

# Smart Digital Census

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This white paper introduces the concept of a smart digital census, a form of large-scale survey that provides reports in real time and improves in terms of efficiency and accuracy during its conduction, effectively leading to a cost effective, highly efficient, significantly more accurate, and citizen-friendly replacement of traditional census. Such a revolutionary form of census is presented based on experiences of actual survey done in the state of Uttar Pradesh in India (proof of concept), combined with a detailed deep dive into the history and purpose of census.

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## 1. INTRODUCTION

### 1.1. WHAT IS CENSUS?

Human capital is the most critical capital for contemporary societies' wellbeing and progress. Providing an accurate and reliable assessment of this capital at small area, regional and national levels is of paramount value for evidence-based governing, civil societies, academics and researchers, as well as for all members.

The essential purpose of the population and housing census is to provide that assessment. Aside from the answer to the question "How many are we?" there is also a need to provide an answer to "Who are we?" in terms of age, sex, education, occupation, economic activity and other crucial characteristics, as well as to "Where do we live?" in terms of housing, access to water, availability of essential facilities, and access to the Internet.

The answers to these questions provide a numerical profile of a nation which is the sine qua non of evidence-based decision-making at all levels.

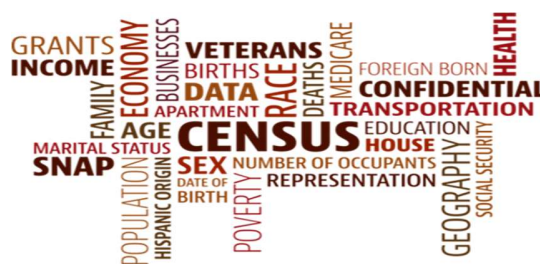


Figure 2: Census Word Cloud



Figure 1: Topics on which Census provide information

Census is the basis for

- reviewing the country's progress in the past decade;
  - monitoring the ongoing schemes of the government and plan for the future;
- Census provides detailed and authentic information as explained in Figure 2.

### 1.2. ESSENTIAL FEATURES



Figure 3: Essential Features of Census

### 1.3. CURRENT PRACTICES OF CONDUCTING CENSUS IN INDIA

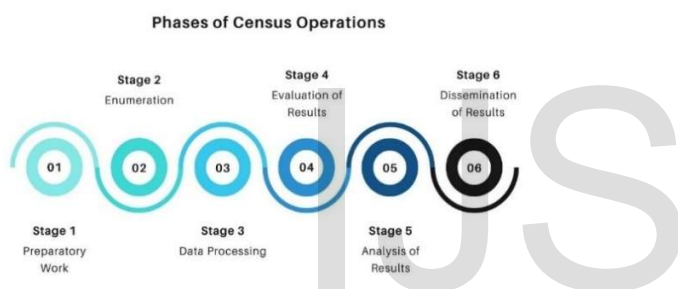


Figure 4: Phases of census operations

## 2. GLOBAL INNOVATIONS

### Innovation 1: Using Satellite Imagery to Check Addresses

Before the Census Bureau can count every person in the country, it must first collect addresses for every housing unit. One way the Census Bureau uses this address list is to mail census materials, including invitations to respond online, by phone or by mail. Census Bureau employees used to “canvass” neighborhoods in person, jotting down new addresses and correcting old ones on paper.

This long-running operation, known as Address Canvassing, is one of the ways the Census Bureau updates its Master Address File or MAF. Address canvassing was costly and time-consuming. Employees travelled a total of 137 million miles to update the MAF before the 2010 Census. In 2015, the Census Bureau began using aerial images from a network of satellites.

### Innovation 2: Introducing Online Self-Response

The 2020 Census was the first time everyone had the option to respond to the census online as well as by phone or mail.

The Census Bureau had an Internet Self-Response tool designed to make it easy to complete the questionnaire online and keep responses secure. Directions for responding online would be included in letters, postcards and other mailings sent to most homes beginning in mid-March.

Every response submitted on the internet shall be encrypted. That means data are changed into a code that only Census Bureau data analysts can read. Responses travel through a secure cloud computer network and the Census Bureau locks them in a “digital vault”.

