India's digital inclusion story

Lessons from the synergy of digital connectivity and DPIs

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MSC
MicroSave Consulting

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Department of Telecommunications
Ministry of Communications
Government of India

INDIA
MOBILE
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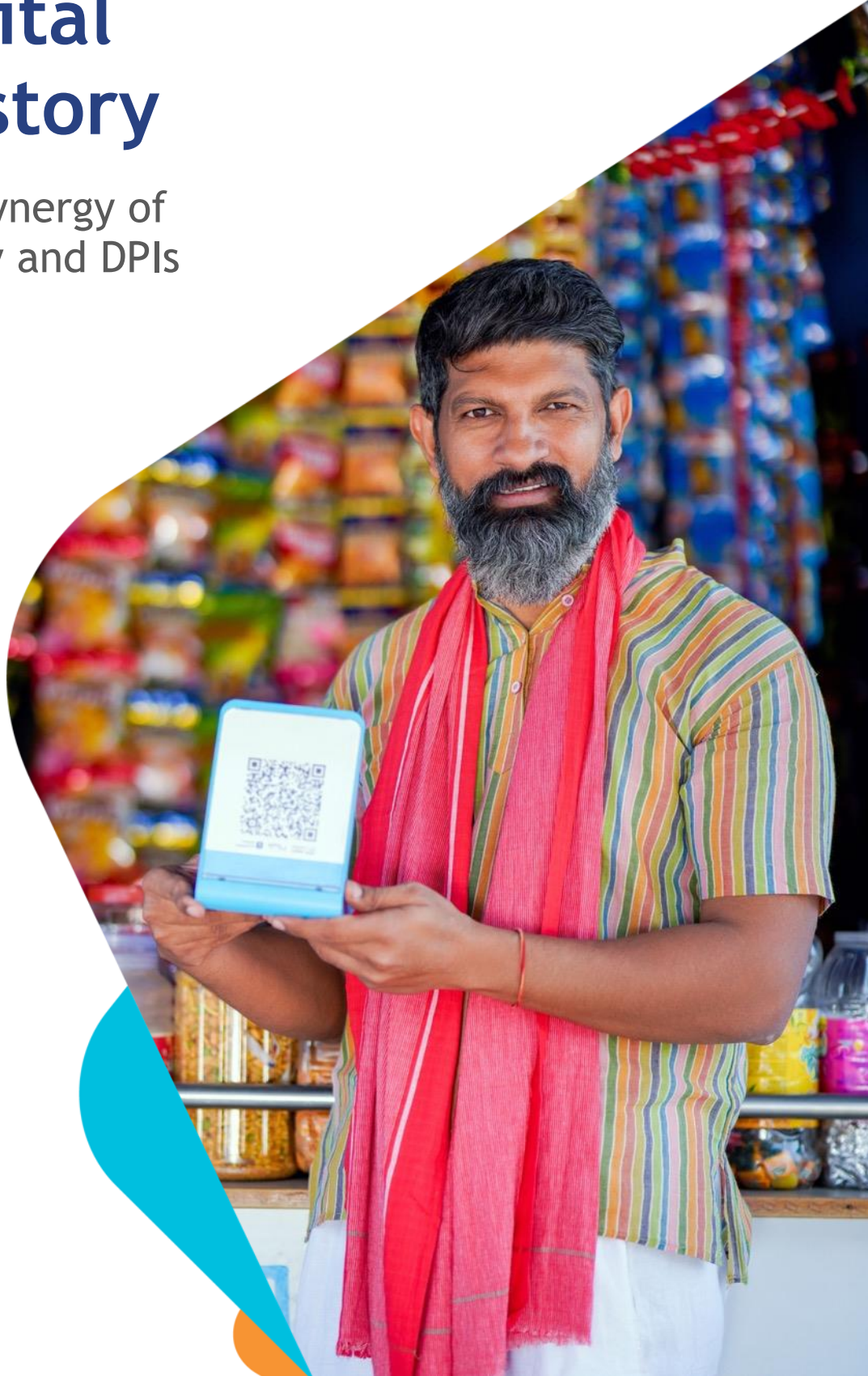
DoT foreword

It is a matter of great privilege and pride for me to introduce this insightful report, "India's Digital Inclusion Story: Lessons from the Synergy of Digital Connectivity and Digital Public Infrastructures." This report, authored by Microsave Consulting in collaboration with the Indian Mobile Congress, delves into the profound transformation of India's digital landscape. It emphasizes the critical role that digital connectivity and Digital Public Infrastructures (DPIs) have played in the nation's digital inclusion journey, showcasing exemplary use cases across sectors such as Identity, Financial Services, Healthcare, Agriculture, and Education.

In recent years, India has undergone a remarkable digital revolution, and the Department of Telecommunications, Government of India, has played a significant role in facilitating this transformation. The relentless pursuit of digital inclusion and the provision of affordable, accessible, and robust telecommunications services have been at the core of our mission. The symbiotic relationship between digital connectivity and DPIs has been instrumental in achieving these objectives.

I extend my appreciation to the dedicated team at Microsave Consulting and the Indian Mobile Congress for their rigorous research, detailed analysis, and comprehensive documentation of India's digital inclusion journey. Their collaborative efforts have produced a resource that is not only enlightening but also invaluable for policymakers, researchers, and practitioners worldwide.

It is my belief that "India's Digital Inclusion Story: Lessons from the Synergy of Digital Connectivity and Digital Public Infrastructures" will serve as an illuminating guide for governments, industry leaders, and stakeholders who are committed to advancing digital inclusion within their own domains. This report exemplifies how, through strategic investments in digital infrastructure, we can empower our citizens and build a more inclusive and connected society.

As we continue to navigate the ever-evolving digital landscape, may this report inspire new partnerships, innovative solutions, and a shared commitment to global digital inclusion. I trust that it will act as a catalyst for further transformative initiatives, not only within India but also as a source of inspiration for nations worldwide.

Warm regards,

Dr. Neeraj Mittal

Secretary, Department of Telecommunications, Government of India

IMC foreword

I am delighted to introduce this remarkable report, "India's Digital Inclusion Story: Lessons from the Synergy of Digital Connectivity and Digital Public Infrastructures." This collaborative effort between Microsave Consulting and the Indian Mobile Congress explores the digital landscape of India and the significant role that digital connectivity and Digital Public Infrastructures (DPIs) have played in shaping our nation's digital inclusion narrative. This report delves into the transformative use cases across sectors such as Identity, Financial Services, Healthcare, Agriculture, and Education, shedding light on the innovative solutions that have revolutionized the Indian digital ecosystem.

The Indian Mobile Congress has been at the forefront of fostering digital inclusion and innovation in the telecommunications sector, and it is indeed a proud moment to see our collective efforts culminate in this insightful report. The synergy between digital connectivity and DPIs has been pivotal in our mission to bring digital services to every corner of our vast and diverse nation.

I would like to extend my heartfelt appreciation to the dedicated teams at Microsave Consulting and the Indian Mobile Congress for their rigorous research, insightful analysis, and comprehensive documentation of India's digital journey. Their combined efforts have produced a report that not only informs but also inspires, providing policymakers, researchers, and practitioners with a valuable resource that transcends boundaries.

I am confident that "India's Digital Inclusion Story: Lessons from the Synergy of Digital Connectivity and Digital Public Infrastructures" will serve as an invaluable reference for stakeholders across the globe. It is a testament to how strategic investments in digital infrastructure can empower citizens and foster inclusive and resilient societies.

As we navigate the ever-evolving digital landscape, may this report serve as a catalyst for innovation, collaboration, and the shared commitment to achieving global digital inclusion. It is a testament to the collective vision that drives us to ensure that the benefits of digitalization reach every citizen, irrespective of their geographical location or socio-economic background.

Warm regards,

Mr. P. Ramakrishna

CEO, Indian Mobile Congress

MSC

MSC foreword

I am delighted to introduce this report, "India's Digital Inclusion Story: Lessons from the Synergy of Digital Connectivity and Digital Public Infrastructures." India's journey toward digital inclusion has been transformative, driven by the powerful combination of digital connectivity and Digital Public Infrastructures (DPIs). This report offers a deep dive into India's evolving digital landscape, highlighting global use cases across critical sectors.

India has made remarkable progress in utilizing technology to enhance the lives of its citizens. DPIs have played a pivotal role in enabling seamless collaboration between individuals, businesses, and the government within a connected digital ecosystem. They have underpinned India's digital revolution by providing a robust identity framework, extending financial services, improving healthcare access, enhancing agricultural practices, and revolutionizing education.

In a world increasingly defined by digital advancements, India stands as a beacon for leveraging technology to drive socio-economic growth. India's digital inclusion story serves as an inspiration for nations globally, showcasing the potential of strategic investments in digital infrastructure to empower citizens and foster inclusivity.

This report intricately explores the web of digital inclusion in India, offering unique lessons drawn from the synergy of digital connectivity and DPIs. It covers a wide spectrum of applications of DPIs across sectors, presenting a rich tapestry of global use cases that underscore their effectiveness in driving positive change. From the transformative impact of the Aadhaar system on identity management to the revolutionary approach of the JAM Trinity in financial inclusion, this report reveals a treasure trove of insights.

As you navigate through the report, you will discover how digital infrastructure is being leveraged to enhance healthcare delivery, optimize agricultural practices, and reshape education systems. These insights demonstrate the adaptability and scalability of India's digital model, providing valuable lessons for nations working to bridge the digital divide and achieve comprehensive inclusion.

I commend the dedicated team at MicroSave Consulting (MSC) for their rigorous research, insightful analysis, and comprehensive documentation of India's digital journey. Their unwavering commitment to providing in-depth and actionable insights has transformed this report into an invaluable resource for policymakers, researchers, and practitioners worldwide. I welcome the partnership between IMC and MSC. IMC is the leading forum for industry, government, academia, and think tanks and is the biggest technology event in Asia. We at MSC are delighted to be partnering with IMC.

Connectivity and Digital Public Infrastructures" will serve as a guiding light for those aspiring to replicate India's success within their own contexts. As we continue to navigate the ever-evolving digital landscape, may this report inspire new partnerships, innovative solutions, and a shared commitment to global digital inclusion.

Warm regards,

Mr. Manoj Sharma

MD, MSC

Executive summary

Over the past decade, India has seen transformative moments that have propelled its digital revolution onto the global stage. The collaboration between the public and private sectors has been a driving force to foster innovation, improve service delivery, and prioritize user-centered experiences. These initiatives have evolved digital infrastructure and given rise to disruptive ICT innovations, adaptable regulatory frameworks, supportive policies, and an unwavering commitment to customer-centricity. The Department of Telecommunications (DoT), Ministry of Communications, Government of India, has played a central role in this remarkable journey, serving as a pivotal force in facilitating digital connectivity.

Against the backdrop of current and emerging development challenges in both developed and developing economies, India's extensive digital connectivity and pioneering Digital Public Infrastructure (DPI) programs stand as beacons of progress in the nation's digital economy.

These DPIs are now well-positioned to serve as valuable benchmarks to craft resilient and inclusive digital service delivery models in other economies. Their significance is particularly evident in how they can advance financial and digital inclusion, with a special emphasis on individuals from economically disadvantaged backgrounds, and offer valuable lessons to address the unique socioeconomic issues faced by both developed and developing nations.

This report highlights crucial Indian case studies across diverse areas, such as identity, financial services, healthcare, education, and agriculture. It underscores the potential for these cases to be replicated and adopted to benefit developed and developing nations alike.

1.

Identity:

Aadhaar, India's unique digital identity system, has been pivotal as a transfer catalyst across various sectors to elevate efficiency and grant citizens greater empowerment. By the close of 2022, Aadhaar had facilitated more than USD 310 billion in disbursements to significantly bolster citizen empowerment. The introduction of e-KYC and e-auth services has streamlined onboarding and authentication procedures to mitigate fraud risks substantially.

2. Financial services:

India's dedicated efforts in digital payments have significantly reinforced financial inclusion and spurred economic growth, as exemplified by initiatives, such as the Unified Payments Interface (UPI) and the Account Aggregator framework. UPI's widespread adoption has garnered international recognition and expanded its footprint to nations including Singapore, South Korea, Bhutan, and the UAE.

The Account Aggregator framework and OCEN have introduced a democratized approach to financial services to enable secure, consent-based data sharing and standardize the lending process. These innovative Digital Public Infrastructures (DPIs) can potentially serve as models for adoption by other countries to enrich their digital financial service ecosystems. These innovations can contribute to comprehensive financial inclusion by addressing challenges, such as limited interoperability and enhancing credit access for individuals and small businesses.

3. Healthcare:

In the realm of healthcare, India has made significant strides to use digital transformation, as evidenced by the Ayushman Bharat Digital Mission, CoWIN, e-Sanjeevani, Digital Infrastructure for Verifiable Open Credentialing (DIVOC), and similar initiatives. These DPIs exemplify India's commitment to foster innovation and accessibility in healthcare. Through DIVOC, two billion COVID-19 vaccination certificates have been issued across five countries, which include India, Indonesia, Jamaica, Philippines, and Sri Lanka.

The insights drawn from these DPI innovations extend beyond India and offer valuable lessons for other nations. These lessons empower countries to elevate their healthcare systems' effectiveness to lead to improved health outcomes and foster global inclusivity in healthcare services. Notably, these initiatives underscore the central role of connectivity to drive this transformative healthcare evolution.

4. Education:

India's digital infrastructure initiatives, which include DIKSHA, DESH-Stack, NDEAR, and others, have taken substantial steps to ensure equitable access to high-quality education. These initiatives offer valuable insights for other nations and contribute to the global promotion of inclusive education.

For example, while home tutoring is well established in developed countries, India's DIKSHA digital education platform enhances this approach. It provides various resources, interactive tools, and assessment opportunities that facilitate comprehensive learning experiences for students educated at home. The DESH stack can address global skills mismatch by preparing individuals for the evolving job markets of the future by promoting skill development, reskilling, and upskilling.

5. Agriculture:

The global agriculture sector, a linchpin of the world economy, faces multifaceted challenges. India's digital transformation in agriculture, exemplified by initiatives, such as Agri Stack, offers valuable lessons. This digital infrastructure strives to simplify processes for farmers and streamline government welfare programs by connecting diverse stakeholders on a unified platform.

Agri Stack comprises various components, including farmer registries, unified service interfaces, and a consent manager, fostering data-driven efficiency and accessibility. India has also nurtured a thriving AgriTech startup ecosystem and implemented innovative programs, such as Soil Health Cards and the National Agricultural Market. These digital endeavors enhance market access, promote transparency, reduce post-harvest losses, and ensure equitable credit access to foster global food security and prosperity.

The lessons derived from India's DPI initiatives in these domains emphasize the critical role of connectivity and innovation in tackling urgent development challenges. These insights extend beyond India's borders and offer valuable knowledge for countries across the globe. The connection between digital connectivity and DPI represents a national achievement and a global opportunity to empower individuals, enhance livelihoods, foster prosperity, and address current global needs.

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Chapter 1
An overview of India's digital transformation

India's exemplary work in digital connectivity

In the past decade, India's digital revolution has garnered international recognition, thanks to the collaborative efforts between the public and private sectors. These partnerships have been instrumental in driving innovation and delivering user-centric services.

On the one hand, these technological advancements have propelled India's remarkable progress in improving business efficiency, enhancing global competitiveness, and positioning the nation for substantial future growth. On the other hand, they provide the means for the public and private sectors to reshape the country's current social and economic landscape to foster equitable growth and progress.

India's population-scale Digital Public Infrastructure (DPI) initiatives are crucial to advance financial and digital inclusion, especially among underserved populations, which ensure technology-driven solutions are accessible to all.

The Department of Telecommunications (DoT), Ministry of Communications, Government of India, has been at the core of this remarkable journey and has been pivotal to enable connectivity, leading to a paradigm shift in the delivery and adoption of digital services to the masses. This department shapes policies, oversees spectrum management, regulates the telecom sector, and fosters infrastructure growth to make digital technology accessible to every citizen.

> Through continuous endeavors of the DoT, India has achieved remarkable milestones in digital connectivity. The nation now boasts a teledensity[1] of 84.58%[2], with 881.1 million Internet subscribers (as of July 2023). Additionally, the ambitious BharatNet program has successfully connected around 200,000 *gram panchayats*,[3] which showcases significant progress in the expansion of digital infrastructure and accessibility.

However, these long strides in India's journey of the digital revolution were not an overnight phenomenon. India's digital connectivity journey began with the liberalization of the telecom sector in the early 1990s, ushering in the participation of private players. Needless to say, the government's vision and the exceptional efforts and the private sector's implementation prowess have synergistically propelled this initiative. A clear example of this is the widespread availability of mobile phone services, which has now reached a zenith.

