Article

Transitions towards Sustainable and Resilient Rural Areas in Revitalising India: A Framework for Localising SDGs at Gram Panchayat Level

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Abstract: Twenty-first century rural development (RD) demands a new paradigm of sustainability capable of addressing the difficulties and leveraging on the possibilities, such as climate change, demographic shift, international competitiveness, and rapid technological progress. Amidst these challenges, it is necessary to have a guiding framework from a long-term perspective that aids the integration of current RD policies while allowing space for location and community-specific innovations for implementing sustainable and resilient development strategies. India has witnessed several schemes and programmes for RD with exclusive objectives, varied focus areas, and separate domains, resulting in compartmentalisation in policy frameworks and disjointed implementation. Such initiatives were also often ideated from an urban perspective when it came to peri-urban rural areas or offered a generalist rural perspective (when referring to other rural regions, including those nested in ecological zones, thereby disregarding their local relevance). Accordingly, this study proposes a synchronised SMART village framework to tailor existing RD approaches for sustainable transformations aligned with the sustainable development goals and with a possibility of scaling its applicability in the local context. We initially conducted a bibliometric analysis to gain a comprehensive understanding of the emerging transformative approaches to RD, such as smart village (SV). Though in its nascent stage, the SV initiatives in India primarily envision information and communication technology enabled transformations in rural areas, often forcing villages to establish the relevance of such interventions. The study recognises key challenges to RD in India by using the problem tree analysis and further defines a SMART village framework that can be catalytic in transforming rural areas towards a sustainable and resilient state.

Keywords: smart village; sustainable rural development; rural vulnerability; SMART village framework; PRISMA analysis; problem tree analysis

1. Introduction

Over the centuries, varying social, economic, and ecological forces have catalysed numerous transformations in how human settlements are shaped and operated [1]. The ever-exacerbating human actions have impacted the earth's natural resources and outpaced the planet's carrying capacity [2]. The resultant global challenges such as climate change, resource depletion, environmental degradation, and their local ramifications, such as conflicting resource sharing between regions, differentiated developments of urban and rural areas, unemployment, malnourishment, and poverty [3], make it imperative to search for holistic approaches for the development planning of underdeveloped regions.

Rural regions, particularly in the Global South, are inherently vulnerable due to their persisting poverty traps, social stratifications, population decline, predominant nature-based livelihoods, administrative incompetence, weak planning, and geographic isolation [4]. Addressing these endogenic vulnerabilities becomes imperative and calls for an alternative development framework to ensure rural sustainability under rapidly changing

risk landscapes. Various platforms have long advocated a need for synergetic frameworks emphasising natural resource conservation and well-being to achieve sustainable development. In the year 2015, the global community adopted three ground-breaking agreements, namely the '2030 Agenda for Sustainable Development' [5], the 'Paris Climate Change Agreement' [6], and the 'Sendai Framework for Disaster Risk Reduction 2015–2030' [7,8], to promote the assimilation of sustainable development principles into policy. Although efforts are being made, the far-distanced goal of localising these frameworks and converting them into actionable plans for rural areas remains challenging [9]. In addition, there is a need to promote a consistent approach to the three global agendas' planning, execution, and reporting that will allow for more efficient use of resources, improved planning, and enhanced impacts of various initiatives. It will also assist in reducing future conflicts and ineffective execution of policies, allowing for the more efficient and productive achievement of shared agenda goals.

Against this backdrop and in line with sustainability and resilience, this research aims to define a framework for the future-ready development of rural regions, particularly at the Gram Panchayat level, which is a basic governing institution in Indian villages. This is in response to the country's rapidly transforming economy and the sustainability challenges faced by rural settlements. India's large and expanding economy, expected to become the third largest in the world by 2030 [10], is based on government economic reforms over the past three decades that promoted growth through liberalization, privatization, and deregulation [11]. Additionally, India has a thriving start-up environment with innovations and technology and is home to some of the world's most pioneering and dynamic companies in the IT, pharma, and renewable energy sectors. Thus, science and technology (S&T) and information and communication technology (ICT) has helped transform the country's economy from a traditional agrarian-based economy to a knowledge-based one. These efforts are also touching the transformations in rural sectors through government policies leveraging S&T innovations for safe and alternative livelihood, better service delivery, and improved quality of life for the rural populace.

Over the years, the Indian government's objectives for RD have changed from survival to safety and in recent times are focused towards sustainable development [12] across multiple sectors, including agriculture, infrastructure, microfinance, community, and environmental conservation. Resultantly, to bring the vision of sustainable RD to reality, the government of India recently suggested many policies, schemes, and programme initiatives [13]. The smart villages (SV) approach is one of them. According to different institutions and organizations, such as the United Nations Development Programme (UNDP), International Telecommunication Union (ITU), and European Union, the SV concept primarily relates to the use of S&T and ICT along with essential local assets to improve the provision of rural amenities in a highly effective manner [14]. For instance, Digital India, 2015 and the Shyama Prasad Mukherji Rurban Mission (SPMRM), 2016 are two initiatives that seek to promote sustainable RD by leveraging ICT and S&T. These initiatives aim to enhance economic, social, infrastructure, and environmental dimensions in rural areas, while also striving towards achieving the SDGs [15]. Along with the central government's initiatives, several state governments have indicated an interest in SVs, as further elaborated in Section 2.4, and are working to make them a reality through public-private partnerships [16].

The notion of SV has evolved into a globally accepted approach for enhancing the rural quality of life and addressing growing developmental concerns [17]. While SV is not a novel concept, it lacks a widely acknowledged definition. However, the concept of SV states that "local resources and technology should function as drivers for development [18], allowing education and local business possibilities, increasing health and welfare, promoting democratic involvement, and boosting the standard of living for people of rural villages" [19]. Accordingly, the innovative aspects of development are often correlated with other elements, such as the SDGs [20].These address, individually, sustainability, well-being, access to green energy, education, management of water resources, women's

and girls' empowerment, sustainable economic growth, dignified employment, ensuring resilient infrastructures, supporting innovation, and reducing inequities [21]. Thus, at its core, SV intentionally increases participatory democracy, security, and gender equality while providing clean water, sanitation facilities, a nutritional diet, and establishing efficient jobs [14].

However, applying scientific and technological instruments to transforming rural regions in India poses several challenges towards its implementation and sustenance. Several studies have expressed concern for the urbanization of rural regions as a spin-off effect of the intrinsic benefits of improved infrastructures [22,23], drawing rural populations to metropolitan areas for better jobs, and infrastructure [24], thereby straining urban resources [25] and employment opportunities [26]. The current approach to SV solely emphasizes the application of technological solutions for rural infrastructure development and fails to address all aspects of rural life comprehensively. A more holistic approach that encompasses all dimensions of rural development, such as agriculture, environment, economy, social welfare, infrastructure, and governance, is necessary; thus, intending to prevent rural-urban migration and bring rural communities toward self-sufficiency, eventually. This study postulates a SMART village (SMART-V) framework that encompasses various dimensions such as sustainable environment, manageable economy, adaptive society, responsive governance, and technological infrastructure. The SMART-V thus provides a multi-dimensional evaluation framework for establishing the local relevance of sustainable development strategies and one that can provide a basis for enhancing the performance and capacities of the local governing units at rural scale.

