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Intersectoral Convergence and ICTs

Integrated ICT Approaches to Rural Poverty Reduction

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Abstract

As reforms have paved the way for India's rapid economic expansion in recent years, particularly in the service sector, Information and Communications Technology (ICT) has assumed a dominant role as the underwriter of India's growth. Outside of the commercial applications where ICT has been most extensively applied so far, ICT also holds great potential to drive human development, narrowing gaps between the rich and the poor as well as rural and urban areas. In many development-adjacent sectors, particularly education, agriculture, and health, platforms and initiatives have already demonstrated ICT's promise as a transformational suite of technologies which democratize information and dramatically reduce transaction costs.

However, even greater progress is possible if initiatives apply an intersectoral approach which applies best practices from other sectors, highlights synergies between sectors, and identifies pitfalls stemming from hidden competition of priorities between sectors that could otherwise derail a project. Intersectoral analysis also recognizes how advances in the sectors under study contribute to growth in the broader economy. By applying an intersectoral lens, individual programs can be strengthened, new opportunities can be identified, and ICT can be more thoroughly woven into a tapestry that benefits all aspects of people's lives.

ICT-driven development has not entirely ignored intersectorality, but opportunities abound for improving these initiatives by applying a more holistic lens. In particular, the field of nutrition is most sorely in need of mainstreaming within the many different siloed development objectives that touch upon it. Data, the foundation of ICT, provides great opportunities for refining programs of all types, but also carries great risks to privacy and potentially social equality. And untapped synergies exist between the cutting-edge advances in the Education sector and educational initiatives in other sectors which have not benefited from the same intentional pedagogical design.

Background: India's Development Challenges

Economy-wide Issues

Since an economic liberalization program rescued the country from the brink of crisis in 1991, India has experienced consistently high levels of growth. Incentives for foreign investment, a more open import/export system, and market deregulation have paved the way for economic expansion, particularly in the service sector. Further reforms in key areas, such as land acquisition, labor laws, exit policy and greater decentralization in decision-making authority from the federal to the state governments could have the potential to boost India's growth even further.

However, a rising tide has not lifted all boats. Economic growth has largely fueled and been fueled by increased consumption by the wealthy, which has been reflected by rising income inequality over the past 30 years. Extreme poverty has beaten a hasty retreat in the past two decades, but insecurity remains for hundreds of millions of poor Indians in the form of unreliable income and employment, inadequate access to health services, uneven education quality, and increasingly unpredictable climate patterns. For these groups of people, particularly the rural poor, systems must be put in place to eliminate hurdles to participating in the healthy growth which the country has otherwise enjoyed.

Information and Communications Technology (ICT) represents the best toolkit for involving these excluded citizens in the development of their country. A set of technologies, tools and platforms which eliminate or dramatically lower barriers to participating in any type of transaction, ICT can catalyze the inclusion of regions and populations previously written off by the market economy as not being cost-effective enough to provide services to. Through improved service delivery, simplified access to quality resources, reduced search costs, and smart data analytics, ICT provides a suite of applications that together drive more inclusive, equitable and sustainable development.

Agriculture

One of the largest sectors of the Indian economy, agriculture accounts for 49% of the employment and one-sixth of the GDP. The green revolution, starting in the mid-1950s, ushered India from food insecurity and dependence on imports to food self-sufficiency. But as global population and demand for food rise, the sector must deliver lower prices to consumers by reducing waste and improving supply chain management, developing "smarter" agriculture, and incentivizing farmers to increase their production.[1]

India's National Policy for Farmers identifies ICTs as one of the frontier technologies for overcoming the aforementioned issues in agriculture. There is a general agreement that use of ICTs and digitization in general leads to increased efficiency and reduces transaction time and costs. ICTs comprise a wide spectrum of applications and devices ranging from radio, television and telephone to more sophisticated and emerging technologies like smartphone applications, multimedia messaging platforms like WhatsApp, drones, blockchain, Machine to

[1] World Bank 2017. ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. Updated Edition. Washington, DC: World Bank

Machine [M2M], Internet of Things [IoTs], cloud computing, Big Data and data analytics, and satellite networks. Digitization has provided the capability for convergence of the traditional network technologies which, when combined with data availability, appropriate applications and the right enabling environment, can unleash the tremendous innovation potential of the agriculture sector responsibly.[2]

Health

E-health is defined as "the cost-effective and secure use of ICTs in support of health and health related fields, including health care services, health surveillance, health literature and health education, knowledge and research.[3] ICT has played a crucial role in revolutionizing the way healthcare is delivered in India by providing more efficient ways of accessing, processing, communicating, sharing and storing health care information. Through ICTs, health care service delivery has become more accessible in rural areas. ICTs help reduce medical errors and improve patient compliance, patient security, and overall data protection. ICT also acts as a catalyst for speedy delivery of healthcare services, makes it possible to put data to use in real time, and can help reduce the operational cost of healthcare and related administrative services. As a result, ICTs have helped improve the safety, efficiency, timeliness, transparency, reliability, accuracy, accessibility, affordability and equity of healthcare delivery.

In the health sector, ICTs offer a vast array of possible application areas. Mobile technology, notable for its low cost and user-friendly nature, is being applied for purposes such as data collection, community health worker training, and early warning and agent mobilization. E-consultation through telemedicine is helping expand health care delivery to remote regions with poor infrastructure. Monitoring of real time healthcare data has been made possible through web-based technologies like Health Information Systems. Electronic Health Records (EHRs) help track patient data throughout the treatment cycle. Geographic Information System (GIS) and GPS have applications in areas such as risk mapping and disease surveillance. Other potential applications of ICT in health include, but are not limited to, health promotion, behavior change communication, supply chain management, tracking of vital events, and management of healthcare finances.

E-Health has undoubtedly catalyzed the transformation of health systems, but numerous challenges remain. Geographic and socio-economic factors influence internet connectivity, availability and accessibility. Technology is creating a digital divide between those who have access to it and those who do not. The high cost of ICT interventions makes their implementation a challenging task in low-resource contexts, and funding ICT interventions for healthcare delivery purposes remains a major concern. Currently, ICT applications are fragmented with a lack of interoperability. Issues related to breached confidentiality of health records have also surfaced, inhibiting the development of common registration systems and unique patient identifiers which remain non-existent to date. Health workers also currently lack the organizational and technical capacity to apply ICT solutions in rural areas, while additional political, social and cultural factors continue to pose a challenge to all ICT interventions. Given the technical, financial, organizational, and cultural challenges, sustainably scaling up e-Health initiatives requires intense efforts, coordination and planning.

[2] FAO and ITU 2016. e-Agriculture Strategy Guide: Piloted in Asia-Pacific countries. Bangkok
[3] http://apps.who.int/gb/ebwha/pdf_files/wha58-rec1/a58_2005_rec1-en.pdf.

Education

Over the last two decades, India has remarkably transformed its education landscape. With well-planned expansion and a student-centric learning-driven model of education, India has not only improved its enrollment numbers, but is also gradually enhancing its learning outcomes. At the same time, the Indian education system faces pressing issues inhibiting its potential to fully contribute to India's inclusive growth. There is a need for quality teachers, career-relevant curricula, financial aid for students, and adequate facilities to meet the diverse linguistic, cultural, regional and local education needs of such a large country.

India has been striving to resolve the longstanding tension between excellence and equity through targeted and judicious applications of ICT tools to address the above challenges. According to the 2016 National Policy on Education, "*ICT should be made an integral part of school education where it is used as an aid to teachers and students. Teachers have to gradually become facilitators and encourage self-learning by students…ICT can no longer be treated as a school subject; it has to become a way of learning process…Use of IT for 'big-data' as a management and governance tool. It is suggested that a designated national agency should be encouraged to conduct experiments in regard to potential use of ICT in the field of education, and also monitor various initiatives being taken all over the country*." With a national shift having taken place from simply providing education to all to ensuring a quality education for all, ICT has become a focal point of efforts to sustainably provide the best possible education to all students.

Monetary and Time Benefits of ICT

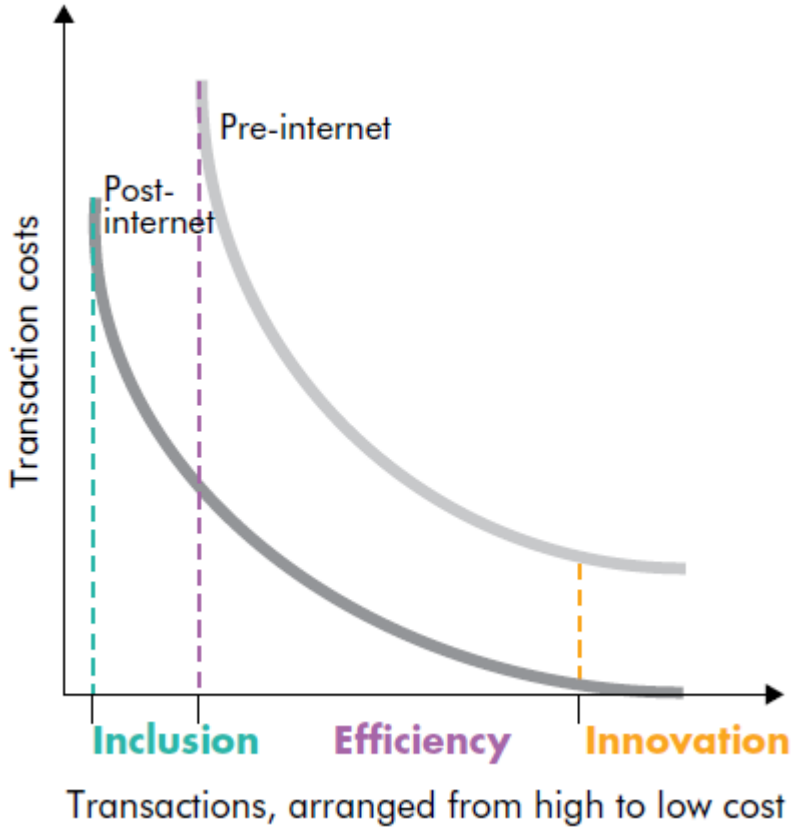

Figure 1: The effects of falling transaction costs

Source: World Bank (2016).

