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Contents

An ICT approach to rural metamorphosis: A white paper

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Foreword

Launched under the leadership of Prime Minister Narendra Modi in 2015, India's Smart Cities Mission is a progressive multi-year effort to boost economic growth, technological innovation and sustainable development across cities in India.

But if there can be smart cities, then why not smart villages? So, with this thought, the government launched the Shyama Prasad Mukherji Rurban Mission (SPMRM) in February 2016. SPMRM is an attempt to transform rural areas into 'economically, socially and physically sustainable spaces' or smart villages 'which would trigger overall development in the region', according to the Ministry of Rural Development.

Villages are India's future, and smart villages will help in mitigating rural to urban migration, generate employment, reduce the digital divide and improve the work-life balance of residents.

The mission will create village clusters that minimise rural migration to cities through skill development programmes. There will be a separate approach for the selection of clusters in tribal and non-tribal districts. For the selection of clusters, the ministry is looking at factors like demography, economy, tourism, significance as place of pilgrimage and transportation corridor impact. Under the scheme, 300 clusters will be developed with an investment of 5,100 crore INR in three years.

The Smart Village Conclave organised on the third day of One Mega Event, i.e. 12 May 2016, will further explore the needs of village sustainability. The conclave will be attended by Members of Parliament, pradhans, sarpanches, innovators and influencers.

Finally, I would like to take this opportunity to thank our knowledge partners, PwC India, for preparing this high-quality white paper titled 'Smart villages: An IoT and ICT approach to rural metamorphosis'. This white paper highlights the importance of smart solutions for establishing smart villages as well as healthy communities.

Prem Behl
Chairman, Exhibitions India Group

A sizeable segment of the Indian population resides in rural areas, and agriculture continues to be the primary source of income in these regions. Thus, it is imperative not to neglect the development of villages since they are the food bowls and source of livelihood for the majority of our population. Moreover, growing urbanisation is putting pressure on already strained resources in urban regions. The number of people residing in urban regions of India is forecast to rise from 31% in 2011 to 50% by the year 2050. Everyone aspires to have a better quality of life with good healthcare, education, utilities and a sizeable number of job opportunities. However, if these aspirations of people residing in rural regions are addressed, migration to urban regions could be curbed to some extent, thereby relieving the pressure on already overburdened urban areas. With this in mind, the government launched the Shyama Prasad Mukherji Rurban Mission (SPMRM) to make our villages the growth drivers of the country. The SPMRM scheme intends to catalyse regional growth, which will benefit both urban and rural regions by enhancing rural areas and de-burdening urban regions.

The transformation of rural regions with smart villages will ultimately lead to economic growth and inclusive growth with digital and financial inclusion. The entire ecosystem will be uplifted with the penetration of technology into smart villages, which will expedite the nation's advancement and create a happy, holistic society. The journey to smart villages will require a massive overhaul in social, physical, environmental and governance ecosystems, accompanied by capacity building for both governing authorities and citizens. Apart from leveraging technology for the betterment of quality of life, the smart villages must be developed in harmony with citizen groups residing in these villages to ensure holistic development which is in line with their aspirations. Consultations with these groups must be an integral part of discussions during smart village planning and designing phases.

The objective of this white paper, which has been prepared for the third Smart City Expo 2017 organised by the Exhibitions India Group in New Delhi, is to highlight the need for smart villages as well as presents case studies of global and domestic smart village initiatives. The paper also includes a framework for rural metamorphosis to smart villages, key enablers and the adoption of technology-intensive smart solutions for smart villages. It is expected to drive conversations on smart solutions for transforming the country's villages.

Neel Ratan
Partner and Leader, Government and Public Sector
PwC India

Introduction

In today's global economy, villages ('gaons') or countryside areas continue to grapple with the challenge of mass migration to urban areas, which is driven by a quest for better opportunities and better quality of life. Changing trends in trade, with continuous pressure from people and the government, further complicate the situation. In order to overcome these challenges, villages have begun to transform themselves. However, these initiatives are often driven by immediate circumstances and undertaken without defined methodologies or standard development plans. The existing information and communication technology (ICT)/ Internet of things (IoT) methodologies have transformed the lives of even the urban population and can tremendously help villages metamorphose into smart villages. ICT/IoT initiatives will definitely help villages retain their people and provide them with liveable surroundings that are at par with those of cities.

'Gaon': A cluster of houses

'Gaons' (the word for villages in Hindi) have always been a vital part of civilisation in India. A majority of the Indian population lives in rural areas. The history of Indian villages goes back to ancient times, where kingdoms comprised a major city and several villages. In these kingdoms, villages were a collection of households that cultivated the adjoining land. During the 1800s, the structure of Indian villages changed drastically.

Walking was the only mode of transport in ancient times. There was no alternative transport system for villagers until vehicles such as bullock carts, palkis, horse carts and boats were invented. These continued to be the primary means of transportation for many centuries. It was only in the late 1800s and early 1900s that villages witnessed a revolution in terms of transportation due to the introduction of buses, trains and other automobiles. The educational system has also significantly evolved throughout the history of Indian villages. In the ancient period, Indian villagers used to be taught Vedic and other Hindu scriptures. These scriptures were the only means of education. From 1800 to 1900, diverse streams of education such as medicine and engineering became available.

Similarly, in the case of occupations, cultivation and agribusiness were the prominent source of livelihood for villagers in ancient times. A great shift occurred in the 1800s when villagers started to move to urban areas and abandon their traditional occupation. Following rampant industrialisation, villagers began to be work as employees or labourers in urban areas.

In summary, Indian villages have witnessed a massive socioeconomic upheaval in the modern period. With widespread access to electricity and telecom facilities, villages are geared up for a new revolution.

The heart of the matter

According to the Planning Commission, a settlement with a maximum population of 15,000 is considered as a 'village'. India has more than six lakh villages.[1] As per 2011 Census data, 68.84% of the Indian population lives in rural areas, and only 31.16% lives in rural areas. The rate of India's urbanisation (namely the annual percentage change in the proportion of the urban population) is higher (1.1%) than the global average (0.9%).[2]

Agriculture is the main source of livelihood in Indian villages, along with poultry, pottery, fishing, rice and sugar industries. Villages in India are faced with the challenge of mass migration to urban areas by people seeking better opportunities and better quality of life. The major reason in most of the cases is social and economic stress and weak financial support. As per a Census report, rural to urban migration increased from 42% in 2001 to 56% in 2011.[3]

