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AI and Robotics:
Implications for Poverty and
Marginalization

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AI and Robotics Implications for the Poor

Joachim von Braun

Abstract

Artificial intelligence and robotics (AI/R) have the potential to result in great change of livelihoods. While individual impacts of AI/R on, for instance, employment, have been subject to a lot of research, how AI/R may affect the poor is scarce. This paper aims to draw attention to how AI/R may impact the poor and marginalized and highlights research needs. A thought experiment compares the future situation of the poor in an AI/R scenario to a scenario without AI/R. A framework is established that depicts poverty and marginality conditions of health, education, public services, work, small businesses including farming as well as voice and empowerment of the poor. This conceptual framework identifies points of entry of AI/R, and is complemented by a more detailed discussion of the way in which changes through AI/R in these areas may relate positively or adversely to the livelihood of the poor. This paper concludes that empirical scenarios and modelling analyses are needed to better understand the different components in the emerging technological and institutional AI/R innovations and identify how they will shape the livelihoods of poor households and communities.

1 Introduction

Artificial intelligence based on the utilization of big data, machine learning, and applications in robot technologies will have far-reaching implications for economies, the fabrics of society and culture. It can be expected that artificial intelligence and robotics (AI/R) offer opportunities but also have adverse effects for the poor segments of societies and the effects will differ for specific applications of AI/R. The implications of AI/R for poverty and marginalization are so far not much studied, but are important for ethical considerations and AI/R related policies.

A framework of opportunities and risks is considered here for conceptualizing this review. The thought experiment shall aim to compare the future situation of the poor without AI/R versus with AI/R. In other words, in order to derive potential implications for the poor, a theoretical framework is needed that captures the structural and dynamic factors shaping incomes and livelihood capabilities of the poor without AI/R and that identifies points of entry of AI/R as well as their impact on poor households and communities. Such a framework is outlined in Section 2. There are several caveats to such framing. For instance, the field of AI/R is quickly developing bringing about changes of limited predictability. Uncertainties furthermore surround potentially changing regulatory regimes and policies that will frame AI/R innovations and applications.[1] It is important to also stress that "the poor" are not at all a uniform set of people but that this descriptor denotes a highly diverse group whose composition changes over time, for which reason the AI/R impacts on diverse groups of the poor will differ. Poverty and inequality effects will also be context-specific across countries, partly depending on infrastructures. AI/R may theoretically reduce poverty while increasing inequality or vice versa.

Key areas particularly relevant for poor people's livelihood in that they are likely to be significantly impacted by AI/R in the medium and long term are *education, health, financial and public services, employment, small businesses incl. farming, natural resources management, voice and empowerment*. These key areas form the structure of this review. In the final section, some policy measures will be discussed that might contribute to pro-poor AI/R innovations and applications.

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[1] It is important to highlight that access to ICTs supporting infrastructure for the poor (incl. network coverage, speed, costs) is very unequal. The Pontifical Academy of Sciences addressed this issue in a conference: *Connectivity as a Human Right*, 10 October 2017, Scripta Varia 140, Vatican City, 2018. Further information on costs and connectivity are, for instance, available regarding the network speed by country (SPEEDTEST n.d.)), the expansion of the 4G coverage (McKetta 2018)), the Price Index (ITU 2019), and further figures on global digitalization (Kemp 2018). Moreover, the gender bias has to be kept in mind when reflecting on benefits and challenges of AI/R for the poor and marginalized. Research found that women have less access to ICTs, especially in areas where many of the poor live. Compared to men, women in South Asia are 26% less likely to own a mobile phone and 70% less likely to use mobile internet. In Sub-Saharan Africa, the shares are 14% and 34%, respectively (GSMA 2018).

2 A framework of AI/R impacts on the poor and marginalized

There has been significant progress in the reduction of poverty in the developing world over the past few decades. In 1990, 36% of the world's people lived in poverty (income of less than US$1.90 a day in 2011 purchasing power parity (PPP)). By 2015, that share had declined to 10%. The number of people living in extreme poverty stood at 736 million in 2015, indicating a decrease from nearly 2 billion in 1990 (World Bank 2018). This progress is the result of various factors, including economic growth reaching the poor and, in many countries, an increase in attention to social protection policies. The capacities to design and implement social protection policies have become more widespread over the past two decades, thus contributing to a more effective poverty reduction. This review of potential AI/R impacts on the poor pays particular attention to Sub-Saharan Africa because the region currently accounts for most of the world's poorest, whose absolute number in Sub-Saharan Africa is increasing (World Bank 2018). At the same time, Sub-Saharan Africa has the world's youngest population being home to over 200 million young people (aged between 15 and 24 years) who can quickly learn and adapt to new technologies such as AI/R.

