Social and economic cost-benefit analysis of sanitation in Odisha State, India

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ABSTRACT

This study estimates the social and economic impact of achieving full sanitation in Odisha State, the first time such a study has been conducted at a sub-national (entire State) level in India. The economic costs and associated social benefits to society via the elimination of open defecation by 2025 are estimated and compared to progress at the current pace. The findings show that net benefits of sanitation conservatively amount to at least 1.6% State GDP (range 0.4 to 2.7% under varying growth and discount rates). The benefit-cost ratio is estimated at 5.7 (range 3.1 to 7.7). These results provide strong evidence to planners and decision-makers that sanitation gives significant returns, both social and economic, on investment and gives ample evidence for the acceleration of the elimination of open defecation.

Key words | BCR, cost-benefit analysis, India, Odisha, sanitation

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ABBREVIATIONS

ALRI	acute lower respiratory infection
APL	above poverty line
AWC	Anganwadi Centre
BCC	behaviour change communication
BCR	benefit-cost ratio (economic return per unit of currency spent)
BPL	below poverty line
CBA	cost-benefit analysis
CBO	community-based organization
CPCB	Central Pollution Control Board
Crore	10,000,000
DAP	di-ammonium phosphate
DDWS	Department of Drinking Water Supply
DISE	District Information System for Education
DLHS	District Level Health Survey
Ecosan	ecological sanitation
EWS	economically weaker sections
FAO	Food and Agriculture Organization
GDP	gross domestic product
GoI	Government of India
HIG	high income group
IEC	information, education and communication
IHHL	individual household latrine
ILCS	integrated low cost sanitation scheme
IPC	interpersonal communication
IRC	IRC International Water and Sanitation Centre
JMP	Joint Monitoring Programme
K	potassium
Kg	kilograms
Lakh	100,000
LIG	low income group
lpcd	litres per capita per day
LPG	liquefied petroleum gas
M&E	monitoring and evaluation
MDG	Millennium Development Goal
MHUPA	Ministry of Housing and Urban Poverty Alleviation
MHRD	Ministry of Human Resource Development
MIG	middle income group
MLD	million litres daily
MOP	muriate of potash
MoRD	Ministry of Rural Development
MoUD	Ministry of Urban Development

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MRP	maximum retail price
N	nitrogen
NFHS	National Family Health Survey
NGO	non-governmental organization
NGP	Nirmal Gram Puraskar
NIUA	National Institute of Urban Affairs
NPV	net present value
NSSO	National Sample Survey Organization
O&M	operation and maintenance
P	phosphorus
PHED	Public Health Engineering Department
RCT	randomized control trial
SEAR-D	WHO South-East Asia Region epidemiological strata D
SSA	Sarva Shiksha Abhiyan
SSP	single superphosphate
TSC	Total Sanitation Campaign
UN-HABITAT	United Nations Human Settlements Programme
UNICEF	United Nations Childrens' Fund
WHO	World Health Organization
WSP	Water and Sanitation Program, World Bank

INTRODUCTION

Diarrhoea is the second most common cause of child death globally and India has the largest number of child deaths directly attributable to diarrhoea (UNICEF/WHO 2009). Water, sanitation and hygiene (WASH) is key to diarrhoea reduction as inadequate WASH provision contributes to over 80% of the diarrhoea burden (WHO 2002) as well as being critical in combating pneumonia. India tragically lost more than 600,000 children under five years of age in 2010 due to diarrhoea and pneumonia; almost 30% of the global total (UNICEF 2012). India also hosts the largest number of people not using sanitation facilities, with 620 million people still open defecating (WHO/UNICEF 2013). Progress on sanitation has proven slow in India with the percentage of open defecators dropping only from 64 to 50% over the decade 2001 (191.96 million households) to 2010 (246.69 million households) (Census 2001, 2011).

Rural sanitation in India is led by the Ministry of Drinking Water and Sanitation (MDWS) through a national programme 'Nirmal Bharat Abhiyan' (NBA), formerly known as the Total Sanitation Campaign. National efforts on sanitation in India have resulted in a decline in the numbers of people defecating in the open while progress has also been made on school sanitation, though the pace of this change varies across states (WaterAid 2008). In addition to NBA in rural areas, an urban sanitation programme, the Integrated Low Cost Sanitation Scheme (ILCS), is in place to promote urban sanitation (MHUPA 2008).

