Technology and the Developing World

BY AMITTAI WEKESA '24

Cover image: People using mobile phones. Mobile computing and communication is one of the modern technologies driving innovation in developing and least-developed countries.

Source: Wikimedia Commons

Abstract

It is notable that some countries – specifically the developing and the least-developed countries – lag behind others in developing and using technology. While this might put them at a disadvantage, it also uniquely positions them to implement technology from the ground up to tackle their big issues such as poverty and other developmental problems. This research paper attempts to analyze themes surrounding the technological gap between developed countries and developing/least-developed countries and predict future opportunities for developing/least-developed countries to use technology and boost growth and development.

Introduction

Developed countries are generally categorized as those that have a per capita income level higher than $12,000 (on average, developed nations have a per capita income of $38,000) while developing nations fall in the per capita income range of $1,000 to $12,000, and least-developed nations fall below the $1,000 mark (Advocates for International Development, 2019). Currently, developing and least-developed nations are significantly behind developed nations in terms of adopting technology, which puts them at a serious disadvantage. To understand this gap and how it can be bridged, it is useful to understand the history of technological inventions.

History of Technological Developments

How and why exactly does technology develop? A persistent driver in the past has been energy. According to the first law of thermodynamics, energy can neither be created nor destroyed – it is only possible to transform energy between different forms. But the law does have one

