

Digital Participatory Rural Appraisal Approach for Smart Sustainable Rural Development

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1 ABSTRACT

Participatory Rural Appraisal (PRA) has long been used in India and globally to enable communities to analyse their own living conditions and co-design development solutions. However, rapid digital transformation, characterized by smartphones, geospatial platforms, IoT sensors, artificial intelligence, and digital public infrastructure, have expanded the scope of PRA into a more powerful, data-driven, and scalable approach, known as Digital Participatory Rural Appraisal (DPRA). DPRA integrates human centred participatory tools with digital technologies to support evidence-based planning, inclusive governance, climate adaptation, and sustainable rural development.

The present article is an attempt to develop a concept for local community participation by the application of digital technologies for preparation of Smart Sustainable Village Development Plan. The paper discusses about the guiding principle and participatory methodology for inclusive digital participation of local community for sustainable village planning and development. In short, the present paper outlines the DPRA framework, methods, implementation model, case applications, and policy directions for Gairdikhata Cluster of villages in Haridwar district of India.

Key words: Digital PRA, Community Participation, Sustainable Development, Village Planning, Smart.

2 INTRODUCTION

Rural development has long been recognized as a cornerstone for equitable and sustainable growth across the globe. It has been a central focus of policy discourse in developing nations, particularly in countries like India, where nearly 65% of the population still resides in rural areas (World Bank, 2023). While traditional approaches have emphasized infrastructure, agriculture, and social welfare, the recent digital revolution has introduced new opportunities for strengthening community participation. Digital technologies, including information and communication technologies (ICTs), mobile applications, social media, e-governance platforms, and artificial intelligence are increasingly being deployed to empower rural communities, improve decision-making, and enhance access to essential services. Conceptualizing Community Participation in the Digital Era refers to the active involvement of local populations in decision-making, planning, and implementation of development initiatives. In the digital context, participation is increasingly mediated through online platforms, digital tools for knowledge sharing, and citizen-led data generation.

Now in the contemporary rural India it is more important to evolve participatory and inclusive rural planning process to understand the rural community needs and over all social and economic development. Seventeen Sustainable Development Goals (SDG) adopted by the United Nations General Assembly in 2015 as '2030 Agenda' representing a comprehensive approach to sustainable rural development. One of the key steps toward achieving higher levels of sustainability and the Sustainable Development Goals (SDGs) is to address economic disparities, climate change, and access to modern technologies and basic infrastructures. The concept of smart rural communities, although somewhat trendy, has gained significant attraction in this regard. While the smart city initiative is well-known, it is complemented by the Indian Smart Village initiative, aimed at leveraging Information and Communication Technology (ICT) to benefit people living in rural areas.

Comprehensively designed smart villages are expected to provide a fundamental framework for rural communities to enhance their participation at the local level, improve their economic, social, and living conditions, and, thereby, increase their resilience. Within the "Digital India" plans, the Indian government envisions a complementary approach, where smart villages not only drive economic growth in rural areas by producing goods and services but also serve as national and international markets. Consequently, there is a pressing need to design and develop villages with strong internal and external connections while preserving their independence in providing employment, services, and a high quality of life.

3 UNDERSTANDING THE CONCEPT OF DIGITAL PARTICIPATORY SMART SUSTAINABLE RURAL DEVELOPMENT.

The development of villages is a crucial factor in the progress of the nation. Therefore, village development should be envisioned in a manner that promotes self-sufficiency in delivering essential services, generating employment opportunities, and fostering strong global connectivity, denoting the concept of a “Smart Model Village”. The term "model" conceptually implies the design of an activity or situation that serves as an exemplary model for replication. In this context, a model village represents a sustainable community capable of generating and sustaining the resources needed to enhance its well-being. This enhancement is achieved by reinforcing the pillars of sustainability, including livelihood, infrastructure, and services. Smart villages rectify social oversights by providing a conducive environment for sustaining family relationships across different generations without disrupting their way of life. The vision behind smart villages is that they can serve as catalysts for development across various domains, including education, health, productive enterprises, clean water and sanitation, environmental sustainability, and participatory democracy. This, in turn, contributes to further progress and improvement. Digital India is a government campaign launched in India with the aim of providing electronic access to government services, improving online infrastructure, enhancing Internet connectivity, and fostering digital empowerment in technology. This initiative encompasses plans to establish high-speed internet networks in rural areas. Digital India revolves around three core components: the development of secure and reliable digital infrastructure, the digital delivery of government services, and the promotion of universal digital literacy.