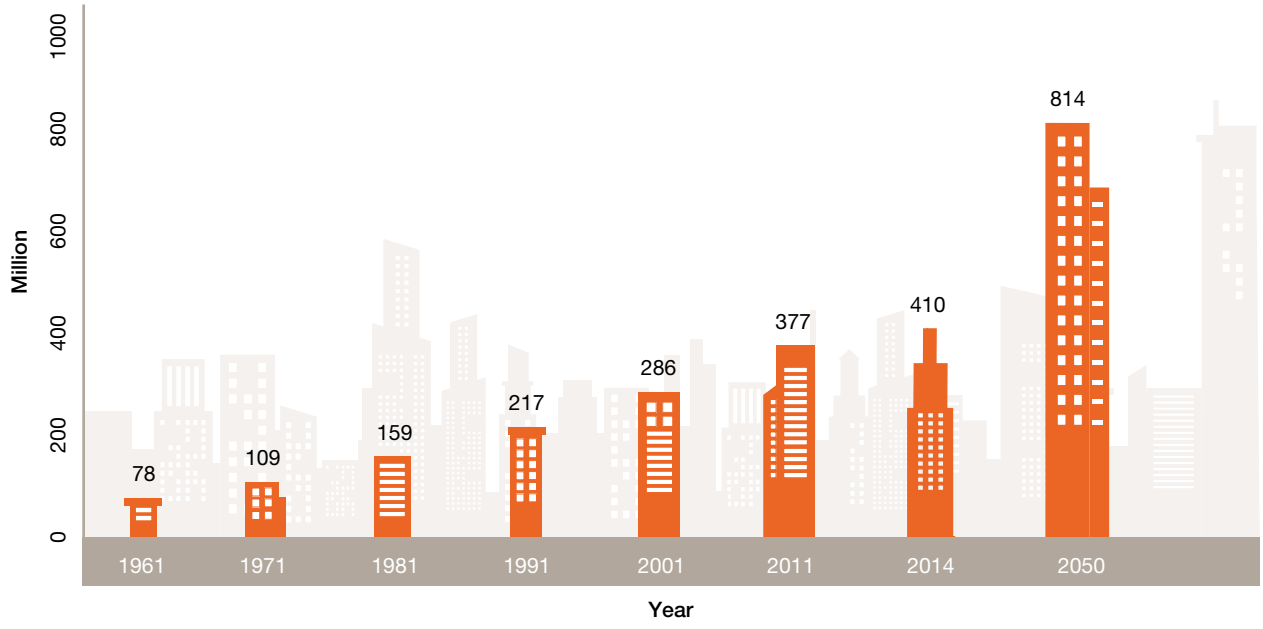
Another challenge that villages face is a shortage of employment opportunities. The permeable capacity of the agricultural sector is very low as diminishing returns have already set in in the agriculture sector. As more educational avenues become available to the rural population, the quantum of relocation to urban areas will see a tremendous increase. The only way to prevent this is to induce an 'inverse movement' by providing basic infrastructure and utilities and promoting industrialisation. This will lead to a steady increase in the employment opportunities in villages and ultimately solve basic issues in rural areas and ensure a healthier lifestyle.

The government is well aware of these challenges and has announced many schemes for the upliftment of the rural population. At the same time, villages themselves need to undertake initiatives to define or enhance their independent strategy to become a part of tomorrow's urban growth. Some villages have already taken the necessary steps in this direction.

Currently, Indian villages are focusing on many areas, such as poverty eradication, healthier lifestyle opportunities, and basic amenities such as potable water, sanitation, good health, better nutrition and basic infrastructure facilities through innovative programmes of self-employment.

According to the 2011 Census, every fifth urban resident lives in slums. In the Municipal Corporation of Greater Mumbai, about half of the population lives in slums. Slums are defined as settlements which are inhabited mostly by large numbers of non-employed migrants. The proliferation of slum areas and the resulting societal and monetary pressures may reduce if the standard of living in villages improves. This can also mitigate the effects of poverty, unemployment and lack of infrastructure on urban hubs.

Urban population in India



Source: Census of India 1961 to 2011
Note: The figures for 2014 and 2050 are taken from UN DESA, 2014.

Global overview: Migration from rural to urban areas

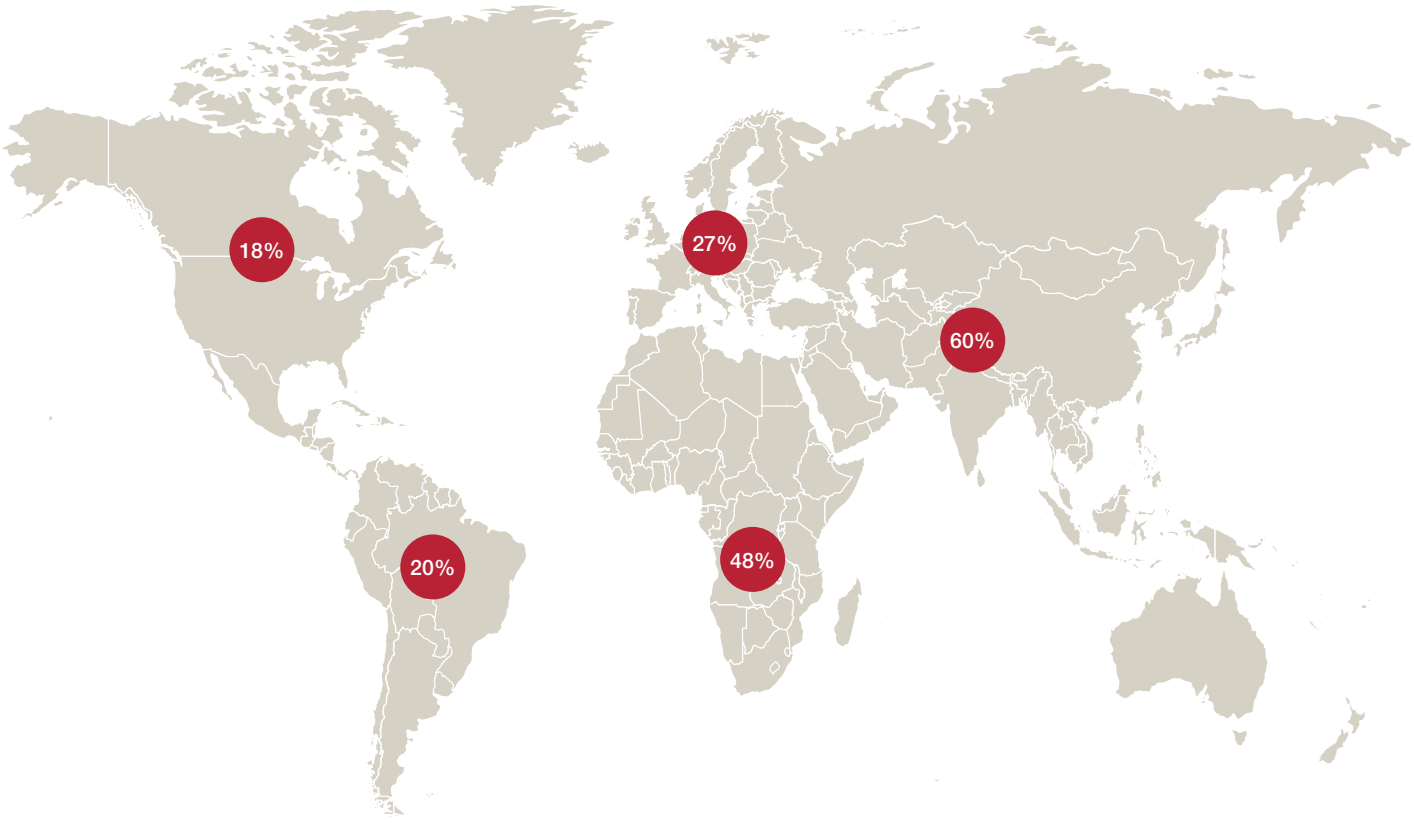
Globally, more people live in urban areas than in rural areas, with 54% of the world's population residing in urban areas in 2014. In 1950, 30% of the world's population was urban. By 2050, 66% of the world's population is projected to live in urban areas.[4] Migration from rural to urban areas has historically played a key role in the rapid growth of cities and, together with the reclassification of rural localities into urban centres, it continues to be an important component of city growth. However, natural increase—that is to say, the difference between births and deaths on site—can add significantly to urban growth, particularly in countries where fertility levels remain high. Today, natural increase makes a larger contribution to urban population growth than internal migration and reclassification in a majority of developing countries.[5]

