AI, the new wingman of development

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Abstract

The study explores the potential benefits of implementing artificial intelligence (AI) in seven development sectors that receive significant funding from the World Bank. The study provides an overview of the challenges faced by these sectors, including agriculture, healthcare, education, finance, energy, infrastructure, and data. The findings reveal that AI can expedite the achievement of development goals in most of these sectors. The study shows that many organizations already utilize AI to address development challenges in diverse fields. AI is seen as a crop whisperer in agriculture that can help small farmers in low-income and lower-middle-income countries increase their crop productivity. AI can act as a doctor's sidekick in healthcare by assisting healthcare professionals in providing effective and efficient health services. In education, AI can revolutionize learning by providing personalized grading and feedback, helping with personalized tutoring, and customizing therapy and learning for children with autism spectrum disorder. In finance, AI can act as a humane banker by providing access to formal credit for those currently excluded. AI can act as an energy and infrastructure wizard by improving energy efficiency, traffic management, road infrastructure monitoring, power grid monitoring, and water infrastructure monitoring. Finally, AI can act as a data weaver by assisting with improving poverty statistics. The study suggests that the World Bank should promote and finance projects and organizations that use AI to tackle some of the most challenging development problems.

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Executive summary

The study delves into the potential benefits of implementing artificial intelligence (AI) in seven development sectors that receive significant funding from the World Bank. The findings of this study reveal that AI can expedite the achievement of development goals in most of these sectors. The study shows that many organizations already utilize AI to address development challenges in diverse fields. To further advance this progress, the World Bank should finance projects and organizations that use AI to tackle some of the most challenging development problems. A summary of findings regarding the transformative potential of AI in various development areas follows.

- **AI, the crop whisperer**

  Over the past five decades, crop production in most lower-middle-income countries (LMICs) has increased, but crop productivity growth has been slow. Meanwhile, low-income countries (LICs) have not experienced growth in either crop production or productivity. Notably, 84 percent of the world's small farmers, who earn $2 a day, are located in low-income and lower-middle-income countries (FAO 2021). Given growing populations, changing dietary preferences, climate change, water scarcity, and limited arable land, it is critical to enhance the productivity of small farmers for global food security. Many organizations in low-income and lower-middle-income countries are leveraging AI to provide efficient and effective solutions, including controlling crop diseases and pests, optimizing irrigation, and managing crops based on local soil and weather patterns. The World Bank provides significant funding to agriculture projects, but the spread of technology through these projects remains limited. The World Bank can improve the outcomes of its agriculture projects by financing projects and supporting organizations that employ AI to address agricultural challenges.

- **AI, the doctor's sidekick**

  The lack of healthcare professionals, particularly doctors and nurses, poses a critical challenge in low-income and lower-middle-income countries. Most of these countries fail to meet the standard set by the World Health Organization (WHO), which requires 44.5 healthcare professionals, including midwives, nurses, and doctors, for every 10,000 members of the population (WHO 2020). Furthermore, the quality of health care in many of these countries is substandard. Domestic general government health spending as a percentage of current health expenditures in low-income countries has declined, while in lower-middle-income countries, it has increased very slowly over the past two decades. In this context of limited financial and human resources, AI technologies can help countries provide better healthcare to their citizens. Several organizations in developing nations are utilizing AI for various healthcare applications, such as predicting loss to follow-up in studies of tuberculosis (TB) patients, digital imaging, preventing blindness, managing depression and anxiety, and disease surveillance. Despite the World Bank's funding of digital healthcare initiatives, its financing for AI-related projects in healthcare is still scarce.

- **AI, the learning revolutionizer**

  In recent decades, primary and secondary school enrollment has significantly increased in most low-income and lower-middle-income countries. However, students' learning outcomes in these countries still lag their high-income countries (HICs) counterparts. In low-income countries, 94 percent of students at the primary level cannot achieve minimum reading proficiency, while 87 percent cannot reach minimum math proficiency (IEG 2022). Many organizations in these countries are using AI to provide personalized learning and create smart classrooms to address

this issue. A randomized controlled trial of an AI intervention for personalized learning in a government school in India found that students who used AI learned twice as much as those who did not. Despite the World Bank's focus on improving learning outcomes, its investments have not yielded the desired results. Therefore, it would be prudent for the World Bank to support projects that use AI in education to enhance students' learning outcomes in developing countries.

- **AI, the humane banker**

  Access to credit is crucial for financial inclusion. However, about 1.5 billion people in developing countries cannot access formal credit. About 40 percent of micro, small, and medium enterprises (MSMEs)—significant providers of employment in developing countries—have unmet funding needs totaling about $5.2 trillion each year (IFC 2017). Many underserved individuals and MSMEs cannot access credit because they cannot provide the necessary information to formal institutions to evaluate their creditworthiness. Furthermore, the loan sizes and terms many low-income individuals and MSMEs require make it unprofitable for formal banks to underwrite loans. AI can potentially be a game-changer for these underserved individuals and MSMEs. Many organizations in developing countries use AI to analyze alternative data sources, such as online shopping habits, utility and phone bill payment history, phone usage information, social media profiles, and satellite imagery, to determine creditworthiness. These organizations also use AI to create customized credit products for low-income individuals and MSMEs. Small and medium enterprises (SMEs) comprise a significant portion of the World Bank's finance portfolio. However, given the enormous credit needs and the difficulty in evaluating the creditworthiness of MSMEs, the World Bank should finance projects that use AI to channel much-needed financing to the underserved population.

- **AI, the energy and infrastructure wizard**

  Approximately 577 million people in Sub-Saharan Africa lacked access to electricity in 2020 (Parada, Pirlea, and Wadhwa 2023). Furthermore, even those connected to the power grid often report issues with its reliability. In low-income and lower-middle-income countries, infrastructure disruptions can lead to significant economic losses. For instance, annual sales losses of up to $82 billion from power outages, and about $6 billion from disruptions in water supply infrastructure, have occurred (Mimmi 2021). Poor-quality roads reduce the utilization of transport infrastructure, causing a loss of more than $107 billion annually (Mimmi 2021). To address the energy and infrastructure-related challenges, many organizations in different countries are implementing AI to enhance energy efficiency, facilitate inspection and maintenance of infrastructure, and improve city traffic management. However, most of these initiatives are currently implemented in developed nations. To achieve development goals more efficiently, the World Bank, a major financier of energy and infrastructure projects, should support projects and organizations using AI in developing countries' energy and infrastructure sectors.

- **AI, the data weaver**

  Accurate poverty data are essential for creating effective development policies and programs. However, obtaining poverty statistics can be a time-consuming and costly process. The World Bank's Living Standards Measurement Study (LSMS) can cost up to $2 million annually to conduct in a country and involves training and deploying numerous enumerators to remote and insecure areas (Burke et al. 2021). Many countries lack updated and reliable poverty data, especially when these data are most needed, such as during the COVID-19 pandemic. Recent studies have shown that AI and alternative data sources, such as satellite imagery and mobile phone Call Detail Records (CDRs), can yield timely and cost-effective high-quality poverty statistics. For instance,

Yeh et al. (2020) used satellite imagery to predict asset wealth in more than 20,000 African villages, taking only 30 hours and costing only a few thousand dollars. Given the efficiency and effectiveness of using AI to estimate poverty statistics, the World Bank should proactively incorporate AI and other alternative data sources to support the poverty statistics obtained from on-the-ground surveys.

This study shows that AI can become a reliable wingman of development. Leveraging the capabilities of AI as a development tool can significantly enhance project outcomes. AI's multifaceted functionality renders it a valuable asset in various development sectors. AI might not be a cure-all for development problems, but it can be a crucial tool to create a considerable positive impact.

Introduction

According to the 2023 Sustainable Development Goals (SDGs) report by the United Nations, progress is insufficient toward achieving 50 percent of the targets, and has either stalled or reversed in about 30 percent of the targets (UN 2023). Here are some current and projected status of certain SDGs:

- If things do not change, it is expected that 575 million people will be living in extreme poverty by 2030, and only one-third of countries will have reduced their national poverty levels by half.
- More people are experiencing hunger and food security now than in 2015. In 2022, an estimated 735 million people (9.2 percent of the world population) faced chronic hunger, about 100 million more than those experiencing chronic hunger in 2019.
- The COVID-19 pandemic has led to the most significant decrease in childhood vaccinations in 30 years. While the maternal mortality rate (MMR) declined slightly from 2015 to 2020, it is still three times higher than the 2030 target. Tuberculosis (TB) and malaria deaths have increased since before the pandemic.
- Only six countries are expected to meet universal secondary education targets by 2030. Eighty-four million children will be out of school, and about 300 million students will lack basic numeracy and literacy skills by 2030.
- With the current rate of progress on affordable and clean energy, an estimated 2 billion people will still rely on polluting fuels and technologies in 2030.

If the existing trend continues, it is unlikely that most of the SDG targets will be met. Therefore, governments, development organizations, and other partners must utilize all available tools to accelerate the progress toward achieving the SDG goals.

Artificial intelligence (AI) is one such tool that can play a significant role in achieving development goals (box 1). McKinsey & Company (2018b) identified more than 400 AI use cases in 19 industries, making AI a general-purpose technology (GPT) that can affect all sectors of the economy, just like electricity and computers (Bresnahan and Trajtenberg 1992). As a GPT, AI holds great promise in influencing development considerably. A study by Vinuesa et al. (2020) found that AI could enable 79 percent of targets across all SDGs and 82 percent of societal outcome metrics like SDG 1 on the elimination of poverty, SDG 4 on quality education, SDG 6 on clean water and sanitation, SDG 7 on affordable and clean energy, and SDG 11 on sustainable cities.

The World Bank supports more than 12,000 development projects across approximately 189 countries.[1] In 2023, the World Bank provided $128 billion in loans, grants, equity investments, and guarantees to partner countries and private businesses (World Bank 2023a). As a result, the World Bank is a significant stakeholder and investor in diverse development areas such as agriculture, health, education, energy, and infrastructure. Successful and efficient completion of these projects is vital for achieving development goals by 2030. Moreover, the current World Bank President aims to enhance the organization's efficiency to accomplish more in less time and with fewer resources. AI has the potential to play a significant role in achieving this goal by improving the efficiency and effectiveness of World Bank-funded projects in various development areas. AI could revolutionize the World Bank's operations and expedite progress toward achieving development targets.

This study aims to explore the potential of AI in enhancing the efficiency and effectiveness of projects across various development sectors. It analyzes the challenges faced in seven crucial development areas: agriculture, health care, education, finance, energy, infrastructure, and data. The study then evaluates the potential of AI technology in addressing these challenges. It also examines the World Bank's financing

in these areas and determines whether they are investing in AI to address the identified challenges. Finally, the study highlights organizations successfully using AI to tackle development challenges in low-income and lower-middle-income countries.

Box 1. What is Artificial Intelligence (AI)?

In the literature and the popular press, many different terminologies like AI, machine learning (ML), deep learning (DL), supervised and unsupervised learning, Generative AI, and so on, are used interchangeably. However, all these terms have different meanings.

Artificial intelligence (AI): The field of AI involves the development of computer programs that can imitate human thought and perform tasks in the real world, just like humans (Columbia Engineering n.d.).

Machine learning (ML): ML is a branch of artificial intelligence that employs computer algorithms to train models for various prediction tasks using data. These ML models can perform multiple tasks, including pattern recognition, classification, and driving cars autonomously (Coursera 2023).

Deep learning (DL): DL is a type of machine learning that utilizes algorithms known as artificial neural networks (ANNs), which imitate the workings of the human brain to accomplish various tasks (Coursera 2023).

Supervised learning: Supervised learning is used to train machine learning models. It involves using labeled datasets to teach the model how to classify an object, predict an outcome, or perform other prediction tasks. Examples of tasks that use supervised learning include classification and regression [IBM (Supervised) n.d.] .

Unsupervised learning: This technique involves training the ML model on unlabeled data. The model is used to identify patterns or groupings within the data without any external input. Unsupervised learning is used for tasks such as clustering and dimensionality reduction [IBM (Unsupervised) n.d.].

