



The 4th Industrial Revolution in Africa – Opportunities and Challenges

Published on December 10, 2018 by Czirják Ráhel

Since the 18th century, industrial revolutions have fundamentally changed the economy, mankind's relationship with nature, and everyday life. This process still lasts today, but now we can talk about the Fourth Industrial Revolution. Although technological achievements made throughout the centuries are regarded by most people as the means and signs of development, the complex process called the industrial revolution and the accompanying technical

advancement also have their downsides. In our study composed of several parts, we explore the latest stage of the industrial revolution from Africa's perspective, and we seek answers to the question as to what risks and opportunities it holds for the Black Continent.

The complexity of the topic prevents us from undertaking its fully comprehensive study, as there would certainly be a segment that we would not cover even in the case of a study composed of several volumes and conducted in collaboration with the experts of many other fields of science. Instead, we attempt to grab the potential effects of the fourth industrial revolution along three dimensions – economy, infrastructure and (natural) environment –, narrowing these dimensions to a certain extent, with regard to the fact that the study still would be too large-scale without doing so. Keeping all these in view, the aim of our study series is to provoke some thought, inviting readers to contemplate it and unfold a professional debate. Part One is about economy, Part Two is about infrastructure and the final part is about the natural environment, from Africa's perspective.

Industrial revolution – from the steam engine to artificial intelligence

The industrial revolution has fundamentally changed mankind's relationship with nature, the methods of economic production, and, consequently, everyday life. As a result of the original accumulation of capital and embourgeoisement, the process, first unfolding on the British Isles, has been going on until today – but now on a global level. The approximately 250-year-old history of industrial revolutions can be divided into different stages. The academically most widespread division differentiates between three major eras, on the basis of the technology exerting the greatest impact on the economy: the initial period of the industrial revolution – in other words, the First Industrial Revolution – lasted from the 1760s to the 1840s,^[1] with the steam engine being the most dominant invention, replacing the use of animal effort in agriculture, and allowed the launch of mechanised production in the industry. The most significant technological achievement of the Second Industrial Revolution – which lasted roughly from the 1870s until World War I – is electric power and its widespread use, and, in relation to it, the beginning of mass production.^[2] The Third Industrial Revolution began about in the late 20th century – roughly in the 1960s – and is hallmarked by electronics, information technology and the automatization of production.^[3]

By now, there is a Fourth Industrial Revolution we can talk about, which is building upon the digital revolution of the third one, but forms a distinct, new era, due to the velocity and scope of technological advancement and its impact exerted on systems – including systems of production, management or governance –, argues Klaus Schwab, founder and Executive Chairman of the World Economic Forum. [4] The Fourth Industrial Revolution is characterised by the fusion of various technologies, blurring the lines between the physical, digital, and biological spheres, [5] which, apart from the transformation of different disciplines, the economy and the industry, also raises the question as to what it means to be human. [6]

The new era called Industry 4.0 is characterised by such inventions and research directions as artificial intelligence, robotics, the Internet of Things (IoT – internet-based connectivity of various devices, objects), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. [7]

As a practical consequence of the scientific-technological advancement, production is and may be becoming more flexible. On the one hand, this is the result of applying robotics in manufacturing, as “smart equipment” communicates with the environment while continuously measuring various parameters of the process, making the adjustment of production during the process easier, if necessary. [8] The growing volume of data also allows of better adaptation to customers’ needs. The Internet and 3D printing, for example, liberalise access to technology, making the decentralisation of production possible. [9] That is, in the present stage of the industrial revolution it is becoming more and more possible to establish small plants producing cheaply and flexibly. [10]

Thus, the Fourth Industrial Revolution offers several opportunities, but it also entails risks. Below, we are exploring these from Africa’s point of view.

Africa’s economy – premature deindustrialisation

**Africa's Roadmap to the Fourth Industrial Revolution:
Digital Transformation & Cyber Security**



With the industrial revolution, the restructuring of the economies affected has begun, which is primarily reflected by the re-stratification of employment, which means the following development path in the case of the countries of the Western world: the first step is the flow of workforce from agriculture into industry, that is, industrialisation, later followed by a transfer of workforce released from the agricultural sector into the tertiary sector (second step). The third step is deindustrialisation, when industry gradually starts to lose from its weight due to a decrease in its share in total employment and an increase in the services sector – while there is a continuous decline in the primary sector. In the post-industrial development phase workforce flows only from the industry into the tertiary sector. [\[11\]](#)

The structural transformation of the economy is an important issue as the long-term sustainability fundamentally depends on it and on the fact whether economic growth is accompanied by social development. The structural change generating growth started on the Black Continent in the decade after decolonisation in: the flow of workforce from less productive sectors and areas towards more productive ones – that is, from agriculture into the processing industry and services, from rural areas into cities –, and from the informal sector into the formal one began. But by the 1980s-1990s, the transformation process had almost completely run out of steam, [\[12\]](#) and today we can talk about Africa's "premature deindustrialisation" – as Rodrik calls it [\[13\]](#) –, as the decrease in the economic weight of the industry has taken place earlier than its level of development would have justified. [\[14\]](#)

