Research Data Management and Scientific Evidence: A Strategic Imperative for SDGs

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Abstract

Scientific evidence comprises Data, Information and Knowledge (DIK) often presented in a pyramidal structure. Data are the foundation base of the pyramid, followed by the information layer and the knowledge layer at the top. Data are rudimentary and expand into information and knowledge—the DIK pyramid—and also constitute scientific evidence. Such evidence is critical for demonstrating prospects, best practices and successful development models. The Internet and the evolution of the Web have resulted in easily discernible data that serve as scientific evidence in the form of big data. Transformation of the African continent through the 17 Sustainable Development Goals (SDGs) rests on the availability of scientific data. Data are not a panacea for societal problems but data science can nevertheless open up possibilities for innovations that could help fight hunger, poverty, inequalities and underdevelopment. There is also a huge potential for big data to serve as evidence for successes and failures of the SDGs. However, without its proper creation, planning, verification, storage, security and organisation; big data cannot be used appropriately. This is where Research Data Management (RDM) adds value, mainly because RDM is concerned with planning and organisation of data in the entire research cycle, including the dissemination and archiving of results. This chapter draws on examples from Kenya, Malawi and South Africa to analyse RDM as a strategic imperative for scientific evidence in the transformation of Africa through the SDGs, with a specific reference to SDG 4 on the quality of education.

Keywords

Data management · Scientific evidence · Quality education · Africa

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10.1 Introduction

The United Nations 2030 Agenda on Sustainable Development is a representation of ‘a new coherent way of thinking’ about the natural, social and economic essentials (Nilsson et al. 2016, p. 320). These authors argue that a palpable fundamental to the agenda of the SDGs is

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implementers' (citizens, researchers and policymakers) capability to theorise, conceptualise and visualise the 'connecting dots' that help to intertwine the goals with respective specific targets and indicators even though their interdependency has not been spelled out in any of the UN publications. Approaching the implementation of Sustainable Development Goals (SDGs) in silos or as separate entities will be incoherent and counterproductive. The SDGs champion inclusivity in diversity while also balancing contextual interests and priorities for efficient and effective implementation in various unique settings. Coherent policies and strategies for the SDGs demand policymakers to work on principles, methodologies and rubrics for thinking systematically and multilaterally to identify allies, collaborators and potential partners (Jones et al. 2008; Moyo and Sowa 2015). Of utmost importance, policymakers 'need up-to-date empirical knowledge on how the goals and interventions of one sector affect another positively or negatively' (Nilsson et al. 2016, p. 321). These authors contend that the achievement of SDGs requires knowledge-based actions on all dimensions, targets and indicators.

This chapter explores how the provision and management of data, particularly research data, as a major contributor to knowledge inputs, can enable action research and action learning at multiple scales of the learning subsystems to demonstrate success or failure of SDGs (Huys et al. 2004). The main argument of the chapter is that if data are not properly managed, scientific evidence to demonstrate value and return on investment in SDGs will be difficult to measure. In this chapter, we therefore argue for Research Data Management (RDM) to be viewed as a strategic imperative for the SDGs. RDM refers to a set of services dealing with storage, access and preservation of data generated from research projects that support the full data life cycle including data management planning, digital curation, metadata creation and conversion of datasets (Chiware and Mathe 2015). The specific objectives of the chapter are to:

- explore the role of RDM in provision of testimonial data (scientific data) for deliverables of SDGs;
- establish what scientific evidence tells us about priorities for African states for informing the direction and implementation of SDGs;
- determine sources of data to uncover the silences in SDGs and obstacles which should be removed in order to realise the objectives of any of the SDGs; and
- find out which methodologies can be used to harness data that reveals the success or failures of SDGs.

