

Village-Level Sustainable Development through Improved Public Health Infrastructure: A Review

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Abstract: Sustainable village development depends not only on economic growth and physical infrastructure but also on the availability, accessibility and long-term functionality of public health infrastructure. Among the most essential components of village-level public health systems are safe drinking water, sanitation facilities, drainage networks, solid and liquid waste management, hygiene practices and community participation. In rural settlements, inadequate sanitation, poor drainage and unsafe drinking water contribute to waterborne diseases, vector-borne infections, environmental degradation, school absenteeism, reduced productivity and poor quality of life. This review paper examines the role of improved public health infrastructure in promoting sustainable village development, with special emphasis on sanitation, drainage and drinking water facilities. The paper reviews conceptual perspectives, policy initiatives, health implications, implementation challenges and sustainable strategies for village-level infrastructure development. The review indicates that sustainable rural transformation requires an integrated approach combining safe water supply, household and community sanitation, greywater management, stormwater drainage, hygiene awareness, local governance, community ownership and regular operation and maintenance. The paper concludes that improved public health infrastructure is not a supplementary component of village development; rather, it is a foundational requirement for health security, environmental sustainability and inclusive rural progress.

Keywords: Sustainable village development, sanitation, drainage, drinking water, public health infrastructure, rural development, WASH, greywater management.

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I. Introduction

Villages form the social, cultural and economic foundation of many developing countries. In India and several other rural-dominant societies, a large proportion

of the population continues to live in village settlements where agriculture, small-scale occupations, local markets and traditional social institutions shape everyday life. However, the development of a village cannot be

assessed only through roads, electricity, housing or income levels. A genuinely sustainable village must also ensure safe drinking water, effective sanitation, proper drainage, clean surroundings and healthy living conditions [1].

Public health infrastructure at the village level includes the physical and institutional systems that protect community health. These include drinking water sources, household tap connections, handpumps, overhead tanks, water-quality testing systems, household toilets, community toilets, school toilets, anganwadi sanitation facilities, drainage channels, soak pits, greywater treatment units, solid waste disposal systems and local health-awareness mechanisms. Such infrastructure directly influences the health, dignity and productivity of rural communities [2].

Sanitation, drainage and drinking water are deeply interconnected. Unsafe drinking water can cause diarrhoeal diseases and other infections. Poor sanitation can contaminate soil, groundwater and surface water. Inadequate drainage can lead to stagnant water, mosquito breeding, foul smell, waterlogging and environmental pollution. Therefore, these three sectors should not be treated as separate development activities. They must be understood as an integrated public health infrastructure system.

The concept of sustainable village development involves long-term improvement in quality of life without damaging environmental resources or excluding vulnerable sections of society. A village becomes sustainable when its infrastructure is functional, affordable, locally managed, environmentally safe and socially inclusive. Hence, the improvement of sanitation, drainage and drinking water facilities is central to rural sustainability [3].

II. Objectives of the Review

The main objectives of this review paper are:

- To examine the relationship between public health infrastructure and sustainable village development.

- To review the importance of sanitation, drainage and drinking water in rural public health.
- To identify major challenges in the implementation and maintenance of village-level health infrastructure.
- To suggest integrated and sustainable strategies for improving sanitation, drainage and drinking water systems in villages.
- To highlight the importance of community participation, local governance and behavioral change in sustaining rural infrastructure.

III. Methodology

This paper is based on a narrative review method. Secondary sources such as policy documents, reports of national and international organizations, academic studies, review articles and rural development frameworks were examined. The review focuses mainly on literature related to water, sanitation and hygiene, rural infrastructure, sustainable development, public health, drainage management, greywater treatment and community participation.

The review approach is thematic rather than statistical. Relevant literature was organized under major themes such as safe drinking water, sanitation, drainage, health outcomes, environmental sustainability, governance, behavioral change and implementation barriers. This method is useful because village-level public health infrastructure is a multidisciplinary topic involving public health, rural planning, environmental science, civil engineering, sociology and governance studies.

IV. Conceptual Framework

The conceptual framework of this review is based on the idea that sustainable village development is achieved through the interaction of four major dimensions:

Public Health Dimension

This dimension includes disease prevention, hygiene promotion, safe water consumption, toilet usage, waste disposal and reduction of environmental health risks.

When sanitation, drainage and drinking water systems function properly, the disease burden in a village is reduced.

Environmental Dimension

This dimension includes protection of groundwater, prevention of soil contamination, control of stagnant water, management of greywater, rainwater harvesting and safe disposal of waste. Environmentally sound infrastructure helps maintain ecological balance within and around the village [4].

Social Dimension

This dimension includes dignity, gender safety, school attendance, inclusion of marginalized households, participation of women, awareness among children and community ownership. Sanitation and drinking water facilities especially affect women, children, elderly persons and socially disadvantaged groups.