Between 1960 and 2010, 18 per cent of the workforce flowing out of the agricultural sector went into the industry, 88 per cent of whom found employment in the manufacturing industry. But the African manufacturing industry is dominated by informal small enterprises, which have low productivity due to their technological standards, market relationships and financial resources. Therefore, despite growing workforce, the industry's contribution to the GDP increased only slightly in 2010 compared to 1960: from 24.3 per cent to 27.8 per cent. [\[15\]](#)



	Agriculture	Manufacturing industry	Services
Africa	16	11	54
European Union	2	15	74
East Asia and the Pacific	5	23	60
South Asia	18	16	53
Latin America and the Caribbean	5	14	67
North America	1	12	80

Table 1. Sector shares of gross domestic product in world regions (2014-2015, %)[16][17]

82 per cent of workforce released from agriculture found employment in the tertiary sector – the productivity of which is even lower than that of the industry –, which considerably increased the significance of services to the national economy – by 2010, it had produced half of the GDP and employed 73 per cent of the workforce, but this all happened while productivity decreased, as services are also predominated by the technologically underdeveloped informal sector. [18]

That is, despite the fact that the workforce that had become superfluous in agriculture flowed into other sectors, only a small degree of structural transformation took place in Africa's economy – as most of the workforce went to the low-productivity services sector instead of the more productive manufacturing industry, which has a minor growth-generating effect. Consequently, the economic

growth of the continent is not the result of internal development but is the benefit of an advantageous external context – such as the growing demand for raw materials in the first fifteen years after the turn of the millennium was. [19]

But what impact may the technological achievements of the Fourth Industrial Revolution have on Africa's economy? One of the important features of the new era is that it is transforming the methods of production, which entails both potentials and risks.

The impact of the 4TH Industrial Revolution on Africa's economy

One of the most frequently mentioned threats is the replacement of more and more human labour by robots, [20] which might lead to growing unemployment primarily in developing countries, where – as a result of a post-Fordist economic transition – production was relocated to from centre countries due to their cheap workforce. In this way, automatization mainly threatens with the extinction of workplaces requiring low qualifications – primarily in the manufacturing industry.

But the weight of the manufacturing industry is much less on the Black Continent than in, for example, Southeast Asia: it produces only 10 per cent of the GDP [21] – in Southeast Asia this figure is more than double, 24 per cent [22] –, and employs only 7 per cent of the workforce. [23] But this seemingly small share of 7 per cent may be much larger if looked at on a lower territorial level. In Ethiopia, for example, automatization threatens 44 per cent of employees. Furthermore, forecasts suggest, between 2015 and 2030, 29 million people will enter the labour market on the continent annually, therefore Africa urgently needs to create new jobs – and not to threaten or extinguish them. [24]

But the Fourth Industrial Revolution also shows potential for Africa. Thanks to various studies and the Internet, small-scale manufacturing is becoming increasingly competitive, because, among others, automatization is getting increasingly cheaper, the customisation of products becomes possible even for a larger circle of customers, and raw materials are cheaper. [25] In their study, Erik Brynjolfsson and Andrew McAfee present the efforts of Heartland Robotics to provide 'cheap robots-in-a-box that make it possible for small business owners to

quickly set up their own highly automated factory, dramatically reducing the costs and increasing the flexibility of manufacturing'. [26]

Thus, the technological innovations of the Fourth Industrial Revolution may put small enterprises into position by enabling an increasing number of people to launch flexible, small-scale manufacturing which is competitive even against large companies. Collectively, these new businesses – although none of them may ever create billion-dollar businesses themselves – create millions of new jobs and they can exert more considerable effect on the labour market than a single large company would. [27]

Entrepreneurs, being champions of innovation, play a key role in the life of the economy by developing and introducing new technologies and methods of production. [28] In this respect, Africa, where the proportion of entrepreneurs within the working-age population is the highest, 22 per cent, has enormous potential. [29] But basically, the Black Continent can use the opportunity offered by high entrepreneurial potential and the latest stage of the industrial revolution if two conditions are met: appropriate qualifications and adequate infrastructural background.

Several studies have already justified the relationship between education and the performance of a given country: before the turn of the millennium, Barro calculated that an extra year in education (that is, increasing average schooling by one year) raises the growth rate of the economy by of 1.2 percentage points per year. [30] In their calculations, Wilson és Briscoe concluded that an overall 1 per cent increase in school enrolment rates leads to an increase in GDP per capita growth of between 1 and 3 per cent. [31] A study conducted in 2007 found that an extra year spent in education increased wages in Kenya by about 11.3 per cent and in Tanzania by 8.3 per cent. [32]

In the context of the industrial revolution, education, on the one hand, is essential to enable people to use the achievements of the industrial revolution, and by adjusting them to their environment, to further develop their environment, and to devise new, innovative ideas, procedures and solutions. On the other hand, education is likely to have an important role in eliminating the threat posed by automatization, as human labour tends (and will tend) to be replaced by robots in jobs requiring lower qualifications. But with re-training, and increasing the level of qualifications, the workforce concerned can be employed in other segments.