10.2 Contextual Framework

Library and Information Science (LIS) is founded upon management of data, information and knowledge, entities often presented in a pyramidal structure. At the bottom of the pyramid is data, followed by information and knowledge with wisdom at the apex (Fig. 10.1). Due to its intangibility and complexity, wisdom is impossible to harness into a manageable entity. It is a known fact that data are the foundation for information and knowledge. As argued by Ackoff (1989) and visualised by Bird (2008), scientific evidence comprises data, information and knowledge which results in wisdom (applied knowledge). Consequently, the fundamental pillar of LIS is the Data, Information, Knowledge and Wisdom (DIKW) model, often presented in a pyramidal structure demonstrated by Bird (2008) as follows:

Data are rudimentary and expands into information and knowledge. Considering the DIKW model, data management presents a new opportunity for librarians to support the research process. Although in the past it seemed daunting, librarians' experience with organising information so that it can be found has proved to be the skill needed to provide data management services (Surkis and Read 2015). In developed

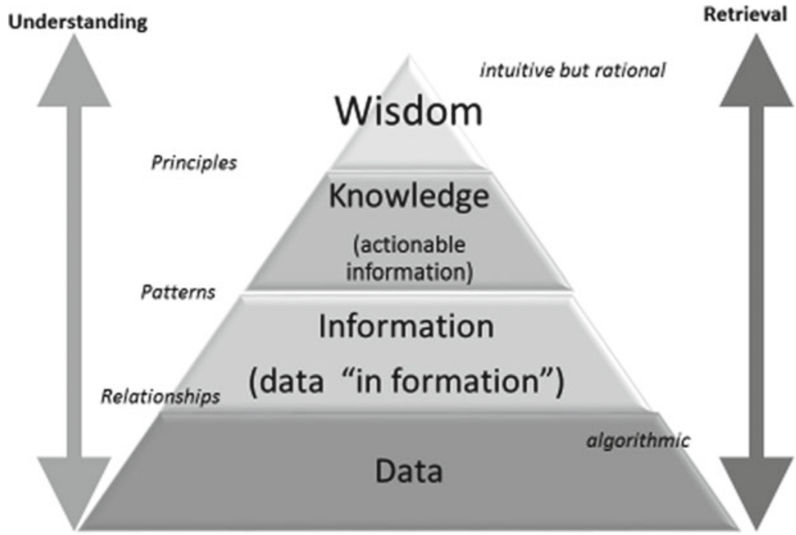

Fig. 10.1 DIKW model (Bird 2008)

countries and a few African countries, librarians have taken on a number of roles grounded in the principles of data management, including working towards bridging the gaps between librarians and researchers (Chiware and Mathe 2015; Cox et al. 2016; Cox et al. 2017).

Scientific evidence is testimonial data that is critical in demonstrating prospects, best practices and successful development models. It has potential to reveal, as evidence, societal challenges, problems and crises. The Internet and its evolution have resulted in easily discernible data that serve as scientific evidence in the form of big data (Cope and Kalantzis 2016). The premise that the achievement of SDGs requires knowledge-based actions makes knowledge availability and accessibility an imperative. Considering the data, information and knowledge pyramid, we argue that without data there will be no information and knowledge. We propose that RDM guides the planning and the entire process of sourcing, collecting, storing and openly sharing data as scientific evidence to support strategic actions and informed decision-making. Currently, open sharing of data is possibly inhibited by factors such as unwillingness of researchers to embrace open scholarship; scepticism around open data; limited awareness of research support tools and platforms for open data; limited knowledge of metadata for data description as well as protection of data as one's intellectual property. Moreover, knowledge-based actions must be grounded in expertise, empowerment and continuous research and learning, which in turn require the use of relevant and adequate data, as well as information and communication technologies as essential inputs and catalysts (Nilsson et al. 2016).

10.3 Research Data Management

Given that the data life cycle is integral to RDM, it is crucial to unpack it prior to discussing RDM. Figure 10.2 illustrates the research data life cycle from the UK data archive.

'Data lifecycle stages require data management to ensure that the researchers document how they collected their data, transformed it from raw to processed, analyzed data; ensuring that it is described in an understandable manner' (Surkis and Read 2015, p. 154). The stages are important because understandable data easily leads to scientific testing, validity of original results or reanalysis of data in an entirely different context.

All DIK stakeholders, libraries, institutions, researchers and funders have been pooling scarce resources to build infrastructure and expertise for data management (Berman and Cerf 2013).