### Innovation 3: Introducing Mobile Devices to Enumeration

From collecting census responses and job applications to storing questionnaires, the Census Bureau used millions of pieces of paper to gather and file information. It relies much more on technology – and much less on paper. In 2020, census takers who go door-to-door to help people respond would collect information on smartphones using a custom application created by the Census Bureau. To protect privacy, administration encrypt all data and devices require two-factor authentication to be unlocked.

## 3. LIMITATIONS OF TRADITIONAL APPROACH

The main cost item is for the temporary work force (enumerators, supervisors, etc.) that has to be recruited and trained, and has to work for a few weeks or longer periods. . Apart from the cost for census field staff, the cost of printing, distributing, collecting a huge number of census forms, entering the data (manually or using scanners) and processing them is also very high. The expenditure on census was Rs 2,200 crore. 733,600 crore tons of paper was used during the Census.

One major issue raised was that census enumerators did not necessarily ask all relevant questions. People reported that census enumerators filled questions about gender without asking the question. This became an issue for transgender people who might look outwardly like one gender but consider themselves the other gender.(Census 2011,India).

Working at such a massive scale inevitably led to problems because of the number of people involved – 25.4 lakh people worked on the Census, 21 lakhs of whom were

enumerators. Three years after the Census of 2011, many teachers in Nagpur (India) reported that they had not yet received their full salary.

**Another problem that arose was the prevalence of proxy enumerators in Andhra Pradesh, where enumerators outsourced their work to other people.** In Hyderabad, the Times of India reported that an enumerator left his forms with a neighborhood's watchman, promising to return in 4 days to collect the filled forms. **Data visibility is not in real-time, to process complete census is a huge undertaking and will require many years to complete the whole tabulation programme of the census data.** By the time the data is published, it becomes out of date and cannot be used for any policy matter. **Data Processing took around 1.5 years using the ICR technology in 2011 census of India.**

#### 4. WHAT IS DIGITAL CENSUS?

It is commonly known that the art of population census taking goes back many centuries. Ever since the end of the nineteenth century, there have been efforts to take advantage of a succession of newly available technologies to make such large and costly statistical enquiries more efficient and effective. A census is labor-intensive, requiring large numbers of temporary staff. Personnel costs usually are the principal component of census budgets, with expenditure for information and communication technology coming second. Even small improvements in the methodologies used, or in the effectiveness of the equipment, can result in important gains in quality and/or cost-effectiveness of the whole operation.

Digital Census is a method of collecting the census data using new technology advancements like through a mobile application, a web-based portal.

*Smart Digital Census takes conventional digital census to the next level, by using unique technologies that can help improve the process of census while it is being conducted, and in the process making the entire process smarter and much more effective than a conventional digital census. While a digital census is limited to use of digital technologies while collecting data from the citizens, a smart digital census does much more, by using many more innovations that tie up with the process of data collection.*

**Think of it this way: what if the enumerator on ground doing data collection using the digital technology is also supported by an artificially intelligent guide who is constantly making the process easier for them; while also**

**making the outputs easier for the administrators in real time.**

##### 4.1. INNOVATIVE FEATURES OF DIGITAL CENSUS

Templates have been around for some time now. Templates refer to a pre-existing structure that can help you reduce the time for app creation. When it comes to mobile applications, templates can reduce the hassle and time to market for developing apps. Since the UI already exists in the template, government do not need to assign a sizable amount of money on the development of the frontend. This is one of the most expensive portions of app development, where governments spend thousands of rupees. Government Units will not have to wait for another decennial census to take place so that they can decide the certain aspects of policies like the beneficiaries to be part of welfare programmes, the umbrella of people under Below Poverty Line etc.

Since the data would be visible on real time basis, it will help the administration to track the changes in the population characteristics and in administering and formulating of policies. Citizens will be updating the information and government would not need to keep crores of files lined up, it will also prevent the loss of data.

