



Data and Artificial Intelligence as Tools to Fight Poverty: Some Notable Applications in Agriculture and Health Care

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About 4 billion people in the world are poor or vulnerable to falling into poverty. This article presents an overview of data and artificial intelligence applications to address agriculture- and health care-related challenges facing this population.

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In 2018, about 4 billion people in the world were poor (household income/day of less than US\$1.90) or vulnerable to falling into poverty (household income/day of US\$1.90–US\$11).¹ This bottom 4 billion population, which mainly lives in low- and middle-income countries (LMICs), could benefit as much from transformative innovations, such as those related to data and artificial intelligence (AI), as much as, if not more, than rich consumers living in high-income countries.

Data and AI are being used to address health, social, humanitarian, economic, and environmental problems facing LMICs. The availability of open sourced AI such as TensorFlow; diffusion of smartphones; and rapid reduction in the costs of hardware, data storage, and data transmission are facilitating the development of AI applications to benefit low-income people in LMICs. These developments have facilitated a wide range of economic activities. For instance, AI's business value in

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Africa is expected to surpass US\$45 billion by 2025.² In this article, we present an overview of data and AI applications to address agriculture- and health-care-related challenges facing low-income people in LMICs.

DATA AND AI IN IMPROVING THE WELFARE OF SMALLHOLDER FARMERS

Data and AI are likely to help about 500 million smallholder farms worldwide, which employ more than 2 billion people and produce about 80% of the food products consumed in Asia and Africa³ in many different ways. For instance, AI-based tools can be used to increase crop productivity. Smallholder farmers are less likely to be manipulated by dominant value chain actors due to the increased accuracy of measurements of their crops' quality- and sustainability-related indicators with AI-based tools. All of these increase the likelihood of receiving fair payment for their products and services.

ENHANCING NEAR-TERM CROP PRODUCTIVITY

Simpler and user-friendly AI tools are available to help predict near-term crop productivity for smallholder farmers. For instance, PlantVillage is a free smartphone app that is being used in Kenya and other African countries to diagnose diseases in crops such as cassava and potato. The app provides a diagnosis with a high level of accuracy by talking with an AI assistant, Nuru ("light" in Swahili).⁴ In a test of machine learning models in the typical high light and temperature settings of an African farm, the app was found to perform twice as well as human experts in making accurate diagnoses. The United Nations (UN) Water Productivity through Open access of Remotely sensed derived data (WaPOR)⁵ portal is the main data source for the PlantVillage Nuru. The WaPOR

database uses NASA satellite-derived data and computes relevant metrics for crop productivity. Other databases incorporated in the PlantVillage Nuru include weather forecast data; a soil dataset for Africa; and the UN Crop Calendar, which is a series of algorithms on adaptive measures that can be taken under certain conditions.⁶ By integrating diverse data, the AI assistant can provide information about crops' drought tolerance and the suitability of crops in different areas.⁷

The app uses TensorFlow, which is Google's open sourced AI.⁸ The app's early application has been to help farmers in Africa identify fall armyworm infections.⁹ Not much technical knowledge or literacy is needed to use the app. Farmers point a phone at the crop with a disease. PlantVillage has been adopted by the UN's Food and Agriculture

page.¹³ In this way, the app provides a real-time view of the infestations across maps of Africa to help other app subscribers.⁴ In Kenya, the PlantVillage AI tool is used to send messages using short message service to farmers across the country.⁶

MEASURING THE QUALITY OF FARM PRODUCTS IN AN ACCURATE AND PRACTICAL WAY

Farmers are vulnerable to exploitation by middlemen and other supply chain partners due to the inherent difficulty of directly measuring the quality of farm products. Currently, middlemen make decisions regarding the quality of commodities such as coffee. They have an incentive to downgrade the quality. Middlemen prefer vague and imprecise measures

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Organization (FAO). It monitors the spread of the voracious caterpillar in around 70 countries. The Nuru uses machine learning and AI to tell a farmer if a worm is damaging crops. It also provides information to stop the pest. Nuru runs on standard Android phones.¹⁰

When farmers connect their devices online, the Fall Armyworm Monitoring and Early Warning System (FAMEWS) mobile app uploads the collected data. As of early 2019, there were about 10,000 registered users of the FAMEWS system, which was available in 13 languages.¹¹

The data are validated by national fall armyworm focal points and are subsequently added to a global database.¹² Anyone can freely access the database from the FAO Fall Armyworm home

of quality. They often set the prices of these products and make decisions as to how much and when farmers growing the crops are paid.¹⁶ In the current supply chains, there is a challenge in accurately measuring the quality of commodities such as coffee.