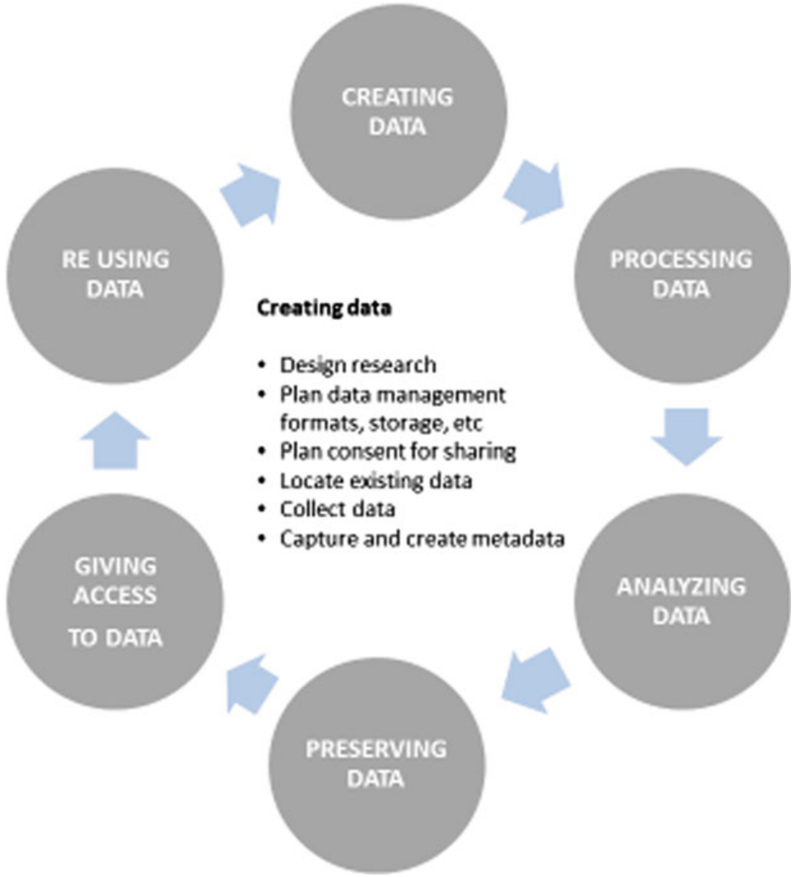

Fig. 10.2 UK data archive illustration of research data life cycle (http://library.nuigalway.ie/digitalscholarship/researchdata/researchdatalifecycle/). Accessed 20 September 2018

The outcome includes initiatives such as consortia for negotiating licences for software, programmes and electronic resources. In view of open scholarship, open science and open data, some governments, international organisations, funding agencies and publishing houses have issued a series of RDM policies in recent years. Researchers are encouraged or required to share research data along with their research outputs. It has become mandatory in many countries such as Australia, South Africa, the United Kingdom and the United States for research funded by public funds to comply with open data policies, that is, publications and data emanating from publicly funded research should be deposited in open data repositories. Therefore, research data sharing and reuse during the research data life cycle has become paramount. Additionally, researchers are now required to submit their RDM plans when they apply for funding. These movements have presented an opportunity for data to be accessible, thus making scientific research that serves as evidence for SDG indicators available to the public.

10.4 Unpacking the Role of Data as Scientific Evidence

Science has been going through a paradigm shift (Hey et al. 2009). It started as experimental science, which primarily focused on natural things, and then became theoretical science characterised by the evolution of scientific laws, principles and equations. This was followed by computational science, which featured simulations of phenomena, and ultimately arrived at the current science paradigm for the digital age: collaborative and computational data-intensive science, whereby data are captured by instruments and generated by technology through simulations and sensor networks. Data-intensive science, also known as e-science or e-research, relies on technologies and tools to support data amalgamation and collaboration for analysis and data mining, data visualisation and data exploration for scholarly communication (Tenopir et al. 2011; Rieger 2010).

Data drives science and constitutes the foundation for research and innovation. Consequently, it is important to put systems in place that will advance research tools and technologies for data management. The critical aspects are data acquisition and modelling, collaboration and data visualisation, learning analytics and data mining, dissemination and sharing of data, archiving and preservation of data.

We therefore argue that some of these data could serve as scientific evidence for SDGs such as good health and well-being, gender equality, clean water and sanitation. Testimonial data enable the implementation and monitoring of the SDGs. Thus, SDG indicators are part of big data and therefore should be FAIR (Findable, Accessible, Interoperable and Reusable). FAIR data offers a unique opportunity to ensure that the benefits of big data and the data revolution are extended to under-resourced countries and communities so that no one is left behind. So far, RDM and data curation is proving effective in making data FAIR. Governments, decision- and policymakers need to embrace big data as scientific evidence that should be FAIR, because it potentially impacts on sustainable development practices and policies.