Global reviews of the economic arguments for sanitation show that it is a very solid investment (Hutton 2013). An analysis of the economic impacts of sanitation across four Asian countries estimated approximately 2% of total GDP is lost due to inadequate sanitation (Hutton *et al.* 2008). The costs of inadequate sanitation in India are estimated to be the equivalent of 6.4% of GDP or US $53.8 billion, based on 2006 figures (WSP 2010). This figure, at US $48 per person, is much higher than the other Asian calculations which ranged from US $9.3 in Vietnam to US $32.4 in Cambodia. Pattanayak *et al.* (2010) estimated that households in rural India could save 5% of monthly cash expenditures with improved WASH.

No analytical studies have been conducted so far in India at the state scale to comprehensively quantify at this level the potential economic and social gains from achieving total sanitation. This is a serious gap as estimates of the net economic and social benefit to society from sanitation can be a powerful advocacy for increased funding, strengthening policy, enhancing political interest and increasing programme prioritization and impact.

This study estimates the economic and social benefits to Odisha State from the provision of sanitation and draws on Ohikata *et al.* (Social and Economic cost benefit analysis of sanitation in Orissa, India. UNICEF India [unpublished report]). Both social and economic benefits are presented because while sanitation's economic benefits are sizeable, they would be underestimated if such social benefits in terms of averted illness, increased productivity, time saving, etc. are not taken into account. It is also recognized that while lower and cheaper levels of sanitation are possible to eliminate open defecation, the costing for this study is done as per levels of the NBA guidelines and the GoI policy. In fact, this is more conservative as it increases the costs and thus decreases the estimated net benefits.

Odisha State was chosen for this analysis due to its poor sanitation progress and its diarrhoea burden which is substantially above the national average (Cronin & Dutta 2011). Odisha State has a population of over 40 million (Census 2011) due to rapid population growth; 85% live in rural areas. Under five years of age mortality rate in 2005 in Odisha was 90.6%, which was higher than the national average of 74.3% (NFHS-3). About 46.4% of the population is classified as below the poverty line, which is a very high proportion in comparison with the national average of 27.5%. In terms of the state economy, Odisha's GDP per capita, Rs. 23,403, is also lower than the national average of Rs. 33,283. It is ranked 19th out of 35 States/Union Territory (NIC 2009). Odisha's economy is mineral-based and it is the highest producer of aluminium in India. Even though economic growth of 8% was registered in 2010, the state is still ranked 22nd out of 23 in India in its Human Development Index rating (UNDP 2012).

Open defecation in the state declined only from 85 to 78% between 2001 (7.66 million households) and 2011 (9.87 million households) (Census 2001, 2011) which would mean a huge acceleration (an order of an increase of seven times) is required to achieve an open defecation-free state by 2025. Moreover, there is a significant urban–rural disparity in the water and sanitation sector with the proportion practising open defecation ranging from 40.9 in urban to 88.2% in rural areas in Odisha (NFHS-3). Hence, significant challenges and massive targets underline the need for increased impetus on sanitation acceleration in the state. This paper attempts to add to the policy and implementation discourse for accelerating sanitation progress in the state by calculating the costs and benefits to ensure a fully sanitation-covered population and showing the significant economic and social benefits from total sanitation in the state.

METHODOLOGY FOR ESTIMATING COSTS

Background

Net economic benefits are computed in this study by estimating the total cost and benefit differential of two potential scenarios, 'full sanitation' and 'business as usual', over the time period 2010 to 2025 (Figure 1). Such an analysis is based largely on the methodology of previous economic costs of poor sanitation, e.g., Hutton *et al.* (2008), although outcomes are interpreted from a benefit viewpoint. Full sanitation means the elimination of open defecation with facilities in line with the technical guidelines of NBA. The incremental additional cost to accelerate sanitation is the additional expenditure that has to be incurred over and above the 'business as usual' scenario to achieve full sanitation. This includes additional hardware costs, including sanitation facility construction and O&M costs, and additional software costs including information, education and communication (IEC) for the behaviour change as well as the monitoring and evaluation (M&E) system. Although the cost estimates focus on household latrines, the cost of shared toilet facilities are included too, as are school sanitation costs.

