services; and vi) regulations – comprising effectiveness of law-making bodies, judicial independence, the efficiency of the legal system in settling disputes, efficiency of the legal system in challenging regulations, laws relating to ICTs and software piracy rate, and percentage software installed, totalling 21 indicators in this index (Abbasabadi and Soleimani, 2021).

This present review underscores the identification of specific indicators used to evaluate ICT development. In addition to the widely employed ICT Development Index, the study by Miranda and Lima (2012) incorporated several specific indicators, including the Number of Internet Hosts, the Internet Penetration Index, and the Evolution of Programming Language and Communication Protocol. These indicators were strategically employed to facilitate a comparative analysis of ICT development across diverse nations, enriching the evaluative framework. The Number of Internet Hosts serves as an indicator of internet infrastructure, providing insights into the prevalence and distribution of internet hosts within a given nation. Meanwhile, the Internet Penetration Index is utilized to gauge the extent of Internet access and usage, expressed as the number of Internet users as a percentage of the total population. Furthermore, the Evolution of Programming Language and Communication Protocol functions as an insightful indicator of the internet infrastructure connected to the human-machine interface (Miranda and Lima, 2012). These specific indicators contribute to a more targeted perspective on various dimensions of ICT development. It is worth noting that similar studies conducted by Chereshnia (2023), Damrah et al. (2022), Khan et al. (2022), and Megbowon and David (2023) adopt a comparable approach by focusing on specific areas such as mobile telephone subscriptions, mobile cellular subscriptions, internet penetration index, and online purchase and business rate. This targeted approach allows for a more detailed exploration of distinct dimensions within the realm of ICT development.

The trend of employing specific indicators for the evaluation of ICT development is not unique to the study by Miranda and Lima (2012), as similar evaluation approaches have been observed in studies conducted by Chereshnia (2023), Damrah et al. (2022), Khan et al. (2022), and Megbowon and David (2023). Chereshnia's (2023) focused on Internet Penetration Index and Purchases and Business Rate, while Damrah et al. (2022) and Megbowon and David's (2023) examination of Mobile Cellular Subscriptions and Internet Penetration Index. Additionally, a study by Khan et al. (2022) investigated the Internet Penetration Index, Mobile Cellular Subscriptions, and Fixed Telephone Subscriptions in their analysis. This deliberate and targeted approach enhances a heightened depth of exploration within the overarching domain of ICT development, providing a more intricate understanding of distinct dimensions within this field.

3.3. Dynamics social implications of ICT indicator–Thematic analysis

The eighteen articles have yielded four themes of ICT indicators and social implications: i) digital development measurement, ii) digital divide gap quantification, iii) strategic planning and development policy, and iv) human and social capital measurement. The four themes are developed to comprehend the aim and social implications of ICT indicators.

3.3.1. Digital development measurement

Digital development measurement is pivotal in understanding the impact of ICT expansion on creativity, economic modernization, and the transition towards an information society. Various indicators play a crucial role in gauging digitization, examining three significant dimensions of ICT development: i) access to ICT tools, including digital devices and internet infrastructure; ii) the use and applications of ICT tools; and iii) the skills and knowledge required to access and use ICT tools (Miranda and Lima, 2012; Novo-Corti and Barreiro-Gen, 2015; Hincu et al., 2011; Abbasabadi and Soleimani, 2021; Gerpott and Ahmadi, 2015; Chereshnia, 2023). In addition, other indicators such as the utilization of digital content (Borjigin et al., 2016), access to digital services (Moldabekova et al., 2021), and businesses' readiness (Moldabekova et al., 2021; Abbasabadi and Soleimani, 2021) undertaking as indexes to measure the level of digitalization by not only focusing on facility and infrastructure but more in-depth to ICT application. Typically, these indicators assess the degree and level of ICT readiness, intensity, and societal or global implications. An examination of ICT indicators was also conducted to determine which indicators positively correlate with ICT development and which areas require improvement for successful innovation (Bilan et al., 2023; Masoura and Malefaki, 2023).

3.3.2. Digital divide gap quantification

Digital divide gap quantification encompasses disparities in access, utilization, and proficiency with ICT, giving rise to inequalities among individuals, regions, and nations. These disparities can lead to socioeconomic gaps between thriving and struggling countries (Hincu et al., 2011). In the context of the increasing importance of digital tools in daily life, indicators have been devised to measure the level of ICT development and quantify the digital gap across societies, regions, and nations. Despite progress in disseminating ICTs and moving towards a global information society, persistent digital development gaps exist, especially between high-income developed countries and developing or less developed nations. The use sub-index, a key indicator within the ICT development index, is widely used to assess access and effective utilization of ICT in different nations, exposing income-related factors as significant contributors to digital gaps between developed and developing nations (Hincu et al., 2011; Miranda and Lima, 2012). Other indicators, such as the Networked Readiness Index, Digital Economy and Society Index, and Digitalization Index, demonstrate a similar trend in measuring the digital gap. Comparing these indices with ICT indicators reveals geographical or demographic disparities in ICT development levels, underscoring the need to intensify positive ICT innovation to bridge the digital gap (Novo-Corti and Barreiro-Gen, 2015; Chereshnia, 2023; Masoura and Malefaki, 2023) and improve quality of life as ICT adoption increases (Perez-Martinez et al., 2023).