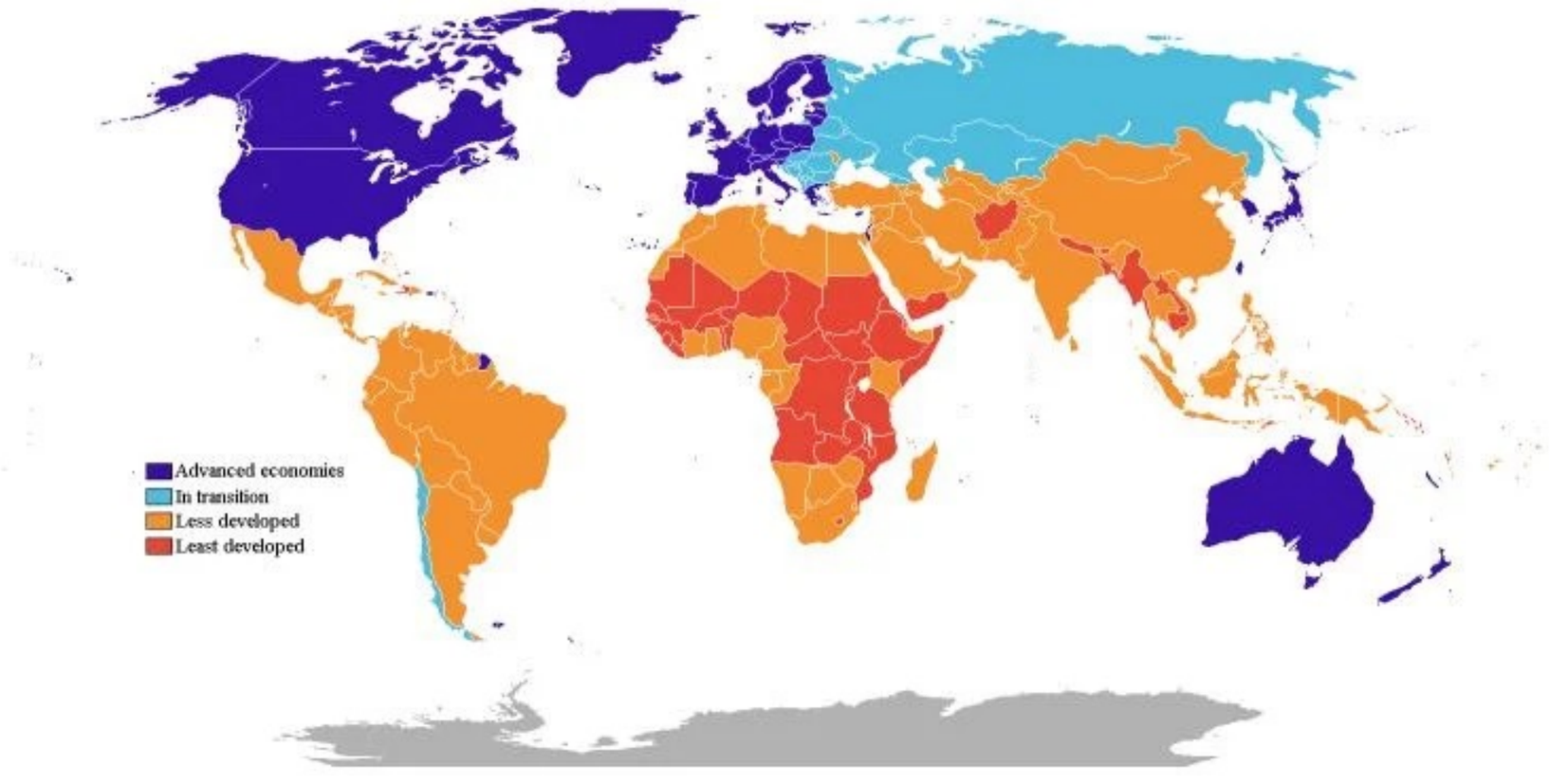

Figure 1: A world map showing the distribution of countries classified as developed, developing, and least-developed. Developed countries fall under the "advanced economies" and "in transition" labels (dark blue and light blue), developing countries fall under the "less developed," (orange) and least-developed economies fall under the "least developed" (red) labels respectively.

Source: Wikimedia Commons

special caveat. Einstein's special theory of relativity relates a body's mass to its energy using the equation E = mc^2. In short, the equation means that mass can be converted to energy and vice versa. (Fernflores, 2019). This equation has real-world applications – specifically in energy production. For example, nuclear fusion uses a manageable amount of energy to combine two atomic nuclei and, in the process, converts a slight amount of their mass into energy. However, nuclear physics was a non-existent field until the late 1800s and early 1900s when Henri Becquerel, Marie Curie, and Pierre Curie made significant discoveries about radioactivity (Marie Sklodowska Curie, 2020).

Prior to the discoveries of radioactivity and nuclear fusion, elementary methods were employed to produce energy. One of the earliest ever energy sources was fire, which archaeologists estimate first came into use about two million years ago. However, it wasn't until around 8000 BCE that proper human settlements evolved, and agriculture became common practice (Technology Timeline, 2020). Once concentrated settlements started developing, people began seeking more resourceful means of utilizing their land and resources. For a long time, productive work – agricultural activity or the work of craftsmen, was done entirely with manual, hand-held tools The use of metals such as copper, bronze, and iron over the traditional use of less strong wood emerged from 3000 to 600 BCE to make manual labor somewhat easier.

More proper use of energy to power devices was the steam engine, which is actually thought to have been pioneered by the Greeks in 62 CE. However, it was not until the 19th century that steam engines had widespread, productive use in factories, steamships, and railroad transportation. This lag in productive use is true of many pioneering inventions. Before the turn of the common era, basic concepts of windmills, gunpowder, microscopes, and even telescopes had already been developed. In 1703, Gottfried Leibniz pioneered the binary number system that is used in virtually all computers today. In 1769, Wolfgang von Kempelen developed the first speech synthesizer. And in 1801, Joseph-Marie Jacquard's automated cloth-weaving loom which used punched cards to store patterns inspired a similar method of data storage in first-generation computers (Technology Timeline, 2020). These new inventions required a mechanism for power storage. Sure enough, around 11 years later the first battery was invented.

"Prior to the discoveries of radioactivity and nuclear fusion, elementary methods were employed to produce energy."