The difference between the differential benefit and the differential cost from 2010 to 2025 is the net benefit, and is calculated using the formula

$$\Delta\text{Economic Benefit}_{A-B} = \Delta\text{Benefit}_{A-B} - \Delta\text{Cost}_{A-B}$$

Scenario A: Full sanitation coverage and use in 2025
Scenario B: Low sanitation coverage and use in 2025, at present rate of improved sanitation increase
where $\Delta =$ differential change.

The benefit derived from full sanitation is estimated based on estimated economic gain in the areas of health, sanitation and education. The monetary values of the benefits are computed using standard economic techniques. A discount rate of 3% has been assumed for computing the

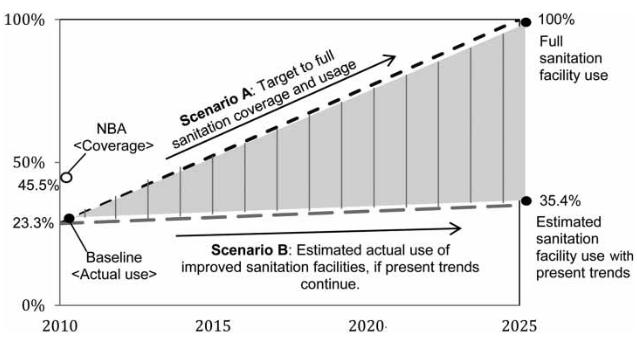

Figure 1 | Concept of the social and economic cost-benefit analysis of sanitation.

net present value (NPV). The costs are expressed in Indian rupees with benefits converted into monetary values as benefits from direct cost savings and time savings.

Due to rapid population growth in urban areas, the urban population will have increased from 15% of the total population in 2001 to 20.5% by 2025 (NCP 2006). Similarly, it is assumed that the total number of households will increase while the mean household size will decrease in line with current trends (NCP 2006).

Several assumptions have been necessary but a key rationale has been to use data and assumptions that overstate costs and understate benefits and so the actual net benefits may be even greater than those estimated here. It is assumed that the real value for net state GDP and per capita net state GDP increases at 2% per annum. The latest reliable data are used where possible although there is a time gap in the statistics, such as health survey data in 2005–2006 (from NFHS-3 which is the last and most comprehensive such data set) and the economic data from 2007.

Household sanitation

The 'improved' sanitation use and coverage trends are calculated based on existing statistical data (sources: 1993: NSS49r, 1996:NSS52r, 1999: NFHS-2, 2000: MICS (2001), 2001: Census (2001, 2011), 2006: NFHS-3) using a linear regression (WHO/UNICEF 2013). Annual increases in sanitation use is estimated as 0.67% in rural areas and 0.79% in urban areas which are used to estimate the two sanitation growth scenarios. The detailed breakdown of sanitation facility types in 2010 and 2025 are estimated (NSSO 2004; NIUA 2005), NFHS-3 while the sanitation costings (Table 1) reflect the key essential components.

The unit construction cost of latrines (based on No. W-11037/6/2005-CRSP of MDWS) are provided for below poverty line (BPL) households, school toilets and the community toilet blocks (Table 2); baseline calculations use 2010 figures with sensitivity analyses done with a range of other costs and benefits.

Table 1 | Summary of sanitation cost categories and stakeholders

	IHHL		Shared toilet facility			School water and sanitation facility		Tourist accommodation			
	Construction	O&M	Construction	User charge	O&M	Construction	O&M	Renovation	O&M	IEC	M&E
BPL HH	○	○	○	○	○	–	–	–	–	–	–
APL HH	○	○	○	○	○	–	–	–	–	–	–
Government	○ (as incentive)	–	○	–	–	○	○	–	–	○	○
Private education Institute	–	–	–	–	–	○	○	–	–	–	–

IHHL = individual household latrine; O&M = operation and maintenance; IEC = information, education, communication; M&E = monitoring and evaluation; BPL HH = below poverty line household; APL HH = above poverty line household.

