Systematic Literature Review on Smart Living Technologies in Smart Villages

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***Abstract*— The rapid advancement of technology has paved the way for innovative solutions in the development of smart villages, transforming rural areas into digitally empowered communities. This systematic literature review explores the various smart living technologies implemented in smart villages, focusing on their applications, benefits, and challenges. The review synthesizes research findings from numerous studies to provide a comprehensive understanding of how technologies such as the Internet of Things (IoT), artificial intelligence (AI), and renewable energy systems contribute to enhancing the quality of life in rural areas. Key areas of impact include healthcare, education, agriculture, and infrastructure development. The analysis highlights the significant role of community engagement and government policies in the successful implementation of smart living technologies. Despite the promising potential, the review also identifies persistent barriers such as digital literacy, funding, and infrastructure constraints. The findings aim to inform policymakers, researchers, and practitioners on the current state and future directions of smart living technologies in smart villages, ultimately contributing to sustainable rural development.**

Keywords—smart living, technology, smart village

I. INTRODUCTION

Smart living technologies have gained prominence in the development of smart villages, with the goal of improving the quality of life and well-being of rural residents through innovative solutions. The integration of Internet of Things (IoT) technology with smart governance, resource management, and service provision is reshaping rural areas, reflecting the progress made in smart cities [1]. By incorporating indicators from smart city concepts, smart villages are adopting smart governance, technology, resources, services, living, and tourism to establish sustainable and efficient rural environments [2]. These technological advancements are not exclusive to urban areas but are essential for enabling smart living in rural regions, encompassing villages and suburbs [3].

Efforts to establish connectivity in rural areas through IoT technologies have been a focal point of research, emphasizing the significance of efficient fronthaul and backhaul connectivity for IoT traffic in rural areas. Furthermore, the utilization of technologies like High Altitude Platform Stations (HAPs) and LoRaWAN for smart home purposes in rural regions illustrates the potential for enhancing connectivity and monitoring in smart farming practices [4]. The integration of IoT across various sectors, including healthcare monitoring, agriculture, and energy management, is transforming rural development by providing real-time data and insights for decision-making [5][6][7].

The use of blockchain-enabled IoT devices in healthcare and the deployment of smart meters in remote areas further underscore the transformative impact of technology on rural living standards [8] [9]. These advancements not only enhance the efficiency of rural operations but also promote environmental sustainability by optimizing resource utilization and reducing energy consumption. The evolution of smart metering systems using unmanned aerial vehicles and IoT in smart grids signifies a shift towards automated and innovative services tailored for rural and remote regions [10].

In the context of smart villages, the integration of IoT technologies with machine learning and edge computing is facilitating the development of self-management architectures in nursing homes and real-time data processing for vehicular edge computing in rural areas [11]. Moreover, the implementation of IoT systems for remote monitoring of water points, seedling growth, and ambulatory healthcare services showcases the versatility of smart technologies in addressing various rural challenges.

The systematic integration of smart living technologies in smart villages is reshaping rural landscapes by enhancing governance, connectivity, healthcare, agriculture, and environmental monitoring. The synergy between IoT, blockchain, edge computing, and machine learning is driving sustainable development and improving the quality of life for rural communities. As research and innovation in smart living technologies continue to progress, the future holds promising prospects for creating inclusive, efficient, and technologically advanced smart villages.

II. BACKGROUND STUDY

The concept of smart villages has emerged as a response to the growing need for rural development through the integration of advanced technologies and innovative solutions. Smart villages aim to enhance the quality of life, promote sustainability, and improve governance in rural areas by leveraging digital tools and connectivity. These initiatives align with the principles of Industry 4.0, emphasizing the use of smart technologies to drive progress and address the challenges faced by rural communities [12].

The integration of cognitive processes of artificial intelligence and modern infrastructure challenges forms the basis for modeling smart villages, focusing on enhancing efficiency and productivity in agricultural practices. By incorporating digital technologies tailored for agriculture, smart villages can optimize resource utilization, improve crop yields, and streamline farming operations [13]. This approach underscores the importance of leveraging AI and digital tools to transform traditional rural practices and promote sustainable agriculture.

