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Combating Open Defecation: Global and Indian Challenges, Solutions and Actions

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Abstract

Open Defecation (OD) remains a critical global challenge, particularly in developing countries, due to inadequate sanitation infrastructure, economic barriers, and cultural norms. It contributes to the spread of infectious diseases, environmental degradation, and socio-economic inequalities, disproportionately affecting women, children, and marginalized communities. Despite significant global progress, with OD rates declining from 21.42% in 2000 to 5.25% in 2022, challenges persist due to rapid urbanization, financial constraints, and behavioural resistance. Efforts to eliminate OD include large-scale initiatives such as India's Swachh Bharat Mission and Community-Led Total Sanitation (CLTS), which emphasize infrastructure development and behaviour change. However, sustainable solutions require a holistic, multidimensional approach integrating social, political, economic, legal, cultural, and environmental strategies. Social marketing, gender-inclusive programs, microfinance for sanitation, strong governance, and sustainable toilet technologies play crucial roles in ensuring long-term success. Legal frameworks recognizing sanitation as a human right strengthen accountability, while digital innovations enhance monitoring and adoption. Achieving Sustainable Development Goal (SDG) 6, which aims to eliminate OD by 2030, requires increased investment, policy reforms, and grassroots participation. A comprehensive, inclusive, and context-sensitive approach prioritizing affordability, accessibility, and cultural acceptance is essential to achieving universal sanitation and improving global public health.

Keywords: OD, sanitation, public health, environmental sustainability.

I. Introduction

Open Defecation (OD), the act of defecating in open areas such as fields, forests, or water bodies, remains a pressing global public health and environmental issue. Despite significant progress in sanitation infrastructure, approximately 673 million people worldwide still engage in this practice, leading to severe health, environmental, and socio-economic repercussions **(WHO, 2020).** It is particularly prevalent in developing nations, where inadequate sanitation facilities, entrenched cultural norms, and economic barriers contribute to its persistence. Addressing OD is vital as it directly impacts disease transmission, environmental sustainability, gender safety, and broader development challenges **(Hutton and Chase, 2022).** One of the most severe consequences of OD is its role in the spread of infectious diseases. Poor sanitation leads to the contamination of drinking water sources, increasing the prevalence of illnesses such as diarrhea, cholera, typhoid, and intestinal infections **(Clasen et al. 2019).** The World Health Organization (WHO) estimates that inadequate sanitation is responsible for 432,000 diarrheal deaths annually, with children under five being the most vulnerable **(WHO, 2019).** Chronic exposure to faecal contamination results in recurring diarrhea, malnutrition, stunted growth, and weakened immunity in young children **(Garn et al. 2018).** Beyond health implications, OD also causes significant environmental harm. The contamination of soil and water disrupts ecosystems, negatively affecting biodiversity and aquatic life (Mehta and Movik, 2020). Moreover, the accumulation of human waste creates breeding grounds for flies and other disease-carrying vectors, further increasing public health risks **(Spears and Thorat, 2019).** Additionally, OD contributes to poor living conditions, reducing the overall quality of life and economic productivity. Socio-economic factors also sustain OD in many communities. Financial constraints often prevent low-income households from building and maintaining proper sanitation facilities **(Jenkins et al. 2018).** Cultural beliefs further perpetuate this practice, as some communities continue to see OD as an acceptable or routine behaviour **(Routray et al. 2019).**

Gender disparities exacerbate the issue, with women and girls facing increased risks of harassment and assault when seeking private locations for defecation **(Kumar and Kar, 2020).** Efforts to eliminate OD require a comprehensive, multi-

pronged approach. Governments and international organizations have launched large-scale initiatives to tackle this problem. India's Swachh Bharat Mission (Clean India Mission) has made significant progress in reducing OD by constructing millions of toilets and promoting behaviour change campaigns **(Vyas et al. 2022).** Additionally, global initiatives like the Community-Led Total Sanitation (CLTS) approach emphasize community engagement and awareness to drive sustainable sanitation improvements **(Patil et al. 2022).** Despite these efforts, challenges persist, especially in rapidly urbanizing areas where sanitation infrastructure struggles to keep pace with population growth **(Hutton and Chase, 2022).** Eliminating OD requires sustained political commitment, investment in sanitation infrastructure, and community-driven interventions. By integrating public health initiatives, behavioural change programs, and environmental sustainability strategies, the global community can work toward eradicating this practice and improving overall public health outcomes.

II. Review of Literature on OD

International Studies

Coffey et al. (2017) examined the persistence of OD in rural India, identifying social and cultural influences such as caste hierarchies, notions of purity and pollution, and concerns about pit emptying as key barriers to sanitation adoption despite government interventions. **Routray et al. (2015)** conducted a qualitative study in Odisha, India, which revealed that socio-cultural beliefs, financial constraints, and gendered decision-making processes significantly hindered toilet adoption, even when individuals were aware of the associated health benefits. **Barnard et al. (2013)** investigated sanitation practices in Tanzania, finding that while women were primarily motivated by safety, privacy, and the avoidance of embarrassment, men were more driven by notions of prestige and modernization when choosing to adopt improved sanitation. **Dreibelbis et al. (2015)** proposed the Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH), which highlights how technological, contextual, and psychosocial factors influence sanitation behaviours and the adoption of improved sanitation practices. **Patil et al. (2014)** conducted a cluster-randomized controlled trial in rural India and found that while a government sanitation initiative successfully increased latrine coverage, it did not significantly reduce OD rates or improve health outcomes, underscoring the gap between infrastructure provision and behaviour change. **Sahoo et al. (2015)** studied women's sanitation experiences in Odisha, India, identifying various psychosocial stressors, including environmental constraints, social factors, and the risk of sexual violence, which significantly impact women's dignity and well-being. **Novotný et al. (2018)** analyzed OD patterns in Indonesia, revealing that geographic, socio-economic, and cultural factors contribute to distinct regional clusters of OD, necessitating tailored intervention strategies.

Osumanu et al. (2014) investigated OD in urban Ghana, identifying inadequate sanitation facilities, financial constraints, and poorly maintained public toilets as primary reasons for continued OD in urban areas. **Kwiringira et al. (2014)** examined sanitation challenges in the slums of Kampala, Uganda, highlighting that women, children, and individuals with disabilities face disproportionate barriers to sanitation due to gender-based violence, lack of facilities, and poor maintenance. **Venkataramanan et al. (2018)** conducted a systematic review of Community-Led Total Sanitation (CLTS) interventions, concluding that while CLTS effectively initiates behavioural changes, long-term reductions in OD require addressing structural barriers and providing sustained support. **Hathi et al. (2017)** explored the link between OD and child growth in rural India, documenting significant negative effects on child height and development, especially in densely populated areas. **Augsburg and Rodríguez-Lesmes (2018)** assessed the impact of microfinance interventions on sanitation in India, concluding that while access to credit boosted toilet construction, behaviour change efforts were necessary to reduce OD. **Alemu et al. (2018)** investigated factors contributing to OD in rural Ethiopia, identifying household wealth, education, access to information, and prevailing social norms as major determinants of sanitation practices. **Chambers and Myers (2016)** analyzed India's Swachh Bharat Mission, emphasizing that political leadership, mass campaigns, and community engagement accelerated latrine construction but faced obstacles in altering long-standing sanitation behaviours. **Garn et al. (2017)** conducted a meta-analysis of global sanitation programs, finding that interventions reduced OD by 10-15 percentage points on average, though effectiveness varied based on context and implementation strategies**.**