The next chapter focusses on another important condition of tapping the potential of the Fourth Industrial Revolution: an adequate infrastructural background.

Infrastructure on the black continent

Infrastructure is a term of Latin origin; it means a fundamental structure, a fundamental building, or, in general, fundamentals, that is, ‘the fundamentals, the antecedents and the prerequisite of the creation, existence and development of a thing’.[33] Some sources claim that the term was first used in the USA during World War II: devices and equipment to supply the army, and the facilities ensuring their transport and normal operation were called infrastructure. [34] Other sources date the first use of the notion to the times of the Napoleonic Wars. [35]

There are several ideas about the meaning of the term, widespread in vernacular language by now: for example, some classify all factors related to human activity and functioning but arable land under the definition of infrastructure, while another approach regards the entire environment of microeconomic processes, including nature, as a part of infrastructure. [36]

Fundamentally, this is a term with technical content, [37] ‘a basic requirement of economic activities, services, the life and development of countries, regions and settlements. Therefore infrastructure has a decisive role in the socio-economic development’.[38] That is – referring to the chapter focussing on economic impacts – adequate infrastructure, as well as adequate schooling, is a pre-requisite to harnessing the economic potential of the Fourth Industrial Revolution.

In Hungarian and international academic literature, countless methods of grouping infrastructure can be read, but we present only one kind of classification below – the one that best suits the approach of this study paper. Within infrastructure, we can differentiate between technical or linear infrastructure, and social or human infrastructure. This latter one includes housing, the facilities for commerce and catering, institutions of health and medicine, education and culture, as well as various facilities for sport, mass holidays, recreation and leisure.[39] This article, however, does not focus on these, but the technical infrastructure, which is more closely related to economic activities, and includes traffic and transport, energy supply, water supply, sanitation, waste water management, and the network and facility systems of information and telecommunications. [40]

**Africa's Roadmap to the Fourth Industrial Revolution:
Digital Transformation & Cyber Security**



About the state of Africa’s technical infrastructure, the Africa Economic Report 2017[41], prepared by the World Economic Forum, argues that the infrastructure deficits are rated as one of the top three constraints for Africa’s development. Within this, the level of development differs widely across sectors: the development of water, electricity, and transport infrastructure is “limited” or “disappointing”, although comparatively better outcomes have been seen in telephony and communication and, to some extent, sanitation, but it still lags well behind the world average. Electricity supply is the least developed sector of infrastructure on the continent.