India is a culturally diverse and geographically expansive nation; centralised planning could only work up to a point with its one-size-fits-all approach [27]. Thus, it is required to understand what 'SMART development' is in the local community context. This research contributes to the sense perceptions of the SV by positioning it within broader conceptual experiences in sustainability and illustrating its practical implementation across several Indian villages. Subsequently, this study addresses the following research questions (RQ): RQ1: Why is there a need for a synchronised framework to address sustainable rural development (SRD)?; RQ2: What are the challenges and their implications for SRD?; RQ 3: How does the SMART-V approach aid in achieving SRD? Accordingly, the key objectives of this study are (1) to provide a guiding framework that supports the synchronization of current policies while exploring new possibilities based on local characteristics, (2) to overview the thrust area of existing RD initiatives, and (3) to highlight the role of SV in addressing the emerging challenges for SRD in developing countries such as India. By contextualizing SV within the broader conceptual framework of sustainability research, this study significantly contributes to existing knowledge on the subject. The study involves a literature survey based on a systematic review depending on the scope and objectives of the study. Along these lines, the paper is organised as follows: Section 2 sheds light on the need for innovative approaches to RD and provides an overview of the SV paradigm in the context of India's RD mission. It also explains the methodology used for literature analysis and uses problem tree analysis to explore the significance of sustainability in resolving growing challenges for RD. Section 3 proposes the synchronised SMART-V framework for achieving sustainability through objective analysis and discusses the results and recommendations in Section 4. Substantially, Section 5 summarises the key conclusions and research limitations. Finally, the paper concludes with acknowledgements and references.

2. Materials and Methods

This section outlines the methods and overview of existing literature on RD. In this section, there are four subdivisions. The first section explains how the PRISMA analysis method conducted the literature review. The second section reviews the literature on emerging concerns in SRD and the necessity for new RD paradigms. Furthermore, the concept of SV in the context of global and Indian initiatives is discussed. Likewise, in the

last subdivision, problem tree analysis (also known as situational analysis) has helped map out the drivers of causes and their effects on rural issues.

2.1. Literature Analysis

Although overview papers in the domain of smart SRD are few, there are papers from allied disciplines that review the literature in their fields. In this study, referring to RQs, a systematic review was conducted using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) method guidelines proposed by Liberati et al. (2009) [28]. Following the PRISMA guidelines, the study primarily executed search queries in the Web of Science (WOS) database, and additional high-quality online sources such as books and conference proceedings. The results of the WOS basic search are depicted in Figure 1. In this case, two independent searches were conducted in the "ALL" category using the keywords "Rural Development" and "Smart Villages". Using our set search keywords, we initially retrieved 128,276 (Rural Development: RD) and 419 (Smart Villages: SV) papers from WOS. In the context of RD, the study then modified the documents focusing on SV to filter out the search question to 'RD + SV', through which we identified 88 research documents. Secondly, to identify research studies focusing on framework formulation in the context of SV, the study applied another search query with the keywords 'SV + Framework', which identified 74 research documents. After the manual screening, the study extracted the literature database titles, and the relevant literature was determined, regardless of the field of study, year of publication, type of document, etc. Furthermore, in the next step of shortlisting research documents, the study selected 67 documents for assessment. In addition to the WOS database search, the study considered 27 other research materials and grey literature-like reports, conference papers, working papers, books, and websites for this study.
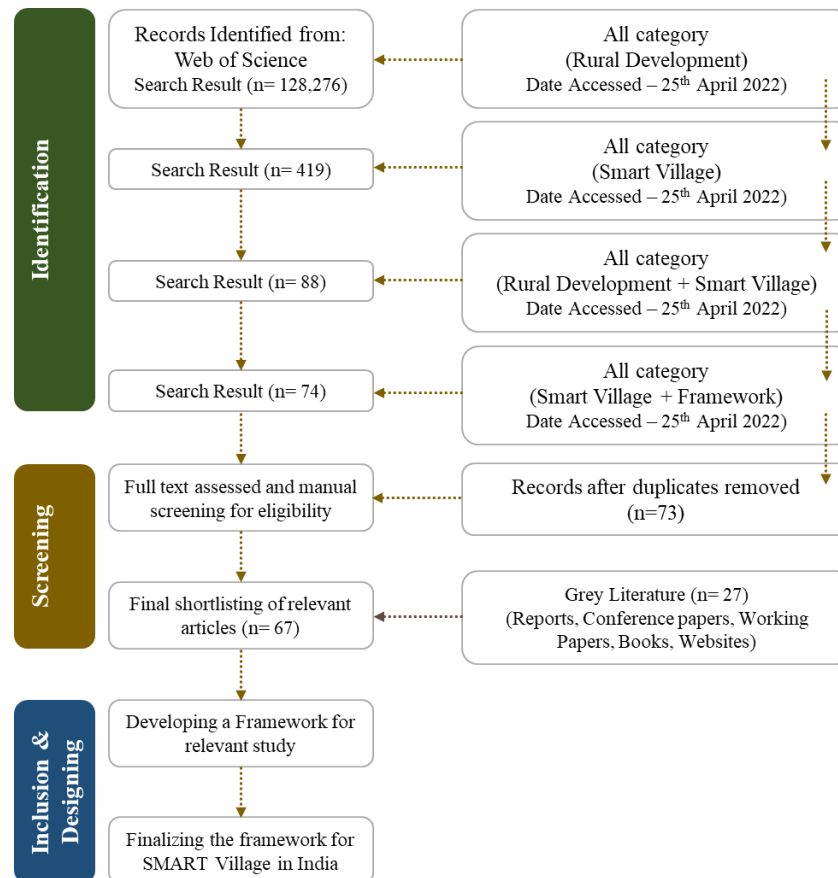

Figure 1. Prisma flow application (Source: Author, based on [28,29]).

2.2. Paradigm Changes in Rural Development

RD refers to the comprehensive development of rural regions to enhance the quality of life of rural populations [30]. In this respect, it is a broad and multidimensional notion that includes the growth of agricultural and related activities, traditional crafts, cottage industries, community services and amenities, socioeconomic infrastructure, and, most importantly, human resources in rural regions [9]. Conventionally, India's policies were centred on improving the economic and social conditions of agrarian society's vulnerable groups [31], particularly emphasising agricultural productivity [32]. However, the most recent and significant RD paradigm emphasises the multifunctional structure of rural regions and the need to ensure the sustainability of their growth [33]. Even though there are many government efforts at all levels—central, state, and local—the growth rate has not kept up with the rising requirements [34]. Separate flagship initiatives focused on various sectors, such as health (NRHM) [35], education (SSA) [36], and livelihood (NREGA, NRLM) [37,38], have already been established but have had limited success as highlighted in Table 1. If conventional rural development initiatives had been more effective, rural poverty would have been significantly reduced [39]. Perhaps, one of the rationales for the RD initiative's inadequacy has been an absence of a comprehensive emphasis on the village as a unit. Thus, conventional approaches must be redefined, and new perspectives for RD strategies must be established. The concepts and methods for assessing and managing rural change need to shift from theoretical, managerial, and centralised approaches to more constructionist, participatory, and decentralised rural change perspectives [40].

Table 1. Urban-rural divide in development sectors.

Sector	Parameters	Urban	Rural
Expenditure poverty	% People below poverty line (2011–2012) (Tendulkar estimates)	14%	26%
	% People below poverty line (2011–2012) (Rangarajan estimates)	27.2%	31.3%
Education	Literacy Rate–2011	85%	68.9%
	Avg. years of school education of working population	8.42	4.72
Health	Infant Mortality Rate–2017	23%	37%
	Life Expectancy at birth–2012–2016	72.2%	67.4%

Source: Census India 2011 [41], National Health Profile (NHP) of India-2019: Ministry of Health and Family Welfare 2016 [42,43].

Accordingly, several researchers, agencies, and international organizations have developed effective frameworks for reducing rural poverty, human slavery, and inequality, besides achieving sustainability [32]. Table 2 summarizes the progression of rural development thinking and techniques, highlighting the old paradigms based on prior policies and schemes [31], further emphasizes some of the new challenges and opportunities, and outlines some of the core characteristics of the new rural development approach for emerging villages [44].