Governance Dimension

This dimension includes gram panchayat planning, village water and sanitation committees, operation and maintenance systems, local monitoring, financial management and convergence of government schemes. Without governance, infrastructure may be constructed but not sustained. In short, construction is the easy chapter; maintenance is the peer review from reality [5].

V. Importance of Drinking Water in Sustainable Village Development

Safe drinking water is one of the most basic requirements of human life. In rural areas, drinking water may be obtained from wells, handpumps, borewells, ponds, streams, piped systems or household tap connections. However, the availability of water alone is not sufficient. Water must be safe, adequate, accessible, affordable and reliable [6].

Unsafe drinking water can contain biological contaminants such as bacteria, viruses and parasites, or chemical contaminants such as fluoride, arsenic, nitrate, iron and heavy metals. These contaminants may cause acute and chronic health problems. Children are especially vulnerable to waterborne diseases because of

lower immunity and higher exposure to contaminated surroundings [7].

A sustainable village water system should include source protection, water-quality testing, household-level awareness, safe storage, regular supply and local maintenance. Piped water supply can reduce the time spent in collecting water, particularly for women and girls. It can also support hygiene practices such as handwashing, toilet cleaning, menstrual hygiene management and household cleanliness [8].

Drinking water infrastructure should not be planned only as a supply system. It must be part of a larger water-security framework. This includes groundwater recharge, rainwater harvesting, protection of ponds, prevention of sewage contamination and reuse of treated greywater for gardening or agriculture where appropriate. When drinking water planning ignores sustainability, the result may be source depletion, seasonal scarcity and dependence on tankers [9].

VI. Role of Sanitation in Village-Level Public Health

Sanitation refers to the safe management of human excreta, wastewater, solid waste and hygiene-related practices. In rural areas, sanitation improvement often begins with toilet construction, but sustainable sanitation requires much more than toilet availability. It requires regular use, proper maintenance, safe containment, faecal sludge management, water availability and behavioral acceptance.

Open defecation has historically been one of the major public health problems in rural areas. It can contaminate land and water sources, spread disease and reduce dignity and safety, particularly for women and girls. Household toilets improve privacy, dignity and convenience. School toilets help reduce absenteeism, especially among adolescent girls. Anganwadi sanitation facilities protect young children and improve early childhood care environments [10].

However, toilet construction alone does not automatically produce health benefits. Behavioral change is essential. Some households may continue open defecation because of habit, lack of water, poor toilet design, pit-filling concerns, social beliefs or maintenance

problems. Therefore, sanitation programmes must combine infrastructure with awareness campaigns, community mobilization and follow-up monitoring.

Sustainable sanitation also requires attention to faecal sludge and pit management. If toilets are constructed without safe containment or emptying systems, contamination risks may continue. Twin-pit toilets, septic tanks with safe desludging and decentralized treatment systems can support sanitation sustainability when properly designed and maintained [11].

VII. Drainage as a Public Health and Environmental Requirement

Drainage is often treated as a minor civil-work component in village development, but it is central to public health. Poor drainage leads to stagnant water, muddy streets, mosquito breeding, foul odor, damaged roads and contamination of household surroundings. In many villages, wastewater from kitchens, bathrooms and washing areas flows openly into streets. During the rainy season, this mixes with stormwater and creates unhygienic conditions.

A good village drainage system should manage both greywater and stormwater. Greywater is wastewater from bathing, washing utensils, washing clothes and kitchen use. It usually contains soap, organic matter, food particles and suspended solids. Though less dangerous than sewage, untreated greywater can still create environmental and health problems when discharged openly [12].

Drainage systems may include open drains, covered drains, soak pits, leach pits, kitchen gardens, sedimentation units, constructed wetlands and decentralized wastewater treatment systems. The choice depends on local soil type, groundwater level, rainfall, settlement pattern, available space and financial capacity.

In low-cost rural contexts, decentralized drainage and soakage systems may be more practical than large underground sewerage systems. However, poorly designed soak pits can fail if soil permeability is low or groundwater is high. Therefore, technical planning must be based on local hydrogeological conditions. Drainage

is a humble technology, but when ignored, it becomes a mosquito hotel with free breakfast [13].

VIII. Link between Sanitation, Drainage and Drinking Water

Sanitation, drainage and drinking water form a connected public health triangle. If one side is weak, the entire village health system becomes unstable. For example, a village may have drinking water facilities, but if drainage water stagnates near handpumps or pipelines, contamination risk increases. Similarly, household toilets may be available, but if faecal sludge is not safely managed, groundwater pollution may occur. A drainage system may exist, but if it is blocked with solid waste, wastewater will overflow and create health hazards [14].