ICT yields significant time and monetary benefits to those who use it, as the above figure illustrates. Technologies ranging from simple telecommunications to the internet have steadily yet dramatically reduced search and transaction costs, to the point of becoming nearly non-existent in a digital environment. As a result, three phenomena have taken place:

i. Inclusion: transactions which were formerly prohibitively expensive are made affordable and cost-effective through the use of ICT, expanding the market.
ii. Efficiency: transactions which took place under obsolete means become cheaper, faster or more convenient thanks to new technologies, yielding gains in productivity.
iii. Innovation: when the marginal cost of individual transactions becomes almost negligible, resources are freed up for additional innovation in the economy.

Thus, ICTs can promote inclusion, induce efficiency and lead to innovation in the economy, thereby benefiting all stakeholders.

Sustainable Agriculture

Agriculture is a very important sector of the Indian economy, accounting for 49% of the employment and one-sixth of the GDP. Information and communication have always mattered in agriculture, as updated information allows farmers to benefit through better and informed decision making. Public agencies have long sought, with limited success, to identify effective ways to share information with farmers in order to advise them on all aspects of the agricultural cycle from pre-sowing to post harvest. ICTs have emerged as a very strong tool to share information with farmers effectively, efficiently and at minimal cost.

The three major applications of ICT in agriculture are:

- Empowering farmers through better communication and knowledge sharing;
- Providing insurance, finance, remote sensing, weather prediction, and other supplementary services;
- Improving the efficiency of the agriculture supply chain and expanding market access for farm inputs and post-harvest to the benefit of farmers.

A review of the existing literature on this subject suggests the need to develop decision support systems for farmers. Such comprehensive information systems, which would provide customized advisory for the choices individual farmers face such as which crops to sow, when to sow, when to harvest, and whether to instantly sell or go for storage, all within the context of a developing country dominated by highly risk-averse smallholder farmers, are yet to emerge. ICT provides a set of tools for addressing this gap.

ICT, especially mobile phone-based communication, can be a tool of choice for introducing customized decision support systems relevant at the level of the individual farmer. However, building such a system requires all information about the farmer and his field such as soil type, soil health, climatic conditions of that area, market conditions, crop prevalence, irrigation, farmer's economic situation, and risk absorption capacity. All of the above information, when processed with respect to individual context, can be compiled to provide advisory services which can help the farmer in his/her crop choice, harvesting, and sale schedule. The effectiveness of such a decision support system depends directly on the accuracy of the data being fed into the system. ICT can play a huge role first in the collection and generation of such data, and then in the communication of such advisories (based on scientific analysis of these data) which farmers can use for their benefit.

New Approaches to Data Collection

Soil

The 2007 National Policy for Farmers states that soil health enhancement holds the key to raising farm productivity. In keeping with this policy, the Soil Health Card (SHC) scheme was launched by the central government in February 2015, revolving around issuing "Soil Cards" to farmers detailing crop-wise recommendations of nutrients and fertilizers required for individual farms. 107 million farmers were provided SHCs in 2015-16 to 2016-17 and close to 85 million farmers have been provided SHCs in the present cycle (2017-18 to 2018-19)[4]
Features of the SHC scheme and soil sampling include:

[4] https://soilhealth.dac.gov.in/publicreports/dashboardtargetreport

- Soil samples drawn on a grid approach of 2.5 ha in irrigated areas and 10 ha in rain-fed areas;
- Analysis of twelve soil health parameters including primary nutrients (NPK), secondary nutrients (S), micronutrients (B, Zn, Mn, Fe, & Cu), and other factors (pH, EC &OC);
- Implementation of unified soil sampling criteria;
- Application of GPS-based soil sampling to create a systematic database and allow monitoring of changes in soil health over the years.

Data from the SHC scheme is compiled on the Soil Health Card Portal,[5] which has been created for registration of soil samples, recording test results of soil samples and generation of SHCs along with fertilizer recommendations. The SHC Portal promotes uniform adoptions of location codes aligned with the Census, allowing uniform panel data to be generated. The sample tracking feature embedded in the system provides alerts to farmers about sample registration and SHC generation through SMS and e-mail. The SHC Portal aims to generate and issue SHC-based General Fertilizer Recommendations under the advisory of state governments. Based on test results, these recommendations are calculated automatically by the system. The SHC program represents the first step in developing a single national database on soil health for future use in research and planning.

At the state level, Karnataka is taking the lead in preparing a Land Resource Inventory (LRI) for site-specific planning and development of watersheds on a scientific basis under the Sujala-III project sponsored by the Watershed Development Department of Karnataka and funded by the World Bank. The LRI comprises soil health and water parameters captured plot wise in a systematic manner through ICT-based techniques such as remote sensing, GIS and GPS. By interfacing land resource data with spatial data, the LRI allows analysts to consider various management scenarios to optimize land usage. Following this, the initiative will issue proactive advice to promote the well-being of farmers and the sustainable usage of natural resources.[6] The LRI is currently being implemented in 11 districts covering 9.66 lakh[7] ha across 2531 micro watersheds, benefiting 7.02 lakh households in the state.

Weather

In India, five day weather forecasts are made available at the district level via a national portal for farmers.[8] Immediate extreme weather alerts are also made available at the block level and SMS advisory is triggered to registered farmers for the same.

Karnataka, in addition to leading the country in data collection for soil health, is also a pioneer in the field of weather monitoring and forecasting. The Karnataka State Natural Disaster Monitoring Centre (KSNDMC) has taken up path breaking initiatives such as designing and installing a dense network of Solar Powered and GPRS enabled Telemetric Rain Gauges (TRG) stations. This network covers all 5625 Gram Panchayats and Telemetric Weather Stations

[5] www.soilhealth.dac.gov.in
[6] Hegde et al., "Site-specific land resource inventory for scientific planning of Sujala watersheds in Karnataka." Current Science, 2018.
[7] One lakh is 100,000
[8] Portal available at https://www.farmer.gov.in/WeatherReport/weatherreport.aspx

(TWS) within all 747 Hoblis (administrative division comprising a number of adjoining villages in Karnataka) in the state.

The key features of the KSNDMC weather system include:

- Automatic data collection every 15 minutes around the clock and throughout the year from all stations;
- Generating and disseminating high-resolution weather forecasts through SMS to farmers at the Panchayat and Hobli level;
- Varuna Mitra, an interactive help desk to answer public queries via telephone on weather forecasts at the Panchayat and Hobli level.[9]

Land Use and Ownership

Maintaining land use and ownership records is the responsibility of state governments in India, some of which have excelled and some of which have lagged. Digitization of land and revenue records is currently being undertaken by the states under the Digital India Land Records Modernization Program (DILRMP). Data available through September 2018 reveals that while 87% of villages have computerized records, transfer of ownership records have been computerized in only 50% of villages. Moreover, only 20% of villages had computerized the record-of-rights, which records possession[10].

However, there are a few pioneer states in India in this regard. The state of Karnataka is a leader in several aspects related to digitisation of land records, digitisation of crop survey data collection and also in automated weather data collection and forecasts (through KSNDMC). Under its Bhoomi portal,[11] all land related documents such as Record of Rights, Tenancy and Crops (RTC) or Pahani, and Mutation Reports were digitized and are being made available to citizens and farmers, accessible even in rural areas through dedicated Kiosk Centres. In another state, Andhra Pradesh, one recent technology-led pilot in partnership with the Swedish startup ChromaWay applies blockchain technology to the maintenance of land records, eliminating fraud and errors and greatly reducing the administrative burden of land registration and title transfer.[12]

Sustainable Public Health

E-Health is an umbrella term comprising many ICT services including telemedicine, mobile health (mHealth), Electronic Health Records (EHRs) and Health Information Systems. Each of these ICT interventions have brought their own bundle of benefits to healthcare.

Healthcare Access

m-Health

m-Health, or mobile health, is defined as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, Personal Digital Assistants

[9] Reddy and Prabhu, 2016, Natural Disaster Monitoring System – Karnataka Model
[10] https://theprint.in/opinion/indias-woeful-land-records-will-have-trouble-identifying-a-farmer-eligible-for-rs-500-month/188360/
[11] https://landrecords.karnataka.gov.in/service2/RTC.aspx
[12] https://chromaway.com/cases/

(PDAs), and other wireless devices."[13] m-Health is radically expanding the capacity to deliver health care services to far and remote regions. m-Health involves the use of voice and short messaging services (SMS), general packet radio service (GPRS), 3G and 4G mobile telecommunication systems, GPS, and Bluetooth technology.[14] Mobile technology seems to touch on all facets of health care delivery systems. Mobile phone calls can be used to seek help in emergency situations, text messaging can act as an early warning system, and handheld devices can collect, collate, transfer and disseminate data in real time. m-Health can also play a crucial role in outbreak investigation and infectious disease management.[15] CommCare Mobile, an international mobile platform, is being used by front-line workers to gather data in the field, communicate with other healthcare workers, and send SMS reminders to beneficiaries. Be He@lthy, an ITU-WHO m-Health initiative, also harnesses the potential of mobile technology to address the burden of non-communicable diseases across the globe.[16] Other mobile apps used to make healthcare delivery more efficient include mSwasthya Patient Monitoring, Safe Pregnancy and Birth, DHIS-2, and NewBornCare.