Table 2. The paradigm shift: transformation to a new rural development.

	Old Paradigm	New Context	New Paradigm
Principles	Focus on rural areas only	Widening inequalities between rural and urban	Rural areas inextricably linked to cities, regions and national context
	Growth will follow agricultural and industrial development	Climate change	Women critical for RD
		Rapid population growth in many developing countries	Governance capacity is key
		Information revolution	
Key target Sector	Agriculture	Agriculture unable to provide sustainable livelihoods for growing populations	Multi-sectoral: all economic sectors that can contribute to productive growth: agriculture, rural industry, services, tourism, ICT, biofuels.
	Rural communities	Urban areas not able to productively absorb large inflows of rural migrants	
Main approach	Project-based	Sustainable Development Goals	Tailored to the specific context (natural, economic, social, and institutional)
	Agricultural Technology	Multi-dimensional poverty assessment and Multi-dimensional Country Review	Prioritized and realistic
	Green Revolution	Community-driven development	Well-sequenced to maximize synergies
Key actors	Agricultural ministries, agricultural research and extension, donors, local governments, and farmers	Greater participation by non-state actors including the private sector, rural communities, Civil Society Organization (CSOs) and NGOs	Multi-agent: participation and collaboration of broad set of stakeholders across public and private sectors and from national to local

Source: OECD, 2016 [44].

Considering this, a 21st-century village in India needs to incorporate specific vital themes and approaches such as sustainability, resilience, or smart village, which would be essential for its success. The new paradigm for RD must accelerate the appropriate changes required to bring us closer to the SDG goals, the fulfilment of which will be strongly intertwined with boosting rural communities' capacities, opportunities, and levels of well-being. The altered paradigm emphasizes the importance of context-specific approaches that maximize synergies between different domains of RD. Accordingly, a SV is built on the grounds of science, technology, engineering, regulations, and management to build next-generation sustainable villages [45]. A subsequent portion of the study will go into further detail about the SV Approach.

2.3. Global Interpretations on SV

S&T and ICT have demonstrated substantial opportunities for humanity's benefit in various disciplines, such as food security, livelihood potentials, energy, and capacity building, with the potential to address and serve the developing needs of locals [46]. Research in various developing countries worldwide has emphasised the potential of these technologies for RD through the SV approach, thus they will play an essential role in achieving rapid and sustainable RD in the subsequent years. For instance, the primary goal of the *IEEE Smart Village: Empowering Off-Grid Communities* [47] program, started in 2010, aims to adopt more comprehensive and inclusive approaches to delivering access to energy in rural areas, with the key consideration being how renewable energy sources

are integrated with ICT [48]. In addition to promoting their sustainability and scalability, this initiative also educates communities on constructing and designing off-grid solar power panels. South Asia, South-East Asia, East Africa, West Africa, South America, Central America, the Caribbean, and Mexico are regions where the initiative's activities are ongoing [49].

Similarly, the *Consultative Group on International Agricultural Research* (CGIAR) programme on Climate Change, Agriculture, and Food Security (CCAFS), 2011 [50], is one of the most propulsive global initiatives. They strive to reduce the climatic footprint of expanding agricultural operations while maintaining their benefits to the community while considering innovative technology and services developed in conjunction with local communities [51]. The climate-smart village is being developed and implemented within this framework in many regions, with over 30 climate-smart villages, as in New Zealand, Australia, and Thailand [45]. Likewise, the comprehensive scheme of the European Union's Smart Village Plan (2014–2020) [52] highlighted that SVs are not only for the construction of new infrastructures but also for social innovation and the building capacity of locals [53]. Additionally, since the thrust of the current study is on developing countries, experiments from South Asian countries notable from low and lower-middle-income countries (LLMIC) such as India [46], where a majority of the population lives in rural regions, the SV approach also needs to be studied.

2.4. SV Initiatives in India

Initiated with the "Digital India" Programme in 2015, the digital transformation played a vital role in improving transparent, efficient, and cost-effective rural governance [54]. The government of India and several public and private, non-governmental organizations are working on developing digital technology for rural areas [16] by providing broadband connectivity, digital literacy, and e-governance services. For instance, the availability of cashless electronic transactions aids in generating new business [55]. Similarly, India's S&T field has made a substantial contribution to the advancement of the nation's growth [56] by supporting high-level basic research and the development of novel technologies inclusive of addressing the technical needs of the average person by developing relevant skills and technology. Appropriate rural technology utilizes local or regional competence to manage local demands without relying on external influences [57]. It comprises common and affordable technologies to benefit ordinary people and their communities. However, due to the number of challenges, these digital initiatives have had minimal influence on rural people's lifestyles. There is widespread illiteracy, irregular electrical supply, substantial bandwidth concerns, financial concerns in developing ICT infrastructure, a significant shortage of skilled project leaders, and so on [58].

Different states have given other names to the SV initiatives. While the programmes' goals are similar, the initiatives' focus areas differ [59]. However, there is no compilation of how many SV have evolved or mainstreamed in India; instead, various fragmented lists and web portals are dedicated to specific villages, making it challenging to keep track of the numbers [45]. Table 3 provides further details on the different SV approaches implemented by various communities throughout India in recognised domains of RD and with their objectives. Furthermore, as rural areas vary considerably in terms of geographic location and socio-cultural diversity, effective smart interventions will necessitate a strategy tailored to the specific location [60]. Accordingly, by studying selected villages from India taking part in the government programme on SV development, the possibilities for replication or upscaling of such initiatives for other villages are contemplated. Even though no village under this approach in India has incorporated all of the components envisioned in the SMART-V, the cumulative knowledge gathered from these villagers' efforts may pave the way for gaining smartness in their particular development sectors.

Table 3. Various approaches and their objectives under different domains of SV in India.

Domain of Development	Approaches	Objectives	Examples (Villages)
Smart Environment	Planting native trees, Afforestation	Managing the built and natural environment to improve livability	Betul, Madhya Pradesh
	Reuse and Recycling of waste materials		Payvihir, Melghat, Maharashtra
	Use efficient cook stoves to reduce deforestation caused by traditional biomass energy sources such as charcoal/ wood	The reduction of waste production, monitoring and managing pollution, emission reduction, achieving energy efficiency, and accelerating the local energy transition	Anadwan, Hemalkasa, Gadchiroli, Maharashtra
	Acting as regional ecotourism hubs		
Smart Energy	Provision of clean and sustainable energy	To reduce resource depletion the use of fossil fuels needs to be reduced	Chhotkei, Odisha
	Implementation of Smart Nano grid	Need for efficient use of renewable energy sources	Odanthurai, Coimbatore, Tamil Nadu
	Use of Renewable sources of energy such as solar, wind and hydro power		Dharni, Jehanabad, Bihar
Smart Water Management	Rain Water Harvesting	To improve ground water level	Ralegaon Siddhi, Ahmednagar, Maharashtra
	Water percolation tanks		
	Dams constructed by waste Materials	To monitor, control and regulate the usage and quality of water resources as well as maintain the associated equipment	Hiware Bazar, Ahmednagar, Maharashtra
	Rejuvenate rivers		Anadwan, Hemalkasa, Maharashtra
	Drinking RO water in schools		
	Water purification Plants	To reduce water wastage	Dhanora, Dholpur Rajasthan
	Soil and water conservation		
Smart Sanitation	Individual toilets	Reducing the burden of disease	Ramchandrapur, Telangana
	Recycle and Reuse of waste water	To create environments that enhance dignity, self-esteem, and safety particularly for women and girls	
	Monitoring quality of potable water		