During enumeration exercise, enumerators will have the GIS Maps in their devices which will help them to reach out to every settlement, so no one is left uncounted. It will avoid non-inclusion and double inclusion of units that may result in under or overcounting. Also tailored communication and partnership campaign can be designed to motivate people to respond in the remote parts of country as depicted by GIS maps.

Constant feedback loops will help the government to reorient existing systems as well as shape the new ones. Bottlenecks will be alleviated without the need to replace whole system. This will help in promote SDG goals under the cluster of peaceful and inclusive society

More surveys per enumerator will be possible as there will be pre-determined fields and scroll down option in the app and if the enumerator is taking the response of a particular area, he will not have to fill the fields again and again, they will be auto filled, saving his time.

Table 1: Comparison between different types of Census

	Traditional Census	Digital Census	Smart Digital Census
<b>Pre-work</b>	Regular	Regular	Very High, as systems are customized to become guides for enumerators based on secondary research; also, auditing and other innovative mechanisms need to be defined right at the start of survey
<b>Data Collection</b>	Enumerator goes on ground with pen and paper, collects data, and later the paper data is transferred to a central database	Enumerator goes on ground with a digital system (mobile application or a laptop), collects data, and data immediately syncs with the central database	Enumerator goes on ground with a digital system (preferably, mobile app), gets guided by the app itself to do faster data collection, and data immediately syncs with the central database and an auditing system that improves the process through real time or daily recommendations
<b>Data Outputs</b>	Data normalization and standardization takes up a lot of time, before outputs are created	First level outputs are expected to be created in real time, and then improvements may be required before final submission	Outputs are created in real time (initial checks, auditing, visualization, all happen at the same time)

#### 4.2. ADVANTAGES AND DISADVANTAGES OF DIGITAL CENSUS

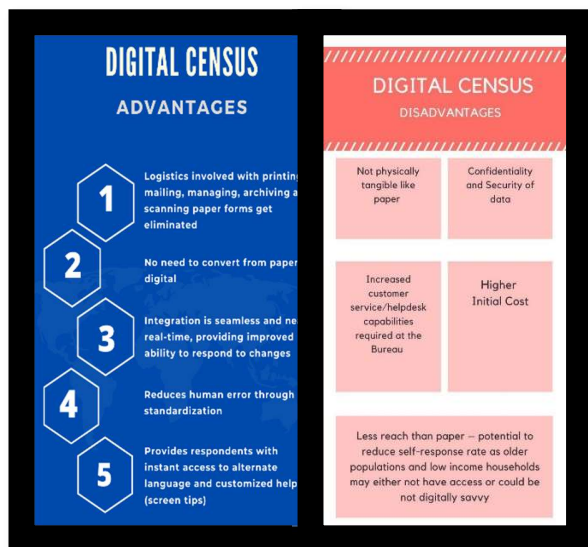


Figure 5: Advantages and Disadvantages of Digital Census

challenges of transferring data from paper to digital do not exist in this case. So, smart digital census replaces hundreds of back-end staff with a few technical staff; with the back-end staff free to focus on other innovative works.

Also, with the conception of a smart digital census, right at the start of the census, technical expertise requirement should not pose a problem. Most importantly, with increased technical expertise, regular customer service requirements will reduce significantly, as much of the customer service is handled by the intelligent systems themselves. This means that the overall costs will also be lesser.

- **Higher Initial Cost:** A comparison of the expected budgets of a smart digital census vs a traditional census paints a different picture. In today’s world, smart technologies are flexible, requiring almost zero capital expenses (as they can be flexibly handled during operations). There is no expense for developing any system or for having data infrastructure, in a smart digital census, as existing technologies or products can be used on a pay-per-use basis.

#### 4.3. HENCE SMART DIGITAL CENSUS

The Smart Digital Census targets all the disadvantages in the conventional digital census and removes most of them.

Smart Digital Census is where enumerators go on ground to take surveys, but they use new age technology enabled systems to do the same, with a lot of technology-driven pre-work that makes their process easier, faster and much more accurate, while also making it real time for immediate actions driven out of recommendations out of the surveys.