Table 2 | Costs of facilities used in the calculations

Sanitation facility type		Average construction cost per household (Rupees) Rural	Urban
i	Pour flush toilet with double leach pit	4,700	4,700
ii	Pour flush toilet with single leach pit	3,700	3,700
iii	Toilet connected to sewerage line (including toilet construction and initial sewer connection fee)	6,700	17,000
iv	Toilet connected to septic tank	17,700	26,000
v	Ecosan toilet	9,600	9,600

Source: Revised TSC guideline (DDWS 2007), WSP (2007), UN Habitat (2007).

A percentage of the investment cost is used for the estimates of O&M costs (Toubkiss 2006; Hutton *et al*. 2008). Estimated unit cost of construction and O&M for shared facilities, at 2010 prices is based on WSP (2007, 2008) and UN-HABITAT (2007).

School sanitation

Over 80% of schools in Odisha have a drinking water supply facility; 57% of schools have a common toilet but only one-third have a girls' toilet as of 2010 (NUEPA 2004–2010). The number of schools requiring construction of water and sanitation facilities is computed by multiplying the total school number by the percentage of schools without girls' toilet facility and the percentage of schools without common toilets separately. The number of schools requiring renovation is estimated by multiplying the estimated number of schools by the percentage of schools with girls' and common toilet facilities separately and the percentage not functioning. UNICEF (2008) found that 20% of surveyed schools have non-functional facilities and it is assumed that all non-functioning facilities require renovation. This study assumes new construction and renovation work for existing schools (both public and private) will be completed within a five-year period as per Government targets.

Rs. 20,000 of public funds was available in 2010 per school sanitation facility in government schools. The material costs increase due to inflation, and so actual construction costs can be much higher. The costs of a full sanitation facility, including handwashing and incineration facilities (DDWS 2008) is estimated based on the Schedule of Rates (SoR) of 2005, with an enhanced cost index of 18% to adjust for increased costs. The estimates are also applied to private schools. Annual O&M costs in schools are estimated as 5% of construction costs. Total O&M costs between 2010 and 2025 are estimated based on the number of schools in place in 2010.

Demand generation (IEC) costs

Only two-thirds of the total fund released for sanitation in Odisha has been utilized between 1999 and 2010. Hardware components account for 91% and the remainder was spent on communication and administrative costs. An average demand generation cost per household is estimated on five years of records of 'actual' expenditure. This comes to, on average, Rs. 116 per household, a very small component of the available fund. This is the amount taken for Scenario B while Scenario A assumes the full demand generation allocation will be spent, i.e., Rs. 506 per household.

METHODOLOGY FOR ESTIMATING BENEFITS

Background

The impacts of improved sanitation are estimated in three key areas (Table 3) using conventional economic valuation techniques, based on Hutton *et al*. (2008, 2009). Costing for journey time to open defecation and waiting time for shared facilities adjusted for India are based on the range of values used in Hutton *et al*. (2008, 2009).

Other benefits have also been identified but are not estimated here, such as full improved nutrition benefits, saved time and expenditure due to improved water quality, better environment leading to rising property value, increased fish production, expanded tourism, increased leisure activities, privacy, security, dignity and social status. The increased economic opportunities from an expanding sanitation industry are also not factored in.

Health

The relative risks of mortality and morbidity are taken from Fishman *et al*. (2004) to estimate attributable fraction (AF) in relation to malnutrition. The estimated counterfactual prevalence rates of severe and moderate underweight are higher than the rates of Hutton *et al*. (2008), ranging from 0.05 to 0.1% in severe underweight and 2–3% in moderate, given the current high prevalence of the severe and moderate underweight nutritional status in Odisha. The cause-specific death rate by age group from global burden of disease estimates (WHO 2008) is used for estimating diarrhoea, ALRI, malaria, measles, other causes and intestinal nematode infections. The disease incidence rate of diarrhoeal diseases, ALRI and malaria are taken from NFHS-3 (2005–2006), as per the target population in the benefit categories (Table 3). Data on diarrhoea treatment of children