Table 3. *Cont.*

| Domain of Development	Approaches	Objectives	Examples (Villages)
Smart Connectivity	Integrate ICT solutions, applications, and services into smart technology solutions for various domains, such as agriculture, water management, education, and healthcare	Application for environmental monitoring	Mori Village, East Godavari, Andhra Pradesh
	To allow rural communities to become more aware of their social, economic and political rights, engage in governance processes at all levels	Involving rural communities is expected to lead to better awareness, engagement, and knowledge about their own development.	Paniyara, Uttar Pradesh
		Forming base for many entrepreneurs and start-ups within social innovation.	
Smart Agriculture/Horticulture	Infusion of technology for agriculture Practices	To gather data from the environment to monitor weather conditions	Climate SV Noorpur Bet, Punjab
	Improving capacity building of farmer	To provide benefit of allowing farmers to use a precarious resource such as water carefully.	Hiware Bazar, Ahmednagar, Maharashtra
	Improvisation in farming practices such as irrigation and crop cultivation		Eraviperoor, Kerala
Smart Health	Assisting mobile health diagnostic solutions which required relatively low levels of local medical skill	Application of health services to remote areas such as remote patient monitoring, remote medical assistance, simultaneous monitoring and reporting, notifications and alert management	Anadwan, Hemalkasa, Gadchiroli, Maharashtra
			Nandangram, Dinajpur, West Bengal
Smart Education	By introducing skill development centres run by village residents who have links with the nearby city and a reasonable degree of organizing capability	To increase students' engagement and enable teachers to adapt to students' skills, interests and learning preferences.	Paniyara, Uttar Pradesh
	By generating distance and adaptive learning which reduces the need to move to towns or cities to achieve higher levels of education.	To establish innovations centres for students/youth	Nandangram, Dinajpur, West Bengal

Source: Author, based on [59,61].

2.5. Problem Tree Analysis (PTA)

Referring to RQ2, this section focuses on the socioeconomic and environmental challenges that rural communities worldwide face. In the current context, rural populations are more vulnerable to extreme poverty, starvation, social marginalization, environmental harm, etc. [62]. The emergence of these challenges and barriers harms the person's living conditions and creates obstacles to their advancement. Accordingly, by adopting problem tree analysis [63], a structural analysis tool, the subsequent study will address some of the inevitable problems for RD and their negative consequence in Stage 1. However, Stage 2, Section 3.2 will further describe how SMART interventions can act as catalysts to overcome the challenges for the same and how further SMART-V will lead to sustainability by achieving SDGs.

PTA: Stage 1: Problem Analysis

Poverty, illiteracy, unemployment, social conflicts, homelessness, crime, and violence all lead to insecurity and threaten RD. Thus, by identifying the primary causes and their most significant impacts, PTA assists in developing a realistic perspective and knowledge of the situation [63]. Thereupon, Figure 2 illustrates Stage 1: Problem Analysis, which provides a brief of causes and their negative consequences on RD under five key development domains, namely environment, economy, social, governance, and infrastructure. It also generates a summary of the current unfavourable conditions for RD.
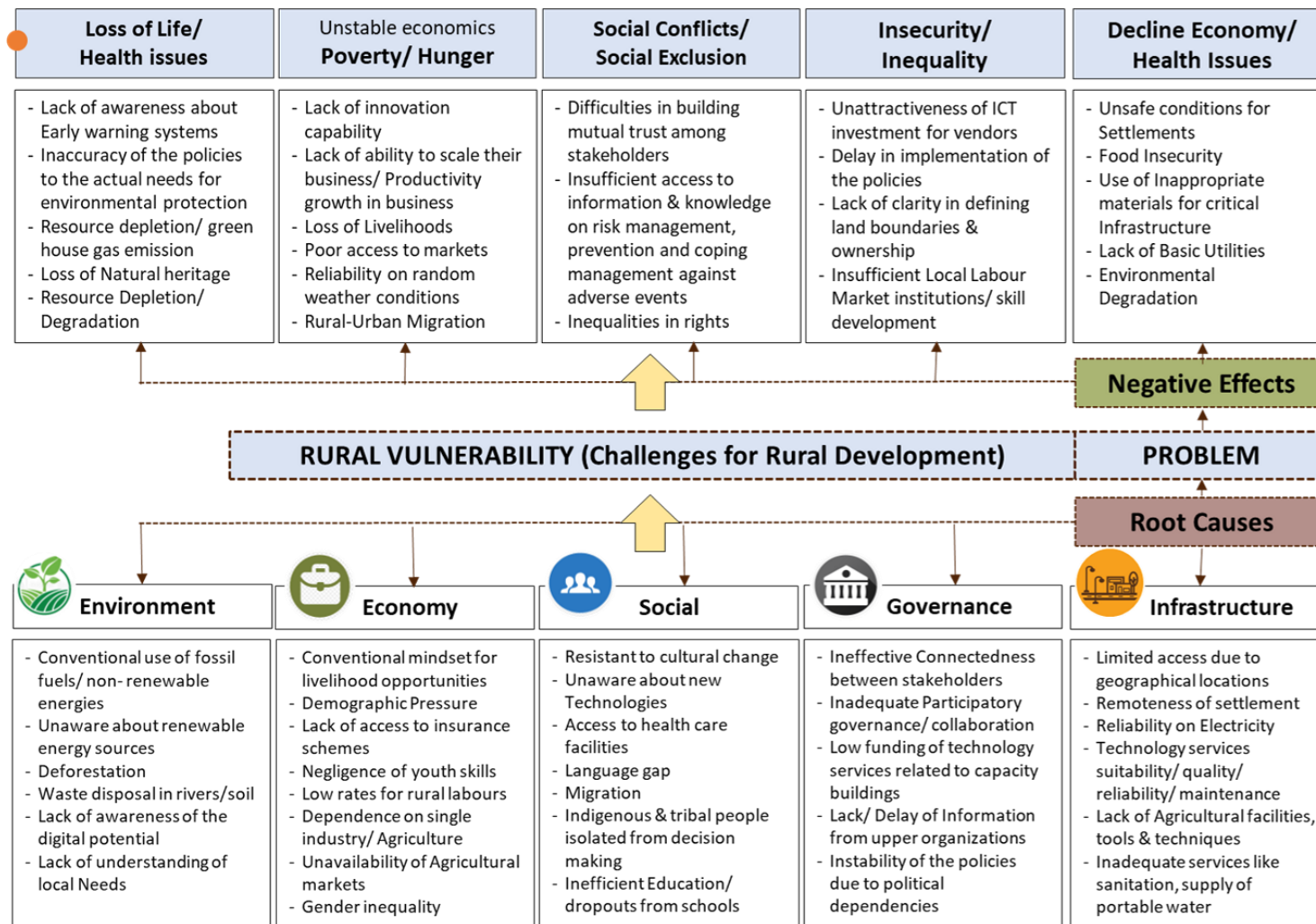
Figure 2. Stage 1-Problem Analysis—(identifying negative aspects) defines the focal problem, its immediate and direct causes, and its effects, (Source: Author, based on [63,64]).

For instance, under the infrastructure as development dimension, through the air-water-soil nexus [65], the shortage of, or inadequate attention to, public services in rural areas promotes environmental degradation [66] leading to health issues, too. Furthermore, the control of water supply, sewage, and stormwater drainage has traditionally been assigned to different agencies. Due to the lack of a comprehensive strategy to manage these closely interrelated activities, opportunities are lost for recycling and establishing a circular economy around water, energy, and materials. Similarly, limited roads or poor access to roads increase transportation costs, limit the availability of high-quality inputs, and confine the use of local markets for sales of farm products, purchases of consumer goods, and options for off-farm jobs, resulting in a lack of ability to scaleup their business. Poor road access has also restricted rural people's access to essential social infrastructures such as education and health care [67] leading to rural–urban migration.