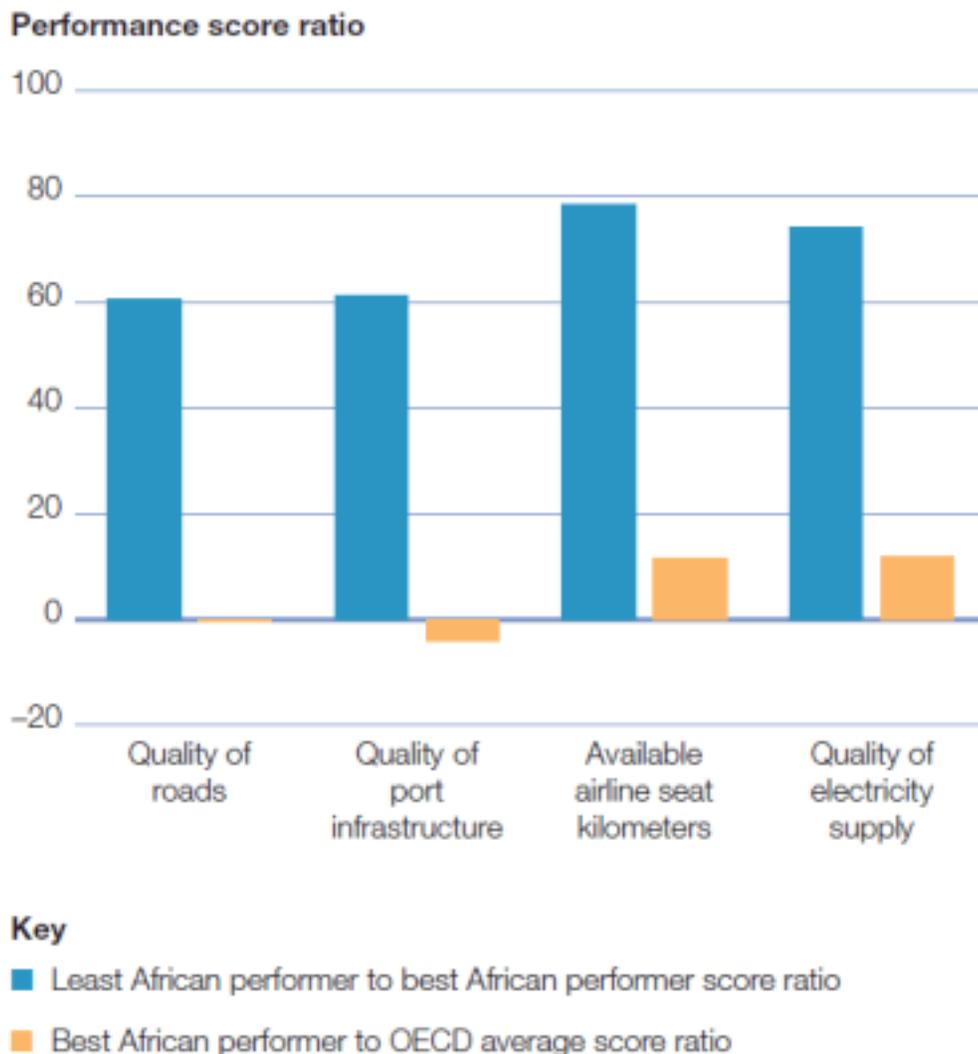


Figure 1: Quality of infrastructure in Africa[42]

Fundamentally, it can be established that the (both qualitative and quantitative) underdevelopment of Africa's traffic and transport infrastructure is still holding back the economic development of the countries on the continent, as it – among others – hinders the market access of products, significantly increases transportation costs and adversely affect the flow of foreign direct investment. With an average of 204 kilometres of roads per 1,000 square kilometres of which only one quarter is paved, Africa lags far behind the world average of 944 kilometres per 1,000 square kilometres. [43] This is not only a barrier to the connectivity between settlements – regions and countries – but it has a negative impact (mainly) in cities: low road density versus high concentration of population causes congestions, which are significant sources of pollution and accidents. [44]

The situation of the African railway network is similar: its total length of 75,000 km, on a surface of 30.2 million km², translates into a density of approximately 2.5 km for 1,000 km², which is far below that of other regions and the world average of 23 for 1,000 km². [45] The network itself is extremely fragmented, connection between countries is hardly provided, partly because tracks with different gauges have been built in each country, [46] and 17 African countries do not have railways at all. [47] The average technical speeds of African railways are about 30 to 35 km/hr, they railways in Africa carry only 2 per cent of the global railway passenger traffic and 7 per cent of the goods traffic. [48]

Consequently, costs of transportation (including all its means) in Africa are among the highest in the world, which makes trade more expensive, considerably reducing the competitiveness of African products in the world market. Poor road, rail and port facilities add 30 to 40 per cent to the costs of goods traded among African countries. [49] Transportation costs may amount to even 77 per cent of the value of export in landlocked countries. [50]

Taking into all these into consideration, the World Bank seems to be fair to use such attributes as “limited” and “disappointing” when describing the quality of transport-related infrastructure.

The impact of the 4TH Industrial Revolution on Africa's infrastructure

Beyond more traditional elements of infrastructure, internet, and in a broader sense, information and communication technologies (ICT) are of great significance

in the latest stage of the industrial revolution as they reduce geographical distances between, for example, economic actors, to zero.

In Africa, ICT infrastructure and usage have improved significantly, enabling many people to access services that they could not even dream about. Mobile phones have enabled millions of Africans to manage their businesses more effectively through, for example, providing an opportunity for mobile banking (see: M-Pesa). Nonetheless, the gap with advanced economies on ICT usage has increased – it is even larger today than 10 years ago–, hindering the capacity of the continent to embrace the Fourth Industrial Revolution. [\[51\]](#)

M-Pesa – mobile banking in Africa

M-Pesa (M for mobile, pesa is Swahili for money) is a mobile phone-based money transfer, financing and microfinancing service, launched in Kenya in 2007 by Vodafone for Safaricom and Vodacom, the largest mobile network operators in the East African country. Since then, the service has been used by almost 30 million users in 10 countries. Practically, M-Pesa is a branchless banking service enabling customers to deposit, transfer or withdraw money with the help of their mobile phones – via text messages – for a considerably lower administration fee than the one charged by banks. [\[52\]](#)



Figure 2: M-Pesa[\[53\]](#)

Economists Tavneet Suri (Massachusetts Institute of Technology, MIT) and William Jack (Georgetown University) examined the social impacts of the system for the period of 2008-2016. They found that the service lifted 200,000 households out of extreme poverty by increasing financial resilience: it provided immediate access to small-amount loans, enabled savings and, as a result, the launch of business activities. The authors found that with the help of M-Pesa, approximately 185,000 women could move out of agriculture into business. [\[54\]](#)