Telemedicine

Telemedicine literally means distance healing. It is defined as "the delivery of healthcare services, where distance is a critical factor, by all healthcare professionals using ICTs for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for continuing education of healthcare providers, all in the interests of advancing the health of individuals and their communities.".[17] Telemedicine involves the use of computers and telecommunication systems to provide health care services, especially in rural and remote regions which are isolated from the mainstream. It provides accessibility to specialized health care services in emergency situations and helps reduce cost and time involved in travelling to health facilities. The integration of telemedicine with GIS can also assist in epidemiological surveillance. Telemedicine's potential for detecting, treating and providing follow-up care to cancer patients is currently being explored by the twin initiatives ONCONET-Kerala and ONCONET-India.[18]

Health Data Management, Collection and Tracking

Health Information Systems

Health Information Systems "collect data from health sector and other relevant sectors, analyze the data, ensure their overall quality, relevance and timeliness, and convert data into information for health-related decision making." [19] As per WHO, the four key functions of Health Information Systems are data generation, compilation, analysis, communication and information use. Health Information Systems are also being used for the purposes of disease surveillance and building capacities of health workers.

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[13] World Health Organization. 2005. "58th World Health Assembly Report." Geneva: WHO. http://apps.who.int/gb/ebwha/pdf_files/wha58-rec1/a58_2005_rec1-en.pdf.
[14] https://www.who.int/goe/publications/goe_mhealth_web.pdf
[15] https://doi.org/10.1038/s41586-019-0956-2.
[16] World Health Organization and International Telecommunication Union, 2017
[17] Bhowmik, Debjit, S Duraivel, Rajnish Kumar Singh, and K P Sampath Kumar. 2013. "Telemedicine- An Innovating Healthcare System In India." *The Pharma Innovation* 2 (4): 20.
[18] https://doi.org/10.4172/2167-1079.1000260
[19] https://www.who.int/healthinfo/statistics/toolkit_hss/EN_PDF_Toolkit_HSS_InformationSystems.pdf

Existing Health Information Systems in India

- **Integrated Disease Surveillance Project (IDSP) Portal:** a web-based portal facilitating online reporting of disease surveillance data under the Integrated Disease Surveillance Program (IDSP). The IDSP program is one of the National Health Programs launched in November 2004 under the National Health Mission (NHM), and is currently running in all States and UTs in India.

- **Mother and Child Tracking System (MCTS):** a centralized web-based application launched in 2009 and developed by the National Informatics Centre (NIC). MCTS is an initiative by the Ministry of Health and Family Welfare to leverage ICT to deliver a full spectrum of healthcare services to pregnant women and their children up to five years of age.

- **eHMIS (Electronic Health Management Information System):** a web based digital initiative under the NHM designed to collect, collate and analyze health-related data from the lowest health facility to the national level.

- **Nikshay:** a web-based platform which helps keep track of Tuberculosis patients and monitor the performance of India's TB program. Nikshay has been implemented at the national, state, district, and Tuberculosis Unit (TU) levels.

- **NAMMIS (National Anti-Malaria Management Information System**): a web-based platform set up by the National Vector Borne Disease Control Programme (NVBDCP) to track and periodically review Malaria indicators.

Emerging Health Information Systems in India

- **Digital LifeCare:** a web and Android-based platform built by Dell which will be used by health departments in public sector across the country to facilitate deployment of auxiliary nurse midwives (ANMs) as well as the screening and management of non-communicable diseases (NCDs). Initiated as a pilot in the state of Karnataka in 2014, it has been customized since 2017 to be deployed in all States and UTs across India.
- **National Health Stack (NHS):** a visionary digital framework supporting various health verticals and their branches at the national and state levels in both the public and private domain. Though conceptualized within the context of the Pradhan Mantri Rashtriya Swasthya Suraksha Mission (PM-RSSM) under Ayushhman Bharat Yojna, NHS will be designed beyond PM-RSSM as a holistic platform.

E-health Records

Electronic Health Records (EHRs), also called as Electronic Medical Records (EMRs), are a systematic collection of patient records in digital format. "An Electronic Health Record is a long term record for a patient, detailing his or her involvement with individual healthcare organizations and episodes of care…Electronic Health Records aggregate patient-centric health data from the patient record systems of multiple independent healthcare

organizations".[20] EHRs help share patient data with different organizations for various purposes including patient care, decision making, planning, and research. As a key component of the "e-hospital," EHRs maintain e-records through the patient treatment cycle including patient registration, lab testing, pharmacy, accounts, and discharge.[21]

Sustainable Education

Education for sustainable development is about equipping individuals, community groups, businesses and government to live and act sustainably, as well as giving them an understanding of the environmental, social and economic success involved. UNESCO aims to improve access to quality education in sustainable development at all levels and in all social contexts, transforming society by reorienting education and helping people develop the knowledge, skills, values and behaviours needed for sustainable development. By integrating sustainable development issues, such as climate change and biodiversity, into teaching and learning, individuals are encouraged to be responsible actors who resolve challenges, respect cultural diversity and contribute to creating a more sustainable world.

Beyond educating individuals in sustainable development, sustainable education must also be socially inclusive by necessity. India has succeeded in maintaining high enrolment figures in its schools, but serious disparities in education quality continue to exist within the country. ICT provides various solutions for addressing this inequality and providing all students regardless of location, social status, or age access to a quality education that will allow them to equitably participate in the economies of the future.

Quality Education in Rural Schools

The stagnant state of rural education itself has been a major concern for educational policymakers in India. Pratham's Annual Status of Education Report (ASER) 2016 revealed that despite increased enrolment, a significant proportion of children in Classes 1 to 8 in government and rural private schools could not read text suitable for Class 2 students or do simple arithmetic their age-group may be expected to do. The high rate of dropouts—nearly 50% by age 14—compounds this problem. ICT holds great promise for education, especially in rural areas, if it is optimized and tailored to local needs. India's ICT Policy in School Education is inspired by ICT's tremendous potential for enhancing outreach and improving education quality, as demonstrated by early innovator teachers. The ICT Policy in School Education aims to prepare youth to participate creatively in the establishment, sustenance and growth of a knowledge society leading to all-round socioeconomic development of the nation and global competitiveness.

MHRD's flagship initiative for improving education quality at the secondary level, Rashtriya Madhyamik Shiksha Abhiyan (RMSA), itself features an ICT component centered around creating computer labs within schools and introducing computers directly to classrooms. In the research and non-profit space, prominent Computer-Assisted Learning (CAL) projects in India include Pratham's CAL program in Mumbai and Vadodara, a randomized trial from 2000 which found measurable improvements in math and language skills at primary schools receiving computers and trainings on integrating them into education. Another prominent initiative was Media Lab-Asia (ML-A), a 2002 partnership between MIT's Poverty Action Lab

[20] S. Ramanathan. 2014. "Role and Pros & Cons of ICT in Health Care Sectors in India" I (XVIV).
[21] Ali, Rubaiyat. 2014. "E-Gov Products and Services," January, 3.

and the central government which introduced a software platform to ten rural and ten urban locations in India. This CAL intervention found a significant impact on learning outcomes and computer literacy from Grade VII onwards. Bearing the results of this research in mind, RMSA has increasingly encouraged the direct incorporation of ICT-based education in the classroom by placing computers in classrooms, rather than standalone labs where they can easily be ignored.

In the last decade there have been plenty of initiatives launched across India by government or supported by government to promote the use of ICT in educational practices, focusing on teaching delivery, educational material, improving enrolment and overall community participation. The most established and widely used platform is DIKSHA (Digital Infrastructure for Knowledge Sharing). It was launched in September 2015 as a collaboration between the Ministry of Human Resource Development (MHRD), the National Council for Teacher Education (NCTE), and the EkStep Foundation as a state-level open and customizable digital education platform intended to host a comprehensive set of educational resources. DIKSHA has compiled a set of features intended to help teachers develop into more interactive and engaging educators. These are offered on a flexible platform currently supporting ten Indian languages that can cater to the varied educational needs of India's diverse population. EkStep also provides high levels of technological support to states working to develop their own ICT systems for education.

DIKSHA's core objective is to host Open Educational Resources (OERs) for schoolteachers, teacher educators and student teachers. Resources such as lesson plans, concept videos, and worksheets mapped to local curricula are offered in conjunction with personalized professional development training and assessments to aid teachers in identifying their strengths and areas of improvement. It also gives teachers the opportunity to contribute their own training content, classroom resources, and advice to a community that aims to reach five million teachers in India. DIKSHA's reach additionally makes it an excellent means of communication between teachers and institutions.

Some of the other ICT initiatives launched by government or private organizations in order to improve the quality of educational material, teaching delivery, enrolment statistics, and overall community participation include:

1. **Meghshala**: includes over 2500 "teachkits," multimedia modules aligned to the Karnataka state curriculum and prepared by master teachers. These lessons incorporate tested techniques that strive to provide inexperienced teachers with in-context training in applying best pedagogic practices to everyday teaching. Since teachers and schools may lack the familiarity or infrastructure to implement ICT-based education in their own classrooms, teachers are provided trainings in the technology and then given computers and solar powered projectors to use the platform in their classrooms as intended. It primarily targets government schools and low-income private schools in both urban and rural areas.
2. **Saransh**: a web portal introduced in November 2015 by the Central Board for Secondary Education (CBSE) to promote ICT usage in schools. The platform incorporates six loosely connected tools, including self-review tools, a data-driven decision support system for parents, hosting for e-books and other educational materials, a framework for interaction between teachers and parents, data uploading and real-time generation of performance statistics going back three years, and data visualizations to clearly present and explain these statistics. For CBSE affiliated schools, Saransh can help teachers and parents analyze student performance, monitor progress, and identify any necessary remedial measures.