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[1] As per the International Telecommunication Union (ITU), teledensity refers to the number of telephone connections (fixed lines and mobile phone subscribers) per 100 inhabitants within a geographical area.

[2] Telecom Regulatory Authority of India (TRAI), "Highlights of subscription data as on 31st July, 2023", September 27, 2023, Accessed October 06, 2023. https://www.trai.gov.in/sites/default/files/PR_No.98of2023_0.pdf

[3] Department of Telecommunications, "BharatNet Project", Accessed October 06, 2023, https://dot.dashboard.nic.in/DashboardF.aspx

The Economic Survey 2022-2023 highlighted the crucial role of digital infrastructure in driving economic growth, which underscores the transformative impact of the Digital India Campaign launched in 2015. This initiative has led to more Internet subscribers in rural areas in the past three years (2019-2021) compared to their urban counterparts (95.76 million against 92.81 million in rural and urban areas, respectively).[4]

Through sustained and well-coordinated efforts, India has earned global recognition for its pioneering role to establish a robust digital ecosystem and DPI. This recognition was reaffirmed through the recent G20 New Delhi Leaders' Declaration, which underscores DPI's importance in delivering societal scale.[5]

This robust digital infrastructure has become a bedrock to serve other ambitious government initiatives. These include the *Pradhan Mantri Jan Dhan Yojana* (PMJDY), initiated in 2014, which is a National Mission for Financial Inclusion. The term "Jan" signifies people, and "*Dhan*" represents money, which reflects the mission's goal to extend banking services to every household nationwide with a particular focus on rural and underserved regions. This ambitious initiative has substantially expanded the formal banking system's reach to promote financial inclusion among the population.

"Aadhaar," which translates to foundation, is the national biometric identification system introduced in 2009. It serves as a cutting-edge digital identity solution that facilitates swift and secure verification in various service delivery transactions, such as bank account openings and ration distribution. It has paved the way for cost-effective validation of an individual's identity.

The widespread use of mobile phones and mobile networks across the country, facilitated by the Department of Telecommunications, ensures citizens can access financial services and government information from any part of the country

Together, the *Jan Dhan*, *Aadhaar*, and Mobile form the JAM Trinity, a cornerstone of the government's efforts to improve the delivery of social welfare benefits and financial services to citizens. The JAM Trinity has enabled India to build the world's largest Direct Benefit Transfer (DBT) system and disbursed USD 4.5 billion to 160 million beneficiaries during the COVID-19 pandemic.[6] This integrated approach has enhanced the effectiveness and transparency of government schemes, contributed to poverty reduction, increased financial inclusion, and ensured timely delivery of social security benefits to the citizens.

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[4] Ministry of Finance, "Economic Survey 2022-23", January 01, 2023, Accessed October 06, 2023, https://www.indiabudget.gov.in/economicsurvey/doc/echapter.pdf

[5] Economic Times, "G20 New Delhi Declaration: Digital Public Infrastructure, international governance for AI in focus", September 09, 2023, Accessed October 06, 2023, https://economictimes.indiatimes.com/tech/technology/g20-new-delhi-declaration-digital-public-infrastructure-international-governance-for-ai-in-focus/articleshow/103539992.cms?from=mdr

[6] Pramod K.Verma. " Driving inclusion and innovation at scale", indiastack.global, February, 2023, Accessed October 08, 2023, https://www.indiastack.global/wp-content/uploads/2023/02/Dr-Pramod-Verma-ID-Session.pdf
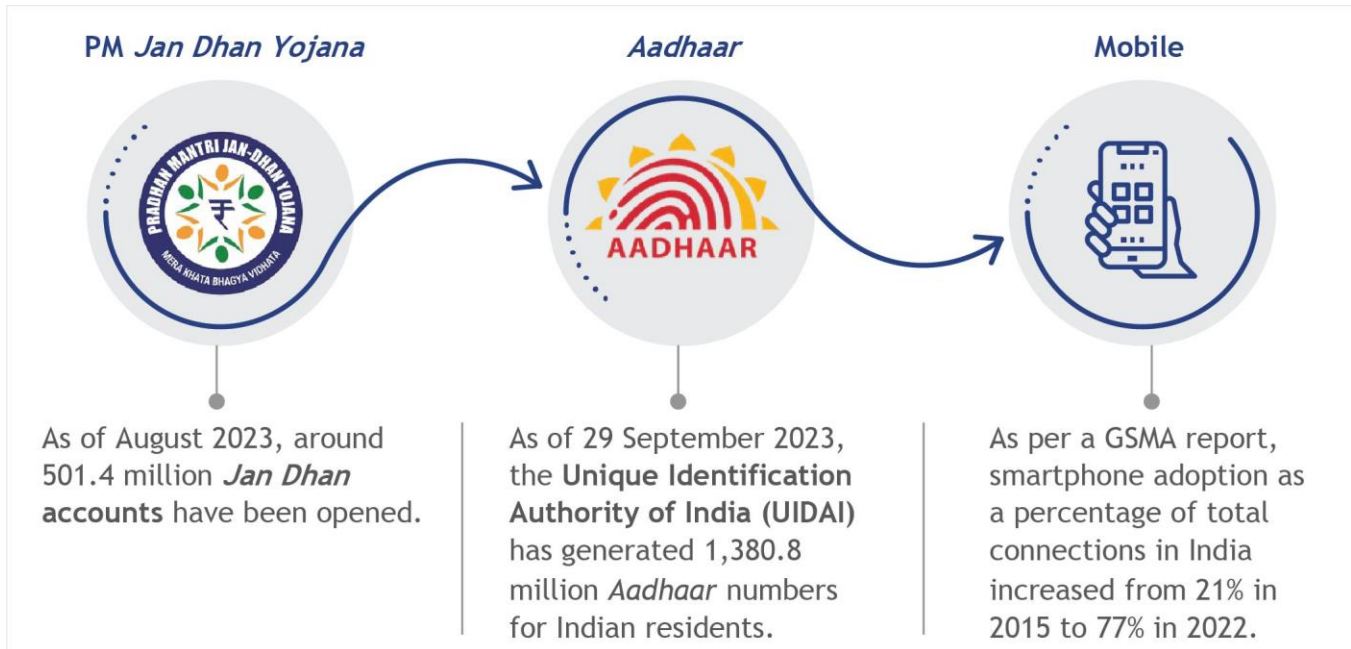
Figure 1: Milestones achieved under JAM (*Jan Dhan, Aadhaar*, Mobile) trinity

India has accomplished the world's swiftest 5G deployment and currently possesses the globe's second-largest 5G network. 5G services were launched in India on 1st October 2022, and as of August 2023, more than 3,00,000 sites have been installed in 714 districts in India.[7] This demonstrates India's commitment to staying at the forefront of technological advancement.

India's impressive progress on digital connectivity and further building a world-class DPI provide valuable lessons for countries embarking on their digital transformation journeys. It underscores the importance of a design approach focused on expanding digital connectivity and creating a strong digital ecosystem to promote growth and development while using technology to address both present and future global challenges.

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[7]Gulveen Aulakh, Live Mint, "India has largest 5G network in the world: Vaishnaw", August, 2023, Accessed October 08, 2023, https://www.livemint.com/industry/telecom/india-has-largest-5g-network-in-world-vaishnaw-11690919124083.html

Chapter 2
Digital connectivity in India:
A journey through technical advancements

Growth of digital connectivity in India

India has witnessed remarkable progress in delivering telecommunication services to its populace in the past decade. With 1176.85 million telephone subscribers (as of July 2023), India has the second-largest subscriber base globally. Increased telecommunications penetration in India is evident in the growth of the overall teledensity, which has reached 84.58 % as of July 2023, which happened to be 41.08 % in July 2009. This growth in telecommunication has enhanced the cost-effective outreach and accessibility of a wide range of mobile-based services such as e-governance, online education, and e-health, among others, thereby enhancing penetration and usage.

Growth of Internet subscribers

India witnessed rapid growth in the Internet after the widespread deployment of 4G[8]. As of March 2023, the number of Internet subscribers[9] in India has reached 881.3 million[10] compared to 251.6 million in March 2014, that is, a 250% growth between 2014 and 2023.[11]

Improved Internet connectivity also enhances communication, makes it easier for people to connect, share ideas, and access essential services, and ultimately boosts overall societal progress.

A rise in the number of Internet subscribers in India have promoted digital inclusion and provided access to education, information, and job opportunities for a larger portion of the population. This growth has stimulated economic development by fostering e-commerce, digital entrepreneurship, and technology-driven innovation. The growth is both in terms of the number of subscribers and the Internet's penetration among the population.

The total Internet subscribers per 100 population, considered an important indicator for Internet penetration, has grown to 65.3 (as of March 2023) from 24.1 in 2015 (as of March 2015).[12]

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[8]TRAI, "Wireless Data Services in India: An Analytical Report", 2019, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/Wireless_Data_Service_Report_21082019.pdf

[9] Number of Internet subscribers do not depict the share of the population with Internet as some individuals can have multiple subscriptions

[10] TRAI, "Performance Indicator Report", March 2023, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/QPIR_21082023_0.pdf

[11] TRAI, "Performance Indicator Report", March 2014, March 2023, Accessed October 06, 2023

[12] Telecom Regulatory Authority of India (TRAI), "Performance Indicator Report", March 31, 2023, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/QPIR_21082023_0.pdf

Internet subscribers in India (2014-23)
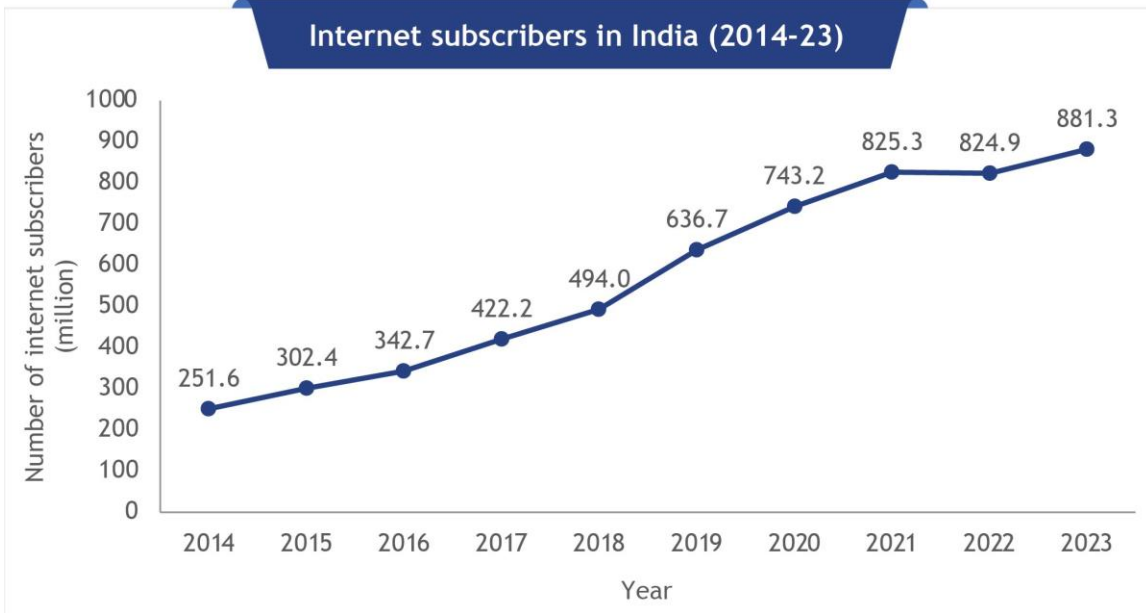

Figure 2: Growth of total Internet subscribers in India from 2014 to 2023[13]

Total Internet subscribers per 100 population (2015-2023)
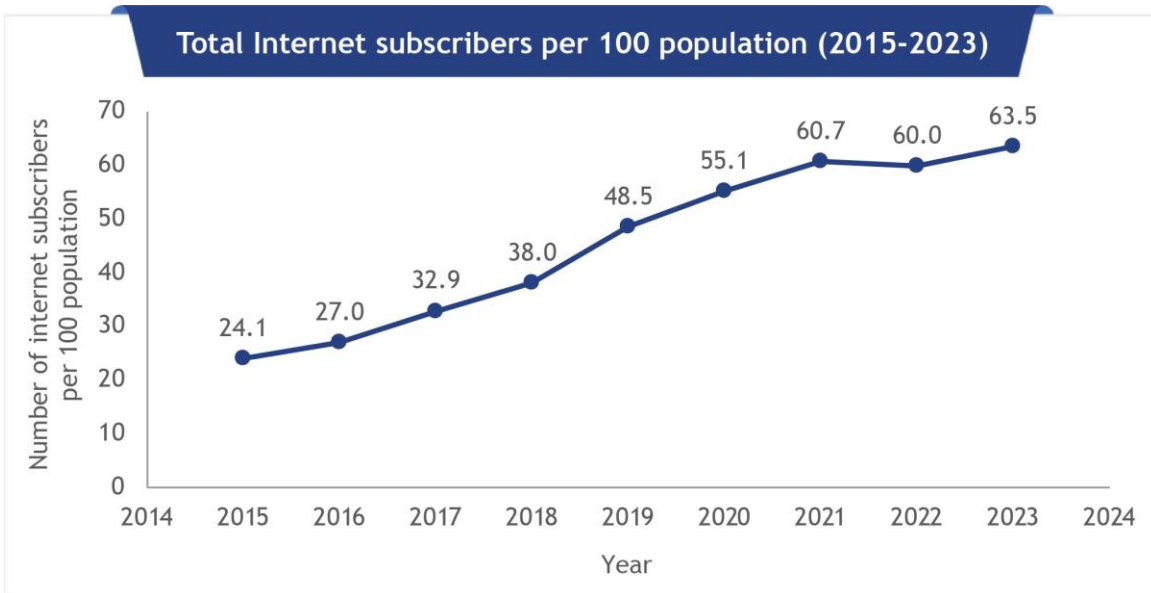
Figure 3: Growth in total Internet subscribers per 100 population between 2015- 23 (as of March 31, 2023)[14]

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[13] Data as of 31 March of the mentioned year on X-axes; the number of Internet subscribers do not necessarily depict share of the population with the Internet as some individuals can have multiple subscriptions. Based on Telecom Regulatory Authority of India's (TRAI) Performance Indicator Reports from 2014 to 2023.

[14] Telecom Regulatory Authority of India (TRAI), "Performance Indicator Report", March 31, 2023, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/QPIR_21082023_0.pdf

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Growth of rural subscribers

India is predominantly a rural country, with about 65% of its population living in rural areas.[15] Enhancing Internet accessibility in rural India has been vital to bridge the urban-rural digital divide and ensure equitable opportunities for education, employment, and information access. This has empowered rural communities by enabling e-governance services, telemedicine, and access to marketplaces, fostering economic growth and healthcare advancements.

Improved rural Internet connectivity also drives agricultural efficiency, knowledge sharing, and overall development, and contributes to the nation's progress.