Being poor is not defined just by lack of income. Critical for well-being are access to education, to basic utilities, health care, nutrition, and security.[2] In Sub-Saharan Africa, low levels of consumption and high levels of food insecurity are often accompanied by challenges in nonmonetary dimensions. Poverty is to a great extend a matter of structural forces such as exclusion, discrimination and the deprivation of rights, governance deficiencies and corruption, and the forces of ecological change that increase the vulnerability of the poor as many of them depend on natural resources living at the margins in rural areas or in high-risk margins of urban areas. These aspects are captured by the concept of marginality.[3] Marginality encompasses broader approaches such as relative deprivation and social exclusion or the capabilities approach. Furthermore, relative deprivation builds on the idea that the value of objective circumstances depends on subjective comparisons (Stark and Bloom 1985). The relative deprivation concept adds an important dimension to absolute poverty concepts because it involves comparisons with other people. AI/R may change the patterns of comparing one group of people with "others". Such comparisons may include the comparison of people aided by robotics with others not having access to a specific robotics aid, or even a direct comparison of people and robots, for instance when robots take on tasks, which had previously been taken care of by low-income workers. Certainly, AI/R will change patterns of relative deprivation.
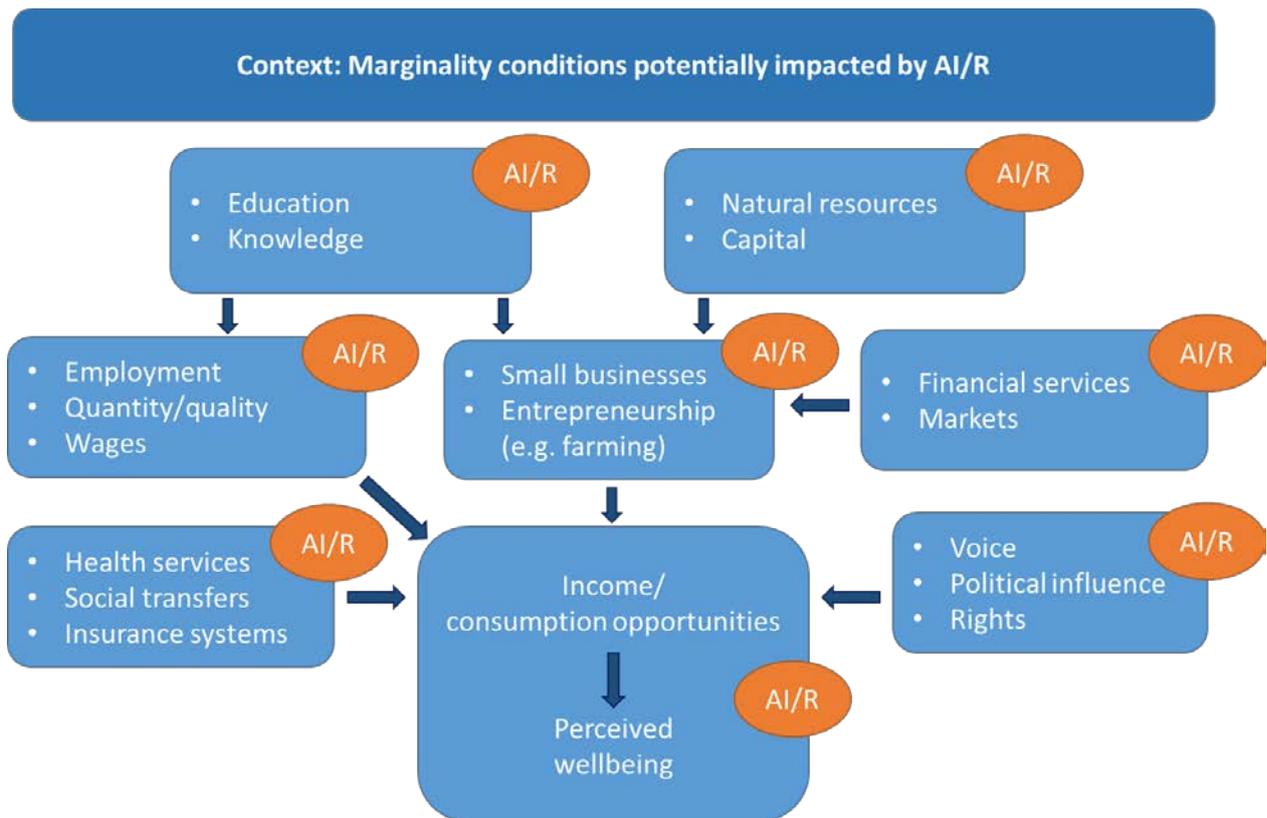
2.1 A framework

Following the above-mentioned framing, Figure 1 outlines a set of factors influencing poor households and their members' wellbeing. Each of these factors as well as the forces determining marginality may be impacted by AI/R as depicted within the building blocks of Figure 1. There are many potential points of entry for AI/R on the different dimensions of this framework. Naturally, these emerging, disruptive technologies bring about both opportunities and risks for poor households.