Denver, CO, USA-based startup Bext360 combines AI with other technologies such as satellite images, blockchain, and AI to track coffee supply chains. Bext360's kiosks in Uganda evaluate coffee beans using its Bextmachines. A Bextmachine is a Coinstar-like device that employs smart image recognition technology machine vision, AI, the Internet of Things, and blockchain to grade and track coffee beans. It takes a 3D scan of each bean's outer fruit.¹⁷ Bextmachines analyze farmers' coffee cherries

and coffee parchment deposited at collection stations and sort them to assess quality. Farmers who supply bigger and riper cherries are paid more. Bext360's systems store data related to the time, date, and location of transactions and amount of payment. Bext360's systems also include indicators related to sustainable sourcing and satellite images to show if producers are polluting the water.¹⁸

BEING REWARDED FOR ENGAGING IN SUSTAINABLE FARMING PRACTICES

Multinational computer technology corporation Oracle has partnered with the World Bee Project, which monitors bees to tackle the pollinator and pollination crisis, to help farmers manage bee populations and pollinator habitats. The plan is to take images of the farm with drones or

In the coffee industry, for instance, costs related to paperwork and physical inspection are estimated to be as high as US\$0.91 per pound of coffee. Likewise, coffee bean quality is mostly determined by cupping, which is used to evaluate various aspects of a coffee sample. A cupping session involves different senses, such as taste, smell, and feel. The goal is to differentiate coffees from one another.²⁰ The process is manual and is carried out by the industry's certified tasting experts. It is an expensive and time-consuming process. Cupping is not affordable to most of the world's 12.5 million smallholder farmers accounting for 60% of the world's coffee beans. They cannot determine or manage the quality of their crop.²¹

Agriculture tech startup Demetria aims to transform this process using

as size, shape, and color. The company is also working with the Colombian National Federation for Coffee Growers [Federación Nacional de Cafeteros (FNC)] to develop apps for farmers, which are likely to help them track bean quality and price their beans.²³

DATA AND AI IN IMPROVING HEALTH OUTCOMES

Four billion people in the world lack access to basic health services.²⁴ The global shortfall in health workers is expected to exceed 12.9 million by 2035.²⁵ AI solutions can address an overburdened health-care system in LMICs and help achieve three primary goals of a health-care system: a) to keep people healthy; b) to treat people who are sick; and c) to provide affordable, efficient, and cost-effective health-care services.²⁶

AI's direct benefits in LMICs also stem from the democratization and decentralization of medical knowledge and excellence. Medical AI has surpassed even the world's best medical professionals in delivering medical breakthroughs.

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satellites and utilize AI-based image recognition algorithms to evaluate whether the way a farmland is managed supports bee colonies and other pollinators in a sustainable way.¹⁹ Research has indicated that farms that allocate a certain proportion of their land to plant flowering crops such as spices, oil seeds, buckwheat, and sunflowers can increase crop yields by up to 79% due to efficient pollination from bees. An eco-label certificate can be issued to farmers depending on the farm composition. The certification can be stored in a blockchain so that all supply chain partners can see it (for example, during the farm product's journey to the retailer).

PROVIDING A LOW-COST WAY OF DEMONSTRATING THEIR PRODUCE'S QUALITY

Farmers often find it difficult to demonstrate the quality of their farm products.

AI. Instead of using human experts, Demetria's sensors read the biochemical markers of taste.²² The process involves the scanning of green coffee with a handheld device. The collected data are sent into the cloud for analysis using AI. The device uses near-infrared sensors, which shine different wavelengths of light onto green coffee. Each wavelength interacts differently with different organic compounds inside the bean. These interactions are measured and interpreted by the AI system, and a "sensory fingerprint" is created. The "sensory fingerprint data" are sent to a cloud-based intelligence platform, which matches the bean profile to the industry standard coffee flavor wheel. Note that the coffee flavor wheel, which was first developed in the mid-1990s, helps coffee professionals test and evaluate different coffee flavors. It also monitors biochemical markers such

INCREASED ACCESS TO HEALTH-CARE SERVICES

AI has become an increasingly powerful tool to increase access to health-care services in LMICs. One such solution is Germany-based Ada Health GmbH's chatbot symptom checker app. As of May 2020, Ada's chatbot symptom checker app had attracted 9 million users worldwide, including 3 million in LMICs.²⁷ In a study of the eight most popular online symptom assessment apps, the most comprehensive app was Ada (with the ability to cover all possible conditions and user types), which provided a condition suggestion in 99% of the cases.²⁸