Despite these advances, Africa is not in a very good position in terms of the Internet, which can be regarded as one of the corner stones of the latest stage of the industrial revolution, either. Only 20 per cent of Africans have regular access to the Internet, which would be crucial for economic development, as most transactions and most of the economic activity are conducted online.[\[55\]](#) Only 1.4 percent of Africans have access to a broadband connection.[\[56\]](#)

But the digital technology cannot transform the economy of the continent without universal electrification, that is, the completion of the Second Industrial

**Africa's Roadmap to the Fourth Industrial Revolution:
Digital Transformation & Cyber Security**



Revolution. [57] 645 million people lack access to electricity, [58] which is, apart from the difficulties of everyday life, significantly encumbering economic growth.

Currently, the lack of electricity is regarded as the greatest barrier by 39 per cent of African businesses. [59] A study conducted in 2016 revealed that the number of electrical outages for sub-Saharan Africa in a typical month is about 8.5, and their typical duration is about 4.1 hours. [60] As a result of the lack of maintenance work and new investments, and of a growing number of users in recent decades, the power networks of the continent are overexploited, outages are frequent, supply is irregular, while the price of electricity has been increasing. [61]

But new technologies create an opportunity to eliminate infrastructural deficits and to bridge the resulting gaps. A good example can be observed in Rwanda, where the world's first drone delivery service was launched in October, 2016, which delivers blood to hospitals, cutting the waiting time of several hours to 15 minutes. [62] In Rwanda, also called "the country of a thousand hills", topographical conditions and poor roads in rural areas make it very difficult to provide healthcare to patients in more remote areas of the country. In order to improve medical care, the government of Rwanda launched the project in partnership with Silicon Valley-based robotics company, Zipline. Within this framework, a distribution centre has been built in the Muhanga region, where 15 custom-built drones, known as "Zips," take off. They can fly up to 150 kilometres and carry up to 1.5 kilograms of blood. Hospitals can order blood via text message, and have it delivered in 15 minutes on average, eliminating the need for onboard refrigeration or insulation. [63]



Figure 3: Zipline[\[64\]](#)

This system provides supplies in western Rwanda, where about 7 million people live in an area of over 18,000 square kilometres. In order to roll out the service, on the one hand, a drone airport is being currently built in Rwanda, which is scheduled for completion in 2020. On the other hand, the range of delivered products is also planned to be expanded, so that medicines and medical equipment could also be delivered like this.[\[65\]](#)

Nevertheless, the transformation of the economy can be based on the development of infrastructure if there is a critical mass: it requires the distribution of this and similar innovations that change and influence the lives of broad strata of society – and not just some highlights. But on the basis of the present state of the technical infrastructure of the continent, the report of the World Economic Forum suggests, African countries are not equipped to transition to a Fourth Industrial Revolution economy.[\[66\]](#) That is, under the current circumstances, Africa cannot extensively gain the economic benefits provided by the Fourth Industrial Revolution, offered by flexible systems of production through new inventions and technologies.

Surprising as it may seem, there is one field where underdeveloped infrastructure may represent an advantage to the continent, and this one is in the environmental dimension.

Environmental impact

Mankind's impact on the environment can be examined in several different ways. In this article, we are examining the anthropogenic impact created by the industrial revolution starting from how the values of a complex index, the ecological footprint has changed.

The ecological footprint shows the total area of productive land and water required continuously to produce all the resources consumed (e.g. food, energy, etc.) and to assimilate all the wastes produced, without damage, by a defined person, population or activity, assuming a given level of development and resources management.[67] The measurement unit of the ecological footprint is the global hectare, which represents an area of 1 hectare 'the productivity of which equals with the average productivity of the Earth's total biologically productive hectares',[68] that is, a land area with world-average productivity. [69] Different soils, different utilisations of lands have very different productivity, which is averaged in the global hectare on a global level.

If the ecological footprint of men is compared to the biocapacity of the Earth – its carrying capacity –, it reveals how much of the resources available is used. If this rate – expressed in percentages – exceeds 100, we can talk about overexploitation, that is, the Earth is depleted to the detriment of next generations. [70]

Although ecological footprint calculations have been made by the Global Footprint Network, established for this purpose, only since 1961,[71] the Hungarian literature contains a study paper that makes calculations going back further historically, with the help of which the anthropogenic impact on our Globe, rising sharply with the industrial revolution, can be illustrated.

Co-authors Szigeti and Tóth[72] estimated the size of the ecological footprint from historical GDP data going back as far as 10 000 BC, in five specific periods. During their research, they found that not overpopulation, but overconsumption is the primary drive behind the currently experienced, unsustainable development. For almost 12 thousand years, the fullness of the Earth (that is, total eco-footprint

divided by total biocapacity, in percentages) changed proportionally to the growth of the population; however, there has been a dramatic change from the beginning of the industrial revolution. Since then, the extent of consumption and Earth fullness have been exceeding population growth (Figure 4).