3. **Firki**: an open-source online teacher training platform developed by Teach for India and dating back to 2013. The platform focuses on basic teacher competencies and pedagogical tools in close alignment with the formal B.Ed. curriculum. Rather than a purely online approach, Firki relies on a blend between online resources, such as readings, videos and assessments, and in-person facilitation and peer learning. Firki also encourages flexibility in training by dividing its content into modules for classroom instruction, leadership, school and community interaction, and the educational landscape, allowing teachers to access the content most closely aligned to their needs. Firki aims to train 50,000 teachers in India using the portal, directly impacting 196,500 children.
4. **eVidyaloka**: offers a unique solution to improving lower secondary education in rural schools by crowdsourcing volunteer teachers and bringing them to remote classrooms via digital infrastructure. Participating schools set up a digital classroom including an LCD screen, a camera, and a conference microphone, which are set up by community partners. Volunteer teachers use the local curriculum and language of instruction with a primary focus on mathematics, science and English.

The ICT revolution has ensured that learning is no longer restricted to classrooms and libraries. The availability of high-speed internet for every citizen, easy access to government e-services, and allocation of private space on the public cloud are some of the features that will revolutionize the lives of rural populations across India. While Digital India has been gaining momentum and digital access has become the focus of attention nationally, the best way to make rural India tech-savvy is to begin at schools. Despite considerable progress in the incorporation of ICT tools in education programmes, there is still a huge gap between aspirations and reality.

Intersectoral Convergence via ICTs for Sustaining Development Outcomes

Case Studies in Intersectoral Application

Universal Applications

Several ICT-driven initiatives and platforms in use domestically and internationally apply a holistic approach to support the simultaneous achievement of sustainable development across multiple sectors at once. Such integrated platforms, through their intersectoral nature, unlock synergies between areas of sustainable development that would otherwise go ignored. The general approach of these initiatives has been to collate data from across sectors and build e-governance systems around this information to manage competing interests in a systematic, data-driven fashion in collaboration with the relevant authorities.

The Smart Village Program is a cross sectoral initiative that harnesses the potential of ICT and leverages multi-stakeholder collaboration to accelerate the achievement of several Sustainable Development Goals (SDGs) –health, education, agriculture – at the same time. This system demonstrates how an integrated technology platform model can speed up the implementation of several SDGs in rural areas in a cost-effective manner, emphasizing the importance of breaking through siloed approaches to development in favor of integrated approaches. Launched in Niger in 2018, the Smart Village Initiative is supported by ITU in collaboration with the Niger Agence Nationale pour la Société de l'Information (ANSI) and other UN agencies. The project puts technology at the forefront of development by supporting the implementation of e-government systems that will make public services accessible, efficient and effective.

Vikaspedia is a knowledge portal launched by the Government of India in February 2014. It provides information related to six sectors, namely, education, agriculture, health, e-governance, social welfare and energy in 23 local languages. This multi-lingual system aims at providing information, products and services to the 'un-reached' poor communities in India. Vikaspedia was developed by the Ministry of Electronics and Communication, Government of India and implemented by Centre for Development of Advanced Computing (C-DAC) Hyderabad.

The Common Services Centre (CSC) Program is an initiative under the Government of India's National e-Governance Plan (NeGP). It catalyzes the use of ICT to deliver local services related to many sectors, including agriculture, education, and health, in rural areas. As per the CSC 2.0 Scheme, at least one CSC per Gram Panchayat is planned.

Agriculture Education Portals

Agriculture interfaces with education at two main levels. At the level of higher education, agriculture universities are responsible for training the country's future researchers and extension agents. These extension agents are then responsible for educating the country's vast population of farmers in agricultural and market best practices. ICT solutions have been implemented to streamline both levels of education within this system, but room for optimization based on best practices learned from the education field remains.

Higher Education

The Agriculture Education Portal, by the Indian council of Agricultural Research (ICAR) is an ICT initiative to strengthen higher agricultural education in India. It gives insight into various agriculture education platforms in India, updates of achievements in the agriculture-education domain, various agriculture education initiatives and reforms in the country, and much more. The system aims to maintain and improve the quality of higher agriculture education. One of its objectives is to establish an independent web-based integrated e-learning portal for agriculture education in India.

Outside of educating future specialists, one of the primary mandates of agriculture universities is research and development (R&D) aimed at raising agricultural productivity per hectare. Increased and sustained investment in agricultural R&D can help develop high yielding seed varieties designed for higher yields or resistance to disease, drought, pests and new technologies, and new management systems. Research can also develop new uses for products (such as dry land crops) to help stimulate demand. ICT can play a very important in taking these innovations to the farmer.

Agronomic Advisory Services

Agriculture is knowledge intensive. Farmers may require agronomic advice for many reasons, like when their crops are affected by disease or pests or when they encounter any other unexpected risk. Due to the huge diversity of Indian agriculture and the large number of farmers (approximately 145 million as per the latest Agricultural Census from 2015-16), catering to such information needs of the farmers at the individual levels is a challenge. In other words, agricultural extension at the individual farmer level remains an unresolved or at best partially

resolved aspect of Indian agriculture. In this context, an illustrative, noncomprehensive list of the many public and private initiatives using ICT for agronomic advisory, including startups, is detailed below.

Public Sector Initiatives

- **mKisan Portal**: disseminates government extension information and various topical and seasonal advisories to registered farmers, while providing additional native-language services via SMS. An agricultural value-added service (Agri-VAS), mKisan also offers access to two pull channels, an IVR menu, and a helpline upon purchase of a subscription package costing 1INR per day, purchasable in packs of 10, 20 or 30 days.[22]
- **Farmers' Portal**: compiles available public information on agricultural activities. Farmers can get information about package of practices, crop/seed varieties, common pests, seed dealer networks, fertilizers and pesticides, machinery and tools, and meteorological advisories.[23]
- **Soil Health Card Portal**: registers and maps soil samples, generating data on soil health and targeted fertilizer recommendations.
- **Kisan Call Centres**: allows farmers to make queries in their own dialect on a toll-free telephone hotline. Working in 14 different locations covering all the States and UTs, these call centres are open seven days a week from 6 AM to 10 PM nationwide. Recent additions to KCC services include technological features such as Voice Media Gateway, Dedicated Internet Bandwidth, Provision of Voice Mail during call waiting period and summary SMS services. Presently, farmer queries are answered in 22 local languages.

Private Sector Initiatives

- **Cropin**: uses remote sensing, AI, and ML to issue data analyses of crop health, pest and disease surveillance, and yield prediction to agribusinesses. Advisories are optimized for land parcels larger than 200 acres, so their clients are farming companies, FPOs, commodity traders and F&V exporters, agro seed and chemical companies, corporate CSR divisions, government bodies, NGOs, and development agencies which in turn provide and help their partner farmers with Cropin solutions.
- **Jayalaxmi Agrotech**: provides info about the crop cycle for a particular in audio and video format and local language through an app, which also compiles crop disease information and pest management, irrigation, and fertilizer needs.
- **Precision Agriculture for Development (PAD):** provides two-way communication with farmers via weekly voice messages sent to a farmer's mobile phone and by direct response to any agricultural question that a farmer logs. In collaboration with Coffee Board, PAD has also developed Coffee Krishi Taranga, an IVR-based digital mobile extension service. Any coffee planter with a feature phone will be able to access this service, which will provide customised information and services to coffee growers to increase productivity, profitability and environmental sustainability. They presently work in Orissa and Gujarat and with farmers affiliated with the Coffee Board of India.
- **PEAT**: provides plant disease and pest diagnosis through a smartphone application. The App captures geo-tagged photos of crop disease and/or pest attack and suggests remedies

[22] https://www.mkisan.gov.in/default.aspx
[23] The portal is available at https://www.farmer.gov.in/

instantly. Piloted and used in Andhra Pradesh, the app has 1 million downloads and works for 15 crops.

- **FarmBee**: provides info on 450 crop varieties, 1300 markets, and 3500 weather locations for farmers.
- **Agrostar**: implements a missed call solution and Android app for farmers to use for advisory as well as to buy agricultural inputs.
- **Nubesol**: a Crop Management Information System primarily developed for the sugarcane industry. Nubesol applies Remote Sensing to advise farmers on increasing farm productivity, reducing input costs, and finding harvesting and transportation solutions to minimize tonnage loss and sugar recovery loss.
- **Destaglobal:** Destatalk and Siddhi App are initiatives of Destaglobal for farmers. Destatalk is an extension platform harnessing social media platforms along with phone calls to reach farmers. Through the Siddhi App, farmers can see farm inputs for procurement and prices in their vicinity. Services are free for farmers and charged only on buyers and sellers from/to farmers. They work with around 60000 farmers.
- **Mycrop/Agrichain**: provides inputs and gathers data through a platform for smartphone users and through farmer mitras for those without a smartphone, generating insights and delivering advisories.
- **Kultivate**: applies a franchisee approach to enable its client crop experts in the country to provide precise crop advisory to member farmers. Kultivate equips its expert clients with weather, remote sensing, epidemiological, and market price data to customize advisory to individual farmers. It also helps experts communicate with farmers via mobile phone.
- **Digital Green**: distributes agriculture information to small scale farmers, encouraging sustainable agricultural practices. Launched in 2008 as an initiative of Microsoft, the system uses digital video recordings and "COCO Internet", a distribution video database.

Finally, ICT is particularly vulnerable to replicating inequities inherent in other development programs, particularly where prior levels of knowledge are required to take full advantage of services. Of particular import to India's farmers, many of whom are illiterate, are ICT tools which they can interact with despite their limited education. Some of the above platforms provide options for personal, verbal interaction with extension agents in farmers' local languages.