Over time, it seems that technological developments have been employed with greater haste. For example, it only took about ten years after Michael Faraday developed the first-ever, primitive electric generator for a practical electric motor to be implemented using the same concept employed in modern motors (Technology Timeline, 2020). This motor enabled the use of electric batteries to drive physical engines, which was a significant step that allowed further development of mobile machines such as trains.

The next major era in the evolution of science and technology, taking place in the 19th century, involved the transportation sector. As new technology that enabled faster, longer-distance travel was introduced, civilizations could operate more efficiently – shipping and

Figure 2: Marie Curie, one of the revolutionaries who paved the way for modern technologies. Curie was the first female Nobel laureate and the first person to win a Nobel prize in both physics and chemistry in recognition of her contributions to nuclear physics. On the 4th of July, 1934, Curie died of aplastic anemia, a blood disease caused by exposure to nuclear radiation.

Source: Wikimedia Commons

sending messages over long distances. The 19th century was the setting for a communications revolution too. In the 1830s, Charles Wheatstone, William Cooke, and Samuel Morse developed the first functional electronic telegraph – a forerunner of the modern telephone – which Wheatstone and Cooke used to send a message from England across the Atlantic to Morse in the United States. Another method of communication, the fax machine, emerged in the 1840s. Fax machines necessitated a standard keyboard format, so the QWERTY layout – which is still used in modern computers – was pioneered in 1868 (Technology Timeline, 2020).

"This is a significant reason why developing and least-developed countries are lacking in terms of infrastructure development, and therefore general economic prosperity: they are behind in developing and using technology."

The next wave of developments came courtesy of the rivalry between Thomas Edison and Nikola Tesla in the late 1800s. Edison pioneered phonographs in 1868, but his most significant contributions were in the field of electricity. In the 1880s, Edison opened the world's first power station based on direct current (DC) power, which Nikola Tesla briskly followed with his invention: alternating current (AC). What followed was a bitter competition that resulted in Edison electrocuting an elephant using alternating current, Tesla's invention, on January 4th of 1903 to show that alternating current is dangerous and should not be adopted by society. Other modern technologies, such as X rays for biological imaging and basic, fundamental space rocketry theories, had also been born at the end of the 19th century (Technology Timeline, 2020).

The 20th century brought an even greater array of inventions. In 1912, chemist Gilbert Lewis formulated the chemistry used in rechargeable lithium batteries. It took just ten years to go from the first monochrome television in the 1920s to the first color television in the 1930s. In contrast, it took an entire 45 years to go from the first use of radio waves for the idea of using a space-based "mirror" to bounce radio waves from one side of the planet to the other was conceptualized. The development of space technology and other modern technologies enabled even more discoveries and innovation. And the development of transistors allowed engineers to build vast, sophisticated circuitry onto small boards, which was a significant step toward modern microprocessors and integrated circuits. Memex, the first digital storage device which was developed by a US engineer called Vannevar Bush, was also a forerunner of modern computer storage devices. (Technology Timeline, 2020).

Figure 3: The steam engine, one of the early devices designed to harness energy.

Source: Wikimedia Commons

The Technology Gap Revisited

A nation's economic and developmental sustainability is very much contingent on its ability to create or otherwise acquire and adapt to new technologies. This is a significant reason why developing and least-developed countries are lacking in terms of infrastructure development, and therefore general economic prosperity: they are behind in developing and using technology ('Utoikamanu, n.d.). It must be noted that these countries do not lack the capacity and determination to catch up with their more developed peers; rather, they have faced and continue to face challenges such as political instability, poverty, and other developmental challenges. For example, The Democratic Republic of Congo (DRC) has rich mineral deposits, but its growth is crippled by political instability and a decrepit government (Cackler et al., 2008).

Figure 4: Young African soldiers in Burundi. Burundi and multiple other least-developed countries have been plagued by civil wars and instability, which is a hindrance to their development. Burundi's Civil War took place from 1993-2005.

