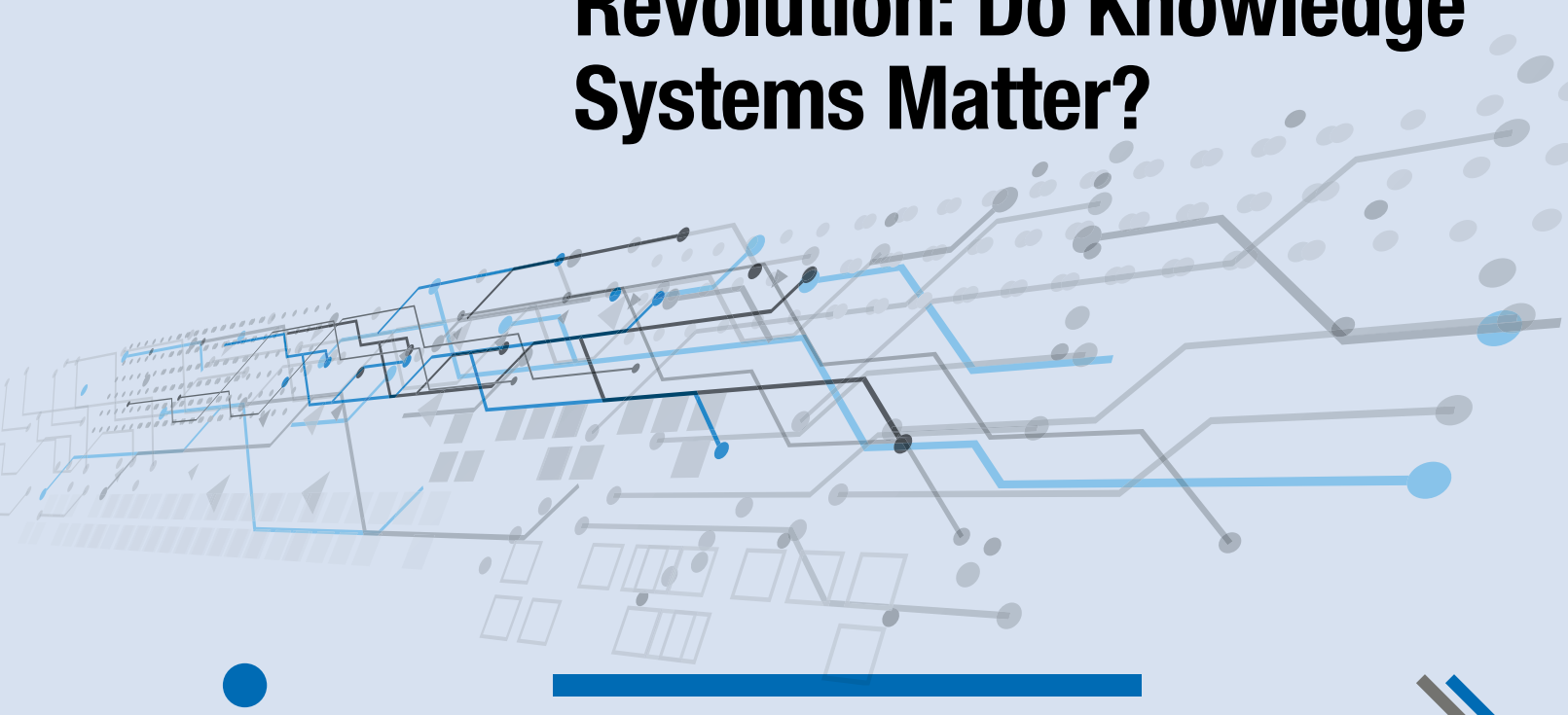
Discussion paper

State Capability, Policymaking and the Fourth Industrial Revolution: Do Knowledge Systems Matter?



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The analysis and conclusions presented in this paper are those of the authors and do not reflect the views of HELVETAS Swiss Intercooperation. The authors would like to thank HELVETAS Swiss Intercooperation for supporting the research for this paper; Sophie Gillespie for proof reading and copy editing; Patricia Peralta for the graphic design; and Andrea Ordóñez, Luis Carrizo and Kirsi-Marja Lonkila for their comments and suggestions.

Contents

Acronyms and Abbreviations

AI	Artificial Intelligence
AIPI	Akademi Ilmu Pengentahuan Indonesia / Indonesian Science Academy
GDP	Gross Domestic Product
GNI	Gross National Income
ICT	Information and Communication Technology
OECD	Organisation for Economic Co-operation and Development
SDGs	Sustainable Development Goals
4IR	Fourth Industrial Revolution

1 Introduction

In 2016, a group of young Indonesian scientists published *Sains45: Indonesian Science Agenda Towards a Century of Independence* (AIPI 2016). The publication was the culmination of a series of symposia titled "Frontiers of Sciences", which had taken place over the previous two years. The young scientists looked to 2045, when Indonesia will celebrate 100 years of independence, and asked with some concern what it would be like to work as a scientist in Indonesia then. The young scientists identified 45 key policy issues, which will determine the country's transition to a knowledge economy. They called for the design of policies and development strategies with a strong research and science foundation (*ibid*.).

The aspirations, concerns and questions about the future of the young Indonesian scientists are not unique. They reflect aspirations, concerns and questions about the future of society that are posed all over the world by researchers, citizens, civil society and policy makers.

In this discussion paper, we set out to explore the opportunities and concerns that accompany the imminent Fourth Industrial Revolution for policymaking and the knowledge systems that inform policy decisions, particularly in middle-income countries.[1] Overall, middle-income countries are home to five billion of the world's seven billion people and 73 per cent of the world's poor people; they represent about one third of the global Gross Domestic Product (GDP) and are major engines of global growth (World Bank 2018).

As a discussion paper, our aim is not to provide answers at this stage but rather to identify the most relevant questions to explore. We aspire to: 1) stimulate discussion among researchers, practitioners, policy makers and research funders interested in the impacts of the 4IR, in particular on the implications for middle-income countries; 2) explore current research and literature to build a research hypothesis and suggest some key definitions; 3) suggest key research questions and areas for further investigation; and 4) inform the co-design of a collaborative research project to study the changes in the capabilities of governance and knowledge systems in middle-income countries.

1.1 Definitions and Problem Statement

In his bestseller *Homo Deus. A Brief History of Tomorrow,* Yuval Noah Harari argues that humanity is at the brink of a new evolutionary era. One element of this new era is the accelerating technological development that Klaus Schwab (2016) has called the Fourth Industrial Revolution (4IR), and described as "the confluence of technological breakthroughs, covering wide-ranging fields such as Artificial Intelligence, robotics, internet of things, autonomous vehicles, nanotechnology, biotechnology, energy storage, and quantum computing" (*ibid.*: 7).

The 4IR and its transformative scientific and technological advances are transnational by nature and embrace a rapid pace of change. This brings a lot of uncertainty not only technologically but also economically, politically and socially (Mulgan 2018). These elements challenge state institutions to understand and keep up with the impact the changes have on citizens, civil liberties and political systems. Some see a risk that we gradually become subjects of digital systems that we can barely understand – let alone control – and that our societies and political systems can be subordinated to the power of

[1] Middle-income countries are a very diverse group of countries that, according the World Bank (2018), have a GNI per capita between USD 1,006 and USD 3,955 (lower middle-income) and between USD 3,956 and USD 12,235 (upper middle-income) (World Bank 2018).

those who control the new technologies and digital systems (Susskind 2018; Tegmark 2017; World Wide Web Foundation 2017).

