# Rural Smart Village based on the Internet of Things using Cloud Data analytics

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**Abstract: The Internet of Things (IoT) shall be able to incorporate transparently and seamlessly a large number of heterogeneous end systems, while providing open access to selected subsets of data for the development of a plethora of digital services. This project aims at designing and executing the advanced development in automation of smart villages. Building a general architecture for the IoT is hence a very complex task, mainly because of the extremely large variety of devices, link layer technologies, and services that may be involved in such a system. In this paper, we focus specifically to rural IoT systems that, while still being quite a broad category, are characterized by their specific application domain. Rural IoT's, in fact, are designed to support the smart village vision, which aims at exploiting the most advanced communication technologies to support added-value services for the administration of the village and for the citizens. This project hence provides advancements and automation in noise monitoring, village energy consumption, smart lighting and environmental monitoring by enabling technologies, protocols, and architecture for an rural IoT. Furthermore, the project will present and discuss the technical solutions and best-practice guidelines to the smart village project.**

**Keywords: IoT, Smart Village, Protocols, Cloud, Energy Consumption, Noise, Environment, Monitoring.**

## I. INTRODUCTION

The Internet of Things (IoT) paradigm promises to connect billions of devices to the Internet. This paradigm covers a large number of topics from purely technical issues (e.g. routing protocols, semantic queries), to a mix of technical and societal issues (security, privacy, usability), as well as social and business themes. IoT applications, both existing and potential, are equally diverse. If we are to summarize all of them into one, then it's enabling the machine perception of the real world and seamless interactions with it. Environmental and personal health monitoring, monitoring and control of industrial processes including agriculture, smart spaces and smart cities are just some of the examples of IoT applications. The IoT is expected to integrate heterogeneous data sources such as sensors[6] and sensor networks (for instance, power grids), smart mobile devices, and social media (Twitter, Facebook, and so on) to make the aforementioned application domains "smarter." Cloud computing is already becoming the de facto platform for hosting and processing the big data these sources generates.

To design robust applications, developers need appropriate tools and methods for testing and managing [8]their applications on real hardware in large-scale deployments. In the early days of IoT research, the availability of smart devices was limited and only recent advances in technology increased their availability at lower costs. Although experiments were mainly small-scale and conducted in research labs, they allowed for an improvement in understanding the impact and limitations of real hardware[7] on performance of protocols and design choices. However, the daunting logistical challenge of experimenting with thousands of small battery-powered nodes is the key factor that has greatly limited the development of this field.

Overcoming the technical challenges and socio-economic barriers of a wide-scale IoT [2]deployment in our daily lives requires a thorough, practical evaluation of IoT[1] solutions using interdisciplinary, multi-technology, large-scale, and realistic testbeds. The ability to test IoT solutions on a larger scale and outside of research labs, i.e., in real environments and with real end users has been considered only recently. These new testbeds aim to design and deploy experimentation environments that will allow for i) the technical evaluation of IoT[12] solutions under realistic conditions, ii) the assessment of the social acceptance of new IoT solutions, and iii) the quantification of service usability and performance with end users in the loop.

The objective of this paper is to discuss a general reference framework for the design of an rural IoT. We describe the specific characteristics of a rural IoT, and the services that may drive the adoption of rural IoT by local governments. We then overview the web-based approach[13] for the design of IoT services, and the related protocols and technologies, discussing their suitability for the smart village environment. Finally, we substantiate the discussion by reporting our experience in the "Gudlavalleru Smart Village" project, which is a proof-of-concept deployment of an IoT in the village of gudlavalleru (Andhra Pradesh) and interconnected with the data network of the village panchayati. In this regard, we describe the technical solutions adopted for the realization of the IoT village and report some of the measurements that have been collected by the system in its first operational days.

## II. MOTIVATION

IoT develops high quality voluntary International Standards that facilitate international exchange of goods and services, support sustainable and equitable economic growth, promote innovation and protect health, safety and the environment. a new concept and a new model, which applies the new generation of information technologies, such as the internet of things, cloud computing, big data and space/geographical information integration, to facilitate the planning, construction, management and smart services of villages. Developing Smart cities / villages can benefit synchronized development, industrialization, informationization, and agricultural modernization and sustainability of cities / villages development. The main target for developing smart villages is to pursue convenience of the public services, delicacy of village management, liveability of living environment, smartness of infrastructures, long-term effectiveness of network security. A smart sustainable village is an innovative village that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of rural operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.