Semi-supervised learning: This technique utilizes both labeled and unlabeled data to train a model for making predictions based on input variables. This method combines elements of both supervised and unsupervised learning (Geeks for Geeks 2019).

Reinforcement learning (RL): This is a machine learning technique in which the model learns by trial and error, using its own actions and experiences as feedback to improve. The model is penalized for bad decisions and rewarded for good ones so it can learn the correct actions to accomplish a specific task. This type of learning is currently used in playing games and controlling robots (Bhatt 2019).

Generative AI (Gen AI): Gen AI generates content uses artificial neural networks and semi-supervised machine learning techniques to train the models. This type of AI is designed to create new data similar to the data it was trained on. This branch of machine learning is commonly used to generate new text, images, or music. ChatGPT and Google Bard are examples of Generative AI (NVIDIA n.d.).

Natural Language Processing (NLP): NLP is a subfield of machine learning that assists computers in comprehending and examining text and spoken words. NLP can use supervised and unsupervised learning methods to achieve diverse tasks, such as text classification, sentiment analysis, grouping similar text documents without labels, and machine translation (Shetty 2022).

Agriculture

The agriculture conundrum

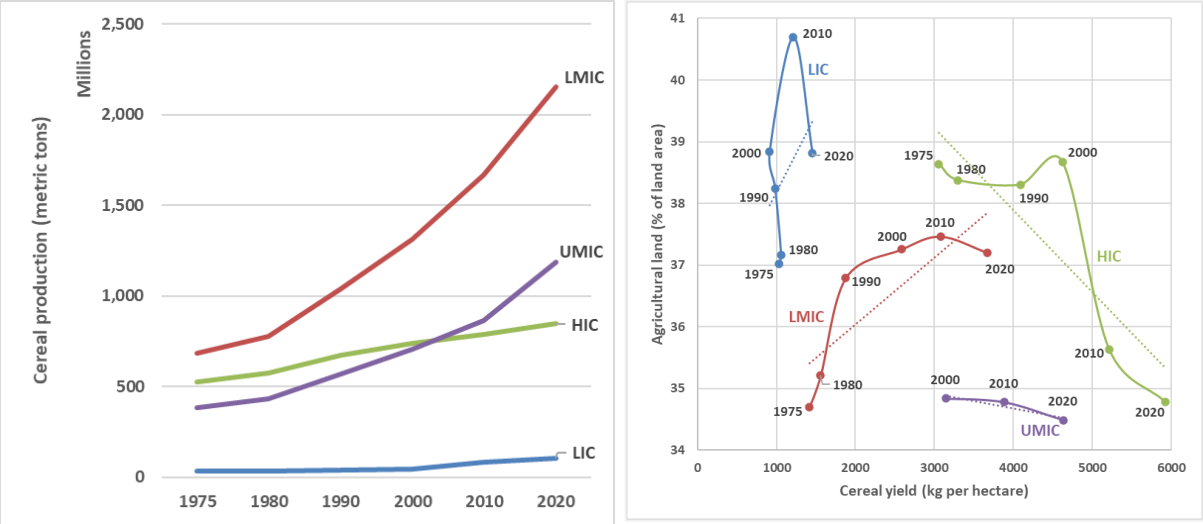
Primary crop production in the world surged by 54 percent from 2000 to 2021, the Food and Agriculture Organization (FAO) reports (FAO 2022). However, this growth has not been evenly distributed across all income groups. As seen in figure 1, panel a, low-income and lower-middle-income countries, upper-middle-income countries (UMICs), and high-income countries have experienced an increase in crop production in the last five decades, with lower-middle-income and upper-middle-income countries showing a significant increase in production. Unfortunately, crop production in low-income countries barely improved from 1975 to 2020. The increase in output in lower-middle-income, upper-middle-income, and high-income countries could be either due to an expansion of agricultural land, or improvement in agriculture productivity, or both.

Both high-income and upper-middle-income countries have reduced their agricultural land as a portion of total land (figure 1, panel b). Nevertheless, their cereal production has continued to rise. This indicates that high-income and upper-middle-income countries have enhanced agricultural efficiency, which has led to higher crop yield per hectare and excellent crop production despite less land under cultivation. In contrast, lower-middle-income countries expanded their agricultural land from 34.5 percent in 1975 to 37 percent in 2020. During the same time frame, their crop yield increased 2.3 times, from roughly 1500kg to 3500kg per hectare. Lower-middle-income countries have accomplished this by increasing agricultural land and by improving agriculture productivity. However, it took lower-middle-income countries almost 55 years to triple their crop yield (Economist 2018). Moreover, compared to high-income and upper-middle-income countries, lower-middle-income countries are still far behind in crop yield. High-income countries have doubled the crop yield per hectare compared to lower-middle-income countries , and upper-middle-income countries produce about 1000kg more per hectare than lower-middle-income countries. Advanced machinery, improved seed, fertilizer, and new irrigation technologies have helped transform agriculture in these higher-GDP countries (Goedde et al. 2020).

Furthermore, since 2010, agricultural land has decreaed in lower-middle-income countries. Therefore, with looming climate change uncertainty, decreased agrarian land, and a fast-growing population, ramping up crop yield in lower-middle-income countries will only be possible by improving agricultural efficiency through technology. Like lower-middle-income countries, low-income countries also increased their agricultural land, going from around 37 percent to 39 percent, but made no significant improvement in crop production or yield. Consequently, low-income countries experienced minimal progress in agricultural efficiency over the last five decades. The land used for agriculture has also decreased since 2010. Thus, to enhance efficiency in agriculture, low-income countries must also adopt technology.

Figure 1. Cereal-crop production by income group between 1975 and 2020

a. Cereal production **b. Agriculture land versus cereal yield**



Source: Original calculations for the *World Development Report 2024* using World Bank Open Data. https://data.worldbank.org.
Note: HIC = high-income countries; LIC = low-income countriess; LMIC = lower-middle-income countries; UMIC = upper-middle-income countries.

Eighty-four percent of all farms are small holdings with less than two hectares in farm size and produce about one-third of the world's food, FAO reports (FAO 2021). Most poor smallholder farmers reside in low-income and lower-middle-income countries, living on less than $2 a day (Fanzo 2017; World Bank 2016). Therefore, with increasing population, changing diet, worsening climate change, increasing water scarcity, and limited arable land, improvement in the agriculture productivity of smallholder farmers will be crucial to increase agriculture production in low-income and lower-middle-income countries.

There are many ways to improve agriculture productivity, but simple agriculture advisory and extension services can significantly improve agriculture efficiency. For example, a meta-analysis by Fabregas, Kremer, and Schilbach (2019) found that the transmission of agriculture information through basic mobile phones increased yields by 4 percent and the likelihood of using recommended agrochemical inputs by 22 percent. Some common activities in agriculture advisory and extension services include providing technical assistance and training to farmers on crop and livestock production, promoting new technologies and practices, facilitating access to inputs and markets, soil and water management, and pest and disease control (FAO 2023). These extension and advisory services can help farmers make informed decisions based on their farm and local environment.

However, many challenges exist in undertaking agriculture extension and advisory activities. It is estimated that there are more than one million extension service agents in developing countries. However, at 1000 to 1, the number of farmers to extension service agents is skewed in many countries (Fabregas, Kremer, and Schilbach 2019). In India, only 6 percent to 16 percent of farmers in different states reported receiving advice from an extension agent in the past year (Cole 2017). Moreover, expanding these extension services is very expensive (Fabregas et al. 2023). They have limited reach, especially in far-flung and conflict-stricken areas. There is also limited evidence of the impact and cost-effectiveness of traditional extension services (Fabregas, Kremer, and Schilbach 2019).

In recent years, farmers in some regions of the world have been accessing advisory and extension services through radio and mobile messages. However, the advice provided through these channels tends to be general and not specific to individual farmers and their unique local conditions. For smallholder farmers

to reap the full benefits of these services, the advice they receive must be tailored to their specific circumstances. Personalized agricultural extension and advisory services aim to offer farmers accurate, timely, and affordable information, including about planting and irrigation schedules, soil management, fertilizer and pesticide application, local weather prediction, and individualized pest and disease information. Incorporating AI can significantly enhance extension and advisory services for farmers. This is due to AI's ability to offer personalized and precise information promptly. AI can also expand the accessibility of advisory and extension services to farmers residing in remote or conflict-stricken areas, providing them with the critical information they require.

Where does the World Bank stand?

The World Bank has continuously increased the number of projects and the funds allocated to agriculture advisory and extension services. Between 1998 and 2008, the World Bank provided $23.7 billion to agriculture; of this, $2 billion was for research, extension, and advisory projects; about 60 percent was for extension and advisory services (World Bank 2011a, 39). Similarly, between 2008 and 2023, the World Bank provided about $35 billion to agriculture; of this, $6.8 billion was committed to 150 projects for agriculture extension, research, and other support activities.[2] The agriculture extension, research, and other support activities accounted for the second-highest number of projects and net funding in the World Bank's agriculture portfolio between 2008 and 2023.

However, an evaluation by the World Bank's Independent Evaluation Group (IEG) found that the achievement of advisory and extension services outcomes was below average compared to the rest of the agriculture portfolio. Moreover, the review also pointed out that only 15 percent of the completed projects reported any level of adoption of technologies for research and extension in agriculture (World Bank 2011a, 40). A recent evaluation of World Bank's support for agrifood systems between 2010 and 2020 by the Independent Evaluation Group (IEG) found that the World Bank's productivity-enhancing investments are not sufficiently diversified beyond major staples, and their support to the countries to increase agricultural productivity was not commensurate with the country needs. The report also highlighted that World Bank support in agriculture has been less effective in improving productivity in low-income and lower-middle income countries (IEG, 2022b). The World Bank's endeavors have largely fallen short of their intended objectives, failing to stimulate the adoption of novel technologies in agriculture. The utilization of AI has the potential to significantly enhance the efficacy of the World Bank's agriculture portfolio by providing targeted, timely, and precise services. Therefore, it would be prudent for the World Bank to include AI projects in its portfolio to augment its performance within the agriculture sector.

AI, the crop whisperer

In recent years, many organizations in both developed and developing countries have demonstrated the advantages of integrating AI into their agricultural services to support farmers. These examples highlight the diverse applications of AI in agriculture, presenting a significant opportunity for governments, development organizations, and other stakeholders to incorporate this technology into their programs. AI can prove a valuable tool in the agricultural extension and advisory value chain, as evidenced by several successful use cases. These range from identifying crop diseases and pests to optimizing irrigation and managing crops based on local soil and weather patterns. To highlight some of the work in this area, a discussion of select organizations using AI in agriculture follows.

CottonAce, AI-powered pest management

Cotton farming is critical for the livelihood of about 29 million farmers across the globe, particularly smallholder farmers. Unfortunately, these farmers often face significant crop losses due to pest infestations. For example, in 2019, pink bollworms caused losses of 20 percent to 30 percent of the cotton crop in Maharashtra, India, a major cotton producer (Elbehri and Chestnov 2021, 19). Addressing this problem requires the timely detection of pest infestations and the application of pesticides in appropriate amounts. However, this can be daunting because applying pesticides too soon can kill the beneficial pests, and using them too late will be useless. The CottonAce AI application delivers immediate and localized expert advice on the right amount and time for pesticide application to farmers' smartphones. This application is available in English and eight other Indian languages and can function offline. More than 30,000 farmers have used the application in six states in India (Wadhwani AI 2022, 15). A study conducted in Karnataka, India, found that using CottonAce can lead to a revenue gain of up to 24 percent (Elbehri and Chestnov 2021, 20).

Nuru, the AI assistant

Nuru is an AI-powered application developed by PlantVillage. Nuru helps with crop disease diagnosis, anomaly detection, and forecasting based on ground and satellite data and provides automated responses to farmers' questions. Nuru can detect multiple diseases in cassava, fall armyworm infections in African maize, potato disease, and wheat disease. The application has been used in Kenya and other Eastern African countries.[3] The AI assistant works offline, making it suitable for use in remote rural areas. In 2020, Mrisho et al. conducted a study that found Nuru very effective in diagnosing cassava disease, with an accuracy rate of 65 percent. This outperformed agricultural extension agents (40 percent to 58 percent) and farmers (18 percent to 31 percent). Interestingly, the study also revealed that the use of Nuru for just two weeks led to an improvement in the diagnostic abilities of extension workers.