Evaluation studies on smart village strategies and challenges provide valuable insights for policymakers and practitioners involved in rural development initiatives. By assessing the effectiveness of smart village approaches and identifying potential obstacles, researchers offer recommendations to enhance the implementation of smart village projects and ensure their long-term sustainability [14]. These evaluations contribute to the ongoing discourse on smart village development and inform decision-making processes at the local and national levels.

Sustainable development principles are at the core of smart city and village initiatives, emphasizing community-centered approaches and the responsible use of information and communications technology. By focusing on calm technology, community building, and the identification of community leaders, designers of ICT solutions can create inclusive and sustainable environments that prioritize the well-being of residents [15]. These core principles guide the development of smart villages, ensuring that technological advancements are harnessed to benefit local communities and promote environmental stewardship.

III. Research Method

The method chosen is Systematic Literature Review, which is used to analyze and review the smart living technologies in smart village. The purpose of this method is to reviewing the smart living technologies in smart villages, based on the existing journals. Web of Science, Science Direct, Scopus, Springer Link and Emerald are the online research database that are chosen in order to find the related articles. Those four online researches database provide substantial scientific articles and journals from various study fields, especially the ones related to smart living technologies implemented in village or rural area.

IV. Result

A. *Study Fund*

The keywords used in this paper were Smart living OR Smart Home OR internet of things And (rural OR village). Search using the year filter from 2019 to 2024. he process begins with the Identification phase, where a total of 1,493 records are sourced from six databases, including SpringerLink (426 records), Web of Science (323 records), ScienceDirect (271 records), Emerald (210 records), IEEE (196 records), and Scopus (68 records).

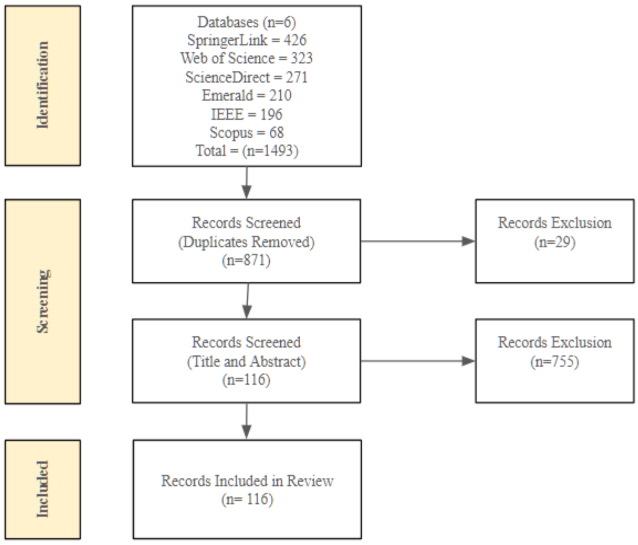

Fig. 1. Data collection process visualized according to the PRISMA guidelines

B. *Selected Studies*

The chosen journals or research papers are according to these inclusion Criteria:

- Articles that explicitly state in the title or abstract about the use of smart living that can be applied in villages or rural areas (Implementation of smart living technologies such as IoT, smart grids, telemedicine, smart agriculture, renewable energy solutions, and digital education platforms)
- The article publishes between 2019 - 2024

Exclusion criteria:

- Articles that do not involve the implementation of smart living technologies
- Articles that belong to Review/survey category

In the Screening phase, duplicate records are removed, resulting in 871 unique records. These records undergo a preliminary screening, leading to the exclusion of 29 records. The remaining 842 records are then screened based on their titles and abstracts. This more detailed screening results in the exclusion of 755 records, leaving 116 records.