In the present context the smart dimension of development is more often a sectoral approach. In international as well as in Indian scenario, the present smart approach reveals the piece meal approach of infrastructure development grounded with Information and Communication Technology e.g. Smart Water, Smart Energy, Smart Agriculture etc. A comprehensive approach for analysis of smart initiative and practices integrated with traditional indigenous knowledge-based economy, environment and societal needs fostering innovation of the rural community is missing. “Smart Village Concept” should necessarily be bottom-up integrated approach. The communities should be put behind the steering wheels instead of imposing development paradigms which is incompatible with the community’s desires, their social and cultural environments. An integrated inclusive approach, for felt need, demand and supply is required for making it more sustainable and resilient.

This leads to the basic concept of a smart sustainable rural development. i.e. a process whereby the optimum use of local resources can be sustained over several generations in the context of available technology and skills. To achieve inclusive, smart, and sustainable spatial planning, town planners in India should embrace innovative ideas for public participation. This can be facilitated by harnessing the power of Geographic Information Systems (GIS) and Internet of Things (IOT) technologies. These tools enable more effective and inclusive engagement with the rural community, allowing for the integration of local knowledge and perspectives into planning processes. In today's rapidly changing world, where information and digital technologies are advancing at a remarkable pace and costs are decreasing, leveraging of these technological advancements becomes even more critical. By doing so, town planners can create more dynamic and responsive development strategies that address the evolving needs of rural communities while ensuring the responsible and efficient use of rural resources.

Therefore, the meaning of ‘Smart Villages’ adopted in the paper is identification of local potential, strengths and opportunities of rural communities and to improve resilience through innovative solutions. Present paper frames the process of effective digital participatory model by using IoT technologies. This Model tries to understand and analyze dynamism of a village/ regional ecological-economic cultural system in a participatory approach. Participatory approach adopted in platforms of IoT to be called Digital Participatory Approach. Participatory Rapid Appraisal (PRA) approach, in combination with the use of digital technologies, will lead to empowering rural community by taking the initiative to find practical innovative solutions for both existing complex challenges and appropriate opportunities for sustainable and inclusive rural development. Digital Participatory Rural Appraisal will have to ensure the employment opportunities and skill updation, particularly among the small land holders, the landless labourers, and women to make development inclusive. Conceptually Smart Village Planning Model is an integration of Digital Participatory Inclusive Model and Sustainable Physical Planning Model.

4 SELECTION OF STUDY AREA

In order to identify the idealistic suitable village cluster and also to have true representation of Smart Village Planning Model (SVPM), various types of village ecosystems were studied with the help of Participatory Rural Appraisal (PRA) techniques. Among the various type of village ecosystems studied, Gaidikhata Cluster in Haridwar District, Uttarakhand has been taken as the study area. This cluster is chosen as because of the fact that the Gaidikhata Cluster itself depicts all uniqueness of the village ecosystem. In fact, it is worthwhile to point out here that this cluster itself represents all typical characteristics of different type of village communities (like tribal community, resettlement forest dweller community, advance agricultural community). The present cluster also represents all typical characteristics of physical and geographical setting (like plain, undulating land, hills and mountain topography); the micro-climatic variation, dense forest cover; the various zonation of land-uses in the form of valley zone, above valley zone, semi-arid zone, humid zone. Moreover, located under the shadow of big urban center, Haridwar, this cluster shows cultural cohesiveness and functional linkages. Lastly, the most important characteristic which determined for selecting the cluster is the administratively oneness of the cluster of villages being part of the one Naya Panchayat, one Block, one District

5 METHODOLOGY FOR DPRA

Information technologies in form of IoT have triggered a profound transformation in our way of life in the 21st century. These technologies have not only reshaped human behavior but also have ushered a new lifestyle marked by increased demand for transparency in governance and decision-making processes. The application of IoT Technologies will give planner to analyze the complex rural development problems and issues virtually through development of simulation model of real-world problems providing many options to evaluate the rural development decisions for implementation on the ground. 'Digital Participatory Rural Appraisal (DPRA) through the application of IoT technologies endows sustainable development of rural community by enabling importance for involvement of all levels of community (professional and local) in the process of planning and development leading towards to evolve the 'Digital Smart Participatory Village Planning Model' (DSPVPM). To achieve inclusive, smart, and sustainable rural planning, this innovative approach provides a framework for public participation by leveraging digital tools such as Geographic Information Systems (GIS) and IoT for more effective data collection, analysis, and collaboration among stakeholders. These technologies align with the global trend of rapid changes in information technologies, coupled with cost reduction can be invaluable in enhancing the right decision making for inclusive, smart, sustainable rural development.