3. Results

3.1. Strengthening the Concept of SMART Villages (SMART-V)

Referring to Section 2.5, it is evident that rural communities face complex and inter-related challenges that a single sector cannot effectively address. Adopted by this study, Figure 3 depicts the core concept of the "SMART" approach, which uses an abbreviation instead of a prefix for the word "Village". The figure showcases how the SMART approach will address the five dimensions of rural development: environment, economy, social, governance, and infrastructure. The SMART approach is sustainable, measurable, adaptable, responsible, and technological and will promote holistic development. This new approach justifies the need for more SDGs because it recognizes the interconnectedness of the various aspects of sustainable development in a coordinated manner. As mentioned above, the SMART abbreviation stands for:
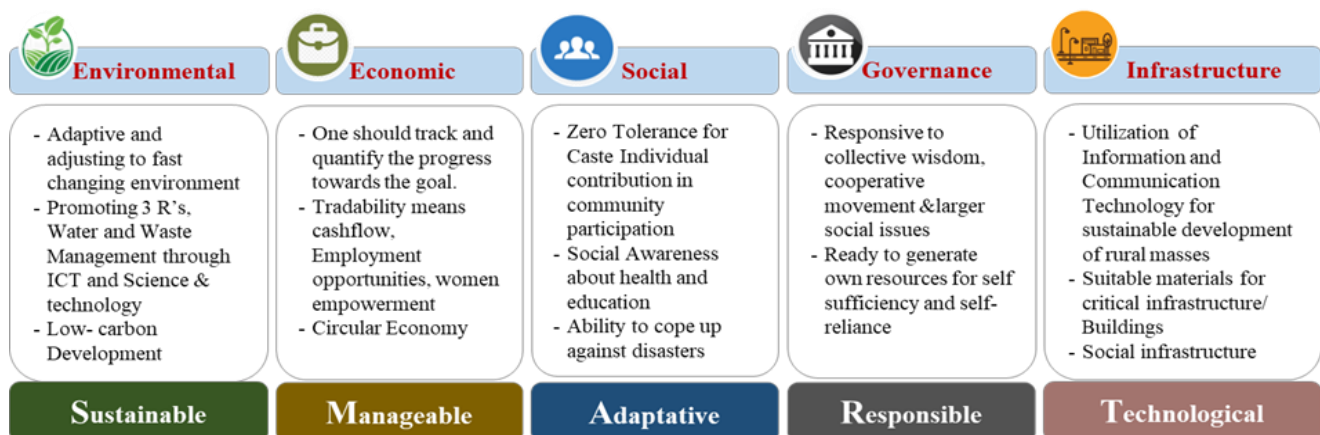
Figure 3. The fundamental concept of SMART is applied across various dimensions of RD (Source: Author, based on [68,69]).

- Sustainable Environment: Environmental sustainability should be included in RD initiatives because rural communities rely heavily on natural resources for livelihoods and growth, and because of their susceptibility to climate change and risks from energy, water scarcity, and food [70]. Likewise, increased concern about climate change and growing recognition of the necessity for low-carbon development paths should emphasize boosting access to modern energy services through renewable energy technologies [71].
- Manageable Economy: Linear economy models result in the loss of natural resources, excessive pollution, and socioeconomic inequalities [72]. Thus, integrating a circular economy may convey RD, which involves a concept or system that preserves as much of a product's added value as possible while eliminating waste. Similarly, in many rural economies, low density and declining local markets are critical barriers to

long-term stability [73]. Digitalization, for example, can provide new development prospects and potential for better and more diverse occupations in rural areas [74]. Studies anticipate that new technologies will enable rural goods and services to reach more distant markets faster and at a lower cost. Likewise, enhancing opportunities at the village level, the role of self-help groups (SHGs), women entrepreneurship that generates services and jobs, and local skill development programmes for youths will enhance the economic rate [75].

- Adaptive Society: Positive outcomes are encouraged by the ability to adapt to a quickly changing environment [76]. Globalization and digitalization are forcing society to become more complicated [77], demanding more novel solutions to problems such as natural catastrophes, communication issues, migration, inequality, and social injustice. Such losses can be avoided by including climate risks and adaption strategies in programme planning, design, and execution to minimize distress. As a result, there is a need to comprehend, address, and adapt to changes affecting people, groups, and societies.

- Responsible Governance: If implementation capacity is inadequate, a consistent and comprehensive plan will not work [78]. Building governance capacity and transparency at all levels are thus essential for an effective method. Governments that showcase responsibility and responsiveness to their population, and integrity in their reporting on the use and distribution of public resources and decision-making are identifiable as having good and responsible governance [79]. A responsible government fosters community involvement in policy and service delivery.

- Technology and Infrastructure: The infrastructure of the country is its backbone. It contributes significantly to national economic growth [80] by lowering transaction costs, boosting rural-urban links, and developing capacity, all of which are essential components of any developing nation's strategy. According to many studies, rural development depends on electricity, irrigation, water, sanitation, and road infrastructure, which may enhance productivity, savings, income, and tourism, resulting in better employment prospects and health conditions for rural people [81]. Likewise, due to technological advancements, some of the energy sources introduced in rural areas include the development of practical uses of renewable sources such as solar, wind, and waterpower, as well as the introduction of smokeless stoves. Furthermore, the study considers the health sector as one of the areas that have efficiently utilized technology, including providing clean drinking water, improving sanitation and health services, and offering low-cost balanced diets.