The current systems of public policy and decision-making evolved during the 1870s alongside the Second Industrial Revolution. They were influenced by a belief in science and rationality and the emergence of new techniques for the division of labour and mass production, which led to linear and mechanistic decision-making processes along top-down hierarchies. The problem is that "governments today have to address the 21st-century challenges with 19th-century institutions" (Elmi & Davis 2018).

The authors of this paper argue that during the 4IR, sustainable economic growth and prosperity of middle-income countries will require new and increased capabilities for societies to use technology and knowledge to tackle so called "wicked hard" policy problems (Andrews *et al.* 2015: 126). Moreover, increasingly capable computing machines, the possibility of continuous connectivity and the increasing datafication or digitisation of citizens' lives will most likely change the nature and meaning of knowledge production and use in policy decisions. This is likely to offer new opportunities for the achievement of the Sustainable Development Goals (SDGs) and more equitable economic growth within the natural limits of our planet (Pellini *et al.* 2018; Carden 2017). Preliminary findings from the State of the SDGs programme from Southern Voice,[2] an international network of 48 think tanks from around the globe, highlights that the technological changes emerging from the 4IR are likely to have important implications in the countries of the global south, in particular SDG 4 (Quality of education), SDG 8 (Decent work and economic growth), SDG 10 (Reduce inequalities) and SDG 16 (Peace, justice, and strong institutions).[3]

At its heart, this paper is about the link between the 4IR and politics, and how knowledge can play a role to make the most of that link. The imminent technological changes require political, ethical and moral responses from state institutions (Susskind 2018). We argue that strong capabilities of knowledge systems are instrumental to the growth of a 21st-century economy and institutions. There is limited focus on, and growth in, the capabilities of knowledge systems in middle-income countries. This trend exacerbates the inequities that permeate global development. The development assistance community has largely failed to address this central problem.

In this paper, we define knowledge systems as *the interaction of research, innovation, higher education and citizen and professional knowledge. These interact in order to produce, provide, demand and use knowledge to support the development of public policies.*

The current education and research systems in most middle-income countries are not fit for purpose. They are not preparing a new generation of citizens and leaders to address the changes the 4IR will bring. While technological advances seem to provide unlimited opportunities for those with a good idea and a strong sense of entrepreneurship, inequality in the world between high- and middle- or low-income countries will continue to expand so long as the latter struggle to adapt their knowledge and policymaking systems to the emerging technologies. Finally, we need to recognise that technological changes will vary in different countries and sectors. This will require that knowledge and governance systems adapt as well. Further, this will have implications on the ways in which development programmes and projects supporting and building state and civil society capabilities are funded, designed and implemented.

This is not an entirely new challenge. It has also historically taken time to adapt to the technological transformations and societal changes the industrial revolutions have brought about. Antonio Gramsci (1971: 275–276) has described a situation like this as a "solstice" and an "interregnum", where "the old world is dying, [but] the new one has not yet been born."

2 See http://southernvoice.org/.

3 See https://sustainabledevelopment.un.org/sdgs.

1.2 Guiding Questions and Approach

This discussion paper is a high-level exploration of the themes outlined briefly above to identify specific areas for further investigation. The guiding questions for this paper are:

- What are the key elements of the 4IR?
- What does the literature say about the impact of this revolution on societies and economies, and in particular on middle-income countries?
- What are the implications of 4IR for the achievement of the SDGs in middle-income countries?
- What does the literature say about the challenges for governance and the ways knowledge can inform policy during the 4IR?
- What are the questions that require further investigation?

The discussion paper is based on a review of selected research, project and private sector literature; interviews with key informants in Albania, Argentina, Australia, Finland, Indonesia, Italy, Kosovo, Serbia, South Africa and Tanzania; and an online survey.[4]

The audiences that we want to engage with through this discussion paper are those groups interested in changes in policymaking processes due to the 4IR: policy researchers in think tanks; universities and government policy analysis units; development practitioners in funding organisations; implementing teams; and policy makers and civil servants interested in testing new ways for expanding the use of knowledge in policy.

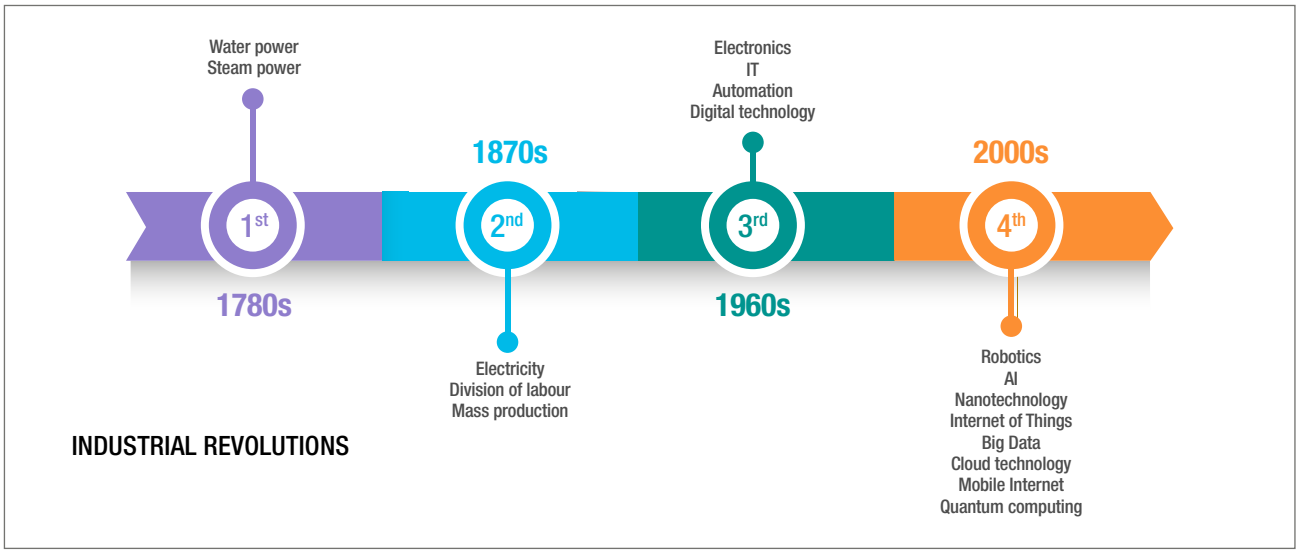
In the next section we explore the landscape of the social, economic and political changes that the 4IR is bringing. In Section 3 we zoom in on the specific changes that the 4IR calls for in governance and policymaking. Section 4 focuses on the changes and implications of the 4IR for the knowledge systems used as a background for policymaking. In Section 5 we present our suggestions for areas of further research and investigation.

[4] This online survey was held between November 26th and December 7th: it took an average of 22 minutes to fulfill and was targeted to experts who are already working on the related issues; we received 14 responses.

2 The Fourth Industrial Revolution and the Transformation of Our Societies

The 4IR will fundamentally change our societies and economies. What separates the 4IR from the previous industrial revolutions (see Table 1), is that the pace of technological breakthroughs is unprecedented and the scale and complexity of the transformation are unlike any seen before. The changes affect almost every industry in every country; the breadth and depth of the transformation demands changes in entire systems of production, management and public governance. The response cannot be left to state institutions alone but requires the active engagement of citizens, the private sector, the academy and civil society.