3.3.3. Strategic planning and development

Strategic planning and development policy benefit immensely from the use of ICT indicators as valuable tools. These indicators enable policymakers to assess the level of digitalization in the telecommunication sector and discern the strengths and weaknesses of societies, regions, or nations. Bridging the digital divide stands as a crucial factor in a nation's development agenda, and ICT indicators play a pivotal role in formulating applicable policies and directing attention to critical areas in ICT development that necessitate investment and management focus (Hincu et al., 2011). By employing practical policy tools, policymakers can effectively reduce disparities between societies, regions, and nations, as highlighted by Borjigin et al. (2016). Time-series data is widely used to illustrate the level of digitalization and forecast the future, enabling the development of strategies for ICT development that balance the strengths of different societies, regions, and nations (Borjigin et al., 2016). Additionally, ICT indicators can help explain the need for new digital solutions to improve ICT-related sectors and increase policy interventions to contribute to socio-economic development (Moldabekova et al., 2021; Gerpott and Ahmadi, 2015; Megbowon and David, 2023). Inclusive, ICT indicators are essential in providing insights for policymakers worldwide to develop innovative strategies in facing digital economy challenges (Masoura and Malefaki, 2023) and ensuring that appropriate ICT-related policies align with a nation's development plans to enhance environmental quality, bridge the digital divide, boost ICT competitiveness, and boost economic and social growth (Khan et al., 2022; Moldabekova et al., 2021; Gerpott and Ahmadi, 2015).

3.3.4. Human and social capital measurement

The development of ICT has become increasingly important for human and social capital. As the internet continues to grow as the global backbone of the information society, ICT is being used more for communication, information sharing, business, and entertainment (Miranda and Lima, 2012). The number of people who use the internet and new technologies is increasing, making individual users drivers of digitalization. ICT indicators play a significant role in developing ICT infrastructure and social aspects such as education, regulations, economic issues, and IT skills (Binsfeld et al., 2017). IT skills are a crucial part of human capital, as they are associated with high digital knowledge and capabilities (Moldabekova et al., 2021; Lnenicka and Machova, 2022), which are equally necessary as infrastructure in developing ICT. ICT indicators also promote ICT skills for job-related procedures, employment, and performance-based measures for

individuals and businesses (Novo-Corti and Barreiro-Gen, 2015; Abbasabadi and Soleimani, 2021; Moldabekova et al., 2021). Additionally, ICT indicators measure innovation, human capital, and technological infrastructure to promote economic growth by emphasizing the importance of maximizing ICT skills in the labor force (Solomon and Klyton, 2020). Furthermore, social capital indicators are used to assess the value of the livelihoods of societies that receive ICT advancements. These indicators have proven that societies that receive ICT development have higher social capital values in terms of trust, norms, and networking compared to those without access to or use of ICT (Nakono and Washizu, 2021).

4. Discussion

The proliferation of digital technologies and infrastructure in our daily lives has transformed ICTs into an essential tool, particularly during the COVID-19 pandemic. Moreover, the United Nations has acknowledged the significance of ICT innovation and evolution in creating sustainable livelihoods that are economically, socially, and environmentally sound. The increasing global consensus on ICT development has opened up new approaches and opportunities, particularly for those living in poverty, to achieve social development goals by accessing and using new technologies (UN, 2022). Such goals may include advancing education, sharing information, enhancing communication, promoting political, health, economic, social, and cultural well-being, and various other aspects of social development facilitated through ICT tools. The pursuit of greater ICT advancement by individuals, societies, regions, or nations has resulted in an uneven distribution and a digital divide in access and usage of technology. The digital divide creates social disparities that favor those with access, competence, and experience in using digital services and modern electronic networks compared to those who do not have access to or cannot utilize ICTs (Hincu et al., 2011). These inequalities may result in imbalances in society and hinder progress in global development.

According to recent statistics by the ITU (2023), one-third of the world's population, equivalent to approximately 2.6 billion individuals, remain offline and have never used the internet. This data highlights the pervasive digital divide, which necessitates a concerted effort to ensure balanced development through ICT advancement. To assess the degree of development, relevant ICT development indicators or indexes can be applied to measure balanced development. Access, use, and skills are the most widely used indicators globally to evaluate the penetration of ICT development among societies and nations. The scoring of penetration rate serves as a means of digital divide quantification, displaying the progress of development of ICT innovation and advancement of a society or nation and revealing which society or nation is performing better and which needs improvement in ICT development.