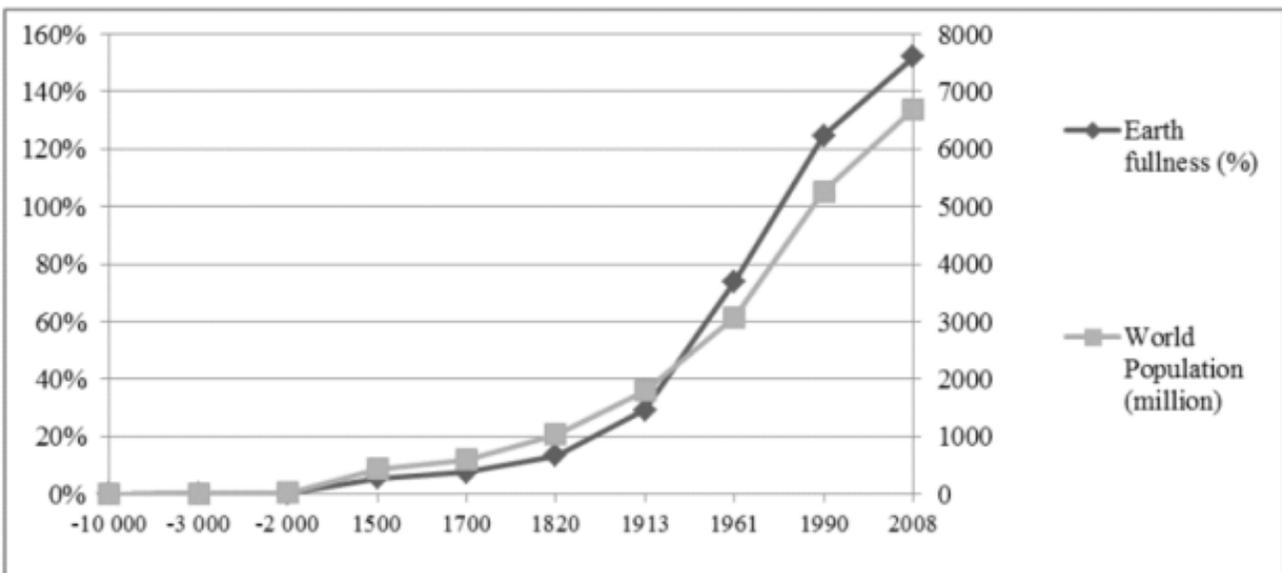


Figure 4: Long term changes in Earth fullness and world's total population, from 10.000 B.C. to 2008 [73]

The changes in the overexploitation of the Earth is well illustrated by the following data: Earth fullness (ecological footprint/biocapacity, %) was 0.05 per cent at the birth of agriculture (10 000 B.C.), 0.17 per cent in 3000 B.C., 5.48 per cent at the beginning of the Great European Conquests (1500) and 13.48 per cent at the advent of the industrial revolution (1820).[74] Today, this value almost reaches 170 per cent![75] That is, the exploitation of Earth's natural resources has increased parallel to technological advancement, at an accelerating rate. While at the dawn of the history of mankind, it took approximately 7,000 years to triple exploitation of the biocapacity of the globe (from the birth of agriculture to the appearance of civilisation), in Early Modern Times it took only 300 years (from the great European Conquests until technological-scientific revolution). In the two centuries lasting from the beginning of the industrial revolution until today, the anthropogenic impact – calculated with this method – has increased tenfold.[76]

However, the extent to which regions and continents with different levels of development exploit the biological capacities of our globe vary. Figure 5 demonstrates that the developed world (North America, Oceania and Europe) has the largest ecological footprint, while developing continents score around the world average or below.[77] That is, the environmentally conscious – or at least claiming to be so – Western world with a high standard of living puts much more pressure on the environment than the global South, giving much less consideration to environmental viewpoints and having a lower level of income.[78]