Table 3 | Benefit categories

Benefit categories	Details
1. Health	
Saved health treatment cost	Diarrhoea attributed to inadequate sanitation for all age groups. Acute lower respiratory infection (ALRI) and malaria attributed to inadequate sanitation via malnutrition for children under 5
Productive days gained due to illness averted	Gained income opportunity for adults and gained school days for children 5–14. Time value of caring for ill person by adults
Lifetime income loss averted	Lifetime income loss averted from adult and child death by diarrhoea, ALRI, measles, malaria, and other causes attributed to inadequate sanitation
2. Sanitation	
Saved access time	Time value of travel/waiting time for defecation
Fertilizer output from human waste	Value of human waste as fertilizer from the double leach pit toilets and Ecosan toilets
3. Education	
School days gained from absenteeism averted	Gained school days from absenteeism due to menstrual period attributed to inadequate sanitation in schools averted. Computed for girls only
School days gained from dropout averted	Gained school days from dropout/never attending school children attributed to inadequate sanitation in schools averted. Computed for both boys and girls

under five and source of health care are also from NFHS-3. The average health treatment cost of health services and the proportion of severe cases are estimated based on Dror *et al.* (2008).

To calculate productive days gained due to illness averted the annual state GDP per capita is converted to daily and hourly values. Separate values are used for rural and urban per capita income, based on the Economic Survey 2008–2009 (NIC 2009) as well as opportunity costs for children due to illness averted. Time of adults accompanying to health care and/or caring for sick persons is also estimated as sick children and adults with a severe disease case need to be accompanied to the health care facility and cared for by an adult. We also estimate the additional lifetime income from adult and child deaths averted. This is calculated for deaths from diarrhoeal diseases and helminths in all age groups, and deaths from ALRI, measles, malaria, and other causes associated with diarrhoeal diseases via malnutrition in children below five years of age as per Hutton *et al.* (2008).

Sanitation

Time for defecation only, and not urination, is considered here. Women may spend more time than men to find a place ensuring privacy (UN-Water 2006). We assume people spend 5 min in rural and 10 min in urban areas as waiting time for shared toilet users, and 10 min in rural and 15 min in urban areas as journey time to find a safe and secluded spot for defecation, based on the ranges used by Hutton *et al.* (2008). The additional time for urban areas is borne out by surveys in four cities of Madhya Pradesh showing that 26% of toilet blocks are properly maintained but are overcrowded (UN-HABITAT 2007).

Fertilizer output

In Odisha, the agriculture and animal husbandry sectors account for 23.4% of net state domestic product (NSDP), and 65% of Odisha's population is engaged in these sectors (DoAFP 2008). Despite heavy reliance on agriculture in the state's economy, Odisha's fertilizer consumption, 46 kg per hectare, was much lower than the national average of 104.5 kg during 2005–2006 (DoF 2006). Safely stored faeces can be an excellent fertilizer and result in significant savings, of course assuming access from toilet to land is possible and can be done safely. Here, only faeces from users of toilets with a double leach pit and both faeces and urine from Ecosan toilet users are included in potential benefits. In order to estimate the unit price of nutrients as fertilizer, nutrient basis fertilizer price is used for estimation and FAO (2005) provide typical application rates while maximum retail prices of fertilizers for each nutrient, N, P and K were taken from Goverment of India Department of Fertilizer figures (http://fert.nic.in).

Education

The economic implications of girls' school absentee days due to menstrual hygiene and girls' and boys' lost school days are estimated. Even when facilities exist, poor maintenance and lack of consideration for gender-related privacy can increase the absenteeism 10–20% (IRC 2005). Adequate school sanitation facilities can increase girls' enrolment rate; attendance rates for Odisha are taken from NFHS-3. It is assumed that girls attending schools with inadequate facilities or without any facility miss an average 10 days per year due to a preference to remain home to avoid being at school during each menstrual cycle. These gained school days from averted absentee days are valued at 15% of daily value of average GDP per capita, based on Hutton *et al*. (2008).

RESULTS

Costs

Total estimated costs of sanitation by 2025 are 100 billion Rs. for Scenario A and 37 billion Rs. for Scenario B. Over half the total costs of both scenarios is toilet construction but for Scenario A, software costs are the second largest distribution while for Scenario B it is toilet O&M costs (Figure 2). Differential costs are the difference between scenarios and of this 63 billion Rs., 82% is for rural areas.

Total benefits

The total calculated incremental economic benefits from improved sanitation (moving Scenario A to B) in the period 2010–2025 is 272.6 billion Rs. The impact of these benefits are estimated as two-thirds rural and 52% of the total benefits are categorized into age group of children under 15 years old, and 43 percent in age group above 15 years old.