The present paper delves into the intricacies of complex smart planning decisions, that are embedded in the procedure for the establishment of a Smart Village Model i.e. 'Smart Participatory Village Planning Model' (SPVPM). Undoubtedly, in the present cybernetics age IoT technologies provide the swiftest means to access, gather, analyze, and disseminate spatial information and also offer innovative and sustainable solutions through digital participatory approaches on the one hand and empowering rural communities and effective governance on the other. However, the adoption of such technologies poses challenges, including technological complexity; high costs, varying literacy levels, societal awareness, and accessibility issues. These challenges contribute to a digital divide, particularly affecting low-income groups. Consequently, the paper endeavors to address the main question of how low income and illiterate society can effectively and democratically access these technologies for participating and providing real-time spatial rural information into digitally tested designs leading into the rural development on the ground.

In overall, the paper frames a "Digital Smart Participatory Village Planning Model" through application of DPRA (intermingling both Geographic Information Systems (GIS) and IoT technologies as a spatial planning tool) to cultivate inclusive, smart and sustainable rural community in Gaidikhata cluster of Haridwar district, Uttarakhand. The central focus of this study revolves around the issue of providing economically disadvantaged sections of the rural community with access to the internet and IoT technologies to enable the effective people's participation in the rural planning and execution of development initiatives.

Indeed, beyond the imperative of achieving sustainable and inclusive development for the Gaidikhata Cluster, there is a pressing need to establish the DPRA with the aid of emerging Information and Communication Technologies (ICTs), such as IoT and GIS. The success of digital model for Gaidikhata Cluster is dependent upon the multiple challenges, like leadership role, skill development, sustainable land-

use planning and fostering a participative and responsive rural community. Gaidikhata cluster faces increasingly complex socio-economic and environmental challenges, especially regarding the competitiveness of the village community for survival. The sensitivity of forest-dwelling communities adds another layer of complexity, underscoring the need for thoughtful and culturally sensitive approaches when applying advanced technologies to address social issues. The establishment of the DPRA offers a pathway to address multifaceted challenges and create a sustainable, responsive, and inclusive future for Gaidikhata cluster and similar rural communities. It requires careful consideration of the local context and active community engagement to ensure the success of these technological advancements in a socially responsible manner.

Recognizing the unique challenges faced by the Gaidikhata Cluster, where a significant portion of the rural community i.e. only 34 % have limited familiarity with internet, smartphones and other digital technologies, thus, it becomes evident that presenting a DPRA in Gaidikhata cluster may not effectively able to connect to local rural community and continue to extend the participatory gap between spatial rural planning and application of IoT technologies. Hence, in Gaidikhata cluster, where planning and governance process evolve within a socially uncertain environment, a more comprehensive "DPRA" is required with collective intelligence, social awareness, and local wisdom of the village community.

To achieve this, a collective intelligence system, by using crowd wisdom is developed with the assistance of IoT technologies in a Common Participative Platform. The Interactive applications is designed to provide rural services and facilitate the implementation of the DPRA. This can then be introduced to the local village communities through smart farming and off-farm activities, efficient rural service delivery, intelligent mobility management systems, streamlined planning processes, and active community participation. Hence, the rural development approach, centers around leveraging the wisdom and collective intelligence of the local community to co-create and implement a Smart Village Planning Model which is not only technically advanced but also socially relevant and inclusive. This encompasses three fundamental elements:

- (1) Innovative Technological Solutions: This includes both hard (physical infrastructure and tools) and soft (software, applications, digital platforms) technological innovations.
- (2) Local Community: The local community plays a central role. It is characterized by leadership, responsiveness, intelligence, and creative thinking which are essential for active community engagement and contribution to the planning and development process.
- (3) Government: The government's role is pivotal in terms of setting policies, rules, governance structures, and demonstrating political will to support and enable the implementation.