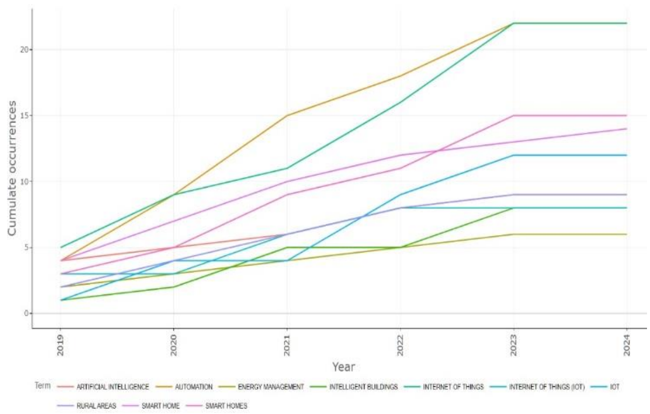

Fig. 2. Trends Topics

The data in the chart reveal several notable trends in the adoption and interest in various advanced technologies from 2019 to 2024. Notably, terms such as "Artificial Intelligence" and "Internet of Things" show a significant and steady increase in cumulative occurrences, reflecting a growing emphasis and investment in these cutting-edge technologies. Similarly, "Smart Home" and "Smart Homes" demonstrate substantial growth, indicative of the rising popularity and implementation of smart home solutions among consumers. In contrast, terms like "Automation," "Energy Management," and "Intelligent Buildings" exhibit a more gradual increase, suggesting a steady yet less rapid expansion in these areas. Meanwhile, the term "Rural Areas" shows minimal growth, highlighting a slower adoption or interest in smart technologies in rural settings compared to urban areas. Overall, the trends suggest a broader and accelerating integration of advanced technologies, particularly in urban environments, while highlighting areas where growth is more measured

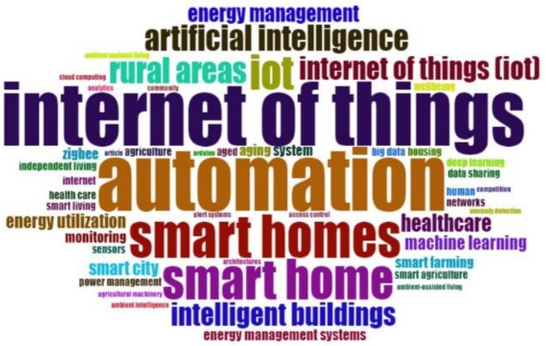

Fig. 3. Word Cloud

Word cloud visualizes the relative frequency of various technology-related terms, with the size of each term indicating its prominence. "Internet of Things," "Automation," "Smart Homes," and "Smart Home" are the most prominent terms, suggesting they are the most frequently mentioned or focused on in the dataset. Other significant terms include "Artificial Intelligence," "IoT," "Internet of Things (IoT)," "Energy Management," "Intelligent Buildings," and "Rural Areas." This visualization highlights key areas of interest and discussion within the technology sector, emphasizing the importance of interconnected devices, automation, and smart home technologies

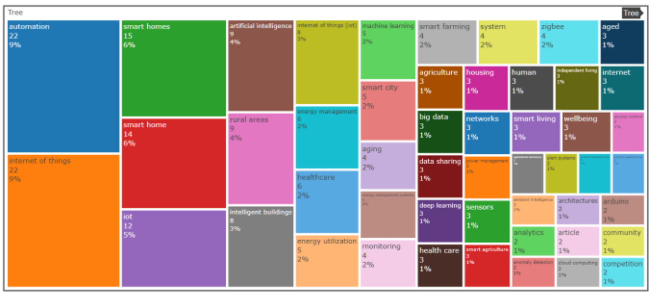

Fig. 4. Tree Map

This treemap visualization represents the frequency and distribution of various technology-related terms, with each rectangle's size corresponding to the term's prominence. "Automation" and "Internet of Things" are the largest sections, indicating they are the most frequently mentioned terms. Other significant terms include "Smart Home," "Artificial Intelligence," "IoT," and "Rural Areas," each occupying substantial space. Smaller rectangles represent less frequently mentioned terms such as "Machine Learning," "Healthcare," "Energy Management," and "Intelligent Buildings." This visual highlights the dominant topics in technology discussions, emphasizing the focus on automation and interconnected devices