Source: Wikimedia Commons

Most least-developed and developing countries were not even proper nations until the mid-1900s when their colonization and occupation by European powers ended. In contrast, the United States is 244 years old, and most of the Western European nations are far older even than that Developing and least-developed countries have only started taking steps towards industrialization relatively recently. Although they capitalized on earlier developments, it still takes years for the development culture and an appropriately-skilled workforce to develop. This results in most developing and least-developed countries needing technology they do not develop. Most devices such as cars, consumer electronics, technology-based services, and even industrial equipment are imported from developed nations. This phenomenon is known as technology transfer.

Technology Transfer and Factors Contributing to the Technology Gap

Numerous international forums such as the Annual Forum of Developing Country Investment Negotiators, organizations such as The United Nations, and agreements such as The United Nations' sustainable development agenda have acknowledged the importance of transferring technology to developing countries. If done correctly, this transfer can empower states to build their capacity for growth and sustainability. However, even with the import of technology, developing and least-developed countries often lack a sufficiently skilled workforce. For instance, the net school enrollment rate for school-aged children was less than 9% in the least-developed countries in 2013 compared to a worldwide 33% average. In 2015, 40% of all out-of-school children resided in least-developed countries ('Utoikamanu, n.d.). Most African countries fall in the developing/least-developed category. In 2013, Africa had an average of 7 scientific and technical journal articles per million people, compared to 1100 in developed nations ('Utoikamanu, n.d.). Therefore, a crucial step to closing the technological gap is enhancing access to education and ensuring more children go to school.

Infrastructure constraints also pose a significant challenge to developing and using technology in developing and least-developed countries. For example, some of these countries lack reliable connectivity to the world through internet infrastructure, and most of them lack universal connectivity. Today's world is highly dependent on online access and collaboration, so the lack of connectivity hinders these countries' interaction with other countries and ultimately limits their development. Similarly, developing other forms of infrastructure such as transport and energy, are vital too for a nation's economic growth.

Native Development and Use of Technology in Developing Countries

Technology has and will continue to be instrumental in the industrial and economic progress of developing countries. Recent polls show that an astonishing 83% of adults in developing economies have mobile phones (Klapper, 2019). Entrepreneurs and developers in developing and least-developed countries have capitalized on this extensive use of mobile phones to create innovative technology and services that use mobile phones as portals to multiple industries. However, one of the biggest challenges for such development is the lack of capital. In recognition of the immense potential that such initiatives have in creating a positive impact and returning a profit, several programs have emerged to source funding. One such program is Kiva, an online platform that allows people worldwide to sign up and pool money to microfinance high-impact technology and

"Most African countries fall in the developing/least-developed category. In 2013, Africa had an average of 7 scientific and technical journal articles per million people, compared to 1100 in developed nations."

Figure 5: An M-Pesa sign at a restaurant that allows payment through the financial service. M-Pesa allows isolated populations to access financial services that would otherwise be more difficult to access.

