

Improving Delivery of Sustainable Rural Sanitation by Applying Systems Thinking

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CENTRE FOR RURAL DEVELOPMENT AND TECHNOLOGY

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Thesis

**Improving Delivery of Sustainable Rural Sanitation
by Applying Systems Thinking**

by

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Centre for Rural Development and Technology

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Certificate

It is certified that the thesis entitled " **Improving Delivery of Sustainable Rural Sanitation by Applying Systems Thinking**" being submitted by **Mr Partha Pratim Das** for award of the degree of **Doctor of Philosophy** in the Centre for Rural Development, Indian Institute of Technology Delhi, is a record of the student work carried out by him under my supervision and guidance. The matter of this thesis has not been submitted for any other degree or diploma.

Dated

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Acknowledgement

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Abstract

Sustainable sanitation remains a significant challenge in many parts of rural India, where rapid demographic shifts, resource limitations and gaps in governance are impacting sustainability of sanitation solutions and natural resources. This study applies a systems thinking approach to explore the complexities of rural sanitation service delivery by focusing on the interconnections of infrastructure, stakeholder participation and behaviour change.

A comprehensive literature review was conducted to establish the foundation of the study through four focus areas namely- sanitation interventions, issues in implementation, context-specific innovations and integration of strategies for identifying the gaps and areas of further interventions required in the existing system. The review mapped the gaps in the existing system revealing that while infrastructure-based interventions have improved the sanitation coverage of the country; usability, maintenance and long-term sustainability of sanitation facilities remain a major concern. Despite many policy-level interventions such as Swachh Bharat Mission (SBM), achieving a sustainable sanitation system requires a more holistic, multi-dimensional approach that considers not only tangible factors such as infrastructure, but also considers intangible factors such as socio-cultural behaviours, economic and environmental sustainability. Many government initiatives have been continuously working towards improving delivery of water and sanitation facilities, but failed to consider the aspects of maintenance of the facilities, waste management system, water scarcity and population growth combined with a shifting demography. Additionally, sanitation solutions often fail to account for the diverse needs of different demographic groups, such as elderly, women and people with disabilities. The study highlights the need for contextualised, user-centric approaches that integrate socio-cultural practices of the local communities along with technological advancements to create a sustainable sanitation ecosystem.

This research applies a mixed-methods approach combining qualitative and quantitative data collection methods to capture data through field studies in Uttar Pradesh and Assam, for analysing the current sanitation scenarios, user experiences and systems for policy implementation. The field study locations were selected with a motive to understand the existing scenario of the sanitation ecosystem in two regions representing distinct socio-environmental conditions. The western region of Uttar Pradesh was studied which is going through a rapid urban expansion and water contamination, while Assam with its flood-prone geography and humid climate conditions struggles with seasonal disruptions to sanitation infrastructure and crisis in water access.

The findings in these areas indicate that there are many systemic challenges that persist in the sanitation system. It is found that the waste management systems in the rural areas are still inefficient or non-existent which is increasing the risk of disease and environmental degradation. The lack of context specific strategies for stakeholders and their behaviour change leads to communities often reverting back to old habits such as open defecation considering non-functional toilet facilities or issues of water accessibility.

An Actionable Framework is proposed by the research integrating persona specific solutions and an index for sustainable systems with the use of Digital Twin technology for real-time monitoring. The research emphasises on the importance of contextualised and participatory way of problem solving through inculcation of nature centric values and awareness for ensuring long-term viability and sustainability of rural sanitation systems.

The study concludes that ensuring long-term viability of rural sanitation systems requires adoption of contextualized, behaviourally informed and nature-centric strategies that can bridge the existing gaps in sanitation service delivery to establish a sustainable sanitation system for the present and future generations of human society.

सारांश

ग्रामीण भारत के कई हिस्सों में सतत स्वच्छता अब भी एक महत्वपूर्ण चुनौती बनी हुई है, जहाँ तीव्र जनसांख्यिकीय परिवर्तन, संसाधनों की सीमाएँ और शासन-व्यवस्था में मौजूद कमियाँ स्वच्छता समाधानों तथा प्राकृतिक संसाधनों की स्थिरता को प्रभावित कर रही हैं। यह अध्ययन प्रणालियों-चिंतन (systems thinking) दृष्टिकोण का उपयोग करके ग्रामीण स्वच्छता सेवा-प्रदाय की जटिलताओं का अन्वेषण करता है, जिसमें अवसंरचना, हितधारकों की भागीदारी और व्यवहार परिवर्तन के अंतर्संबंधों पर ध्यान केंद्रित किया गया है।