Talking Book, an ICT platform implemented in Ghana starting in 2009 to provide literacy training, provides a potentially more interesting pathway to addressing these limitations. Through an interactive audio device, Talking Book conducts literacy trainings in five core areas directly relevant to rural livelihoods: agricultural production, health and nutrition, financial practices, general education, and gender issues. Farmers are also able to use the device to record and share their own agricultural and literacy information. Through this tool, users don't just improve their literacy and absorb agricultural knowledge, they also increase their capacity to engage in a rural economy increasingly designed for literate participants.

Health Education Portals

Much like agriculture, education in the health sector also operates at two levels: that of the trainer and that of the trainee. R&D, increasingly enabled by ICT, is conducted in the higher education space as well as through various public and private institutions. With many of the same factors in play for agriculture also in play here, the following section details specifically how health information platforms in India have negotiated both higher education and community health education through the use of ICTs.

The National Health Portal (NHP) was set up by the Ministry of Health and Family Welfare. It was designed and developed by the Centre for Health Informatics (CHI) under the National Institute of Health and Family Welfare (NIHFW). It acts as a gateway to access authenticated health information for all. It has a vision to make a single point of access for authenticated and consolidated health related information to all citizens of India including students, researchers and health care professionals. The NHP provides information on various health related conditions including women's health, adolescent health, oral health, healthy nutrition and lifestyle, first aid, alcohol use disorder and many more. It gives information on various health initiatives including health ICT initiatives like Mera Aspataal, eRaktkosh, and My Health Record, in addition to other various mobile applications, online registration system, and telemedicine efforts.

Aarogya is another one of India's health information portals. It provides useful and comprehensive information on various diseases and medical conditions. It has health information for both genders and different age groups on a range of topics including communicable diseases, maternal and child health, non-communicable diseases, oral health, mental health, ENT Care, emergency care and many more. Aarogya also provides for peer-to-peer education by hosting various support groups for cancer patients and addicts, among others.

Nutrition

India's record of undernutrition presents a stubborn challenge, with intersectoral convergence between agriculture, health, education, livelihoods, and gender necessary to ensure positive nutrition outcomes (Ved and Menon 2012). At the same time, because of large size and interconnected nature, agriculture is perhaps the single most important sector that influences nutritional levels in India (Dev 2012). Thus agriculture, health and education all have a bearing on improving the nutrition scenario in India.

Poshan Abhiyaan

The Government of India's Poshan Abhiyaan (translated as Nutrition mission) program seeks to address malnutrition through convergence, use of technology and a targeted approach. The Abhiyaan, launched in 2018, aims to reduce stunting, under-nutrition, anemia (among young children, women and adolescent girls) and low birth weight by 2%, 2%, 3% and 2% per annum respectively.

Poshan Abhiyaan employs ICT-RTM (Information and Communication Technology-enabled Real Time Monitoring) to implement its mission and train support staff, specifically relying on the ICDS-CAS (Integrated Child Development Services-Common Application Software) package. ICDS-CAS is a software application through which village level field functionaries, or Anganwadi Workers (AWWs), capture data from the field on electronic devices (mobile/tablet). This information becomes available through the cloud to the state and national governments on a real time basis through online dashboards.[24] This is expected to improve AWW service delivery and enable the government to engage in fact-based planning and decision-making.

[24] The dashboard is accessible at http://dashboard.poshanabhiyaan.gov.in/#/

Poshan Abhiyaan also makes use of technology in training of its personnel. Thematic training modules on Nutrition and Early Childhood Education (ECE) have been developed to increase workers' knowledge and skills in an ongoing, incremental manner. Trainings are delivered through the e-Incremental Learning Approach (e-ILA). The e-ILA is also available as a mobile application to facilitate self-study by workers[25].

School Nutritional Programs

Early nutrition is important in a child's life, as poor nutrition can influence brain development throughout childhood. Deficiencies in various specific vitamins and minerals including thiamine, vitamin E, and iron can lead to a decrease in mental concentration and cognition. According to the World Food Program,[26] having food at school every day can mean not only better nutrition and health, but also increased access to and achievement in education. A study conducted by Abizari et al (2014) in Ghana showed that energy, nutrient and micronutrient intake were significantly higher and more adequate among children participating in a school meals program. Compared to the control group, anemia prevalence was ten percent lower. It is also a strong incentive to consistently send children to school, where parents know their children will receive meals.

There is a recognition of the inter-linkages between the education goal and all other goals in the Millennium Development Goals framework- "an interconnectedness of all development goals with key interlinkages between education, health, poverty reduction, and gender equality, where improvement in one area has a positive effect on the others" (UNESCO, 2012)[27] . And there has been various research to prove these interdependences between different domains across the world. One such recent study was conducted by the World Food Program[28] on ''How School Meals contribute to the Sustainable Development Goals"[29]. The study shows how school meal programs are helping to achieve various SDG goals with different programs running in different corners of the world.

- **Contribution to Zero Hunger** - When portions are appropriately sized, school meals can improve the nutrition status of preschool children, primary school children and adolescents by addressing macronutrient and micronutrient deficiencies. This leads to enhanced nutrition and health, decreased morbidity, and increased learning capacity.
- **Contributing to Education -** When a school meals program is part of a package of investments in education, it can help maximize the return of these investments, because school meals facilitate access to school, increase enrolment and attendance rates and improve the nutritional status, health and cognitive development of children. A systematic review of 216 education programs in 52 low- and middle-income countries (3IE 2016) found that school meals programs are one of the few education interventions that show positive impact in both school participation (enrolment, attendance, completion) and learning (scores on cognitive, language and mathematics tests).
- **Contributing to Gender Equality -** Girls struggle more than boys for access to education; one in every ten girls in the world is out of school, while with boys this figure is one in

[25] icds-wcd.nic.in/nnm/ILA.htm
[26] https://www1.wfp.org/school-meals
[27] UNESCO (2012). Education and skills for inclusive and sustainable development, UN System Task Team on the Post -2015 UN Development Agenda.
[28]https://www1.wfp.org/
[29] https://docs.wfp.org/api/documents/b91da1b2fa2344f6b9f4bad1cfbca40a/download/

twelve (UNESCO 2015). Women and girls are also more exposed to hunger and malnutrition than boys; they represent 60 percent of all undernourished people in the world (FAO 2010). And when adolescent girls are out of school, they are more vulnerable to forced marriage, early pregnancy, violence and even human trafficking. Well-designed school meals programs can help in bridging gender gaps and breaking the vicious cycle of discrimination against girls. Afridi (2011) evaluated a change in design of a school meals program in rural India, from the monthly distribution of take-home rations to the daily serving of a meal at school. The transition had a significant positive impact on the daily participation rates of children in the lower grades. The average monthly attendance rate of girls in grade one was more than 12 percent higher while there was a small but positive effect on grade one boys' attendance rate. There is also a strong correlation between higher levels of education and a reduction in child marriages. Over 60 percent of child brides in developing countries have no formal education. If all girls in sub-Saharan Africa and South and West Asia had secondary education, child marriage would fall by 64 percent, from almost 2.9 million to just over 1 million (UNESCO 2014).

- **Reducing Poverty and Inequality -** School meals programs have direct benefits for children: they improve their nutrition status, health, and level of education. These direct outcomes further contribute to wider processes such as the reduction of poverty and inequality and economic growth. UNICEF (2015) reports that each additional year of education of a country's population is associated with a 13 to 35 percent increase in GDP per capita. Also, each additional year of education in the 25–34 age group results in a nine percent decrease in the country's poverty rate (measured as the percentage of the population living on less than US$2 per day). School meals programs can also create employment opportunities and improve the livelihoods of the communities near the schools, especially when the food for the school meals is sourced or cooked locally, but more independent research is needed to support this claim.

Particularly in government schools, the quality of meals provided to students through school canteens is one of the largest factors in ensuring positive nutritional outcomes. Doing so, however, requires a nexus of interactions between administrators in the education system, nutrition educators, health data collectors, and agriculture distributors. If schools are recording high rates of malnourishment among their students, it is their responsibility to identify common characteristics of malnourished students, which can be accomplished through ICT-enabled analysis of student health data. If it is determined that schools are providing food of poor nutritional value, possibly out of cost concerns, ICT offers the potential to develop a marketplace for affordable nutritious food to counteract this. Initiatives using ICT to develop transparent food delivery systems and track nutrition outcomes are currently active through the central government.

No Free Lunch

The School lunch Program (SLP) or Mid-Day Meal Scheme is the country's largest food and nutrition assistance program, feeding millions of children every day in India. In 2001, as per Supreme Court orders, it became mandatory to give a mid-day meal to all primary, and later all upper primary school children studying in government and government aided schools. The scheme benefitted 140 million children in government assisted schools across India in 2008, making it the largest school meals program in the world. As a result, the scheme has had significant positive impacts on the height, weight and health of children, in particular for those whose families are suffering the impacts of drought and related crop loss (Singh et al 2014). Furthermore, in a country with a high rate of illiteracy, governmental and non- governmental

organizations have reported that the mid-day meal (MDM) scheme has consistently increased enrollment in schools in India.

To understand the role of technology in improving the delivery of the SLP, the No Free Lunch study was conducted, specifically examining the Mid-Day Meal scheme in Bihar. The study demonstrated how ICT can be leveraged to improve transparency and accountability in the delivery system of such large-scale programs. In Bihar, it was observed that the key challenge with the MDM scheme was its reliance on the middle level delivery machinery in determining the future allocations and performance of the program. To end this, Bihar decided in 2012 to introduce a fully automated IVRS (Interactive Voice Response System)-enabled platform that calls school teachers to record the everyday delivery of meals in the schools. IVRS is a simple technology enabled mechanism that helps to cross tally the food and funding requests received by government officials.