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[2] Such a multidimensional view of poverty has been adopted by the World Bank and it is found that, "[a]t the global level, the share of poor according to a multidimensional definition that includes consumption, education, and access to basic infrastructure is approximately 50 percent higher than when relying solely on monetary poverty" (World Bank 2018, p. 9).

[3] Marginality can be defined as "an involuntary position and condition of an individual or group at the margins of social, political, economic, ecological, and biophysical systems, that prevent them from access to resources, assets, services, restraining freedom of choice, preventing the development of capabilities, and eventually causing extreme poverty" (von Braun and Gatzweiler 2014).

Figure 1: Framework for assessing the impacts of AI/R on poor people

Context: Marginality conditions potentially impacted by AI/R

- Education
- Knowledge

AI/R

- Natural resources
- Capital

AI/R

- Employment
- Quantity/quality
- Wages

AI/R

- Small businesses
- Entrepreneurship (e.g. farming)

AI/R

- Financial services
- Markets

AI/R

- Health services
- Social transfers
- Insurance systems

AI/R

Income/ consumption opportunities

- Voice
- Political influence
- Rights

AI/R

Perceived wellbeing

AI/R

Source: designed by author

Walking through the framework of Figure 1 starting in the middle, the influence of **employment** and **small businesses and entrepreneurship**, respectively, on the **income and consumption opportunities** are of significance. Mobility costs in general will be reduced and opportunities for mobility may also improve for the poor. Labor tends to be the most important asset of the poor. Thus, employment and small enterprise opportunities have a key influence on income and consumption of poor households. One of the great concerns about robotics expresses a labor-force perspective and worries about the potential employment effects. Theoretically, this concern may be derived from the classical model designed by Arthur Lewis (1954; cf. Polanyi Levitt 2008). Lewis' model assumes an unlimited supply of unskilled labor while the opportunity cost of labor determines wages in the modern sector. More specifically, the model supposes a traditional working environment of peasants, artisanal producers, and domestic servants, which is subjected to population pressures. This situation in the traditional sector grants the modern sector "unlimited supplies" of labor, with the wage exceeding the subsistence level only by a small margin. As the modern sector expands, employment and output as well as the share of profits in national income rise. At a certain point, the surplus labor from the traditional sector is exhausted, which leads to the wage rate increasing as productivity further rises. Within the context of AI/R technologies, however, this so-called Lewis inflection point may no longer be reached in emerging economies if there were to evolve an unlimited "robot reserve army" which competes with the labor force of the poor (Schlogl and Sumner 2018). Anxieties result from this scenario.

As a prerequisite for improved access to remunerative employment and business opportunities, **education and knowledge** of poor people are essential. Improving households' education and knowledge base does not only affect the quantity and quality of work but also their wages. Furthermore, **natural resources and capital** play an important role in shaping business opportunities and entrepreneurship. AI/R is likely to have deep impacts on these linkages.

Improving poor people's **access to services and markets**, such as financial, health, and insurance services or social transfers, is another driving factor in increasing and stabilizing poor households' income and consumption opportunities and their wellbeing. AI/R may influence these service sectors and their operations, for instance, by lowering access barriers.

As mentioned above, how (poor) people perceive their situation is heavily influenced by how they view themselves in relation to others, i.e. by how they assess their relative deprivation. By strengthening people's **voice and political influence**, their perceptions as well as their actual wellbeing can be positively influenced. AI/R contributions could be immense in improving accountability and transparency of governments for their citizens, thus ensuring greater service delivery and empowering local development actors and policy makers.

2.2   Opportunities of data and information systems about poverty

The lack of reliable data in developing countries is a major obstacle to planning and investment in sustainable development, food security, and disaster relief. Poverty data, for example, is typically scarce, sparse in coverage, and labor-intensive to obtain. Remote-sensing data such as high-resolution satellite imagery, on the other hand, is becoming increasingly available and inexpensive. An important contribution of AI to poverty reduction is the enhanced capability to **identify the poor**. Data and innovative machine learning-based identification strategies already are advancing to provide a more up-to-date and well-defined information base compared to traditional household surveys or indicator systems (e.g., Zurutuza 2018). For instance, night time lights are substantially correlated with economic wealth. In addition, automated processes can be used to identify - based on satellite images - the roof material, source of light, and access to water sources, to derive households' economic situation. Such data may enable timely interventions by providing real-time alerts to take timely actions.