- **Comfort with Paper:** This can be solved through involvement of enumerators who are more digital savvy as is the case in the changing world today, and by creating a smart system that is simple enough for enumerators without a lot of education. This has been successfully tried in the case study that is referred to later in this paper.
- **Fear of confidentiality of data:** This is unwanted fear, as use of “cloud” in smart digital census has much more flexibility in terms of the security of data. Also, in order to allay this fear further, multiple combinations of data storage options can be used, depending on the level of confidentiality of data.
- **Increased customer service/technical expertise:** Technical expertise is needed at the level of management of the systems and not at the level of collection of data. But such expertise leads to increased accuracy as the

- **Lesser Reach to those with low access to technology:** In the smart digital census, this is not a problem at all; as it is designed to suit everyone, including the ones with zero access to technology, since it’s the enumerators who use technology and not the survey takers. For the survey takers, reach is even more, because enumerators take less time per household in a smart digital census, thus making sure no one is missed.

#### 5. CASE STUDY OF A SMART DIGITAL SURVEY IN THE STATE OF UTTAR PRADESH

Commissioned by the Department of MSME, Government of Uttar Pradesh to UPICO (UP Industrial Consultants Limited), this project undertaken by the team of Sapio Analytics working for UPICO, with support from UFS Limited, was focused on one of the least studied segments that there is, the unorganized sector.

The unorganized sector, due to its sheer nature of being unorganized, has not been studied in such depth; but the challenges for this particularly survey were even more:

- **Speed:** Speed of conducting the survey was of paramount importance so that the knowledge gathered by the same can be used immediately for the economic growth of the state that was reeling under the impact of COVID-19.

- **Major changes in the construct of the society and families:** The pandemic brought in a wave of reverse migration to the state of Uttar Pradesh, besides changing a number of aspects about the society, particularly in the households that had members working for the unorganized sector.
- **Limitations in on-ground travel:** With the pandemic looming, door to door traveling was not easy. It is expected that such limitations may become norms at least for the near future, hence innovative methods to handle the same are needed.
- **Fear of bias:** Various reports on the unorganized sectors across the state have resulted out of research that have been functions of assumptions about the unorganized sector. It was important that any such bias did not color the outputs in the wrong manner.

With all the above mentioned problems, conducting a survey that can deep dive into the unorganized sector, understand their problems to such levels that hyper-localised policies around these problems can be recommended, was a clearly a task that would have taken years with involvement of a mammoth task force, if it were not for the Smart Digital Survey that was conducted.

One limitation in this case study is that the survey did not begin with marking of the households against whether they have members or unorganized sector or not, hence leading to outputs that may not be perfect, but are good enough to serve the purpose behind the survey. Such marking before

sampling, or full scale survey of all households (and not just sampling) would have been the best way to conduct the smart digital census for the unorganized sector in the state of Uttar Pradesh under different circumstances.

Let us look at how the above mentioned challenges were handled for this survey:

- Use of Mobile Applications for data collection in real time
- Use of Algorithms (combining existing Econometric Models with modern Machine Learning Techniques) to derive real time outputs
- Auditing Methods to compare real time outputs with expected outputs, and improve the processes accordingly
- Use of self-surveys (using Whatsapp chat bot, though this was not used extensively) to study the outputs through self-surveys and comparing the same with on-ground surveys to further improve the direction of on-ground surveys, based on required audits
- Enumerator Guidance Systems in the mobile application to help them cover more households in less time
- Use of questionnaire that is simple and less in number to cover larger number of households, while using combination of answers of some of the questions to derive more outputs (this may not be applicable for all such surveys and may have limited scope)

All of the above mentioned innovative techniques contributed to the creation of **India's first smart digital survey**, and one of the world's first such surveys that combined chat-bot, A.I. engines based on feedback loops, and smart mobile applications; that too for a complicated segment like the unorganized sector, with a unique focus on hyperlocal data.

There was a combination of studies conducted across the districts of Lucknow, Meerut, Gorakhpur, and Varanasi, followed by a *high-end use of various data analytics tools designed to analyse the data outputs* in the context of each district, created through high end algorithms supported by secondary research and on-ground work.