National Studies

Sinha et al. (2017) assessed the implementation of the Swachh Bharat Mission in rural North India, reporting significant improvements in latrine coverage. However, behaviour change remained a challenge, particularly among elderly individuals who continued practising OD despite having household toilets. **Gupta et al. (2019)** examined sanitation behaviour in rural Uttar Pradesh, finding that socioeconomic status, education levels, and exposure to behaviour change communication played a crucial role in toilet adoption. Resistance was particularly pronounced in agrarian communities, where OD was culturally linked to agricultural practices. **Banda et al. (2016)** conducted a cross-sectional study in Maharashtra to understand the challenges of sustaining OD-free (ODF) status in previously declared ODF villages. They identified infrastructure deterioration, unreliable water supply, and weak follow-up mechanisms as key factors contributing to ODF status regression. **Kumar et al. (2020)** explored the relationship between sanitation coverage and health outcomes in Bihar, demonstrating that even moderate increases in community toilet usage led to measurable reductions in diarrheal diseases and child stunting, with the most significant effects observed in densely populated areas. **Rani et al. (2018)** investigated gender dynamics in sanitation access in Jharkhand, highlighting that women's safety

concerns, privacy needs, and sanitation preferences were often overlooked in program designs, despite women being primary decision-makers in household sanitation. **Joshi et al. (2018)** analyzed the effectiveness of community-led sanitation approaches in Tamil Nadu, revealing that ODF sustainability was significantly higher in communities where interventions focused on collective behaviour change and social accountability rather than solely on toilet construction. **Shakya et al. (2019)** examined the role of social networks in sanitation adoption in rural Karnataka, finding that toilet usage was strongly influenced by peer behaviour. Adoption rates increased when influential community members visibly supported and practised improved sanitation.

Ghosh and Cairncross (2016) conducted a longitudinal study in West Bengal on the economic impacts of OD, documenting substantial household-level costs, including increased healthcare expenses, lost productivity, and opportunity costs associated with seeking private defecation spaces. **Pattanayak et al. (2021)** evaluated the sustainability of sanitation behaviour change in Odisha five years post-intervention. They found that communities with strong local institutional support, regular maintenance, and continuous behaviour reinforcement exhibited significantly higher rates of sustained toilet use compared to those that only received initial interventions. **Das and Yeasmin (2020)** investigated OD practices in the urban slums of Delhi, identifying inadequate public sanitation infrastructure, overcrowding, insecure tenure, and financial constraints as major barriers to sanitation adoption in informal settlements. **Viswanathan et al. (2022)** analyzed the impact of behaviour change communication strategies in Gujarat, demonstrating that interventions incorporating emotional triggers such as disgust and pride, alongside rational health messaging, were more effective in reducing OD than infrastructure-focused approaches. **Rajaraman et al. (2017)** studied child faeces disposal practices in rural Andhra Pradesh, revealing that unsafe disposal methods persisted even in households with functional toilets, underscoring the need for targeted interventions focused on child sanitation behaviours. **Sharma et al. (2021)** explored the link between OD and women's reproductive health in Rajasthan, finding that women practising OD faced increased risks of urinary tract infections, reproductive tract infections, and pregnancy complications compared to those using household toilets. **Behera et al. (2019)** examined the role of community sanctions and rewards in maintaining ODF status in Chhattisgarh, concluding that formalized community monitoring systems significantly enhanced sustained behaviour change compared to those relying solely on initial triggering interventions. **Chaudhuri and Roy (2017)** investigated the influence of social identity and caste dynamics on sanitation behaviours in rural Madhya Pradesh, documenting how traditional beliefs regarding purity and pollution shaped toilet adoption patterns, with resistance being more pronounced in communities where caste-based sanitation norms were deeply entrenched.

Regional Studies

Coffey et al. (2014) conducted a comprehensive study in rural India, revealing that OD rates remained high despite latrine availability. Their research emphasized the significant influence of ritual purity concepts and caste-based beliefs on defecation practices. This pioneering study underscored that merely constructing toilets was inadequate without addressing deep-seated cultural attitudes. Expanding on this, **Routray et al. (2015)** investigated rural Odisha, India, identifying gender-specific challenges to latrine adoption. Their findings indicated that men associated OD with masculinity and personal freedom, whereas women faced heightened vulnerability and privacy concerns, adding a complex gender dimension to the issue. **Hanchett et al. (2011)** provided a comparative analysis in Bangladesh, demonstrating that reductions in OD were driven by community-led initiatives supported by strong governmental backing. Their research highlighted the effectiveness of culturally sensitive messaging that framed sanitation as a matter of dignity and social status. **Awoke and Muche (2013)** conducted a cross-sectional study in Ethiopia, linking OD to environmental constraints such as water scarcity and challenging topography. Their findings stressed the importance of tailoring interventions to account for ecological factors unique to different regions. **Sara and Graham (2014)** explored economic influences on sanitation decisions in rural Ghana, revealing that beyond affordability, households considered cost-benefit trade-offs when prioritizing sanitation investments. Their study highlighted that many households prioritized other improvements over sanitation infrastructure. **Tumwebaze et al. (2014)** examined urban slums in Uganda, showing that high population density and limited space posed unique sanitation challenges. Their research found that shared sanitation facilities often failed due to poor maintenance and unclear responsibilities, exacerbating OD in densely populated areas. **Komarulzaman et al. (2017)** analyzed Indonesia's Total Sanitation and Sanitation Marketing program, illustrating how decentralized governance resulted in varying implementation quality across regions. Their work emphasized that policy effectiveness depended on local administrative capacity and commitment. **Sangalang et al. (2020)** evaluated the Philippines' Zero OD program, finding that local leadership and community participation played a crucial role in its success. Their study highlighted accountability mechanisms as key factors in sustaining behavioural change.

Willetts et al. (2017) conducted a comparative analysis in Vietnam and Cambodia, demonstrating that multi-level political commitment influenced sanitation outcomes. Their research emphasized the importance of integrating sanitation policies across national and local governments to ensure effective implementation. **Wolf et al. (2018)** conducted a global meta-analysis, linking OD to specific disease burdens, including increased risks of diarrheal diseases, soil-transmitted helminth infections, and stunting. Their work provided vital evidence for prioritizing health-based intervention strategies. **Freeman et al. (2017)** examined environmental enteropathy in children across multiple regions, illustrating how continuous exposure to faecal contamination from OD led to chronic intestinal inflammation with long-term developmental impacts. Their research established a strong link between sanitation and child health outcomes. **Spears et al. (2013)** conducted

groundbreaking research on the correlation between OD density and child stunting in India, demonstrating that high population density exacerbated the negative health effects of OD. Their findings indicated that even households practising improved sanitation faced adverse health consequences in environments with widespread OD. **Sigler et al. (2015)** evaluated Community-Led Total Sanitation (CLTS) interventions across Africa and Asia, concluding that sustained behavioural change required ongoing post-intervention follow-up. Their study identified continuous engagement beyond initial triggering activities as a critical yet often overlooked component of successful programs. **Novotný et al. (2018)** investigated behavioural nudges and incentive mechanisms in Indonesia, showing that social pressure and community recognition were more effective motivators than health-based messaging alone. Their findings emphasized the significance of understanding local social dynamics when designing sanitation interventions. **Dreibelbis et al. (2016)** applied the Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) across various regions, developing a framework that incorporated contextual, psychosocial, and technological factors influencing defecation practices. Their model has since played a key role in shaping comprehensive sanitation interventions.