Table 1. Characterisation of industrial revolutions



Source: Schwab (2016)

An eminent group of scientists was asked what they think life will look like in 2040, when the effects of the 4IR will be widely seen (De Filippo & Frega 2018). According to these scientists, we are likely to be healthier and live longer lives as our ability to modify human DNA continues to expand. Moreover, in 2040, robots will perform routine tasks in our homes and replace workers for hard, repetitive and dangerous production tasks.

What these possible changes would mean in terms of policy is a serious challenge: we have to find the human and financial resources to care for a population that lives longer than before. States will also face new employment and training challenges as the ways and purpose of working will transform and we can anticipate increased migration from countries that have lost the competitive advantage of their skilled labour.

However, none of these policy implications are certain or the only possible options –we as citizens, users, consumers and humans have the opportunity to determine how the transformation will affect our societies and economies. Education, research and innovation, i.e. the knowledge system, have important roles to play. The 4IR, with rapid developments in the capability of computing machines, the increased integration of our lives with digital technology and the quantification of societies will

profoundly transform the political decision-making systems (World Economic Forum 2018; OECD 2017a, 2017b, 2017c; EU 2016; World Wide Web Foundation 2017). The changes are giving rise to what Susskind (2018) calls a *digital lifeworld*: a new and different form of collective life, where technology affects social interactions, economy, human agency and the natural environment. We will now review these elements one by one.

2.1 Social Interactions: Inequality in Access

New technologies change the means of social interaction. Today, more than 30 per cent of the global population use social media platforms to connect, learn and share information. Digital technologies and the dynamics of information sharing in social media ideally provide opportunities for cross-cultural understanding and cohesion. However, on the other side of the coin is the strengthening of like-minded bubbles or inward-looking communities and increasing distrust and hate speech.

The pace and extent of data collection has increased dramatically in recent years, to the point that 90 per cent of the data in existence was generated in the past two years (United Nations Global Pulse 2012) – and the pace of data collection is only increasing (Susskind 2018). The exponential growth in computing and data analysis capacity is evident also in the development of world connectivity. In 1995, less than 1 per cent of the world's population used the internet. In 2017, that figure had risen to around 46 per cent. The milestone of 1 billion internet users was reached in 2005 – the second billion was reached in 2010 and the third in 2014 (Internet Live Stats 2017).

The interesting question is, whether this exponential growth will continue or if we will reach a tipping point, where the poorer countries face obstacles for connectivity. Currently, about approximately 60 per cent of the global population remains excluded from the internet and there is a clear gap between high-income and middle- or low-income countries. For example, in 2016, 98 per cent of Icelanders had access to the internet, while only 1 per cent of Eritreans did (Sample 2018). Iceland is a high-income country with a Gross National Income (GNI) per capita of 45,810 USD, while Eritrea reports a GNI per capita of 1,750 USD (UNDP 2018). It is not clear that the pace of connectivity we have seen to date will continue without significant policy shifts that promote the inclusion of peri-urban, rural and remote communities.

However, many middle-income countries like, for example, Indonesia contribute to the upward trend in connectivity. The number of internet users there grew from 2 million in 2000 to 55 million in 2012 and reached 133 million in 2016, with an increase of 45 million internet users in 2016 alone (Kemp 2017). At the same time, data from Internet Live Stats (2017) show that, in 2016, over half of the Indonesian population of 220 million was online. Nevertheless, large parts of the country are yet to go online, and a disproportionate amount of non-internet users are women (Sample 2018). Maintaining the pace of technological development will likely struggle to materialise in middle-income countries due to inequality in access to technology between high-, middle- and low-income countries and within the middle-income countries themselves.

2.2 Economy

The 4IR is a socio-technical transformation that has direct economic impacts. All the macroeconomic variables –such as GDP, investment, consumption, employment, trade and inflation– will be affected. The 4IR will change the nature of work across all industries and occupations. Economists have pointed out that the 4IR could create greater inequality in labour markets (Brynjolfsson & McAfee 2014). As automation substitutes labour, the net displacement of workers by machines might widen the gap between returns to capital and returns to labour. On the other hand, it is also possible that the displacement of workers by technology will result in a net increase in safe and rewarding jobs (*ibid.*).

The 4IR hence brings new tools for economic development, which create both potential for and risks to middle-income countries. However, due to the digital divide between high- and middle- or low-income countries, "discrepancies remain with regard to access to technologies but also with regard to effective use and socialization of big data and affiliated technologies" (Linkov *et al.* 2018: 3). Achievement of the SDGs is threatened by asymmetries in the collection and use of big data and power shifts between consumers and data driven organisations, as well as the widening knowledge and information gaps between high- and middle-income economies (*ibid.*).

On the positive side, farmers could have better access to information on appropriate seed varieties (especially as climate change affects them) and could more easily optimise pricing with more rapid market information access. Big data can more rapidly track diseases, thereby reducing health hazards. At the same time, many traditional occupations are at risk. For example, driving – which is a major employer globally – will likely be disappearing as automated vehicles become increasingly common (Herweyer *et al.* 2017).

2.3 Human Agency

Neither technology nor the disruption that comes with it are exogenous forces over which humans have no control (Key informant, interviewed 2018). To treat technology as a tool, we need to develop a global, shared view of how technology affects our lives and reshapes our economic, social, cultural and human environments. This shared view can enable a critical process of adaptation to the future, which is the result of decisions taken by legislators, regulators, other people in power positions and citizens, whose engagement in policy decisions can increase through technology (Poole 2017).

When we treat technology as the solution to our problems rather than as a tool to assist us in our policymaking, we may be at the mercy of the (unconscious) biases of the programmers, which are reflected in the algorithms they develop. We may have both a false sense of security and feel powerless in the face of information overload (Bridle 2018).

At its core, the 4IR is not a question of technology but of culture. New technologies are not only tools but rather metaphors that define how we understand the world consciously and unconsciously. The danger is that the complexity of technology underlying the 4IR produces and strengthens inequalities of power (Brynjolfsson & McAfee 2014; Bridle 2018). At the heart of the issue, there is a fundamental question of values and culture: what do equality and justice mean in this future driven by technologies impacting people's lives? How do we level the playing field?

2.4 SDGs and Technological Changes

When it comes to the 17 SDGs agreed by 193 countries in 2015, the 4IR can both enable and inhibit their achievement by 2030.