अध्ययन की आधारभूमि तैयार करने के लिए एक व्यापक साहित्य समीक्षा की गई, जिसमें चार प्रमुख क्षेत्रों—स्वच्छता हस्तक्षेप, क्रियान्वयन से संबंधित समस्याएँ, संदर्भ-विशिष्ट नवाचार, तथा रणनीतियों के एकीकरण—को शामिल किया गया, ताकि मौजूदा प्रणाली में मौजूद अंतरालों और आगे के हस्तक्षेपों की आवश्यकता वाले क्षेत्रों की पहचान की जा सके। समीक्षा से यह स्पष्ट हुआ कि अवसंरचना-आधारित हस्तक्षेपों ने देश में स्वच्छता कवरेज को बढ़ाया है, फिर भी स्वच्छता सुविधाओं की उपयोगिता, रखरखाव और दीर्घकालिक स्थिरता एक प्रमुख चिंता बनी हुई है। स्वच्छ भारत मिशन (SBM) जैसे अनेक नीतिगत हस्तक्षेपों के बावजूद, एक सतत स्वच्छता प्रणाली प्राप्त करने के लिए अधिक समग्र और बहुआयामी दृष्टिकोण की आवश्यकता है, जो केवल अवसंरचना जैसे मूर्त कारकों को ही नहीं, बल्कि सामाजिक-सांस्कृतिक व्यवहार, आर्थिक स्थिरता और पर्यावरणीय स्थिरता जैसे अमूर्त कारकों को भी ध्यान में रखे। अनेक सरकारी पहलें जल और स्वच्छता सुविधाओं के विस्तार के लिए निरंतर कार्यरत रही हैं, लेकिन उन्होंने सुविधाओं के रखरखाव, अपशिष्ट प्रबंधन प्रणाली, जल संकट, तथा बदलती जनसांख्यिकी के साथ जनसंख्या-वृद्धि जैसे पहलुओं पर पर्याप्त ध्यान नहीं दिया है। इसके अतिरिक्त, स्वच्छता समाधान प्रायः वृद्धजन, महिलाएँ और दिव्यांगजन जैसे विभिन्न जनसमूहों की विविध आवश्यकताओं को समुचित रूप से संबोधित नहीं कर पाते। अध्ययन यह रेखांकित करता है कि संदर्भानुकूल, उपयोगकर्ता-केंद्रित दृष्टिकोणों की आवश्यकता है, जो स्थानीय समुदायों की सामाजिक-सांस्कृतिक प्रथाओं को तकनीकी प्रगति के साथ एकीकृत करके एक सतत स्वच्छता पारिस्थितिकी-तंत्र का निर्माण करें।

यह शोध गुणात्मक और मात्रात्मक डेटा-संग्रह विधियों को मिलाकर एक मिश्रित-पद्धति (mixed-methods) दृष्टिकोण अपनाता है, जिसके अंतर्गत उत्तर प्रदेश और असम में फील्ड अध्ययन किए गए, ताकि वर्तमान स्वच्छता परिदृश्य, उपयोगकर्ता अनुभवों और नीतिगत कार्यान्वयन प्रणालियों का विश्लेषण किया जा सके। फील्ड अध्ययन स्थलों का चयन इस उद्देश्य से किया गया था कि दो भिन्न सामाजिक-

पर्यावरणीय परिस्थितियों का प्रतिनिधित्व करने वाले क्षेत्रों में मौजूदा स्वच्छता पारिस्थितिकी-तंत्र की स्थिति को समझा जा सके। उत्तर प्रदेश के पश्चिमी क्षेत्र का अध्ययन किया गया, जो तीव्र शहरी विस्तार और जल-प्रदूषण से गुजर रहा है, जबकि असम, अपनी बाढ़-प्रवण भौगोलिक स्थिति और आर्द्र जलवायु परिस्थितियों के कारण, स्वच्छता अवसंरचना में मौसमी व्यवधानों तथा जल-उपलब्धता के संकटों से जूझ रहा है।

इन क्षेत्रों के निष्कर्ष बताते हैं कि स्वच्छता प्रणाली में अनेक प्रणालीगत चुनौतियाँ बनी हुई हैं। यह पाया गया कि ग्रामीण क्षेत्रों में अपशिष्ट प्रबंधन प्रणालियाँ अभी भी अकार्यक्षम या लगभग अनुपस्थित हैं, जिससे रोगों और पर्यावरणीय क्षरण का जोखिम बढ़ रहा है। हितधारकों के लिए संदर्भ-विशिष्ट रणनीतियों और व्यवहार परिवर्तन के अभाव के कारण समुदाय अक्सर पुरानी आदतों, जैसे खुले में शौच, की ओर लौट जाते हैं, विशेषकर तब जब शौचालय सुविधाएँ कार्यशील न हों या पानी की उपलब्धता में समस्या हो।

शोध द्वारा एक ****कार्यान्वयन योग्य रूपरेखा**** (Actionable Framework) प्रस्तावित की गई है, जिसमें व्यक्ति-विशेष (persona-specific) समाधानों, सतत प्रणालियों के लिए एक सूचकांक, तथा वास्तविक समय निगरानी के लिए डिजिटल ट्विन तकनीक के उपयोग को एकीकृत किया गया है। शोध दीर्घकालिक स्थायित्व और ग्रामीण स्वच्छता प्रणालियों की सततता सुनिश्चित करने हेतु प्रकृति-केंद्रित मूल्यों और जागरूकता के संवर्धन के माध्यम से समस्या-समाधान की संदर्भित एवं सहभागी पद्धति के महत्व पर बल देता है।

अध्ययन का निष्कर्ष है कि ग्रामीण स्वच्छता प्रणालियों की दीर्घकालिक स्थिरता सुनिश्चित करने के लिए संदर्भानुकूल, व्यवहार-आधारित और प्रकृति-केंद्रित रणनीतियों को अपनाना आवश्यक है, जो स्वच्छता सेवा-प्रदाय में विद्यमान अंतरालों को पाटकर वर्तमान और भावी मानव समाज के लिए एक सतत स्वच्छता प्रणाली स्थापित कर सकें।

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List of Abbreviations:

SDG: Sustainable Development Goals
UN: United Nations
GOI: Government of India
CRSP: Central Rural Sanitation Programme
TSC: Total Sanitation Campaign
SBM – G: Swachh Bharat Mission – Gramin
SBM – U: Swachh Bharat Mission – Urban
IHHL: Individual Household Latrine
ODF: Open Defecation Free
SLWM: Solid & Liquid Waste Management
PMAY-G: Pradhan Mantri Awas Yojna -Gramin
IEC: Information, Education, and Communication
JJM: Jal Jeevan Mission
NGO: Non-Governmental Organisation
ISC: India Sanitation Coalition
FICCI: Federation of Indian Chambers of Commerce & Industry
WASH: Water, Sanitation and Hygiene
CW: Constructed Wetland