The study also explored the relationship between such technology-enabled improvements and school attendance and educational outcomes. For this, independent assessments by the central government and an independent NGO (Pratham) were conducted to compare the outcomes before and after the introduction of the program. The results demonstrated the degree to which school meals contribute to child well-being, health and nutrition outcomes, education access, social protection and rural development. They also underlined how streamlining and optimizing the delivery of school meals through ICT can further improve all of the above outcomes.

The School Breakfast Program

Breakfast is often considered the most important meal of the day, yet around the world, children frequently come to school with an empty stomach. According to one study done in Canada, "teachers estimated that children who come to school hungry lose up to two hours a day due to lack of productivity – that's one-third of the school day or almost four months in a school year".[30] Another such study done in India's Punjab state claims "40% of children in Punjab go to school on an empty stomach."[31] With two out of every five children in the primary and upper primary levels going to school hungry, decreased attentiveness and poor concentration is sure to result.

In the United States, food assistance programs have been established to improve the wellbeing of poor and low-income children. The School Breakfast Program (SBP) is one such federal effort to increase regular consumption of a healthful breakfast among school-aged children. It is trying to provide regular consumption of a healthy nutritional breakfast among school-aged children. The SBP started as a pilot program in 1966. In 1975, the US Department of Agriculture (USDA) Food and Nutrition Service (FNS) permanently authorized the program based on the belief that "good nutrition is essential to good learning''.[32] It also administers the Program at the Federal level. All school breakfasts must meet Federal nutrition requirements, though decisions about the specific foods to serve and how the foods are prepared are made by local school food authorities.

[30] https://globalnews.ca/news/3688315/students-school-without-breakfast-lose-hours-report/

[31] https://www.hindustantimes.com/punjab/40-children-in-punjab-go-to-school-on-an-empty-stomach-says-report/story-XTR7DgdDgPTrOVDugGPZHP.html

[32] US Department of Agriculture Food and Nutrition Service. School Breakfast Program: Program History. 2011. http://www.fns.usda.gov/cnd/breakfast/AboutBFast/ProgHistory.htm

Despite having so many benefits of the school breakfast program, there are few barriers as well which can affect the impact of the program. These factors have been observed and studied through various research projects involving observations and interaction with various focus groups. According to a study by Food Research and Action Center, 2002, it was observed that the productivity of the SBP was directly dependent on the efficiency of the school buses arriving on time so as students are not late for their breakfast. Also lack of willingness awareness among the parents about the academic and behavioral benefits of the school breakfast. School administrations also fear that it might take up lot of time and efforts of teachers and they ending up with less instructional time. It might create additional pressure on limited school resources as well. Vermeersch and Kremer (2004) found that the introduction of school meals led to a considerable increase in class-size which in turn adversely affected learning-levels in Kenya. But this program has immense possibilities to fix these issues with better technologically advanced solutions.

Ask Nestlé

Ask Nestlé, as promoted by Nestlé India, is a one-stop solution for child nutrition. Launched in 2019 with a vision of digitizing nutrition education, it provides personalized nutrition advice which is balanced, relevant, scientifically derived and customizable according to the need of the audience. It specifically aims to empower parents with children between 2-12 years old to make informed decisions about food choices and nutrition for their children. Content on the platform has been carefully curated by Nestlé's nutrition experts to help mothers develop customized meal plans designed on the basis of growth tracking, taking into account regional preferences, food choices, and allergies. The platform also aims to bust myths and preconceived notions around nutrition.

This platform, housed on a website, features an AI Assistant called NINA (Nestlé India Nutrition Assistant), built in association with Google. For more detailed inquiries, the service also has a live chat functionality that allows consumers to chat with nutrition experts. It will be supported by a television and digital campaign to offer smart solution to have a healthy lifestyle.

Nestlé India has also introduced its ''Healthy Kids Program'' to raise nutrition, health and wellness awareness among students. Currently, the program is being run with partnership with regional universities, which collect additional data on nutrition in their local areas. Students are taught about seasonal and local fruits, vegetable and cereals, while the program also raises awareness about hygienic practices and daily exercise

Such platforms and programs, developed on a public-private partnership basis, possess great potential to be scaled up for a larger audience across India. Nutritional awareness can be taught to students from a very young age through the school system, and ICT can play a major role in bringing together best practices from both the health and education sectors.

Wearables for Health and Attendance Status

Wearable devices to record physical activity/ monitor health parameters of individuals are gaining currency. More than 300 such devices were on the market at the end of 2015, with 40% as fitness trackers, 40% for lifestyle/ computing and around 10% for healthcare adoption[33]. Assuming these geotagged devices are integrated with the school education system, they can lead to better monitoring and provide real time data about routine information which needs capturing like teacher and student attendance, student health and nutrition status. Predetermined levels of outlier behavior could send alerts for action to the concerned stakeholder (teacher, parent, school authority, health department etc.). However, any such initiative requires research from human safety and robustness and reliability of technology points of view. Moreover, such initiatives are also very sensitive from the standpoint of individual and data privacy. Such social aspects have an equal, if not greater, bearing on the rollout of such technology-driven monitoring efforts.

Estimating the Macroeconomic Impacts of ICT Interventions

As discussed in the prior sections, evolving information and communications technology will not only translate into rapid advances in quality, efficiency, and inclusivity for several sectors directly related to development. Advances in ICT will also improve coordination between these sectors, advancing intersectoral development outcomes across the board. As a side effect of these trends, the continuing integration of ICT into all sectors of the economy will unlock new avenues for economic growth, including all the societal change that comes with that. While ICT usage is far more advanced in certain sectors of the economy, and largely lagging in the sectors under consideration in this project, successful implementation and mainstreaming of ICT within and between these sectors will generate nationwide growth in both urban and rural areas in some of the largest parts of the Indian economy. On the other hand, ICT, and especially AI, will lead to unpredictable employment consequences and changing skill requirements in some of the economy's most labor-intensive areas.

ICT as a Localized Source of Increased Productivity

In terms of the economic consequences of ICT, new technologies can be conceptualized as sources of increasing productivity in the classic production function. ICT, specifically, does this in two ways. First, by serving as a portal to an immense pool of resources, ICT reduces or even eliminates the search costs related to identifying quality markets, networks, connections, and resources. In fields ranging from e-commerce to distance education, the high quantity of resources made easily accessible through ICT makes finding and connecting with quality resources that much easier and more straightforward. In other words, ICT massively reduces search costs related to both distance and time for individuals and organizations alike.

Second, the new connections enabled through this technology reduce the direct monetary costs of accessing new resources by increasing competition among suppliers for access to a newly empowered customer base. A rural farmer no longer must, for example, rely on the word of a local agent to receive a fair price for crops. Through ICT, he or she may connect with a number of different buyers to receive prices for their goods approaching the true market value. By serving as an improved middleman over analog and traditional systems, ICT of all stripes reduces the rent-seeking inherent in market inefficiency and delivers better outcomes for actors on both sides of the supply-demand equation.

[33] https://www.din.de/blob/160444/56136d9f7c1b2d5a6826c844742903db/wearables-data.pdf

The catalyzing role ICT plays in economic growth is readily demonstrable in the classic Cobb-Douglas production function, replicated below:

$$Q = \sum_{i=1}^{n} A_n K_n^{\alpha_n} L_n^{1-\alpha_n}$$

In the above equation, total production Q, or GDP, is given as the sum of production for all sectors in the economy n. Production by sector is the product of three factors: total factor productivity (TFP) in the sector A, the amount of capital in the sector K to the power of the share of productivity attributable to capital α, and the amount of labor in the sector L to the power of the share of productivity attributable to capital 1 – α. ICT increases productivity for labor and capital alike, boosting the TFP and output as a result.

Input-Output Modeling Approach

A typical classical production function would not separate TFP by sector as in the above example, preferring to model an economy in which technological advances have diffused throughout the economy and equalized between sectors. For India, this assumption is manifestly untrue. Geographic and human capital barriers have inhibited adoption of digital technology in some sectors, while successful adoption in sectors such as manufacturing have been spurred on by market forces which have been lacking in other sectors, such as education. For these reasons, TFP, and the extent of technological advancement by extension, must be treated as separate in each sector because these advances are not truly fungible and mobile between different parts of the economy.

Outside of the constraints of the classical production function, production in an economy can be modeled through the input-output framework, a model which arose to fill the needs of central economic planners. The input-output model tracks the movements of all resources in an economy. Based on the assumption that industries produce outputs by using inputs from other industries in fixed ratios, the framework identifies what exactly these ratios are. Doing so allows planners to calculate how changes in one or multiple industries will ripple across the entire economy, and what sorts of investments will be required to meet targets for priority industries.

Increased GDP from an initial advance in one sector in the input-output model can be traced to first order, second order, and third order effects. First order effects arise when an increase in technology, limited to that initial sector, increases output in that sector. Second order effects relate to the increased demand for inputs from that sector, and the resulting increases in outputs for those sectors feeding into it. And finally, third order effects refer to how the increased income by workers both in the key industry and in secondary industries translate into increased demand for consumer products. As a brief example, a technological advance limited to the manufacturing industry increases manufacturing output and increases demand for manufacturing inputs from sectors such as mining and forestry. The increased aggregate incomes of those working in all of these industries propels higher consumption in sectors such as agriculture, education and health.

The input-output method has some flaws. Regional and sub-regional input-output analyses are rare to nonexistent, meaning only a national-level analysis is possible. This precludes the possibility of examining technology's impact on the rural-urban divide, although sectors such

as agriculture can be arbitrarily mapped as rural and analyzed that way. More importantly, it assumes that the input ratios for each sector remain fixed. In reality, technological advances and shifting preferences mean that what each sector demands is constantly in flux, and these tables quickly go out of date. India's most recent finalized input-output table dates back to 2007-2008, a time before the widespread advent of smartphones and other mobile digital technology. However, this data still proves useful for entry-level analysis of the impact of ICT-driven development in our target sectors.