Measuring access and use of ICT tools, as well as online content and services, through the application of ICT development indicators can create equal opportunities and reduce social exclusion among users in the information society, as noted by Hincu et al. (2011). Additionally, the results of applying ICT development indicators can be used to indicate the upturn or downturn of digital development during certain phenomena. For example, research conducted by the International Telecommunication Union in 2021 using the ICT indicator revealed an additional 782 million people having access to the internet during the COVID-19 pandemic since 2019. This was due to the implementation of widespread lockdowns and school and workplace closures, combined with people's need to access information, news, health updates, e-commerce, and online banking, which resulted in a boost in the usage of internet connectivity.

The use of ICT indicators is a common approach in research and policymaking circles to measure digital development. These indicators serve as a guide to evaluate and monitor ICT progress and provide researchers with relevant information to improve ICT development (Whyte, 2000). Research has found that ICT indicators play a critical role in determining a society's or nation's development through ICT and in boosting other sectors. As a result, policymakers must examine the best strategies and policy goals to enhance digital performance. The focus of continuous research is to identify the extent of access, use, and skills of ICT infrastructure and facilities and explore their socio-economic impacts. However, the ICT indicators primarily concentrate on access and use before evaluating ICT skills because skill development depends on access and use of ICT tools (Novo-Corti and Barreiro-Gen, 2015; Masoura and Malefaki, 2023). Policymakers are likely to prioritize increasing ICT access and use before focusing on developing e-skills to enable effective ICT-related policy formulation. Nevertheless, skills are equally important as access and use of ICT tools and lead to a better understanding of the digital economy and country rankings (Binsfeld et al., 2017; Megbowon and David, 2023).

Reliable and accurate ICT indicators data and statistics are crucial for policymakers and decision-makers to formulate policies and strategies that drive ICT growth and measure its impacts. Mahan (2007) asserted that these indicators help monitor and evaluate the level of ICT-related economic and social mobilization. However, previous ICT indicators have been criticized for not measuring socially relevant outcome criteria, such as access, with the use of ICT indicators being more dominant than the skill index (Gerpott and Ahmadi, 2015). Effective measurement of ICT development requires a range of social indicators that capture the multifaceted impact of ICT on society. These include digital literacy and skills, access and connectivity,

and ICT usage and adoption. Skills are a critical factor in determining the effective use of ICT tools and measuring the potential impact of ICTs on socioeconomic development (Miranda and Lima, 2012). This study highlights several key indicators, such as the level of education and knowledge, adult literacy, and the environment of individuals, businesses, and governments. These indicators are included in indices like the Networked Readiness Index, ICT Development Index, Digital Economy and Society Index, and Digital and Technological Readiness Index. These social indicators relate to human and social capital, measuring ICT readiness, capabilities, skills, and social networking among societies. By employing these comprehensive indicators, the efficiency and effectiveness of ICT advancement can be measured, leading to improved national performance towards a prosperous, technologically advanced information society.

5. Conclusion

In this review, eighteen papers from the Web of Science database were systematically evaluated to understand the scope of ICT indicators in measuring ICT developments. The Web of Science database was chosen due to its extensive collection of scholarly articles, though this selection may introduce biases by excluding other databases. The review employed the PRISMA technique to ensure a methodological search and to obtain reliable and relevant articles. The primary objectives of this study were to identify the types of indicators used to measure ICT development and the social implications of these indicators. The study identified several indexes, including the ICT Development Index, Networked Readiness Index, Digitization Index, Internet Penetration Index, Number of Internet Hosts, Technological Readiness Index, and software/protocols development, which can be used to measure digital performance. The four primary themes that emerged from this review were digital development measurement, digital divide gap quantification, strategic planning and development policy, and human and social capital measurement.

The main objective of ICT indicators is to determine the level of accessibility, effectiveness, and results of ICTs used by individuals, societies, and nations. These indicators provide relevant data to policymakers and decision-makers to formulate the best ICT-related policies to bridge the digital gap among societies and nations. By measuring the ICT's access and use penetration score, these indicators can also help improve and bridge the digital divide among different sections of society. Although ICT development indicators or indexes are not the best measurement tools to measure digital performance, they are reported to quantify performance in a broader view at regional and national levels. However, the challenge lies in identifying smaller scales, such as understanding ICT development implications for individuals or societies and forming the best indicators to analyze these groups' readiness, use, and impacts. The disparity between the gaps in the measurement of a broader view and the smaller scope remains a development issue and leads to inaccurate ICT development reporting for references.

In conclusion, ICT indicators are essential for assessing and monitoring the impact of ICTs on society, economy, politics, and the environment. To ensure that the ICT-related policies are relevant to a nation's economic growth and beneficial to societies towards becoming a global information society, it is essential to form indicators or indexes that are methodically relevant to the current situation and assess the different geographical and societal backgrounds. The formation of indicators should focus as a whole set, not only globally but also on measuring and analyzing the smaller scope to ensure that the ICT advancement and innovation are more effective and efficient, leading to the growth of society and nations.

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Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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