While rural areas may have initially lagged behind urban areas in terms of teledensity and Internet subscribers, they now demonstrate remarkable progress and have sustained consistent growth, as depicted in Figure 3.
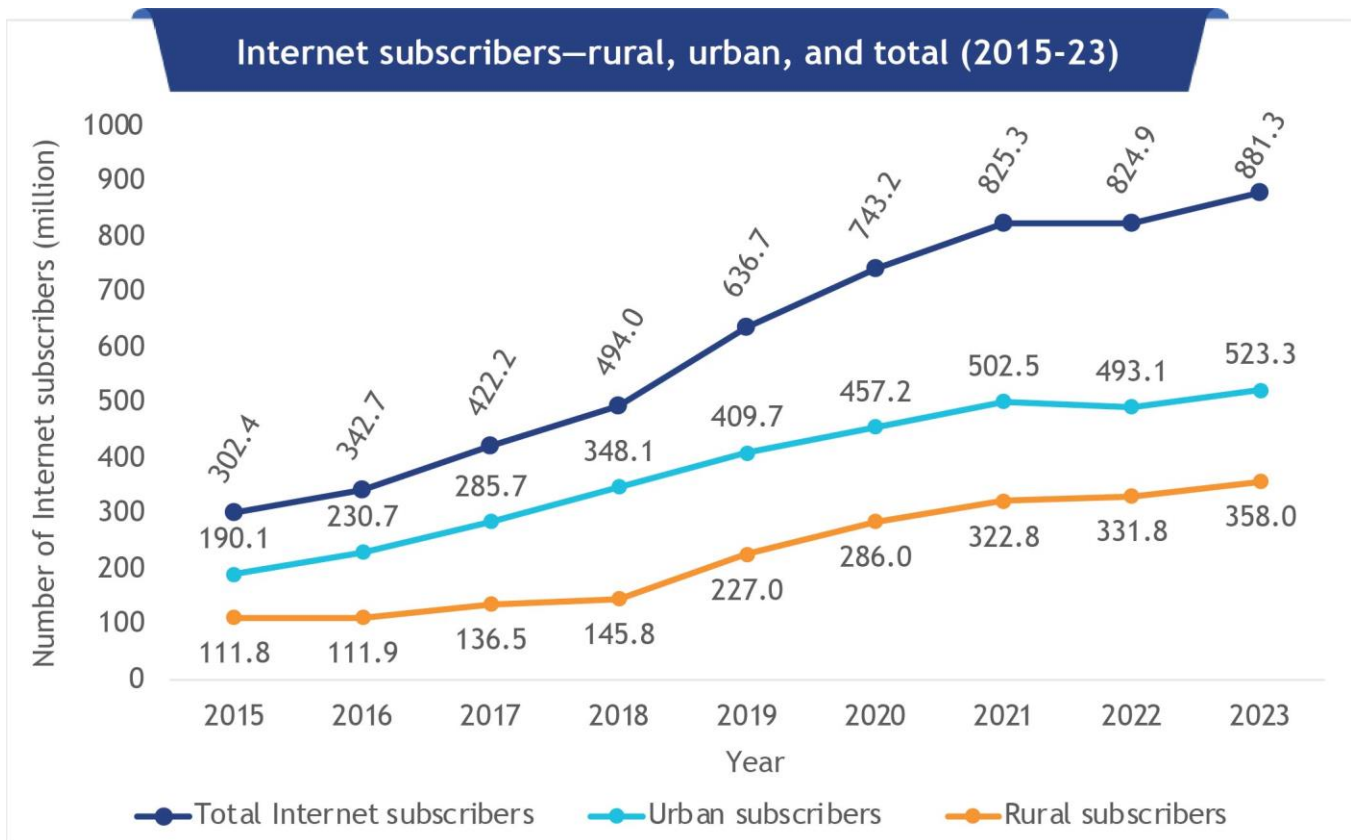

Internet subscribers—rural, urban, and total (2015-23)

Total Internet subscribers: 302.4 (2015), 342.7 (2016), 422.2 (2017), 494.0 (2018), 636.7 (2019), 743.2 (2020), 825.3 (2021), 824.9 (2022), 881.3 (2023)

Urban subscribers: 190.1 (2015), 230.7 (2016), 285.7 (2017), 348.1 (2018), 409.7 (2019), 457.2 (2020), 502.5 (2021), 493.1 (2022), 523.3 (2023)

Rural subscribers: 111.8 (2015), 111.9 (2016), 136.5 (2017), 145.8 (2018), 227.0 (2019), 286.0 (2020), 322.8 (2021), 331.8 (2022), 358.0 (2023)

— Total Internet subscribers — Urban subscribers — Rural subscribers

Figure 4: Growth in rural Internet subscribers between 2015-2023 (as of 31st March 2023)[16]

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[15] World Bank, "Rural Population (% of total population)", 2020, Accessed October 10, 2023

[16]Telecom Regulatory Authority of India (TRAI), "Performance Indicator Report", March 31, 2023, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/QPIR_21082023_0.pdf

Rural Internet subscriptions increased by 220% between 2019 and 2023, whereas urban Internet subscriptions during the same period grew by 175%.[17] On a positive note, rural areas added more Internet subscribers (130.98 million) compared to the urban ones (113.55 million)[18] between 2015 and 2023.

Decline in cost of data and growth in usage of data

> Indians can access wireless data at extremely low prices. As of September 2023,
> 1 GB of data costs INR 13.2 (USD 0.16) on average in India, which is one of the lowest in the world.[19]

The year 2016 was a watershed moment for telecommunications in India owing to the widespread deployment of 4G.[20] From 2016, the cost of wireless data started declining rapidly coupled with a growing usage of data. For instance, the cost of data declined sharply in India from INR 269 per GB in 2014 to INR 11.8 in 2018. On the other hand, the average usage of data per user per year increased from 3.2 GB per user per year in 2014 to 92.3 GB per user per year in 2018.

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[17]Ministry of Finance, "Economic Survey 2022- 23", https://www.indiabudget.gov.in/economicsurvey/doc/eschapter/echap12.pdf ; TRAI Performance Indicator Reports (March 2015 and March 2023)

[18]Ministry of Finance, "Economic Survey 2022- 23", https://www.indiabudget.gov.in/economicsurvey/doc/eschapter/echap12.pdf ; TRAI Performance Indicator Reports (March 2015 and March 2023)

[19]Cable, "Worldwide mobile data pricing: The cost of 1GB of mobile data in 237 countries", September, 2023, Accessed October 06, 2023, https://www.cable.co.uk/mobiles/worldwide-data-pricing/

[20]TRAI, "Wireless Data Services in India: An Analytical Report", 2019, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/Wireless_Data_Service_Report_21082019.pdf
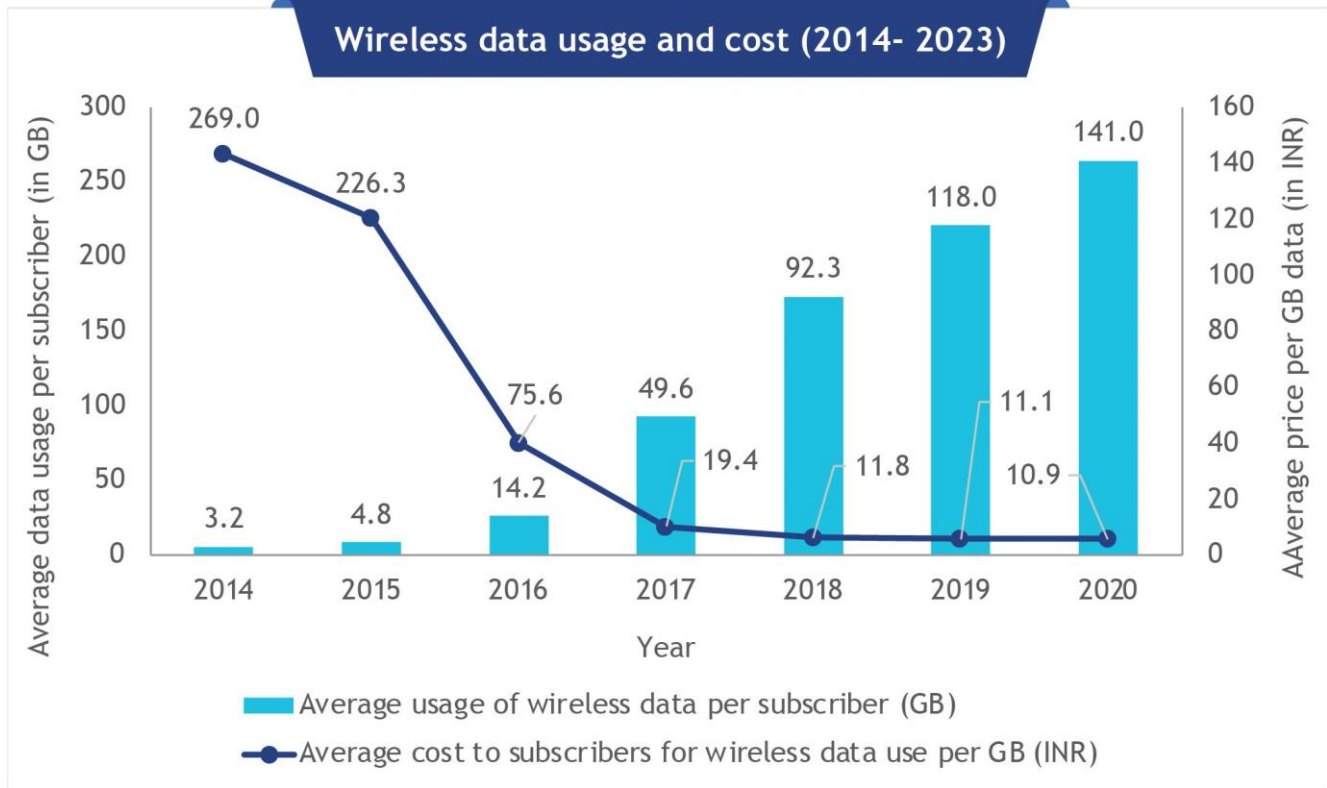
Wireless data usage and cost (2014- 2023)

Figure 5: Analysis of cost and usage of wireless data between 2014 -2020[21]

Increasing number of smartphone users

> The number of smartphone users has increased significantly in India, especially since 2016. As per a report by GSMA, smartphone adoption (percentage of total connections) increased up to 77% in 2022 from 21 % in 2015[22].

As of 2021, India had 750 million smartphone users out of 1.2 billion mobile users, as per a report by Deloitte.[23]

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[21]TRAI, "Wireless data services in India: An analytical report", 2020, Accessed October 06, 2023, https://www.trai.gov.in/sites/default/files/Wireless_Data_Service_Report_21082019.pdf

[22]GSMA, "India: on the road to a digital nation", 2022, Accessed October 06, 2023, https://www.gsma.com/asia-pacific/wp-content/uploads/2022/09/India-report-FINAL-WEB.pdf

[23]Deloitte, "TMT predications 2022", February 2022, Accessed October 06, 2023, https://www2.deloitte.com/content/dam/Deloitte/in/Documents/technology-media-telecommunications/in-TMT-predictions-2022-noexp.pdf

> The report also predicts that smartphone demand in India will increase at a CAGR of 6% in the rural market compared to a CAGR of 2.5 % in the urban market, fueled by higher Internet adoption.

Furthermore, device affordability (device cost as a share of income) has also improved significantly over the past five years.[24]

Department of Telecommunication's (DoT) initiatives toward connectivity in rural and remote regions

The Department of Telecommunication has launched several initiatives to improve connectivity within India, especially in rural, remote, and insurgency-affected areas. These include Bharat Net, which connects 2,50,000 Gram Panchayats (village councils) through optical fiber; Comprehensive Telecom Development Plan (CTDP) for the North-Eastern Region, which installs towers to provide mobile connectivity to uncovered villages in the remotest part of the country; CTDP for Islands, which lays submarine cables to connect the Islands of India, that is, Andaman and Nicobar Islands and Lakshadweep Islands with the mainland; Network for Insurgency-Affected Areas, which provides mobile services in 2199 locations in 10 states.

These initiatives were crucial to reducing the digital gap by extending essential online services to remote and rural populations. By doing so, they provided access to education, healthcare, and employment opportunities and strengthened social bonds and unity among communities in these underserved areas, promoting inclusive development.

Technological advancements: Fastest 5G rollout in the world

India's technological capabilities have been steadily growing from strength to strength.

> As cited earlier, the 5G rollout in India has been one of the fastest in the world. Within eight months of launch (October 2022 to May 2023), a 5G network has been rolled out, which spans 28 states and eight union territories with more than 200,000.[25]

Moreover, in tandem with the swift expansion of telecommunication infrastructure, India has been actively advancing toward self-sufficiency and positioning itself as a hub for exporting mobile technologies. A significant milestone in this journey occurred during the 2022 edition of the India

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[24]ICRIER, "State of India's Digital Economy Report", 2023, Accessed October 06, 2023, https://icrier.org/pdf/State_of_India_Digital_Economy_Report_2023.pdf

[25]PIB, "Fastest 5G rollout", May 2023, Accessed October 06, 2023, https://pib.gov.in/PressReleasePage.aspx?PRID=1927062

Mobile Congress (IMC) when India's Prime Minister unveiled the 5G Non-Standalone (NSA) Core, a product designed and developed by the Centre for Development of Telematics (C-DOT).[26]

A consortium led by C-DOT has developed the 4G-5G stack. The consortium developed the software and manufactured the equipment for the rollout of the 4G-5G stack.[27] With the successful introduction of an indigenously developed 4G and 5G stack, India has taken a significant stride toward self-reliance in telecommunication technologies.

The introduction of indigenous technology is expected to reduce infrastructure and operational costs for telecom service providers, with a few providers adopting the 4G-5G stack in its early stages. Studies indicate countries increasingly seek affordable technology to introduce 5G services.[28]

> Since the indigenous technology is meant for domestic use and is also available for adoption by other countries, as per the Centre, more than 18 countries have expressed interest in India's 4G-5G stack.[29]

Connectivity x development

he role of digital infrastructure, including connectivity in socioeconomic development, is well-recognized. Digital infrastructure serves as the foundational pillar of a digital nation upon which digital services and applications are created, stored, distributed, and consumed.[30] India's digital infrastructure, bolstered by initiatives, such as *Aadhaar*, UPI, and *Jan Dhan*, proved pivotal to address developmental needs and mitigate the COVID-19 impact.

Robust telecommunications ensured seamless connectivity for remote work, telemedicine, and e-learning during the pandemic.

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[26]PIB, "The Prime Minister, Shri Narendra Modi launched wholly indigenous 5G NSA Core designed and developed by C-DOT, at India Mobile Congress 2022",October 01, 2022, Accessed October 06, 2023, https://pib.gov.in/PressReleasePage.aspx?PRID=1864252

[27]Jatin Grover, "Explainer: The 4G-5G technology stack", Financial Express, March 09, 2023, Accessed October 06, 2023, https://www.financialexpress.com/life/technology-explainer-the-4g-5g-technology-stack-3002960/

[28]Global Mobile Suppliers Association, "5G-Market Snapshot February 2023", Accessed October 06, 2023, https://gsacom.com/paper/5g-market-snapshot-february-2023/

[29]PIB, "Fastest 5G rollout", May 2023, Accessed October 06, 2023, https://pib.gov.in/PressReleasePage.aspx?PRID=1927062

[30]GSMA, "India: on the road to a digital nation", 2022, Accessed October 06, 2023, https://www.gsma.com/asia-pacific/wp-content/uploads/2022/09/India-report-FINAL-WEB.pdf

The innovative Digital Public Infrastructure (DPI), Digital Public Goods (DPGs), and Digital Public Platforms (DPPs) provide scalable models for identity, finance, healthcare, education, and agriculture.

Connectivity acts as a linchpin to enable these solutions to tackle global issues, such as poverty, access to education and healthcare, and food security, to usher in a more equitable digital future.

Chapter 3
Transforming sectors through digital connectivity: Exploring key use cases

Convergence of digital connectivity and DPI in furthering inclusion

Digital transformation has welcomed an era of inclusion and empowerment, with substantial growth in Internet penetration, mobile network accessibility, and broadband services, enhancing connectivity and digital access for individuals.

> As per a report by the United Nations Development Programme (UNDP), DPIs hold the potential to globally accelerate economic growth by a substantial margin of 20-33% by the year 2030 through financial DPI.[31] Additionally, the uptake of digital identity systems has the potential to unlock an economic value of 3-13% of a nation's GDP.[32]

The proliferation of digital connectivity has served as the cornerstone to establish India's Digital Public Infrastructure (DPI), a phenomenon that has garnered international recognition and acclaim. Furthermore, a report published by the Bank of International Settlements in 2019 underscores India's remarkable achievement in financial inclusion, attributable to its robust digital public infrastructure.[33]

> Due to its DPI, India managed to compress a progress trajectory that would have ordinarily spanned 47 years into a mere seven years.[34]

Aadhaar's use to facilitate direct benefit transfers has streamlined the delivery of government subsidies and curtailed their leakage by a commendable 14%.[35] Crucially, these transformative outcomes would have remained beyond reach had the foundational digital connectivity infrastructure not been in place.

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31 UNDP, "Accelerating the SDGs through Digital Public Infrastructure", 2023, Accessed October 06, 2023. https://www.undp.org/sites/g/files/zskgke326/files/2023-08/accelerating_the_sdgs_through_digital_public_infrastructure.pdf

32 Bhaskar Chakravorti, "The Case for Investing in Digital Public Infrastructure", Harvard Business Review, 2023, Accessed October 06, 2023. https://hbr.org/2023/05/the-case-for-investing-in-digital-public-infrastructure

33 Derryl D'Silva et al., "The design of digital financial infrastructure: lessons from India", 2019, Bank for International Settlements. Accessed October 06, 2023. https://www.bis.org/publ/bppdf/bispap106.pdf

34 The Rockefeller Foundation, "Digital Public Infrastructure for an Equitable Recovery", 2021, Accessed October 06, 2023. https://www.rockefellerfoundation.org/wp-content/uploads/2021/08/Co-Develop-Digital-Public-Infrastructure-for-an-Equitable-Recovery-Full-Report.pdf

35 Ibid.

Figure 6: India's Digital Public Infrastructure

The combination of enhanced connectivity and the establishment of a strong Digital Public Infrastructure (DPI) in India catalyzed India's progress to promote inclusivity and digital empowerment nationwide. This expanded connectivity has democratically widened access to information, empowered individuals and communities, and enabled active participation in the digital age.