Africa and Asia are home to nearly 90% of the world's rural population. India has the largest rural population (857 million), followed by China (635 million). (UN, 2014)

In India, an estimated 20 million people migrate temporarily. Over 60% of this movement is between rural areas, with a majority of the people migrating from drought-prone provinces to regions of irrigated agriculture. Nevertheless, recent research suggests that as a consequence of agricultural mechanisation, migration is increasingly towards urban centres and non-farm occupations. In northern Bihar, this type of movement has grown from 3% of the total migration in 1983 to roughly 24% in 2000.[6]

In Africa and Asia, circular migration is the predominant form of movement in many nations and regions. In drought-prone areas like Asia, there is a long tradition of temporary migration as a coping strategy.[7] The levels of urbanisation have increased most rapidly between 1950 and 2000—from 14.5 to 36% in Africa, and from 16.3 to 36.8% in Asia.[8]

In Europe, in terms of the urban/rural distribution, the situation is one of urban growth and rural decline. In 1970–2000, the continent's urban population grew by 111 million (a 27% increase), while its rural population contracted by 39 million (a 16% fall). In 2000–2030, the urban population is projected to increase by 24 million (4.7%), while the rural population is expected to decline by 55 million (27%).[9]



Rural population across the world

Africa and Asia are urbanising faster than other regions and are projected to become 56% and 64% urban respectively by 2050.

Source: United Nations

Smart village initiatives around the world

Many initiatives are being implemented worldwide to make villages self-sustainable by using smart technology like ICT and IoT and hence reducing migration towards urban areas. Some of the examples of global smart village initiatives are:

1. The Millennium Villages Project[10]

The Millennium Villages Project involves partnership between academia, civil society, local governments, United Nations agencies and the private sector to achieve the millennium development goals (MDGs). The holistic approach focuses on an integrated package of interventions in agriculture, education, health, roads, power, ICT, water and sanitation, and business development. During the first five years of its operation, the Millennium Villages Project has achieved success by increasing food security, reducing hunger, improving education, decreasing maternal and childhood mortality, improving local infrastructure, and controlling malaria, AIDS and tuberculosis. The Millennium Villages Project currently operates in 14 clusters of villages in 10 countries in sub-Saharan Africa, reaching more than 5,00,000 people. It has demonstrated how ICT and broadband can be used to enhance development through projects ranging from mobile applications for decision-making support in the health sector, to the use of mobile phones for data collection and systems management, to classrooms enabled with innovative technologies. The project, in particular, focuses on using ICT in three crucial areas: strengthening primary health systems though expanded mobile-health services; scaling up access to high-quality secondary education for girls through connectivity at schools; and providing access to renewable energy (electricity) and safe water using smart metering and broadband-enabled systems.

2. Infopoverty Programme by OCCAM[11]

In 2001, the Observatory for Cultural and Audiovisual Communication (OCCAM) launched the Infopoverty Programme, which focuses on creating ICT villages in remote areas and ensuring primary services in food security, e-health and e-learning to the population. The OCCAM programme focus on the following key ICT initiatives to fight against poverty: 1) telemedicine—to provide professional medical services through ICT in cases where access to healthcare is limited; 2) e-learning—to promote remote teaching, making learning interactive not only for primary and secondary schools but also for continuing education; 3) e-agriculture—to promote food security; 4) e-governance—to enhance services related to public administration.

3. Institute of Electrical and Electronics Engineers (IEEE) Smart Village[12]

IEEE is a professional association. IEEE Smart Village stimulates social enterprise by providing renewable electrical systems, start-up training and ongoing support to help poor, energy-deprived communities globally build for sustainable prosperity. IEEE Smart Village empowers off-grid communities through education and the creation of sustainable, affordable and locally owned entrepreneurial energy businesses. IEEE Smart Village already serves more than 50,000 people in 34 villages via pilots in Cameroon, Haiti, India, Kenya, Nigeria and South Sudan. It's a proven model. IEEE Smart Village provides photovoltaic (PV) community charging stations, along with training and support, to local entrepreneurs in off-grid communities, who then lease portable battery kits to homeowners. IEEE Smart Village offers the following programmes: Community Based Education, Vocational Training and SunBlazer II. SunBlazer II, the IEEE Smart Village flagship product, is a modular, easy-to-install PV solar-based community charging station.

Case study:

1. India: IEEE Smart Village co-founder Robin Podmore took the first step in meeting with potential partners, such as the Electrical Research and Development Association (ERDA), a cooperative research institution created by the Indian Electrical Industry and Utilities with the support of Government of India and Gujarat state government. In 2016, IEEE Smart Village expanded its partnership with the Global Himalayan Expedition (GHE).

2. Kenya: The IEEE Smart Village project in Kenya seeks to enable improved living standards by increasing access to electricity to approximately 900 of the world's most underserved people. IEEE Smart Village provides a community charging station at Kristy's Cape Academy, a private primary school from pre-kindergarten through Grade 4, which has no connection to the electric grid. The station will provide much needed electricity to the school and serve as a source of sustainable income.

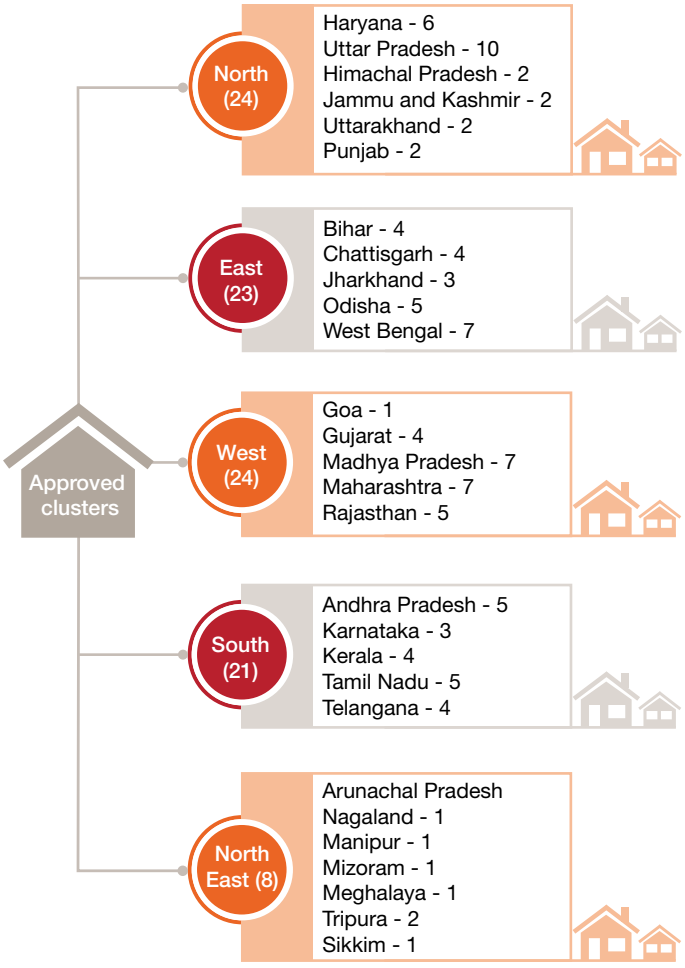
Case study: Terrat Village, Tanzania[13]

For other businesses in Terrat, key improvements include significant cost reductions. For example, grocery shops, bars, hairdressers and tea rooms were previously powered by diesel generators. With electricity from the biodiesel generators, these businesses have reduced their daily electricity costs by up to 95% per day. This has resulted in expansion and diversification involving both capital investment (e.g. in milling and welding machines) and investment in labour (e.g. hiring more staff). Terrat has benefited from significant improvements in education, environmental sustainability, food security, health and general quality of life outcomes. As a result, the youth of Terrat are less inclined to migrate to the city in search of a better life.