*Through a deep use of new age technologies and an on-ground workforce, in coming up with various numbers for the unorganized sector spanning multiple demographics and sectoral activities, the report proposed a granular micro-level policy recommendation*, that could help enable the unorganised sector to get its fair share of pie in the resource allocation. Resulting it to be streamlined with the main economy of the nation. The core aim of the report was to come up with a well-designed policy recommendation plan for the improvement of the unorganized sector, backed by

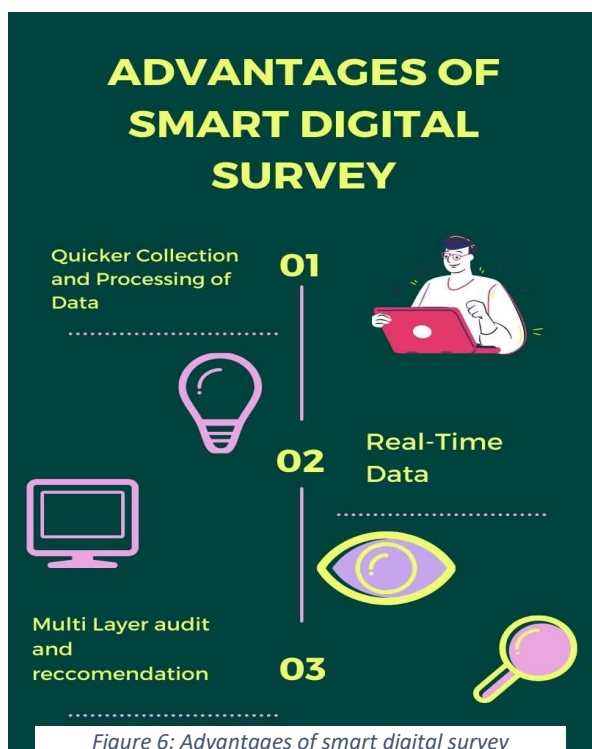


Figure 6: Advantages of smart digital survey



data driven results, aided by a deep study of policies across the world in similar scenarios.

*The report also provided critical data outputs that can be used by various departments for relevant planning and decision making, besides the recommendations generated in the report.* The data outputs were accompanied by analysis to help the decision makers, besides being useful for the core policy recommendation.

The team involved in the report included enumerators and their supervisors, responsible for conducting on-ground survey work and collecting data in a pre-planned manner, that was derived based on the work by a team of secondary researchers, who helped create the templates needed by the enumerators for an effective data collection through a mobile app rather than the traditional method of using paper and pen.

*This marks the start of a unique concept of digital survey that was done using an Android based mobile application with novel methods of auditing integrated with the same. The data from the survey was made intelligent through a combination of algorithms combined with data analytics tools.*

A smart digital census system also believes in the power of smart visualisation of various outputs, that can be used for quick grasp of the situation, based on which immediate actions can be taken.

*“If you have to show the seriousness of a situation in just a few seconds, use of a visual heat map focused on colours without numbers may do the trick.”*

~ Shri. Jayant Kumar Banthia, Census Commissioner of India from 1999 to 2004 (oversaw the 2001 census), former Chief Secretary, Government of Maharashtra.

In our interaction with Mr Banthia, we understood the importance of visualisation, and realised that smart digital census can't be created without a focus on visualisation, that is able to speak to the decision makers in just a few seconds if required. Use of graphs along with heat maps (using proprietary GIS technologies) for this case study helped in all aspects of this study. In future studies, additional visualisation can be done in the form of 3D GIS.

Continuous Auditing of the data enabled us to efficiently analyse data on a frequent basis along with detection of anomalies, outliers, inconsistencies and other factors.

Availability of real time data enabled us to enhance our degree of reliability on the quality of data collected hence mitigating the risk of wrong collection of data and ensuring that the sample selected reflected the true population. Real-time analytics helped us pinpoint issues the moment they arise, and in some cases, catch them before they occur.