Several key DPI components have streamlined access to vital services and catalyzed transformative changes in diverse sectors. These components include *Aadhaar*, UPI, and the ABDM, which provides residents with a digital ID, an interoperable payment system, and a digital health infrastructure respectively.

In the subsequent sections, we delve deeper into five areas—identity, finance, health, education, and agriculture—and emphasize the pivotal role of connectivity to help develop a robust digital ecosystem in India and explore their global relevance to address current and emerging development challenges.

Sector in focus: Identity

A recognized legal form of identification is essential for individuals to establish their identity, which enables them to participate fully in society and the economy. This fundamental right is a cornerstone for accessing services and opportunities that empower citizens.

> The importance of providing a legal identity to individuals is underscored by the objective outlined in the SDG Target 16.9, which aims to provide legal identity for all individuals, including birth registration by 2030.[36]

The United Nations emphasizes that digital inclusion significantly enables economic development across 13 out of the 17 SDGs.[37] Identification is vital to advance various SDG targets, such as enhancing financial inclusion, expanding social protection, improving healthcare accessibility, ensuring equitable education for all, promoting sustainable agriculture, and fostering good governance.[38]

The World Economic Forum, in a comprehensive report, emphasized the importance of having a **robust digital identity infrastructure** in place to unlock social and economic progress.[39] The potential impact of a robust digital ID system in helping attain these objectives is of profound significance.

> As per McKinsey, nations that effectively implement a digital ID system could realize economic benefits, which range from 3% to 13% of their GDP by 2030.[40]

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[36]UN SDG Goals. Accessed October 6, 2023. https://sdgs.un.org/goals

[37]United Nations, "Igniting SDG Progress through Digital Financial Inclusion", 2018. Accessed October 06, 2023. https://sustainabledevelopment.un.org/content/documents/2655SDG_Compendium_Digital_Financial_Inclusion_September_2018.pdf

[38]World Bank, ID4D. Accessed October 6, 2023. https://id4d.worldbank.org/guide/good-id-supports-multiple-development-goals

[39]World Economic Forum, "Identity in a Digital World: A new chapter in the social contract", 2018, Accessed October 06, 2023, https://www3.weforum.org/docs/WEF_INSIGHT_REPORT_Digital%20Identity.pdf

[40]McKinsey Global Institute, "Digital identification: A key to inclusive growth". Accessed October 6, 2023. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/digital-identification-a-key-to-inclusive-growth

Current and emerging challenges

As per the ID4D Global Dataset on Global ID Coverage (2021), approximately 850 million individuals worldwide lack official proof of their identity.[41] Further, it also estimates that 90% of this population resides in low-income and lower-middle-income countries.[42] Depriving individuals of a legal identity has far-reaching implications, including impeding the overall economic growth of nations. A few of the challenges faced globally are listed below.

1. **Public service delivery:** Having a robust, verifiable digital identity that can be used interoperably enhances public disbursement of government services and payments. It also helps make the delivery cost-effective and direct to the beneficiary's bank account.[43] As per a World Bank study, during the COVID-19 pandemic, countries that used digital databases could cater to 51% of their population with cash transfers compared to 16% for the countries that did not rely on digital databases to target eligible individuals.[44]

2. **Social exclusion:** The lack of a formal identity may lead to social exclusion of the individual. In Nepal, for instance, 13% of men and 26% of women lack the necessary citizenship certificate for activities, such as land ownership and banking, which deprives them of basic services.[45,46] Not having a formal identity also bars individuals from casting their vote and further limits their participation in society.

3. **Economic exclusion:** The lack of identity impedes formal employment opportunities and hinders economic contributions. It restricts access to financial services, including banking, loans, and insurance, which leaves individuals vulnerable.

4. **Issue of migration:** Migrants, who lack legal identity documents, face heightened vulnerability. Their inability to prove identity hinders travel and limits access to employment and public services.[47] The estimated number of international migrants has proliferated over the past five

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[41]The World Bank, "ID4D Global Dataset, 2021", Accessed October 6, 2023. https://id4d.worldbank.org/global-dataset

[42]World Bank, "Global Findex Database, 2021", Accessed October 6, 2023. https://www.worldbank.org/en/publication/globalfindex

[43]Siddharth Dixit, "India's digital transformation could be a game-changer for economic development", 2023, World Bank Blogs. Accessed October 06, 2023. https://blogs.worldbank.org/developmenttalk/indias-digital-transformation-could-be-game-changer-economic-development

[44] Vyjayanti T Desai, "How digital public infrastructure supports empowerment, inclusion, and resilience", 2023, World Bank Blogs. Accessed October 06, 2023. https://blogs.worldbank.org/digital-development/how-digital-public-infrastructure-supports-empowerment-inclusion-and-resilience

[45]Alan Gelb et. al, "Identification Revolution: Can Digital ID Be Harnessed for Development?", Center for Global Development, 2017. Accessed October 6, 2023. https://www.cgdev.org/sites/default/files/identification-revolution-can-digital-id-be-harnessed-development-brief.pdf

[46]McKinsey Global Institute, "Digital identification: A key to inclusive growth". Accessed October 6, 2023. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/digital-identification-a-key-to-inclusive-growth

[47]United Nations Economic Commission for Latin America and the Caribbean, "The impact of COVID-19: an opportunity to reaffirm the central role of migrants' human rights in sustainable development", 2020. Accessed October 6, 2023. https://repositorio.cepal.org/server/api/core/bitstreams/668d7215-4770-4a94-a052-c55a4f719dd7/content

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decades. In 2020, the total number of individuals who lived in a country other than their country of birth reached 281 million, an increase of 128 million compared to 1990.[48]

As technology continues to progress, digital identities must exhibit **versatility and interoperability** to facilitate enhanced operational efficiency and minimize redundancy in efforts and associated costs.[49]

Harnessing technology and connectivity: Case studies from India

The emergence of verifiable digital identities has ushered in a multitude of opportunities. These digital identities have catalyzed the **creation of new markets and businesses** within the private sector, facilitated speedy and **efficient delivery of government services, and engaged more proactively with citizens**, which has helped **enhance overall governance**.[50]

India's solution to catering to its large population and providing them with a legal digital identity was setting up its digital public infrastructure, *Aadhaar*. It laid the cornerstone for an efficacious identification system and opened up several practical applications.

Aadhaar has revolutionized India's digital landscape, providing the nation with a dependable and **verifiable form of identification**. Before *Aadhaar*, only **one in every 25 individuals possessed formal identification**, and only **one in four held bank accounts**.[51] Since its launch in 2009, *Aadhaar* has amassed **1.38 billion Indian citizens under its cover**.[52]

Its core objective is to provide each citizen with a unique and biometrically verifiable **12-digit identification number** linked to their **fingerprints and iris scans**. This unique number can be cross-referenced with biometric data in the centralized database to unlock quick authentication for millions of Indians, thus contributing significantly to citizen empowerment.[53]

Aadhaar's widespread adoption has transformed India's identification ecosystem, streamlined identity verification, and replaced multiple government-issued IDs for authentication purposes.[54] This

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[48] International Organization for Migration, World Migration Report 2022, 2021, Accessed October 06, 2023. https://publications.iom.int/books/world-migration-report-2022

[49] World Economic Forum, "Identity in a Digital World: A new chapter in the social contract", 2018, Accessed October 06, 2023, https://www3.weforum.org/docs/WEF_INSIGHT_REPORT_Digital%20Identity.pdf

[50] World Economic Forum, "Identity in a Digital World: A new chapter in the social contract", 2018, Accessed October 06, 2023, https://www3.weforum.org/docs/WEF_INSIGHT_REPORT_Digital%20Identity.pdf

[51] Derryl D'Silva et. al, "The design of digital financial infrastructure: lessons from India", BIS, 2019. Accessed October 06, 2023, https://www.bis.org/publ/bppdf/bispap106.htm

[52] Aadhaar Dashboard, UIDAI. Accessed October 06, 2023, https://uidai.gov.in/aadhaar_dashboard/

[53] Siddharth Dixit, "India's digital transformation could be a game-changer for economic development", 2023, World Bank Blogs. Accessed October 06, 2023, https://blogs.worldbank.org/developmenttalk/indias-digital-transformation-could-be-game-changer-economic-development

[54] Siddharth Dixit, "India's digital transformation could be a game-changer for economic development", 2023, World Bank Blogs. Accessed October 06, 2023, https://blogs.worldbank.org/developmenttalk/indias-digital-transformation-could-be-game-changer-economic-development

transition has enabled a multitude of services built upon the *Aadhaar* infrastructure, led to better operational efficiency, and reduced associated costs across sectors.

The government has harnessed *Aadhaar* to target beneficiaries precisely and disburse cash transfers directly to them.

> By the end of 2022, *Aadhaar* facilitated disbursements cumulatively worth USD 310 billion through more than 6 billion beneficiary transactions across various government direct benefit transfer initiatives.[55]

Aadhaar stands as a pivotal catalyst to unlock novel avenues for the Indian economy and serve as the facilitator to a host of digital services that seek to benefit citizens. As we progress into subsequent sections, *Aadhaar's* foundational role as an identity layer becomes crucial in providing the base for other use cases, a few of which include:

1. DigiLocker

A government-backed platform provided to *Aadhaar* holders in India, DigiLocker offers secure **digital document storage and sharing capabilities**. This service was introduced with the primary goal to simplify document management for citizens and foster digital empowerment.

> With more than 150 million registered users and 60 million monthly active engagements, it has streamlined document access while enhancing government service efficiency and transparency.[56]

This government-operated mobile and web app has gained recognition and legal backing through the Information Technology (Preservation & Retention of Information by Intermediaries Providing Digital Locker Facilities) Rules, 2016.[57] Additionally, DigiLocker's cloud-based approach for secure and

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[55]Leslie D'Monte, "Nandan Nilekani: Account aggregators make access toloans easy", Mint, 2022. Accessed October 06, 2023, https://www.livemint.com/news/india/nandan-nilekani-account-aggregators-make-accesstoloanseasy-11670868724715.html

[56]Sridhar Rajendran, "15 Crore and Counting: DigiLocker Leads the Charge in India's Digital Revolution", DigiLocker Blog, 2023. Accessed October 06, 2023, https://blog.digilocker.gov.in/15-crore-and-counting-digilocker-leads-the-charge-in-indias-digital-revolution/

[57]Ministry of Electronics and Information Technology, Preservation & Retention of Information by Intermediaries Providing Digital Locker Facilities Rules, 2016, Accessed October 06, 2023. https://www.dla.gov.in/sites/default/files/pdf/aboutUS/preservation-and-retention-of-information-by-intermediaries-providing-digital-locker-facilities-rules-2016.pdf

scalable systems can potentially serve as a global best practice to offer digital empowerment while simplifying document access for citizens.

2. e-KYC

The e-KYC service allows for **identity verification. It** allows residents to authenticate and authorize the Unique Identification Authority of India (UIDAI) to securely share their *Aadhaar* data electronically.[58] This digital process replaces the need for physical copies of identity documents and significantly **reduced the risk of fraud, counterfeit document usage, manual auditing, and costs associated with the traditional KYC process**.[59]

> As per an IMF report, the cost incurred in conducting know your customer (KYC) processes in India has been substantially diminished, slashing from USD 12 to a mere 6 Cents for conducting e-KYC.[60]

The *Aadhaar*-enabled e-KYC process simplifies the process for citizens and saves significant processing costs for authenticating agencies.

3. e-Auth

Aadhaar authentication enables agencies to verify the identity of *Aadhaar* number holders through the UIDAI authentication service on a secure private network. This service validates the identity of *Aadhaar* number holders by cross-referencing their details with the Central Identity Data Repository, using factors, such as biometrics, demographics, or one-time PINs based on the specific service requirements.[61]

Aadhaar's establishment as a digital public infrastructure has revolutionized service delivery for both government and private entities and improved efficiency and effectiveness. This foundational infrastructure has catalyzed advancements within various sectors and empowered citizens to engage seamlessly with the digital ecosystem.

India has demonstrated the potential of an interoperable and easily verifiable digital ID system to enhance economic growth across a large population. Several developing countries have expressed interest in using India's expertise to establish their digital ID systems.

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[58]Identity, India Stack. Accessed October 06, 2023, https://indiastack.org/identity.html

[59]Identity, India Stack. Accessed October 06, 2023, https://indiastack.org/identity.html

[60] Cristian Alonso et al., "Stacking up the benefits: Lessons from India's digital journey", 2023, International Monetary Fund. Accessed October 06, 2023, https://www.imf.org/-/media/Files/Publications/WP/2023/English/wpiea2023078-print-pdf.ashx

[61] Identity, India Stack. Accessed October 06, 2023, https://indiastack.org/identity.html

India's indigenous **Modular Open Source Identity Platform (MOSIP)** offers a cost-effective and modular solution for governments and user organizations developed by the International Institute of Information Technology, Bangalore (IIIT-B).[62]

> Sierra Leone, Ethiopia, Togo, and Sri Lanka are among the countries that have entered a partnership with MOSIP to assist with their digital identity systems.[63]

India has taken the lead in sharing its identity innovations with the world to promote inclusive growth and development.

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[62]MOSIP. Accessed October 6, 2023, https://mosip.io/index.php

[63]MOSIP, "MOSIP and Sierra Leone Sign MoU to Pilot National Digital ID System", January 10, 2023, Accessed October 6, 2023. https://mosip.io/news-events/mosip-and-sierra-leone-sign-mou-to-pilot-national-digital-id-system

Sector in focus: Financial services

Financial services comprise a critical component of the economic growth of each country. Improvements in access, usage, and quality of financial services aid the development of a country across sectors. As per the United Nations, innovations in financial services can help countries achieve various SDGs since they impact various sectors.[64]

> The financial services industry has the highest impact on four SDGs, including eliminating poverty (SDG 1), providing quality education (SDG 4), increasing industry, innovation, and infrastructure (SDG 7), and reducing inequalities (SDG 10).[65]

Among other improvements in the financial services industry, the proliferation of digital financial services is key to achieving these goals.

The growth of digital payments worldwide has helped enhance financial inclusion over the past decade. More than USD 3.45 billion digital transactions are conducted globally daily as of March 2023.[66] The rise in smartphone ownership, access to the Internet, a responsive regulatory framework, and a greater focus on customer-centricity have led to this growth in digital payments.

With the rise in the usage of digital payments, customers seek ease of access, convenience, speed, and security in financial services. As a result, financial service providers have increasingly deployed solutions that use digital public infrastructure to ease the customer experience and encourage digital payments among the masses.

Estimates suggest the deployment of DPIs can help accelerate the adoption of payments and credit products by more than 20% globally.[67] Existing solutions around using DPI to improve access, availability, and efficiency of financial services can potentially solve many global issues in the financial sector.

[64]KPMG, "SDG industry matrix for financial services", 2021, Accessed October 06, 2023, https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2017/05/sdg-financial-services.pdf

[65]Robert G. Eccles, "The Importance Of The Financial Services Sector To The Sustainable Development Goals", December 22, 2019, Accessed October 06, 2023, https://www.forbes.com/sites/bobeccles/2019/12/22/the-importance-of-the-financial-services-sector-to-the-sustainable-development-goals/?sh=68995c9f66b7

[66] GSMA, "State of the Industry Report 2022", Accessed October 06, 2023, https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2023/04/GSMA-SOTIR-2023_Web-1.pdf

[67]UNDP, "The human and economic impact of Digital Public Infrastructure", Accessed October 10, 2023, https://www.undp.org/publications/human-and-economic-impact-digital-public-infrastructure

Yet, the agenda of improved financial inclusion and growth in the use of digital payments has had its own set of challenges for customers, service providers, and governments globally.

Current and emerging challenges

- ❧ **Lack of access to formal financial services:** More than 24% of the adult population across the globe lack access to a formal bank account, and more than 85 million unbanked adults continue to receive government transfers in cash.[68] The lack of regulated digital bank accounts limits the ability of financial service providers to provide suitable solutions for customers, especially those from low- and middle-income (LMI) households.