The app is free to download. Users input symptoms and preexisting medical conditions. AI-based questioning then pinpoints possible diagnoses and recommends the next steps, such as resting or seeking professional help.²⁹ Ada Health has been working in Tanzania

since 2017, partnering with the Swiss philanthropic organization Fondation Botnar. Tanzania has one doctor per 25,000 people. Ada Health partnered with Botnar to launch a localized version of its app in Swahili in 2019.³⁰ The Ada app is reported to optimize 160 disease models to ensure that the app correctly factors in the conditions and symptoms that are more common in Tanzania and East Africa compared to other parts of the world.³¹

COPING WITH THE SHORTAGE OF SPECIALTIES SUCH AS OPHTHALMOLOGY AND RADIOLOGY

AI is likely to have a powerful impact on areas such as ophthalmology and radiology. Several AI apps use images of human eyes so that practitioners, technicians, or even patients can diagnose possible diseases. They no longer need the expertise of ophthalmologists. This is especially important for low-income people in LMICs who lack access to health specialists.³² According to the World Health Organization, about 70 million Indians suffer from diabetes and also face the risk of blindness. There are only 11 eye doctors for every 1 million people. The Aravind Eye Hospital (AEH) based in Madurai in the South Indian state of Tamil Nadu uses AI to diagnose the risk of blindness known as *diabetic retinopathy*, which is among the leading causes of blindness.

The AEH uses neural networks as a new screening method. By analyzing millions of retinal scans with signs of diabetic blindness, a neural network learns to identify the blindness conditions.³³ In a pilot project, nurses in the AEH's 70 satellite clinics, known as *rural teleconsultation centers*, captured the images of patients' retinas. The photos are uploaded onto the cloud, where AI works in combination with the specialists to detect and diagnose the disease.³⁴ The algorithm can diagnose the problem in a few seconds. The machine learning algorithm can detect problems that eye doctors could not.³⁵ As of

2018, about 2,000 patients were benefiting from the service.

In 2021, the AEH also introduced the AI-based Smart Vision Spectacles (SVS), which is claimed to help visually impaired people move around with more confidence. The SVS costs ₹22,000 (US\$292). The wearer can listen to texts in English and 73 Indian regional languages. It is fitted with two devices that look like a USB pen drive. One of the devices has a camera that can capture images within 2 m and warns of obstacles. It stores images and details of people who are known to the wearer. If a person is in the vision line, it identifies the name and other details of the person.³⁶

FIGHTING FAKE DRUGS

The Nigerian startup RxAll's AI-based handheld device fights fake drugs, which is a US\$200 billion industry.³⁷ It assesses a drug's compound by connecting the device to a cloud-based database. The database contains informa-

tion related to what the drugs should contain. The information is sent back to an app on the phone. The database is updated using AI. It has been used in Myanmar. The company also plans to enter into other LMICs, such as Ghana, Cambodia, and Kenya.¹⁴

RxAll's handheld authenticator RxScanner is used by patients to verify their drugs. The RxScanner can identify the quality of a prescription drug in 20 s. It displays results in real time via mobile apps.¹⁵

Data and AI applications, although at a nascent stage of development, are already bringing positive economic, health, and social outcomes among low-income people in LMICs. The costs and ease with which

such applications can be developed and deployed are making them increasingly accessible to low-income people. For instance, just like in high-income countries, people in LMICs can freely download and use AI-based online symptom assessment apps (for example, Ada). Developments in AI are making it possible to access similar apps to assess specific diseases such as diabetic retinopathy, stroke, bone fractures, and Alzheimer's.

Some challenges, however, remain. For instance, it would be unreasonable to expect that most farmers easily change their farming practices and switch to AI-based apps to take actions. As noted previously, however, when more farmers adopt AI-based solutions and increase their farm productivity, other farmers in their social circle are also likely to adopt them.

Where there currently are some barriers, these are not insurmountable, and progress is being made in overcoming these obstacles. It is the responsibility

Denver, CO, USA-based startup Bext360 combines AI with other technologies such as satellite images, blockchain, and AI to track coffee supply chains.

of diverse stakeholders—governments, nongovernmental organizations, international development organizations, academic institutions, the private sector, and others—to ensure that marginal groups also benefit from this transformative innovation. 

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