Smart village initiatives in India

1. National Rurban Mission (NRuM), Ministry of Rural Development, Government of India

NRuM was launched by the Hon'ble Prime Minister on 21 February 2016. NRuM follows the vision of 'Development of a cluster of villages that preserve and nurture the essence of rural community life with focus on equity and inclusiveness without compromising with the facilities perceived to be essentially urban in nature, thus creating a cluster of "Rurban Villages"'.[14] The objective of NRuM is to stimulate local economic development, enhance basic services and create well-planned Rurban clusters. The larger outcomes envisaged under this mission are: (i) bridging the rural-urban divides—namely economic, technological and those related to facilities and services; (ii) stimulating local economic development with an emphasis on reduction of poverty and unemployment in rural areas; (iii) spreading development in the region; and (iv) attracting investment in rural areas. A Rurban cluster is a cluster of geographically contiguous villages with a population of about 25,000 to 50,000 in plain and coastal areas and a population of 5,000 to 15,000 in desert, hilly or tribal areas.



As far as practicable, clusters of villages will follow the administrative convergence units of gram panchayats and will be within a single block/tehsil for administrative convenience.

Village level – Desirable projects/components:

- Household level:
  - Skill development training linked to economic activates
  - LPG gas connections/smokeless choolhas
  - 24x7 piped water supply
  - Solid waste management
  - Individual toilets
- Village level:
  - Village streets with streetlights and drains

Cluster level – Desirable projects/components:

- Solid waste treatment/vermicomposting for organic farming
- Upgradation of primary
- Secondary and higher secondary schools
- Agro-processing/agri-services (dairy farming, organic farming)
- Inter-village roads/connectivity to the nearest urban centre with public transport
- Fully equipped mobile health unit
- Full digital literacy and e-gram centre

2. Smart Cities Project: 60 Smart Villages in India[15]

Faced with the challenge of transforming rural India, the Centre has selected 60 villages in three districts—Rajgarh, Sehore and Satna—which will be developed as smart villages under the ambitious Smart Cities **(or villages)** project. The government will provide funds for the development of specific aspects of these villages. Under this project, each village will get 25 crore INR. The government will focus on climate change, smart energy, agriculture and water. Smart village development will be brought about in the state in coordination with the Environment Planning and Coordinating Agency (EPCO). The proposal was developed in association with the National Bank for Agriculture and Rural Development (NABARD) and will focus on uplifting rural areas through greater credit flow to give a push to the agriculture and rural non-farm sectors. The duration of the project is three years. Twenty villages have been selected for development in districts tagged as climate-smart villages.

3. Madhya Pradesh: 1,100 'climate-smart' villages[16]

Madhya Pradesh has embarked on an ambitious plan to develop 1,100 'climate-smart' villages with the aim of preparing farmers to manage climate change risks timely and ensuring good productivity. Hundred villages in each of the 11 agro-climatic zones of the state will be taken up under the plan, which will cost about 150 crore INR every year. The focus will be on integrated agriculture, comprising animal husbandry and fisheries, in addition to traditional farming. Agroforestry will also be adopted in these villages. The work is being taken up under the National Agriculture Development

Programme (NADP) and Indian National Mission on Sustainable Agriculture. The Centre has also appointed the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the UN organisation, as the nodal agency for developing climate-smart villages.

4. Maharashtra: 50 smart villages[17]

According to the Chief Minister of Maharashtra, the state will develop 50 smart villages. Harisal village in the Melghat region of Amravati district will be the first smart village. The village is currently known as the malnutrition capital. The purpose behind developing smart villages is to bring financial prosperity to the villages along with better educational and healthcare facilities. These developments will be undertaken with the assistance of Microsoft and will lead to sales and marketing opportunities in these villages. The Government of Maharashtra is emphasising a transparent and efficient administrative mechanism to achieve citizen-centric service delivery through people's participation while designing the governance system.

5. Gujarat: 300 'smart' villages[18]

The Government of Gujarat has decided to make 300 villages across the state self-reliant. The vision adopted by the Gujrat government is on the lines of the smart cities concept and will enable the villages to become clean and hygienic. The government has decided to bring about this transformation in a phased manner, with the first phase involving 300 villages. The state government will provide a special grant to shortlisted villages to implement the development plans proposed by the respective gram panchayats. The villages will be identified by taluka- and district-level committees and will be further shortlisted by the state-level committee consisting of experts on the basis of the gram panchayat's performance. As per the framework, the key evaluation parameters include cleanliness, toilets, drop-out rate in primary schools, anganwadi facilities, malnutrition ratio, vaccination of children and 'Apno Taluko, Vibrant Taluko' (ATVT) services. Throughout this entire process, the Government of Gujrat will keep the 'soul of villages' intact.

6. Andhra Pradesh: Smart Village Smart Ward Programme[19]

As part of Swarnandhra Vision 2029, the state of Andhra Pradesh aspires to be among the best three states in the country by 2022, the best state by 2029 and to be a leading global investment destination by 2050. The focus shall be not only on socioeconomic development but also on the happiness level in society. To realise this vision, the government has adopted a mission-based approach to create the appropriate social and economic infrastructure and has initiated seven missions, five grids and five campaigns to create awareness and seek participation from all stakeholders. The programme focuses on improved resource-use efficiency, empowered local self-governance, assured basic access basic amenities and responsible individual and community behaviour to build a vibrant and happy society with the partnership of individuals, NRIs, elected representatives, corporates and business houses, NGOs, philanthropists etc. The framework of Andhra Smart Villages comprises the following parameters: human development, social development, economic development, environment development and good governance. A smart village/ward encompasses sustainable and inclusive development of all sections of its community, so that they enjoy a high standard of living.

Government schemes to support smart villages

7. Unnat Bharat Abhiyan (UBA)[20]

UBA is a programme by the Ministry of Human Resource Development, Government of India, to uplift rural India. The programme is being launched in collaboration with the Indian Institutes of Technology (IITs), National Institutes of Technology (NITs) and other leading government engineering institutes like the College of Engineering, Pune, across the country. The programme involves engaging with neighbouring communities and using technologies for their upliftment. Vision: To involve professional and other higher educational institutions of the country in the process of indigenous development of self-sufficient and sustainable village clusters in tune with the notion of 'GramSwaraj' propounded by Mahatma Gandhi. It also aims to create a virtuous cycle between society and an inclusive university system by providing knowledge and practices for emerging professions and to upgrade the capabilities of both the public and the private sectors.