Plantix

Plantix is an AI-powered smartphone application that helps farmers diagnose plant diseases, pests, and nutrient deficiencies during cultivation. The app offers information on symptoms, triggers, controls, and preventative measures to prevent yield loss. Like other AI tools, Plantix uses a machine learning model to predict pests and diseases (USAID 2018). Farmers and extension workers upload about 20,000 images of infected plants daily for analysis (CGAIR 2023). According to Plantix, farmers report a 90 percent improvement in their farming. The application can accurately identify more than 500 pests, diseases, and nutrient deficiencies for more than 50 crops with a precision rate of more than 85 percent (Elbehri and Chestnov 2021, 13).

Soilsens

Soilsens is a low-cost, cutting-edge AI system that leverages Internet of Things technology [4] and sensors to deliver highly effective irrigation solutions for small-scale farmers. Its portable moisture system has advanced sensors that measure soil moisture, soil temperature, ambient humidity, and temperature. With this system, farmers can easily monitor soil moisture levels in their fields and receive real-time irrigation alerts and recommendations on the mobile application based on the captured data (UNDP 2021). This device can be used across all crops and geographies. According to Soilsens,[5] using their AI system can improve yield by 20 percent and reduce water usage by 27 percent (2030 World Resource Group 2017).

- Kilimo

  Kilimo is an AI platform that uses machine learning algorithms to estimate the water needed for a seven-day cultivation period. It considers various factors, including field data, satellite images, and historical databases, to provide farmers with periodic advice on the appropriate amount of irrigation necessary. Kilimo empowers farmers to utilize the available resources more efficiently by optimizing water usage. Furthermore, Kilimo offers customized irrigation solutions tailored to the crops grown, ensuring maximum yield and minimal waste. Farmers in Argentina, Brazil, Chile, Paraguay, Peru, and the United States benefit from Kilimo's technology. In 2019, Kilimo helped save up to 15 billion liters of water on 50,000 hectares of land (IDB 2020).

In addition to these organizations, many other enterprises are harnessing AI's power to tackle diverse agricultural issues (box 2). One such example is GramworkX, which uses AI to aid farmers in effectively managing, optimizing, and monitoring their water usage.[6] Similarly, CropIn leverages AI to offer timely advice on risk management, sales, warehousing, and sustainable farming practices.[7]

Box 2. With a Moo Moo here and a Moo Moo there![a]

AI can have a significant positive impact on agriculture. However, it will not only reshape farming practices but can also positively influence allied areas such as animal husbandry, fisheries, forestry, and wildlife management. Connecterra, for example, is utilizing AI for the early detection of diseases in cows. By analyzing cow behavior and movements through sensors and AI, Connecterra can predict illnesses.[b] Similarly, Stellapps employs AI for monitoring and disease prediction in cows.[c] Early detection of diseases can lead to a reduction in antibiotic use and an improvement in milk quality.

Rainforest Connection uses AI technology to monitor the sounds of the rainforest and identify potential threats, such as illegal logging, in real time.[d] Mbaza AI, developed by Appsilon, uses computer vision to automatically detect and classify wildlife from camera trap images, assisting researchers in more efficient and real-time monitoring of wildlife.[e] NatureDots employs AI to provide real-time water quality data for fish farms, allowing aquaculture farmers to enhance their output.[f] Sentinel AI utilizes AI for image and acoustic monitoring, automatically detecting vulnerable/invasive species and poachers in real-time.[g] Pano uses cameras on mountaintops and AI to detect traces of smoke, aiding in the early detection of forest fires and controlling their spread.[h]

a. “Old Macdonald Had a Farm” lyric. Available at: "https://wordsforlife.org.uk/activities/sing-old-macdonald-your-child/
b. "Connecterra app." https://connecterra.ai/product/connecterra-app/.
c. “Stellapps." https://www.stellapps.com/whitepapers/.
d. "Rainforest Connection—Stopping Illegal Logging and Protecting Wildlife." https://rfcx.org/.
e. "Mbaza AI for Biodiversity Monitoring." https://appsilon.com/data-for-good/mbaza-ai/?utm_medium=social&utm_source=linkedin&utm_campaign=d4g-newsletter&utm_content=19.
f. "Naturedots." https://naturedots.com/.
g "Sentinel: Conservation X Labs." https://sentinel.conservationxlabs.com/.
h. "Pano AI." https://www.pano.ai/.

Health care

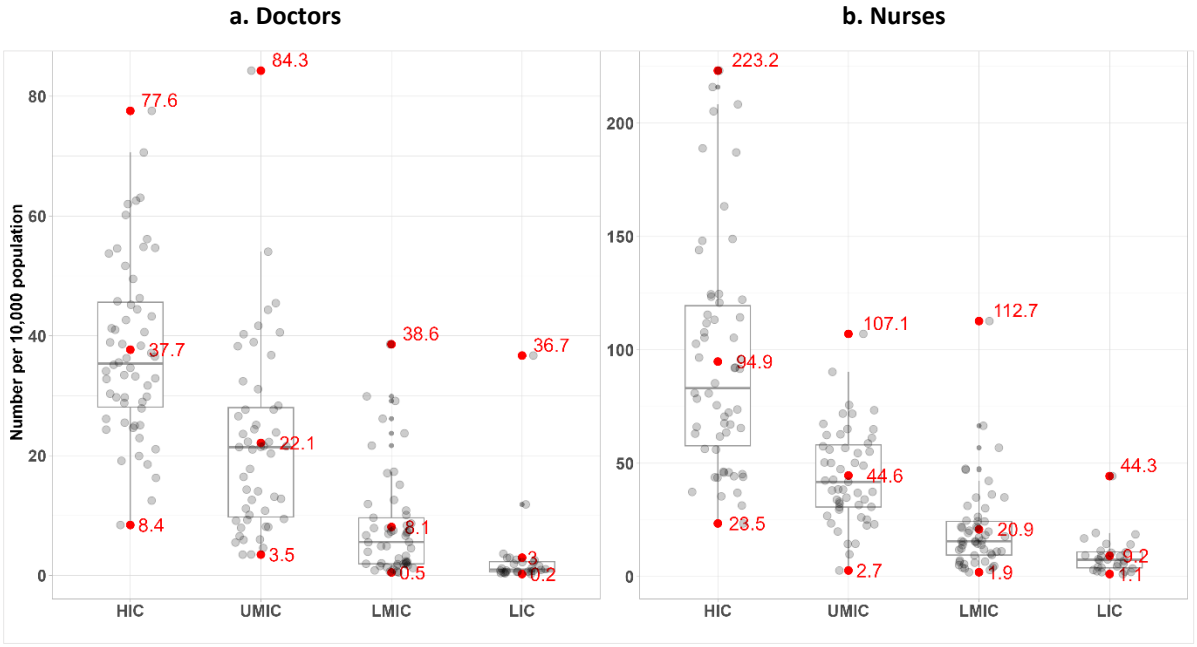
Where are all the doctors?

The World Health Organization (WHO) recommends a human resources for health (HRH) threshold of 44.5 doctors, nurses, and midwives for every 10,000 population members (WHO 2020). Figure 2 illustrates the distribution of doctors and nurses in various countries, categorized according to their income groupings per 10,000 population. Most low-income and lower-middle-income countries fall far below the WHO's recommended HRH threshold. They also fall below their respective group mean of doctors (8.1 and 3) and

nurses (20.9 and 9.2). Moreover, there are more extreme outliers in these income groups than in upper-middle-income and high-income countries, leading to an increased mean for low-income and lower-middle-income countries. Eliminating these outliers would decrease the mean for these groups, indicating a more severe HRH scarcity in low-income and lower-middle-income countries than what comes across from figure 2.

Moreover, not only do many low-income and lower-middle-income countries face a shortage of health care workers, but they also struggle with delivering quality health care services. A study by Kieny et al. (2018) found that the health care workers in seven lower-middle-income countries in Africa had an accuracy rate of only one-third to three-quarters when diagnosing medical conditions. In addition, on average, health care professionals followed clinical guidelines for common conditions less than 45 percent of the time in these countries.

Figure 2. Doctors and nurses per 10,000 population

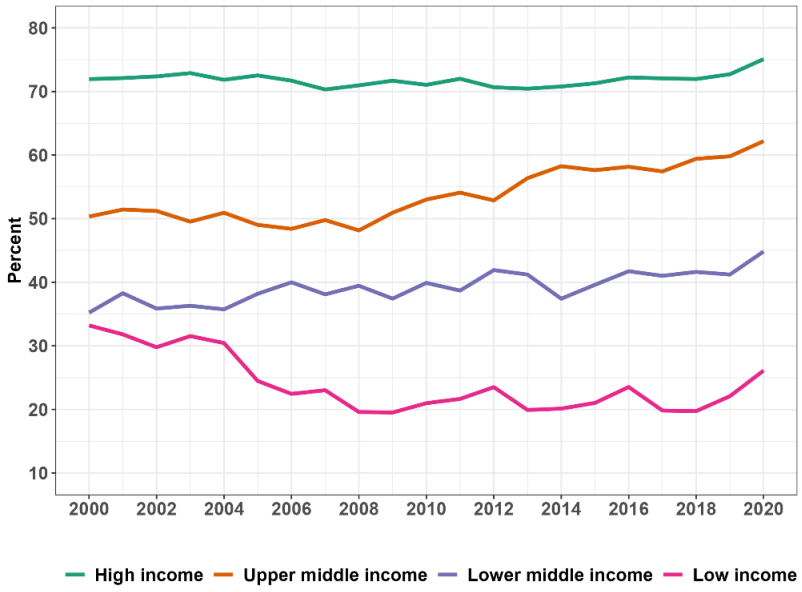


Source: Original calculations for the *World Development Report 2024* using World Health Organization (WHO) Global Health Workforce Statistics Database. https://www.who.int/data/gho/data/themes/topics/health-workforce.
Note: The figure is created based on a country's most recent available health workforce data between 1990 and 2020, as many countries lack up-to-date information. The red dots show the income group's minimum, mean, and maximum. Each grey point on the plot indicates a different country. HIC = high-income countries; LIC = low-income countriess; LMIC = lower-middle-income countries; UMIC = upper-middle-income countries.

The allocation of funds by a government toward health care has an influential positive effect on the health and wellness of its citizens, leading to improved health outcomes (Anwar et al. 2023). As the population grows and the demand for health care professionals increases, it becomes imperative for the government to augment its health care budget. Figure 3 illustrates the domestic general government health expenditure (GGHE-D) as a percentage of current health care expenditure (CHE) for a median country within different income groups. High-income and upper-middle-income countries allocate considerably more funds toward health care than lower-middle-income and low-income countries. However, the gap in GGHE-D spending between lower-middle-income and low-income countries has widened for the median country since 2004. Furthermore, the disparity between lower-middle-income and upper-middle-

income countries is also expanding, while the gap between upper-middle-income and high-income countries is contracting.

Figure 3. Domestic general government health expenditure (GGHE-D) as a percentage of current health expenditure (CHE) (percent)



Source: Original calculations for the *World Development Report 2024* using World Health Organization (WHO) indicators, https://www.who.int/data/gho/data/indicators/indicator-details/GHO/domestic-general-government-health-expenditure-(gche-d)-as-percentage-of-current-health-expenditure.

The increasing prevalence of double disease burden of communicable and noncommunicable diseases in low-income and lower-middle-income countries necessitates a greater allocation of resources toward health care. However, this is a formidable challenge because many countries continue to face limited fiscal space in the aftermath of the COVID-19 pandemic, which will result in a decline in government health expenditures for many years (World Bank 2023b, 103).

Integrating digital technology into health care systems has proven cost-effective for countries with limited financial resources to enhance their medical capabilities. The countries that had already adopted digital technology before the pandemic were better equipped to handle the COVID-19 crisis and had lower mortality rates (World Bank 2023b, 12). According to McKinsey & Company (2023a), incorporating digital tools into African health care systems could increase efficiency by 15 percent by 2030. This increase in efficiency can enable countries to allocate more resources toward reaching a broader patient base.