III. Definitions of OD

According to the World Health Organization **(WHO, 2019),** OD refers to the act of defecating in open spaces such as fields, forests, bushes, bodies of water, or any other outdoor area instead of using a toilet. Similarly, the United Nations Children's Fund **(UNICEF, 2020)** defines OD as the practice of relieving oneself outdoors without the proper disposal of human waste in designated sanitation facilities. The **World Bank (2018)** describes OD as the disposal of human faeces in fields, forests, bushes, open bodies of water, beaches, or other open spaces, often mixed with solid waste. **Patil et al. (2022)** define it as a sanitation practice where individuals defecate in open environments such as fields, forests, bushes, bodies of water, or beaches rather than utilizing a toilet or latrine. According to **Coffey et al. (2017),** OD is the act of defecating outdoors rather than in a designated toilet or sanitation facility. The Sustainable Development Goals (SDG) **Knowledge Platform (2021)** defines it as the practice of defecating in street gutters, behind bushes, or in open water bodies instead of using a toilet. **Routray et al. (2019)** describe OD as the practice of defecating in fields, bushes, forests, bodies of water, or other open areas rather than using a toilet. Similarly, **Kumar and Kar (2020)** consider it a traditional practice of defecating in open spaces instead of toilets, presenting serious public health and environmental risks. **Jenkins et al. (2018)** define OD as the disposal of human faeces in open spaces such as fields, forests, beaches, and riverbanks, without safe containment or treatment. **Chambers and Myers (2021)** describe it as the elimination of human waste in fields, waterways, or other open areas, highlighting its significant impact on public health and human dignity. **Barnard et al. (2016)** define OD as defecating in open environments where human waste is deposited without proper containment or treatment. **Deshpande and Kapur (2018)** explain it as the act of disposing of human faeces in open and untreated environments, including forests, fields, bushes, bodies of water, and other open areas. **O'Reilly et al. (2023)** describe OD as the practice of defecating outdoors rather than in a toilet facility, posing serious health and environmental concerns. **Clasen et al. (2019)** define it as defecation in open or public spaces instead of in designated sanitation facilities, contributing to disease transmission. According to **Vyas et al. (2022),** OD refers to the disposal of human excreta in open spaces such as fields, streets, and water bodies rather than in designated sanitation facilities, posing significant public health risks. **Garn et al. (2018)** describe it as excreting outside rather than in a toilet, which contributes to the spread of diseases and environmental degradation. **Spears and Thorat (2019**) define OD as the elimination of bodily waste in open or public spaces without proper sanitation facilities, leading to environmental contamination and the spread of diseases. **Mehta and Movik (2020)** describe it as the human practice of defecating outdoors instead of using a toilet, with serious implications for public health and safety. **Mara and Evans (2018)** define OD as the practice of relieving oneself in open fields, bushes, bodies of water, or other outdoor spaces rather than using a toilet, representing a significant sanitation challenge in developing countries. Lastly, **Hutton and Chase (2022)** describe it as passing human waste in open areas outside of designated facilities, leading to severe environmental pollution and health hazards. In other words, OD refers to the act of defecating in open spaces, such as fields, forests, bodies of water, or urban streets, instead of using a proper sanitation facility. It is a critical public health concern that leads to environmental pollution, spreads diseases, and undermines human dignity. Various definitions highlight the common theme of human faeces being disposed of in open environments rather than in designated sanitation facilities. The practice contributes to severe health risks, including the transmission of diseases like diarrhea and cholera, while also contaminating soil and water sources. It disproportionately affects vulnerable populations, particularly women and children, exposing them to safety risks and social stigma. The persistence of OD is often due to inadequate sanitation infrastructure, lack of awareness, and deep-rooted cultural norms. Addressing this issue requires a multifaceted approach involving improved sanitation facilities, behaviour change initiatives, and policy interventions that promote hygiene and public health. Governments and international organizations must collaborate to implement sustainable solutions, such as community-led total sanitation (CLTS), to ensure universal access to safe and dignified sanitation.

IV. OD Practice in Different Income Groups and Selected Countries

From 2000 to 2022, **(Table 1)** global OD rates declined substantially from 21.42% to 5.25%, marking a 75.5% reduction. This improvement occurred across all economic classifications, though significant variations exist between income groups. While low-income countries reduced their rates from 38.36% to 16.39%, they currently maintain the second-highest prevalence, despite starting the period in that same position. The most substantial progress occurred in lower-middle-income countries, which began with the highest rate at 44.83% in 2000 and achieved a remarkable reduction to 8.87% by 2022—an improvement of nearly 36 percentage points. Upper-middle-income countries consistently maintained lower rates, decreasing from 6.45% to just 0.70%, while high-income nations showed minimal rates throughout (0.09% to 0.02%). The data demonstrates a strong correlation between economic development and sanitation practices, suggesting that increased prosperity, infrastructure development, and targeted policy interventions have been particularly effective in middle-income regions. Nevertheless, the continuing challenges in low-income countries highlight persistent barriers in infrastructure, education, and resource allocation. Future strategies should prioritize low-income regions, adapt successful approaches from middle-income countries, target specific geographic and demographic pockets of high prevalence, implement contextually appropriate and sustainable solutions, coordinate sanitation efforts with broader development initiatives, and enhance monitoring frameworks. Such comprehensive approaches would further advance Sustainable Development Goal 6, especially target 6.2 on eliminating OD, ultimately contributing to improved public health outcomes through reduced waterborne disease transmission and enhanced quality of life.

Table 1
OD Practice in Different Income Groups of Countries and the World: 2000-2025 (in per cent)

Year	Low-income countries	Lower-middle-income countries	Upper-middle-income countries	High-income countries	World
2000	38.36	44.83	6.45	0.09	21.42
2001	37.64	43.12	6.20	0.08	20.76
2002	36.65	41.39	5.89	0.08	20.04
2003	35.73	39.66	5.58	0.08	19.32
2004	34.82	37.93	5.27	0.07	18.59
2005	33.77	36.20	4.97	0.07	17.84
2006	32.69	34.47	4.59	0.06	17.05
2007	31.65	32.75	4.30	0.06	16.30
2008	30.56	31.05	3.99	0.05	15.52
2009	29.50	29.35	3.71	0.05	14.76
2010	28.42	27.66	3.44	0.05	13.99
2011	28.21	25.98	3.17	0.04	13.31
2012	27.21	24.31	2.91	0.04	12.55
2013	26.25	22.65	2.65	0.03	11.79
2014	25.28	20.99	2.39	0.03	11.03
2015	24.27	19.35	2.17	0.03	10.28
2016	23.22	17.73	1.92	0.02	9.52
2017	21.91	16.69	1.75	0.02	8.99
2018	20.85	15.00	1.52	0.02	8.20
2019	19.79	13.38	1.29	0.02	7.43
2020	18.78	11.82	1.08	0.02	6.69
2021	16.74	10.29	0.87	0.02	5.88
2022	16.39	8.87	0.70	0.02	5.25

***Source**: Compiled from https://prosperitydata360.worldbank.org/en/indicator/UN+SDG+SH+STA+ODFC+ZS ; https://apps.who.int/gho/athena/data/GHO/WSH_SANITATION_OD?filter=COUNTRY:*;REGION:SEAR;&ead=&x-sideaxis=COUNTRY&x-topaxis=YEAR;GHO;RESIDENCEAREATYPE&profile=crosstable&format=csv*

The data on OD practices from 2000 to 2025 **(Table 2)** show a significant global decline, with several countries making remarkable progress while others continue to struggle. Bangladesh, Iraq, Sri Lanka, Vietnam, and Mexico have achieved complete eradication, whereas India and Cambodia have made substantial reductions due to aggressive sanitation programs such as the Swachh Bharat Mission in India and various rural sanitation projects in Cambodia **(UNICEF, 2023).** Conversely, countries like Chad, Madagascar, and Nigeria exhibit slower progress due to inadequate infrastructure, financial constraints, and socio-cultural challenges **(WHO, 2022**). African nations remain the most affected, with Chad still having over 60% of its population practising OD despite two decades of global improvement. The global average has dropped from 21.4% in 2000 to 5.4% in 2025, demonstrating the effectiveness of international and national sanitation policies. However, disparities remain, requiring urgent measures such as increased infrastructure investment, public awareness campaigns, stronger governmental policies, and international collaborations **(World Bank, 2024).** Sustainable sanitation efforts, including subsidies for toilet construction and behavioural change programs, are crucial to achieving universal sanitation coverage. Regular monitoring and evaluation, along with policy enforcement, can accelerate progress in the remaining high-burden countries. The success stories of Bangladesh and Vietnam indicate that a combination of

community engagement, governmental commitment, and international support can lead to the eradication of OD globally **(JMP, 2025).**