Scientific evidence is data, information and knowledge gathered from scientific research that has been conducted ethically, methodically and systematically, using established research methods and approaches with validity and reliability (Mårtensson et al. 2016) that takes much expertise, time, resources and patience to conduct. For research to be meaningful, it has to be presented and communicated in accessible language to make it possible for decision-makers to accept it as evidence (Saunders 2013). According to Compound Interest (2015), scientific evidence in health and medicine consists of anecdotal expert opinions, animal and cell studies, case reports and case series, cohort studies, randomised controlled trials and systematic reviews. Arguably, these sets of evidence may be extended to other disciplines. There is no doubt that scientific evidence has to be authentic, without bias; of critical importance, it should be conducted through scientific research designed to produce quality data, information and knowledge that can serve as evidence for actionable results.

Transformation of the African continent through 17 sustainable development goals rests on the availability of scientific data with which to measure successes and failures. Although data are not a panacea for systemic societal challenges; the diffusion of data constitutes a genuine opportunity to implement innovative strategies, and to tackle poverty, hunger and social exclusion (Letouzé 2011). For big data to be useful for SDGs, it should be properly created, planned, verified, organised, secured and stored. This is where RDM could add value to SDGs, because it is mainly concerned with planning and organisation of data in the entire research cycle, including dissemination and archiving of results (Whyte and Tedds 2011). Intrinsic scientific processes yield data that is well managed through systematic RDM.

Evidence of models and mechanisms providing positive outcomes in delivering science literacy, including health literacy, is essential in order to build on what is known and also to adapt or develop innovative new approaches where there may be gaps or failings. Saunders (2013, p. 3) raised thought-provoking arguments on scientific evidence by commenting that

> [Scientific] evidence is presented by proponents in much the same way that evidence is given in a court case, usually to back up policies or decisions that will impact people's lifestyles. But, unlike in a court case, we are rarely told exactly *where* the evidence comes from and *why* it's evidence. Most of us hear of 'scientific evidence' from journalists, newsreaders, politicians or media commentators, and often we don't have the opportunity to check the facts ourselves.

DIKW resource description including datasets is done through creation of metadata, which represents the existence of intellectual property, content creators, digital object identifiers and other bibliographic details of the DIKW resource. The effort to create metadata for DIK resources and research datasets is very different from what is required for research publications. While publications can be accurately described by librarians, good quality metadata for research datasets (scientific evidence) require the contribution of researchers involved in its production. Their knowledge of the domain is required to adequately document the way the dataset was produced so that others can reuse it. 'Involving the researchers in the deposit stage is a challenge, as the investment in metadata production for data publication and sharing is typically higher than that required for the addition of notes that are only intended for their peers in a research group' (Amorim et al. 2016, p. 2). As the research paradigms in science become data-intensive and collaborative (Hey et al. 2009), researchers are promoting data as the 'infrastructure of science', critical in forming 'the basis for good scientific decisions, wise management and use of resources, and informed decision-making' (Tenopir et al. 2011, p. 1). Although cultural differences exist between the disciplines of social sciences and natural sciences, the former is changing to require greater access to data and more transparency (Guest et al. 2012; Elman and Kapiszewski 2013). Both of these call for a strong emphasis on data devolution, depositing and sharing, which is achieved through RDM.

10.5 Tripartite Matrix: Scientific Evidence, African States' Priorities and Sustainable Development

The foundation of SDGs is to promote the quality of life through economic growth, social inclusion, better health and education, and environmental protection. Under this new strategy, countries and their national development plans need to implement transformation priorities, policies, programmes and projects for economic, social and political development and growth anchored in 17 SDGs (United Nations Development Programme 2016). In the process of implementing the SDGs, scientific evidence must provide valid and accurate data about the priorities of African states in a seamless tripartite matrix. Scientific evidence forms the fundamental basis that provides the parameters and indicators necessary for achieving sustainable development practices by African states. RDM makes research data available for critical analysis of reliable and credible information, which is required for strategic planning and decision-making. The direction and implementation of SDGs require knowledge, research programmes, collaboration and partnership between policy-makers, practitioners and other stakeholders. RDM is an important field of research and practice increasingly employed to provide value-based scientific evidence that can be useful in supporting practical application and implementation of SDGs. Sustainable development practices are built on quality research and educational programmes (Siobhan 2014) as well as information, knowledge and information communication technology. The tripartite matrix offers a seamless way of connecting the scientific evidence with the priorities of African states in SDGs through RDM.