- Rural development is a national necessity and has considerable importance in India because of the following reasons.
- About three-fourth of India's population live in rural areas, thus rural development is needed to develop nation as whole.
- Provision of basic infrastructure facilities in the rural areas e.g. schools, health facilities, roads, drinking water, electrification etc.
- Provision of social services like health and education for socio-economic development.
- Increase in industrial population can be justified only in rural population’s motivation and increasing the purchasing power to buy industrial goods.
- The main objective of the rural development programme is to raise the economic and social level of the rural people.

## III. RELATED WORK

Rural development has always been an important issue in all discussions pertaining to economic development, especially of developing countries, throughout the world. In the developing countries and some formerly communist societies, rural mass comprise a substantial majority of the population. Over 3.5 billion people live in the Asia and Pacific region and some 63% of them in rural areas. Although millions of rural people have escaped poverty as a result of rural development in many Asian countries, a large majority of rural people continue to suffer from persistent poverty. The socio-economic[5] disparities between rural and urban areas are widening and creating tremendous pressure on the social and economic fabric of many developing Asian economies.

### 3.1 Smart Village Concept and Services

The Smart village is a key to service sectors, such as Smart Governance, Smart Mobility, Smart Utilities, Smart Buildings and Smart Environment. These sectors have also been considered in the gudlavalleru smart village project to define a ranking criterion that can be used to assess the level of “smartness” of Gudlavalleru village. On the technical side, the most relevant issue consists in the non interoperability of the heterogeneous technologies currently used in city and rural developments. In this respect, the IoT vision can become the building block to realize a unified rural scale ICT platform[12], thus unleashing the potential of the Smart village vision.

#### 3.1.1 City Energy Consumption

A rural IoT may provide a service to monitor the energy consumption of the whole village, thus enabling authorities and citizens to get a clear and detailed view of the amount of energy required by the different services (public lighting, transportation, traffic lights, control cameras, and so on). In turn, this will make it possible to identify the main energy consumption sources and to set priorities in order to optimize their behavior. In order to obtain such a service, power draw monitoring devices must be integrated with the power grid in the villages. In addition, it will also be possible to enhance these services with active functionalities to control local power production structures.

#### 3.1.2 Smart Lighting

In order to support the optimization of the street lighting efficiency is an important feature. In particular, this service can optimize the street lamp intensity according to the time of the day, the weather condition in presence of people. In order to properly work, such a service needs to include the street lights into the Smart village infrastructure. It is also possible to exploit the increased number of connected spots to provide WiFi connection to villagers. In addition, a fault detection system will be easily realized on top of the street light controllers.

**3.1.3 Environmental Monitoring** (Temperature, Humidity, air quality)

Temperature, Humidity and some gases sensed data will be stored in cloud and it can be monitored by accessing Internet. The air quality targets for 20% reduction in green house gas emissions by 2020 compared with 1990 levels, a 20% cut in energy consumption through improved energy efficiency by 2020, and a 20% increase in the use of renewable energy by 2020. Communication facilities can be provided to running devices be connected to the infrastructure. In such away, people can always finds the healthiest path for outdoor activities and can be continuously connected to their preferred personal training application. The realization of such a service requires that air quality and pollution sensors be deployed across the village and that the sensor data be made publicly available to citizens

## IV. SMART VILLAGE ARCHITECTURE REFERENCE MODEL (SVARM)

From the analysis of the services described in Section II, it clearly emerges that most Smart Village services are based on a centralized architecture, where a dense and heterogeneous set of peripheral devices deployed over the rural area generate different types of data that are then delivered through suitable communication technologies to a control center, where data storage and processing are performed. A primary characteristic of a rural IoT infrastructure, hence, is its capability of integrating different technologies with the existing communication infrastructures in order to support a progressive evolution of the IoT, with the interconnection of other devices and the realization of novel functionalities and services. Another fundamental aspect is the necessity to make (part of) the data collected by the rural IoT easily accessible by authorities and citizens, to increase the responsiveness of authorities to village problems, and to promote the awareness and the participation of citizens in public matters.