The health benefits make up over 80% of the total or 230 billion Rs. Splitting the health benefits, lifetime income loss averted accounts for 74% of the total amount, health treatment costs averted for 22.6% and productive days gained due to illness averted for 3.4%. It is estimated that a total of over 98,000 deaths due to diarrhoea are averted for the 15-year period due to full sanitation with children under five years accounting for 82% of this and the vast majority from rural areas (84%).

A total 81.1 million hours are saved due to not accompanying to a health care facility or going to a pharmacy, and a total 674.7 million hours are saved due to not caring for an ill person. Due to disease morbidity averted, a total of 41 million school days and 206 productive days can be gained over the time period. Total economic value of gained productive time and school days are 7.5 billion Rs.

The lifetime income loss averted is calculated by multiplying the estimated mortality averted by unit values of

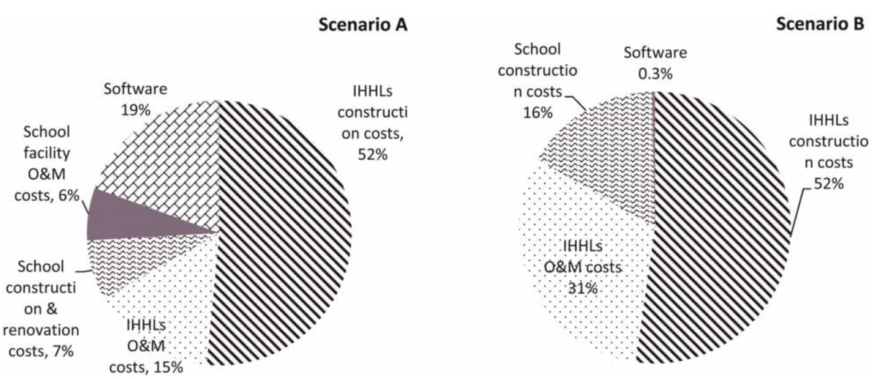

Figure 2 | Breakdown of sanitation cost estimates, by sub-category, for Scenarios A and B.

lifetime income, amounting to 231 billion Rs. in the 15-year period. The highest proportion is diarrhoea accounting for 55%, followed by other causes for 24%, ALRI for 14%, measles for 5%. Children under five make up 94% of this total estimate.

Total benefits gained due to sanitation are in the order of 54 billion Rs., saved journey time makes up over 98% of the total. Meanwhile, although the percentage of fertilizer output is only 2% of the sanitation category, the amount of benefits gained is in excess of 1 billion Rs.

167.9 million school days can be gained from school sanitation improvement resulting in a total economic benefit of over 3 billion Rs. 55.4% of this is due to averting girls' lost school days due to poor sanitation and 37.3% is linked to menstrual hygiene management.

Net economic benefit

Total economic benefit is estimated by deducting the differential cost from the differential benefits (Figure 3) and the net economic benefit comes to over 224 billion Rs. by 2024–2025 or 14,968 Rs. (NPV) per annum; this is an average per capita benefit of 370 Rs. in NPV. The benefit-cost ratio (BCR) is calculated as 5.7; i.e., dollar return per dollar invested.

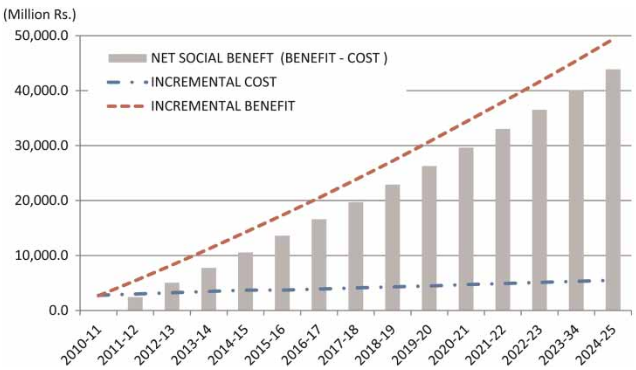

Figure 3 | Net social and economic benefits from sanitation over period 2010–2025.

SENSITIVITY ANALYSIS

Uncertainty is evaluated by sensitivity analysis of the key variables of growth rate and discount rate which have been varied in the ranges of 0 to 4% and 1 to 10%, respectively (Table 4).