10.5.1 Role of RDM in Provision of Scientific Evidence for SDGs Deliverables

Novel approaches of RDM integrating DIK into practicable planning and decisions have helped to translate the SDG pillars into tangible deliverables. The quality education in South Africa, Kenya and Malawi is important for the much needed scientific evidence to support the increasing usefulness of RDM in achieving the SDGs. Education plays an important role in transformation, changing human beings and society through scientific evidence. It is crucial for reducing vulnerability to economic, social and environmental dislocation and building more resilient systems. In developed countries, research indicates that education enables people to perform better economically, it enhances health and extends life span, it promotes civic engagement and also improves a sense of well-being (see International Council for Science and International Social Science Council 2015; Karani and Preece this volume).

Sustainable education also needs strong support from the stakeholders whose critical inputs are useful in providing information for planning and decision-making. According to United Nations Educational, Scientific and Cultural Organization (UNESCO) (2014), the roadmap for implementing the global action programme on Education for Sustainable Development (ESD) includes increasing the capacities of educators and trainers to more effectively deliver education for sustainable development, scaling up education for sustainable development programmes and mobilising multi-stakeholder education for sustainable development networks. Therefore, data become scientific evidence to serve as indicators of positive or negative change in these efforts. The degree of achievement or failure of the transformation agenda deliverables can only be determined with scientific data. For instance, the number, duration, content and implementation period of an education programme can serve as data for monitoring and evaluation of such a programme. Moreover, in a multicultural and multiracial terrain such as South Africa, the inclusion of different races and cultural groups in a network can serve as testimonial data of a multi-stakeholder network.

The notion that RDM is a strategic imperative for SDGs' scientific evidence compels policymakers and practitioners to understand RDM and its dynamics. This is because 'the scale and complexity of RDM support requirements mean that a wide range of services from advocacy to technical support, are needed at different stages of the research data lifecycle' to effectively harness data that will serve as SDG indicators (Cox et al. 2017, p. 2195). In their international study of RDM activities, services and capabilities in higher education libraries, Cox et al. (2017) observed that skills and capabilities necessary are not yet in place in many parts of the world. Furthermore, these scholars observed glaring inconsistency in the delivery of RDM support service. It is apparent that RDM support service has not yet matured into models and theories. In the implementation of sustainable quality education particularly in the African context, there is a need to expeditiously prioritise RDM skilling and capabilities.

Sustainable quality education also needs the collaboration and support of people, communities and stakeholders. Research in data management underlies the practical issues and challenges of sustainable quality education. This brings into focus the need to produce and share data, information and knowledge from multifaceted approaches and strategies, and to make these available to policymakers, practitioners and societies. The modern digital economy requires entails strategic planning and decision-making processes that depend upon RDM analytics in order to provide timely information through technological solutions, The Internet of things and social media platforms. This validates the fundamental aspect of aligning RDM with the practices and policies of the SDGs.

10.5.2 Planning and Implementation of Quality Education

Stronger emphasis on planning and implementing quality education is important in understanding the numerous dynamics and challenges that African countries normally face, ranging from limited resources to human personnel. Implementation processes supported with scientific evidence and research must provide information and knowledge from all the stakeholders in the lifelong learning process (see Karani and Preece this volume). In implementation of sustainable education for development, it is mandatory to provide for inclusive participatory engagement, tailor the goals to the local context, plan well and monitor and evaluate the results.

As the field of big data continues to grow and evolve, coordination will be necessary to assess educational needs. The education and training community will help determine how to structure the data science curricula and how to reallocate educational resources to meet the demand for specific skill sets. At this early stage, maintaining agility and flexibility in undergraduate as well as graduate curricula and programmes is necessary to ensure that cutting-edge concepts and techniques are being incorporated (Networking and Information Technology Research and Development Program 2016).