Our smart digital survey enables the enumerator to have a pre-determined questionnaire, recommended based on their location and other demographic parameters as instructed to them, with certain known fields already filled. This saves time and helps in quicker collection of data with a smaller number of enumerators used.

Below is the screenshot of the application questionnaire used during the survey

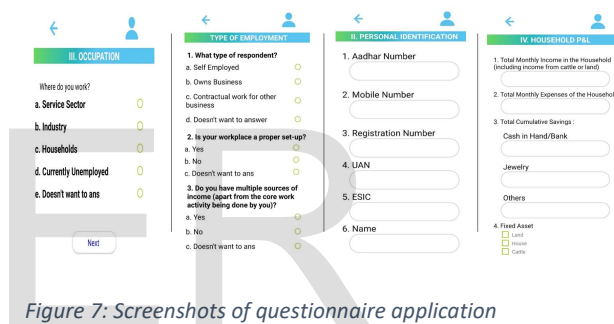


Figure 7: Screenshots of questionnaire application

## 6. BENEFITS OF SMART DIGITAL CENSUS

This paper focuses on a number of benefits that smart digital census provides over any other traditional form of census, or even the conventional digital census.

Here is a summarised understanding of the said benefits:

- **Financial Benefits**

When seen from the context of the case study (survey done in the state of Uttar Pradesh for the unorganised sector), this benefit comes out very clearly.

A much lesser number of enumerators can cover a large population, as compared to a traditional census, and in a much lesser time. Both the number of people and the time taken are effectively the major costs involved in the process of data collection.

In addition to the same, cost is further reduced through absence of later post-processing work due to the real time nature of the same. Of course, the technology costs are

additional, but their numbers are much lesser than the benefits in cost due to the technology.

- **Social Benefits**

More personalized interactions with the citizens: Technology enables the interactions to be more personalized, especially the technologies around the enumerator guidance. This makes sure that people are involved and helps in reducing inaccurate information.

Feeling of contribution to change: Since the process is real time and provide outputs very quickly; if the authorities choose to publish parts of the same, the citizens feel more involved in contributing to the change, and this participation leads to ensuing social benefits.

- **Administration Benefits**

The benefits for the administration, in terms of increased efficiency and accuracy have already been mentioned multiple times in this paper. The administration sees better results in less time, with intelligent recommendations, at a reduced cost, and particularly useful in situations like the current pandemic where dependency on digital technologies is higher.

## 7. WHY INDIA IS READY FOR CHANGE?

India is among the top two countries globally on many key dimensions of digital adoption.

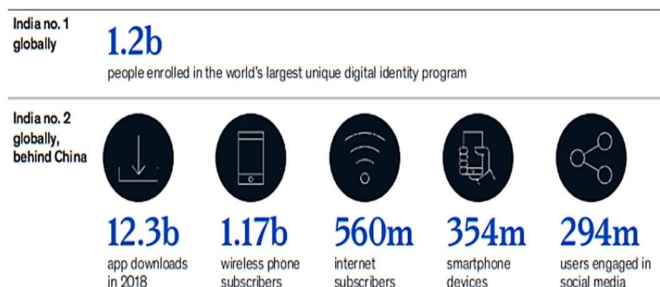


Figure 8: India's digital adoption at a glance (Source: PricewaterhouseCoopers, Strategy Analytics; Telecom Regulatory Authority of India, Unique Identification Authority of India)

With more than half a billion internet subscribers, India is one of the largest and fastest growing markets for digital consumers, and the rapid growth has been propelled by public and private sector alike. India's lower-income states are bridging the digital divide, and the country has the potential to be a truly connected nation by 2025. Much more growth is possible. As India's digital transformation unfolds, it could create significant economic value for consumers,

businesses, microenterprises, farmers, government, workers, and other stakeholders.