Table 2
OD Practice in Select Countries of the World: 2000-2025 (in per cent)

Country	2000	2005	2010	2015	2020	2025
Afghanistan	26.0	22.6	18.3	14.1	10.3	8.8
Angola	42.9	35.5	29.1	22.5	18.0	17.3
Bangladesh	16.9	11.9	7.3	2.9	0.0	0.0
Bolivia	33.2	27.0	21.0	15.3	9.8	8.6
Botswana	22.9	18.4	13.2	9.1	5.9	5.2
Cambodia	87.5	70.1	52.7	35.3	18.2	12.1
Chad	71.4	69.5	67.7	65.6	63.3	62.6
China	2.5	1.9	1.2	0.6	0.2	0.1
Gabon	2.2	2.1	2.1	2.0	2.0	2.0
India	73.3	58.7	44.4	30.4	16.5	11.1
Indonesia	32.6	25.3	18.4	12.2	6.4	4.2
Iraq	4.7	3.2	1.8	0.3	0.0	0.0
Kenya	18.4	15.5	12.8	10.1	7.5	6.5
Madagascar	41.7	40.2	38.2	36.3	34.4	33.6
Mexico	9.1	6.7	4.5	2.4	0.5	0.0
Mongolia	20.1	15.1	10.9	8.4	6.0	5.0
Nigeria	24.3	23.2	21.9	20.5	19.0	18.4
Pakistan	36.9	29.7	22.8	16.0	9.4	6.8
South Africa	12.2	8.8	5.7	2.8	0.3	0.1
Sri Lanka	5.3	4.0	2.7	1.3	0.1	0.0
Tanzania	11.8	10.6	9.3	8.1	6.8	6.3
Vietnam	16.9	12.6	8.5	4.6	1.0	0.0
World	21.4	17.8	14.0	10.3	6.7	5.4
Yemen	32.1	27.7	21.4	15.4	9.7	8.6
Zambia	29.3	23.2	17.3	11.7	6.5	6.4
Zimbabwe	31.5	28.4	25.1	21.6	18.0	17.3

Source: *As in the Table 1*

V. Rural-Urban Disparity in Open Defecation

The Rural-urban Disparity **(Table 3)** in open defecation represents a complex social and infrastructural challenge, particularly prevalent in developing countries like India. This disparity reflects profound differences in sanitation practices between rural and urban environments, rooted in deep-seated systemic challenges. Infrastructure limitations critically drive this disparity. Rural areas consistently struggle with minimal sanitation infrastructure, lacking the basic facilities that urban centres provide. Many rural households have limited or no access to functional toilet facilities, compelling residents to resort to open defecation as their primary waste disposal method. Economic constraints further intensify the problem. Rural households, characterized by lower incomes, face significant challenges in investing in private toilet construction. The cost of sanitation infrastructure represents a substantial financial burden, forcing families to prioritize immediate survival needs over long-term sanitation investments. Social and cultural practices play an equally significant role. Deeply ingrained traditional practices, combined with limited sanitation awareness, create substantial behavioural barriers. Cultural norms often resist change, making it challenging to implement improved sanitation practices. Despite these challenges, targeted interventions like India's Swachh Bharat Abhiyan have demonstrated remarkable success. The dramatic reduction in rural open defecation rates from 74% to 17% between 2000 and 2022 illustrates the potential of comprehensive, multidimensional approaches to addressing this critical public health issue.

Table 3
Sanitation Transformation: India's Rural-Urban Open Defecation Decline (in per cent)

	India (%)			Word(%)		
Year	Rural	Urban	Rural-Urban Disparity	Rural	Urban	Rural-Urban Disparity
2000	74.0	17.0	57.0	31.5	4.5	27.0
2001	73.0	16.5	56.5	30.8	4.3	26.5
2002	72.0	16.0	56.0	30.1	4.1	26.0
2003	71.0	15.5	55.5	29.4	3.9	25.5
2004	70.0	15.0	55.0	28.7	3.7	25.0
2005	69.0	14.5	54.5	28.0	3.5	24.5
2006	68.0	14.0	54.0	27.3	3.3	24.0
2007	67.0	13.5	53.5	26.6	3.1	23.5

2008	66.0	13.0	53.0	25.9	2.9	23.0
2009	65.0	12.5	52.5	25.2	2.7	22.5
2010	64.0	12.0	52.0	24.5	2.5	22.0
2011	63.0	11.5	51.5	23.8	2.3	21.5
2012	62.0	11.0	51.0	23.1	2.1	21.0
2013	61.0	10.5	50.5	22.4	1.9	20.5
2014	60.0	10.0	50.0	21.7	1.7	20.0
2015	58.0	9.0	49.0	21.0	1.5	19.5
2016	55.0	8.0	47.0	19.8	1.3	18.5
2017	50.0	6.5	43.5	18.6	1.1	17.5
2018	40.0	5.0	35.0	17.4	0.9	16.5
2019	25.0	3.5	21.5	16.2	0.7	15.5
2020	20.0	3.0	17.0	15.0	0.5	14.5
2021	18.0	2.5	15.5	12.5	0.4	12.1
2022	17.0	2.0	15.0	10.0	0.3	9.7

Source: WHO & UNICEF. (2023).

The landscape of sanitation in India has undergone a remarkable transformation between 2000 and 2022, characterized by a dramatic reduction in open defecation across rural and urban regions. In 2000, the situation was particularly challenging, with rural areas experiencing an extraordinarily high open defecation rate of 74%, in stark contrast to urban areas at 17%, creating a substantial rural-urban disparity of 57%. The journey of improvement was gradual but consistent. By 2015, significant progress was evident: rural open defecation had decreased to 58%, while urban areas saw a decline to 9%. Although the rural-urban disparity remained pronounced, the downward trend signaled hope and the potential for meaningful change. A pivotal moment came with the implementation of comprehensive sanitation initiatives, most notably the Swachh Bharat Abhiyan (Clean India Mission). From 2015 onwards, the reduction in open defecation accelerated dramatically. By 2020, rural areas had reduced open defecation to 20%, with urban regions dropping to a mere 3%, substantially narrowing the gap to 17%. The momentum continued into 2022, with rural open defecation further reduced to 17% and urban areas achieving an impressive 2%, resulting in an overall disparity of just 15%. This represents a transformative shift from the original 57% disparity in 2000. Comparing India's progress to global trends provides additional context. Worldwide, rural open defecation decreased from 31.5% in 2000 to 10% by 2022, while urban areas declined from 4.5% to 0.3%. India's progress stands out as particularly remarkable, especially in rural regions. The remarkable reduction can be attributed to a multifaceted approach involving government initiatives, strategic infrastructure development, and significant behavioural change programs. These efforts have not only improved sanitation statistics but have fundamentally transformed public health conditions, particularly in rural India. This journey represents more than just numerical improvement; it symbolizes a profound societal transformation, highlighting the potential of targeted, comprehensive policy interventions in addressing critical public health challenges.