Depending on the assumed growth rate of per capita income and the discount rate, the NPV net benefit of sanitation varies from Rs. 42 billion to Rs. 726 billion over a period of 15 years. This amounts to variation in the average NPV per year from 0.3% to 5.2% of state GDP. Variations in the potential lifetime income of a child, i.e., the income opportunity/productivity lost during the age 0–15 years, showed a low variation in results (Ohikata *et al*. Social and Economic cost benefit analysis of sanitation in Orissa, India. UNICEF India [unpublished report]).

Another area for sensitivity analysis was in terms of costing and various scenarios have been modelled (Table 5). This shows that even with doubling of costs, BCR rates still remain competitive, ranging from 1.6 to 5.9, highlighting that even with conservative inputs sanitation provides strong economic and social returns.

DISCUSSION AND CONCLUSION

The estimates show that Odisha could gain in the region of Rs. 2.2 billion (USD 4 billion) as NPV if full sanitation use is

Table 4 | Impact on total net NPV with varying discount and growth rates (all figures are in million Rs.)

	Growth rate = 0%				Growth rate = 2%				Growth rate = 4%			
DR (%)	Total NPV	AA NPV	Av GDP %	BCR	Total NPV	AA NPV	Av GDP %	BCR	Total NPV	AA NPV	Av GDP %	BCR
1	213,788	14,253	1.5	4.8	378,774	25,252	2.7	7.7	726,299	48,420	5.2	13.8
3	136,525	9,102	1.0	3.8	224,515	14,968	1.6	5.7	395,945	26,396	2.9	9.2
5	92,881	6,192	0.7	3.3	144,093	9,606	1.0	4.5	236,577	15,772	1.7	6.7
10	42,463	2,831	0.3	2.5	60,446	4,030	0.4	3.1	88,377	5,892	0.6	4.0

DR = discount rate; AA = annual average; NPV = net present value; Av GDP % = average NPV as % of state GDP; BCR = total benefit-cost ratio total BCR (in NPV).

Table 5 | Increased costing: impact on Total Net Present Value with varying Discount and Growth rates (all figures are in million Rs.)

	Growth rate = 0%				Growth rate = 2%				Growth rate = 4%			
Discount rate (%)	Total NPV	Average NPV/Year	Average NPV as % of state GDP	Total BCR (in NPV)	Total NPV	Average NPV/Year	Average NPV as % of state GDP	Total BCR (in NPV)	Total NPV	Average NPV/Year	Average NPV as % of state GDP	Total BCR (in NPV)
3	109,801	7,320	0.8	2.5	197,791	13,186	1.4	3.6	369,220	24,615	2.7	5.9
10	26,103	1,740	0.2	1.6	44,086	2,939	0.3	2.0	72,018	4,801	0.5	2.6

DR = discount rate; AA = annual average; NPV = net present value; Av GDP % = average NPV as % of state GDP; BCR = total benefit-cost ratio total BCR (in NPV).
Pour flush toilet with double leach pit 10,000 Rs. as per revised NBA guidelines of December 2013. Other costs were doubled: pour flush toilet with single leach 7,400 Rs. Toilet connected to sewerage line (including toilet construction and initial sewer connection fee) estimated as 13,400 Rs. in rural and 34,000 Rs. in urban areas. Toilet connected to septic tank calculated as 35,400 Rs. in rural and 52,000 Rs. in urban areas. Ecosan toilet 20,000 Rs.

achieved by 2025. The annual average net economic benefit is approximately Rs. 15 billion, which accounts for 1.6% of the state GDP of 2007–2008 assuming a growth rate of 2% and a discount rate of 3%. This value of state GDP, under varying growth rates, varied from 0.4 to 2.7% of state GDP, substantial figures even under the conservative estimates used here. The growth rates have been especially conservative (0–4% while average growth rates for 2005–2011 were in the order of 8%, although there is no way of knowing whether the state can sustain such growth to 2025, hence the conservative nature of the growth rate estimates here).

WSP (2010) estimate India lost an average of 6.4% of GDP due to poor sanitation; considering 72% of this was in health benefits this equals 4.6% of GDP lost on health impact alone, much higher than the 1.9% estimated in this study. This difference may be because economic development is lower in Orissa than the India average but also reflects that estimates used here are more conservative and is a cost-benefit analysis as opposed to the economic loss focus of WSP (2010).