Source: Wikimedia Commons

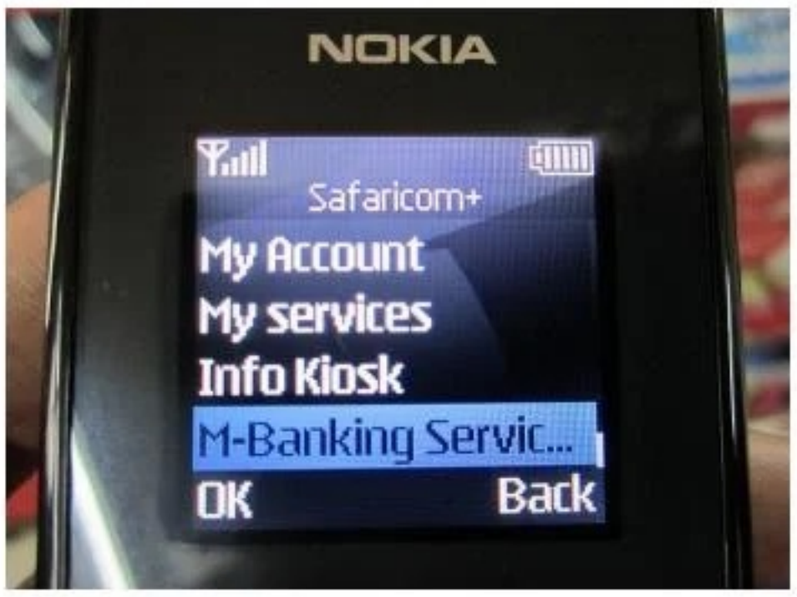

Figure 6: M-Pesa menu. The service allows people to send and receive payments straight through their phones without the need to access the internet.

Source: Wikimedia Commons

social impact entrepreneurs in developing and least-developed countries (Roodman, 2009).

Some of the most successful ideas in developing and least-developed countries utilize mobile phones as gateways to industries and products that are not physically available in specific areas. These services can range from banking, health, information services, and even e-commerce. For example, phones have been used to access banking services, health information, weather information, online markets for goods, and many other virtual spaces. The success of past technological applications in developing and least-developed countries also motivates new technological innovations to solve new problems (Cackler et al., 2008).

"In Malawi [...], an SMS-based service called Airtel 321 provides maternal advice, child-care, and nutritional information to pregnant mothers in their native language, which makes it easier, faster, and cheaper for mothers to access necessary information."

Perhaps the most successful mobile service in developing and least-developed countries is mobile money. Mobile money is an SMS-based money transfer and monetary storage tool that was first developed in Kenya but has been adopted in many developing and developed countries worldwide. The Kenyan pioneer program called M-Pesa was rolled out in 2007 to widespread success. M-Pesa appealed to people in rural areas, a demographic of people previously underserved in financial and banking services. In 2014, 58% of the adult population in Kenya had an M-Pesa account, a number that is likely higher today (Thorstein et al., 2018). With M-Pesa, clients do not have to travel long distances to get banking services such as sending money or receiving money – they merely have to visit an M-Pesa agent in the local town where they can deposit money into an account linked to their phone number, or they can withdraw money from their account. The process of sending money is even more straightforward: just key in the recipient's phone number, select an amount to send and confirm your account pin code. Due to this simplicity, many people, especially rural farmers and entrepreneurs who needed to frequently send and receive money, preferred it over traditional banking services (Conocimiento, 2019).

With time, M-Pesa has accomplished integration with traditional banking options, thus extending the service's reach and giving users the chance to send money to or take money from their bank accounts without physically visiting a bank. This integration has dramatically improved the efficiency and ease of banking, one of the reasons M-Pesa in Kenya and similar services in other countries have been widely adopted. In fact, in the financial year ending June 2020, an estimated 43% of Kenya's annual GDP flowed through M-Pesa. A study by the Massachusetts Institute of Technology estimated that M-Pesa had helped lift 194,000 Kenyan households out of extreme poverty, 2% of the estimated total number of families in the country (Conocimiento, 2019).

The health sectors in developing and least-developed countries have also seen tremendous growth due to technological developments. Most developing countries have a hard time developing advanced medical equipment and building hospitals for their entire populations (Casarez, 2016). The use of key technologies has immensely helped bridge the gap in access to healthcare. In Malawi, for example, an SMS-based service called Airtel 321 provides maternal advice, child-care, and nutritional information to pregnant mothers in their native language, which makes it easier, faster, and cheaper for mothers to access necessary information ('Utoikamanu, n.d.). Similar services in Tanzania and Rwanda have also experienced much success. Zipline, the Rwandan service, even has a partnership with the national government to deliver medical supplies using drones, which dramatically reduces the time required for deliveries and bypasses poor roads and other transport challenges ('Utoikamanu, n.d.).