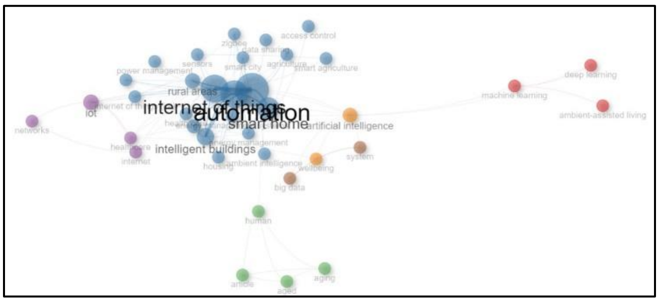

Fig. 5. Co-occurrence Network

Figure 5 shown network diagram visualizes the relationships and connections between various technology-related terms. The size of each node represents the frequency or prominence of the term, with larger nodes indicating more frequently mentioned terms.

C. *Smart Healthcare*

IoT devices in healthcare offer significance convenience, especially for elderly patients and those living in urban areas. These devices, such as blood pressure monitors and pulse oximeters, enable remote monitoring by gathering important health information. This functionality allows for continuous health monitoring and also functions as an alert system for timely medical actions. These technologies improve health monitoring, increase patient participation, lower re-hospitalization rates, and provide easy access to healthcare, especially for older persons in distant places. This strategy empowers people in controlling chronic diseases and improves health outcomes by allowing for timely medical interventions [16].

In [17], fog computing services is introduced for managing real-time notifications. Fog computing improves real-time notifications in healthcare by processing data closer to the source, lowering latency, and allowing for faster responses to crucial health situations. It enables immediate local data analysis, efficient bandwidth utilisation by selecting relevant data, and greater reliability through continuous local processing during network outages. The solution is scalable, allowing for more IoT devices, and it provides context-aware notifications that prioritise alerts depending on urgency. Furthermore, fog computing works with emergency systems to automate warnings, which improves reaction times and overall patient care.

HomeSense project designed by VandeWeerd et al. employs ambient sensing technologies to promote healthy living and independence among older persons, allowing them to age in place [18]. Wireless sensors are placed around the home to monitor daily activities and detect potential health issues early on, allowing for timely interventions. It collects large amounts of data for real-time analysis and long-term health trend monitoring, thereby improving care coordination and giving carers with vital insights. This system helps family members or caregivers to stay updated on the elder's health status especially those living in urban areas.

D. Smart Education

The potential of improving the education sector could be seen through the IoT-Based Virtual E-Learning System IoT-Ve-LS for integration of internet of things technology with virtual and augmented reality for an engaging learning experience [19]. It fosters automatic ICTs, use the cloud database to consolidated resources, and encourages the social collaboration of students as well as teachers. They range from security and accessibility for students as well as conservation by informing students on sustainable practices, incorporating real-time data, and encouraging creativity in developing initiatives toward smart cities. This way, it ensures that employing the knowledge and skills that are imparted in the areas of emerging technologies and sustainable development, students can prepare for employment after their academic session.

E. Smart Agriculture

Smart agriculture, also known as precision farming, maximizes agricultural techniques and increases crop yields by utilizing cutting-edge technologies like smart sensors and the Internet of Things (IoT). This creative farming method combines a number of technologies to better monitor and manage agricultural resources, increasing sustainability and productivity.

Precision Farming: Using technology to collect and analyze farm data in order to make well-informed decisions is known as precision farming. Farmers may more precisely apply inputs like water, fertilizer, and pesticides and monitor field conditions in real-time by using GPS, drones, and satellite imaging. This focused strategy minimizes environmental effect, cuts expenses, and reduces waste [20][21]. To ensure optimal water consumption, precision farming techniques, for instance, can assist in identifying sections of a field that require more or less irrigation [22].

IoT in Agriculture: IoT devices are essential to smart agriculture because they offer real-time data on a range of factors, including crop health, temperature, humidity, and soil moisture. These gadgets can be linked to a centralized system that evaluates the information and gives farmers useful insights. IoT in agriculture facilitates more efficient supply chain management, livestock monitoring, and irrigation system automation [23][24]. For instance, IoT-enabled smart irrigation systems can automatically modify watering schedules in response to soil moisture levels, resulting in healthier crops and water conservation [25].