Mirza (2018) outlines the processing of data on poverty in a "Knowledge Discovery in Databases" for a data mining approach. Jean et al. (2016) propose a machine learning approach to extract large-scale socioeconomic indicators from high-resolution satellite imagery. They suggest a learning approach in which nighttime light intensities are used as a data-rich proxy and train a model to predict nighttime lights from daytime imagery simultaneously with learning features that are useful for poverty prediction. The model applies filters that identify different terrains and structures, including roads, buildings, and farmlands. These learned features are informative for poverty mapping and approach the predictive performance of household survey data collected in the field.

Jean et al. (2016) demonstrate the usefulness of AI for estimating consumption expenditure and asset wealth from high-resolution satellite imagery. Using survey and satellite data from five African countries—Nigeria, Tanzania, Uganda, Malawi, and Rwanda— they show how a convolutional neural network can be trained to identify image features that can explain up to 75% of the variation in local-level economic outcomes. This could transform how to track and target poverty in developing countries (Jean et al., 2016, p. 790). In addition, accurately mapping populations can inform infrastructure planning. Facebook, for instance, has set itself the goal to develop the most detailed population density maps by using satellite imagery, machine learning algorithms, and population statistics (Bonafilia et al. 2019). Maps for Africa have already been completed[4] and maps for the rest of the world are expected to be added in the near future (Singh 2019). Such information can help to ensure that connectivity and other infrastructure reaches the entire population even in remote, sparsely populated areas.

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[4] Available at https://data.humdata.org/dataset/highresolutionpopulationdensitymaps

3 Education and knowledge links with AI/R

AI/R may be of great benefit to the poor to the extent that these technologies enhance their access to education and knowledge, upskill their capabilities in the labor market, and increase their income earning capabilities in small businesses and farming. However, education systems tend to directly and indirectly exclude or marginalize the poor: directly through school fees or low quality education in poor communities, and indirectly through a lack of time on the part of the children and other constraints on the part of the parents in poor communities. Time constraints arise for millions of children that work besides participating in schooling; when excessive time is spent at work, education suffers and life-time earnings are reduced as Mussa (2018) shows for cohorts of rural child laborers in Ethiopia. The inequalities tend to grow with levels of education, i.e. secondary and tertiary levels. Girls remain underrepresented in these levels leading to gender gaps (von Braun 2018). Digital literacy constraints may additionally inhibit the acquisition of skills by use of interactive distance learning systems empowered by AI. Still there are new opportunities through AI/R in education which foster the inclusion of the poor.

Du Boulay et al. (2018) argue that AI technologies can assist both educators and learners by providing personalized support for students, offering tools for teachers to increase their awareness, and freeing up time to provide nuanced, individualized support. Nye (2015) reviews intelligent tutoring systems (ITS) targeting the developing world. An interesting example from Kenya is the "Kio Kit" (BRCK n.d.), a fully integrated education platform designed in Kenya which turns a school room into a digital classroom using tablet computers, wireless tablet charging and securing the tablets in a hardened, water-resistant, lockable case. Such education platforms empowered by AI when accessible by the poor in marginal rural areas could make a big difference in the future. However, barriers to use ITS need to be addressed, including students' basic computing skills and factors like hardware sharing, mobile-dominant computing, data costs, electrical reliability, internet infrastructure, language, and culture (Nye 2015).

AI-assisted translation and speech recognition may hold great potential for the poor by overcoming barriers of language and illiteracy. Google's speech-to-text service, for instance, uses neural network models to convert audio to text, including several languages of relevance to the poor, such as Swahili, Zulu, Cantonese, Mandarin, and several Indian languages (Google Cloud 2019). These technologies could substantially increase access to information and services for disadvantages groups. For now, the data requirements to train machine learning algorithms or neural networks still pose an obstacle to including less commonly spoken languages. However, as more and more written and spoken material is being digitalized and made accessible online, big data analytics will become increasingly efficient and further improve over time.

4 Health services for the poor facilitated by AI/R

The poor have difficulties to claim their rights to public services. The health sector is particularly interesting for AI/R applications, given the ongoing digitalization of all types of health data and health information. The long-term potential for advancing the field of digital health and precision and personalized medicine can be immense when AI/R supported medical and public health decision-making reduces costs (Ciechanover 2019). Yet, these innovations still tend to be far from reaching the poor. Fernandez-Luque and Imran (2018) find that while there are many examples of the use of artificial intelligence in **health services and humanitarian assistance**, they are largely limited to outbreak detection while their application in low-income countries or areas in crisis is under-researched. The International Telecommunication Union (ITU 2018) has established a new Focus Group on "Artificial Intelligence for Health" (FG-AI4H, 2019) in partnership with the World Health Organization (WHO). The governance and delivery of health and care services are usually the responsibility of a government – even when delivered through private providers and health insurance systems. Standardized assessment frameworks with open benchmarks for the evaluation of AI-based methods for health, such as AI-based diagnosis, triage or treatment decisions, are under consideration; as these developments bring down costs, they may enhance poor people's access to health services.