8. Pradhanmantri Adarsh Gram Yojana (PMAGY) Model Village[21]

Prior to PMAGY, the Adarsh Gram scheme was implemented in pilot mode in 1,000 villages of Assam, Bihar, Himachal Pradesh, Rajasthan and Tamil Nadu, with an allocation of 20 lakh INR per village. The target villages under the scheme were those with more than 50% of the population belonging to Scheduled Castes (SCs).

Case study: PMAGY Model Village: Punsari village, Gujarat

Located in Gujarat's Sabarkantha district, Punsari village has emerged as a model village with modern urban amenities such as 24X7 power supply, WiFi connectivity, CCTV cameras to ensure security, and pucca roads connecting the village with other villages and towns. Punsari was awarded with Best Gram Panchayat Award by the central and state government in 2011. Other important features of the village include a reverse osmosis plant which supplies 20 litres of water to each household at 4 INR, use of solar power for agricultural purposes, accidental insurance cover to one member of every household, air-conditioned primary schools with no dropouts, bus facility for all households, and focus on behavioural change through campaigns and awareness drives. For the last purpose, 120 loudspeakers have been installed in different parts of the village.

9. Sansad Adarsh Gram Yojana (SAGY)

The Central Government's SAGY initiative aims to involve MPs more directly in the development of model villages. By adopting a village(s) under this initiative, an MP has the opportunity to directly benefit all sections of a village community in an integrated, efficient and participatory fashion.

Roles of various entities in SAGY: Role of an MP – The primary roles and responsibilities of an MP under SAGY are identifying the gram panchayat, facilitating the planning process, mobilising additional resources as and when required under the plan and filling in critical gaps using Members of Parliament Local Area Development Scheme (MPLADS) funds. Two national-level committees will monitor the implementation of the scheme: One committee will be headed by the Rural Development Minister and include the ministers in charge of planning and programme implementation. The second committee will be headed by the Secretary, Rural Development, with representatives from various other ministries/departments relevant to SAGY. The state-level committee will be headed by the State Chief Secretary and include experts from various disciplines. The Secretary of the State Rural Development Department will serve as the member-convenor of this Committee.

10. MPLADS[22]

MPLADS was introduced in December 1993. The objective is to enable Members of Parliament (MPs) to suggest and execute developmental works of capital nature based on local needs, with an emphasis on the creation of durable assets. Under this scheme, each elected member of the Lok Sabha suggests developmental works in his constituency. The elected members of Rajya Sabha can recommend works in any district of her or his state. Nominated members of the Lok Sabha and Rajya Sabha may also select works for implementation in one or more districts anywhere in the country.

Rural metamorphosis

Rural development remains an important issue in discussions pertaining to economic growth. Villages are becoming an increasingly important part of urban growth. They have different cultures and responsibilities, which are driven, to a large extent, by day-to-day necessities like water and hygiene which pose different risks. For many village institutions, this is the time to define or shape an independent strategy that will enable them to become a part of future urban growth. This process of transforming into smart villages is can be referred to as a metamorphosis. Merriam Webster defines this term as '…a change of physical form, structure or substance especially by supernatural means or **a striking alteration in appearance, character, or circumstances'.**

The above definition is the most relevant in the context of rural development as villages need to transform in terms of the following aspects: **Appearance** by means of infrastructure development, **character** by building newer forms of businesses, and **circumstances** by changing lifestyles and the facilities available to each resident.

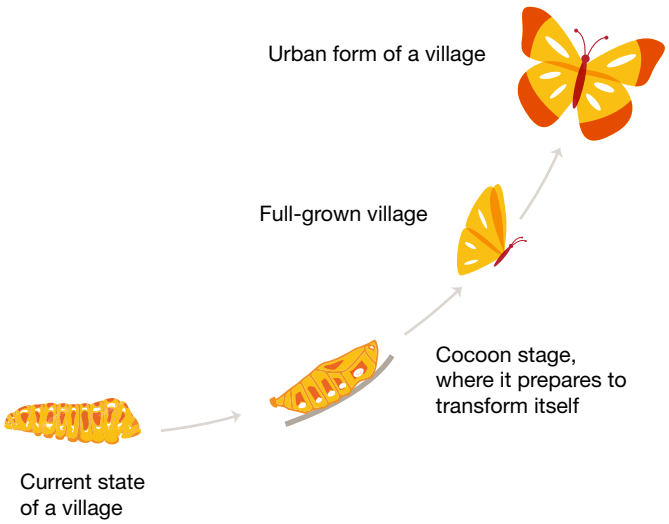
While ensuring development and capturing several of the benefits of urban living, smart villages must focus on retaining some traditional features of rural life. This will empower villagers to enjoy healthy and happy lives, find sustainable means of living and connect to communities globally. These factors will give them the freedom to choose between the traditional journey of a city or happy life in a smart village.

The transformation of villages into smart villages that are ready and prepared as future cities is a huge and remarkable journey and hence we are calling it a metamorphosis.

The transformation process encompasses a cocoon or evolution phase, where smart solutions like basic necessities, future planning, capacity building and citizen awareness need to be considered.

The cocoon (generically referred to as a pupa) stage is not a dormant one, as many people think. On the contrary, it is during this phase that the pupa undergoes significant change—the caterpillar starts to transforms physically into an adult butterfly! During this stage, wings and antennae fully form and the chewing mouthparts of the caterpillar transform into the sucking mouthparts of the butterfly.

The metamorphosis of a village into its urban form



The journey to becoming smart

The situations and challenges involved in developing urban areas—for instance, population, landscaping, and economic activities—are different from those in the case of rural areas. Many researchers believe that the technologies developed for smart cities, such as smart water solutions, smart bus transport and smart energy solutions, may be useful for smart villages as well. Researchers also reported that the smart village system can be developed along the lines of a smart city model.[23] Issues related to physical infrastructure, social life, environmental issues and governance can be resolved using different parameters and solutions which can be accessed through ICT and IoT. However, the solutions (components) will vary from region to region for villages, based on the available resources and opportunities. The following are some general guidelines for the development of smart villages.

Physical infrastructure

Addresses issues related to physical infrastructure of villages like smart roads, walkways, street lights, community gardens, government buildings and community spaces.