3.2. Achieving Sustainability through SMART Interventions

PTA: Stage 2: Objective Analysis

From Stage 1: Problem Analysis, as described in Section 2.5, the study reframed each identified problem into a desirable positive result. Accordingly, as Figure 4 discusses, an objective tree representing future SMART solutions, referring to Section 3.2, to the issues. These SMART interventions transform root causes and effects into root solutions and identify influencing entry points [63]. Thus, leveraging SMART interventions can help to address the challenges facing rural communities and promote sustainable development by achieving desired SDGs that can benefit both present and future generations.
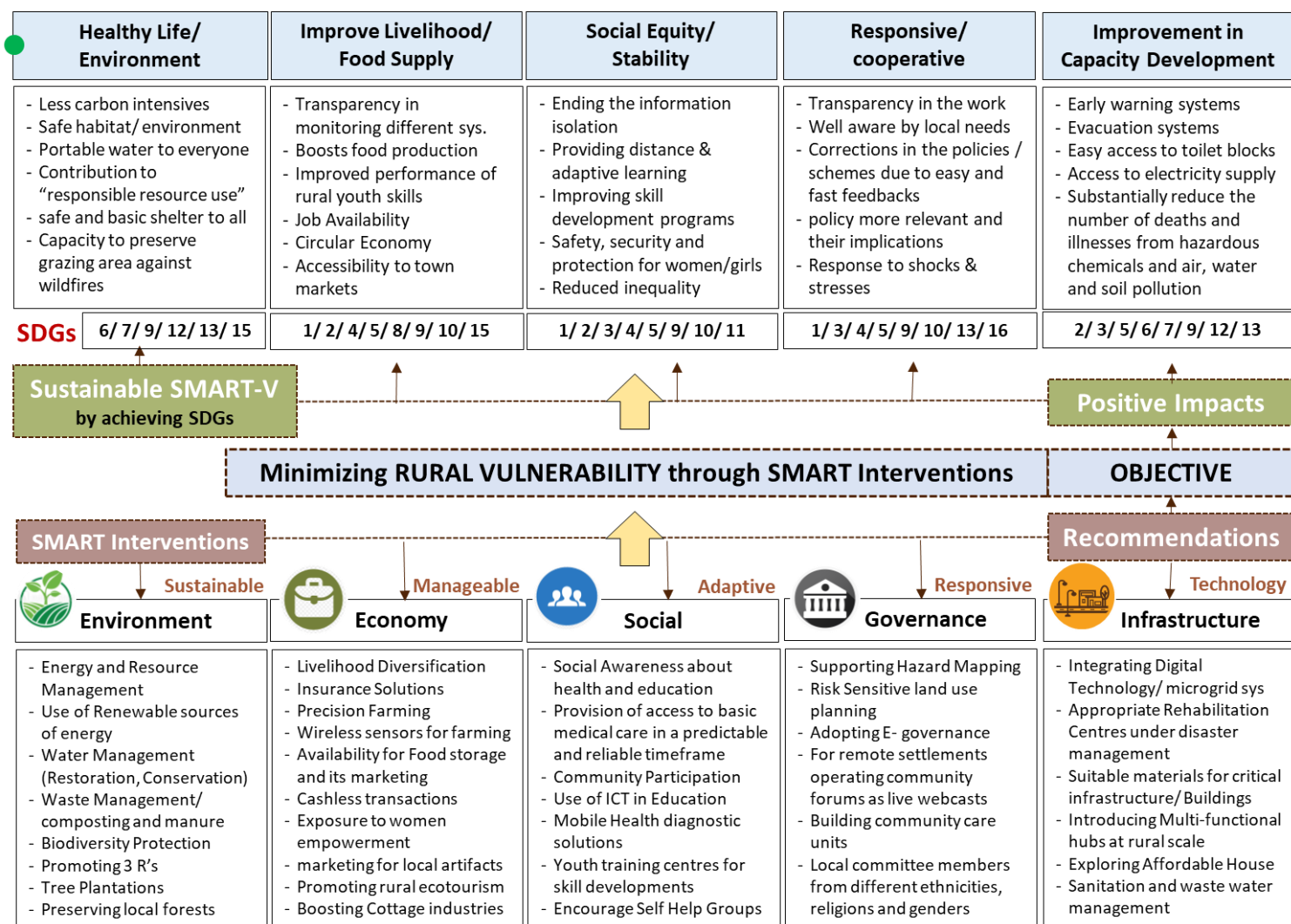
Healthy Life/ Environment	Improve Livelihood/ Food Supply	Social Equity/ Stability	Responsive/ cooperative	Improvement in Capacity Development
- Less carbon intensives - Safe habitat/ environment - Portable water to everyone - Contribution to "responsible resource use" - safe and basic shelter to all - Capacity to preserve grazing area against wildfires	- Transparency in monitoring different sys. - Boosts food production - Improved performance of rural youth skills - Job Availability - Circular Economy - Accessibility to town markets	- Ending the information isolation - Providing distance & adaptive learning - Improving skill development programs - Safety, security and protection for women/girls - Reduced inequality	- Transparency in the work - Well aware by local needs - Corrections in the policies / schemes due to easy and fast feedbacks - policy more relevant and their implications - Response to shocks & stresses	- Early warning systems - Evacuation systems - Easy access to toilet blocks - Access to electricity supply - Substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution

SDGs

6/ 7/ 9/ 12/ 13/ 15	1/ 2/ 4/ 5/ 8/ 9/ 10/ 15	1/ 2/ 3/ 4/ 5/ 9/ 10/ 11	1/ 3/ 4/ 5/ 9/ 10/ 13/ 16	2/ 3/ 5/ 6/ 7/ 9/ 12/ 13

Sustainable SMART-V by achieving SDGs

Positive Impacts

Minimizing RURAL VULNERABILITY through SMART Interventions — **OBJECTIVE**

SMART Interventions — **Recommendations**

Sustainable **Environment**	Manageable **Economy**	Adaptive **Social**	Responsive **Governance**	Technology **Infrastructure**
- Energy and Resource Management - Use of Renewable sources of energy - Water Management (Restoration, Conservation) - Waste Management/ composting and manure - Biodiversity Protection - Promoting 3 R's - Tree Plantations - Preserving local forests	- Livelihood Diversification - Insurance Solutions - Precision Farming - Wireless sensors for farming - Availability for Food storage and its marketing - Cashless transactions - Exposure to women empowerment - marketing for local artifacts - Promoting rural ecotourism - Boosting Cottage industries	- Social Awareness about health and education - Provision of access to basic medical care in a predictable and reliable timeframe - Community Participation - Use of ICT in Education - Mobile Health diagnostic solutions - Youth training centres for skill developments - Encourage Self Help Groups	- Supporting Hazard Mapping - Risk Sensitive land use planning - Adopting E- governance - For remote settlements operating community forums as live webcasts - Building community care units - Local committee members from different ethnicities, religions and genders	- Integrating Digital Technology/ microgrid sys - Appropriate Rehabilitation Centres under disaster management - Suitable materials for critical infrastructure/ Buildings - Introducing Multi-functional hubs at rural scale - Exploring Affordable House - Sanitation and waste water management

Figure 4. Stage 2-Objective Analysis (achieving SDGs through SMART interventions). (Source: Author).

For instance, the environmental dimension identifies unconventional fossil fuel use as the cause in Stage 1, leading to negative impacts such as natural resource depletion and health issues. Replacing this with the SMART intervention in stage 2 using renewable energy sources such as solar or wind can lead to zero carbon emissions, lowering pollution and paving the way towards a healthy environment. This endeavour caters to SDGs 7: Affordable and Clean Energy, 9: Industry Innovation and Infrastructure, 12: Responsive Consumption and Production, 13: Climate Action, and 15: Life on Land. Likewise, as outlined in Stage 1, ineffective connectedness between stakeholders or inadequate participatory governance leads to policy implementation delays or lack of clarity in defining work responsibilities, resulting in insecurity and inequality. In Stage 2, establishing community care units with a committee of people of various ethnicities, religions, and genders will enable the authorities to provide adequate services per local requirements [82].