There are clear advantages for **worker health** from AI/R, for instance, when unhealthy work tasks can be handed over to robots. Pesticide spraying in fields is an important example, including the drone-based detection and mapping of insect infestations at micro level for optimal targeting. A similar safety-enhancing example is the employment of AI technology to improve the safety of mining workers by reducing their intensity of work and exposure to risky assignments.

Another important area of application with particular relevance to the poor is the detection and prevention of **malnutrition**, which is one of the leading causes of infant mortality in developing countries. Khare et al. (2017) designed a prediction model for malnutrition based on a machine learning approach, using the available features in the Indian Demographic and Health Survey (IDHS) dataset. Their findings suggest that this approach identifies some important features that had not been detected by the existing literature. Another example is the Child Growth Monitor app developed by the German NGO Welthungerhilfe which identifies malnutrition in children using inbuilt infrared cameras for scanning and machine learning to correlate the scan with anthropometric measures (Welthungerhilfe 2018). The app was pre-tested in India and the results are promising. It may replace the manual measures of weight and height, which are costly, slow, and often inaccurate. Apps also offer targeted nutritional advice directly to households. Numerous nutrition apps already exist which monitor food intake and provide dietary recommendations to its users. One available feature of these apps, which is enabled through deep learning, is the tracking of macronutrient content by taking a photo of the meal to be consumed. In the future, these apps may be used for personalized dietary advice and tailored health messages also in developing countries. In this way, smartphone apps can be a low-cost intervention for improving dietary quality and health even in remote areas with limited access to dieticians or health workers.

AI-enabled **diagnostic tools** could improve health services in remote areas (Wood et al. 2019). These technologies could support self-diagnosis or assist health workers. For example, researchers at Stanford University have trained an algorithm to diagnose skin cancer from images (Kubota 2017). AI-technologies also enable a faster detection of emerging epidemics such as Ebola or Zika (Wood et al. 2019). It will be important to ensure that AI technologies are adapted to poor people's needs and characteristics. Research has shown that using training data from specific population groups may exclude some social groups (Gershgorn 2018). Moreover, diagnostic tools will only be useful if they are complemented with improved access to treatment for the poor.

5 AI-assisted services and social transfers

A large share of the poor lack access to formal financial services such as banking, credit or insurance. In 2017, only one third of adults in rural Sub-Saharan Africa owned a bank account and only 5% held a loan from a formal financial institution (World Bank 2019a). Similarly, only few smallholders in the region held crop insurance in 2016 (Hess and Hazle 2016). AI could assist in particular in facilitating access to credit and insurance for the poor.

Banks are often reluctant to provide **loans** to low-income households because they are unable to assess the risk of loan default. AI-based systems can assist in credit-scoring by using data collected by mobile phones, such as call-detail records, social network analytics techniques or credit and debit account information of customers (Óskarsdóttir et al. 2019), and combining them with agronomic, environmental, economic, and satellite data. M-Pesa (M is for mobile, "pesa" is Swahili for "money") is a noted mobile finance application, which started in Kenya in 2007. M-Pesa allows people from all around the country, even in the most remote areas, to transfer money directly, saving considerable amounts of time and money. In 2018, about 70% of the adult population of Kenya was registered. While M-Pesa is not AI based, it facilitates recording even small business and farm performance and financial transactions including productivity, expenses and revenues, and thus facilitates that customers can build their credit profiles. This big data combined with machine learning contributes to obtaining reliable data based on which lending decisions for small borrowers can be made.

AI could also assist in the provision of **insurance** to a large number of dispersed, low-income customers by providing high-quality data, minimizing uncovered basis risk and lowering cost delivery mechanisms. In view of climate change and the related increase in weather risks, important areas are weather services and weather risk insurances building upon AI-enhanced weather observation and monitoring at pixel levels.[5] For instance, index-based insurance using remote-sensing data has shown to be promising as a means of providing crop insurance products in areas and to customers that were previously out of reach (De Leeuw et al. 2014; Coleman et al. 2017). AI can also help to monitor or develop efficient index-based insurances for pastoralists by predicting livestock mortality sufficiently in advance to ensure ex-ante asset protection insurance.