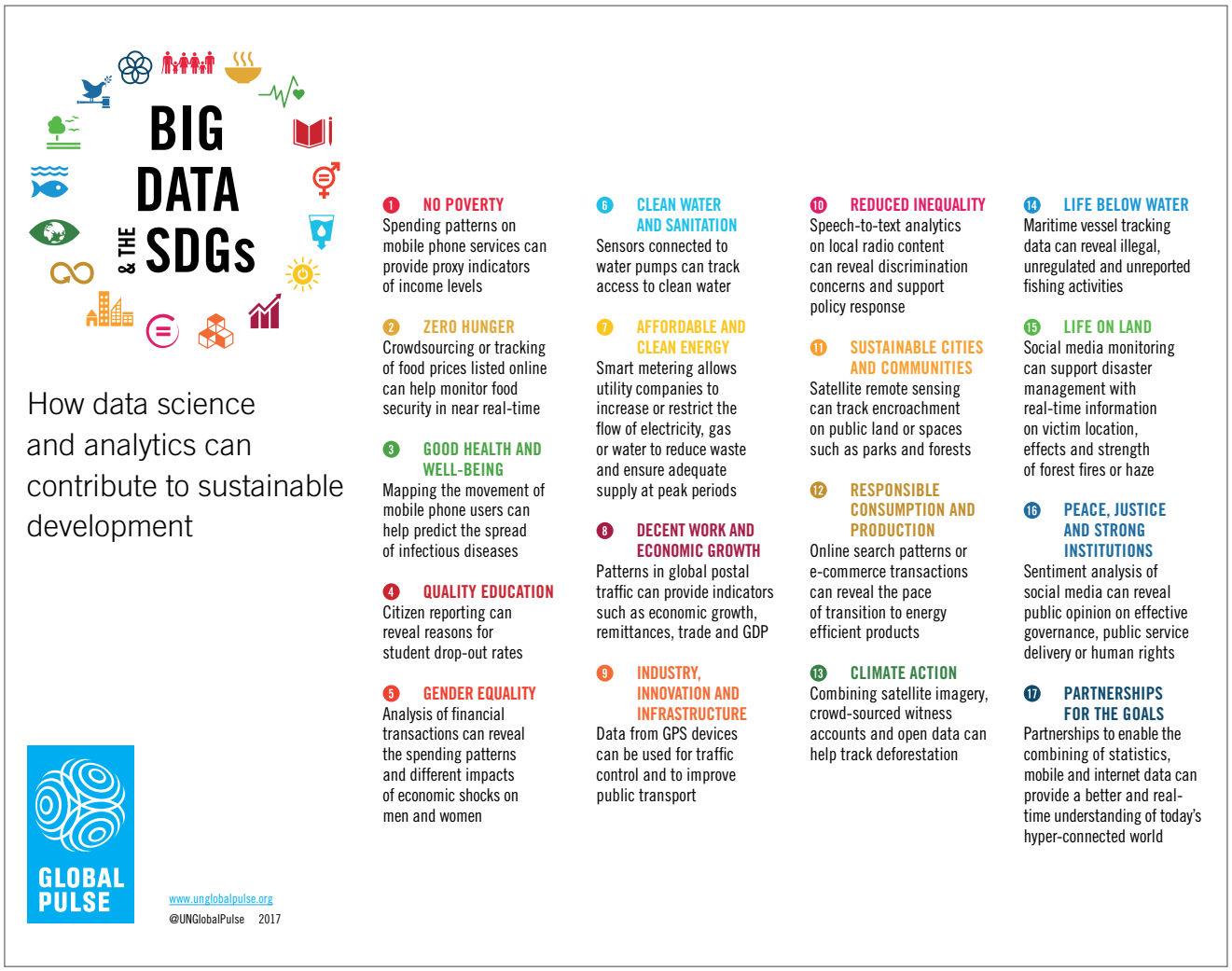
Knowledge can play an important role; indeed in 2013 an expert group meeting took place bringing together scientists and policy makers to discuss he best ways to strengthen the science–policy interface in support of the SDGs. The expert group meeting was meant as an occasion both for the scientific community to discuss among itself how science can best inform the SDG process, and for the scientific community to initiate a dialogue with the policy makers, who are engaged in intergovernmental deliberations on the SDGs. We argue that these processes need to engage all parts of the knowledge system, including the roles of citizens, if we are to effectively address these goals.

At the moment the emphasis on how technology can support the achievement of the SDGs centres on solutions linked to Information and Communication Technology (ICT) and data science. While ICT is mentioned explicitly in only four out of the 17 SDGs, there is great potential for ICT and new emerging

digital technologies to play a key role in attaining all 17 SDGs by making more systematic use of science, technology and innovation as well as citizen and professional knowledge across all of these areas (BMZ 2017, Stuart et al. 2015, Carr-Hill 2013).

The United Nations Global Pulse, the United Nations Secretary-General's flagship innovation initiative on big data, gives some examples of how data science and analytics can contribute to the SDGs (Figure 1).

Figure 1. Big data and the SDGs



Source: United Nations Global Pulse 2017

These examples highlight the opportunity that governments now have, though the use of big data, to shed light on disparities in society that were previously hidden to other sources of evidence. Many governments still do not have access to adequate data on their entire populations. This is particularly true of the poorest and most marginalised, whom government policies will need to focus on if they are to achieve zero extreme poverty and zero emissions by 2030, while leaving "no one behind" in the process (United Nations nd).

3 The Fourth Industrial Revolution and Policymaking

To reiterate a point we made in the last section, the changes brought by the 4IR are not inexorable forces of nature. They are tools "made by people for people" (Schwab 2016: 105), which people will use to take decisions, institute regulations and strengthen socio-economic development (Poole 2017). In order to reduce the negative effects of the transformation and create a more positive and equal future, governance systems need to react; they need to adapt and lead the transformation. Governments have to keep up with very fast technological and knowledge advances and handle the changes that occur simultaneously in multiple areas of economies and societies. This means subjecting their structures to the levels of transparency and efficiency that will enable them to maintain their competitive edge. If they cannot evolve, they will face increasing disruption.

However, legislators, civil servants and regulators struggle to make the shift from the IT and digital technologies of the Third Industrial Revolution to the multiple technological changes of the 4IR (Schwab 2016). The use of these new technologies in policy processes clashes with capability and institutional barriers. Middle-income countries' governments struggle to address the barriers they face day-to-day, such as limited funding to conduct research and low quality of research as well as inadequate rules and regulations for producing, accessing and using research. They (and the development agencies and government partners with which they collaborate) struggle to imagine and plan the systems, processes, regulations and capabilities that may be required in a few years while addressing today's problems.[5]

The point we explore in this section of the paper is that with the 4IR, politics and policymaking will have to change and adapt, as will other areas of social and economic life. In the more distributed system that the 4IR implies, policy processes will need to shift from a focus on individual problems to an interdisciplinary approach that treats problems as interrelated. The pace of the changes brought by the new digital technologies is simply too fast and complex for a traditional linear and top-down approach. In the next subsections we explore in more detail some of the changes that are likely to occur.

[5] The Knowledge Sector Initiative is a programme funded by the Australian Department of Foreign Affairs and Trade and implemented in cooperation with the Indonesian Ministry of National Development Planning/National Development Planning Agency. The programme supports more effective development policies through better use of research, data and analysis and works with research providers and government agencies to strengthen the quality and policy-relevance of research and how it used for policymaking in Indonesia (See: www.ksi-indonesia.org/en/home/). The Building Capacity to Use Research Evidence programme was implemented between 2013 and 2017 with funding from the UK's Department for International Development in 12 countries. The objective of the programme was to test ways to improve evidence use in selected ministries; test innovative online training methods to improve the skills of individuals to make evidence-informed decisions; and establish open policy dialogues between government officials, civil society and the research sector (See https://bcureglobal.wordpress.com/). The Performing and Responsive Social Sciences (PERFORM) is a project of Swiss Agency for Development and Cooperation, implemented by HELVETAS Swiss Intercooperation and the University of Fribourg. The overall goal of the project is to focus on strengthening the relevance of social sciences for social and political reforms in Albania and Serbia, and it has been implemented between 2015 and 2018 (See www.perform.network/).

3.1 Artificial Intelligence, Data and Governance

Governance is concerned with making decisions and exercising authority to guide the behaviour of individuals and organisations (World Economic Forum 2018). Governance is traditionally considered to be the remit of government and public institutions in the forms of legislative and executive acts. These decisions are informed and/or driven by political views and, to different degrees, by knowledge, experience and expertise depending on the type of political regime and the capability and resources in the knowledge system.