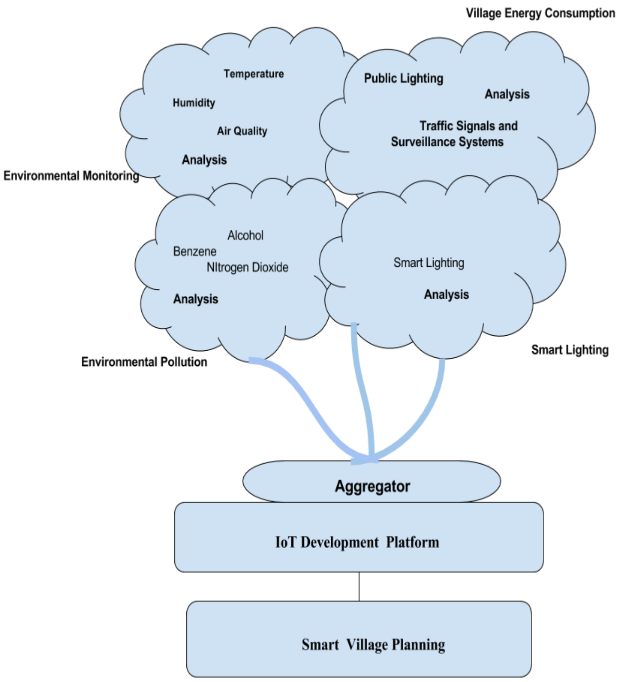


Figure 1: Generic Smart Village Architecture

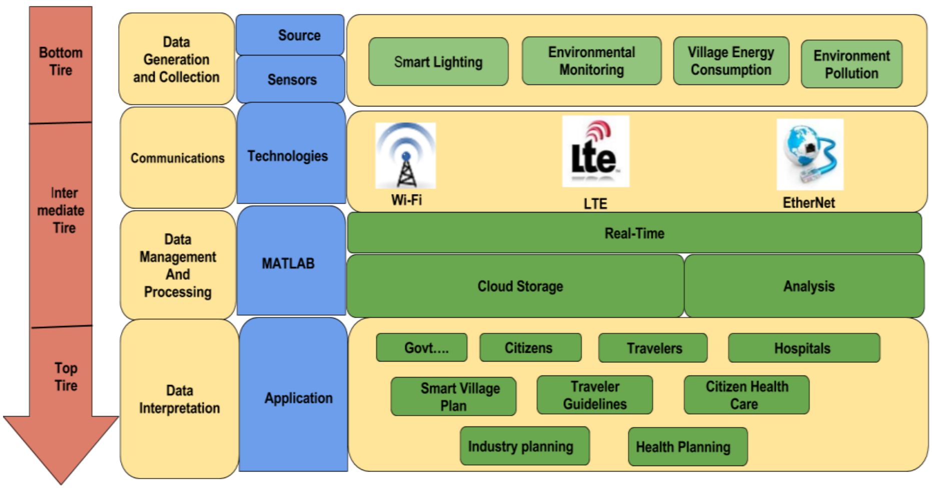


Figure 2: Smart Village Architecture Reference Model (SVARM)

Based on the needs of the smart village and rural planning, we propose 3-tier architecture to analyze IoT data to establish smart villages. The complete architecture is shown in Fig. The 1st tier is the bottom tier, then second one intermediate tier, and finally the top tier. The functionality of each tier is described below.

**Tier I: Bottom tier**

This layer handles data generation through various IoT sources and then collects and aggregates that data. Because many IoT sensors participate in the generation of data, there is a significant amount of heterogeneous data produced with varying formats, a different point of origin and periodicity. Moreover, various data have security, privacy, and quality requirements.

**Tier II. Intermediate tier**

This tier is responsible for the communication between sensors and from sensors to relay nodes through WiFi technology, and relies on gateway or base station and then on the Internet using various communication technologies, such as Wi-Fi, LTE, Ethernet, and etc. This layer is the main layer of the entire analytical system and is responsible for data processing means that the sensor will collect the information from existing environment that data will be directly send to Cloud storage. From the cloud data the user will perform analysis for the management of information and processing.