In recent years, **social protection programs** including cash transfers to the poor, some of them implemented with certain conditions such as children's school participation, and labor-intensive public works programs (PWPs) have expanded in many countries. By combining different datasets, machine learning can contribute to increasing the efficiency of targeting social interventions and improving the identification of the extent of humanitarian responses in the course of crises. For instance, PWPs benefits are sometimes obscured such that PWPs become deficient, e.g. when not targeting the intended beneficiaries or due to leakages related to corruption. The main objective of PWPs is to provide social protection to the working-age poor by transferring cash or in-kind to beneficiaries to protect households' consumption while at the same time promoting savings and investments in productive assets, the generation of public goods, and the provision of trainings to support rural transformation. AI-based tools can enable real-time monitoring by facilitating the collection, processing, management, validation, and dissemination of data for operations, accountability, and policy decision making. In the case of vast PWPs in India, the development of a management information system (MIS) to support program processes and structures ensured more reliable and on-time management of big data that come from multiple sites and levels of program implementation, thus minimizing errors, frauds, and corruption (Subbarao et al. 2013).

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[5] Aerobotics (South Africa) is an example for machine learning on aerial imagery to identify problems in crop yields (World Wide Web Foundation 2017).

6 AI/R effects for the poor in employment, small business, and smallholder farming

The impact of AI/R on employment is perhaps the most widely debated issue when it comes to distributional effects of these technologies.[6] The main concern relates to the loss of jobs for low-skilled labor, which is of particular relevance to the poor. The capacity to work is the key asset of the poor, be it in the labor market, or as small entrepreneurs in the service sector, or in the small-farm sector.

Emerging economies face a challenge of **employment** generation. Advances in industrial automation and labor saving technologies could further exacerbate this trend. Schlogl and Sumner (2018), in adaption of the above-mentioned Lewis model of economic development, use a framework in which the potential for automation creates "unlimited supplies of artificial labor" particularly in the agricultural and industrial sectors due to technological feasibility. This is likely to push labor into the service sector, leading to a further expansion of the already large and low-productive service-sector employment. Gries and Naudé (2018) assess these issues by incorporating AI-facilitated automation with modelling to allow for demand-side constraints and thereby finding less adverse effects for employment. Acemoglu and Restrepo (2017) distinguish two potential effects. First, robots may displace and thereby reduce the demand for labor (displacement effect). Through linkages within global value chains, workers in low-income countries may also be affected by robots in higher-income markets, which could reduce the need for outsourcing such jobs to low-wage countries overseas. As a result, low-skill, labor-intensive industrialization, as observed in many East Asian countries, may no longer be a promising development model. Second, robot use could increase the demand for labor either by reducing the cost of production which leads to industry expansion (price-productivity effect) or by increasing total output overall (scale-productivity effect). The key question from a poverty and distributional perspective will be which jobs are replaced and which are generated. Policies should aim at providing the necessary social security measures for affected workers while investing in the development of the necessary skills to take advantage of new jobs created. This is easier said than done especially for the poor who start often from a very low level of education.

Small businesses can grow rapidly thanks to digital opportunities, expanding their boundaries and reshaping traditional production patterns. The rise of digital platform firms means that technological effects reach more people faster than before. Technology is changing the skills that employers seek. Ernst et al. (2018) point out that opportunities in terms of increases in productivity can ensue, including for developing countries, given the vastly reduced costs of capital that some applications have demonstrated and the potential for productivity increases, especially among low-skilled workers. Makridakis (2017) argues that significant competitive advantages will accrue to those utilizing the Internet widely and willing to take entrepreneurial risks in order to turn innovative products/services into commercial success stories.

A large proportion of the poor live on **small farms**, particularly in Africa and South and East Asia. Digital technologies, services, and tools can offer many opportunities for smallholder farmers to make more informed decisions, and to increase productivity and incomes. Key benefits of digitalization include greater access to information and other services including finance, links to markets, a sustainable increase in productivity, and better informed policies.[7] Examples are:

- Land ownership certification: In many developing countries, land rights are unclear and contested. Smartphones, cameras or drones, which can capture geospatial and topographical

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[6] See, for instance, Acemoglu and Restrepo (2017); Chiacchio et al. (2018); Frank et al (2019); Korinek (2019); Korinek and Stiglitz (2017), also published in Agrawal et al. (2019); and Marin (2018).

[7] A study on 81 countries revealed significant positive effects of an increase in ICTs adoption on agricultural productivity already at the early stages of digitization (Torero and von Braun 2005; Lio and Liu 2006). Substantial progress was made in this regard in the past decade.

data – using, for example, Global Positioning Systems and global navigation satellite systems – are therefore useful tools for land mapping and land tenure programs. If this geospatial data and land transaction history is saved through blockchain technology, land registries could become extremely robust.

- Precision technologies: including big data, satellite imagery, sensors, robotics, drones, etc.[8] For instance, in South Africa, the drone startup Aerobotics is using drone technology and AI to assist farmers in optimizing their yields, thereby greatly contributing to cost reduction. In Kenya, AI and big data analytics provide useful information about farming trends and productivity based on data that is generated through soil analysis. Another AI-assisted application is image recognition to diagnose plant diseases, to offer information about treatments, and to monitor the spread of diseases based on photos of the plant taken with a smartphone.