AI technologies can further enhance the efficiency gained from digital tools, potentially improving health outcomes by up to 40 percent and reducing treatment costs by up to 50 percent (Frost and Sullivan 2016). For instance, integrating AI can aid radiologists in saving 33 percent of their time without compromising the quality of their diagnosis (World Bank 2023b, 169). A study by Lång et al. (2023) revealed that using AI for mammogram screening resulted in a 20 percent increase in cancer detection. Implementing AI in health care can provide high-quality medical services at a lower cost in impoverished and remote areas, which is especially beneficial for low-income and lower-middle-income countries that lack skilled health care professionals, as illustrated in figure 2.

Where does the World Bank stand?

The World Bank invested $22 billion in 619 health care projects between 2005 and 2016 (World Bank 2018, 8). These projects have mainly focused on primary care, prevention and control activities, and maternal and child health care services (World Bank 2018, 50). The World Bank has also been supporting health care projects in various countries to enhance the quality and quantity of health care providers. The Bank has invested approximately $5 billion in nurse education and training across 50 countries (Tanaka and Miyamoto 2022). However, an Independent Evaluation Group (IEG) evaluation reported that the performance of the World Bank's health care funding between 2005 and 2016 was below the average performance of the total funding portfolio (World Bank 2018, 15).~~D~~ Furthermore, a study by Liu et al. (2016) predicts that the global demand for skilled healthcare workers will increase to 80 million by 2030, resulting in a global shortage of around 15 million healthcare professionals. Despite the World Bank's substantial support for improving HRH, the situation will remain challenging for lower middle income and low-income countries. They will face difficulty expanding their healthcare services due to the scarcity of skilled healthcare workers.

As noted, AI technologies can significantly benefit health care in low- and middle-income countries by improving efficiency, providing personalized services, and reducing costs and disparities. Between 2012 and 2022, the World Bank committed $4 billion to advance digital health initiatives. However, only one health care project incorporating AI received funding during this period, amounting to $0.8 million (World Bank 2023b, 32–35). This represents a mere 0.02 percent of the total funding allocated for digital health projects. Given the potential of AI to significantly enhance health care in countries with limited resources, this allocation of funding for AI is inadequate. To optimize the impact of health care funding in low-income and lower-middle-income countries, the World Bank should prioritize backing AI-related health care projects.

AI, the doctor's sidekick

In 2016, a 60-year-old female patient was diagnosed with acute myeloid leukemia. Despite attempts with various cancer drugs, her treatment proved challenging for her health care providers. Consequently, the doctors turned to the Watson AI system to analyze the patient's health information. Remarkably, the AI system revealed that the patient suffered from a different form of leukemia. Furthermore, the AI system recommended an alternative treatment plan that proved effective in treating the patient's condition (Otake 2016). This example demonstrates the significant usefulness of AI systems, particularly in low-income and lower-middle-income countries, where a shortage of qualified health care professionals, and timely diagnosis and treatment of patients, are significant challenges. Many research studies and real-life examples from various organizations have shown the advantages of incorporating AI in health care. The discussion that follows highlights examples and organizations utilizing AI in the health care industry.

- ### Predicting loss to follow-up and mortality in TB (tuberculosis) patients

  A study by Jiang et al. (2023) estimates that the projected number of TB-related deaths rose from 1.4 million in 2019 to 1.6 million in 2021. A key contributing factor to these fatalities is the phenomenon of loss to follow-up (LTFU) when patients who at one point in time were actively participating in a clinical research trial have become lost at the point of follow-up in the trial. The World Health Organization (2021) indicates that the LTFU rate remained consistent at 6 percent from 2012 to 2019. It is imperative to anticipate and prevent LTFU to save lives and halt the spread of TB. In response to this challenge, Wadhwani AI has developed an AI solution that effectively predicts the risk of LTFU and mortality. This solution had been implemented across 157 health care facilities in Haryana, India, as of April 2023. In 2024, Wadhwani AI will leverage this

technology to forecast and provide targeted TB treatment to around 12,000 patients (Economic Times 2023).

- AI-based Digital Imaging and Communications in Medicine (DICOM)

Low-income countries only have about two radiologists per million people, while high-income countries have 98 radiologists per million (Frija et al. 2021). The scarcity of skilled radiologists in remote and rural areas is also a significant issue in many countries. An AI-powered DICOM assistant could prove extremely useful in low-resource settings. The Medical Imaging and Diagnostics Lab (MIDL) in Pakistan has developed an AI model that can aid radiologists in analyzing and diagnosing breast cancer, brain cancer, and tuberculosis in mammograms, chest X-rays, and brain MRI images, respectively. This AI assistant can save time and resources and offer a second opinion to radiologists.[8]

- Preventing blindness

ProsperiA is a company based in Mexico that utilizes AI to automate the process of retinal screening. This helps in identifying patients who are at risk of developing retinopathy, disease of the retina that can lead to impairment of vision or blindness, and providing them with timely treatment that can prevent its onset (ProsperiA 2023). Such automated tools can help reduce the incidence of this illness and curb the expenditure associated with the direct and indirect costs of such illnesses. This technology also indirectly addresses the shortage of ophthalmologists in impoverished regions worldwide.[9]

- Managing depression and anxiety

Yana (you are not alone) is a chatbot that assists individuals dealing with depression and anxiety through generative AI technology. Since its debut in 2020, Yana has been dedicated to helping Spanish-speaking individuals. As of 2022, it had aided more than 6 million people and attracted $1.8 million in investment (Economist 2022). In a crisis, the chatbot can seamlessly connect individuals with the government's suicide hotline.

- AI-powered microscope

Access to qualified pathologists is a significant issue for low-resource countries and remote locations. SigTuple, a startup based in Bangalore, has developed an AI solution to analyze urine and blood images and preclassify cells into different types and subtypes, providing results in minutes. The images are uploaded to the cloud for classification, and anyone can access the results online (WIPO 2023). Pathologists can use the insights delivered by the AI to make further diagnoses, which is particularly useful in areas with limited access to pathologists.

- Event-based disease surveillance

Wadhwani AI has developed a disease surveillance system that effectively gathers digital reports and news content from various online sources. Through this system, the collected information is classified into various interest groups based on the content of the articles. The outcomes of this classification are then presented through a dashboard that seamlessly connects to the Indian government's Integrated Health Information Platform. This platform enables officials to track outbreaks and generate alerts based on the information presented. This AI-powered solution can analyze digital information in ten Indian languages and has analyzed 9 million articles to date, raising multiple red flags and generating 450 alerts (Wadhwani AI 2022, 20). The timely alerts have potentially saved many lives, making this system an invaluable tool in disease surveillance.

The health care industry has witnessed a surge in AI solutions, addressing various challenges and enhancing patient care. One such example is TeleDx, which employs AI to tackle diabetic retinopathy and boasts a monthly usage by more than one million individuals.[10] Unima leverages an AI-based mobile application for diagnosing tuberculosis,[11] while other organizations such as and Infervision,[12] Qure AI,[13] and Xolani Health[14] leverage AI with DICOM to diagnose various diseases. Another innovative solution is Talovstudio's mobile application, which employs AI and phone sensors to assist individuals with blindness and deafness.[15] These AI-powered solutions are revolutionizing the health care industry by offering efficient and effective ways to address various health challenges (box 3).

Box 3. "Remember my name … you'll be screaming it later."[a] —The AI nurse

Sunita is a community health care worker residing in a rural village in India. She goes door to door in the village, providing critical assistance to women with pregnancy nutrition and prenatal, delivering them to health care facilities for delivery, and providing ante-natal check-ups and post-birth training on breastfeeding and complementary nutrition for children. She is acutely aware that her services are indispensable to the health and well-being of women and newborns in her village, as the nearest hospital is two hours away. Despite a primary health care center within the village, the facility is not adequately equipped to meet the health care needs of the local population. One of Sunita's key responsibilities is to measure the weight of newborns, a crucial indicator of mortality, particularly in the first month of life. She takes excellent care to measure the weight of all newborns in the village as frequently as possible. However, the weighing machine in her village is prone to malfunctioning, leading to inaccurate weight measurements.

This is an illustrative example, but many frontline workers in developing countries, like Sunita, face the same issue of unrecorded birthweights. According to Doherty and Kinney (2019), approximately 48 percent of birthweights go unrecorded because babies are born outside of health facilities or equipment in the facilities is faulty. This is a severe problem in low-income and middle-income countries in Asia and Africa. To solve this problem, Wadhwani AI is creating a smartphone AI application that can accurately record a baby's weight, body length, and other vital measurements. The organization is conducting field tests with 4,799 babies enrolled in the program. (Wadhwani AI 2022, 32) Although the solution is still in development, AI technology like this can provide health workers like Sunita with tools to deliver world-class care to remote and underserved areas of the world.

a. A quote by Florence Nightingale. Available at: https://blog.nursing.com/florence-nightingale-quotes.

Education

Enrollment does not mean learning

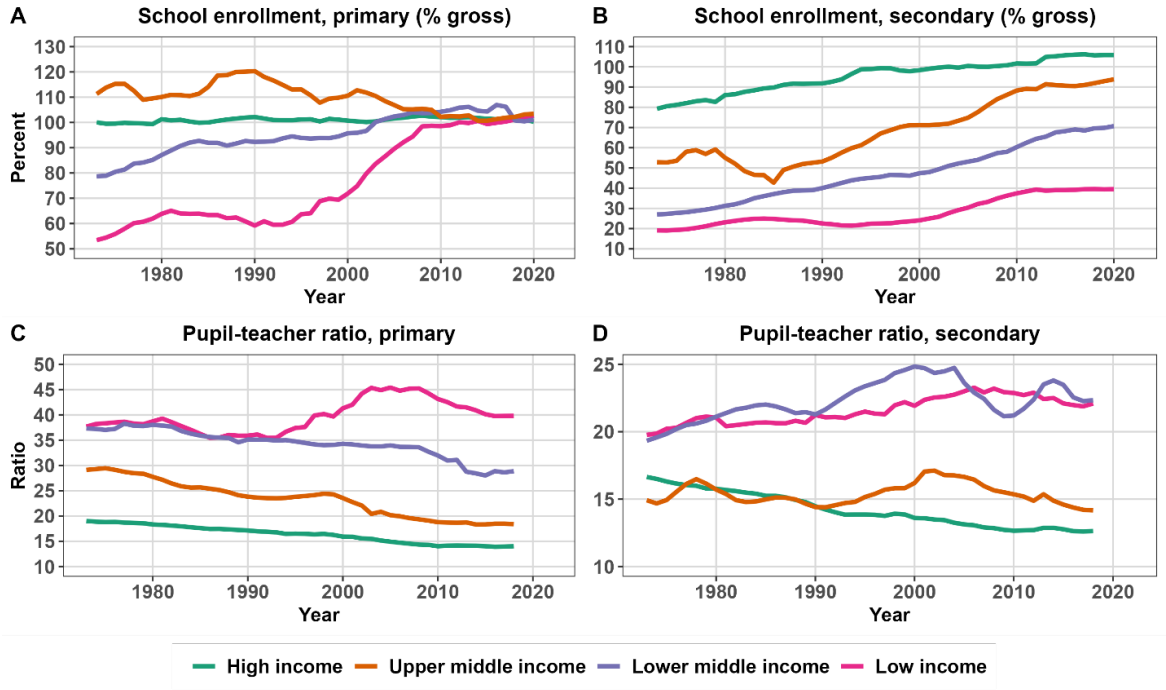
Over the last few decades, increasing school enrollment rates at primary and secondary levels has been a significant accomplishment in education. By 2020, primary school enrollment rates had reached approximately 100 percent for low-income countries and lower-middle-income countries, up from 55 percent and 80 percent, respectively, in 1975 (figure 4, panel a). Secondary school enrollment rates have also increased for all income groups since 1975 (figure 4, panel b), growing from 19 percent to 40 percent for low-income countries and from 27 percent to 70 percent in lower-middle-income countries by 2020. However, the pupil-teacher ratio does not mirror a similar positive trend. A lower pupil-teacher ratio can significantly impair students' academic achievement and learning, as documented by the Brookings Institution (2011). While there is no prescribed pupil-teacher ratio, countries with superior learning outcomes can provide some guidance. For example, the average pupil-teacher ratio in member countries of the Organization for Economic Co-operation and Development (OECD) in 2019 at the primary level was

15; at the secondary level, this ratio was 13 (OECD 2019). The average teacher-student ratio in public schools in the United States was 15.9 in 2020.[16] Most low-income and lower-middle-income countries still have much work to do to catch up with the pupil-teacher ratio numbers from these high-income countries. For example, low-income countries have not been able to effectively match the student-teacher ratio with the increase in enrollment at the primary level, as shown in figure 4, panel c. The pupil-teacher ratio in low-income countries increased from 38 in 1975 to 45 in 2005 before decreasing to 40 in 2018. However, lower-middle-income and upper-middle-income countries have been able to reduce the pupil-teacher ratio from 37 and 29 in 1975 to 27 and 18 in 2018, respectively. At the secondary level, the pupil-teacher ratio rose in both low-income and lower-middle-income countries, increasing from 20 to 22, respectively, between 1975 and 2018, as shown in panel d. By contrast, upper-middle-income and high-income countries have decreased their pupil-teacher ratio at the secondary level.