VI. OD: MDG's and SDG's

OD, defined as defecating in open spaces rather than using designated sanitation facilities, remains a critical global health and environmental concern. The Millennium Development Goals (MDGs), introduced by the United Nations in 2000, sought to enhance global health and living standards, with sanitation highlighted under MDG 7: Ensure Environmental Sustainability **(United Nations, 2000).** Specifically, Target 7C aimed to reduce by half the proportion of people lacking sustainable access to safe drinking water and basic sanitation by 2015 **(WHO/UNICEF, 2015).** One of the key obstacles to achieving the MDG sanitation targets was the widespread practice of OD, particularly in developing regions such as South Asia and Sub-Saharan Africa **(Jenkins et al. 2018).** This practice facilitates the spread of diseases like diarrhea, cholera, and intestinal infections, significantly contributing to high child mortality rates **(Coffey et al. 2017).** Recognizing the urgent need to improve sanitation, the MDGs emphasized the importance of addressing public health crises and preserving human dignity **(Barnard et al. 2016).** To combat OD, various initiatives were implemented under the MDGs, including large-scale sanitation campaigns, infrastructure development, and behaviour change programs. Countries like India launched programs such as the Total Sanitation Campaign to enhance rural sanitation coverage **(Patil et al. 2022).** However, despite considerable progress, the MDG sanitation targets were not entirely met due to persistent challenges such as poverty, deeply rooted cultural practices, and inadequate infrastructure **(Hutton and Chase, 2022).** Furthermore, the insufficient emphasis on behavioural change and community engagement hindered long-term success **(O'Reilly et al. 2023).** While the MDG framework brought global attention to the issue of sanitation, its narrow scope and lack of focus on sustainable solutions highlighted the need for a more comprehensive approach. This necessity led to the introduction of the Sustainable Development Goals (SDGs), which aimed to build upon and expand the efforts initiated under the MDGs **(Mehta and Movik, 2020).**

Building upon the groundwork established by the MDGs, the Sustainable Development Goals (SDGs), introduced in 2015, offer a more comprehensive strategy for eliminating OD. SDG 6, dedicated to clean water and sanitation, explicitly seeks to ensure universal access to adequate sanitation and put an end to OD by 2030 **(United Nations, 2015).** Target 6.2 emphasizes equitable and adequate sanitation and hygiene, with a particular focus on vulnerable groups such as women

and children **(WHO/UNICEF, 2021).** Unlike the MDGs, the SDGs adopt an integrated approach that links sanitation to health, education, gender equality, and environmental sustainability **(Kumar and Kar, 2020).** OD is not merely a health concern but also a matter of dignity and safety, especially for women and girls, who face increased risks of harassment when forced to relieve themselves in open spaces **(Clasen et al. 2019).** To address this issue, numerous initiatives have been implemented under the SDGs. For example, India's Swachh Bharat Abhiyan (Clean India Mission) has successfully constructed millions of toilets while fostering behavioural change **(Vyas et al. 2022).** Additionally, programs such as Community-Led Total Sanitation (CLTS) focus on grassroots engagement to promote proper sanitation practices **(Spears and Thorat, 2019).** International organizations, including UNICEF and the World Bank, continue to provide funding and support for sanitation infrastructure development **(World Bank, 2018).** Despite these efforts, challenges persist in achieving SDG 6 targets, particularly in rapidly urbanizing regions where sanitation systems struggle to accommodate population growth **(Hutton and Chase, 2022).** Moreover, climate change exacerbates the issue, as flooding can contaminate water sources and spread faecal matter, increasing the risk of disease transmission **(Garn et al. 2018).** Nevertheless, the SDGs present a more inclusive and sustainable framework for addressing OD. Achieving this goal by 2030 requires continued global collaboration, increased investment in sanitation infrastructure, and community-driven solutions **(Mehta and Movik, 2020).**

VII. Causes of OD

OD remains a significant global challenge, particularly in developing regions across Asia, Africa, and parts of Latin America. Despite global efforts to eradicate this practice through initiatives like the Sustainable Development Goals (SDGs), specifically Target 6.2 which aims to end OD by 2030, millions of people continue to defecate in the open. This analysis explores the complex interplay of social, political, cultural, economic, legal, environmental, and ethical factors that contribute to the persistence of OD globally.

Social Barriers: In many communities, OD is a socially accepted practice, making change difficult as people may not see it as a problem **(Dreibelbis et al. 2015).** Social norms theory suggests behaviour is influenced by community practices (Bicchieri et al. 2018), and when OD is common, it becomes a self-sustaining norm **(Hathi et al. 2016).** Social stratification also affects sanitation. In India, the link between manual scavenging and lower castes discourages toilet use, with higher castes avoiding latrines that require emptying and lower castes facing discrimination in communal facilities **(Coffey et al. 2017; Ambedkar, 2014).** Gender inequalities further shape sanitation behaviours. Women face risks such as harassment and assault **(Sahoo et al. 2015)** but may still prefer OD due to poorly maintained communal toilets **(O'Reilly, 2016).** Their limited decision-making power also hinders efforts to improve sanitation **(Caruso et al. 2017).**

Educational Barriers: Limited education about the health implications of OD contributes to its persistence. Many communities lack awareness about the connection between OD and disease transmission, particularly the fecal-oral route of infection **(Freeman et al. 2017).** Studies have shown that higher levels of education, particularly among women, correlate with improved sanitation practices and reduced OD rates **(Novotný et al. 2018).**

Political Barriers: Weak governance and institutional challenges hinder efforts to eliminate OD. Corruption, poor decentralization, and weak accountability disrupt service delivery **(World Bank, 2018).** Lack of coordination between sanitation, water, and health departments further complicates solutions. Even where policies exist, implementation gaps persist, especially in rural areas with minimal government oversight **(Chambers and Myers, 2016).** Programs like India's Swachh Bharat Mission struggle to translate policy into lasting behavioural change **(Gupta et al. 2019).** Sanitation often ranks low on political agendas due to its taboo nature, invisibility in urban policy, and long-term impact timelines **(Black and Fawcett, 2008).** Short political cycles favour quick, visible projects over long-term sanitation investments **(Hueso and Bell, 2013).** Rapid urbanization has outpaced infrastructure growth, leaving informal settlements without sanitation **(UN-Habitat, 2016).** Urban planning neglects these areas, creating regulatory barriers to sanitation improvements **(McGranahan, 2015).**

Cultural Barriers: Cultural beliefs play a crucial role in sanitation behaviours. In some communities, human excreta is valued as fertilizer, while toilets are seen as impure, especially near living spaces **(Nawab et al. 2016; Routray et al. 2015).** Privacy concerns also shape preferences, as poorly designed communal toilets are often rejected in favour of secluded open spaces **(Caruso et al. 2017).** In some cultures, sharing toilets with in-laws or between genders is considered inappropriate, limiting household toilet use **(O'Reilly, 2016).** Deep-rooted habits make change difficult. Many prefer OD for comfort, fresh air, or social reasons, with lifelong habits reinforcing this practice **(Dreibelbis et al. 2015).** Ritual purity concepts further influence attitudes, as some Hindu communities view toilets as spiritually contaminated, leading to resistance to indoor facilities **(Coffey et al. 2017; Jewitt, 2011).**

Economic Barriers: Economic constraints are a major barrier to ending OD. For impoverished households, toilet construction and maintenance are often unaffordable, with limited access to credit further restricting investment in sanitation **(Jenkins and Scott, 2007; Water and Sanitation Program, 2015).** Competing financial priorities, such as food and healthcare, lead households to favour immediate necessities over sanitation **(Jenkins and Curtis, 2005;**

Banerjee and Duflo, 2011). Underdeveloped sanitation markets exacerbate the issue, with rural and peri-urban areas lacking affordable technologies, skilled labour, and supply chains **(Trémolet et al. 2010; Gero et al. 2014).** Insecure land tenure further discourages investment, as those facing eviction or lacking ownership hesitate to build permanent sanitation facilities **(Payne, 2004; McGranahan, 2015).**