- ❧ **Limited interoperability in retail payments:** With the rise in digital payment solutions, customers seek safe, secure, and interoperable instant payments. The interoperability of payment systems needs to include three key aspects: technical, regulatory, and usage interoperability.[69] Despite the rise in instant payment systems, some countries face challenges in developing interoperable payment systems due to the specificity of payment systems for specific use cases, potential increase in FSPs' compliance burden, and reduced resilience in case of system failures.[70]

- ❧ **Lack of access to credit facilities:** Individuals and small businesses need access to quality collateral and financial assets. They often need to borrow from informal lenders due to a lack of access to formal and affordable financial services and financial and digital footprints. This leaves such borrowers susceptible to predatory lending from informal moneylenders and prone to economic shocks. Estimates peg the annual credit gap for MSMEs in developing countries at a staggering USD 5.2 trillion.[71]

Harnessing technology and connectivity: Case studies from India

1. Unified Payments Interface (UPI)

The National Payments Corporation of India (NPCI) introduced UPI as a real-time interbank payment system that integrates multiple bank accounts into a single mobile application of any participating bank. It has enabled a seamless payment experience for individuals, businesses, and the government by allowing payment service providers to innovate on top of the existing technology infrastructure to build user-centric applications.

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[68]World Bank, "Global Findex Database, 2021", July 13, 2023, Accessed October 06, 2023, https://www.worldbank.org/en/publication/globalfindex

[69]World Economic Forum, "Defining and measuring interoperability", April, 2022, Accessed October 06, 2023, https://www3.weforum.org/docs/WEF_Defining_and%20Measuring_Interoperability_2022.pdf

[70]World Bank, 2021, "Interoperability in Fast Payment Systems", September 2021, Accessed October 06, 2023, https://fastpayments.worldbank.org/sites/default/files/2021-10/Interoperability_in_FPS_Final.pdf

[71]World Bank, "SME Credit Finance Gap 2018", Accessed October 06, 2023, https://www.worldbank.org/en/topic/smefinance

UPI drives India's day-to-day digital payments, with more than 300 million active users and 9 billion in average monthly transactions.[72]

It has become one of the safest and most preferred modes for P2P and P2M transfers. P2P payments account for about 75% of UPI transactions, while P2M payments account for the remaining 25%.[73]

Several initiatives contributed to UPI's adoption and growth and improved customer convenience. These include the launch of "AutoPay," the introduction of UPI as a payment method to place IPO bids, the one-time mandate and invoice-in-the-box feature, guidelines on the UPI API's usage, the introduction of B2B as a separate category of UPI payments, the launch of online dispute resolution, and UPI number.[74]

In 2022, NPCI launched UPI123Pay, which allows feature phone users to use the UPI platform. UPI123Pay's launch points toward the further adoption of digital transactions in rural India, where most citizens still do not own smartphones. NPCI took this initiative to further ease customer experience through the launch of Hello! UPI, a conversational payments solution in 2023. Presently, 323 banks are live on UPI.
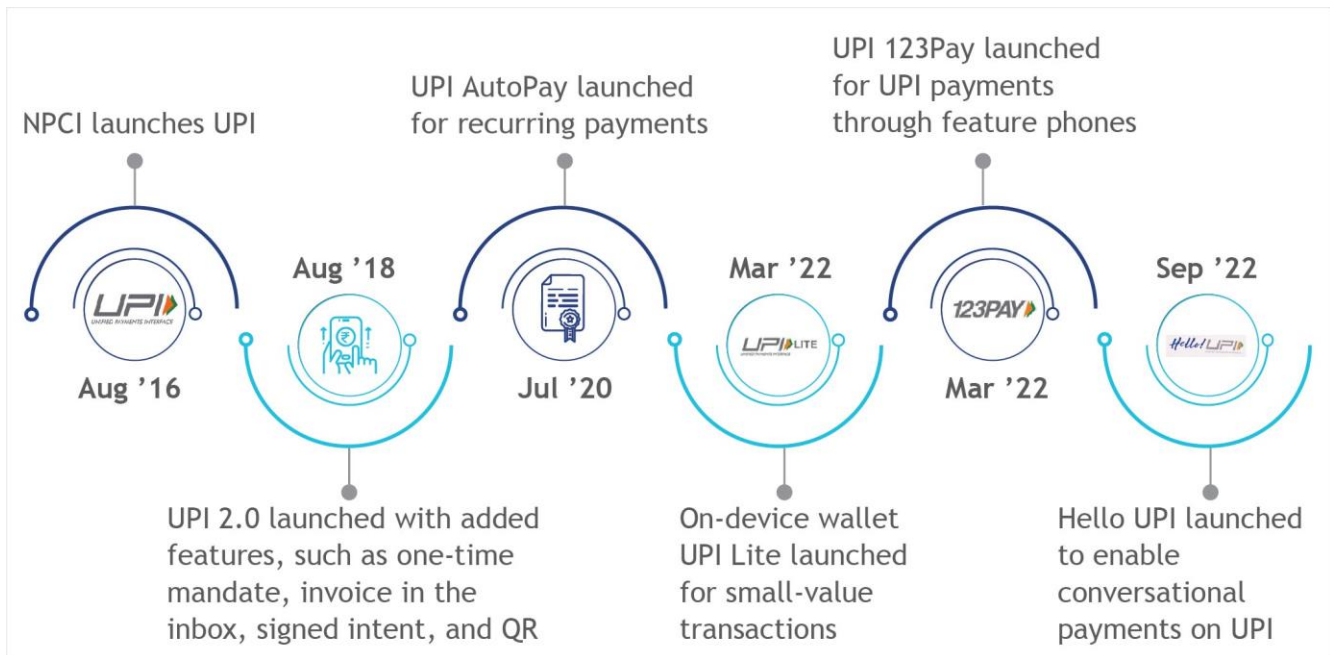

Figure 7: Product offerings under UPI which increased its adoption

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[72]Microsave Consulting, "Payment Instrument Rails, 2023", Accessed October 06, 2023, https://microsave.net/pin-rails/

[73]NPCI, "UPI Ecosystem Statistics, 2023", Accessed October 06, 2023, https://www.npci.org.in/what-we-do/upi/upi-ecosystem-statistics

[74]NPCI, "Auto Pay", Accessed October 06, 2023, https://www.npci.org.in/what-we-do/upi/upi-autopay

UPI's global acceptance has also expanded in recent years. Several partnerships have emerged across multiple countries to launch UPI. These will be crucial to make the payments of remittances easy and convenient.

> UPI soft-launched in Singapore in collaboration with the Network for Electronic Transfers, Singapore's electronic payment service provider that manages and operates the country's clearing and payments infrastructure. Its rollout is in advanced stages in South Korea, Bhutan, and the UAE. The most recent partnership was with Lyra Network in France.

2. Account aggregator framework and OCEN

India's account aggregator (AA) framework is a consent-based system that enables data sharing across financial institutions under India Stack.[75] Account aggregators serve as consent managers who permit an easy flow of financial data by serving as a conduit between customers' financial information providers and users. The AA framework enables users to link all financial accounts securely to one data handle and provide consent to share the data with other financial institutions. Currently, 56 banks, FinTechs, NBFCs, and ~1.1 billion customer accounts are live on the AA system.[76]

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[75]PIB, "Know all about Account Aggregator Network- a financial data-sharing system", September 10, 2021, Accessed October 10, 2023, https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1753713

[76]Financial Express, "PNB, 3 other PSU banks activate account aggregator system", July 15, 2022, Accessed October 06, 2023,https://www.financialexpress.com/industry/banking-finance/pnb-3-other-psu-banks-activate-account-aggregator-system/2594066/

Neelanjit Das, "71 percent consumers open to sharing data on account aggregator platforms, finds report", August 08, 2022, Accessed October 06, 2023, https://www.outlookindia.com/business/71-consumers-open-to-sharing-data-on-account-aggregator-platform-finds-report-news-214933
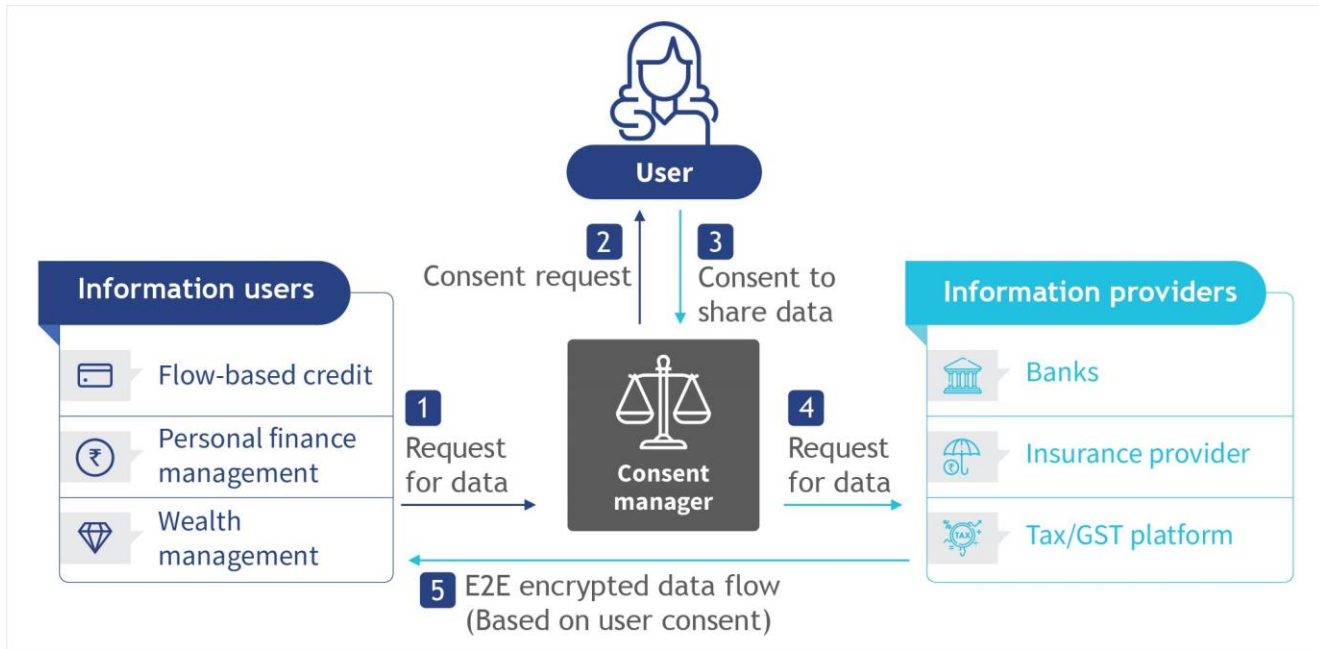
Figure 8: Data empowerment and protection architecture

The AA framework will democratize financial services through easy, secure, and consent-based data transfer, give customers more control over their data, and reduce processing costs for banks and NBFCs through better access to data. In 2022, the RBI included the Goods and Services Tax Network (GSTN) in the AA network as a financial information provider to facilitate cash flow-based lending to the MSMEs that lack credit history based on their GSTIN records.[77]

Building on these efforts, access to financial services has advanced further through the OCEN (Open Credit Enablement) initiative. Historically, equitable access to credit for India's diverse population was a significant problem that restrained India's economic development. As per the Standing Committee on Finance (2021-22), less than 40% of MSMEs in India avail credit from formal financial systems and instead depend on costly and unreliable informal sources of credit.[78]

OCEN digitizes the lending process end-to-end based on the AA Framework principles. It standardizes the loan life cycle across financial institutions and marketplaces. Under the OCEN Framework, credit demand is shared with all potential lenders in the open network. All relevant data on the potential borrower is equally accessible to potential lenders. Borrowers are presented with multiple offers while competition in loan provision is enhanced and human bias in lending decisions is contained.

The deployment of DPIs in financial services has proven to improve access, usage, and quality of financial services while catering to the diverse needs of customers. India's innovations in DPIs can potentially facilitate the delivery of financial services in other countries. Countries can adopt

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[77]Economic Times, "GSTN included in financial information providers list under account aggregator framework", November 23, 2022, Accessed October 06, 2023, https://m.economictimes.com/news/economy/policy/gstn-included-in-financial-information-providers-list-under-account-aggregator-framework/articleshow/95720790.cms

[78]Ministry of Finance, "Strengthening credit flows to the MSME sector", March, 2022, Accessed October 06, 2023, https://loksabhadocs.nic.in/lsscommittee/Finance/17_Finance_46.pdf

solutions, such as UPI, to ease the process of payments for individuals and businesses, and address the issue of limited interoperability in instant payments. Further, UPI's adoption would help enhance the payment alliance between India and partner countries.

Similarly, OCEN can help countries ease access to credit for individuals and small businesses. Solutions like the UPI have witnessed traction among the urban and educated people and are equally popular in rural areas and among the less educated. On the supply side, such solutions have the potential of considerably reducing the cost of financial services, which is the need of the hour globally. These developments have made both developed and developing countries seek solutions to enhance their payments and credit ecosystem and deploy India's DPIs to improve their digital financial services ecosystem.

Sector in focus: Healthcare

Access to quality healthcare is a basic necessity for every individual. The World Health Organization's (WHO) constitution recognizes health as a fundamental human right.[79] Healthcare as a sector impacts the entire global population and is linked closely with development. The interconnectedness of the health and development landscape also reflects in the 2030 agenda for sustainable development.[80] Moreover, healthy individuals can better contribute to the social and economic development of their communities and countries.[81]

Research suggests that good health positively enables development and can help drive productivity and boost economic growth,[82,83] besides enhancing the quality of life.

> For instance, a Brookings study estimates that the scale-up of cost-effective interventions in healthcare would boost the GDP across all developing countries by USD 4.4 trillion in 2040. The study also estimates that for developing countries, every USD 1 invested in healthcare would give an economic return between USD 2 and USD 4.84

[79]Dr Tedros Adhanom Ghebreyesus, "Health is a fundamental human right", WHO, December 10, 2017, Accessed October 06, 2023, https://www.who.int/news-room/commentaries/detail/health-is-a-fundamental-human-right

[80]UNDP, "Connecting the dots: Towards a more equitable, healthier and sustainable future", 2022, Accessed October 06, 2023,https://www.undp.org/sites/g/files/zskgke326/files/2022-01/UNDP-Connecting-the-Dots-Towards-a-More-Equitable-Healthier-and-Sustainable-Future-V2.pdf

[81] UNDP, "Connecting the dots: Towards a more equitable, healthier and sustainable future", 2022, Accessed October 06, 2023,https://www.undp.org/sites/g/files/zskgke326/files/2022-01/UNDP-Connecting-the-Dots-Towards-a-More-Equitable-Healthier-and-Sustainable-Future-V2.pdf

[82] D.T. Jameson et al., "Global health 2035: a world converging within a generation", The Lancet online, December 3, 2013, Accessed October 06, 2023, https://www.thelancet.com/article/S0140-6736(13)62105-4/fulltext

[83] D. Bloom et al., "The effect of health on economic growth. A production function approach", Sciencedirect.com, 2004, Accessed October 06, 2023, https://www.sciencedirect.com/science/article/abs/pii/S0305750X03001943

[84] Brookings, "How investing in health has a significant economic payoff for developing economies", July 21, 2020, Accessed October 06, 2023, https://www.brookings.edu/articles/how-investing-in-health-has-a-significant-economic-payoff-for-developing-economies/

Sustainable Development Goal 3 seeks to ensure healthy lives and promote well-being for all, at all ages.85

This goal tries to address all major health priorities: reproductive, maternal, newborn, child, and adolescent health; communicable and non-communicable diseases; universal health coverage; and access for all to safe, effective, quality, and affordable medicines and vaccines.[86]

Current and emerging challenges

1. **Poor access:** Access to vital healthcare services remains a persistent challenge for a significant proportion of the global population.[87] Further, a slowdown is currently evident in the expansion of access to essential healthcare services, compared to the pre-2015 gains: SDG indicator[88] 3.8.1, which represents coverage of essential health services, rose only three index points to 68 by 2021.[89]

2. **Rising healthcare costs:** The cost of healthcare is another big challenge that countries face, especially low- and middle-income countries (LMICs). The proportion of the population that spends more than 10% of their household budget on health out of pocket (OOP) (SDG 3.8.2) has worsened since 2015 at an average of 0.2 percentage points per year to reach 13.5% in 2019 (about 1 billion people), as per WHO.[90] Further, in 2019, 4.9 % of the global population was pushed into extreme poverty due to OOP payments for health.[91]

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[85] United Nations, "Goal 3: Ensure healthy lives and promote well-being for all at all ages", Accessed October 03, 2023, https://www.un.org/sustainabledevelopment/health/

[86] UNICEF, "GOAL 3: GOOD HEALTH AND WELL-BEING", Accessed October o4, 2023, https://data.unicef.org/sdgs/goal-3-good-health-wellbeing/#:~:text=SDG%203%20aims%20to%20prevent,and%20regions%20are%20priority%20areas.

[87] UN, "United Nations Sustainable Development Goals Tracker", Accessed October 06, 2023, https://www.un.org/sustainabledevelopment/health/#:~:text=Ensuring%20healthy%20lives%20for%20all,predict%20and%20counteract%20health%20challenges

[88] The global indicator framework has 231 unique indicators that are used to measure progress made toward various sustainable development goals.