3.3. Proposed SMART-V Framework (SMART-VF)

As mentioned in Section 2.2, there is a need for a synchronized framework to address SRD because rural areas face unique challenges and opportunities that require tailored solutions. Additionally, RD initiatives often involve multiple stakeholders, each with their priorities and goals, resulting in fragmented efforts and a lack of coherence. A synchronized framework can help to align these diverse efforts and ensure a more integrated approach to SRD. It can also help to avoid gaps, identify synergies, and promote a more holistic understanding of sustainability, leading to more effective and impactful outcomes.
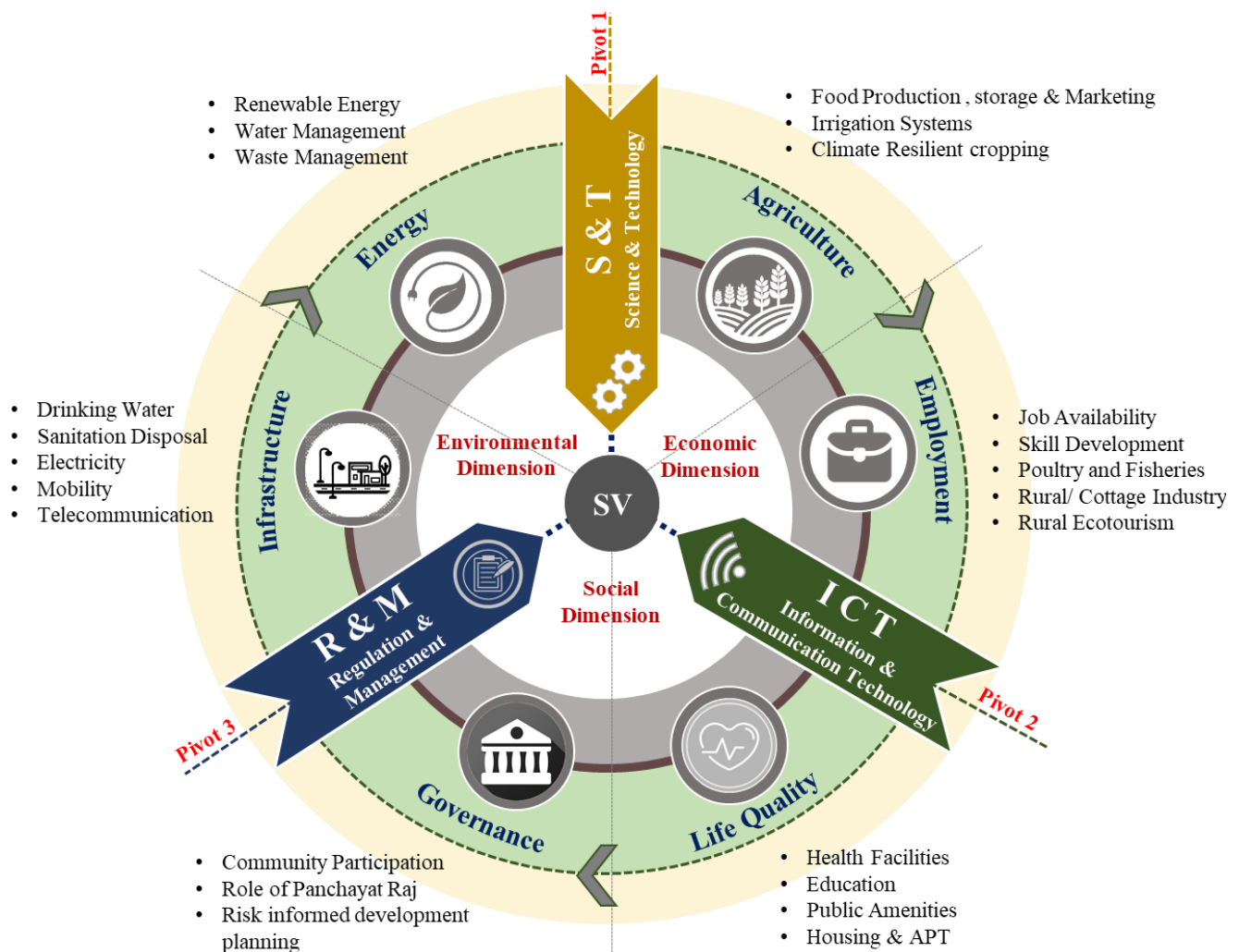
Regarding the notion of SMART-V stated in Section 3.1, we have formulated the theoretical framework for SMART-V. Considering the sustainable aspects of the economic, environmental, and social dimensions, the proposed framework may build around six key structuring elements: agriculture, governance, village services, resource management, employment, and life quality. As elaborated in Figure 5, this framework may accelerate the establishment of next-generation SMART-V by focusing on three key pivots: (a) Information and Communication Technology (ICT), (b) Science and Technology (S&T), and (c) Regulations and Management (R&M).

3.3.1. Science and Technology (S&T)

The application of S&T in rural areas has the potential to play a significant role in bringing about agricultural productivity and reinforcing resource management [83], and resolving the conflict between significant food demands and limited farmland [84]. Meanwhile, agriculture is vulnerable to natural hazards because of several unforeseeable natural calamities. Thus, relying on technology through early warning systems is essential to avoid this risk. Likewise, technological interventions in the agriculture sector, such as farm management software, precision farming, wireless sensors, climate-smart agriculture, resilient crops, and agricultural machinery [85], contribute to fulfilling the expanding population's food demand [86].

Similarly, energy is also required to achieve rural industrialization [87]. Thus, SMART-V focuses on creating and exploring alternative renewable energy sources, including hydro, solar, and wind, for electricity generation. In addition, water is one of the essential resources for any region's development. Thus, SMART-V may endeavour to enhance potable water supply in rural areas by developing and implementing S&T methods for water collection, conservation, and recycling [20]. For instance, under rainwater harvesting, improving surface runoff capacity, land surface catchment methods, borewell groundwater recharge, and percolation tanks can be used [88]. Likewise, waste management does not execute appropriately and endangers the environment and human health [89]. People in rural regions usually need more awareness and methods to properly manage solid waste, leading to harmful behaviours such as open burning or rubbish dumping [90]. Thus, implementing new S&T practices such as biowaste management techniques such as biogas, vermicomposting, anaerobic digestion, composting bins at the household level, and plastic and paper recycling plants at Gram Panchayat levels will make it so local conditions may

improve from social, environmental, and health perspectives. Analogously, these S&T initiatives call for community involvement, transfer of technology knowledge, assessment and review of existing rural systems, the use of solar energy for electrification, and so on. Furthermore, innovative and appropriate construction techniques that use local skills, materials, and resources will all help rural communities. As a result, in the dynamic SMART-VF, the technology pivot was placed as one of the critical ways of facilitating SMART initiatives.

- Renewable Energy
- Water Management
- Waste Management

- Food Production, storage & Marketing
- Irrigation Systems
- Climate Resilient cropping

- Drinking Water
- Sanitation Disposal
- Electricity
- Mobility
- Telecommunication

- Job Availability
- Skill Development
- Poultry and Fisheries
- Rural/ Cottage Industry
- Rural Ecotourism

- Community Participation
- Role of Panchayat Raj
- Risk informed development planning

- Health Facilities
- Education
- Public Amenities
- Housing & APT

Figure 5. A theoretical framework for smart village, (Source: Author).

3.3.2. Information and Communication Technology (ICT)

Meanwhile, S&T refers to a collection of techniques, skills, or methods in producing services or accomplishing objectives. In contrast, ICT is used as terminology for devices, mobiles, services, networks, and applications that range from pre-existing aids such as landlines, TVs, radios, and satellites to cutting-edge internet-era technology and sensors. ICTs serve as one of the functional pivots for the SMART-VF, accelerating economic and social growth in rural regions. People in rural areas can effectively connect with the local, regional, and national economies by using ICTs. For example, they can use banking services and access many career opportunities that would otherwise be beyond reach. ICTs can raise knowledge among the rural populace about new agricultural technology, allowing them to contribute to the country's GDP. Additionally, the numerous ICTs can help to expand education among many of the rural population and connect them effectively with their urban centres. It has aided in bridging gaps and giving access to clinical information, specialised

expertise, and health services, saving time, money, and lives [91]. Thus, narrowing the digital divide not only helps to bridge the infrastructure gap but will also bring the rural people to the mainstream for the nation's development [92]. Furthermore, access through internet ICTs can improve rural people's awareness of livelihood opportunities provided by government services [93]. As a result, ICT may enhance people's quality of life by improving their living conditions in remote and rural locations and delivering significant commercial, social, and educational advantages.

3.3.3. Regulation and Management (R&M)

Furthermore, there is a growing demand for SMART rural development administrators who can think strategically, make decisions based on prior findings, efficiently manage rural areas' resources, and enhance the possibility for regions' growth. Rural communities and non-governmental organisations (NGOs) are more courageous and accepting initiatives and attempt to promote social innovations. However, they need help making decisions about the area's development, failure to implement their ideas, and various risks associated with a short-term investment [94]. Thus, the third pivot, R&M, by local governance (Panchayat Raj) includes community involvement, transparency, enforced legal standards, majority opinion, concern and stakeholder engagement, equality for all, accountability, effectiveness and efficiency, and strategic vision. Hence, R&M can aid with this by (1) offering awareness, (2) enhancing processing efficiency, and (3) making proceedings easier.