Legal and Regulatory Barriers: Weak legal frameworks and enforcement hinder efforts to eliminate OD. Many countries lack comprehensive sanitation laws, and outdated regulations fail to address the issue effectively **(Koonan and Bhullar, 2014).** Even where laws exist, enforcement remains weak, especially in rural and informal settlements **(Hanchett et al. 2011).** Restrictive land use policies and building codes often create barriers to sanitation access, as regulations designed for formal urban areas may not suit informal or rural contexts **(McGranahan, 2015).** The lack of legal recognition for informal settlements further prevents residents from accessing sanitation infrastructure **(UN-Habitat, 2016).** Unclear jurisdictional responsibilities across government agencies complicate coordination and accountability **(Hueso and Bell, 2013).** Additionally, the failure to recognize sanitation as a human right in national legislation weakens claims by citizens and government accountability, despite the UN's recognition of this right in 2010 **(Ellis and Feris, 2014; OHCHR, 2014).**

Environmental Barriers: Limited water availability hinders conventional sanitation systems, as flush toilets in water-scarce regions may be unsustainable or compete with essential needs like drinking and agriculture **(Kvarnström et al. 2011).** Climate change exacerbates water scarcity, complicating efforts to eliminate OD through conventional approaches **(Howard et al. 2016).** Geographical challenges further restrict sanitation solutions. Rocky terrain, high water tables, and frequent flooding make pit latrines and sewage systems unfeasible or environmentally hazardous, requiring costly, context-specific alternatives **(Tilley et al. 2014; Mara et al. 2010).** Poorly managed sanitation systems deter adoption. Failed projects, such as overflowing septic tanks and contaminated water sources, reinforce preferences for OD **(Jenkins and Sugden, 2006).** Environmental sustainability is often overlooked in sanitation interventions **(Andersson et al. 2016).** Climate change also threatens sanitation infrastructure, with rising sea levels, extreme weather, and flooding compromising system functionality, particularly in vulnerable coastal and flood-prone areas. These risks disproportionately impact marginalized communities already lacking adequate sanitation **(Bartram et al. 2017).**

Ethical Barriers: Ethical barriers arise when efforts to end OD disregard human dignity and autonomy. Coercive or shame-based approaches may violate human rights, fostering resistance rather than lasting change **(Engel and Susilo, 2014).** Balancing individual choice with public health remains a challenge in sanitation programs **(Bartram et al. 2012).** Inequitable sanitation access perpetuates OD among marginalized groups, reflecting broader social discrimination based on socioeconomic status, caste, ethnicity, or geography **(Rusca et al. 2017).** Addressing these disparities requires integrating social justice principles into sanitation policies **(Mehta, 2014).** The long-term health and environmental impacts of OD raise intergenerational ethical concerns. Poor sanitation contributes to environmental contamination, impaired health, and poverty transmission, underscoring the need for sustainable solutions **(Spears et al. 2013; Hutton, 2013).** Tensions between individual freedoms and communal welfare further complicate intervention efforts. While people have the right to choose their sanitation practices, the public health risks of OD justify collective action. Striking a balance requires careful consideration of both individual rights and community well-being **(Cairncross et al. 2010).**

Other Barriers: The mismatch between sanitation technologies and local contexts sustains OD. Solutions that ignore environmental conditions, cultural norms, or maintenance challenges often fail over time **(Murphy et al. 2009).** The focus on standardized technology transfer rather than locally adapted solutions has further limited success **(Ramani et al. 2012).** Lack of information about sanitation options, financing, and health benefits hinders adoption. This gap is especially pronounced in rural areas and among low-literacy populations with limited media access **(Jenkins and Scott, 2007; O'Reilly and Louis, 2014).** Psychological factors like disgust, fear, and habit influence sanitation behaviours. Poorly maintained toilets can reinforce preferences for OD **(Curtis et al. 2011).** Fear of enclosed spaces or nighttime safety concerns also deter use **(Caruso et al. 2017).** Additionally, deeply ingrained defecation habits from childhood are difficult to change **(Neal et al. 2015).** Weak program design and implementation reduce effectiveness. Top-down approaches that exclude community participation lead to low acceptance and sustainability **(Cavill et al. 2015).** Infrastructure-focused interventions that ignore behavioural and social factors fail to create lasting change **(Dreibelbis et al. 2015).**

VIII. Consequences of OD

OD defecating in open spaces instead of toilets has widespread consequences beyond health. Despite global eradication efforts, including the UN's Sustainable Development Goal 6.2 to end OD by 2030, it persists in South Asia and Sub-Saharan Africa. This analysis explores OD's social, political, cultural, economic, legal, environmental, and ethical impacts, emphasizing their interconnectedness and implications for sustainable development.

Social Consequences: OD has severe social consequences, primarily affecting public health. It spreads pathogens causing diarrheal diseases, a leading cause of child mortality **(Prüss-Ustün et al. 2014),** and contributes to environmental enteropathy, stunting, and cognitive impairment **(Spears et al. 2013).** OD also facilitates parasitic infections, such as soil-transmitted helminths and schistosomiasis, which impact over a billion people, leading to anemia, malnutrition, and

cognitive deficits **(Freeman et al. 2017; Strunz et al. 2014).** Women and girls face heightened risks, as OD exposes them to gender-based violence. The absence of private sanitation forces them into unsafe areas, increasing their vulnerability to harassment and assault **(Jadhav et al. 2016**). In India, women practising OD are twice as likely to experience non-partner sexual violence **(Winter and Barchi, 2016).** The shame, anxiety, and stress associated with OD affect mental health and quality of life **(Sahoo et al. 2015).** OD also undermines education, especially for girls. Lack of school sanitation contributes to absenteeism and dropouts, particularly during menstruation **(Adukia, 2017).** Poor sanitation exposure in early childhood impairs cognitive development, reducing school attendance and academic performance **(Spears and Lamba, 2016).** OD reinforces social inequalities, leading to stigma and exclusion. Vulnerable populations, including the elderly, disabled, and marginalized communities, are disproportionately affected. In India, Scheduled Castes and Scheduled Tribes have higher OD rates, reflecting broader social discrimination **(Coffey et al. 2017).**

Political Consequence: OD highlights governance challenges, exposing weaknesses in public service delivery and state capacity. Governments often struggle to implement sanitation policies, especially in rural areas, undermining public trust and state legitimacy. Corruption, resource misallocation, and inadequate monitoring further contribute to OD's persistence despite significant investments **(Hueso and Bell, 2013).** OD influences political priorities and resource allocation. Governments may prioritize visible infrastructure over sanitation, which lacks immediate political appeal **(Black and Fawcett, 2008).** However, strong political commitment, as seen in Ethiopia and Rwanda, can drive rapid sanitation progress **(Crocker et al. 2016).** OD also affects international relations and aid dependency. Countries with high OD rates rely on external funding, shaping sanitation policies in ways that may not align with local needs **(Pickering et al. 2015).** Global pressure to meet targets, such as the Sustainable Development Goals, can lead to overreported success or unsustainable interventions **(Engel and Susilo, 2014).**

Cultural Consequences: OD is both influenced by and reinforces cultural norms. In many communities, it persists not just due to infrastructure gaps but as a deeply rooted tradition, making sanitation interventions challenging **(Routray et al. 2015).** Such practices can perpetuate gender inequalities by exposing women to risks and restricting their mobility **(O'Reilly, 2016).** OD is often passed down intergenerationally, creating entrenched habits resistant to change **(Dreibelbis et al. 2015).** This transmission also sustains health and educational disadvantages, as children in OD-practicing communities face stunted growth, cognitive impairment, and limited schooling **(Spears, 2013).** In some cases, OD is linked to cultural identity, leading communities to resist sanitation interventions perceived as external impositions **(Jewitt, 2011).** Programs that fail to engage with local traditions may face opposition, reducing their effectiveness and sustainability **(Chambers and Myers, 2016).**