First Order (Direct) Effects

As discussed, first order or primary economic impact refers to the direct effect of productivity increases on the output of the sectors where technological advances took place. For the purpose of this paper, joint and simultaneous advances in the sectors of education, health and social work, and agriculture, hunting, forestry and fishing are considered, using April 2019 nominal GDP as a baseline and estimating the present size of each sector using the 2011 input-output table.

Productivity Increase	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Expected GDP in Target Sectors (USD Millions)	276814	279582.2	282350.3	285118.5	287886.6	290654.8	293422.9	296191	298959.2	301727.3	304495.5

Second Order (Indirect) Effects

In contrast with first order effects, second order impact considers the increased output resulting from increased demand for goods from other sectors resulting from increased productivity in target sectors. This leverages the insights of the input-output table to pinpoint the spillover effects from sectors which become more productive through the use of ICT onto other sectors which do not experience the same shock.

Productivity Increase	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Expected Secondary Output (USD Millions)	1642866	1643496	1644127	1644757	1645388	1646018	1646649	1647279	1647910	1648540	1649171

Third Order (Whole Economy) Effects

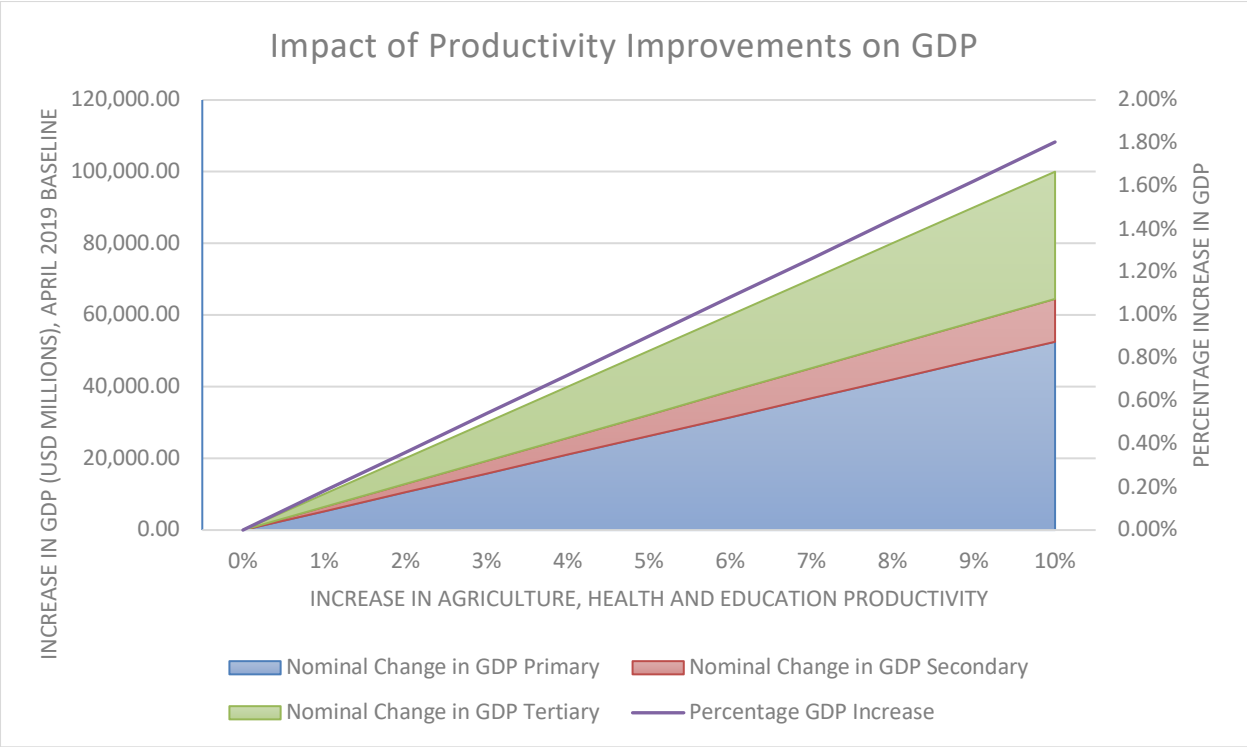
Third order or tertiary effects stand apart from primary and secondary effects by referring to the components of GDP which "exit" the domestic production cycle. In contrast with primary and secondary effects, which refer to output either solely within sectors of interest or output immediately reinvested in production for other sectors as a result of these increases, tertiary

effects look at factors such as household consumption, government consumption, gross fixed capital formation, changes in inventories, imports, and exports.

Productivity Increase	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
Expected Tertiary GDP	999631.9	1001502	1003372	1005241	1007111	1008981	1010851	1012720	1014590	1016460	1018330

Aggregate Impact and Discussion

The overall expected GDP impact of productivity increases in the agriculture, health and education sectors is summarized in the graph below.



This analysis predicts the impact of productivity increases on GDP, but it does not tell the entire story, particularly as far as ICT is concerned. ICT, in particular AI, will have an unpredictable impact on employment, wages, and by extension, household income. New technologies will also unpredictably alter the sectoral inputs necessary to generate output in a given sector. Future iterations of this analysis should examine these ICT-specific effects to predict overall impacts on household income, particularly for vulnerable low-income workers working in these sectors in positions vulnerable to automation. The analysis could further be developed by attempting to generate a regional urban/rural model. This could be done by assigning specific sectors as urban or rural and examining changes in inequality resulting from these productivity shocks.

An Agenda for Intersectoral ICT-Driven Development

India has experienced remarkable success in developing ICT solutions for its development challenges. However, many of these solutions remain siloed in such a way as to limit the positive lessons and interactions that can be drawn from developments in other sectors. The seeds of a holistic intersectoral approach to ICT-driven development have been planted, but now is the time to identify opportunities for coordination, learning, and collaboration between sectors that can take India's development to the next level.

Mainstreaming Nutrition

Nutrition touches on many of the key issues in rural development, including agriculture, health, education, gender, and economic wellbeing. As per the World Bank Report on "Improving nutrition through multisectoral approaches", the key sectors for maximizing nutrition impacts include health, agriculture and food security, education (especially girls' education), poverty reduction, social protection, water and sanitation, environment and climate change, private sector, trade and intellectual property rights[2]. The Sustainable Development Goals recognize nutrition's impact on the achievement for these relevant goals, imposing nutrition targets for each of them, and India has introduced a development agenda in alignment with the SDGs. Yet one of the reasons malnutrition has persisted in India is a continued failure not to recognize, but to act upon the interrelated nature of these factors.

To this point, ICT initiatives in all the aforementioned sectors have failed to mainstream nutrition due to its intersectoral nature. A more strategic usage of ICT, one which fosters partnerships between the many interrelated actors with a say in nutrition outcomes while steadfastly tracking health data and acting on the insights that emerge, can reverse this situation and help create a healthier population. For example, ICT can foster food security at the local, national and global levels as well as inclusive rural development through increased production and productivity, reduced operational costs, and improved access to markets, information, credit, and building capacity. Where such benefits are specifically tied to nutrition, for example by applying part of the health budget to subsidize nutritious foods through ICT facilitation, then the market trajectories inhibiting good nutrition can be reversed.

Data Equity and Accessibility

ICT deals with the production and usage of data almost by definition, which means that data is the foundation of all ICT. Maintaining best practices around data collection and management generates large positive externalities for all related sectors, something which all ICT-driven interventions should remain conscious of. On the other hand, failure to identify unconscious biases emerging during data collection could have negative and far-reaching consequences for the inclusion of communities that have traditionally been excluded from service provision. Data collection must strike a balance between quantity, or using the tools of ICT to generate as much data as possible for future improvement of data-driven initiatives, and quality, or the recognition and mitigation of unconscious biases that could be replicated or even automated in future applications of ICT.

Data Production as a Feedback Loop

With data running as the backbone of any ICT initiative, data serves as both an input and an output of these programs. Supplementary ICT techniques, such as remote sensing for agriculture, can further enhance this throughput, generating more data for public consumption even as more data is used to produce more refined results. Any ICT-driven intervention should stay conscious of this feedback loop, identifying ways both in which data can be collected more

efficiently through ICT and ways in which data can be recycled either within a platform or through a different initiative or even sector. One way in which to do this is to maintain an intersectoral perspective while designing tools for data collection. Maximizing the attributes tied to each data point, within the reasonable limits of data collection tools and privacy concerns, will exponentially lead to more potential applications of the same data within and outside any project.

Conscious Biases in Data Collection and Automated Processes

As easy as it is to assume that data is an objective reflection of the world's reality, the fact is that like all tools, it reflects the needs and views of those who designed it whether consciously or unconsciously. In development, failure to understand what groups may be excluded from data often means that these groups to not see the benefits of programs intended to help them. After all, we can only change that which we can measure.

ICT is particularly vulnerable to the downstream effects of data bias in two ways. First, given the infrastructure and human capital requirements of ICT implementation, it is spectacularly easy to design interventions data that only reflects the needs of potential users while ignoring those for whom the same technology remains out of reach. A mobile app using a written survey to gather data about what users need, for example, is likely only to cater to the needs of the literate. In rural development, this platform would exclude a large segment of the population which likely has vastly different needs.

Second, with the advent of Artificial Intelligence, these biases can take on a life of their own. Correlations between groups and development outcomes are hardcoded into automated systems at the point when data is collected, unless provisions are put in place to regularly update this data. If, for example, this initial data illustrates high rates of gender bias in local economies, and routines are automated, then services provided through these systems that are not conscious of this bias could replicate the same inequity. This possibility will likewise increase exponentially as data is gathered in a more intersectoral fashion, with more sectors tied to each data point directly correlating to a greater potential for unexpected consequences. Therefore, while the potential of accelerated data collection should be recognized, it should also be seen as a double-edged sword.