**Tire III. Top Tier**

The last layer is the interpretation layer, which is the usage of the results of analyzed data and the generation of reports. Here, the generator results are announced and used for many applications, such as smart village planning, Travelling, Industry planning, Citizen health care, Hospitals, Travelling guide lines, Health planning and etc. We also designed an implementation model of the system that outlines the complete details of all the steps performed while implementing the system. Initially, every system generates their data, such as Smart Lighting, Village Energy Consumption, Environmental Monitoring, and Environmental Pollution and so on. In every system, there is a relay node that is responsible for collection of data from all the sensors in the system. It uses WiFi technology to communicate with the sensors. The relay handles collecting data from all sensors and then sends the data to the analytical system through the Internet. To perform the feasibility study and understand the importance of the system, a detailed analysis is performed on various IoT datasets. The analysis is performed to show that how a smart village can be built by using the proposed system, how the deployment of sensors matters for building a smart village.

**Case study: SVARM (Smart Village Architecture Reference Model)**

Integrated environmental monitoring and management based on IoT is an enduring and active topic, not only for the scientists and engineers, but also for the public and the administrators, and it covers broad issues and involves many technologies in the Computer and information sciences. In this section, existing environmental monitoring, smart lighting and energy consumption management issues are discussed with a focus on SVARM, as well as with IoT technology.

SVARM based on IoT has broad scenario in both scientific and industrial areas, as SVARM are not only good solutions but also integrated platforms for complex tasks, and the features of IoT are exactly suitable for data collection and processing in the perception layer of reference model. Among the application fields where SVARM and IoT solutions can provide competitive advantages and play important roles, environmental monitoring and management would be one of the most representative areas. This paper focuses on the integration of key technologies from IoT in typical environmental monitoring ,smart lighting and energy consumption management task, taking the regional climate change (i.e., air temperature ,humidity and variety of gases) and its ecological responses .

**Study Area:**

The paper focuses on development of Rural Smart Village, which is located in gudlavalleru near to Gudivada.The natural environment in this region is exposed and sensitive to climate change, human activities and the temporal and spatial facts of climate change over the past decades and its ecological responses has been discussed in existing literature.Climatic conditions are decisive factors for restricting the sustainable development in gudlavalleru rural smart village, so understanding the intensity of climate change and its ecological responses is very important for the regional sustainable development in the respective area.

**Data Collection:**

In order to analyze and present the climate change and its ecological responses in the study area[12], multisource datasets were collected from sensors and Web services based on IoT. The information will be collected from past 6 months and take the reading for every 15 seconds in a day from instruments and sensors distributed in the study area(gudlavalleru). The collected information from the sensor will be stored securely in Thing speak cloud storage provider.

**Models and Tools:**

We are using Thing Speak for enables sensors, instruments, and websites to send data to the cloud to store in a channel. Once data is in a Thing Speak channel, you can analyze and visualize it, calculate new data, or interact with social media, web services, and other devices. Thing Speak requires a user account and a channel. A channel is where you send data and where Thing Speak stores data. Each channel has up to 8 data fields, location fields, and a status field. And every channel having their own channel Id and API keys for unique identification. And possible operations with thing speak is Create / list / view / update / delete.

You can send data every 15 seconds to Thing Speak, but most applications work well every minute. Thingspeak can be integrate with, Arduino, Raspberry Pi, ioBridge/ RealTimeio, Electric Imp, Mobile / Web Applications, Social Networks and Data Analytics with MATLAB.

Storing data in the cloud provides easy access to your data. Using online analytical tools, you can explore and visualize data. You can discover relationships, patterns, and trends in data. You can calculate new data. And you can visualize it in plots, charts, and gauges.

Thing Speak provides access to MATLAB to help you make sense of data. You can:

- Convert, combine, and calculate new data
- Schedule calculations to run at certain times
- Visually understand relationships in data using built-in plotting functions
- Combine data from multiple channels to build a more sophisticated analysis