Smart Sensors: Smart sensors, which provide accurate measures of crop state and ambient variables, are crucial components of smart agriculture. These sensors are capable of monitoring plant development, detecting soil nutrient levels, and even early disease and pest identification. Smart sensors allow farmers to optimize their farming techniques and react swiftly to changing conditions by gathering and sending data to a central hub [26][27]. It has been demonstrated that integrating smart sensors into agriculture greatly increases crop yields and lowers input costs [28].

Impact on Crop Yields: The implementation of smart agriculture technologies has a significant effect on total farm productivity as well as crop yields. Through accurate input application and ongoing crop health monitoring, these technologies assist farmers in producing greater yields with fewer resources. Research has indicated that through optimizing planting, fertilization, and irrigation techniques, precision farming and Internet of Things applications can boost crop yields [29]. Furthermore, smart agriculture lessens the environmental impact of agricultural practices, which supports sustainable farming [30].

A notable development in contemporary farming methods is smart agriculture. Farmers may increase output, cut expenses, and advance sustainable agricultural methods by utilizing precision farming, Internet of Things devices, and smart sensors. Because of its beneficial effects on resource management and agricultural yields, smart agriculture is an essential part of farming's future.

F. Smart Home Technologies

Smart home technologies comprise an array of mechanisms and apparatuses intended to mechanize and improve the efficiency, security, and functionality of residential environments. Smart appliances, home automation systems, and sophisticated security and monitoring systems are essential elements of smart home technologies that greatly raise living standards, especially in rural areas Smart home technologies comprise an array of mechanisms and apparatuses intended to mechanize and improve the efficiency, security, and functionality of residential environments. Smart appliances, home automation systems, and sophisticated security and monitoring systems are essential elements of smart home technologies that greatly raise living standards, especially in rural areas.

Home Automation System: The foundation of smart home technologies are home automation systems, which allow for centralized control of a variety of domestic appliances, including lighting, heating and cooling, and entertainment systems. Due to the sensors, actuators, and networking modules included in these systems, homeowners can remotely control their surroundings using smartphones or other devices. For example, integrating Internet of Things (IoT) devices into home automation reduces energy usage and improves ease by enabling smooth control and energy management [20][21].

Smart Appliances: Through connectivity and intelligent features, smart appliances—such as washing machines, ovens, and refrigerators—are made to maximize efficiency and consumer convenience. With the ability to connect with one another and the user, these appliances can offer notifications for predictive maintenance as well as updates and diagnostics. By cutting waste and maximizing energy use, they support a more sustainable way of living [22] [23]. To cut down on food waste, smart refrigerators, for instance, may monitor their contents and recommend recipes depending on what's on hand [24].

Security and Monitoring System: Smart homes come with integrated advanced security and monitoring systems that provide increased safety and peace of mind. These systems include remotely monitored and controllable motion detectors, cameras, smart locks, and alarm systems. Home security is greatly enhanced by features like automated reactions to security breaches, video surveillance, and real-time notifications [25][26]. These technologies provide an indispensable layer of safety in rural locations, where conventional security measures might be less successful [27].

Impact on Rural Living Standards: The level of life in rural areas is significantly impacted by the use of smart home technologies. By offering improved efficiency, safety, and convenience, these technologies help to close the gap between lives in the city and the country. Smart home solutions can ensure better resource management, lower energy costs, and increase security in rural places where access to services and infrastructure may be limited [28] [29]. Moreover, increased integration with larger smart city efforts is facilitated by the connectedness made possible by smart home technologies, which may accelerate socioeconomic growth in rural areas [30][31].

Smart home technologies, which offer many advantages beyond simple convenience, constitute a significant improvement in residential living. These technologies improve people's quality of life, especially in rural areas, by combining home automation, smart appliances, and strong security systems. They also increase safety, efficiency, and general well-being.