This represents a transformation of the smart village planning approach through integrating a social system which empowers the community to create, solve problems, build infrastructure, utilize resources, adapt to changes, secure livelihoods, and more within the context of a 'Smart Village' (Figure 1).

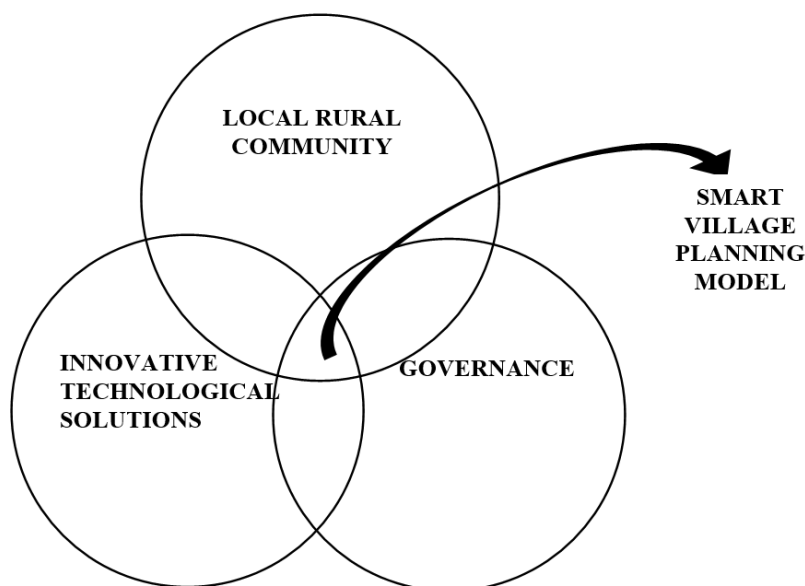


Figure 1: Smart Village Planning Model

In practical terms, the DPRA integrates physical planning and design with the active involvement and influence of the local community, facilitated through a IoT based digital platform. This ensures the technologically advanced smart village development process driven by the needs and aspirations of the rural community it serves (Figure 2).

The Gaidikhata cluster system is designed around an input-output model, which serves as a framework for measuring sustainable development and the quality of life within the community. This model encompasses various sub-systems, each contributing to the overall sustainability and well-being of the community. These sub-systems include: Smart Mobility System, Smart E-Governance, Smart Ecological System, Smart Water Management System, Smart Infrastructure System, Smart Community System, Smart Power Management System, Smart Finance Management System, Smart Social Development System, Smart Economic Development System, Smart Environmental Development System, Smart Creative Community Development System etc. These sub-systems collectively contribute to the smart and sustainable development of Gaidikhata cluster and have capability to adapt, repair, and redesign based on the collective intelligence and actions of the community participation. The most important element of the DPRA is the active participation of the local community in governance and the preparation of Smart Participatory Village Development Plan. The crowd-sourcing model, which involves digital participation, plays a pivotal role in this leveraging the wisdom of crowds to generate effective solutions and make collective decisions, ensuring that the planning and development processes are inclusive, responsive, and driven by the insights and needs of the local community.