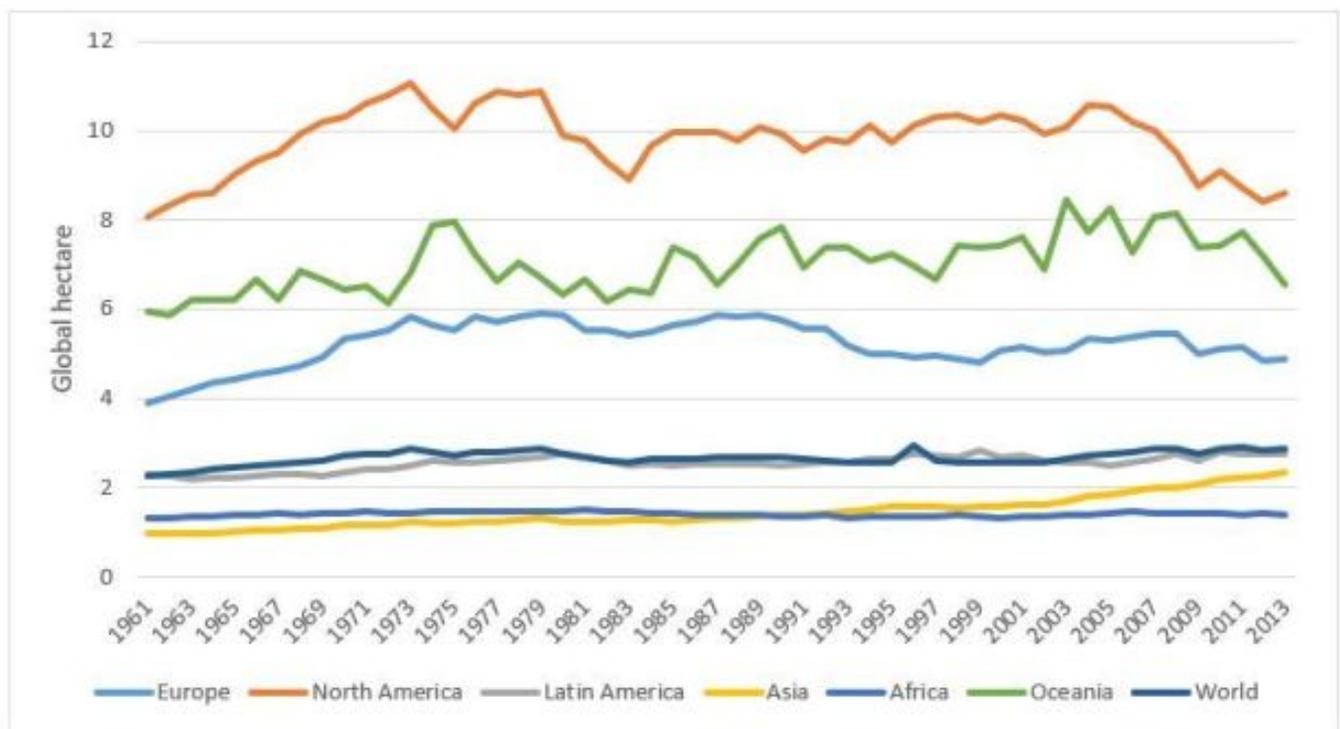


Figure 5: Changes in the ecological footprint of regions (1961-2013) [79]

One of the reasons should be sought in large infrastructural systems being developed from the beginning of the industrial revolution. For example, in the 18th century, the development of modern infrastructural systems began in the urban regions of the developed world to resolve sanitation problems – drinking water pipeline systems, drainage systems –, [80] which, although meet the needs of the population, are unsustainable from an environmental point of view, and have caused the Earth's resources to dwindle.[81]

(Another reason is consumption, which depends on individual decisions made on the basis of income levels and market supply, therefore it can be influenced by education and awareness-raising in case a specific level of economic development is in place.)

In this respect, Africa's infrastructural deficits can be advantageous from an environmental point of view. The continents and its cities have a chance to *'leapfrog outdated and costly systems established during the industrial revolution'*,^[82] and realise environmentally sustainable solutions universally through using renewable energy resources and green energy, becoming increasingly significant in the Fourth Industrial revolution.^[83]

That is, in the last days of the age of fossil fuels, economies counting as underdeveloped find themselves in a favourable situation, as they are not bound by the shackles of traditional industrialisation, therefore they have the prospect of skipping the resource-intensive production and consumption patterns of the Western world, and leapfrog into the post-fossil age.^[84]

'Southern countries face important decisions about introducing and designing infrastructures such as energy, transport, wastewater and communication systems'^[85] to avoid this unsustainable course of the global North, opting for infrastructures which would allow them to embark upon a low emission and resource-light trajectory.^[86]

As for the energy supply of the continent, currently only a little but more than one-third of the population have access to electricity.^[87] Furthermore, due to poor quality of the infrastructure and the lack of maintenance, a quarter of the capacity installed is inaccessible. ^[88]

It is obviously underdeveloped infrastructure and not the lack of resources that is responsible for gaps, as Africa – in addition to petroleum and natural gas – has an extremely favourable renewable energy potential: according to the calculations of the African Development Bank, Africa has 10 TW of solar potential, 350 GW of hydroelectric potential, 110 GW of wind potential and an additional 15 GW of geothermal potential^[89] – most of them unlocked. Currently, one-third (33 per cent) of energy is generated by electric power plants using coal, another one-third (32 per cent) is produced by using natural gas, and 12 per cent is generated by using petroleum. Less than a quarter (23 per cent) of energy production derives

from renewable resources.[90] Other sources estimate this value at 18.9 per cent.[91]