[89] World Health Organization, "World health statistics 2023: monitoring health for the SDGs, sustainable development goals", May 2023, Accessed October 06, 2023, https://www.who.int/publications/i/item/9789240074323

World Health Organization, "Coverage of essential health services (SDG 3.8.1), Accessed October 06, 2023, https://www.who.int/data/gho/data/themes/topics/service-coverage

[90] World Health Organization, "World health statistics 2023: monitoring health for the SDGs, sustainable development goals", May 19, 2023, Accessed October 06, 2023, https://www.who.int/publications/i/item/9789240074323

[91] World Health Organization, "SDG 3.8.2 Catastrophic health spending (and related indicators)", Accessed October 06, 2023, https://www.who.int/data/gho/data/themes/topics/financial-protection

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3. **Inequality:** Inequality in healthcare services remains a stark challenge. Vulnerable populations with greater exposure to health risks continue to have lower levels of access to health services.[92] Poor quality and non-availability of timely healthcare services are a few other problems these vulnerable populations face.

4. **Lack of quality healthcare:** Many countries grapple with challenges in providing a quality, equitable standard of care.[93] A Lancet study estimates that 8.6 million deaths per year in 137 LMICs are due to inadequate access to quality care.[94] Further, an OCED study estimated that safety lapses result in 134 million adverse events and cause 2.6 million deaths each year in LMICs.[95]

Harnessing technology and connectivity: Case studies from India

Worldwide, technology is being used to address challenges and provide better services to citizens across various sectors, including healthcare. The COVID-19 pandemic prompted countries to reconsider existing healthcare practices and accelerate digital transformation.[96] From telemedicine to advanced AI applications, technology is helping address the challenges above in healthcare, such as poor access and high costs, among others.

> Since the past few years, DPIs have emerged to be beneficial in enhancing health outcomes through the sharing of health data (Bahmni or OpenELIS[97], Brazil's Open Health, and France's Health Data Hub[98]), using verifiable IDs and registries (Ayushman Bharat Health Account, a vaccination registry based on the DPG DIVOC).[99]

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[92]World Health Organization, World Health Statistics, 2023, Accessed October 06, 2023, https://www.who.int/publications/i/item/9789240074323

[93]Wolters Kluwer, "Six challenges to delivering quality healthcare", 6 September 2022, Accessed October 06, 2023, https://www.wolterskluwer.com/en-in/expert-insights/six-challenges-to-delivering-quality-healthcare

[94]Margaret Kruk et al., "High-quality health systems in the Sustainable Development Goals era: time for a revolution, The Lancet Global Health Commission, 2018, Accessed October 06, 2023, https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(18)30386-3/fulltext#seccestitle90

[95]L Slawomirski et al., "The economics of patient safety: from analysis to action", Organisation for Economic Co-operation and Development, 2020, Accessed October 06, 2023, http://www.oecd.org/health/health-systems/Economics-of-Patient-Safety-October-2020.pdf

[96]RS Sharma et al., "The Ayushman Bharat Digital Mission (ABDM): making of India's Digital Health Story", CSIT, 2023, Accessed October 06, 2023, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10064942/

[97]Open Enterprise Lab Information System, Accessed October 06, 2023, https://openelis-global.org/

[98]Health Data Hub, Accessed October 06, 2023, https://www.health-data-hub.fr/

[99]UNDP, "Accelerating The SDGs through Digital Public Infrastructure: A Compendium of The Potential Of Digital Public Infrastructure", 2023, Accessed October 06, 2023, https://www.undp.org/publications/accelerating-sdgs-through-digital-public-infrastructure-compendium-potential-digital-public-infrastructure#:~:text=Digital%20public%20infrastructure%20(DPI)%20has,experiences%20on%20a%20global%20scale.

India has launched various initiatives to aid digital transformation in healthcare services. Ayushman Bharat Digital Mission (ABDM), CoWIN (Covid Vaccine Intelligence Network), and e-Sanjeevani are among key initiatives that facilitate digital transformation. The enhanced connectivity and pan-India coverage of these initiatives serve as an enabler for the digital transformation efforts. During the pandemic, India could administer vaccines swiftly, and facilitate telemedicine, and other healthcare services because of the prior investments in connectivity and DPI. A few such examples are enumerated below.

Ayushman Bharat Digital Mission (ABDM)

This initiative was launched in September 2021 in response to the growing need for digital transformation in the healthcare sector in India. This ambitious project's objective is to develop a strong backbone through digital infrastructure to support the integrated digital health infrastructure in the country[100] and establish an integrated, effective, and inclusive health ecosystem.[101] The underlying philosophy is to bridge the existing gaps among different stakeholders of the healthcare ecosystem through digital highways[102] (digital platforms that offer shared public and private services)
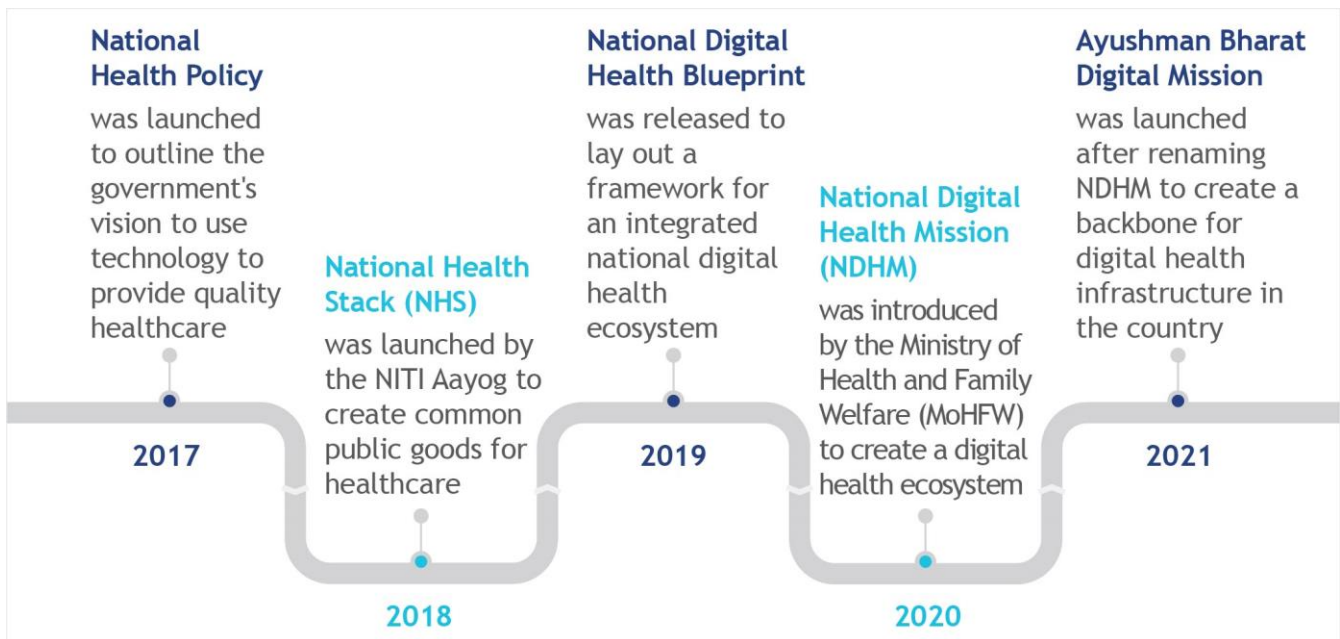

National Health Policy was launched to outline the government's vision to use technology to provide quality healthcare

2017

National Health Stack (NHS) was launched by the NITI Aayog to create common public goods for healthcare

2018

National Digital Health Blueprint was released to lay out a framework for an integrated national digital health ecosystem

2019

National Digital Health Mission (NDHM) was introduced by the Ministry of Health and Family Welfare (MoHFW) to create a digital health ecosystem

2020

Ayushman Bharat Digital Mission was launched after renaming NDHM to create a backbone for digital health infrastructure in the country

2021

Figure 9: Evolution of ABDM in India

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[100]Ministry of Health and Family Welfare, "Ayushman Bharat Digital Mission", Accessed October 06, 2023, https://abdm.gov.in/abdm

[101]RS Sharma et al., "The Ayushman Bharat Digital Mission (ABDM): making of India's Digital Health Story", CSIT, March 31, 2023, October 06, 2023, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10064942/

[102]Ministry of Health and Family Welfare, "Ayushman Bharat Digital Mission", Accessed October 06, 2023, https://abdm.gov.in/abdm

As outlined in the operational strategy, ABDM's architecture is modeled as "Federated Architecture."[103] In this architecture, management and data access occurs in a federated manner where multiple entities will manage health data about users. Further, the ABDM architecture employs common protocols and includes privacy by design.[104]
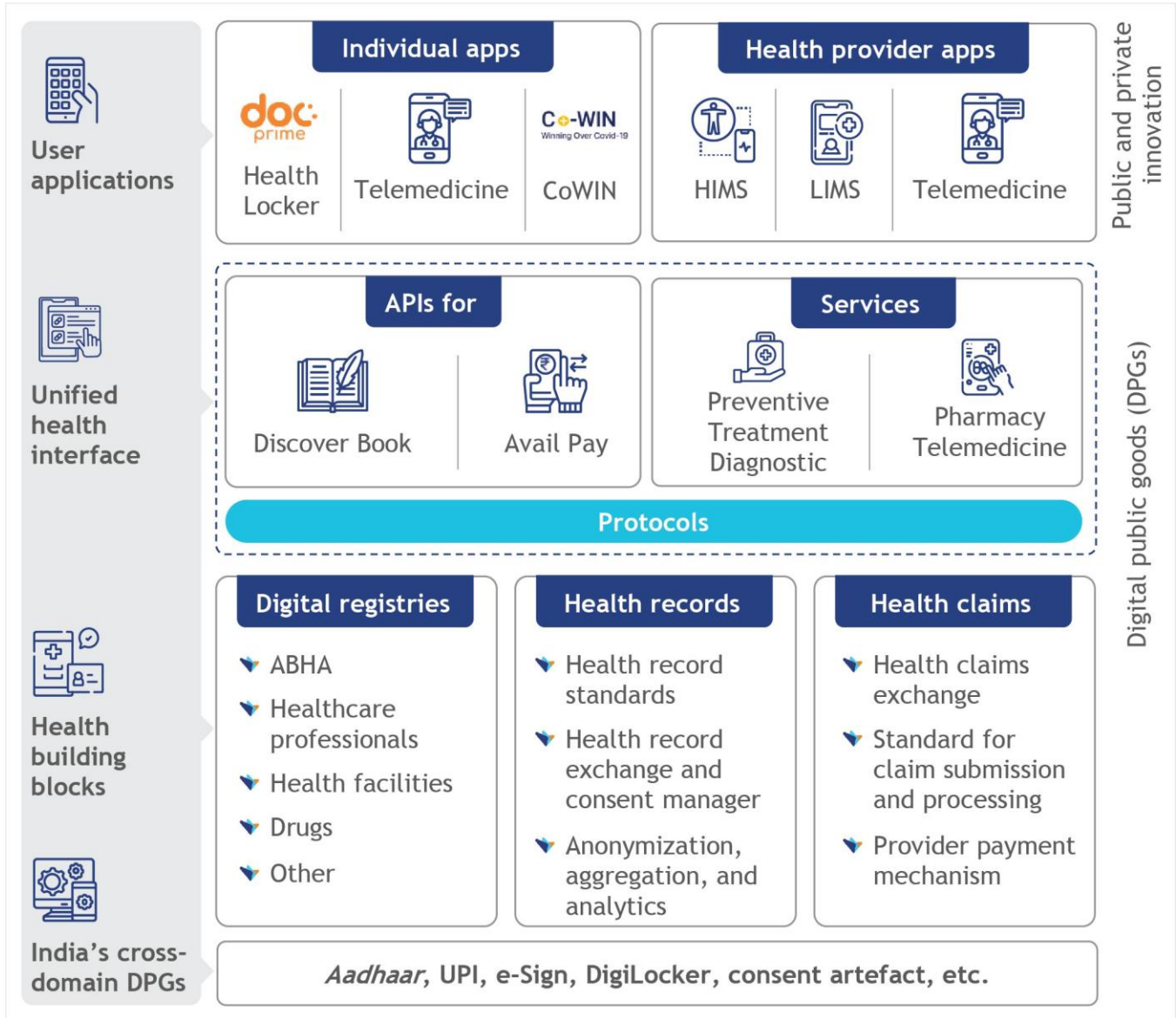

Figure 10 Architecture of ABDM

Various ABDM building blocks and registries have been rolled out since its launch. Following are some key building blocks under ABDM, along with a brief description:

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[103] Ministry of Health and Family Welfare, "ABDM Digital Health Architecture", Accessed October 06, 2023, https://sandbox.abdm.gov.in/docs/architecture

[104] RS Sharma et al., "The Ayushman Bharat Digital Mission (ABDM): making of India's Digital Health Story", CSIT, March 31, 2023, October 06, 2023, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10064942/

(a) **Ayushman Bharat Health Account (ABHA) number:** It is a randomly generated unique identification number to uniquely identify persons, authenticate them, and thread their health records across multiple stakeholders in the ecosystem.[105]

(b) **Healthcare Professionals Registry (HPR):** It is envisaged as a comprehensive repository of all healthcare professionals, including doctors, nurses, paramedics, and other healthcare providers involved in the delivery of healthcare services across different systems of medicine.[106]

(c) **Health Facility Registry (HFR):** It is envisaged as a comprehensive repository of all health facilities of the nation, including both public and private health facilities, such as hospitals, laboratories, and diagnostic labs, across different systems of medicine.[107]

(d) **ABHA application:** ABHA application, or patient health record (PHR), is an electronic application through which patients can maintain and manage their health information (and that of others for whom they are authorized) in a private, secure, and confidential environment.[108]

(e) **Unified Health Interface (UHI):** It is envisaged as an open protocol for various digital health services. The UHI Network will be an open network of end-user applications (EUAs) and participating health service provider (HSP) applications[109] that enable the interoperability of digital health services, similar to the working of UPI for payments.[110] The underlying idea of UHI is to enable digital health services, such as appointment booking and teleconsultation between patients and HSPs.

More than 100 health programs and applications have been integrated with ABDM. It includes government applications, such as the Ministry of Ayush's Ayush Hospital Management Information System (A-HMIS), eSushrut, eSanjeevani 2.0, ESIC, Haryana e-Upchaar, ANM Andhra Pradesh Health EHR, West Bengal Integrated HMIS, as well as 33 apps from private sector innovators.[111]

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[105]Ministry of Health and Family Welfare, "Ayushman Bharat Digital Mission", Accessed October 06, 2023, https://abdm.gov.in/abdm

[106]Ibid

[107]Ibid

[108]Ibid

[109]Ibid

[110]RS Sharma et al., "The Ayushman Bharat Digital Mission (ABDM): making of India's Digital Health Story", CSIT, March 31, 2023, October 06, 2023, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10064942/

[111]PIB, "Over 100 health programs and digital health applications complete their integration with Ayushman Bharat Digital Mission", May 11, 2023, Accessed October 06, 2023, https://abdm.gov.in:8081/uploads/PIB_100_health_program_and_digital_health_applications_integrated_with_ABDM_1_16db33a653_3_aeb9483920.pdf

Digital Infrastructure for Verifiable Open Credentialing (DIVOC)

DIVOC is a flexible and extendable open-source software, built in India as a digital public good to enable countries to roll out large-scale health campaigns, including vaccination and certification programs.[112]

> DIVOC has enabled India and four other countries, including Indonesia, Jamaica, Philippines, and Sri Lanka, to issue more than 2 billion COVID-19 vaccination certificates to its citizens.[113]

DIVOC can potentially facilitate last-mile delivery of other health programs as well at scale.

DIVOC is built as a modular platform, which means that the countries can use the components together or as individual standalone solutions as per their needs. DIVOC comprises two core modules—issue and verify certificates and analytics. Its reference implementation consists of four customizable components—program setup via the orchestration module, facility app, citizen portal, and feedback.

To sum up, DPI and DPGs can potentially aid in inclusion through improved healthcare resource planning, intervention planning, disease surveillance, and vaccination tracking.[114] They can enhance healthcare delivery and access through telemedicine, remote patient monitoring, and e-health initiatives and expand access to quality care. DPI can replace the one-to-one care model with one-to-many. Further, it can strengthen global healthcare systems by improving supply chain management, electronic health records, and interoperability. DPIs empower healthcare professionals with tools for effective patient-centric care delivery due to efficiency in automated administerial tasks, reducing costs.

Countries that invest in DPI and other such innovations in the health sector can potentially transform their healthcare delivery, improve health outcomes, and create a more resilient and inclusive healthcare system. Lessons from India's innovations in DPIs, such as CoWIN, DIVOC, and e-Sanjeevani, among others, can help deploy such interventions globally.