Artificial Intelligence (AI),[6] is defined as "an intelligent system which takes the best possible action in a given situation" (The World Wide Web Foundation 2017: 4). The World Wide Web Foundation suggests three possible areas where AI can strengthen policy systems, in particular for middle- and low-income countries: local economies can become more dynamic as the transaction costs incurred by a lack of information are reduced; the integration of different data sets and social media can help design more targeted public services; and AI-automated voice translation technology allows for greater participation in policy debates by ethnic and linguistic groups and illiterate citizens.[7] There are passionate disagreements on AI and its potential (Box 1). Digital Utopians see the positive opportunities; techno-sceptics think we are a long way from realising the promise of AI; and the Beneficial AI Movement sees both potential and risks, which remain by-and-large poorly understood (Tegmark 2017).

Box 1: Three main schools of thoughts about AI

- **Digital Utopians:** Digital life is the desirable next step in human evolution. The outcome is almost certain to be good.
- **Techno-Sceptics:** There is no need to worry about superhuman AI now. It is likely to take hundreds of years before humans will be able to build it.
- **The Beneficial-AI Movement:** There is a real possibility that we will have superhuman AI during this century and a positive outcome cannot be guaranteed. We need to start researching the difficult and hard questions now to have answers by the time we need them.

A further example of a challenge faced by governance systems due to the 4IR concerns the loss of power (Schwab 2016). In the more distributed system of governance that the 4IR implies, central government authority might be challenged by growing competition from local governments, municipalities and cities testing solutions to social, environmental and economic problems. Governance systems need to develop new ways for governments to relate to their citizens. In a sense, the disruption brought by the 4IR will enhance the need for collaborative forms of interaction within and between societies, organisations, countries and governments.

6 Cache (2015) argues that when talking about AI it is important to discriminate between two different types of artificial intelligence: Artificial Narrow Intelligence (ANI) which refers to a computer's ability to perform a single task extremely well, such as crawling a webpage or playing chess, and Artificial General Intelligence (AGI), which can carry out any cognitive function that a human can. ANI systems do what they are instructed to. AGI systems have the ability to reflect on its goals and decide whether to adjust them. Tegmark (2017) distinguishes them as well: AGI can accomplish virtually any goal, including learning, in contrast to say, the narrow intelligence of a chess-playing program. There is a considerable amount of research (and debate) around AGI (See for example Kelly 2017; Mills 2018).

7 The World Wide Web Foundation (2017) notes that the body of evidence on the social and economic impact of AI is almost exclusively focused on people living in higher-income countries. Middle- and low-income countries have their own set of opportunities and risks, which in some cases are similar to those of high-income countries but not always. For example, globally 87 per cent of men and 77 per cent of women are literate, and the vast majority of these live in middle-income countries. This means that there will be the need to design policies to, on the one hand, improve education quality and reduce illiteracy and, at the same time, adapt digital technologies and AI to a context in which a large number of people are illiterate or functionally illiterate.

Big data and data analytics respond quickly to emergencies and improve public services. However, there are currently considerable barriers when it comes to the usage and quality of the data used by governments, especially in middle-income countries (Key informant, interviewed 2018). The problem is that, in lower-income countries, the data may not be of an adequate quality and in an appropriate format to be used by AI systems (World Wide Web Foundation 2017; Key informants, interviewed 2018).

Technologies such as blockchain are increasingly distributed, which leads to increasing transparency (Lansiti & Lakhani 2017). They have more potential than ever before to inform citizens about the work and performance of government. These technologies, promoting more transparency and enabling democratic inclusive processes, can be viewed as a threat to certain authorities such as, for example, in the case of the Arab Spring uprisings or the social media tax in Uganda (Key informants, interviewed 2018, interviewed 2018; Monbiot 2017; Akumu 2018).

Politics and the political willingness of decision-makers to transform the capabilities of the public administration through technology play a critical role, which is sometimes overshadowed by the potential benefits that technological solutions can bring (Key informants, interviewed 2018). If reforms are viable, legitimate and relevant, they need to introduce technically sound and politically feasible solutions (Fabella *et al.* 2011).

Paul Cairney (2016) has defined policy processes as "the sum total of government action, from signals of intent to the final outcomes." Some argue for a complete rethink of policy processes (Mayer-Schönberger & Cukier 2014), while others argue that applying AI and big data to policy processes will simply add new data (Shaxson 2016). It could also be that making digital technology too critical to decision-making risks undermining the socio-political and cultural dimensions of policy processes (Key informants, interviewed 2018; Davies 2018).

3.2 Emerging Issues in Governance and Decision-Making in the Fourth Industrial Revolution

It is not possible to predict the extent to which new digital technologies will change policy processes or bring new types of knowledge to inform policy decisions. The changes vary from country to country; they will also vary within a country. Middle-income countries have a dual challenge to build the infrastructure to improve connectivity and to develop the human capital required to understand and use the new technologies to adapt policy processes. In this section we describe very briefly some suggestions and emerging ideas on how government actors should prepare for change. The aim is to introduce some of the ideas rather than explore them in depth.

Box 2: ASEAN principles for national and regional governance in the 4IR

- **Speed:** Policy makers must recognise that the process of making rules and setting standards must keep up with technological shifts.
- **Agility:** Government organisations, regulators and policy makers must have flexibility to respond rapidly to changing circumstances, without losing sight of the overarching goals and values.
- **Experimentation and iteration:** Policy makers will need to develop ideas quickly, implement these ideas in time-bound and experimental settings, learn lessons quickly and steer this feedback into the policy-decisions-making process.
- **Inclusivity and multiple stakeholders:** Truly effective policymaking and regulations will require inputs and views from multiple stakeholders.
- **Openness:** The 4IR is a global phenomenon and policies and regulations should continue to support collaboration, sharing and exchange between countries within a region and across regions.

A White Paper co-published by the Asian Development Bank and the World Economic Forum (2017) about the implications of the 4IR for the Association of Southeast Asian Nations (ASEAN) suggests the 4IR will require new approaches to policy design and formulation at the national and regional levels. It urges ASEAN leaders "to think creatively

about how they can upgrade the process of crafting policies, setting standards and writing regulations at a regional scale" (Asian Development Bank & World Economic Forum 2017: 14). The White Paper warns that if they do not manage to do so, their countries and the region may find itself "on the wrong side of this moment of global reset" (*ibid.*).

Lee *et al.* (2018) argue that government institutions should adopt policies that can foster two main strategies: one to govern techno-digital transformation through testing of technologies and experimentation, and one to support leadership and human capital development, which also includes new definitions of teaching and learning objectives in research and higher education. Schwab (2016) suggests that agile forms of government will be needed to help regulators and legislators to continuously adapt to a new fast-changing social and economic environment without stifling innovation, which again will involve and require forms of greater collaboration between state institutions, civil society and business in order to shape regulations. This will also require the strengthening of institutions for research and higher education.

Global issues such as climate change, food security and the global financial system come increasingly to the fore. Governments need to grapple with (and engage citizens in) the question of how international and national governance systems will interact to address these issues and how they will do so in the context of the 4IR.

4 The Fourth Industrial Revolution: Implications for Knowledge Systems

In this section we shift our attention from the implications of the changes brought by the 4IR on policy processes to the consequences for knowledge systems. According to Gévaudan (2017), there is an increasing recognition among governments and international organisations of the importance of mobilising local research, higher education and innovation, as part of wider strategies for socioeconomic development.