Agriculture is one of the critical industries in developing and especially least-developed countries where most of the population participates in subsistence farming. In recent years, climate change and a deteriorating natural resource base have contributed to a decline in productivity, especially in Africa and South Asia. A key to improving agricultural productivity and raising income and sustainability is the adoption of innovative technologies and efficient practices by farmers (Chand & The World Bank, 2019). This will enable farmers to adapt to climate change, adopt new

crops and production systems, raise yields, and improve product quality.

Notably, technology is already offering multiple benefits to agriculture in developing and least-developed countries as international administrations such as The United Nations and The World Bank push for more widespread technology adoption. For example, the introduction of genetically-modified crops that are resistant or adapted to changing climate patterns has not only enabled developing and least-developed countries to cope with climate change, but has also increased production in these countries (Cackler et al., 2008). Transgenic crops such as herbicide-tolerant soybeans could potentially benefit developing economies. Some countries have also made traditional applications of technology to improve agriculture. For instance, the Pink Phone project in Cambodia helps farmers exchange expertise, access resources, and even buy and sell land through their mobile phones, facilitating easier production and sale of farm products ('Utoikamanu, n.d.).

Technology has also greatly improved the transport sectors in developing and least-developed countries. Technological advancements have led to more straightforward, cheaper, and more accessible means of transportation (Lee & The World Bank, 2015). A good case in point is the implementation of a light railway system in Addis Ababa, the Ethiopian capital, in 2015. This railway system has dramatically improved mobility and therefore eased business in the city. A similar approach in Kenya linking the Kenyan capital of Nairobi to Mombasa, a coastal town that acts as Kenya's main port of import and export, has immensely reduced the time taken to transport imported goods from Mombasa to Nairobi where a majority of the clientele lives. This improvement has enhanced import and export trade in the city and encouraged more trade between businesses and people in the two cities (Railway Technology, 2020).

Aviation improvements have also improved export trade. For example, Kenya is one of the biggest exporters of horticultural products to the European Union despite being thousands of miles away. Horticultural products are time-sensitive, but trade is possible because of modern fast transport speeds.

Figure 7: A motorcycle taxi operating in a rural township in Kenya. Due to unequal distribution of resources and infrastructure, rural areas in developing countries tend to be left behind as urban areas develop.

Source: Wikimedia Commons

Future Trends and Caveats

Despite all the advantages offered by technology in the developing world, it is imperative to remain aware of trends and risks around developing and adopting technology in these countries. It is a challenge to ensure the fair distribution of technology in rural and urban areas. Urban areas often end up advancing faster while rural areas remain isolated and behind. This phenomenon tends to create a social divide between rural and urban communities. Adopting new technologies also requires a skilled workforce, meaning citizens in these countries often need to learn new skills and foreign languages to operate imported machinery.

"Kenya is one of the biggest exporters of horticultural products to the European Union despite being thousands of miles away. Horticultural products are time-sensitive, but trade is possible because of modern fast transport speeds."

A majority of the companies and businesses in developing and least-developed countries rely on manual labor. But as companies do adopt automation technologies, the people employed to provide manual work can be quickly rendered jobless. This fact creates a hostile attitude toward technology and makes society opposed to the adoption of specific technologies. On the other hand, companies still using manual models face industry pressure to keep up with their competitors who have adopted faster and more efficient technology processes. When such companies do not adopt new technology, they fall behind, and monopolies tend to arise, potentially hindering further

Figure 8: AI is dreaded by many as an existential threat to human existence, akin to an imaginary game of chess between human intelligence and artificial intelligence. However, artificial intelligence could be the path to a prosperous and more inclusive future.

Source: Wikimedia Commons

innovation. For example, Kenya's M-Pesa service has a 99% market share despite multiple other competitors. Even as companies use technology to empower communities, it is equally essential that a balance of the competitive landscape is maintained.

"Perhaps a strong indicator of the potential interest that Fintech has in developing countries, Chipper Cash was able to raise 30 million USD during a funding initiative held in October 2020, which even attracted the backing of Amazon founder Jeff Bezos."