Integrated planning is therefore essential. Water supply pipelines should be laid safely away from drains and sewage channels. Drinking water sources should be protected from contamination. Drainage channels should be regularly cleaned. Solid waste should not be allowed to enter drains. Greywater should be reused or safely disposed of. Toilets should be connected to safe containment systems.

The integration of these systems contributes to disease prevention, environmental cleanliness and community well-being. It also improves the visual appearance of the village, which has psychological and social value. Clean surroundings can increase community pride and encourage further participation in development activities [15].

IX. Public Health Outcomes of Improved Infrastructure

Improved sanitation, drainage and drinking water infrastructure can produce several positive health outcomes. These include reduction in diarrhoeal diseases, intestinal infections, skin diseases, vector-borne diseases and environmental exposure to pathogens. Clean water reduces ingestion of disease-causing organisms. Toilets reduce environmental contamination. Drainage reduces stagnant water and mosquito breeding. Waste management reduces flies, foul smell and contact with harmful materials.

Children benefit significantly from improved public health infrastructure. Repeated diarrhoeal infections can affect nutrition, growth and school attendance. Safe WASH infrastructure supports better child health and learning conditions. Women benefit through reduced time spent fetching water, improved privacy, menstrual hygiene support and greater safety. Elderly persons and persons with disabilities also benefit when facilities are accessible and located near households.

Public health infrastructure also has economic value. Healthy villagers lose fewer workdays, spend less on medical treatment and maintain better productivity. Thus, sanitation, drainage and drinking water should be considered investments rather than expenses. Preventive infrastructure is cheaper than repeated disease treatment; microbes rarely respect budget constraints.

X. Challenges in Village-Level Implementation

Despite many policy initiatives and infrastructure programmes, several challenges remain in achieving sustainable village-level public health infrastructure.

Inadequate Maintenance

Many infrastructure projects fail because maintenance is neglected. Drains become blocked, handpumps stop working, water tanks are not cleaned and toilets become unusable. Operation and maintenance must be planned from the beginning.

Behavioral Barriers

Infrastructure does not guarantee usage. Some people may resist toilet use, handwashing, waste segregation or community cleaning. Behavioral change requires repeated awareness, social motivation and local leadership.

Water Scarcity

Toilets, hygiene practices and household water use require reliable water availability. In water-scarce villages, sanitation facilities may remain underused. Sustainable water-source management is therefore essential.

Poor Technical Design

Drainage systems may fail due to wrong slope, insufficient capacity, lack of outlet, poor construction quality or unsuitable soil conditions. Technical design must be locally appropriate.

Financial Constraints

Gram panchayats may lack funds for maintenance, repairs and staff. Community contribution, user charges and convergence of schemes may help, but these must be transparent and socially acceptable.

Social Inequality

Marginalized households may be left out of infrastructure benefits. Sustainable village development must ensure inclusion of poor households, landless families, women-headed households, elderly persons and persons with disabilities.

Weak Monitoring

After construction, many systems are not monitored regularly. Without monitoring, small problems become major failures. Local monitoring committees can help identify issues early.

XI. Role of Community Participation

Community participation is one of the most important factors in sustaining village-level infrastructure. When villagers are involved in planning, construction, monitoring and maintenance, they are more likely to use and protect facilities. Participation also improves accountability because people know who is responsible for what.

Village Water and Sanitation Committees, self-help groups, youth groups, school eco-clubs and anganwadi workers can play a major role in awareness and monitoring. Women's participation is especially important because women often manage household water, hygiene and child health. Their knowledge of daily water and sanitation problems is practical and evidence-rich, even if not always written in a journal article.

Community-led planning can identify local priorities such as areas with waterlogging, households without toilets, unsafe drinking water points, blocked drains and waste dumping locations. Participatory mapping can help

prepare village sanitation and water-security plans. Such planning encourages local ownership and reduces dependence on external agencies.

XII. Role of Gram Panchayat and Local Governance

The gram panchayat is the key institution for village-level infrastructure governance. It can coordinate planning, fund allocation, implementation, monitoring and maintenance. Panchayats can also ensure convergence between rural development, health, education, water supply, sanitation and employment schemes.

A strong panchayat-level system should maintain infrastructure records, identify vulnerable households, prepare village development plans, conduct social audits and ensure regular cleaning. It should also create local rules against dumping waste into drains, damaging water points or contaminating public spaces.

Transparency is essential. Information about funds, works, contractors, beneficiaries and maintenance responsibilities should be publicly available. Social audits and gram sabha discussions can improve accountability. Local governance should not stop at construction certificates; it should continue until the infrastructure actually improves daily life.

XIII. Sustainable Strategies for Improvement

Integrated Village WASH Planning

Villages should prepare integrated WASH plans covering drinking water, sanitation, drainage, solid waste and hygiene. Planning should be based on local mapping, household surveys and seasonal risk assessment.