**Experimental Results:**

**Environmental Monitoring**

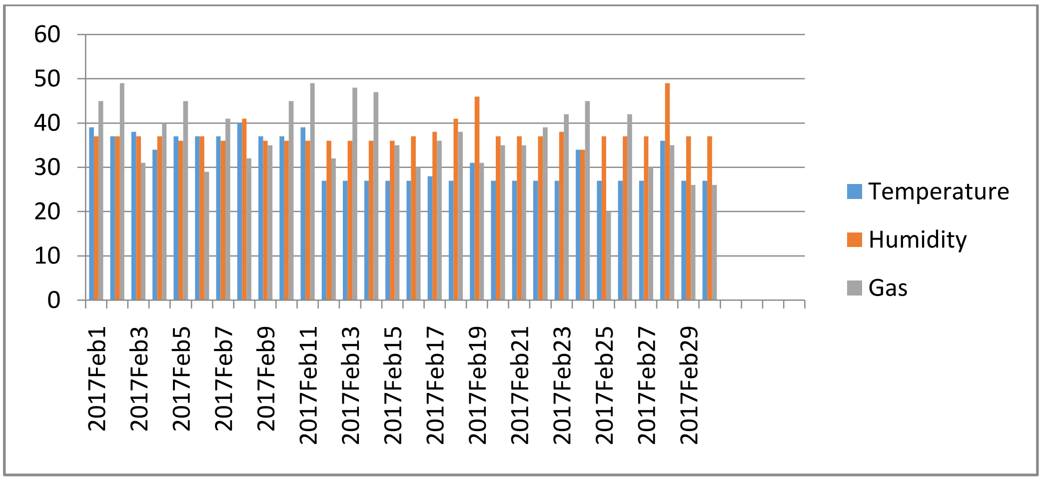


Figure 3: Readings of Temperature, Humidity and Gasses in February 2017.

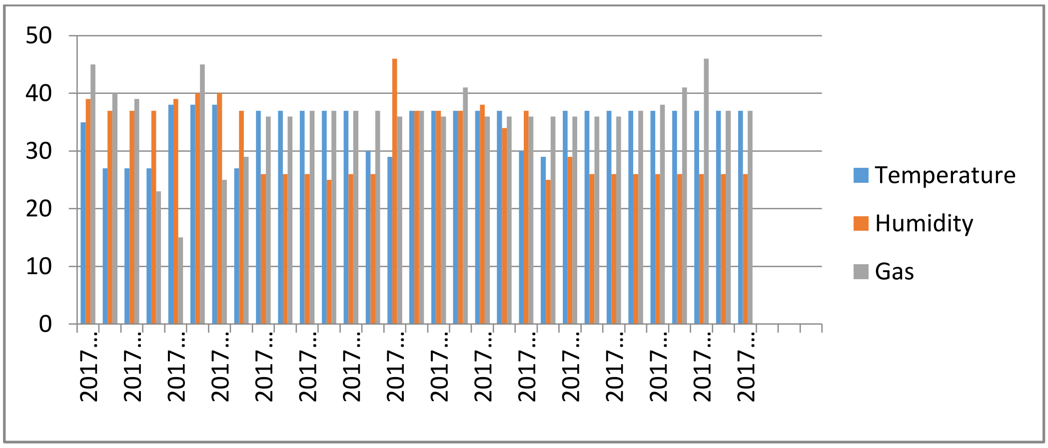


Figure 4: Readings of Temperature, Humidity and Gasses in March 2017.

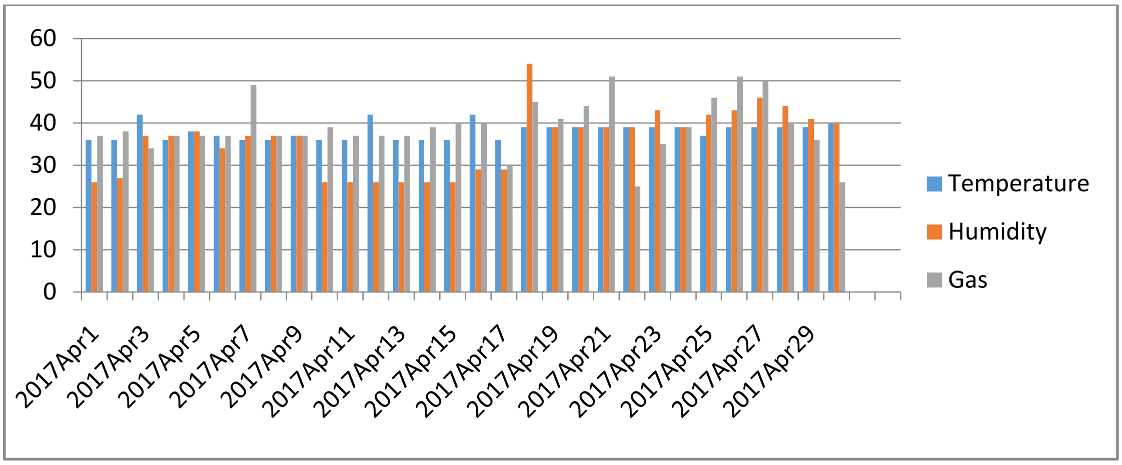


Figure 5:Readings of Temperature, Humidity and Gasses in April 2017.