G. Challenges and Barriers Smart Living in Village

The concept of Smart Villages aims to utilize digital technologies to improve the quality of life and services in rural areas, but several challenges and barriers hinder its implementation. These challenges include the difficulty of integrating diverse data sources and ensuring data quality, inadequate technological infrastructure in rural areas to support big data initiatives, concerns over data privacy and security when handling large datasets, and a lack of technical skills and expertise among farmers and local stakeholders to effectively utilize big data analytics. Addressing these issues is crucial for the successful implementation of smart village projects [32].

There are several challenges associated with implementing smart living technologies for older adults. Many older adults are not comfortable with the use of cameras and microphones for monitoring, citing privacy issues. Additionally, there is a preference for passive monitoring technologies that do not require direct interaction or constant maintenance, which are perceived as less intrusive and more consistent over time [18]. Furthermore, the adoption of new technologies by older adults can be hindered by a lack of familiarity and comfort with these devices. Engaging older adults in the design and testing phases to ensure the technology meets their needs and is user-friendly is essential for successful implementation.

Implementing smart living solutions in agriculture faces several challenges as well. Integrating diverse and heterogeneous data sources from various sensors is complex yet crucial for accurate monitoring. Additionally, infrastructure limitations, such as ensuring reliable internet connectivity in rural areas, present significant obstacles. Data security and privacy are paramount, requiring robust measures to protect sensitive agricultural data from breaches. Moreover, a lack of technical expertise among farmers to operate and maintain advanced IoT systems effectively poses a critical barrier to successful implementation. Addressing these issues is essential for advancing smart agricultural practices [33].

The implementation of ForAlexa, an online tool for developing AI skills for teaching evolutionary biology using Amazon’s Alexa, faces several challenges regarding smart living. Firstly, integrating diverse functionalities and ensuring seamless interaction between the user and Alexa is complex. Additionally, privacy concerns arise as users may be uncomfortable with voice data collection. Ensuring robust data security to protect user information is also critical. Lastly, there is the challenge of creating intuitive and user-friendly interfaces that cater to both educators and students, requiring ongoing refinement and user feedback to optimize the system's effectiveness [34].

H. Future Directions and Recomendations

Future directions for smart living systems for household appliances focus on enhancing the interoperability and integration of various smart devices to create a seamless user experience. Emphasis is also placed on improving energy efficiency and sustainability through advanced energy management systems. Developing robust data security measures to protect user information is crucial. Additionally, increasing the user-friendliness of these systems, particularly for those less familiar with technology, and ensuring adaptability to evolving user needs are key considerations for future development [35].

Similarly, Smart farming using IoT emphasize several key areas. Firstly, there is a need for enhanced data integration techniques to better handle the vast amounts of data generated by various sensors. Improving the interoperability of different IoT devices is also crucial to ensure seamless communication and data exchange. Additionally, the development of more robust cybersecurity measures is essential to protect sensitive agricultural data from potential breaches. Finally, increased focus on user-friendly interfaces and training programs can help farmers effectively utilize IoT technologies for optimal farming practices [36].

Enhancing user interaction and expanding capabilities are crucial for educational platforms. There is a need to improve the user interface to make it more intuitive and user-friendly, allowing educators to easily create and manage AI skills. Enhancing data security measures is crucial to address privacy concerns. Additionally, integrating more sophisticated AI algorithms can improve the accuracy and relevance of responses. Further research and development should focus on incorporating multilingual support and expanding the range of educational topics covered by the platform [34].

V. CONCLUSION

This comprehensive review examines and summarizes recent research, concluding with three main future directions and recommendations. Firstly, for smart living systems in household appliances, there is a need for enhanced interoperability and integration of smart devices to create a seamless user experience. Improving energy efficiency and sustainability through advanced energy management systems, robust data security measures, and increasing user-friendliness, especially for those less familiar with technology, are crucial. Secondly, smart farming using IoT requires better data integration techniques to handle vast sensor data, improved device interoperability for seamless communication, robust cybersecurity to protect agricultural data, and user-friendly interfaces and training programs for farmers. Lastly, educational platforms should enhance user interaction, expand capabilities, improve user interfaces, ensure data security, and incorporate sophisticated AI algorithms and multilingual support. Addressing these challenges will facilitate more effective and widespread implementation of smart living technologies across various sectors.

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