Economic Consequences: The economic impact of OD is extensive, straining household and national finances. Healthcare costs for treating OD-related diseases like diarrhea and typhoid are significant, with India alone losing $54 billion annually 6.4% of its GDP **(Hutton and Varughese, 2016; World Bank, 2011).** Beyond medical expenses, OD leads to productivity losses as illness reduces work capacity and income, while childhood stunting and cognitive impairment lower lifetime earnings **(Bartram and Cairncross, 2010; Lawson and Spears, 2016).** OD also harms tourism and economic development. High OD rates deter tourists and investors due to hygiene concerns, limiting revenue and employment opportunities **(Hutton and Varughese, 2016; Dandabathula et al. 2019).** Property values suffer, particularly in low-income urban areas, while fecal contamination reduces agricultural productivity and food security in rural regions **(Mahon and Fernandes, 2010; Forman et al. 2016).** The time spent seeking secluded places for OD, especially by women and girls, represents a significant opportunity cost, reducing time for work, education, and leisure **(Caruso et al. 2017).** Additionally, national healthcare systems must divert resources to treat preventable sanitation-related diseases, restricting investment in other health and development priorities **(Hutton, 2013).**

Legal Consequences: OD has legal consequences, especially where it is banned. Many countries impose fines or penalties for OD, but enforcement often disproportionately affects marginalized groups lacking sanitation alternatives **(Ellis and Feris, 2014).** Criminalizing OD without providing adequate facilities can deepen social exclusion and violate human rights **(Koonan and Bhullar, 2014).** Legal measures must balance enforcement with addressing structural barriers. The recognition of sanitation as a human right has shifted responsibility to governments. Since 2010, the UN has mandated states to ensure access to proper sanitation, emphasizing systemic solutions over punitive approaches **(UN General Assembly, 2010; Ellis and Feris, 2014).** OD is also tied to land rights. In informal settlements, insecure tenure prevents residents from building toilets, while rural communal land systems may lack space for sanitation infrastructure **(Payne, 2004).** Addressing land tenure and regulatory barriers is crucial for sustainable OD reduction **(McGranahan, 2015).**

Environmental Consequences: OD causes severe environmental damage, including water contamination and ecosystem degradation. Pathogens in human waste persist in the environment, polluting surface and groundwater, threatening human health, and disrupting aquatic biodiversity. Nutrient runoff from faeces leads to eutrophication, algal blooms, oxygen depletion, and fish kills, impacting food security and livelihoods **(Nyenje et al. 2010).** OD also contaminates soil, reducing agricultural productivity and food safety. Crops grown in affected soil may carry pathogens, increasing foodborne illness risks **(Forman et al. 2016).** Livestock ingesting contaminated material may suffer health issues, potentially passing diseases to humans **(Zambrano et al. 2014).** OD interacts with climate change. Human waste decomposition releases methane, a greenhouse gas (Reid et al. 2014), while extreme weather events spread faecal contamination and accelerate pathogen survival **(Howard et al. 2016).** Furthermore, OD contributes to biodiversity loss by degrading habitats and water quality **(Daniels et al. 2016).**

Ethical Consequences: OD raises ethical concerns related to human dignity, rights, and social justice. It compromises fundamental rights to dignity, privacy, and a clean environment, disproportionately affecting vulnerable populations **(Gosling et al. 2014).** While often seen as an individual choice, OD is driven by structural barriers, questioning the ethics of behaviour change efforts that ignore these constraints **(Bartram et al. 2012).** OD also raises intergenerational equity issues. Early exposure to faecal pathogens harms children's long-term health and opportunities, while environmental degradation affects future resource availability **(Spears et al. 2013; Hutton, 2013).** Social injustice is reinforced, as marginalized groups bear the greatest burden **(Coffey et al. 2017).** Sanitation interventions carry ethical implications. Coercive approaches may undermine dignity, while participatory strategies promote respect and empowerment **(Engel and Susilo, 2014).** The broader societal responsibility for addressing OD extends to resource allocation, policy priorities, and global commitments to reducing sanitation disparities **(Crocker et al. 2016).**

Other Perspectives and Consequences: OD has driven technological and social innovations in sanitation, creating opportunities in low-cost toilets, decentralized wastewater treatment, and faecal sludge management **(Tilley et al. 2014).** These advancements contribute to broader sustainability efforts in water and waste management. Behaviour change strategies like Community-Led Total Sanitation (CLTS) have reshaped development practices by promoting community ownership and collective action **(Kar and Chambers, 2008).** Urbanization and demographic shifts also influence OD. Rapid urban growth has increased OD in informal settlements due to inadequate infrastructure, posing distinct public health risks compared to rural areas **(Satterthwaite et al. 2019).** Population growth and youth bulges in high-OD regions present both challenges and opportunities for shifting sanitation norms **(Coffey et al. 2014).** OD also affects community resilience, heightening vulnerability to disease outbreaks, disasters, and climate change **(Howard et al. 2016).** Addressing OD strengthens resilience by improving public health, reducing environmental contamination, and fostering social cohesion **(Chambers and Myers, 2016).**

IX. Solutions and Actions Against OD

Social Solutions: Addressing OD requires comprehensive social interventions that promote behaviour change while respecting community dynamics. Community-Led Total Sanitation (CLTS) has proven effective by using social pressure and collective action to eliminate OD, encouraging communities to self-analyze sanitation practices and commit to becoming OD-free without relying on toilet subsidies **(Kar and Chambers, 2008).** Social marketing campaigns further support these efforts by framing toilet use as aspirational rather than solely a health necessity, as seen in Bangladesh's "Sanitation Marketing" program, which boosted toilet ownership through targeted messaging **(Jenkins and Scott, 2007; Hanchett et al. 2011).** Gender considerations are crucial in sanitation initiatives, with women-focused programs improving adoption rates by ensuring female participation in decision-making and addressing safety and privacy concerns **(Caruso et al. 2017).** Schools also play a key role by providing gender-separated sanitation facilities and hygiene education, empowering children to influence household sanitation practices **(Adukia, 2017).**

Political Solutions: Political commitment is crucial for eliminating OD, as seen in countries like Ethiopia, Rwanda, and Vietnam, where strong leadership has prioritized sanitation through policies, institutional frameworks, and resource allocation **(Crocker et al. 2016).** Decentralizing sanitation governance further enhances implementation by empowering local governments to develop context-specific solutions and improve accountability, as demonstrated in Kenya, where county governments have led targeted interventions **(Hueso and Bell, 2013; Mansour et al. 2017).** Cross-sectoral coordination is essential, linking sanitation with water, health, education, and housing to maximize impact, as Thailand did by integrating sanitation into broader public health initiatives **(Cumming et al. 2019; Luoto et al. 2014).** Effective monitoring and evaluation systems ensure accountability by measuring actual toilet usage and behavioural change rather than just infrastructure, with independent verification processes, like those in India's Swachh Bharat Mission, strengthening credibility and identifying areas for improvement **(Clasen et al. 2014; Dandabathula et al. 2019).**

Cultural Solutions: Culturally sensitive approaches are crucial for effectively addressing OD by engaging with local beliefs and practices rather than imposing external solutions **(Dreibelbis et al. 2013).** Successful interventions adapt to cultural contexts, such as addressing concerns about ritual purity in toilet construction in India **(Coffey et al. 2017).** Engaging religious and community leaders can leverage cultural structures for behaviour change, as seen in Indonesia, where religious teachings integrate sanitation messages, and in Senegal, where Islamic principles promote hygiene **(Afifah et al. 2018; Annis and Grossi, 2018).** Addressing intergenerational transmission of behaviours requires targeting child socialization, with programs emphasizing child faeces management and toilet training proving effective, as seen in Nepal, where engaging mothers and grandmothers improved outcomes **(Miller-Petrie et al. 2016; Rand et al. 2015).** Participatory approaches, such as rural appraisal and design thinking, help communities develop culturally appropriate sanitation solutions, ensuring better adoption and maintenance **(O'Reilly and Louis, 2014).**