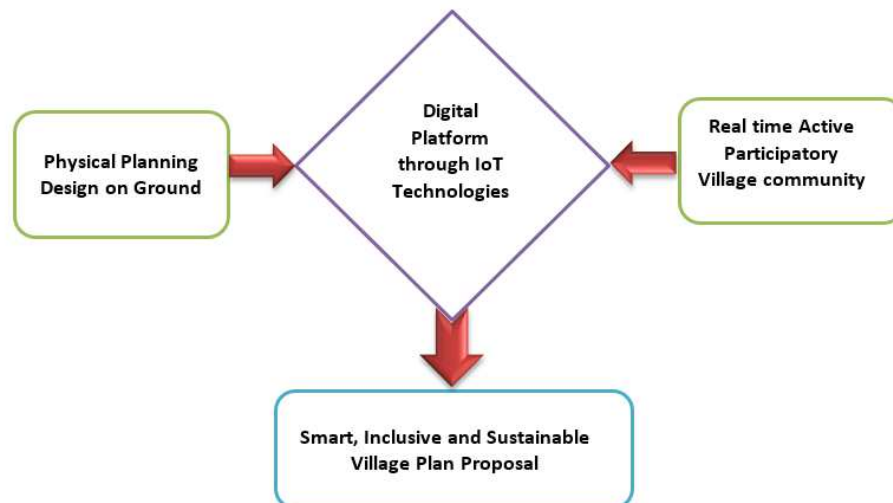


Figure 2: DPRA

6 TECHNOLOGICAL INPUT FOR DPRA

The use of IoT Technologies include social networking sites, like Google Maps Mashups, blogs, YouTube, WhatsApp, and others to disseminate information offering boundless opportunities for social inclusion within the local community, thereafter, transforming rural planning and design into a smart and inclusive process. These technologies encompass participatory web applications that enable villagers to actively participate and create their own content, fostering communication through various mediums such as text, maps, sketches, images, and more. Importantly, these technologies transcend language, culture, and custom differences, making them highly accessible and inclusive and serves as a powerful tool for planners to engage with the local community and vice versa. It facilitates two-way communication and collaboration.

Furthermore, these technologies contribute to transparency in governance by enhancing the interoperability of rural planning processes. It allows greater visibility and understanding in decision-making and resource allocation, ultimately empowering community members to participate effectively in shaping the future of their village. Thus, IoT Technologies in rural planning not only fosters inclusivity but also promotes transparency, enabling active community involvement and collaboration in the planning and development of smart and sustainable villages.

In essence, this enable the aggregation and analysis of unconventional data sources, offering a wealth of traditional information that can be harnessed to shape smart and sustainable village planning. This data-driven approach enhances the precision and effectiveness of rural development initiatives in the Gaidikhata cluster and similar regions.

Here are some examples of how such data can be leveraged:

- (1) Personal Smartphones and Local Cameras
- (2) Smartphone Video Recording and Social Networking Sites
- (3) GPS-Equipped Vehicles:
- (4) Data Mining Techniques

7 CROWDSOURCING FOR DPRA

Establishing the DPRA, especially in a village cluster like Gaidikhata, where only 34 percent of the population has internet access, requires an innovative approach. While the digital divide may pose challenges, it is indeed possible to leverage IoT to establish a Smart Participatory Village Planning Model (SPVPM). To facilitate the effective local community participation, a Core Community Group (CCG) can be formed. Strategy to identify the interested villagers among the least technological savvy village communities who are enthusiastic about supporting the research and to be a part of participatory Core Community Group (CCG) is really a challenging task. These villagers may be referred to as 'LOCAL COMMUNITY FIELDERS' (LCF) at the village level and 'LOCAL COMMUNITY LEADERS' (LCL) at the cluster level. Criteria for selection of LCF and LCL and steps of establishment of SPVM are given below:

- (1) Selection of LCF: LCF members should be chosen from various areas within the villages and represent different communities. They should possess smartphones, have a basic level of education, and, most importantly, express a genuine interest in actively participating in the research.
- (2) Collaboration: The LCF members will work closely with the researcher. Their role will involve active engagement in analyzing content and solving village-related problems and issues using IoT.
- (3) Training and Capacity Building: LCF members are given training for capacity-building and effectively handholding in using IoT applications in their smart phone, for data collection, communication, and disseminating information to the researcher, villagers, planners or managers for further analysis and providing solutions.
- (4) Community Engagement: The LCF, in conjunction with the researcher, will engage the broader community to gather insights, share information, and ensure that local perspectives are considered in the research process.
- (5) Feedback Loop: A feedback loop should be established to continuously assess the progress, challenges, and outcomes of the research. This iterative process allows for adjustments and improvements based on the experiences of the LCF and the community.

By forming and empowering the LCF and LCL, the research can harness the collective intelligence and involvement of interested villagers to overcome the limitations of internet and smart phone access. This approach enables active participation and ensures that the research benefits from local insights and perspectives, ultimately contributing to the success of the DPRA for achieving the Smart Participatory Village Planning Model (SPVPM).

This digital platform will serve multiple purposes, including:

- (a) Access to GIS and Web 2.0 Technology
- (b) Information Sharing with Related Agencies.
- (c) Storage of Public Information and Databases:
- (d) Community Data Analysis
- (e) Influence on Decision-Making:

The LCF will feed/ communicate the village development related data to LCL and LCL to planners or village development managers and then planners will upload on common platform or portal. In this way, the digital

platform is managed "by the people," provides information to village planning authorities "for the people," and generates information "from the people." The common platform should be accessible to all members of the local community, ensuring that it empowers individuals with direct access to digital spatial data relevant to the village cluster. LCF and LCL members should be identified for training and access to GIS and IoT technologies, with a particular focus on ensuring the inclusion of marginalized groups such as the poor and women. This approach not only addresses digital exclusion but also reduces the gap between planning professionals and the local public, fostering a more inclusive and participatory approach for inclusive sustainable village development. This Digital Smart Participatory Sustainable Rural Development Planning Approach employs a crowdsourcing IoT platform at all stages of the village planning process, harnessing collective intelligence to create web-based solutions for complex rural problems. The sequence of the DPRA based SPVPM is outlined as follows:

- (1) Identification of Problems
- (2) Defining Goals
- (3) Establishment of e-Platform
- (4) Collection of Data through crowdsourcing
- (5) Analysis of Data
- (6) Solution and Decision Making
- (7) Designing Solutions
- (8) Implementation of the Plan
- (9) Monitoring of the Plan
- (10) Evaluating the Plan

In overall, the DPRA led SPVPM for rural development reduces planners' dependency on time and space, gradually transforming traditional planning processes into virtual planning. This approach promotes participatory, transparent, and sustainable village planning that actively involves the local community in problem-solving and decision-making.

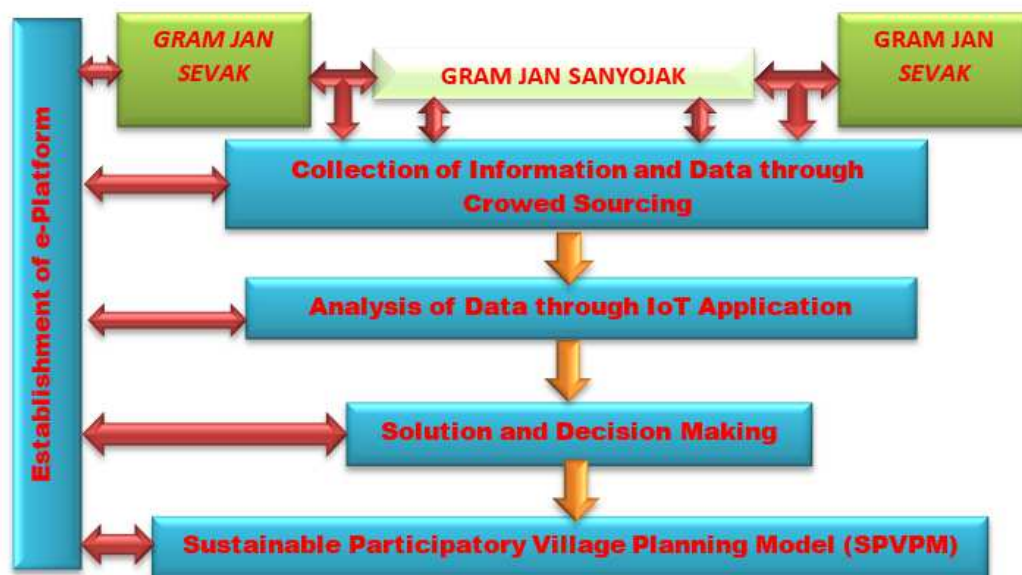


Figure 3: DPRA led Smart Participatory Village Planning Model (SPVPM)

8 CONCLUSION

On the basis of above-mentioned methodology for achieving sustainable, inclusive, integrated, digital participatory spatial planning using DPRA for sustainable development of Gaidikhata cluster, Smart Participatory Village Planning Model tries to understand and analyze dynamism of an existing regional ecological-economic cultural system as an integrated approach on the one hand, and sustainable and inclusive approach adopted on the other. This method aims to overcome digital access barriers. The paper

outlines the functionalities of the digital platform, highlighting its role in accessing, collecting, analyzing, and transferring spatial information. It also emphasizes the platform's role in providing participatory solutions for effective governance and community empowerment. The DPRA approach aims to empower the local village community by giving them the ability to customize the digital platform to meet their specific needs. It enables them to generate and manipulate their own information and spatial data, rather than relying solely on predefined decisions made by higher authorities.

The ultimate goal of DPRA is to make the local community active participants in their village development and planning process. This approach fosters a sense of pride and direct involvement, allowing them to drive their own village's development. The paper appears to propose a noble approach to village planning and development by combining the concept of Smart Village with IoT, ensuring that even communities with limited digital access can actively participate in the process and shape their own development. This approach emphasizes community empowerment and customization of digital tools for local needs.

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