Open Public databases

Finally, the vast flows of data that ICT-driven development will generate will be useless for other development initiatives if it remains locked up in private databases behind ownership restrictions or paywalls. While respondent privacy is a critical concern for open databases, particularly those including geographic identifiers, such identifiers can be displaced in a way that does not compromise data integrity while access to specific indicators is restricted on a need-to-know basis. The USAID-conducted Demographics and Health Survey (DHS), and especially its treatment of HIV data, is an excellent case study in maintaining data accessibility while modeling a respect for privacy.

Pedagogical Approaches to Health and Agriculture Education

ICT-enabled education is not limited to the education sector. It is also relevant to sector-specific trainings, especially for agriculture and health. These sectors currently have ICT platforms in place to train both specialists and everyday practitioners in specific knowledge and techniques,

in a way that mainly reflects the distance education platforms popularized in the education space.

However, these sectors can learn from advances in ICT-enabled education by examining how education platforms concern themselves not just with delivery of educational materials, but also with interactivity, scaffolded assessments, community-driven production of educational resources, and data-driven assessments of student progress and outcomes. DIKSHA, in particular, could serve as the gold standard for how any kind of technical education can evolve along the lines of a societal platform.

ICT-enabled education in the agriculture and health sectors, whether at the community outreach level or at universities, would do well to consciously model the features and capabilities of DIKSHA, soliciting inputs from educators to apply the best pedagogical approach using these platforms for the recipients of this education. These sectors could even directly adopt DIKSHA or any similar platform for their education efforts.

References

Ali, Rubaiyat. 2014. “E-Gov Products and Services,” January, 3.

Anubhav Singh. 2016. “Challenges in Indian Education Sector.” https://www.researchgate.net/publication/293452542_Challenges_in_Indian_Education_Sector

Bhowmik, Debjit, S Duraivel, Rajnish Kumar Singh, and K P Sampath Kumar. 2013. “Telemedicine- An Innovating Healthcare System In India.” *The Pharma Innovation* 2 (4): 20.

ChromaWay. “Chromaway Cases.” Accessed April 2019. https://chromaway.com/cases

Chutani AM.2012. “School Lunch program in India”. Asia Pacific Journal of Clinical Nutrition. https://www.ncbi.nlm.nih.gov/pubmed/22374572

Dakshayani Madangopal and Madhavi Madangopal. 2018. “ICT in education: The rural challenge”. Centre for Communication and development Studies. https://digitalequality.in/ict-in-education-the-rural-challenge/

David Frisvold. “School Breakfast Program Increases Student Achievement in High- Poverty School.” Policy Brief: Center for Policy Research. http://poverty.ucdavis.edu/sites/main/files/file-attachments/cpr-frisvold_school_breakfast_brief.pdf

Department of Revenue, Government of Karnataka. Land Records Bhoomi Portal https://landrecords.karnataka.gov.in/service2/RTC.aspx

Dev, S. Mahendra. 2012. Agriculture-nutrition linkages and policies in India. IFPRI Discussion Paper 1184. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/126931

FAO and ITU 2016. e-Agriculture Strategy Guide: Piloted in Asia-Pacific countries. Bangkok http://www.fao.org/3/a-i5564e.pdf

Grant, Kate and Nine Tiles. “Smart Wearable Devices.” din.de. Accessed April, 2019. https://www.din.de/blob/160444/56136d9f7c1b2d5a6826c844742903db/wearables-data.pdf

Hegde, Rajendra, K. V. Niranjana, S. Srinivas, B.A. Danorkar and S.K. Singh. “Site-specific land resource inventory for scientific planning of Sujala watersheds in Karnataka.” Current Science 115, no. 4(2018): 644-652.

Jukes, Drake & Bundy. 2007. “School health, nutrition and education for all: levelling the playing field”. CABI Publishing, Wallingford. World Health Organization https://www.who.int/bulletin/volumes/87/1/08-059519/en/

Jyoti Narayan Patra and Jayanta Mete. 2014. “The role of ICT in improving the quality of school education in India”.

https://www.researchgate.net/publication/292403689_THE_ROLE_OF_ICT_IN_IMPROVING_THE_QUALITY_OF_SCHOOL_EDUCATION_IN_INDIA

Karnataka State Natural Disaster Monitoring Centre, Bangalore. http://ksndmc.org/

Mathur, Pankaj, Shweta Srivastava, Arati Lalchandani, and Jawahar L Mehta. 2017. "Evolving Role of Telemedicine in Health Care Delivery in India." *Primary Health Care Open Access* 07 (01). https://doi.org/10.4172/2167-1079.1000260.

Ministry of Agriculture and Farmers Welfare, Government of India. mkisan Portal. Accessed April 2019. https://www.mkisan.gov.in/default.aspx

Ministry of Agriculture and Farmers Welfare, Government of India. Farmers' Portal. Accessed April 2019. https://www.farmer.gov.in/

Ministry of Agriculture and Farmers Welfare, Government of India. Soil Health Card portal. https://soilhealth.dac.gov.in/

Ministry of Human Resource Development, Govt of India. 2016. "Some Inputs for Draft National Education Policy." https://mhrd.gov.in/sites/upload_files/mhrd/files/nep/Inputs_Draft_NEP_2016.pdf

Ministry of Women and Child Development, Government of India. "Integrated Child Development Scheme." icds-wcd.nic.in. Accessed April 2019. http://dashboard.poshanabhiyaan.gov.in/#/

Nestlé India, Portal for children nutrition. AskNestle.in. Accessed April 2019. https://www.asknestle.in/

NITI Aayog. 2018. "National Health Stack -Strategy and Approach." http://niti.gov.in/writereaddata/files/document_publication/NHS-Strategy-and-Approach-Document-for-consultation.pdf.

Patnaik, Ila and Shubho Roy. "India's woeful land records will have trouble identifying farmers eligible for Rs 500/month." theprint.in. Accessed April 2019. https://theprint.in/opinion/indias-woeful-land-records-will-have-trouble-identifying-a-farmer-eligible-for-rs-500-month/188360/

Pooja Mehta. "Problems Faced in the Progress of Education in India." http://www.economicsdiscussion.net/articles/problems-faced-in-the-progress-of-education-in-india/2291

Reddy, Srinivasa G.S and C.N. Prabhu. "Natural Disaster Monitoring System – Karnataka Model." Special Publication of The Geological Society of India, no. 5(2016): 1-10.

S. Ramanathan. 2014. "Role and Pros & Cons of ICT in Health Care Sectors in India" I (XVIV).

Sisir Debnath and Sheetal Sekhri. 2016. Indian Statistical Institute, Delhi. “No Free Lunch: Using Technology to Improve the Efficacy of School Feeding Program” https://www.isid.ac.in/~epu/acegd2016/papers/SisirDebnath.pdf

Sri E. Sreenivasulu. 2013. “Role and Importance of Educational for Effective Growth of Indian Economy: An Overview.” IOSR Journal Of Humanities And Social Science. http://www.iosrjournals.org/iosr-jhss/papers/Vol7-issue5/E0753235.pdf?id=6008

The World Bank. 2018. “India Development Update: India’s Growth Story.” World Bank Group. http://documents.worldbank.org/curated/en/814101517840592525/pdf/123152-REVISED-PUBLIC-MARCH14-IDU-March-2018-with-cover-page.pdf

United Nations System Standing Committee on Nutrition. 2017. “Schools as a System to Improve Nutrition: A new statement for school-based food and nutrition interventions.” https://cgspace.cgiar.org/bitstream/handle/10568/89401/Schools_UNSCN-2017.pdf?sequence=1&isAllowed=y

Ved, Rajani; Menon, Purnima. 2012. Analyzing intersectoral convergence to improve child undernutrition in India: Development and application of a framework to examine policies in agriculture, health, and nutrition. IFPRI Discussion Paper 1208. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/127129

Wood, Christopher S., Michael R. Thomas, Jobie Budd, Tivani P. Mashamba-Thompson, Kobus Herbst, Deenan Pillay, Rosanna W. Peeling, Anne M. Johnson, Rachel A. McKendry, and Molly M. Stevens. 2019. “Taking Connected Mobile-Health Diagnostics of Infectious Diseases to the Field.” *Nature* 566 (7745): 467–74. https://doi.org/10.1038/s41586-019-0956-2.

World Bank 2017. ICT in Agriculture: Connecting Smallholders to Knowledge, Networks, and Institutions. Updated Edition. Washington, DC: World Bank http://hdl.handle.net/10986/27526

World Bank. 2016. World Development Report 2016: Digital Dividends. Washington, DC: World Bank http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf

World Food Program. “School Feeding” https://globalnews.ca/news/3688315/students-school-without-breakfast-lose-hours-reporthttps://www1.wfp.org/school-meals

World Health Organisation. 2008. “Health Information Systems.” https://www.who.int/healthinfo/statistics/toolkit_hss/EN_PDF_Toolkit_HSS_InformationSystems.pdf.

World Health Organization, and International Telecommunication Union. 2017. “Be He@lthy, Be Mobile-Fact Pack.”

World Health Organization, and WHO Global Observatory for eHealth. 2011. *MHealth: New Horizons for Health through Mobile Technologies*. Geneva, Switzerland: World Health Organization. https://www.who.int/goe/publications/goe_mhealth_web.pdf.

World Health Organization. 2005. "58th World Health Assembly Report." Geneva: WHO. http://apps.who.int/gb/ebwha/pdf_files/wha58-rec1/a58_2005_rec1-en.pdf.