Over the past decade, the startup scene in developing countries has greatly improved. Jackson (2019) points out that this has led to new innovative ideas that utilize technology to offer cutting-edge solutions for common problems. One area that has seen significant innovation is the finance and banking industries. With the rapid growth of fintech (the use of computer programs and the internet to support banking and other financial services), many startups have emerged. Because they have access to the full power of the internet, such startups can offer way more advantages than those offered by USSD-based and SMS-based services such as MPesa. For example, Chipper Cash, an African cross-border startup, runs a Peer-to-Peer (P2P) service that allows users to send and receive money over the internet for free. Chipper Cash operates in seven countries in Africa: Nigeria, Kenya, Uganda, Ghana, Rwanda, Tanzania, and South Africa. Chipper Cash also offers access to forex trading and even bitcoin trading. Perhaps a strong indicator of the potential interest that Fintech has in developing countries, Chipper Cash was able to raise 30 million USD during a funding initiative held in October 2020, which even attracted the backing of Amazon founder Jeff Bezos (Bright, 2020).

Another trend in the developing world is the rise of artificial intelligence (AI). The AI market in the Middle East and Africa was nonexistent in the early 2000s. In contrast, the industry in these regions grew to an estimated value of $66 million in 2017 (MEST Africa & Lipman, 2019). This has attracted key global players in technology and AI into these regions. For example, Google opened an AI lab in Ghana in 2019. The same year, Microsoft set up its first-ever $100 million Africa Development Hubs in Kenya and Nigeria, matched with a hyper-scale data center in South Africa. Several other companies such as DataProphet and Clevva are spearheading the AI revolution in Africa. DataProphet offers AI data analytics while Clevva uses AI to offer technical and financial consultancy services. In agriculture, an AI startup called My Intelligent Machines uses machine learning algorithms to achieve genomic precision, making it possible to build intelligent breeding programs that minimize the ecological footprints of livestock (Travaly & Muvunyi, 2020). Additionally, AI-based pharmacogenomics companies use artificial intelligence to analyze patient responses to specific treatments based on the patients' genetic markers, which enables more intelligent prescriptions (Travaly & Muvunyi, 2020).

Conclusion

It is true that most developing and least-developed countries lag behind in the development and use of technology. Technology has the potential to immensely boost the growth of developing and least-developed countries if utilized properly. This has been evident in recent years as a more widespread use of technology has immensely boosted growth in these countries. The use of technology also enables these countries to invent new solutions to decades-old problems. Key global players such as Microsoft, Google, and Amazon are starting to recognize that technology is a significant driver for growth in developing nations and are starting to set up a more dominant presence in developing and least-developed countries. Additionally, the startup sector is an important agent pushing the adoption of technology. It is therefore important for developing countries to invest in their startup sectors and cultivate an innovative culture in their citizens by promoting access to education and making it easier for technology entrepreneurs to access funding.

References

Advocates for International Development. (2019, February 18). Understanding the Developed/Developing Country Taxonomy | A4ID. http://www.a4id.org/policy/understanding-the-developeddeveloping-country-taxonomy/

Alatas, S.H.., et al. "Science and Technology Development in the Third World: Competing Policy Perspectives." Knowledge, Technology & Policy, Springer Netherlands, 1 Jan. 1976, link.springer.com/article/10.1007/s12130-999-1012-6.

Bright, J. (2020, November 18). African fintech startup Chipper Cash raises $30M backed by Jeff Bezos. Techcrunch. https://techcrunch.com/2020/11/18/african-fintech-startup-chipper-cash-raises-30m-backed-by-jeff-bezos/

Cackler, J., Gu, E., & Rodgers, M. (2008, March 17). Technology in Developing Economies » Economics » Appropriate Technology. CS 201: Computers, Ethics, and Social Responsibility. https://cs.stanford.edu/people/eroberts/cs181/projects/2007-08/developing-economies/economics-appropriate.html

Casarez, C. (2016, December 15). How the Developing World is Adopting Healthcare Technology - CareCloud. Continuum. https://www.carecloud.com/continuum/how-the-developing-world-is-adopting-healthcare-technology/

Chand, I. & The World Bank. (2019, September 16).