Last but not least, digital transformation is possible only with good connectivity. Countries should invest in improving connectivity to enable innovations in healthcare service delivery, particularly after the challenges faced during the COVID-19 pandemic.

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[112]Digital Infrastructure for Verifiable Open Credentialing, "Introduction to DIVOC", Accessed October 06, 2023, https://divoc.digit.org/

[113]Digital Infrastructure for Verifiable Open Credentialing, "DIVOC's journey so far: country stories", Accessed October 06, 2023, https://divoc.digit.org/

[114]UNDP, "Accelerating The SDGs through Digital Public Infrastructure: A Compendium of The Potential Of Digital Public Infrastructure", August 21, 2023, Accessed October 06, 2023, https://www.undp.org/publications/accelerating-sdgs-through-digital-public-infrastructure-compendium-potential-digital-public-infrastructure#:~:text=Digital%20public%20infrastructure%20(DPI)%20has,experiences%20on%20a%20global%20scale

Sector in focus: Education

Education is pivotal in fostering both personal and societal development and helps nurture critical thinking, creativity, and readiness for careers. It empowers individuals to contribute meaningfully to a flourishing and inclusive society, while also serving as a potent force against social injustices.

> According to UNESCO, if all students in low-income countries were equipped with basic reading skills, an estimated 171 million people could break free from the shackles of extreme poverty.

Furthermore, it envisions a world where every adult completes secondary education. In such a scenario, the global poverty rate could be slashed by more than half, which highlights education's profound impact on combating poverty worldwide.[115]

> **Sustainable Development Goal 4** seeks to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. This goal ensures that all girls and boys will complete free primary and secondary schooling by 2030. It also aims to provide equal access to affordable vocational training, eliminate gender and wealth disparities, and achieve universal access to quality higher education.[116]

Current and emerging challenges

At present, the global education sector faces a range of current and emerging challenges, amplified by recent global events and ongoing societal changes. Some of these challenges are listed below:

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[115]Concern USA, "How does education affect poverty", August 10, 2023, Accessed October 06, 2023, https://concernusa.org/news/how-does-education-affect-poverty/#:~:text=In%20fact%2C%20according%20to%20UNESCO,rate%20by%20more%20than%20half

[116]UNDP, "The SDGs in Action", Accessed October 06, 2023, https://www.undp.org/sustainable-development-goals/quality-education?gclid=Cj0KCQjwvL-oBhCxARIsAHkOiu339irwu1ohAnr2EcKTZgYJ_inuWJSnnDTfyHpOrD5XBCGFTOb_zf0aAonsEALw_wcB

1. **Equity and access:** Ensuring equitable access to education includes access to quality teachers, education materials, and technology. Equitable access must be granted to people, regardless of their socioeconomic status or geographical location.

   - Globally, 64% of 10-year-olds do not meet minimum proficiency levels due to inadequate education.[117]

   - At present, 57 million primary-aged children remain out of school, more than half of them in Sub-Saharan Africa.[118]

2. **Digital divide:** In 2022, the International Telecommunication Union (ITU) reported that 2.7 billion people, roughly one-third of the global population, remain unconnected to the Internet. The digital divide in education exacerbates inequalities and hinders students without access to digital resources from fully participating in online learning and gaining digital skills necessary for the modern workforce.

3. **Teacher shortages and quality:** A major challenge in many regions of the world is the shortage of qualified teachers, particularly in STEM subjects (science, technology, engineering, and mathematics). Ensuring a sufficient number of well-trained educators is crucial for quality education.

4. **Inclusive education:** Addressing the diverse needs of students, including those with disabilities and special needs, particularly in an online or hybrid learning environment, presents significant challenges.

5. **Assessment and evaluation:** Creating fair and reliable assessments for remote and hybrid learning is complex, and calls for innovative assessment methods that reflect real-world skills.

6. **Mental health and well-being:** The COVID-19 pandemic has impacted the mental health and well-being of students, causing stress, anxiety, and burnout, among other problems. Addressing these challenges has now become an essential aspect of education.

7. **Skills mismatch:** Rapid technological advancements are changing the job market, and a gap has been widening between the skills taught in traditional education and those demanded by employers. Preparing students for future job markets and updating curricula to include digital literacy and 21st-century skills is a challenge.

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[117]UNDP, "Accelerating The SDGs through Digital Public Infrastructure: A Compendium of The Potential Of Digital Public Infrastructure", August 21, 2023, Accessed October 06, 2023, https://www.undp.org/publications/accelerating-sdgs-through-digital-public-infrastructure-compendium-potential-digital-public-infrastructure#:~:text=Digital%20public%20infrastructure%20(DPI)%20has,experiences%20on%20a%20global%20scale

[118]UNESCO, SDG Resources for Educators, Accessed October 06, 2023, https://en.unesco.org/themes/education/sdgs/material/04#:~:text=Enrolment%20in%20primary%20education%20in,live%20in%20conflict%2Daffected%20areas

MSC

Harnessing technology and connectivity: Case studies from India

India's school education system is incredibly diverse, with more than 20 regional languages as the medium of instruction and 60-plus educational boards across the country. The country has more than 1.48 million schools, 9.5 million teachers, and 265 million students (pre-primary to higher secondary level), out of whom more than 167 million are in government and aided schools and 88 million are in private and other schools.[119]

With a strong foundation of digital connectivity and digital transformation in the country, India has made significant strides to embrace and implement a DPI for education. It has enabled technologies to effectively prevent anyone from being left behind as they pursue education.

1. **Digital Infrastructure for Knowledge Sharing (DIKSHA)** is the national platform for school education for the benefit of teachers and learners across India. It is an initiative of the National Council for Educational Research and Training (NCERT), the Ministry of Education (MoE), and the Government of India. DIKSHA is a free-to-use school platform with multiple solutions for students, teachers, and administrators. It includes a host of features, such as textbooks that link QR codes to relevant digital content, online courses with digital credentials, assessments, and chatbots.

As reported by DIKSHA, as of 3rd October 2023, the platform has accumulated an impressive 61 billion learning minutes of usage. Learners took part in around 5 billion learning sessions using the DIKSHA infrastructure.[120]

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[119]Shankar Maruwada, "Digital Public Goods for Education: The Indian Experience", March 27, 2023, Accessed October 06, 2023, https://carnegieindia.org/2023/03/27/digital-public-goods-for-education-indian-experience-pub-89341

[120]National Council of Educational Research and Training (Ministry of Education, Govt of India), DIKSHA, Accessed October 06, 2023, https://www.diksha.gov.in/
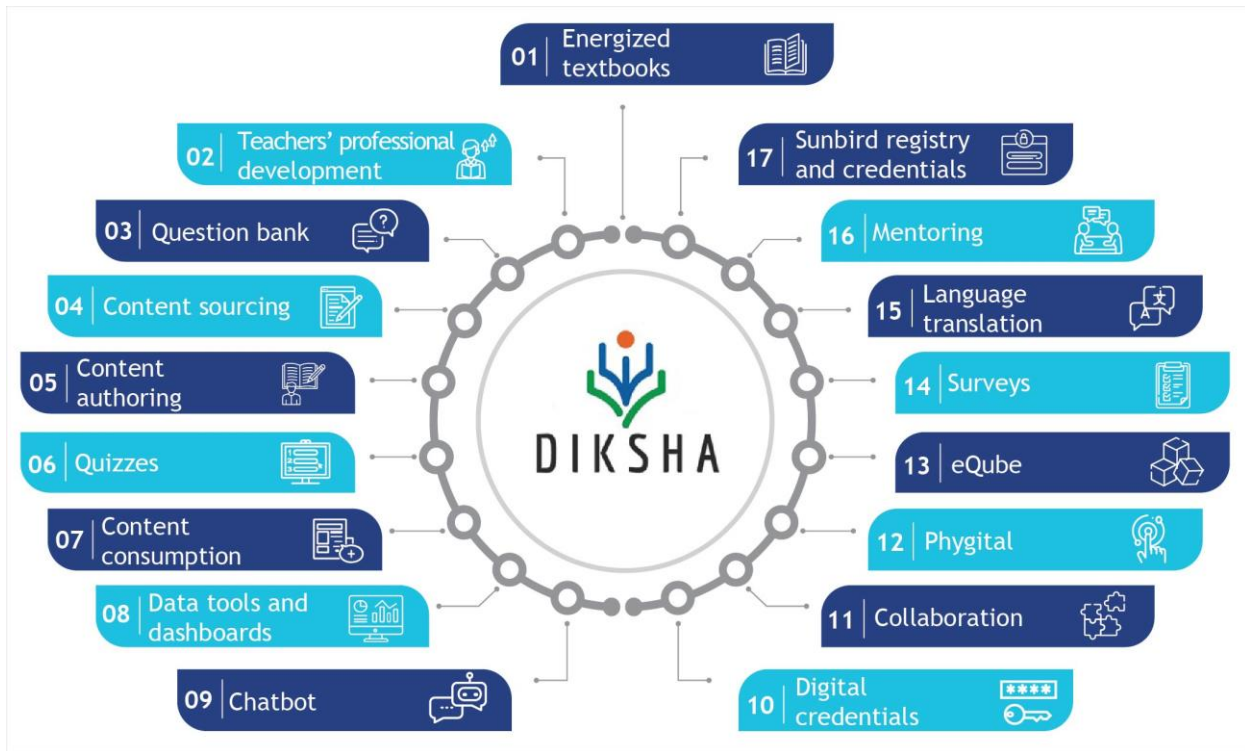
Figure 11: Solutions available through DIKSHA

▼ Since it is an open-source software, DIKSHA offers its foundational components for adoption by other nations. Notably, various government entities, including the Department of Personnel Training, the Ministry of Health and Family Welfare, the Ministry of Sports and Youth Affairs, among others, had chosen to use DIKSHA to train healthcare professionals during the COVID-19 pandemic.

- Remarkably, between April and June 2020, DIKSHA facilitated more than 1.7 million individual training sessions and resulted in certifications for doctors, nurses, and other essential health workers.[121]

▼ In July 2021, the National Digital Education Architecture (NDEAR) was launched. It includes use cases, such as energized textbooks (meaning books that incorporate QR codes), online courses, content authoring, content sourcing, interactive quizzes, question banks, chatbots, analytics, and dashboards.

▼ Amid the pandemic, the extensive teacher's professional development program, **NISHTHA** (National Initiatives for School Heads and Teacher's Holistic Advancement) for elementary

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[121]IMF, "Stacking up the benefits: Lessons from India's digital journey", Accessed Otober 06, 2023, https://www.imf.org/en/Publications/WP/Issues/2023/03/31/Stacking-up-the-Benefits-Lessons-from-Indias-Digital-Journey-531692

MSC

grades, was introduced online via DIKSHA. Subsequently, NISHTHA 2.0 and 3.0 were launched, with a specific focus on secondary education and foundational literacy and numeracy.

- NCERT ensures continuous content delivery to students through the **PM eVIDYA** DTH-TV channels, which operate 24x7 and offer one class per channel spanning classes I to XII.

Another notable initiative in this realm is the **Digital Ecosystem for Skilling and Livelihood**, the **DESH-Stack portal**. Its primary objective is to empower citizens with opportunities for skills development, reskilling, and upskilling through online training.

Furthermore, the portal offers API-based trusted skill credentials, payment options, and a discovery layer to facilitate the search for relevant employment and entrepreneurial prospects.

The **National Education Policy (NEP) 2020** has emphasized the integration of technology to enhance access, flexibility, and quality in education, promoting digital learning and skills development as a fundamental component of education reform.

As part of NEP 2020, the Union Ministry of Education is planning to create "One Nation, One Student ID", called Automated Permanent Academic Account Registry (APAAR) for every student from pre-primary to higher education.

This ID would be in addition to the Aadhaar ID that every student has. The APAAR ID, an educational ecosystem registry or edulocker would be used to track students' academic journeys and achievements.[122]

India's pioneering efforts in digitizing education hold global significance, offering invaluable insights for nations worldwide to consider.

For instance, home tutoring is a well-established practice in many developed countries, and India's digital education platforms, such as DIKSHA, can be vital to enhancing this method. Platforms like DIKSHA empower home-schooled students with structured and comprehensive learning experiences, as they provide a wide array of educational resources, interactive tools, and assessments.

Additionally, these digitization efforts tackle a critical global issue of inclusivity in education. Remote and underserved regions, often overlooked due to logistical constraints, can now use platforms like DIKSHA. This digital transformation bridges the geographical gap, ensuring that

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[122]Sandhya Nair, The Times of India, "Centre now plans 'One nation, One ID' for all school students", Accessed October 16, 2023, https://timesofindia.indiatimes.com/city/mumbai/centre-now-plans-one-nation-one-id-for-all-school-students/articleshow/104433461.cms?from=mdr

students worldwide have access to high-quality educational resources, regardless of their location.

Furthermore, initiatives, such as the DESH stack, can potentially play a significant role to alleviate the global skills mismatch challenge. The DESH stack can serve as a platform to prepare students and professionals for the evolving job markets of the future and facilitate skill development, reskilling, and upskilling to ensure individuals remain relevant in an ever-changing employment landscape.

Sector in focus: Agriculture

The agriculture sector is the backbone of our global economy. It is pivotal to provide food, fiber, and raw materials to sustain human life and industry. Agriculture is vital to economic growth and contributes approximately 4% to the GDP. In some least-developed countries, this sector can even account for more than 25% of their GDP.[123]

> As per the World Bank, agriculture development is one of the most important tools to end extreme poverty, boost shared prosperity, and feed a projected 10 billion people by 2050.[124] This underscores agriculture's pivotal role to simultaneously address these interconnected goals.

> The significance of agriculture aligns closely with **Sustainable Development Goal 2,** which aims to "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture." The SDG recognizes the interlinkages within supporting sustainable agriculture, empowering small farmers, promoting gender equality, tackling climate change, and reducing poverty, among other factors.[125]
> In essence, SDG 2 recognizes that a thriving agricultural sector ensures food security and improved nutrition even as it catalyzes positive societal changes.

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[123] World Bank, Agriculture and Food Overview, Accessed October 06, 2023, https://www.worldbank.org/en/topic/agriculture/overview

[124] World Bank, Agriculture and Food Overview, Accessed October 06, 2023, https://www.worldbank.org/en/topic/agriculture/overview

[125] UN, "Food security and nutrition and sustainable agriculture", Accessed October 06, 2023, https://sdgs.un.org/topics/food-security-and-nutrition-and-sustainable-agriculture#:~:text=The%20Sustainable%20Development%20Goal%20to,rural%20poverty%2C%20ensuring%20healthy%20lifestyles%2C

Current and emerging challenges

However, multiple shocks, including disruptions caused by COVID-19, extreme weather events, pest infestations, and global conflicts, have been significantly affecting global food and agriculture systems. These challenges have led to increased food prices and growing incidences of hunger. Some of the biggest challenges for the global agricultural sector are detailed below:

1. **Climate change:** Altered weather patterns, severe climatic events, and droughts resulting from climate change wield a significant impact on food production, limiting the quality, availability, and accessibility of essential resources, thus undermining the global resilience of food systems. For instance, prolonged drought or heavy rainfall can have adverse effects on soil health. Due to these, global maize yields may decline by 24% in the next 60 years, which will impact many regions, especially those near the Equator, such as North and Central America, West Africa, Central Asia, Brazil, and China[126].

2. **Insufficient agricultural land:** As per the Food and Agriculture Organization (FAO), more than one-third of the 1.38 billion hectares of arable land available worldwide has been irreversibly compromised since 1961 due to extensive land conversion, monocropping, tilling, and other practices.[127]

3. **Growing population:** In 2022, the world population rose to 8 billion, projected to double in the next 50 years, with a consistent growth rate. The increase in population presents the challenge of satisfying greater food demand, with the potential for hunger to arise if agriculture fails to keep pace. As per the World Health Organization (WHO), as many as 828 million people suffered from hunger in 2021, which was an increase of 46 million people from 2020.[128]

   Beyond the hunger concern, the growing population also exerts additional strains on already limited water resources and available arable land.

4. **Biodiversity loss:** Biodiversity plays an important role in maintain the well-being of ecosystems, which, in turn, are essential for food production and the provision of clean air. The negative impacts of biodiversity loss are already evident in several parts of the world. For example, in Gambia, large losses of wild foods have forced the local communities to include industrially processed foods in their diets.[129]

5. **Low investment in agriculture:** Investing in agriculture involves allocating funds for various activities, including food and crop production, processing, and distribution. Nonetheless, this approach may not hold broad appeal for investors, given its significant capital prerequisites and the prospect of comparatively lower investment returns. Additionally, agriculture is characterized by highly volatile market prices, which often deter potential investments.