India's internet user base has grown rapidly in recent years, propelled by the decreasing cost and increasing availability of smartphones and high-speed connectivity, and is now one of the largest in the world. The country had 560 million subscribers in 2018, second in the world only to China. Digital services are growing in parallel. Indians now download more apps— 12.3 billion in 2018—than residents of any other country except China. The average Indian social media user spends 17 hours on the platforms each week, more than social media users in China and the United States. The share of Indian adults with at least one digital financial account has more than doubled since 2011, to 80 percent, thanks in large part to the more than 332 million people who opened mobile phone-based accounts under the government's Jan-Dhan Yojana mass financial-inclusion programme.

The public sector has been one strong catalyst for India's rapid digitisation. The government's effort to ramp up Aadhaar, the national biometric digital identity programme, has played a major role. At the same time, private-sector innovation has helped bring internet-enabled services to millions of consumers and made online usage more accessible. For example, Reliance Jio's strategy of bundling virtually free smartphones with subscriptions to its mobile service has spurred innovation and competitive pricing across the sector. Overall, data costs have dropped by more than 95 percent since 2013: the cost of one gigabyte fell from 9.8 percent of per capita monthly GDP in 2013 (roughly \$12.45) to 0.37 percent in 2017 (the equivalent of a few cents). Average fixed-line download speed quadrupled between 2014 and 2017. As a result, monthly mobile data consumption per user is growing at 152 percent annually—more than twice the rates in the United States and China.