- Farm machineries: tractors mounted with sensors and connected to mobile platforms allow users to remotely capture farm information related to soil, water, and crop conditions, to calibrate usage of inputs accordingly, and to monitor progress. Innovative models such as "uberization" of tractors and farm machinery, which make farm machinery available on rent and make mechanization more effective and affordable for the farmers, are gaining popularity in developing countries.

- Innovations in irrigation and energy: Solar-driven micro irrigation systems can help reduce energy costs and when connected to the grid, allowing farmers to benefit from selling generated surplus energy. AI/R complex system-based algorithms help to build efficient water systems for communal irrigation or optimization of water resources, distribution, and infrastructure planning, for instance.

- ICTs platforms connecting buyers and sellers: a virtual market platform in India, enhancing farmers' access to critical information related to weather, soil health, market prices, and finance. This enables farmers to plan their farming activities, project the potential output and hence bargain for better prices. The data collected by such platforms can be analyzed using AI tools in order to inform decision-making, for instance on which crops to plant depending on demand or price trends or on government investments in logistics infrastructure.

The challenge lies in the effectiveness of these technologies in addressing the field level issues and making these applications user friendly for poor farmers. Hence, the focus needs to be on integrating several of these applications in user-friendly platforms designed with in-built data interpretation and predetermined actions to equip users with end-to-end solutions.

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[8] This section draws on Ganguly et al. (2017),

7 Voice and empowerment

To the extent that AI/R take functions that are currently occupied by poor and marginalized people, these technologies may have adverse effects for their rights and entitlements, and ─ by extrapolation ─ their capacities to influence social and economic policies may suffer. However, if new AI/R functions were usable or even come under control of marginalized and poor people, they might become more empowered. The latter *direct* effect will be more likely if collective actions by the poor are facilitating access at scale to specific AI/R applications such as AI-facilitated land rights, or R-facilitated drone technologies reducing hazardous work on farms.

Yet, so far, there remain huge digital gaps between the rich and the poor, and it may remain the same in the field of AI/R applications for long, thus limiting direct benefits of AI/R for the poor. More impactful may be *indirect effects* of AI on voice and empowerment through social media, given the weight of poor populations in political decision making, including elections or protest movements. The World Wide Web Foundation (2017) emphasizes that "… AI present a tremendous set of opportunities and challenges to human well-being [but] there is also concern that AI programs and decision-making systems supported by AI may include human biases, leading to further discrimination and marginalization" (p.3). Indeed, algorithms and neural networks are not neutral, but are shaped by the data used for training. Caliskan et al. (2017) show that machine learning can take on biases, for example with regard to race or gender when trained with standard textual data from the web. As a result, AI-enabled technologies risk reinforcing existing inequality. There are initiatives that aim to change this, such as the "Whose Knowledge?" initiative which defines itself as a "… global campaign to center the knowledge of marginalized communities … on the internet."[9] They work particularly with women, people of color, communities like Dalits in India, and others to create and improve related content.