Agricultural Innovation & Technology Hold Key to Poverty Reduction in Developing Countries, says World Bank Report. World Bank. https://www.worldbank.org/en/news/press-release/2019/09/16/agricultural-innovation-technology-hold-key-to-poverty-reduction-in-developing-countries-says-world-bank-report

Conocimiento, V. A. (2019, September 27). Mobile technologies for third world development. OpenMind. https://www.bbvaopenmind.com/en/technology/innovation/mobile-technologies-for-third-world-development/

Fallah, M.. "Information Economy and Developing Countries Can They Overcome the Technology Barrier ?", 2005.
Fernflores, F. (2019, August 15). The Equivalence of Mass and Energy (Stanford Encyclopedia of Philosophy). Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/equivME/#MiscAbouEoMc2

Jackson, T. (2019, November 20). Africa's tech startup scene is growing, but who is benefiting? Disrupt Africa. https://disrupt-africa.com/2019/11/africas-tech-startup-scene-is-growing-but-who-is-benefiting/

Klapper, L. (2019, April 10). Mobile phones are key to economic development. Are women missing out? Brookings. https://www.brookings.edu/blog/future-development/2019/04/10/mobile-phones-are-key-to-economic-development-are-women-missing-out/#:%7E:text=Fresh%20Gallup%20World%20Poll%20data,they%20need%20to%20escape%20poverty

Lee, C. W. & The World Bank. (2015, May 14). How ICTs Can Help Transport Systems Evolve. World Bank. https://www.worldbank.org/en/news/feature/2015/05/14/information-and-communication-technologies-facilitate-the-evolution-of-transport-systems

Mafe, E. & World Economic Forum. (2017, November 10). More than half of the world's population is still offline. Here's what we're doing about it. World Economic Forum. https://www.weforum.org/our-impact/creating-hundreds-of-millions-of-new-internet-users

Marie Sklodowska Curie. (2020, June 26). Science History Institute. https://www.sciencehistory.org/historical-profile/marie-sklodowska-curie#:%7E:text=Marie%20Sklodowska%20Curie%20(1867%E2%80%931934,discovery%20of%20the%20radioactive%20elements

MEST Africa, & Lipman, A. (2019, November 28). 5 Predictions for the African 2020 Tech Scene - The GPS. Medium. https://medium.com/the-gps/5-predictions-for-the-african-2020-tech-scene-afc6a8a964d3

Technology timeline. (2020, October 14). Explain That Stuff. https://www.explainthatstuff.com/timeline.html

Railway Technology. (2020, June 10). Mombasa-Nairobi Standard Gauge Railway Project, Kenya. https://www.railway-technology.com/projects/mombasa-nairobi-standard-gauge-railway-project/

Roodman, D. (2009, October 2). Kiva Is Not Quite What It Seems. Center For Global Development. https://www.cgdev.org/blog/kiva-not-quite-what-it-seems

Thorstein, B., Pamuk, H., Ramrattan, R., & Uras, B. R. (2018, July 1). Payment instruments, finance and development. ScienceDirect. https://www.sciencedirect.com/science/article/pii/S0304387818300075

Travaly, Y., & Muvunyi, K. (2020, February 7). The future is intelligent: Harnessing the potential of artificial intelligence in Africa. Brookings. https://www.brookings.edu/blog/africa-in-focus/2020/01/13/the-future-is-intelligent-harnessing-the-potential-of-artificial-intelligence-in-africa/

'Utoikamanu, F. (n.d.). Closing the Technology Gap in Least Developed Countries. United Nations. Retrieved November 1, 2020, from https://www.un.org/en/chronicle/article/closing-technology-gap-least-developed-countries