Social

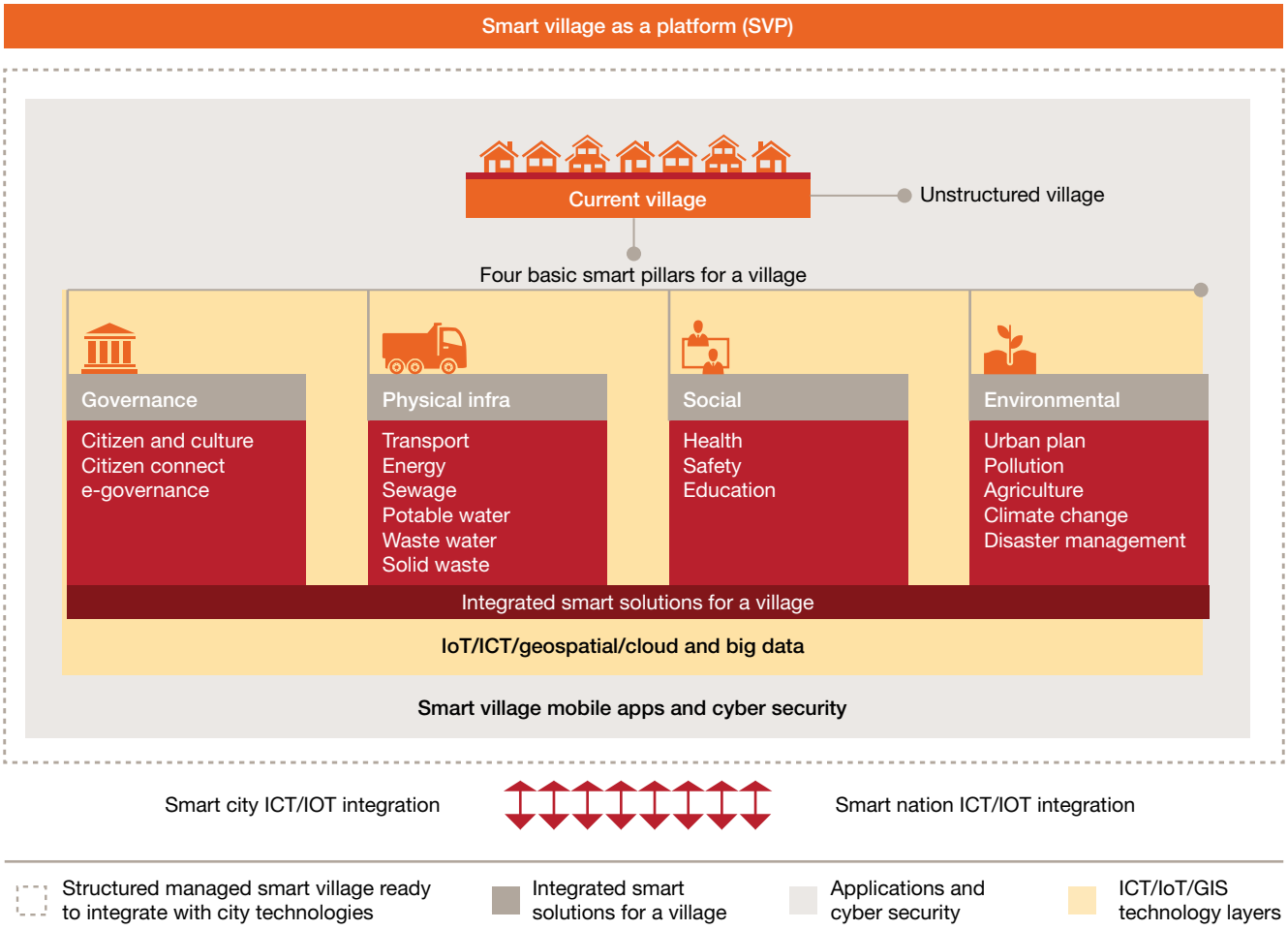
Addresses issues related to community life, social equality, social innovation, proximity services, etc.

Environmental

Addresses issues related to resources and infrastructure available at the local level, covering cleaner technologies, public and private transportation, green cover and green spaces, climate change, alternative energy, etc.

Governance

Addresses local administration and economic factors, including management of governance models, bandwidth, mobility, cloud computing and entrepreneurship



As the above figure indicates, the transformation of an unstructured village into a smart village is centred around these four smart pillars. ICT and GIS technology components rest on these pillars, and these components in turn are the base for the layers of smart solutions. These solutions are embedded within a secure and safe layer and integrated with smart city interfaces. Smart solutions such as smart agriculture, smart health, smart education, smart transport, smart networking and smart access to these solutions are implemented by providing smart and secure mobile apps and a high level of security for data and cashless transactions.

Further, smart solutions are being expanded and integrated with smart city applications and vice versa. A few smart solutions which are useful for the development of smart villages are discussed below.

Smart village as a platform (SVP)

The model for smart villages will comprise interconnected smart solutions in infrastructure as well as ICT. The purpose of the ICT platform is to draw villagers into the management process, both individually and collectively, in order to enhance citizen awareness, implement e-governance for administration transparency, and increase employment through smart ICT and non-ICT solutions in order to upgrade the standard of living and day-to-day activities to a level that is on par with that of urban dwellers.

Forecasted technologies in SVP

IoT and ICT play a very important role in making villages smart.

1. IoT:

'The IoT describes a worldwide network of billions or trillions of objects that can be collected from the worldwide physical environment, propagated via the Internet, and transmitted to end-users. Services are available for users to interact with these smart objects over the Internet, query their states, as well as their associated information, and even control their actions.'[24] IoT paves the way for a smart world by connecting everything. IoT is 'a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network.'[25]

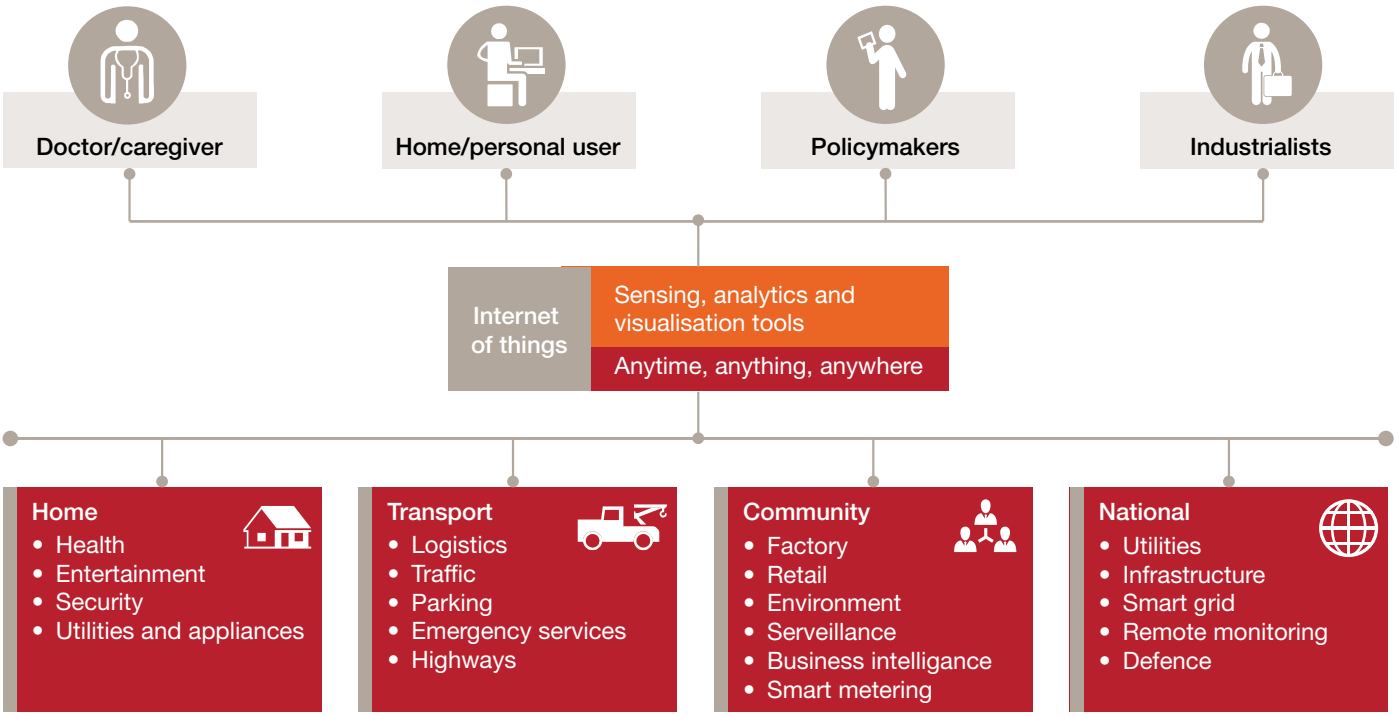
2. ICT

ICT is technology that supports activities involving information. Such activities include gathering, processing, storing and presenting data. Increasingly, these activities also involve collaboration and communication. Hence, IT has become ICT or information and communication technology.[26]

IoT is the latest communications technology, and is the force behind the concept of smart cities and smart villages.