Furthermore, while low-income and middle-income countries have made significant progress in providing access to education, challenges remain in keeping students enrolled and achieving desired learning outcomes. Despite increased enrollment, learning outcomes in these countries have not improved at the same rate. A notable divide in school completion can be seen between low-income and lower-middle-income countries, with a mean of less than 5 years of schooling in many low-income countries and ranging from 6 to 10 years in lower-middle-income countries. By contrast, the mean ranges from 8 to 12 years for upper-middle-income countries, from 10 to 15 years in high-income countries. According to UNICEF (2020), only 28 percent of children in low-income countries and 65 percent in lower-middle-income countries complete secondary school. If the current trend continues, only about one-third of school-age children in these income groups will complete secondary school by 2030.

While some lower-middle-income and upper-middle-income countries tend to have greater mean years of schooling, this does not necessarily lead to better learning outcomes. Most low-income, lower-middle-income, and upper-middle income countries report an average learning outcome below 450, corresponding to test scores across standardized robust international and regional student achievement tests (figure 5). While there are some differences in learning scores between these countries, most fall between 350 and 450. In contrast, most high-income countries report learning outcomes above 450, with the majority clustered between 500 and 550. Moreover, no statistically significant difference in mean learning outcomes was observed between lower-middle-income and upper-middle-income countries for the countries in our sample. Based on these observations, it can be inferred that the increase in enrollment and mean years of schooling has not resulted in proportional improvement in learning outcomes for most low-income and lower-middle-income countries.

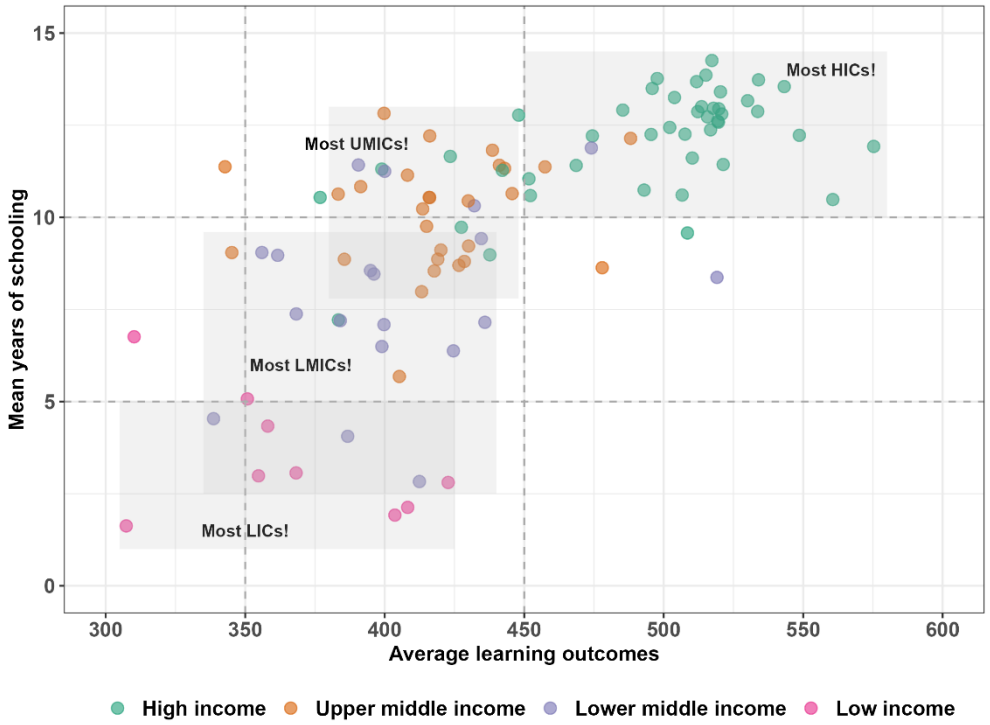
Figure 4. School enrollment and pupil-teacher ratio in primary and secondary schools



Source: Original calculations for the *World Development Report 2024* using UNESCO (United Nations Educational, Scientific, and Cultural Organization) 2023 *UIS Statistics*. http://data.uis.unesco.org/index.aspx?queryid=3409#.

AI technology can benefit countries with high pupil-teacher ratios and low learning outcomes. AI technology has the potential to significantly assist educators in automating routine tasks, thus allowing them to focus more on students' learning. According to research by Bryant et al. (2020), implementing existing AI tools in education can save teachers between 20 percent to 40 percent of their time, which can then be allocated toward activities that further enhance students' learning. Personalizing education using AI can significantly improve students' learning outcomes in low-resource settings. For instance, a study evaluating AI use in government schools in India showed that students who used AI learned twice as much as those who did not. AI technologies have already demonstrated a positive impact on education in different settings. For example, OpenAI's ChatGPT, a generative AI released in November 2022, has become very popular; it was utilized by approximately 100 million unique users as of February 2023, with 30 percent of college students utilizing it for assignments (Chen 2023; ZDNET 2023). In a survey of 1,000 K-12 school teachers and 1,000 students in the United States, 88 percent of teachers and 79 percent of students who used ChatGPT reported positive impacts on their work (Heaven 2023).

Figure 5. Mean years of schooling and average learning outcomes



Source: Original calculations for the *World Development Report 2024* using UNESCO (United Nations Educational, Scientific, and Cultural Organization) 2023 *UIS Statistics*. http://data.uis.unesco.org/index.aspx?queryid=3409#. and Roser, Nagdy, and Ortiz-Ospina 2013.

Note: The figure is based on the most current data available for the mean years of schooling between 2016 and 2022 due to unavailable information for some countries. The figure only shows countries where mean years of schooling and average learning outcomes were available. These data are very scarce for low-income and lower-middle-income countries, and only a few countries in this income group have the information. The average learning outcomes data are from 2020, corresponding to test scores across standardized psychometrically robust international and regional student achievement tests. HICs = high-income countries; LICs = low-income countriess; LMICs = lower-middle-income countries; UMICs = upper-middle-income countries.

Where does the World Bank stand?

From 1962 to 2011, the World Bank invested $69 billion in approximately 1,500 education projects (World Bank 2011b, 1). Their efforts focused on improving school infrastructure, increasing access to education, and promoting fairness in education. However, they lacked a clear strategy for funding projects that aimed to improve learning outcomes (IEG 2011). In 2011, the World Bank adopted a new education strategy to improve quality (World Bank 2011b). While the World Bank projects have successfully improved education inputs and increased enrollment in low-income and lower-middle-income countries, their focus on improving learning outcomes has not yielded the same positive results.

According to the latest report by the World Bank Independent Evaluation Group, in low-income countries, a staggering 94 percent of primary-level children were unable to achieve minimum reading proficiency, while 87 percent were unable to achieve minimum math proficiency (IEG 2022a). Furthermore, the COVID-19 pandemic has exacerbated the learning crisis across all country income groups. In most lower-middle-income countries, reading proficiency at the end of lower secondary school has fallen below 60 percent; in some countries, it has dropped below 10 percent. Learning losses have been documented in 4 out of 5 countries where learning measurement studies were carried out (UN 2022). It is estimated that

the cost of poor basic education outcomes is around $129 billion per year to economic development in developing countries (IEG 2022a).

There is a pressing need for novel approaches and strategies to augment the quality of education and enhance learning outcomes, particularly in low-income and lower-middle-income countries. Given the favorable impact of AI technologies on learning, the World Bank should endorse more AI-based education initiatives to address the learning crisis experienced by many low-income and lower-middle-income countries.

AI, the learning revolutionizer

AI technologies can serve as a teaching assistant in countries that lack enough qualified teachers or instructors who cannot provide adequate support to all students. AI can offer personalized support to each student based on their learning level. In rural and remote areas access, where skilled teachers are often in short supply, AI technologies can also provide students access to world-class education opportunities. The discussion that follows describes some organizations and their work in using AI in education:

- ### Personalized grading and feedback

  Every senior school student in Brazil must take the National Secondary Education Exam, which includes writing an essay. Unfortunately, teachers in developing countries often struggle with time constraints and cannot provide sufficient attention to each student. To address this issue, a randomized controlled trial (RCT) was conducted in 178 public schools in Brazil, involving approximately 19,000 students, to assess whether AI could help improve student writing. The sample was divided into two intervention groups, each comprising 55 schools. In the first group, students received feedback and grades on their essays from both AI and teachers, while the second group received feedback only from AI, without human graders. The control group, consisting of 65 schools, had no access to AI feedback. The study found that students in schools using only AI assistants wrote 32 percent more practice essays and increased their essay grades by about 0.09 standard deviation—which decreased the essay score gap between public and private schools by 9 percent. As a result of these findings, the State Education Department of Espírito Santo has implemented AI writing evaluation tools to provide individualized support to senior high school students, with approximately 30,000 students currently using this tool (Ferman, Lima, and Riva 2021).

  The study demonstrates the potential of AI to help improve student writing skills in developing countries, where teachers often face significant time constraints. AI tools can provide students with additional resources and support and help improve learning outcomes.

- ### Private math tutor

  Amy.app is an AI tool that utilizes dynamic instructional techniques to facilitate student learning in mathematics. Its AI component provides feedback and bridges knowledge gaps as students engage in learning. With more than 500,000 unique questions, the AI navigates between topics and identifies areas of deficiency to address. The Amy.app can operate with basic internet connectivity and integrate with all online learning platforms. In addition, it delivers content in multiple languages, currently supporting four languages with plans for further expansion. This feature makes it a very versatile tool that can be effectively implemented across diverse settings and regions of the world.[17]

- Smart classrooms

  Class Saathi is a quiz tool that utilizes AI technology to assist educators in assessing students' understanding of core subjects. Parents and teachers can obtain valuable learning insights with access to the tool via individual applications. Saathi database has approximately 500,000 questions spanning various subjects such as Mathematics, English, Science, and Social Sciences. The tool's user-friendly interface facilitates personalized content development, skill mapping, customized testing, and score prediction. The Saathi's design also accommodates low-internet and low-electricity environments.[18]

- Personalized therapy and learning for children with autism spectrum disorder (ASD)

  The lack of access to high-quality, cost-effective interventions in developing countries for children with autism is a pressing issue. CogniAble has developed a technology powered by AI that offers assessments and personalized assistance to children diagnosed with autism. It offers a range of approaches tailored to individual cases, including speech and language therapy and special education. Currently, the application is being utilized in more than 10 cities across India, demonstrating the potential of AI to improve the quality of care for children with autism.[19]

- Support for job seekers

  The SkillLab platform uses AI to help people evaluate their skills and experience. It then analyzes this information to deliver delivers personalized education suggestions to guide individuals through career changes caused by various factors. SkillLab also creates a skill profile for users with its AI tool and uses this to match them with job opportunities. SkillLab has helped more than 10,000 people across 32 countries, and its AI solution has reduced the cost of career guidance by 99 percent (Google 2023).[20]

In addition to these examples, other organizations are using AI to transform education. One example is ekidz.eu, which uses AI to provide personalized feedback to help children with reading and language learning.[21] Learnisa uses AI to match learners with personalized online courses from more than 100,000 courses, optimizing their chances of success.[22] Box 4 presents another example.