In Section 1.1, we defined knowledge systems as *the interaction of research, innovation, higher education, and citizen and professional knowledge. These interact in to produce, provide, and demand and use knowledge to support the development of public policies.* Below we will unpack this definition.

Governments need strong knowledge systems to produce, acquire and use the knowledge required to plan for and adapt to the impacts of the 4IR. There will be pressure on governments to adapt their systems and processes of policymaking as well as their processes of public engagement. Digital technologies and social platforms will provide governments with an opportunity to further engage with citizens. Lee *et al.* (2018) note that governments are likely to experience greater uncertainty in the decisions they take due to "new combinations between technologies and markets … [that are] voluntary, unexpected, and uncontrollable." These call for more flexibility in systems as well as in decision-makers.

This scenario raises some questions linked to the uncertainty that comes with it. Will traditional forms of knowledge be able to address complex challenges that seem less and less beyond the control of state actors? How can research, higher education and innovation systems adapt to the new digital technologies? How will digital technologies expand the contribution of citizen and professional knowledge through dialogues, participations and different forms of deliberation in policymaking processes?

The 4IR will lead to changes in the structure of knowledge systems themselves. New technology will contribute to processes and methods to demand, produce and use knowledge to inform policy decisions. This will require strategies and investments to develop the skills and competencies required by individuals and organisations involved in processes to inform policy decisions. Are research and higher education strategies and systems fit for purpose to provide these skills? If policy decisions become more participatory, innovative, flexible and open to learning and innovation, how can knowledge systems respond to this new reality? Moreover, the traditional approach for bringing knowledge into the policy process might be challenged: we will need to deeply rethink it.

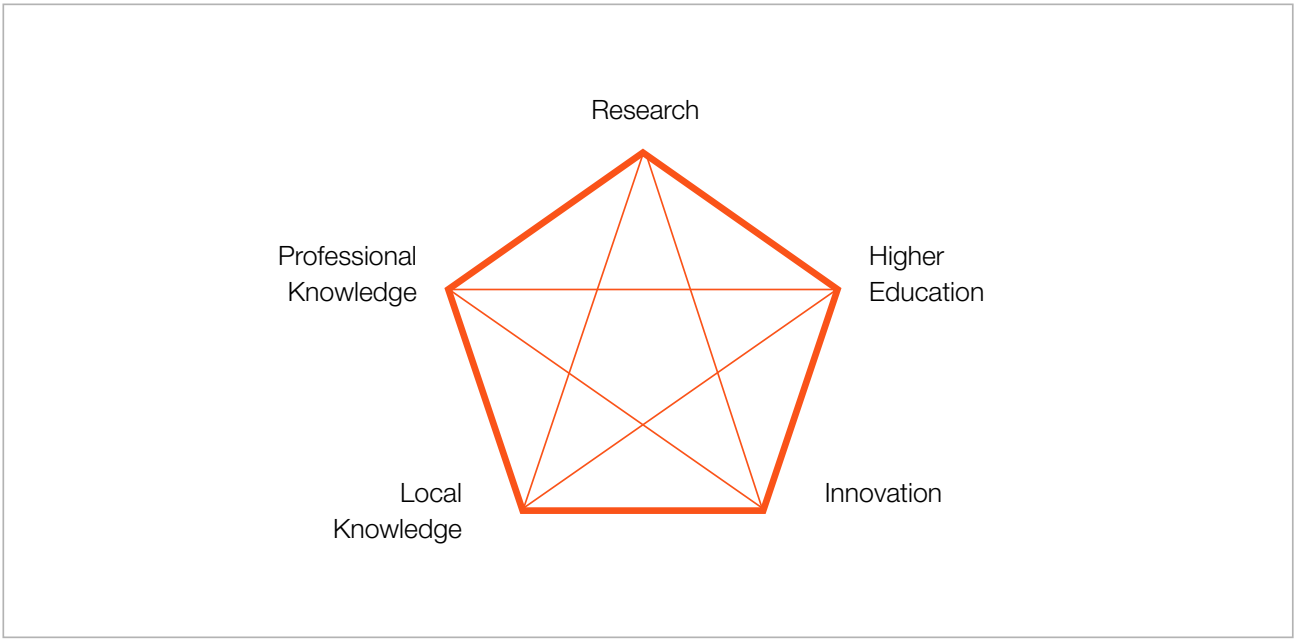
4.1 The Fourth Industrial Revolution as an Opportunity to Make Knowledge Systems More Visible

Donella Meadows (2009: 11) defines a system as "an interconnected set of elements that is coherently organised in a way that achieves something." In brief, a system consists of *elements*, *interconnections* and a *purpose*. *Elements* are the easiest parts to see, because they are visible and tangible (e.g. actors). *Interconnections* are the relationships that hold these elements together. It is more difficult to understand these interconnections and why elements are linked as they are. *Interconnections* often reflect information flows. The *purpose* is the hardest part of a system to spot, as it may not be articulated orally or in writing. The purpose must be deduced from behaviour and actions rather than rhetoric or stated goals.

In practice, working with the concept of knowledge system entails several challenges, especially when trying to assess how they work at the national level. How are research, higher education, innovation and local and professional knowledge understood and how do they affect each other as part of a knowledge system? How can interconnections be identified and described? Sometimes initiatives venture further, looking at ways to change or influence *interconnections* in the system (e.g. forums between researchers and policy makers, coalitions among advocacy organisations and knowledge producers, etc.). This can have a positive impact on the system, but may not last. Very few interventions venture so far as to try to influence or change the system's *purpose*, which is the level of intervention capable of instituting the most profound changes to the system (Meadows 2009).

Here, and shown in Figure 2, we propose five core elements to the knowledge system: research, higher education, innovation, citizens' knowledge and professional knowledge. Each of these has a relationship with the other/s and are mutually reinforcing. For example, all are central to innovation; citizen knowledge often co-creates with formal knowledge generated through research. Our model builds and expands on the *knowledge triangle*, which underpins innovation systems as described by the OECD (2016). In short, this model proposes that the nature, type and quality of the interactions between research, innovation and education are important determinants of the overall performance of innovation systems. Investments in one element tend to not only positively affect the other two elements but also create external impulses, from upgrading the labour market and fostering structural economic change to inspiring society at large – often with a strong, place-based context.

Figure 2. Five core elements of the knowledge system



Source: Authors

Let us define each of our pentagon´s components. Research encompasses the formal research system, which supports basic and applied research on a range of social and natural scientific issues, creating knowledge in a society that can be used in a range of ways. It is usually institutionalised through the development of a national academy of sciences that brings together the most qualified

scientists in the country to provide advice to government, as well a national research funding mechanism to promote the development of the science community. Higher education includes the development of all three levels of higher education (ie, Ba, Ma, PhD) to produce a cadre of critical thinkers and researchers who can both expand the national knowledge base and contribute to innovation and national development. Innovation, which depends on a strong research community as well as strong interactions between ideas and technologies, is about turning ideas into products and services of use to society. Citizen knowledge emerges from a society's experiences and practice. It is the social capital that allows individuals to become citizens and form communities. Citizen knowledge is most often a co-production between communities and their environments. It is often tacitly held and passed on orally from generation to generation. Importantly, like other forms of knowledge, it evolves and changes over time. Professional knowledge is the knowledge held by bureaucrats, intermediaries (such as think tanks) and advocates. Professional knowledge synthesises and consolidates ideas from a range of sources and, most importantly, connects them to context.