IoT objects or entities are connected by a wireless network and embedded with smart decision-making mechanisms. For instance, intelligent waste bins which have bin-level sensors can detect the level of load and allow truck route optimisation, reduce the cost of collection of waste and improve the quality of recycling. For the successful implementation of such a smart waste management service, IoT will need to connect the end devices, i.e. intelligent waste bins, to a control centre where software can process the data and determine the most efficient way of managing the truck fleet.

For the smooth functioning of the entire SVP or system, interaction and coordination needs to take place in a smart way.



A schematic representation of end users and application areas

IoT technologies that can be used in SVPs:

- **RFID:** Radio frequency identification (RFID) assigns identifiable tags to various objects and devices. These tags transmit information which is read by an RFID reader and then used as per the requirements. RFID tags can be attached to physical items and used to convert these to elementary general networked systems. An RFID system can also be seen as a distributed database or even a network of distributed tagged objects (IoT). Furthermore, an RFID system is just a reader and a tag communicating over the air at a certain frequency and comprises readers, antennae and tags. An RFID solution uses a radio frequency (RF) signal to broadcast the data captured and maintained in an RFID chip. For example, RFID tags can be used on waste bins to detect information related to that bin, when that bin is emptied, size and location, etc.
- **3S:** The 3S technology consists of a global position system (GPS), geography information system (GIS) and remote sense (RS), which provide details on the whereabouts of different objects using sensors, satellites, etc., and processes that information. Sustainable development, functional methodology and transverse dissemination of population into rural and urban areas are the need of the hour. Geospatial data and GIS are indispensable components for the construction of smart villages, which entails the mapping of the physical realm into virtual settings. Creation and visualisation of alternative scenarios are possible through GIS-based planning. This helps in determining their possible impacts on future population and land use layer and superimposing employment records layer and economic activities layer.

- **WSN and cloud computing:** A wireless sensor network (WSN) is used to transmit information in IoT. It consists of a network and resources for data storage and computation which are provided by cloud services (location independent). These services can be very easily provisioned for the area where they are required. Sensors comprise an integrated wireless transceiver and have a memory, CPU and battery. However, they have limitations in terms of energy, computation, storage, transmission range and bandwidth. The above characteristics define their functionality, use and cost. A typical WSN system/network consists of numerous sensor nodes (typically hundreds of thousands) which are responsible for collecting information about the environment and sending it to a sink node, which receives the information gathered by the network and delivers it to the WSN end user. WSNs are deployed and used across a variety of applications, including physical security for military operations, indoor/outdoor environmental monitoring, seismic and structural monitoring, industrial robotics, bio-medical applications, health and wellness monitoring, inventory location awareness and upcoming consumer applications.

Technology development and better connectivity with the rest of the world lead to improvements in the lives of villagers. However, their lives can be made even better using IoT SVPs.

Issues in villages

The initial step in designing an SVP will be the discovery of all interconnected objects like sensors, tags, surveillance cameras and communication devices such as emergency push buttons for disaster. Data collected and sent by devices will transmitted through the Internet, stored and processed on the cloud and analysed using the finest big data analytics tools. The objective is to establish smart villages by developing smart village homes, weather systems, education, governance, sanitation and safe water, healthcare systems, surveillance systems and agriculture.

A critical obstacle is that decision-making powers are spread across multiple stakeholders. A possible way to solve this problem is to institutionalise the entire process of resolution and implementation and move the strategic design and administration of smart villages to a single department in each village district.

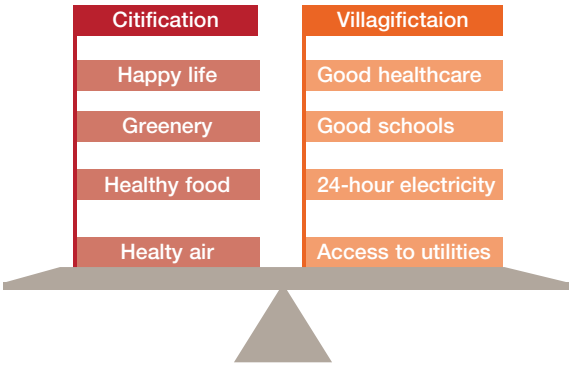
On the technical side, there is an absence of high-end technologies in villages. In this respect, IoT can become the building block to realise a unified village-scale ICT platform.

Finally, with reference to finances, a clear business model is lacking as very few initiatives are undertaken by the public and private sector. IoT integrates various devices equipped with sensing, identification, processing, communication and networking capabilities into a cyber-physical system.

Many cities around the globe have transformed themselves into smart cities. The need of the hour is to upgrade our villages so that villagers who are potential migrants to urban areas do not leave. The optimal use of existing resources and ever-increasing population has strained resources and their utilisation. IoT consolidates various smart technologies. This model of intelligent devices can be extended to villages in order to improve the quality of life of villagers. As villages have slightly different requirements than cities, this paper focuses on those differences and aims to provide relevant solutions.

Adoption of ICT and IoT solutions for transformation of villages to smart villages

'Citification' and 'villagification' are terms used to refer to urban and rural transformation. Villagers need to adopt smart solutions to advance their living standards and city dwellers need to focus on leading healthy lives, breathing clean air and eating nutritious food. Like their rural counterparts, people in cities should also explore farms, eat organic food and celebrate festivals.



For a balance between urban and rural lifestyles, there needs to be a focus on bringing the two to the same level. This will give people the option of living as both a city or village dweller and enjoying the same lifestyle regardless of where they live. Sustaining the equilibrium between the development of rural and urban areas is essential as it will play a vital role and eventually help to curb the movement of rural population into urban areas.

Ground-level dispersion of ICT solutions is an elementary requirement towards the development of a village into a smart village. To that end, there must be a focus on the advancement of villages by encouraging the rural population to accomplish self-sustainability. Smart villages will be connected to towns and cities through ICT.