As a result of the Fourth Industrial Revolution, considerable advancement can be made in the use of renewable energy sources, which – if applied in an environmentally sustainable manner – may provide a solution to the infrastructure deficits of the continent – namely in electricity supply. Smart grids can distribute power across a number of homes in very remote locations, also improving the quality of human capital: children will be able to study at night and meals can be cooked on safe stoves, eradicating indoor air pollution, due to which 600,000 people die annually. [92]

Conclusion

In our study, we sought to capture the impacts which the Fourth Industrial Revolution exerts on Africa and its possible consequences. The study outlined that there is a strong interrelationship between the dimensions discussed (economy, infrastructure, natural environment), hence the impacts of the latest stage of the industrial revolution are very diverse and complex. The system of relationships between the dimensions can be outlined as follows:

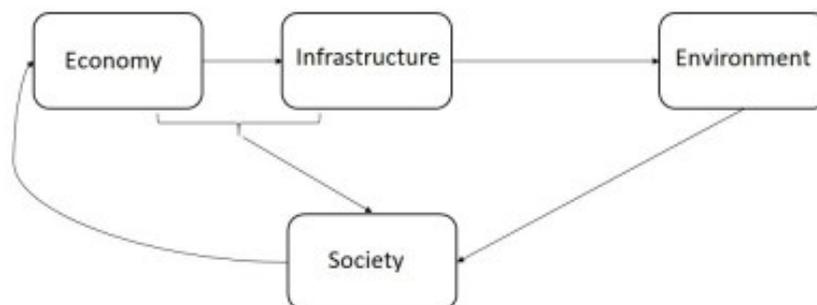


Figure 6: System of relationships between the dimensions studied

Economic development (structure, technological standards, productivity of the economy) is closely related to the state of the infrastructure, as it can be regarded, to a certain extent, as the imprint of and the prerequisite for the economic activity. A considerable part of the financial resources required for infrastructural investments is produced by economic operators, and the elements of infrastructure systems provide the technological background required for economic activities – thus, infrastructure is an essential condition of any economic activity.[\[93\]](#)

These two dimensions fundamentally – but not exclusively – determine the impact exerted on the natural environment by national economies and regions through the weight of the various sectors of the national economy (agriculture, industry, services), the technological standards to which they operate (e.g how much pollution is caused by factories), the energy carriers and raw materials on which the operation of the economy is based, etc.

Economic and infrastructural development, and the condition of the natural environment determine the welfare and well-being of the society: are there enough jobs for people?; do their incomes afford them an adequate standard of living – thanks to the services provided by infrastructure systems?; does the physical environment (built and natural) provide them with a healthy environment?; etc. Although this interrelation system is a very simplified version of reality, it vividly demonstrates how complex the effects of new technological achievements may be.

Along the specific dimensions, our findings about the impact exerted on Africa by the Fourth Industrial Revolution are as follows:

The technological advances of the Fourth Industrial Revolution imply both potentials and threats for Africa. A threat is, for example, replacing human labour by robots – typically in the manufacturing industry -, which would affect only 7 per cent[\[94\]](#) of African employees, but, on a lower territorial level, this figure might be much higher: in Ethiopia, for example, 44 per cent[\[95\]](#) of people active in the labour market are threatened with losing their jobs.

The (potential) impact of new technologies on production – such as flexibility, better ability to adapt to the needs of customers and cheaper production –, however, represents an opportunity for the continent, as small-scale manufacturing

can become more competitive through innovation and the Internet. This might result in the creation of jobs, and would exploit the remarkably high entrepreneurial activity of the continent.

Addressing threats and tapping potentials are subject to two conditions: adequate schooling and adequate infrastructure. In terms of the latter one, there has been considerable development in specific sectors – such as the ICT infrastructure – in Africa in recent years, but it still lags far behind the world average – especially in such more traditional sectors as electricity, water or transport.^[96] In order for the Internet, a key element of the Fourth Industrial Revolution, to have a universal impact, first electric power, the achievement of the Second Industrial Revolution, should be in widespread use on the continent.

According to a report of the World Economic Forum, the continent, with the present state of its technological infrastructure, is not ready to transition to an economic model based on the advances of the Fourth Industrial Revolution.^[97] From an environmental point of view, however, this deficit might be an advantage for Africa, as it has the chance to implement environmentally sustainable solutions through the application of renewable energies and green technologies – becoming increasingly important in these days –^[98] and to avoid the unsustainable development course of the Western world, the elements of which started to evolve at the advent of the industrial revolution.^[99]

Thus, the impacts of the Fourth Industrial Revolution exerted on Africa are extremely complex, we cannot talk about entirely positive or negative consequences. It mostly depends on the continent what practical steps it will take in order to avoid expected threats and tap potentials.

Author: Ráhel Czirják

A full publication can be found on geopolitika at : <http://www.geopolitika.hu/en/2018/12/10/the-4th-industrial-revolution-in-africa-opportunities-and-challenges/>