As with other conceptualisations of the knowledge system, each of the linkages in the pentagon can be strengthened by means of platforms and processes that build bridges between education, research, innovation, citizen knowledge and professional knowledge. The assumption underpinning the *knowledge pentagon* is the potential complements and conflicts between the five elements: their interactions to co-produce useful knowledge becomes more important to facing the different and complex challenges that 4IR brings to governance and policymaking. As noted above, there will be an increasing demand for co-creation of new types of knowledge that stem from the interaction of the different elements of the knowledge system (this is currently more visible in innovation systems, which are usually more open to other systems).

Understanding a system requires mapping all aspects of the system, which is an ambitious as well as promising endeavour. The literature demonstrates that there is a growing recognition of the need to shift focus away from changes to one of the elements (e.g. new research organisations, trained civil servants, etc.) and move to more systemic approaches (e.g. Knowledge Sector of Indonesia). Significant and useful efforts to assess some of the core elements independently have been made, such as those of the *Doing Research Assessment* method developed by the Global Development Network, a public international organisation that supports high quality, policy-oriented, social science research in developing countries, under the Doing Research programme[8]. The method that emerged from this programme can be used to assess the performance of a social science research system. It reflects the fact that doing quality research requires much more than scientific skills and depends also on numerous other factors such as socioeconomic, political and historical context, international dynamics, characteristics of the market for research, supporting policies and services and many others.

This and other similar initiatives demonstrate that it is complex to measure and report on each independent component, so that assessing the whole knowledge system with its five components remains a challenge. It is important to find concrete ways to make a systemic approach feasible so that potential evolutions of the elements are connected and thus increase potential for change. One way forward could be to focus on the interconnections in the system as well as the system's overall goal: this is where the main impacts of how knowledge systems can contribute to addressing the challenges of the 4IR may be found. Among these linkages the most profound changes will probably occur. For example, the What Works Network initiative[9] found that institutions and roles that provide more than one ecosystem function help to connect entire systems, making them stronger and more

8 See www.gdn.int/doing-research-program.
9 See www.gov.uk/guidance/what-works-network.

influential. They also act as pipelines in evidence ecosystems – the absence of which impedes the flow of evidence. Any evidence ecosystem comprises many parts and depends on many different agencies.

The needs to strengthen collaboration among sectors and stakeholders and to work with a deep recognition of the value of a system is clear. As Schwab (2016) affirmed "with effective multi-stakeholder cooperation … the Fourth Industrial Revolution has the potential to address – and possibly solve – the major challenges that the world currently faces." Survey respondents have also stressed interlinkages and relationships as a main area of change that needs to take place in knowledge production to better help policy makers address the challenges of the new technologies.

Cooperation could be enabled within a strong knowledge system: it calls for a government and population that can think critically and in interdisciplinary and cross-disciplinary ways.

4.2 The Evolution of Knowledge Systems

The 4IR will bring change and disruption in knowledge systems. Governments have the opportunity to design policies to prepare the knowledge systems of the future to make better decisions for the wellbeing of all. To succeed, governments will have to design enabling environments (laws and regulations) that help knowledge producers to acquire new skills and strengthen synergies and collaboration; they will also need to provide civil servants and policy makers with the financial means and abilities required to access and use new technologies.

There is a wide set of changes brought by the 4IR that are affecting knowledge systems and will continue to do so over the coming years (See Annex 2). According to the survey respondents, critical changes for research include new data-driven technologies that will allow governments access to real time information. To respond to the change, there is a need to develop processing and synthesis skill, and to promote digital literacy as well as the ability to ensure that data is as reliable and inclusive as possible (and respectful of privacy).

Higher education institutions, in collaboration with governments and industry, need to prepare lifelong learners, emphasising critical thinking and collaboration skills. In terms of innovation, policy experimentation (for example, through open innovation platforms) at different levels (national, local, etc.) will be more accepted and used as a way to test policy solutions, including citizen participation and collective action strengthened by new digital technologies. In terms of local and professional knowledge, much more needs to be done to integrate these as legitimate elements of knowledge systems.

The changes described here have to be seen as part of the overall evolution of the knowledge systems. All these changes demand that knowledge institutions be ready for change at two levels: the adoption of and experimentation with new technologies to increase the technological capacity of organisations, and the implementation of human development strategies to make organisations more creative and resilient. For this reason, as posited by Lee *et al.* (2018), institutions should adopt policies that can foster two main strategies: a strategy to govern the techno-digital transformation and a strategy to support leadership and human development capacity.

5 Conclusions and Suggestions for Further Research

Development is a process of change and transformation that involves finding new and better ways to solve problems. Change can emerge from within a society and political system or be the result of external political influence. Whatever the origin of the change, with it comes unpredictability. Author and activist Jane Jacobs in *The Nature of Economies* (2000: 19) highlights this unpredictability, describing development as an open-ended process, a qualitative change that "can't be usefully thought of as a line, or even a collection of open-ended lines. Development operates as a web of interdependent co-developments."

In this discussion paper we have described some of the changes that the 4IR will bring to bear on the economy, human agency and knowledge systems that inform and support policy decisions. The authors whose work we have reviewed, and the interviews and survey respondents, all agree that there will be significant changes, but they are unsure about how the changes will come about and all their potential consequences.

The changes that will emerge will be part of an ever-expanding web of co-developments, which will follow the principles of evolution rather than engineering (Green 2017). The changes in knowledge systems will vary in different countries and contexts, shaped by previous changes, political traditions, culture, norms, values and so on.

State institutions in middle-income countries have a very difficult task ahead of them. On the one hand, they have to find solutions to the social and economic inequalities between richer urban areas and poorer peri-urban, rural and remote areas. At the same time, they have to design economic policies to move away from reliance on low skilled labour and/or extractive industries and be ready to compete internationally with new technologies and innovation in 10, 20 and 50 years from now. They have to make these decisions under great uncertainty and often without an adequate knowledge base. They must also contend with low capability in the systems of academic and policy research, government and non-government policy analysis and research, data analytics and foresight research.

In middle-income countries, the opportunity cost of not investing in knowledge systems - and fostering interactions among their core components - is very high. Education and higher education institutions that are not fit for purpose will not prepare researchers and civil servants who are able to adapt and adopt new technologies to address the specific economic and social problems of their countries. Nor will they be able to design the enabling environment required to increase productivity, strengthen competitiveness and ensure that a sustainable economic growth benefits all, thus fostering inclusion.

Research systems are equally weak in most middle-income countries. There is an over-reliance on research from elsewhere and a lack of priority given to building a national research culture, essential for strong local innovation. Often citizen and professional knowledge are ignored unless they can co-produce with formal scientific research. Both citizen and professional knowledge are important to successful implementation; ignoring them weakens the potential for success. Together, this suggests weak knowledge systems, leading to the risk that middle-income countries fall further behind as higher-income countries take advantage of the benefits of the 4IR to strengthen their economies as well as their social development.