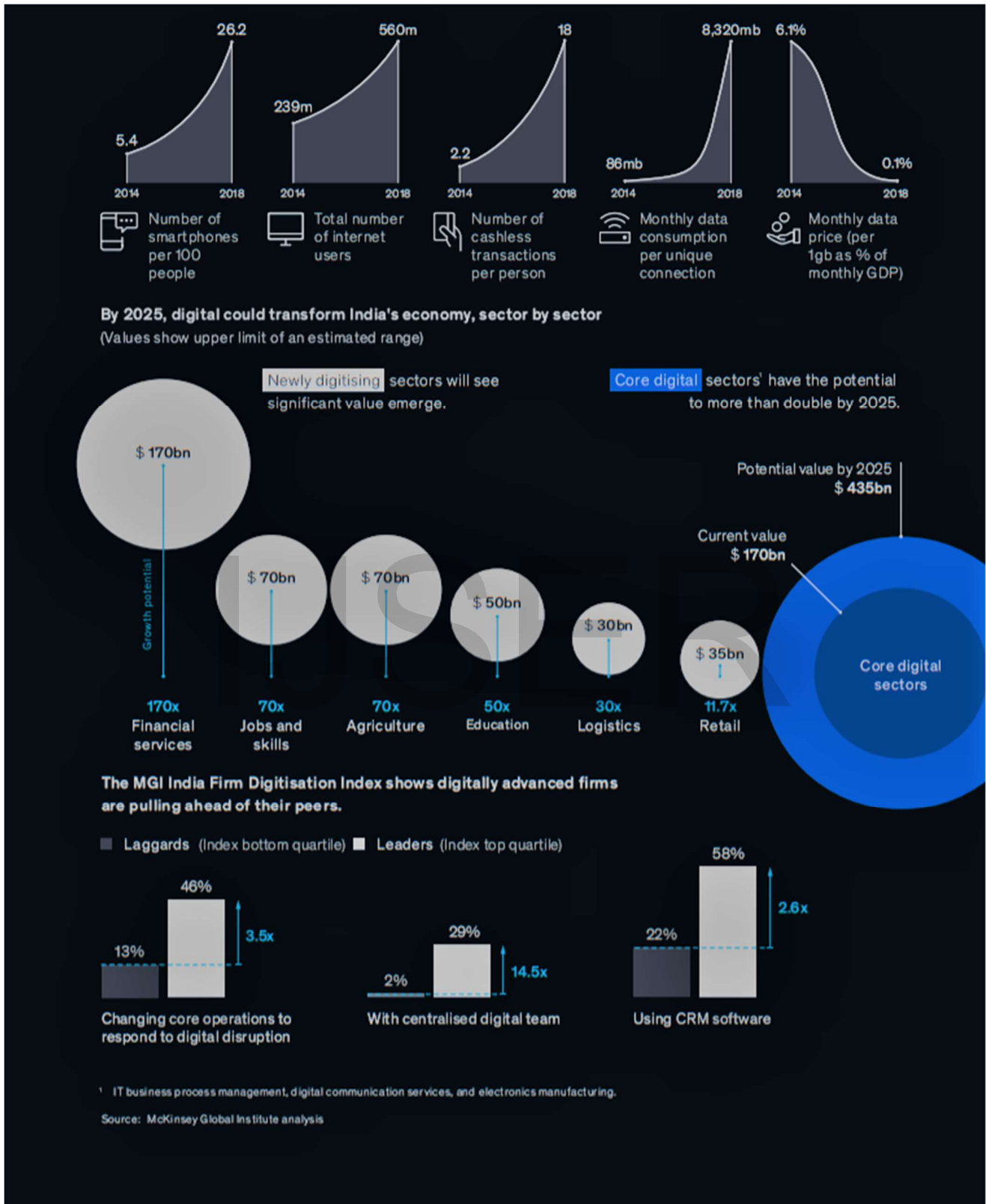


Figure 9: Unlocking the potential of technology in India (Source: McKinsey Global Institute Analysis)

## 8. CONCLUSION

Population and housing census provide a wide range of statistical information on the population – persons, households and housing units. They allow detailed disaggregation of data by small geographic areas and small population groups. However, it is widely recognised that conducting a population and housing census is one of the most expensive and complex data collection operations, comprising of a series of many interrelated activities. The logistical effort required, and the difficulties encountered in contacting and collecting information on the whole population within a limited period, adds to the complexity.

Governments are increasingly facing several challenges in conducting population and housing censuses, ranging from falling participation to increasing data collection costs. Response rates have declined as citizens become increasingly concerned about information security and privacy and the confidentiality of information given to the government. Households are becoming more diverse, dynamic and mobile, making it a challenge to reach people and assign them to a single unique location. These societal, demographic and budgetary trends are making it harder and more expensive to locate individuals and solicit their participation through traditional data collection methods. Moreover, each of these trends threatens the ability of government to deliver high-quality, timely and cost-effective census results.

These challenges are compelling Governments to investigate alternative ways of implementing the census, and ultimately, to modernise and transform the traditional method of conducting a census. Today's information and communication technologies offer unprecedented opportunities to innovate and transform their census operations, dramatically improving performance and census results while reducing costs. Moreover, they can enhance the quality and accessibility of census results. With proper planning, governance and vision, modern technology can help to improve the efficiency (as measured in terms of cost and time savings, productivity gains, increased accuracy) and effectiveness (by, for example, providing better products and service, improved analysis) of census processes.

Recent advances in information and communication technology have changed how routine statistical business processes such as Enumeration Area (EA) design, data capture and validation, data processing, and data dissemination, are being carried-out. The use of such technology has become an integral and vital part of census processes critical for improving the cost, quality (coverage,

accuracy, timeliness) and efficiency of the census. The rapid expansion in mobile connectivity, and rapid progress in technological innovation more broadly (such as cloud computing, smart mobile devices, GPS, web GIS), provide new opportunities for increasing the quality and speed with which census data can be collected and the statistics produced. Advancements in technology has brought digital media in forefront of everyday life. Citizens of India are becoming increasingly comfortable with digital modes and it is expected to grow even further. We are told time and again that data is a prized commodity, but it is very easy to be big data rich, yet still insight poor, if information isn't harvested and analysed efficiently.

Hardware and software as well as mobile data networks are becoming cheaper and better, and infrastructure and capacity that enables effective deployments is increasingly available in all parts of the world. This means that the immense progress in connectivity (in terms of both speed and magnitude) and technology adoption has a large potential for modernizing and complementing traditional statistical collection. New approaches are allowing the collection of data with handheld electronic devices, the Internet and the telephone in a manner that is better, faster and potentially cheaper. It's imperative to say that DIGITAL CENSUS is the way forward for the inclusive development of society as whole. It will benefit both public and private sector and will display the perfect model of public-private partnership.

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