Together with smart cities, smart villages will serve as complementary engines of economic growth, producing goods and services for local rural markets as well as high value-added agricultural and rural industry products for both national and international markets. They will also act as stewards for the environment and, in some cases, function as ecotourism hubs.[27] The rural population comprises a significant part of the total population of a farming-based economy like India. The life of people in villages is typically tougher compared to their city counterparts. There is a dire need to work towards the development of villages along with improving life in cities. Certain elements of smart cities can be directly implemented in villages—for example, the use of cameras and sensors on streets for surveillance and sensors for healthcare. On the other hand, there are certain sectors like agriculture and cattle/livestock rearing which need better ideas for smart working.[28]

ICT has proven potential in many sectors of urban development. As a result, cities are becoming smart and more motivated to implement ICT and improve their infrastructure. The same fundamentals of ICT are applicable to villages, which in turn can make villages more liveable in terms of education, employment opportunities, water supply, healthy lifestyle and housing, thus reducing the migration of village population to urban areas for employment, lowering the burden on urban infrastructure and, at the same time, preparing for the inclusion of villagers within urban limits.

Two key streams of transformations are envisaged for this revolution. One is the development of infrastructure which can connect urban areas to rural areas and by which transportation of goods and material from one place to another is made easy. The second is ICT and IoT technology with which faster networking with the whole world is possible at the touch of a finger. However, the circumstances and challenges involved in developing urban and rural areas are very different. Smart villages will help India become a smart nation. The platform for smart villages needs to be in sync with today's smart cities so that tomorrow's smart villages can easily adopt the changes. In contrast to cities, it will be an easy task to transform villages to 'smart villages' because of the ease of citizen engagement, as the rural population is lower than that of urban areas. Moreover, alteration or modification of infrastructure is easy to carry out, abundant unused land is available for future planning and enhanced standardisation is possible as on-ground realities are very minimal

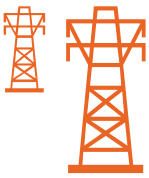
The following are some prospective areas where smart villages will have a measurable and significant impact:

Smart school initiatives in villages can be on an equal footing with their counterparts in modern urban schools.

Newer means of education such as **smart classrooms** connect students in villages to educational institutions around the world. By incorporating insights from sociological and behavioural studies, ICT and IoT technologies can be used to convert a regular tutorial room into a smart classroom that dynamically connects students and analyses conversations, actions, behaviours, etc. This will help in ensuring effective learning and have a positive impact on students as well as their tutors.

Villages can also focus on the development of smart healthcare. This will give villagers easy access to basic healthcare facilities. Further, smart jobs in the healthcare sector can also be created by digitisation and web connectivity. **Smart healthcare** is a suite of ICT services that connects healthcare and computing, enabling the provision of intelligent, data-driven medical services. This enables users to increase their awareness of health-related risks and reduce healthcare costs by efficiently assembling, recording, analysing and sharing big data streams in real time. With the help of IoT technology, both patients and doctors can save time. Doctors can also tend to emergencies quickly, thus reducing the movement of people from villages to cities for high-tech healthcare facilities.

Health initiatives will enable remote health diagnostic solutions and provide access to specialist healthcare.



The key enabler of development in smart villages is sustainable access to smart utilities such as smart electricity, which connects ICT/IoT solutions to other utilities like water, waste water and pipe gas.

Smart utilities, driven by smart technologies, can unify villages by interlocking technologies to give villagers better and healthier lives. **Smart energy** systems give access to all modern ICT/IoT technologies, with no power cuts and 24x7 electricity. **Smart water systems** give 24x7 access to clean and safe potable water through smart metering and supervisory control and data acquisition (SCADA). This is also one of the ways in which surface and groundwater can be effectively utilised. **Smart drainage** ensures drains do not overflow and keeps them clean and free of clogging through ICT technology. Further, smart equipment like mobile toilets may be also be adopted in rural areas to promote disease-free villages, leading to smart sanitation.

Currently, smart urban planning/organised village planning in village communities is scattered. The rise in unplanned settlements may lead to congestion in the future, which is common in cities. To solve this problem, every village needs to have a proper land use plan or a defined, structured pattern for land use growth before it starts growing. Further, specific zones need to be created for education, health and economic activities. Planned development encourages growth in rural areas as it allows businesses to succeed on walkable streets and homes to be close to employees' daily workplaces. Policies for protection of the rural landscape help in preserving open spaces, and preserving air and drinking water quality.

Smart planning strategies can help villages achieve their goals for development and growth while maintaining their distinct rural character.

Smart farming represents the application of modern ICT and GIS technologies in agriculture, leading to a green revolution.

Using sensor-based technology, **smart agriculture** increases the quality and quantity of agricultural production by making farms and farmers more intelligent. Smart farming enables better decision making or more efficient operations and management. Management information systems (MIS), i.e. collecting, processing, storing and disseminating data in the form needed to carry out a farm's operations and functions, are called intentional systems. These MIS are used to predict the patterns and analyse the data to project scenarios which could be useful for farming. Precision agriculture refers to whole farm management with the goal of optimising returns on inputs while preserving resources. It is supported by the widespread use of GPS, light detection and ranging (LiDAR) mapping and aerial images by drones, allowing the creation of maps of the spatial variability of as many factors as can be measured (e.g. terrain features/topography, soil contents, organic matter content, moisture levels, crop yield). Further, agricultural automation and robotics include the application of robotics, automatic control and artificial intelligence techniques at all levels of agricultural production.

Smart transport forecasts demand and supply data and feeds it into transportation planning, thus improving the reliability of the public transportation network by providing visibility on passenger information.

Villagers are easily affected by natural disasters due to lack of preparedness. **Disaster management (DM)** centres can be set up at the village level to address all disaster-related issues. DM cells will also connect to the national level through the central server for monitoring future scenarios.

Village transport or transportation to nearby cities plays an important role in the quality of life of citizens in villages.

Way forward: Villages as mini urban butterflies

Today, there is no doubt that villages need to become smart. The biggest challenge facing all developing countries is making existing technologies accessible to villages through different schemes and activities. These schemes often fail due to lack of strategy, planning and implementation. The smart city ecosystem of a village needs to be established while taking into account the location and investment climate for emerging growth approaches for smart villages. This model should be easy to replicate and should be sustainable for millions of small villages and towns around the world.

By means of smart solutions like solar energy produced and used locally, villages can move to the next level of development. SVPs can reduce the dependence on fossil fuels and contribute to the reduction of greenhouse gases such as carbon dioxide. This will optimise energy saving by 25–30%. E-learning facilities will allow farmers to ask questions on farming and organic ways to cultivate crops online. Making villages self-sustainable could create employment in villages, thus reducing migration to nearby urban areas.

Funds under the existing schemes and across different sectors (health, education, skill development, livelihood, etc.) can be utilised based on the specific demands of a village, after which resources may be channelised into the development of the village.

- Some important Centrally Sponsored Schemes (CSS) may also be utilised for the building of high-quality, sustainable assets such as school buildings, hospitals, road construction, toilets in schools and homes.
- Corporate social responsibility (CSR) funds, of which a much larger corpus is available after the latest amendment to the Companies Act, 2013, may also be used for the purpose of ICT development in villages.
- Self-help groups and gram panchayats can also raise loans, provided they are legally permitted to do so under the state panchayati raj acts.

IoT technologies are close to being standardised and industry players are already producing devices that leverage these technologies in relevant sectors, such as smart water, smart education and smart agriculture.

Many cities around the globe have turned themselves into smart cities. However, the need of the hour is to upgrade our villages in order to accommodate villagers who are potential migrants to urban areas. The optimal use of existing resources and ever-increasing population have imposed restraints on resources and their usage. IoT firms that use various smart technologies in cities can extend their use to villages in order to improve the quality of life of villagers.

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