In African countries, education for sustainable development is a societal value that should include all the stakeholders including national, county, local community, institutions and academia. Information and knowledge generated through education, training and learning provide the foundation for sustainable development policies and practices. A study on evaluation and analysis of case and baseline studies from South Africa, Kenya and Malawi provides useful information in relation to the quality of education and its priority in the African context. In principle, government policies and implementation programmes should be built on solid data, information and knowledge.

10.5.3 Best Practices and Innovations for Research Data Management

Transforming and changing societies through quality education helps African countries and the world in general to understand best practices for sustainable development. Sustainable development practices need to prioritise needs and to ensure proper utilisation of scarce resources. This implies that the priority of the goals and targets determines the allocation of resources in the process of transforming the society at large.

As mentioned earlier, librarians are potential drivers of data management. Nonetheless, because RDM is still an emerging area, there is still uncertainty in many libraries. Consequently, the literature on the best RDM methodologies, practices, models and theories is yet to be developed. Cox et al. (2017) observed that multi-stakeholder involvement in RDM activities and services often includes librarians, research support services, research funding agencies and IT service departments in many higher education institutions. In the RDM arena, collaborations and partnerships are therefore a necessity even though, from time to time, they are likely to result in conflict or tension between the various professionals (Si et al. 2015). There is yet another uncertainty cloud on RDM collaborative frameworks. Moreover, within the library itself, there is still some testing of RDM practices, particularly as to how the current cohort of librarians are going to embrace new roles associated with RDM. Considering that anything could possibly be a source of data, currently multidisciplinary, interdisciplinary and transdisciplinary approaches seem to be a safe mode of practice. Hence, the need for researchers, policymakers and practitioners to establish communities of practice for their RDM activities.

10.5.4 Linking RDM to Data Interconnectedness

Interconnectedness is evident in scientific research given that scientific research is a participatory and inclusive process where various stakeholders such as researchers, research participants, implementers, decision and policymakers as well as funding agencies are involved (Networking and Information Technology Research and Development Programme 2016). In the context of FAIR, interoperability and reusability are testimony to the interconnectedness that underpins open scholarship. We argue that interconnectedness solidifies the Internet of things, big data revolution and linked data, all of which create data that can be harnessed as scientific evidence or testimonial data for the SDGs. There is no doubt that SDGs must be supported with reliable RDM and sharing activities, mainly because data collection and management through various sources help to uncover the silences and obstacles which might hinder the achievement of the SDGs. Data collection and management methodologies have to be systematically applied to determine success or failures of SDGs.

10.6 Conclusion

This chapter has discussed the need to generate and manage data in ways that contribute to both the realisation and monitoring of SDGs. It has used the African contexts to argue that RDM should be viewed as a strategic imperative for SDGs. Thus, RDM is an important field of research and practice increasingly being employed to provide value-based scientific evidence useful in supporting practical application and implementation of the SDGs. It provides much needed relevant and credible data, information and knowledge fundamental for strategic planning and decision-making for policymakers, practitioners and other stakeholders. For RDM to achieve this, it needs to be aligned with practices and policies of SDGs. Librarians are called upon not only to facilitate such an alignment but also to organise and support research, and to make relevant information and knowledge easily accessible.

The chapter further highlights that scientific data should be properly managed and also made discoverable to a broad range of stakeholders involved in decision-making and in the implementation of SDGs. Scientific knowledge is crucial for the delivery of quality education, which is, in turn, necessary for broadening participation in SDGs. African states need to invest heavily in generating scientific knowledge and data relevant to their needs and for meeting the SDGs. The alternative of relying heavily on data generated from the Global North might be damaging in the long run if such data do not speak to African conditions. African states need real practical solutions built on scientific research and evidence in order to achieve the rudimentary goals of sustainable development practices.

In the modern digital economy, physical barriers need not be an obstacle to participation in SDGs by various groups of people as technological advancement has created multiple virtual spaces that enable participants to make their input into implementation, management and monitoring of SDGs. The modern digital economy renders strategic planning and decision-making processes dependent on RDM analytics that provide timely data, information and knowledge through technological solutions, the Internet of things, linked data and social media platforms. This means that policymakers, practitioners and the general public can use technology to produce and share data, information and knowledge from multifaceted approaches and strategies. This draws attention to the role LIS should play in the age of SDGs and how that role transforms the profession of librarians, especially their involvement in society.

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