Box 4. "I cannot teach anybody anything. I can only make them think."[a]

Mindspark is an educational tool that utilizes AI technology to personalize the learning experience for students in Math, Science, and English. With a focus on individual learning styles and needs, Mindspark optimizes the learning process while considering each student's unique learning capacity. Through thought-provoking questions and feedback, Mindspark stimulates critical thinking and fosters a strong conceptual understanding of the subject matter. Weekly reports are generated to inform parents and educators of their student's progress and any areas requiring further attention.[b] Five hundred thousand students use the AI platform, which is available in nine Indian languages (USAID 2021).

An RCT conducted across 40 government schools in Rajasthan, India, demonstrated that Mindspark students scored 0.2 standard deviations higher in Hindi and Math than students in a control group. This evidence attests to the effectiveness of AI in education as a valuable educational resource for students to improve learning outcomes in many low-resource countries (Poverty Action Lab 2019). Karthik Muralidharan, professor of economics at the University of California, San Diego, who headed the evaluation, said, "In 15 years of education research, I've never seen something that has had such a large effect in such a short amount of time. The reason why this is so effective is that you are getting complete customization in a setting where the vast majority of children are so far behind the textbook and the syllabus that is taught in their class" (Poverty Action Lab 2019).

a. Quotation by Socrates. Available at: https://www.goodreads.com/quotes/73059-i-cannot-teach-anybody-anything-i-can-only-make-them.
b. "Learn Maths, Science, English Online / Ei Mindspark." https://mindspark.in/.

Finance

Formal credit, the out-of-reach Holy Grail

Financial inclusion is crucial for economic development that depends on the availability of savings accounts, payment systems, and credit services.[23] Access to formal financial services significantly enhances resilience to financial hardships among individuals and organizations. Unfortunately, around 1.5 billion people in developing economies cannot access formal savings and credit (McKinsey & Company 2023b).

Despite these challenges, there have been notable improvements in account ownership worldwide, with a 50 percent increase between 2011 and 2021. Seventy-six percent of adults worldwide have a bank account with a regulated institution, such as a credit union, microfinance institution, or mobile money service provider. The use of digital payments in developing countries has also grown, with digital payments increasing from 35 percent to 57 percent between 2014 and 2021. The COVID-19 pandemic further accelerated the use of digital payments. In India, for instance, 80 million people using digital payments for the first time during the pandemic (Demirgüç-Kunt et al. 2022).

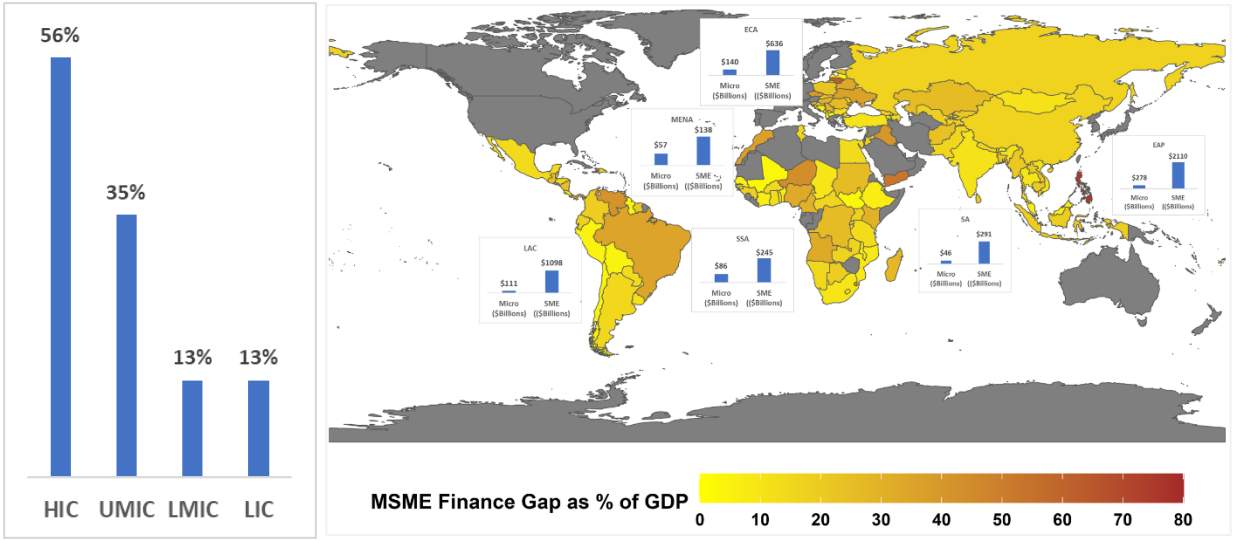
However, progress has not been as great in access to credit, the third pillar of financial inclusion.[24] Approximately 45 percent of adults in developing countries face challenges accessing extra funds within 30 days; family and friends and informal sources are the primary source of extra funds (Demirgüç-Kunt et al. 2022). Furthermore, only 13 percent of adults in lower-middle-income and low-income countries borrow from formal institutions, compared to more than 50 percent of adults in high-income countries access formal institutions (figure 6, panel a).

Small and medium enterprises (SMEs) comprise 90 percent of businesses and 50 percent of employment worldwide.[25] However, 40 percent of micro, small, and medium enterprises (MSMEs) in developing countries have approximately $5.2 trillion in unmet funding needs annually (IFC 2017). MSMEs in developing nations such as Nigeria, Angola, Kenya, Niger, Cameroon, Brazil, Panama, the Republic of Yemen, and the Philippines face a financial gap of more than 30 percent of their respective country's GDP (figure 6, panel b). Among world regions, the MSME finance gap is particularly pronounced in the East Asia Pacific region, where the shortfall totals about $2.4 trillion, followed by Latin America and the Caribbean, with China and Brazil as critical contributors to the gap in their respective regions. In South Asia, India is a key contributor to the credit gap. In India, the MSME sector faces a credit gap of $250 billion to $300 billion, with 92 percent of MSMEs lacking access to formal finance before the COVID-19 pandemic (Dixit 2023). Panel b of figure 6 also demonstrates the notable financial gaps that MSMEs encounter in other regions.

Figure 6. Access to formal finance and the finance gap in regions and income groups

a. Borrowed any money from a formal financial institution or using a mobile money account (percent of population, age 15+)

b. Gap in formal finances for MSMEs



Sources: For panel a, original calculations for the *World Development Report 2024* using data from World Bank, Global Findex Database, 2021, https://www.worldbank.org/en/publication/globalfindex/Data. For panel b, IFC 2017.
Note: Panel b focuses on micro, small, and medium enterprises (MSMEs). Data were not available for countries colored grey. Regions in panel b: ECA = Europe and Central Asia; EAP = East Asia Pacific; LAC = Latin America and the Caribbean; MENA = Middle East and North America; SA = South Asia; SSA = Sub-Saharan Africa.

The preceding analysis indicates that individuals and MSMEs in most developing countries face challenges in accessing formal finance. The lack of access to formal credit is a significant barrier to financial inclusion. Various factors impede individuals' and MSMEs' access to formal credit in developing countries. MSMEs face difficulties obtaining finance from formal institutions such as banks because information to evaluate their creditworthiness is often not available (Abraham and Schmukler 2017). In the absence of information, lenders often resort to higher collateral, making it difficult for MSMEs to obtain formal finance at a reasonable cost. Individuals in low-income communities face similar barriers due to the lack of information to assess their creditworthiness. Furthermore, formal lenders find it impractical to give frequent small working capital loans to MSMEs because the cost of underwriting exceeds the profit (Dixit 2023).

However, AI technologies offer opportunities to serve individuals and organizations that face difficulties accessing formal finance. AI technologies can analyze nontraditional data sources such as online shopping habits, utility and telephone bill payment history, phone usage information, social media profiles, and satellite imagery to evaluate past and future agriculture income, number of employees, and type of roof, among other factors, to determine the creditworthiness of an individual or an organization in the absence of conventional information. In countries like India, where 80 percent of the population lacks a credit score, AI has the potential to provide credit to the underserved population. AI is projected to generate digital and online loans worth $100 billion in India, enabling lenders to reach 350 million first-time credit borrowers while reducing loan delinquencies by at least 33 percent (ICICI 2021). Furthermore, AI models using alternative data sources can help lenders design products that provide more flexible and

personalized terms to borrowers who may have otherwise remained outside the formal credit system (BFAglobal 2018).

Where does the World Bank stand?

About 2 percent to 3 percent of the World Bank's annual commitments are allocated toward financial inclusion projects, focusing on payments, lending, and savings initiatives (IEG 2016). The World Bank's finance portfolio is primarily composed of lines of credit projects targeted explicitly toward countries with lower levels of financial inclusion (IEG 2016). The financial inclusion projects, funded by the World Bank, experienced a growth rate of 20 percent between 2007 and 2013, with a considerable commitment of $9 billion. The World Bank's portfolio on targeted small and medium-enterprises (TSME) contained 7 percent of SME projects and 2 percent of the total commitment value between 2006 and 2012 (IEG 2014). The World Bank's support for financial inclusion has been significant and has increased over the last decade. A recent review of World Bank's financial inclusion support between 2014 and 2022, found that the World Bank financed about 1,700 financial inclusion activities worth about $30 billion (IEG, 2023). However, the report also highlights that the financial inclusion of microenterprises, poor households, women, and other excluded groups has remined limited over this period (IEG, 2023).

The ability of commercial institutions to lend is often constrained by limited information on the creditworthiness of potential borrowers, as well as the challenge of designing products that cater to their unique needs (Kumar, Narain, and Rubbani 2015). To address this issue, a 2016 evaluation by the Independent Evaluation Group recommends that the World Bank explore innovative strategies to better target MSMEs and facilitate their access to formal credit. While increasing credit lines has helped augment the supply of funds, it has not always translated to increased financing. The report further advises the World Bank to identify and adopt innovative financial service delivery models to offer sustainable and cost-effective services to underserved clients (IEG 2016).

The World Bank has prioritized its efforts toward facilitating the growth of SMEs by enhancing their access to finance through innovative solutions. An important aim is to assist its member countries in identifying effective ways to provide financial support to SMEs.[26] As noted, using AI technologies can provide tailored credit options at a lower cost than conventional credit institutions, making it prudent for the World Bank to endorse initiatives and establishments that employ AI to democratize credit access for individuals and MSMEs that traditional lenders have ignored.

AI, the humane banker

Integrating AI technology has presented a promising solution to bring millions of underserved individuals and organizations into the formal financial system. AI technologies can effectively reduce the cost of servicing credit while utilizing nontraditional alternative data sources to reach those at the bottom of the socioeconomic pyramid. Financial technology (fintech) companies worldwide are increasingly leveraging AI tools to extend credit to first-time borrowers. A few of these initiatives are highlighted next.

- Aye Finance

  Aye Finance is a fintech organization headquartered in India that provides micro and small working capital loans to MSMEs. The company initially leverages physical branches to engage with customers in rural areas, but the entire loan process is completed online (Economic Times 2022). To underwrite secured and unsecured small business loans, Aye Finance employs AI. Various data sources, such as invoices, phone call records, text messages, number of machines, number of employees, and production estimates, are utilized to evaluate the loan. Their AI technology processes this information alongside the loan application to determine approval. Aye

Finance operates in 22 states across India and has disbursed more than 500,000 loans totaling more than $900 million.[27]

- Branch

  Branch is a financial technology company that operates in India, Kenya, Nigeria, and Tanzania (IFC 2020). Since its inception in 2015, it has successfully served more than 4 million customers and disbursed about 29 million loans, totaling more than 1 billion dollars.[28] The loan application process involves downloading the Branch mobile application and providing Branch with consent to use the customer's smartphone data. After obtaining the necessary consent, Branch's custom machine-learning algorithm processes thousands of data points to create personalized loan options for the customer. The algorithm leverages nontraditional data sources such as text messages, call logs, contacts, mobile phone details, GPS, and a borrower's loan repayment history to generate loan offers within minutes. By harnessing the power of AI and nontraditional data, Branch has provided millions of customers with tailored, small loan products.