Regarding privacy and access to information rights, the poor are particularly threatened because of their current lack of power and voice. **New forms of regulating the digital economy** are called for that ensure proper data protection and privacy, and help share the benefits of productivity growth through a combination of profit sharing, (digital) capital taxation, and a reduction in working time. Investments in skills need to be enhanced, and the enabling business environment strengthened to include the poorer and more vulnerable groups (World Bank 2017).
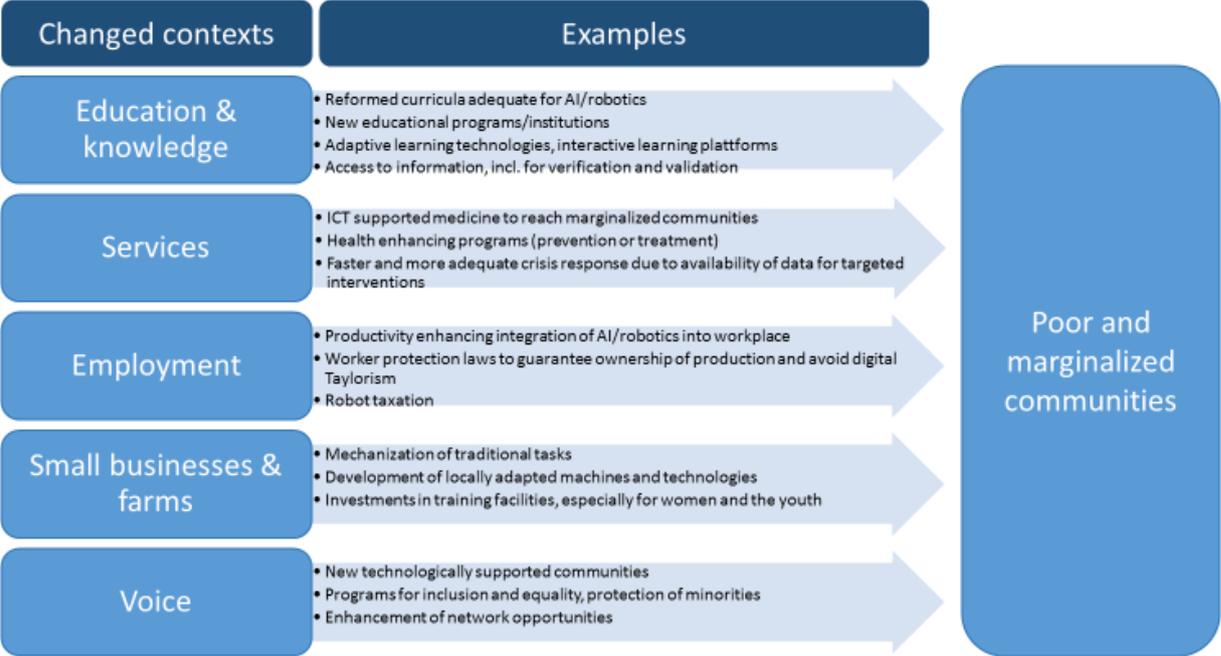
Another important dimension to consider is the impact of AI on human autonomy or agency as information provision and decision-making is handed over to seemingly intelligent machines. This may be a particular concern for the poor and disadvantaged who often have limited access to alternative information sources.

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[9] https://whoseknowledge.org/

8 Policy conclusions

A broadly based **policy agenda** will be needed to include the poor and marginalized in opportunities of AI/R and to shield them from adverse effects. A policy framework is presented in Figure 2. For each of the five areas of influence that were identified in Figure 1 earlier, a set of possible action is listed. For instance in health, AI/R-supported precision medicine may be an example in the long run. In the labor market, a digital and robot tax may theoretically be considered. Bruun and Duka (2018) present a means to mitigate future technological unemployment through the introduction of a basic income scheme, accompanied by reforms in school curricula and retraining programs.

Figure 2: Policy action options for pro poor AI/R

Changed contexts	Examples
Education & knowledge	• Reformed curricula adequate for AI/robotics • New educational programs/institutions • Adaptive learning technologies, interactive learning plattforms • Access to information, incl. for verification and validation
Services	• ICT supported medicine to reach marginalized communities • Health enhancing programs (prevention or treatment) • Faster and more adequate crisis response due to availability of data for targeted interventions
Employment	• Productivity enhancing integration of AI/robotics into workplace • Worker protection laws to guarantee ownership of production and avoid digital Taylorism • Robot taxation
Small businesses & farms	• Mechanization of traditional tasks • Development of locally adapted machines and technologies • Investments in training facilities, especially for women and the youth
Voice	• New technologically supported communities • Programs for inclusion and equality, protection of minorities • Enhancement of network opportunities

Poor and marginalized communities

Source: designed by author

The EU Parliament's European Economic and Social Committee (EESC) declared, "Given the danger of social polarisation in the digital transformation, the EESC is calling on the EU institutions to begin a debate on financing public budgets and social protection systems in an economy with increasing numbers of robots, as taxation on labour is still the main source of tax revenue in Europe. In order to apply the principle of fairness, this debate should consider the redistribution of the benefits of digitalization" (Art. 1.13).

AI/R risks for employment and the poor calls for investing in human capital in order to build the skills in demand in the labor market. In addition, governments need to enhance social protection and extend it to all people in society, irrespective of the terms on which they work. To fund these investments in human capital and social protection, the tax base would have to increase, and that is a serious constraint for low-income countries. At the same time, the development of AI/R technologies compatible to the needs of the poor needs to be on the agenda of social businesses and NGOs. There is a need for more collaboration of AI/R specialists with social scientists to arrive at pro-poor AI/R.

To conclude, there are opportunities and risks of AI/R for the poor and marginalized. AI/R are not neutral in terms of their poverty and distributional effects. Research on the distributional implications of AI/R are not getting sufficient attention. The AI/R opportunities are mainly expected by richer

segments of society but as this situation is changing, for instance with employment in the banking sector, the attention to distributional effects of AI/R will increase. Empirical scenarios and modelling analyses are needed to better understand the different components in the emerging technological and institutional AI/R innovations and identify how the will shape the livelihoods of poor households and communities. Fascination with AI/R must not divert attention from poverty and marginality, but explicitly pay attention to the outcomes for the poor, and focus on inclusive artificial intelligence and robotics.

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