**Smart Lighting and Energy Consumption:**

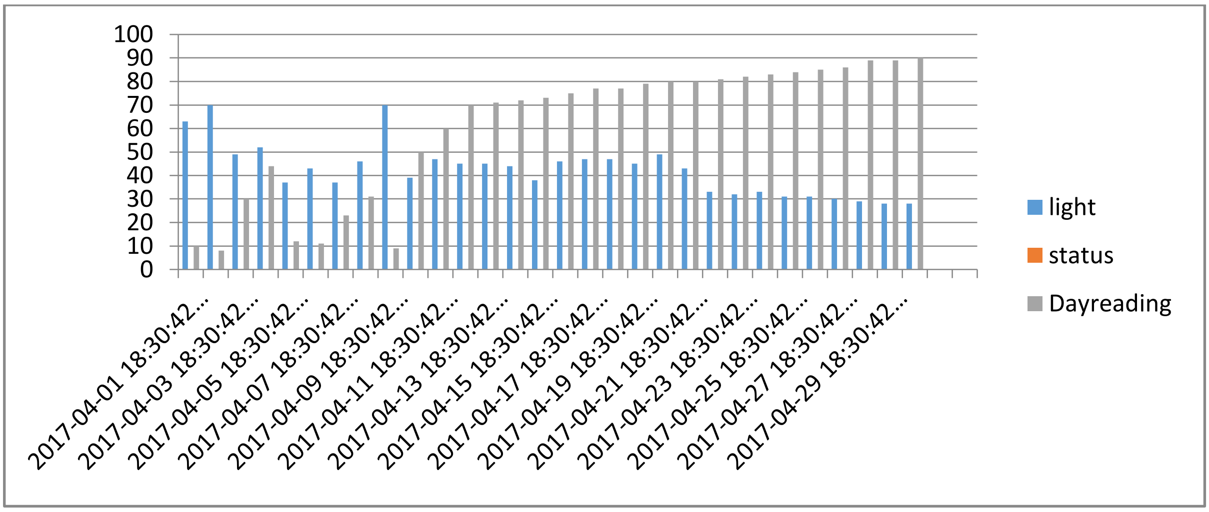


Figure 6: Street Light Reading with Their Respective Energy Consumption.

From the above analysis we will clearly identify the amount of temperature, humidity and gases that area appeared in the village of gudlavalleru. It clearly shows the readings vary from one month to another. If you observe fig3 and fig4 the temperature and humidity reading will rapidly increased due some atmospheric changes in gudlavalleru. Perform the analysis between two months(Feb and Mar) we will identify the amount of improved temperature ,humidity and gases range with the help of MARE and VARE percentages.

Similarly consider the smart street lights reading with respective amount of energy consumed by street lights. Street lights are automated with help LDR sensor. So it is very easy to calculate energy consumption at working hours of street light. When there is low amount of light fall on LDR automatically glows the street light and when there is sufficient amount of light sensitivity it automatically turns off the light. Here based on our village condition the threshold value we took is 70 for the LDR sensor. By using the LDR sensor in our village we save lot of energy consumption around all over the village.

## V. CONCLUSION

Smart village planning can have a major impact on national development. These efforts can increase the decision-making power of society by allowing them to make intelligent and effective decisions at appropriate times. In this paper, we propose a system for smart village planning by using an IoT-generated data analysis[10]. The proposed architecture consists of three tiers that have functionalities including collection, communication, processing, and interpretation. The complete system is developed using node mcu esp8266 to connect with the cloud storage. The simple IoT-based smart city datasets[8], such as vehicular networks, smart parking, smart home, weather, pollution, surveillance, and so on are analyzed for developing a smart city as well as for urban village planning decisions also. The proposed system benefit for villagers while providing them with the facilities to make intelligent and quick decisions.

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