Here, the authors propose questions that require more in-depth research in and on middle-income

countries, to better understand the ways knowledge systems have evolved to date (several coincide with those that survey respondents pointed out). Future research needs to recognise contextual variation and ongoing change and the extent to which knowledge systems are likely to continue evolving as we move further into the transformations the 4IR is bringing. Key questions for further research include:

On knowledge systems

- What are knowledge systems and what does it mean to adopt a systems perspective to strengthen the demand, production and use of knowledge in policymaking?
- In different countries, how have knowledge systems evolved and how are they likely to evolve during the 4IR?
- What are the most important changes and challenges for knowledge systems in the complex decision-making environment of the 4IR?
- What are the characteristics of a knowledge system that is ready to face the challenges of the 4IR?
- How can we redefine what knowledge for policy is and how it is (co-)produced to help policy makers make better decisions?
- How can knowledge systems increase awareness of the implications of the 4IR to citizens' lives?

On governance

- How are policy makers currently using available data, knowledge and digital technologies?
- How do new forms of governance driven by the 4IR affect the production and distribution of knowledge for policy?
- How are new technologies likely to enable new ways to design, implement and evaluate policies that use 4IR technologies and are, at the same time, inclusive and transparent?

On inclusion

- How will the 4IR affect the accomplishment of the SDGs and how can improved knowledge systems help governments better achieve SDGs?
- How will the digital divide affect middle-income countries' capacity to respond to 4IR opportunities and threats?
- How can the opportunities of the 4IR help reduce inequality within countries and between countries?

These questions are broad and ambitious and at the same time very promising. This paper is one of our first steps within a larger initiative, in which a group of organisations will collaborate to explore in more detail the implications of the Fourth Industrial Revolution on policymaking process and the production and use of knowledge to inform those policy processes in some middle-income countries.[10]. Thus, this discussion paper aims at informing the co-design of this collaborative research project to study the changes in the capabilities of governance and knowledge systems in middle-income countries. The project seeks to generate preliminary answers to some of these questions, and to build on related existing initiatives. For example, 50 per cent of the survey respondents are already researching or assessing the implications of new technologies on their policy area or sector, and have also pointed out others working on related issues. Connecting those initiatives and building on their findings and achievements remains an attractive opportunity to contribute to the co-creation of new evidence to support decision-makers.

The purpose of the research project is strategic: we aim to go beyond a description and analysis of what is happening now to stimulate a search for solutions. We recognise the challenge but also the sense of urgency to confront the 4IR in the context of middle-income countries. Failing to address these challenges makes the risk of greater global inequality high. We will probably need to sharpen our focus and discuss with those interested to research this topic which questions to focus on and/or which are the most feasible entry points.

[10] The organisations are: Capability (Finland), Demos Helsinki (Finland), Helvetas Swiss Intercooperation (Switzerland), Politics & Ideas (global), Southern Voice (global), UNESCO Regional Bureau for Sciences in Latin America and the Caribbean, Using Evidence (Canada).

Also, how to respond to (some) questions is as important as the focus of the research project. The findings and challenges shared above imply that traditional sectoral and linear thinking will not help: there is now the opportunity now to shift to more creative and innovative ways to generate action-oriented research. Yet, if we conduct a collective and co-creative project (we are exploring a hub model), we should make decisions on how to structure a process that enables common ground and at the same time allows flexibility to adapt to local contexts. In that direction, we face the challenge of whether we could manage to look into these questions at the global, national and local levels simultaneously (both in terms of knowledge systems and policymaking).

One way to go about this is to explore national strategies and policy for producing a fit-for-purpose education and higher education system to prepare the human capital required by researchers and civil servants in the 4IR, or to explore how the knowledge systems in the selected countries have evolved, and been adapted and shaped by political and historical circumstances. The research should aim at bringing together policy actors, researchers and practitioners to contribute through the research process to the development of knowledge communities that can inform and influence a policy agenda on the development of the capability to use new technology for policymaking.

Another potential way forward is to focus the attention in areas/cases/practices where the main components of the knowledge system concretely interact and operate in a certain systemic way: research, innovation, higher education and/or professional and citizen knowledge are integrated to generate and use evidence for policies related to the challenges of the 4IR.

Our objective with this discussion paper (and the presentation that we held in Bangkok at the Think Tank Initiative Exchange in October 2018) is to launch a discussion by suggesting areas for further research that can be undertaken with selected middle-income countries. Through an international collaborative research project, we will promote leadership in innovation as well as in research and higher education, ready to incorporate professional and citizen knowledge. The research will support those leaders in building the knowledge base they need, to promote action and better prepare their countries for the 4IR. If you or your organisation are interested in this topic and/or want to join this initiative, please get in touch with us.[11]

11 Email contacts on page II and page III.

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Annex 1 - List of Key Informants

Name	Organisation	Country
Blandina Kilama	REPOA	Tanzania
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Annex 2 - List of Possible Changes in Knowledge Systems

Research and policy analysis

- Social science researchers will need to know programming.
- Social science research will be much more integrated with data analytics.
- Big data analytics help with correlation but research is still needed to understand causation.
- Government will be quicker at mapping the knowledge they derive from their own systems and to identify the knowledge they need to fill gaps to inform decisions.
- Foresight research will scan social, economic and technology trends to help inform policy decision and complement research and analysis about current problems.
- Evidence blending may become more prominent: evidence about the effectiveness and cost benefit of interventions and programmes needs to be applied in the context of the settings in which they are implemented. Much of this context-specific evidence is generated in action research (a structured, practitioner-led, reflective process).
- The importance of mutual understanding between scientists and the public will come into focus. The changes of the new technology might cause confusion for individuals in terms of their identity, morality, ethics and relationships. Therefore, scientists should focus on forming a relationship of trust with the public rather than on short term benefits.
- Policy analysis skills within government organisations require multidisciplinary approaches and a blend of research and analysis, as well as working less in silos and with more integrated and coordinated policies.
- National statistical offices are challenged by new data-driven technologies. Statistics collected and compiled by technical experts are giving way to data that accumulates by default and a consequence of sweeping digitalisation.
- Citizen knowledge will be increasingly incorporated into decision-making due to big data capability, but this excludes citizens with no digital footprint or access to technology.

Higher education

- Programming is a new form of literacy that will have to start from primary schools.
- Education systems have to put an emphasis on teaching critical thinking and collaboration skills.
- A combination of liberal arts education and upskilling depending on where you are in your educational journey should take place. The techniques and curriculum deployed in a liberal arts institution can be adapted to a given institution's cultural and financial context.
- The workers of the future will have to be able to learn new skills and unlearn old ones.
- Traditional undergraduate, graduate and research education will remain important to society, but space must be made for adult learners to continue their learning as well. Institutes of HE, in collaboration with governments and industry, need to prepare lifelong learners together.
- Educational institutions should create mechanisms to reinvestigate the teaching and learning objectives of courses designed in schools and highlight technological changes and their effects on industrial applications and life.
- For technical and vocational training systems, the private sector could help to organise work-based learning for students and promote careers through public campaigns, vocational tracks in education and investment in technical and vocational training systems.

Policy and innovation

- Policy experimentation at different levels (national, local, etc) will be more accepted and used as a way to test policy solutions.
- Citizen participation and collective action (and the local knowledge that comes with it) will be strengthened by new digital technologies and a politics of belonging.
- Open innovation platforms can become a tool to combine different knowledge bases and organise innovation-related interactions with external actors. They should foster the combination of knowledge towards innovative solutions on at least three levels: a) a combination of different knowledge bases, including both science and experience-based knowledge; b) a combination of codified and tacit knowledge (i.e. digital platform and physical innovation hubs that represent the new modes of co-working and co-creation spaces; and c) a combination of citizens and public services with the development process in business development and innovations refers to extension of knowledge bases to the people and the public sector of the region.