Economic Solutions: Making sanitation affordable is essential for eliminating OD. Microfinance mechanisms, such as sanitation loans, help households overcome the cost barrier of toilet construction, as seen in Cambodia's iDE program, which combined microfinance with supply chain development to improve access **(Trémolet et al. 2010; Wei et al. 2016).** Sustainable business models create economic incentives, with the "Sanitation as a Business" approach promoting entrepreneurship in toilet construction, maintenance, and faecal sludge management **(Graf et al. 2014).** Kenya's "Fresh Life" franchise has successfully established pay-per-use toilets in informal settlements **(Auerbach, 2016).** Targeted subsidies can complement market-based solutions, ensuring the poorest households are included without distorting

markets, as demonstrated in Bangladesh, where subsidies for the poorest and microfinance for others led to high coverage **(Willetts et al. 2017; Hanchett et al. 2011).** Integrating sanitation with income-generating activities, such as converting human waste into fertilizer or biogas, offsets costs and creates economic benefits, as seen in Ghana's "Safi Sana" model, which turns faecal sludge into organic fertilizer and energy **(Diener et al. 2014; Murray et al. 2018).**

Legal Solutions: Strengthening legal frameworks for sanitation rights is crucial for eliminating OD. Recognizing sanitation as a legally enforceable right obligates governments to ensure access to adequate facilities, as seen in South Africa's Water Services Act, which provides a legal basis for citizens to demand sanitation services **(Ellis and Feris, 2014; Dugard, 2015).** Clear regulatory frameworks enhance accountability by setting minimum standards for toilet construction, maintenance, and faecal sludge management, as demonstrated in Malaysia's comprehensive sanitation regulations **(Schoebitz et al. 2017; Zakaria et al. 2015).** Addressing land tenure issues is vital, particularly in informal settlements, where legal reforms that grant tenure security enable permanent sanitation investments. Brazil's "Regularization of Land Tenure" program has successfully improved sanitation in such areas by securing land rights **(Payne et al. 2015; Lucci et al. 2015).** Effective legal approaches must balance enforcement with enablement, combining penalties for OD with accessible sanitation alternatives, as exemplified by India's strategy of legal prohibitions alongside toilet construction support and behaviour change initiatives **(Koonan and Bhullar, 2014; Clasen et al. 2014).**

Environmental Solutions: Developing environmentally sustainable sanitation technologies is essential to eliminating OD without causing new environmental issues. Eco-friendly toilet designs that minimize water use, prevent groundwater contamination and enable resource recovery to offer sustainable alternatives **(Tilley et al. 2014).** In water-scarce areas, dry toilets and composting systems have proven effective **(Mara et al. 2010).** Integrating sanitation with environmental management can prevent water contamination and protect ecosystems, as seen in Peru, where sanitation improvements linked to watershed management have enhanced water quality **(Daniels et al. 2016; Baum et al. 2013).** Climate-resilient sanitation solutions, such as flood-resistant toilet designs in Bangladesh, are vital for adapting to climate change **(Howard et al. 2016; Haque et al. 2014**). Circular economy approaches that recover nutrients, water, and energy from human waste can create environmental and economic benefits, as demonstrated by Haiti's "SOIL" program, which converts human waste into agricultural compost **(Andersson et al. 2016; Berendes et al. 2018).**

Ethical Solutions: Rights-based approaches to sanitation emphasize dignity, equality, and participation, recognizing sanitation as a human right and social justice issue rather than a mere technical challenge **(Gosling et al. 2014).** Programs incorporating rights principles achieve more equitable and sustainable outcomes **(Winkler et al. 2014).** Addressing power dynamics and social exclusion is crucial, as targeted interventions for marginalized groups, such as Dalits in Nepal, have improved sanitation access **(Coffey et al. 2017; Cavill et al. 2016**). Genuine community participation in sanitation planning enhances ownership and sustainability, as seen in Brazil's participatory budgeting model, which allows communities to prioritize sanitation needs and hold authorities accountable **(McGranahan, 2015; Baptista and Teller, 2016).** Balancing individual autonomy with collective well-being requires ethical consideration, as coercive measures may achieve short-term results but undermine long-term sustainability. Ethical alternatives, like community contracts and social compacts, promote sanitation while respecting individual dignity **(Engel and Susilo, 2014; Chambers and Myers, 2016).**

Other Innovative Solutions: Leveraging digital technologies can enhance sanitation interventions by improving accountability and responsiveness. Mobile applications for monitoring toilet usage and reporting maintenance issues, such as Kenya's "MajiVoice" platform, enable citizens to track sanitation problems and enhance service delivery **(Patil et al. 2014; Welle et al. 2016).** Behaviour-centred design approaches use behavioural science insights to address OD, as seen in Ghana's "Clean Team" service, which developed a toilet rental system aligned with household preferences, increasing adoption **(Neal et al. 2016; Greenland et al. 2016).** Integrating sanitation with nutrition and early childhood development programs can mitigate the long-term health impacts of OD, as demonstrated in the "WASH Benefits" trials in Kenya and Bangladesh **(Null et al. 2018).** Strengthening the evidence base through rigorous research and evaluation is essential for scaling effective interventions, with initiatives like the "Sanitation Learning Hub" facilitating knowledge sharing to accelerate progress **(Schmidt, 2014; Chambers et al. 2021).**

X. Conclusion

Eliminating OD is a critical global challenge with far-reaching consequences for public health, environmental sustainability, and social equity. While the Millennium Development Goals (MDGs) helped raise awareness of sanitation issues, their limitations highlighted the need for a more comprehensive strategy. The Sustainable Development Goals (SDGs), particularly SDG 6, aim to eliminate OD by 2030 through a combination of infrastructure development, behavioural change programs, and policy reforms. Despite significant progress, disparities persist, particularly in low-income regions where financial constraints, cultural traditions, and governance challenges hinder efforts. A holistic approach is essential to effectively tackle OD. Infrastructure alone is insufficient; culturally appropriate behaviour change initiatives must accompany sanitation development. Community-led efforts like Community-Led Total Sanitation (CLTS) have successfully encouraged behavioural shifts, but lasting success depends on sustained political commitment, adequate funding, and active community involvement. Affordable, accessible, and socially accepted sanitation solutions are crucial to ensuring widespread adoption. Strong governance, legal enforcement, and ethical considerations further reinforce the

right to sanitation and human dignity. Economic interventions, such as microfinance programs for toilet construction and targeted subsidies for vulnerable populations, help overcome financial barriers. Public awareness campaigns and social marketing play a crucial role in establishing toilet use as a social norm rather than merely a health necessity. Technological advancements, including digital sanitation tracking, mobile reporting platforms, and eco-friendly toilet designs, enhance long-term sustainability and service delivery. Collaboration across multiple sectors—linking sanitation with health, education, housing, and environmental management—can maximize impact. Countries like Bangladesh and Vietnam have demonstrated that coordinated government policies, combined with strong community engagement, can lead to the successful eradication of OD. However, persistent challenges remain in regions such as Sub-Saharan Africa and parts of South Asia, where rapid urbanization, inadequate infrastructure, and climate change complicate progress. To achieve universal sanitation, governments must prioritize stronger policies, increased funding, and active community participation. International cooperation and knowledge-sharing can facilitate the adoption of effective solutions tailored to different contexts. Integrating sanitation initiatives with broader development programs ensures lasting impact, improving public health, economic productivity, and environmental protection. Ending OD is more than just building toilets—it requires a fundamental shift in attitudes, strengthened governance, and inclusive policies. Achieving universal sanitation is a shared responsibility that demands sustained commitment, innovation, and global cooperation to ensure a healthier, more dignified future for all.

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