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[126] Denisa Ogoyi, "5 Challenges the Agricultural Sector Faces in 2023" February 13, 2023, Earth,org, Accessed October 06, 2023, https://earth.org/challenges-farmers/

[127] World Population Review, "Arable Land by Country 2023", Accessed October 06, 2023, https://worldpopulationreview.com/country-rankings/arable-land-by-country

[128] World Health Organization, "UN Report: Global hunger numbers rose to as many as 828 million in 2021", July 6, 2022, Accessed October 06, 2023, https://www.who.int/news/item/06-07-2022-un-report--global-hunger-numbers-rose-to-as-many-as-828-million-in-2021

[129] Denisa Ogoyi, "5 Challenges the Agricultural Sector Faces in 2023" February 13, 2023, Earth,org, Accessed October 06, 2023, https://earth.org/challenges-farmers/

Harnessing technology and connectivity: Case studies from India

Technology plays a pivotal role in agriculture, transforming it into a more efficient, productive, and sustainable industry. It empowers farmers, improves food security, and contributes to economic growth while addressing the challenges of a growing population and a changing climate.

The Indian government has introduced Agri Stack, which serves as the digital bedrock laid by the government, uniting diverse stakeholders on a single platform. Its purpose is to enhance the agricultural landscape in India by harnessing the power of data and digital services. This collaborative effort aims to deliver significant benefits to farmers and drive positive outcomes for the agriculture sector as a whole.

Agri Stack has a twofold objective:

- Firstly, it seeks to simplify the process for farmers to access affordable credit, procure high-quality agricultural inputs, receive tailored advice, and enjoy more efficient and accessible market opportunities.

- Secondly, it endeavors to streamline government efforts in planning and implementing a range of farmer-centric and agriculture-focused welfare program.
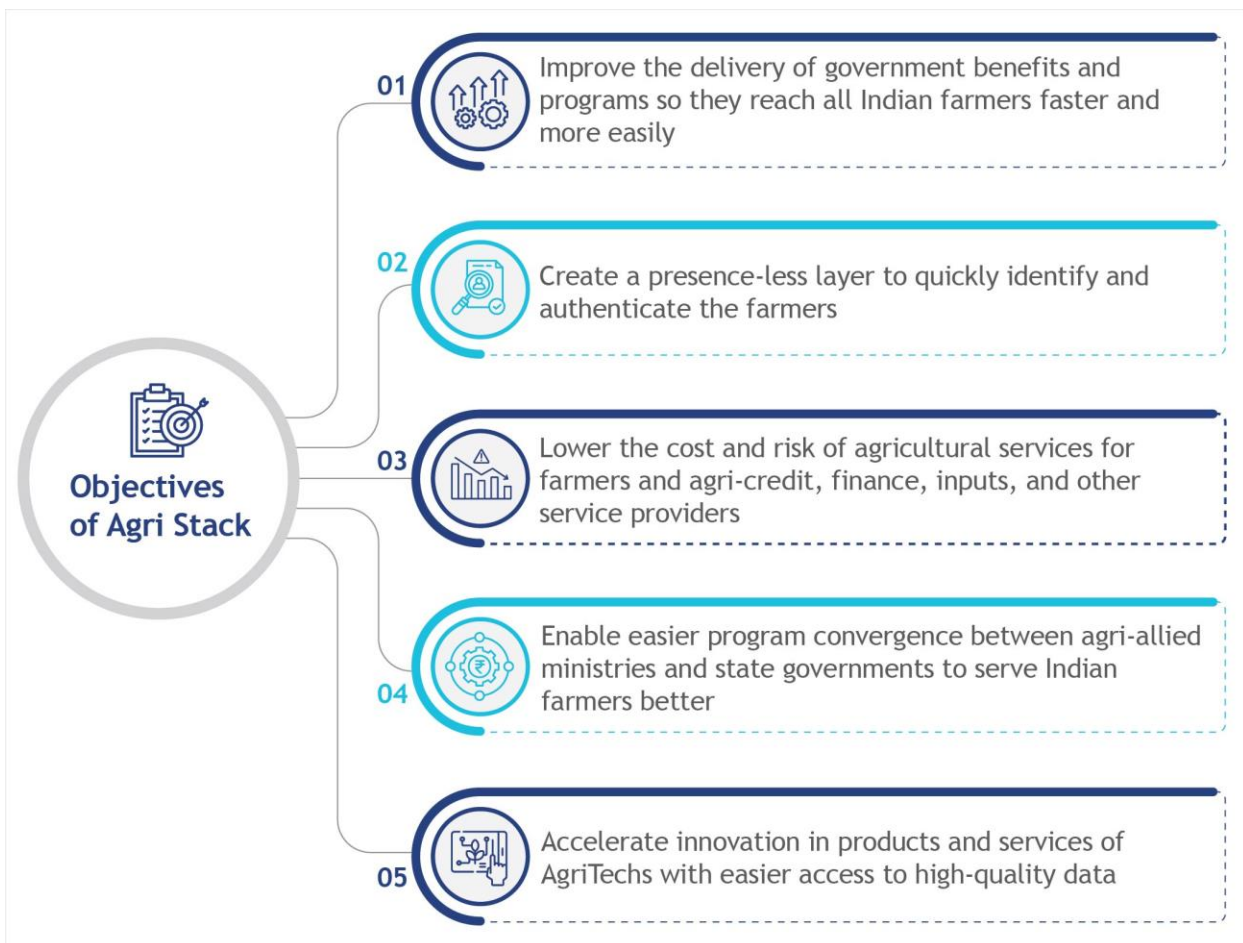

Objectives of Agri Stack

01 Improve the delivery of government benefits and programs so they reach all Indian farmers faster and more easily

02 Create a presence-less layer to quickly identify and authenticate the farmers

03 Lower the cost and risk of agricultural services for farmers and agri-credit, finance, inputs, and other service providers

04 Enable easier program convergence between agri-allied ministries and state governments to serve Indian farmers better

05 Accelerate innovation in products and services of AgriTechs with easier access to high-quality data

Figure 12: Objective of Agri Stack

Agri Stack has been envisioned with the following building blocks:

⟡ **Farmer and farmland plot registries**: A national farmer registry is currently being developed, which would provide each farmer with a unique Farmer ID and verifiable credentials. The registry would be closely tied to individual farmland plot records for planning, advisory, and scheme-related purposes, along with demographic data for identification and scheme eligibility assessment.

⟡ **Unified Farmer Service Interface (UFSI):** This would enable interoperability across stakeholders in the Agri Stack. It is envisioned to be used by the government and authorized private players, such as banks, Agri-Techs, and agriculture value-chain companies, among others   .

⟡ **Crop sown registry**: This is a federated record of crops sown and grown nationwide each season that seeks to incorporate smartphone and image-based methods, including drones and satellites in the future, for crop surveys. This aids governments in understanding issues and planning interventions.

⟡ **Agri Stack sandbox**: This is a controlled simulation environment within the Agri Stack framework. It offers authorized stakeholders access to the Unified Farmer Service Interface (UFSI) and sample datasets from different registries and databases. The sandbox enables safe learning from both successes and failures before fully authorized access to production environments.

⟡ **Consent manager**: The Agri Stack consent manager provides the foundation for data privacy and facilitates data-blind sharing of personal data only with persons or entities for whom the data principal (that is, a farmer) has provided consent. Once provided, consent can be revoked too, which prevents future sharing of data.

At present, 22 Indian states have provided APIs to verify land records. Additionally, 2,000+ AgriTech startups and companies in India are projected to benefit from Agri Stack.[130]

The government has also taken numerous policy initiatives and conducted pilot programs to promote technological innovation within the agriculture sector. Below, we will delve into a few notable examples of these endeavors.

1. The agricultural sector has seen the emergence of more than 1,300 startups exploring transformative technological solutions. The Central government has funded 800 startups with INR 118.65 crores (1.18 billion) under the RKVY's Innovation and Agri-entrepreneurship Development Programme, focusing on AI, IoT, and blockchain in agriculture[131] The 2023-24 budget includes the Agriculture Accelerator Fund, a crucial initiative that supports Agri Tech startups and rural entrepreneurs.

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2. **The Soil Health Cards (SHCs) Scheme**, launched in 2014-15, provides farmers with soil nutrient insights and recommended dosages for fertility improvement. The updated portal now includes a Geographic Information System (GIS) to visualize test results, enhance soil management, and promote climate-smart agriculture nationwide.[132]

> 3. The National Agricultural Market (e-NAM) is an online trading portal that connects Agricultural Produce Marketing Committee (APMC) mandis to establish a unified national market for agricultural commodities. It streamlines procedures, eliminates information gaps, and enables real-time price discovery. As of July 2023, it boasts 1,76,49,674 registered farmers, 2,48,876 traders, 1,10,620 commission agents, and 3,284 farmer producer organizations (FPOs)[133], and facilitatestrade worth approximately INR 2.79 lakh crore (2.78 trillion) .[134]

In conclusion, the global agriculture sector can draw invaluable lessons from India's pioneering initiatives to digitize agriculture, as exemplified by the Agri Stack. These endeavors underscore digital technology's transformative power to address the wide-ranging challenges that agricultural industries face worldwide.

Through digital tools, these efforts hold the potential to enhance global market access, foster price transparency, diminish post-harvest losses, facilitate equitable access to credit, and manage risks effectively. Consequently, agriculture across the globe can evolve into a more economically viable and sustainable livelihood for farmers to ultimately help enhance prosperity and food security at a global scale.

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Conclusion
Globalizing India's success: Sharing lessons with the world

At the recent G20 summit under India's leadership, the G20 nations wholeheartedly endorsed the G20 Framework for Digital Public Infrastructure. This voluntary framework offers recommended guidelines to create, execute, and manage DPI, and emphasizes a collaborative approach to foster a digital public infrastructure rooted in safety, security, accountability, trustworthiness, and inclusivity.

India's G20 presidency has been characterized by a worldwide consensus about the importance of investments in DPI to guarantee inclusive, equitable, and rights-based service delivery.

In this report, we have underscored the substantial potential of India's DPI to yield transformative outcomes across various sectors and address global development challenges. By effectively combining technology, governance, and policy regulations and fostering public-private partnerships, DPI can propel nations toward a growth trajectory. Nonetheless, the adoption and development of DPI call for long-term commitment and planning. Nationally and internationally coordinated policy actions and investments are needed urgently to harness the connection between technology and social development.

This report will serve as a comprehensive resource for governments, policymakers, and stakeholders who seek to use DPI in their endeavors to resolve global challenges, promote inclusivity, and secure a more equitable and sustainable future for all.

Key terms and list of figures

List of abbreviations

Abbreviation	Full form
AA	Account Aggregator framework
ABDM	Ayushman Bharat Digital Mission
ABHA	Ayushman Bharat Health Account
APMC	Agricultural Produce Marketing Committee
C-DOT	Centre for Development of Telematics
CAGR	Compound annual growth rate
CTDP	Comprehensive Telecom Development Plan
DBT	Direct Benefit Transfer
DIKSHA	Digital Infrastructure for Knowledge Sharing
DIVOC	Digital Infrastructure for Verifiable Open Credentialing
DoT	Department of Telecommunication
DPG	Digital Public Good
DPI	Digital Public Infrastructure
e-KYC	electronic know your customer
e-NAM	National Agricultural Market
FAO	Food and Agriculture Organization
FPOs	Farmer producer organizations
GB	Gigabyte
GDP	Gross domestic product
GDP	Gross domestic product
GIS	Geographic Information System
GSM	Global System for Mobile Communications
GSMA	GSM Association

Abbreviation	Full form
GSTN	Goods and Services Tax Number
GVA	Gross value added
HFR	Health Facility Registry
HMIS	Hospital Management Information System
HPR	Healthcare Professionals Registry
HSP	Health service provider
IIIT-B	International Institute of Information Technology, Bangalore
IMC	India Mobile Congress
ITU	International Telecommunication Union
KYC	Know your customer
LMICs	Low- and middle-income countries
MoE	Ministry of Education
MOSIP	Modular Open Source Identity Platform
MSME	Micro, small, and medium enterprises
NCERT	National Council for Educational Research and Training
NDEAR	National Digital Education Architecture
NEP	National Education Policy
NISHTHA	National Initiatives for School Heads and Teacher's Holistic Advancement
NOFN	National Optical Fiber Network
NPCI	National Payments Corporation of India
NSA	Non-standalone
OCEN	Open Credit Enablement Network
OOP	Out-of-pocket
PHR	Patient health record
RBI	Reserve Bank of India
SDG	Sustainable Development Goal

Abbreviation	Full form
SHCs	Soil Health Cards
STEM	Science, technology, engineering, and mathematics
TRAI	Telecom Regulatory Authority of India
UFSI	Unified Farmer Service Interface
UHI	Unified Health Interface
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPI	Unified Payments Interface
USOF	Universal Service Obligation Funds
WHO	World Health Organization

List of figures

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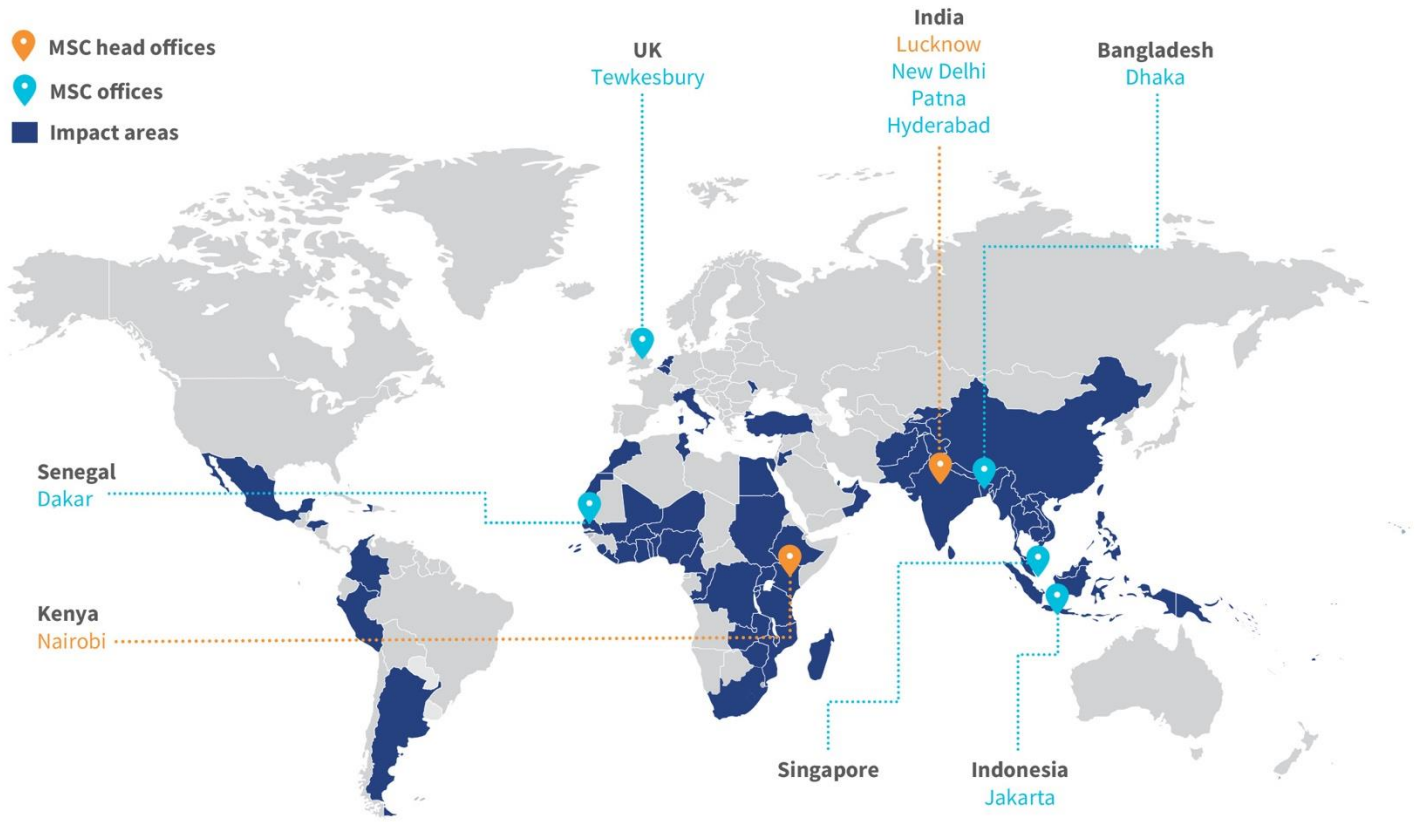
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