Safe and Reliable Drinking Water Supply

Water systems should ensure adequate quantity, regular supply, source protection and periodic testing. Household tap connections, community standposts and protected sources should be maintained properly.

Greywater Management

Greywater should not be allowed to stagnate in streets. It can be managed through soak pits, kitchen gardens,

drainage channels, filtration units or decentralized treatment systems depending on local conditions.

Climate-Resilient Drainage

Drainage systems should be designed to handle seasonal rainfall and extreme weather events. Villages vulnerable to flooding require special stormwater planning.

Behavior Change Communication

Awareness campaigns should focus on toilet use, handwashing, safe water storage, drain cleanliness, waste segregation and menstrual hygiene. Schools can act as behavior-change laboratories for the whole village.

Operation and Maintenance Funds

Every village infrastructure plan should include maintenance funds. User contributions, panchayat funds and government grants can be combined. Without maintenance finance, infrastructure slowly becomes archaeological evidence of good intentions.

Inclusion of Vulnerable Groups

Public health infrastructure should be accessible to all households. Special attention should be given to poor families, persons with disabilities, elderly people, children and socially marginalized communities.

Digital Monitoring

Mobile-based reporting, geo-tagging, water-quality records and dashboard monitoring can improve transparency. However, digital systems should support local action rather than replace community responsibility.

XIV. Discussion

The review shows that improved public health infrastructure is a fundamental requirement for sustainable village development. Sanitation, drainage and drinking water directly influence health outcomes, environmental quality, gender dignity, school participation and economic productivity. These sectors also influence each other. A drinking water system cannot remain safe if sanitation and drainage are poor.

Similarly, sanitation facilities cannot remain useful without adequate water and waste management.

The major shift required is from infrastructure creation to infrastructure sustainability. Many rural development programmes have historically focused on targets such as number of toilets constructed, number of taps provided or length of drains built. While such indicators are important, they do not fully measure sustainability. A more meaningful assessment should include functionality, usage, maintenance, water quality, environmental impact and user satisfaction.

The village must be treated as an ecosystem. Water enters the village through rainfall, groundwater, pipelines or surface sources. It is used for drinking, cooking, bathing, washing and livestock. After use, it becomes wastewater. If wastewater is not managed, it pollutes the same environment from which water is drawn. Thus, sustainable village development requires circular thinking: protect sources, use water efficiently, manage wastewater safely and recharge local resources.

Behavioral and institutional factors are as important as engineering solutions. A technically perfect drain can fail if people dump plastic waste into it. A household toilet can remain unused if behavioral acceptance is weak. A water tank can become unsafe if cleaning responsibility is unclear. Therefore, sustainable solutions must combine engineering, public health, social mobilization and governance.

XV. Policy Implications

The review suggests several policy implications:

- Rural infrastructure policies should integrate drinking water, sanitation, drainage and waste management rather than treating them as separate schemes.
- Maintenance should be made a compulsory component of every village infrastructure project.
- Panchayats should receive technical support for drainage design, water testing and greywater management.

- Community monitoring should be institutionalized through village committees and gram sabhas.
- School-based WASH education should be strengthened to create long-term behavioral change.
- Water-quality testing should be regular and publicly displayed.
- Vulnerable households should be prioritized in infrastructure access.
- Local data should be used for planning instead of uniform one-size-fits-all models.

XVI. Research Gap

Although considerable work has been done on rural sanitation and drinking water, more integrated village-level studies are needed. Many studies examine water supply, sanitation or drainage separately. However, village sustainability depends on the combined functioning of all three systems. Future research should focus on integrated public health infrastructure models, local governance mechanisms, low-cost greywater technologies, community behavior, gendered impacts and long-term maintenance outcomes.

There is also a need for village-specific empirical studies using household surveys, water-quality testing, drainage mapping, health records and participatory rural appraisal. Such studies can generate practical models for different ecological regions such as drought-prone villages, flood-prone villages, tribal villages, peri-urban villages and agrarian villages.

XVII. Conclusion

Sustainable village development cannot be achieved without strong public health infrastructure. Sanitation, drainage and drinking water are not merely basic amenities; they are core determinants of health, dignity, environmental quality and rural productivity. Safe drinking water protects communities from disease and reduces household burden. Sanitation improves dignity, hygiene and environmental safety. Drainage prevents stagnation, vector breeding and waterlogging. Together,

these systems form the foundation of a healthy and sustainable village.

The review concludes that the improvement of village-level public health infrastructure requires an integrated, participatory and maintenance-oriented approach. Infrastructure should be locally appropriate, socially inclusive, environmentally safe and institutionally supported. Community participation, gram panchayat leadership, behavioral change and regular monitoring are essential for long-term success. A sustainable village is not simply a village with constructed facilities; it is a village where those facilities function, are used by all and are maintained for future generations.

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