Similarly, the necessity of the hour is a practical and thorough ICT application in e-governance that gives consolidated solutions for the rural community. SMART organisational and decision-making systems would help governments and their partners to provide better rural services equitably and inclusively, eventually enhancing the quality of life [95]. Accordingly, the SMART-VF will establish what makes a village SMART: affordable green energy, enough housing, water conservation, safe drinking water, early warning systems for extreme weather, and a probable schedule for public transportation and local physicians.

4. Discussion

4.1. Justification for the Need for SMART-V

Conventionally, above other sectors, agricultural production and resource allocation have been emphasised as the primary drivers of rural growth. While agriculture is undeniably essential in RD, the growth of non-farm industries and services can retard rural-urban migration, relieving stressors on urban centres and contributing to a more equitable allocation of resources. Thus, regarding Section 2.2, traditional practices of RD still need to address some of the most critical issues in rural regions. However, SMART-V will design to be sustainable, inclusive, and resilient, focusing on improving the quality of life for rural residents through technology and innovation. There are several fundamental reasons why SMART-V are needed:

- Closing the Digital Divide: SMART-V aims to address the digital divide between urban and rural areas by providing access to technology and digital services to rural communities. This access helps to ensure that rural residents are included in the digital age and can participate fully in the digital economy.
- Promoting Sustainable Development: SMART-V promotes sustainable development by using technology and innovation to address rural communities' challenges, such as poverty, unemployment, and environmental degradation. This SMART-V initiative helps to ensure that rural areas can meet their community's needs while preserving their natural resources for future generations.
- Improving the quality of life: SMART-V aims to improve rural residents' quality of life by providing access to essential services, such as healthcare, education, and energy and creating opportunities for economic growth and job creation.
- Enhancing resilience: SMART-V must be resilient, ensuring that rural communities can adapt to changing circumstances and recover quickly from shocks and stressors

such as climate change or political instability. The SMART-V resilience helps to ensure that rural residents can better cope with the challenges of a rapidly changing world.

Moreover, as stated in Section 2.3, SV activities in developing and underdeveloped countries primarily focus on rejuvenating rural communities through the agriculture sector or addressing inadequate resource management, basic infrastructure, and services (e.g., food, energy, education, water, and employment). In contrast to developed regions such as Europe, these efforts address the need for knowledge innovation, improved productivity, and specialisation in areas with basic infrastructure. Hence, SMART-V is a fluid concept with varying priorities rooted in existing scenarios, and the key aim is to encourage rural regions' endogenous development potential.

However, regarding Sections 3.3.1 and 3.3.2, implementing S&T and ICT would call for innovations in making them affordable and cost-effective for socio-economically weaker rural societies. Innovations in financial mechanisms could also lead to effective implementation of technology and sustainability of framework. For instance, one possible approach is to develop microfinance models tailored to the specific needs of rural communities, such as group-based lending programs that provide small loans to individuals or communities for income-generating activities. Another strategy could be to leverage mobile banking and digital payment systems to improve financial access and inclusion in remote areas where traditional banking services are lacking.

Regarding sustainable development, policies, and infrastructure investments, including decision-makers, academics, and professionals, are required to provide rural regions with the same attention and opportunity as urban ones. Furthermore, there needs to be more clarity in development initiatives due to inadequate categorization of rural areas. Take, for example, the fact that a forest community needs accessibility before it requires food security. As a result, SMART-V development strategies for forest regions will consider different factors than those for other settlements. Thus, the findings suggest that the altered paradigm emphasises the importance of context-specific approaches that maximize synergies between different domains of RD. This approach also empowers communities to take charge of their development and creates a sense of ownership and accountability.

4.2. A Way Forward: Identifying Entry Points to Achieve a Sustainable SMART-V

By addressing the entry points, it is possible to create a sustainable SV that is inclusive, resilient, and able to promote economic and social development in rural areas, to mention a few:

- Access to Technology and Digital Services: Providing access to technology and digital services is a crucial entry point for achieving a sustainable SMART-V. This access includes the installation of infrastructure, such as broadband internet, and the development of digital services and applications that can improve the delivery of essential services, such as healthcare, education, and energy.
- Skill Development: This includes training programs for rural youths in areas such as digital literacy, entrepreneurship, and innovation, as well as the development of technical skills related to technology and digital services.
- Entrepreneurship and Innovation: For sustainability, the SMART-V approach supports the development of new businesses and the commercialization of new technologies, and encourages the development of new approaches for addressing the challenges faced by rural communities.
- Community Engagement: It is another critical entry point which includes the involvement of rural residents in the planning and implementation of SMART-V projects, and ensuring that the benefits of these projects are shared equitably among all community members.
- Partnership and Collaboration: Partnerships are essential for effectively implementing the framework, including developing partnerships between the government, the private sector, civil society organizations, local NGOs, and collaboration between

community stakeholders. The Gram Panchayat can play an essential part in fostering these collaborations.

Moreover, implementation of SMART-VF for localizing SDGs at the Gram Panchayat level will require adopting a holistic approach considering the priorities of local communities, availability of resources and their mobilization, mechanisms for stakeholder engagements, capacity building for local governing units, that is, Gram Panchayat and tool for review and upgradation of various evaluation parameters. Similarly, exploring the avenues and opportunities for stakeholder engagements would assume great significance since it can evolve innovative mechanisms for policy development, implementation, and sustainability of the initiatives, including innovative financing mechanisms through partnerships. The research identifies these essential aspects that could strengthen the framework to transform rural India.

5. Conclusions

This study has gone some way toward enhancing our understanding of the SV approach. The literature review of this study indicates that over the past decades, RD programmes have seen significant changes in scope and substance, ranging from addressing food security issues to a more integrated approach to RD that includes community empowerment and natural resource preservation and management. Furthermore, this study contributes to existing knowledge of SV by providing the strategies under SMART-VF, which is a multi-dimensional approach and emphasises not just one axis of development but also all the sustainable dimensions of RD, such as environment, social, and economy, in parallel. Moreover, the formation of the SMART-V framework guides the integration of well-established concepts in sustainable development, such as green energy, circular economy, livelihood diversification, and regulating e-governance, among others. However, conventional individual approaches to RD tend to focus on specific aspects of RD, which results in ignoring their inextricable linkages. Furthermore, the research has highlighted the need for many questions of further investigations, such as identifying key entry points for the establishment of SMART-V.

Regarding Sections 2.2 and 3.1, considering dynamic circumstances such as changing rural landscape, technological advancement, climate change and environmental concerns, and demographic shifts, a reframing of the SV concept is necessary to ensure that it remains relevant and effective in addressing the challenges of RD in the 21st century. Similarly, concerning Section 3.2, SMART interventions can play a crucial role in achieving sustainability for RD by addressing challenges and promoting innovative solutions that can lead to long-term, sustainable outcomes. The SMART-V includes improving resource efficiency, promoting renewable energy, strengthening disaster resilience, enhancing access to information and services, and enhancing agricultural practices.

The research framework proposed in this paper offers the foundation for examining different research domains' knowledge bases. However, the study would like to highlight certain limitations. For instance, one such limitation is the potential challenge of implementing the framework in rural communities with limited resources and technological expertise. Future studies should use different analysis techniques to broaden this investigation and validate the results. Thus, this study will become an essential reference, allowing academicians and practitioners to comprehensively understand the concept of SV.

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