- Tala

  Tala is a fintech enterprise founded in 2014 that operates in several countries, including Kenya, India, Mexico, and the Philippines. Since its inception, Tala has provided more than $2.7 billion in loans to economically disadvantaged individuals and entrepreneurs (CNBC 2023). The Tala smartphone application allows users to borrow amounts ranging from $10 to $500, with a repayment period of up to 90 days (typically 30 days). Tala's advanced creditworthiness assessment process analyzes approximately 250 data points, including online behavior, mobile device information, payment history for utilities and mobile bills, and text messages (Shetty 2020). Tala's AI algorithm leverages this data to make informed decisions regarding loan approvals.[29]

- Traive

  Traive is a Brazil-based agriculture fintech firm founded in 2018. The organization aims to close the information gap between farmers and lenders. Traive's AI model uses agronomic, satellite-generated, and climatic data variables and historical data to measure credit risk for any farm, regardless of its size. Using the risk profile and the company's mobile application platform, Traive offers a quick and easy channel to underwrite loans at a low cost.[30]

Several other organizations are utilizing AI to transform the finance industry and provide credit to low-income customers and MSMEs (box 5). For instance, Zest Finance utilizes AI and alternative data, such as device, browser, and social media data, to determine a customer's creditworthiness (McKinsey & Company 2018a). CreditVidya uses unconventional data sources to assess a customer's creditworthiness and facilitate connections between lenders and borrowers.[31]

In addition to measuring creditworthiness using alternative data sources, some organizations employ AI to create nontraditional insurance products. Arbol, for instance, uses AI to analyze various climate and location data points such as rainfall, temperature, and soil moisture to underwrite weather insurance contracts. Arbol emphasizes that its use of AI allows it to offer personalized weather insurance products at the most competitive prices.[32] Similarly, oko leverages satellite imagery, weather and climate data, and historical yield information to offer crop insurance through AI technology.[33]

Box 5. Sometimes, a little credit can go a long way

M-Shwari is a savings and loan service based in Kenya that leverages AI tools for credit scoring and risk analysis (IFC 2019). Established in 2012, this service is a joint venture between Safaricom, Kenya's largest mobile phone operator, and the Commercial Bank of Africa (CBA). M-Shwari is a fully regulated bank account in Kenya that provides loans ranging from 60 cents to $300, with a repayment period of up to one month (CGAP 2015).[a] Since its inception, M-Shwari has facilitated Kenyans' borrowing of about $670 million, with an average loan size of $4.8 (Bizna 2022). To request loans through M-Shwari, customers must be active users of M-Pesa, a mobile banking service launched by Safaricom in 2007 (Kagan 2023). The loan application process is quick; customers can request and receive loans within minutes. Two years after its launch, M-Shwari had more than 4.5 million active users and more than 10 million accounts, making it a highly successful venture. As a result of its success, CBA captured more than 50 percent of the loan account market share in Kenya (Suri, Bharadwaj, and Jack 2021).

A recent study by Suri, Bharadwaj, and Jack (2021) analyzed the impact of M-Shwari digital loans on households. The study showed that individuals who qualify for the loan are 11 percentage points more likely to secure any loan. Despite M-Shwari's high-interest rates, the study found that it did not significantly increase the debt burden of its customers. M-Shwari loans helped households become more resilient to adverse shocks; eligible households were 6.3 percentage points less likely to reduce expenses in response to adverse shocks. These findings highlight the potential benefits of M-Shwari digital loans for eligible households needing access to credit.

a. "M-Shwari." https://www.safaricom.co.ke/personal/m-pesa/credit-and-savings/m-shwari.

Energy and Infrastructure

The forgotten grid

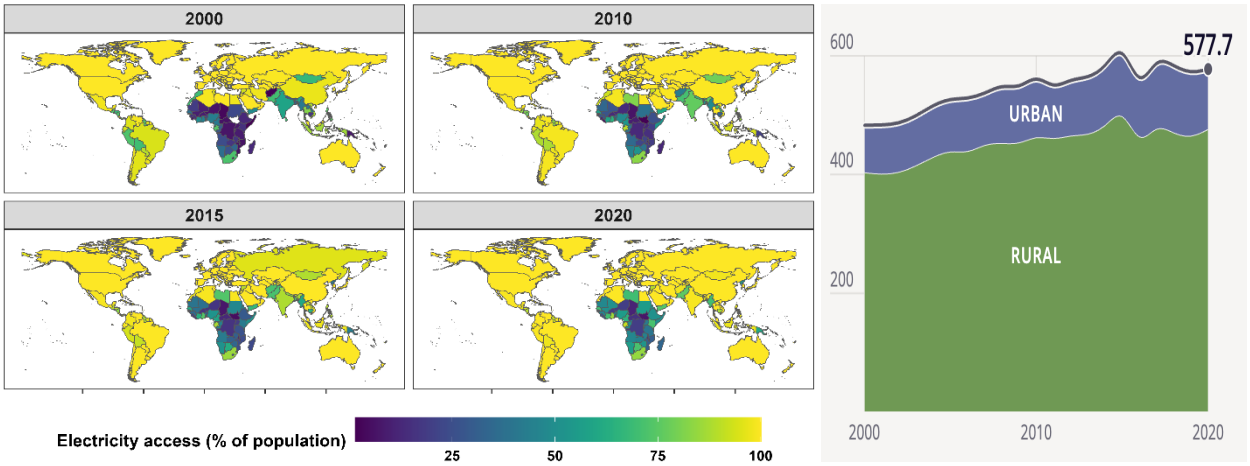
Access to electricity is a critical issue affecting millions worldwide, with Sub-Saharan Africa particularly affected. In 2000, less than half of the population in most countries in South Asia and Sub-Saharan Africa had access to electricity (figure 7, panel a). However, over the past two decades, there has been progress in South Asia, with India leading the way. As of 2020, more than 90 percent of the population in South Asia had access to electricity, on average. In contrast, progress in Sub-Saharan Africa has been slow, with the average access to electricity less than 50 percent, and as low as 14 percent in Malawi, and 19 percent in Burkina Faso and Niger. As of 2020, approximately 577 million people in Sub-Saharan Africa lacked access to electricity, most of them (500 million) in rural areas (figure 7, panel b).

In Africa, access to the national grid is limited, with access available to only 68 percent of the overall population, and 45 percent in rural areas. Even for those connected to the grid, the reliability of electricity is a concern in many African regions, with only 74 percent of connected individuals reporting reliable access (Logan and Han 2022). This lack of electricity has created issues in providing essential services. Half of secondary schools, clinics, and hospitals lack reliable electricity (Economist 2019). A continuous and consistent supply of electricity could greatly benefit the development of these regions. Reliable electricity access could increase economic growth in Sub-Saharan African countries by 2 percent annually (Economist 2017). Due to limited access to the national grid, many Africans are turning to off-grid electricity sources, such as solar and electric generators. Various organizations are utilizing innovative renewable technologies, including AI, to provide efficient and reliable electricity and power to underserved regions worldwide.

Figure 7. Lacking access to electricity

a. Electricity access (% of population)

b. Population without access to electricity in Sub-Saharan Africa (millions)



Sources: For panel a, original calculations for the *World Development Report 2024* using data from Ritchie, Roser, and Rosado 2022. For panel b, Parada, Pirlea, and Wadhwa 2023.

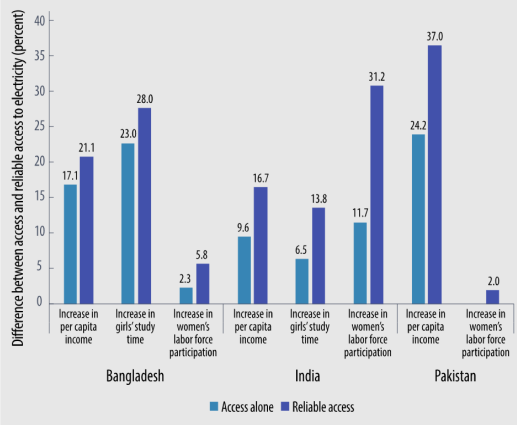
Disrupted infrastructure, the pothole on the road to progress

Maintaining infrastructure is just as crucial as building it, as disruptions can significantly affect individuals and the country's economic development. For instance, a one-day water supply disruption in the Democratic Republic of Congo led to a suspected 155 percent increase in cholera cases (World Bank 2021). Reliable access to electricity could increase women's participation in the labor force by around 19 percentage points in India and significantly boost per capita income in Bangladesh, India, and Pakistan (panel a).

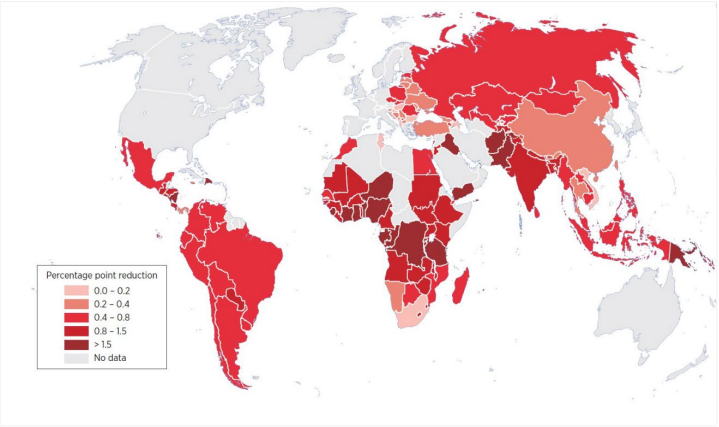
Disruptions to road, electricity, or water infrastructure can reduce the capacity utilization of firms in developing countries forcing them to operate at less than full production capacity (figure 8, panel b). This loss in utilization can result in enormous costs for lower-middle-income countries, such as approximately $82 billion annually in sales losses due to power outages, $6 billion annually in the cost of disruption to water supply infrastructure, and a loss of approximately $107 billion annually due to reduced utilization of transport infrastructure caused by infrastructure disruptions (Mimmi 2021).

Figure 8. Impact of reliable infrastructure

a. Benefits of reliable electricity



b. Average utilization rate loss due to infrastructure disruption (percentage point reduction in capacity utilization)



Sources: Rentschler et al. 2019; World Bank 2021.

AI, the energy and infrastructure wizard

The World Bank has demonstrated a strong commitment to addressing infrastructure shortages in various countries, as evidenced by its significant investment of billions of dollars. The World Bank has allocated $5.5 billion toward enhancing energy efficiency, and its transport portfolio is valued at $34 billion.[34] Given the importance of infrastructure projects in the World Bank's portfolio, it is imperative that the Bank leverages advanced technologies to optimize the efficiency and effectiveness of its investments. AI technology has emerged as a valuable tool in this regard, as it can boost energy systems' efficiency and provide support with effective maintenance and management of infrastructure. A few organizations that successfully use AI to optimize energy and infrastructure investments are described next.

➢ Improving energy efficiency

Azuri Technologies is a provider of innovative solar technology solutions that cater to the off-grid electricity needs of rural households. The company's pioneering pay-as-you-go model enables customers to pay for the product as they use it, with the energy becoming free to use once the payment is complete. Azuri's state-of-the-art system utilizes AI technology to optimize energy consumption by closely monitoring climate conditions and adapting to the customer's energy requirements. This is achieved by automatically adjusting power output, regulating device charging rates, dimming lights, and managing fan speeds (IFC 2020). More than 50,000 people benefit from Azuri's AI-based solar power system, resulting in savings of approximately $2 million on energy expenditure and an offset of 12,000 tonnes of greenhouse gas emissions annually.[35]

➢ Traffic management

Moivision is a global organization that leverages advanced AI technology and IoT to enhance transportation capacity, safety, cost-effectiveness, and performance. With a vast footprint spanning more than 50 countries, Moivision's AI technology optimizes traffic signals to improve traffic flow, mitigate congestion, and reduce pollution. The platform accounts for various modes of transportation, ensuring streamlined and secure travel for vehicles, cyclists, pedestrians, and transit. According to Moivision, the technology can significantly reduce wait times by 40 percent and greenhouse gas emissions by 20 percent; it also decreases vehicle stops by 30 percent to 40 percent, reducing road and tire wear and resulting in cost savings for drivers and cities.[36]

- Road infrastructure monitoring

  CityRover is an organization that helps local governments and city administrations monitor, inspect, and manage roads and infrastructure using AI technology. Its AI device utilizes smartphone cameras that can be easily mounted on the windshield of any vehicle that moves frequently. CityROVER captures high-quality images of incidents and their GPS location as the vehicle travels. This helps to monitor road infrastructure continuously while using minimal resources. The AI system automatically detects and reports road hazards and pavement distress. CityRover's AI system has been used in more than 15 countries and has reported about 400,000 infrastructure-related incidents.[37]

- Power grid monitoring

  Sees.ai deploys autonomous drones that leverage AI technology to conduct assessments of the electricity grid. This technology can also be applied to scrutinize and examine other structures such as railways, roads, oil and gas facilities, and renewable energy plants.[38] This innovative technology is beneficial in monitoring and inspecting infrastructure in demanding environments and hard-to-reach locations. The United Kingdom's National Grid utilized Sees.ai's AI-powered drones to oversee more than 7,200 miles of wires and pylons that carry electricity from power stations to homes and businesses. The AI system assists in determining when power assets need to be repaired or replaced by regularly monitoring their conditions (Vaughan 2018).

- Water infrastructure monitoring

  Fracta is a United States-based organization that assists water utility companies in maintaining their water infrastructure through advanced AI-based technology. Fracta's AI system calculates the Likelihood of Failure (LOF) for drinking water distribution mains, which enables utilities to determine their condition and level of risk. Using this information, utilities can better target their efforts to detect leaks, perform timely maintenance on valves, and avoid disruptive water main breaks, thus preventing interruptions in water supply.[39] Fracta's AI technology is being utilized to inspect 874 miles of utility lines in the United States, resulting in approximately $4 million in cost savings (Mehmood et al. 2020).

Many organizations are applying AI technology to inform decision making about emergencies, maintenance, and investment in various infrastructure sectors through monitoring and inspections (box 6). One example is Asterra, which uses AI technology to detect water leakage from underground pipes. Asterra can improve maintenance efficiency by up to 400 percent using satellite-based leak detection technology.[40] Other companies such as Airpelago,[41] Keen.ai,[42] and Sentient Energy[43] employ IoT and AI technology to aid electric utilities in managing and monitoring grid infrastructure.

Box 6. The toxic tap

In 1986, lead pipes were banned from drinking water in the United States. However, previously installed pipes remained in use, posing a significant risk of lead poisoning. One such case occurred in Flint, Michigan, where a change in water treatment led to increased lead poisoning among citizens. Consequently, city officials sought to replace old lead water pipes. Unfortunately, they were unaware of the areas or homes that contained such pipes, and the excavation and replacement of pipes can be quite costly, ranging from $2,000 to $10,000 (Fussell 2021). In response to this dilemma, the University of Michigan startup BlueConduit employed AI to predict the likelihood of lead pipes in a particular house. This enabled BlueConduit to identify houses more likely to carry lead pipes without excavating every house. The AI system boasted an accuracy rate of more than 80 percent, proving highly beneficial to thousands of Flint residents.

Despite this success, the city later decided against using AI technology due to political pressure. The city decided to dig every house in the county to find the lead pipes. As a result, the accuracy rate dropped to a mere 15 percent. However, in 2019, the US court intervened, and the use of AI technology was restored; this pushed the accuracy rate up to 70 percent (Agrawal, Gans, and Goldfarb 2022). Currently, BlueConduit works with various water systems and municipalities across the United States and has inventoried more than 2 million service lines.[a]

a. "Home–BlueConduit." https://blueconduit.com/.

Data

Poverty, the missing statistics

The World Bank has twin goals: to end extreme poverty; and to promote shared prosperity.[44] The World Bank's mission to eradicate poverty rests upon generating reliable data. These data are crucial for facilitating project funding and implementing effective interventions in developing countries. Poverty statistics play a vital role in this process by aiding the World Bank in identifying impoverished individuals and their locations. Such information is essential to the development of policies and projects that can deliver development goals (World Bank 2023c).

Poverty mapping is a critical tool that provides various levels of geographic aggregation of poverty from national to local levels. Poverty mapping using small-area poverty estimates is essential for effectively targeting poverty reduction programs at the local level. Producing accurate estimates requires both household surveys and concurrent census data (Ziulu et al. 2022).

Unfortunately, obtaining survey data can be challenging in many countries, particularly those experiencing conflicts or natural disasters (Newhouse 2023). A study by Serajuddin et al. (2015) found that 29 countries lacked any survey data on poverty statistics, and 28 countries only had one survey between 2002 and 2011. This situation is even more dire in low-income countries. Many low-income countries have not conducted a census for many decades (table 1). These gaps in data availability present significant obstacles to mapping and addressing poverty at the local level accurately.

Table 1. Year of last census in selected countries

Country	Year of last census
Somalia	1986
Congo Dem. Rep.	1984
Eritrea	1984
Afghanistan	1979
Lebanon	1943

Source: Original calculations for the *World Development Report 2024* using data from Harvard CRCS (2022).

In addition, to obtain poverty estimations, survey and census data must meet certain conditions. First, census and survey must share variables associated with poverty levels. Second, the survey and census should have been conducted within a reasonable time, ideally between three to five years (Ziulu et al.

2022). However, meeting this time constraint can be challenging for low-income and lower-middle-income countries, which may even need help conducting a census every ten years.

Many countries cannot conduct censuses and surveys due to the high costs and logistical challenges. For instance, running a Demographic and Health Survey (DHS) or a World Bank Living Standards Measurement Study (LSMS) in a country can cost $1.5 million to $2 million per year (Burke et al. 2021). This process takes multiple years and involves training and deploying hundreds of enumerators in remote and insecure areas. A population census for an African country can cost hundreds of millions of dollars (Burke et al. 2021). Moreover, a significant challenge of survey data is that they often only represent national or regional levels, making it difficult to obtain reliable data at the local level. Having disaggregated poverty estimates at the local level is crucial for targeting antipoverty programs effectively.

According to the Global Poverty Monitoring Technical Note released by the World Bank in March 2023, the latest available global poverty estimates date back to 2019 (Aguilar et al. 2023). The lack of current and accurate poverty data hinders the creation of effective programs to reduce poverty, especially during crises or emergencies like the COVID-19 pandemic, which profoundly affects the impoverished population.

AI, the data weaver

Generating poverty statistics is challenging and resource-intensive, particularly for low- income and lower-income countries. However, such estimates are critical for the World Bank and the governments of low-income and lower-middle-income countries to optimally allocate limited resources to help those in need.

In recent years, several reputable studies have successfully utilized AI techniques and new data types such as satellite imagery, mobile phone Call Detail Records (CDRs), and social media data to estimate poverty statistics in various countries and regions worldwide (box 7).

For example, in 2020, Yeh et al. developed a DL model to predict asset wealth in more than 20,000 African villages using publicly accessible satellite imagery. The authors reported that it took them about 30 hours to obtain asset wealth predictions from raw satellite images, including a few hours of model training and 24 hours of image processing. The total cost of predictions for the villages in the study would be a few hundred to a few thousand dollars, significantly less than the cost and time required for a nationally representative household survey. Most studies that utilize satellite data use publicly available low- or moderate-resolution daytime or nighttime imagery, which is often free. If high-resolution imagery is needed, it can also be obtained from private providers at a much lower cost than conducting a household survey within the country.

Box 7. Togo's Novissi program

In response to the COVID-19 pandemic, the government of Togo implemented the Novissi cash transfer program in 2020 to provide financial support to those in the informal sector who were facing difficulties. The World Bank contributed $70 million to support Togo's economic recovery program from the pandemic (Debenedetti 2021). Initially, the program aimed to identify the most disadvantaged areas to receive digital cash transfers. High-resolution satellite imagery and AI technology were utilized to identify these areas. However, both poor and nonpoor individuals resided in these areas. To ensure that the most impoverished individuals in these areas received assistance, the program employed AI and mobile phone metadata to predict the consumption patterns of approximately 70 percent of Togo's population. Thanks to AI, more than 57,000 new beneficiaries were identified and prioritized for digital cash transfers between November 2020 and March 2021 (World Bank 2021b).

A study by Aiken et al. (2022) found that the AI approach to recognize patterns of poverty reduced the exclusion error by 4 percent to 21 percent relative to the geographic targeting of the poor considered by the government of Togo.

Many studies have also shown the effectiveness of using nontraditional data sources and AI to improve poverty estimation. For example, Yeh et al. (2020) found that a DL model trained on publicly available satellite data could explain about 70 percent of the spatial variation in ground-measured village-level asset wealth in Africa. Blumenstock (2018) demonstrated the efficiency and accuracy of using mobile phone data to measure economic well-being in Rwanda and Afghanistan.

Burke et al. (2021) reviewed 11 studies that used ML models to predict economic livelihood and found that the models using satellite imagery had a high overall performance with reasonable accuracy in measuring economic livelihood. Moreover, these predictions can be obtained at regular intervals and at a fraction of the cost of conducting regular surveys. The authors also found that in most studies, satellite information explained 50 percent to 75 percent of the variation in survey-measured asset wealth and that this performance tends to improve over time and with the inclusion of high-resolution data.

Combining satellite data with other forms of data like CDR further improved the accuracy. In most cases, the satellite-based estimates performed equally as well or better than traditional survey-based measures. Newhouse (2023) found that studies that combined geospatial data with survey results had more precise poverty estimations than those relying solely on survey data to generate poverty statistics.

Chi et al. (2022) combined Facebook proprietary connectivity, satellite, and mobile phone data to create poverty maps for the 135 lower-middle-income countries at 2.4 km resolution. The model created by the authors could explain 50 percent to 70 percent of the actual variation in household-level wealth in lower-middle-income countries. In another study, Tingzon et al. (2019) created a poverty map of the Philippines using satellite imagery and OpenStreetMap. The ML model developed by the authors explained approximately 63 percent of the variation in asset-based wealth.

These studies demonstrate that AI and new data types can significantly benefit poverty estimation, often matching or exceeding survey-based assessment. Furthermore, utilizing AI is more cost-effective than conducting surveys, which require extensive financial resources and time-consuming efforts. The World Bank should incorporate AI and alternative data like satellite imagery and mobile metadata to complement surveys to generate poverty statistics.

Conclusion

This study described how that AI can significantly enhance the efficiency and effectiveness of development projects across several sectors. Specifically, it explored seven sectors that receive significant funding from the World Bank: agriculture, health care, education, finance, energy, infrastructure, and data. The findings show that many organizations in developing countries are successfully utilizing AI to address various challenges in these sectors.

For instance, AI is used in agriculture to combat crop diseases and pests, optimize irrigation, and manage crops based on local weather and soil patterns. In health care, AI is used for predicting tuberculosis patients, digital imaging, managing depression and anxiety, and disease surveillance. Educational organizations use AI to provide personalized learning support to students, help children with autism spectrum disorder learn, and assist job seekers in evaluating their skills. Finance organizations use AI to build credit scores for individuals and companies outside the formal credit system using nontraditional

data sources such as phone records, text messages, and social media data. AI is used in energy and infrastructure to improve the efficiency of energy usage, as well as inspection and maintenance of road, rail, power, and water infrastructure. The study identified several research papers and a World Bank-funded project showing the potential of using AI and alternate data sources such as satellite imagery and call records data to estimate poverty statistics.

This study demonstrated that AI's impact extends beyond the private sector, and the development sector can benefit significantly from its use. It also highlighted that many organizations in low-income and lower-middle-income countries already use AI technology to tackle challenging problems in various development sectors. However, the World Bank lags in financing and supporting projects that use AI in most sectors. Given AI's transformative potential in improving project efficiency and effectiveness, the World Bank must fund more projects that exploit AI to address various development problems. While AI may not be a panacea for all challenges faced by the development sector, it is an essential tool that can make a significant difference.

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