The average per capita net economic benefit from this elimination of open defecation is Rs. 370. This is averaged out for urban and rural areas although the opportunity costs of time saved in rural areas will generally be less than those of urban areas. Health benefits are more than three-quarters of the overall benefits. Sanitation improvements could result in averting over 175,000 deaths and 227 million morbidity cases may be averted over the time period. In reality, the actual health and nutrition benefits are expected to be significantly larger than the estimates in this study. This is likely to be a very significant benefit given the enormous burden of undernutrition in Odisha and this is an important area for future research.

Sixty-eight percent of the total benefit is generated in rural areas and children under five, who make up less than 10% of the total population of Odisha, can benefit from approximately 52% of the total benefits, mainly due to disease morbidity and mortality. In addition, improved sanitation has the potential to increase gender empowerment and girls' retention in schools. Hence, child health and well-being are the biggest winners from eliminating open defecation.

The BCR of 5.7 compares well with the estimated global BCR value of 5.5 (Hutton 2013). The range under varying discount and growth rates varied widely from 2.5 to 13.8. A key issue from a policy perspective is that the costs are financial costs (expenditures) whereas most benefits are indirect, i.e., they appear as increased income or savings. Hence, the costs expenditure comes from a different 'pocket' than the income indirectly generated or the money saved by households. This has been a major challenge for sanitation advocacy as it is still often perceived as a private good that is traditionally partially or fully covered by households. Currently, most states in India, including Odisha, do not spend their full sanitation allocation funds (as may be seen from the figures shared on the Goverment of India NBA website). This reflects more on capacity issues to fully spend allocations rather than the lack of need of the funds for strengthening sanitation in the state. Thus for states to be able to fully spend allocations and simultaneously get maximum value for this expenditure, capacity gaps in all the major areas of demand generation, supply, monitoring and certification will need addressing.

The direct income generated by the sanitation market and the indirect income generated to other stakeholders (industry, agriculture), as well as the overall increase in tax income for the state itself (coming from private sector, industry and households) means that increased sanitation will not only cost the state less but can also be a major source of revenue, i.e., a double win scenario. To achieve this, the total costs for eliminating open defecation over 15 years amount to the tax revenues for only one year (at 2007–2008 rates). Revenues have risen substantially in the interim period making costing even less of an issue. The sanitation and broader public health discourse would benefit also analysis on actual impacts via rigorous economic studies and RCT approaches. Future research may look at probabilistic approaches to inputs and scenarios to give a broader range of assessment and benefit-cost ratios.

Given the fact that a well-funded sanitation programme, NBA, is in place with Centre funding, its effective roll-out must become a priority for the state purely from an economic perspective, although it is also well known that sanitation brings many more advantages.

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REFERENCES

Census 2001 Office of the Registrar General & Census Commissioner, India Census 2001.

Census 2011 Office of the Registrar General & Census Commissioner, India Census 2011.

Cronin, A. A. & Dutta, S. 2011 Estimating the disease burden linked to incomplete water and sanitation coverage in Orissa State, India. In: *Interlacing Water and Human Health: Case Studies from South Asia* (A. Prakash, V. S. Saravanan & Jayati Chourey, eds). Sage Publications, New Delhi, Chapter 7.

DDWS 2007 *Central Rural Sanitation Programme: Total Sanitation Campaign: Guidelines*. Department of Drinking Water Supply, Ministry of Rural Development, Government of India.

DDWS 2008 *An Inclusive Approach for School Sanitation & Hygiene Education: Strategy, Norms & Designs*. Department of Drinking Water Supply and UNICEF. New Delhi, India.

DoF 2006 Department of Fertilizers, Ministry of Chemicals & Fertilizers Annual Report 2005–2006. Ministry of Chemicals & Fertilizers, Government of India.

DoAFP 2008 Directorate of Agriculture and Food Production Orissa Agricultural Statistics, 2006–07: District Wise Area, Yield & Production of Different Crops for 2006–07, Bhubaneswar, Orissa.

Dror, D. M., Van Putten-Rademaker, O. & Ruth, K. 2008 Cost of illness: evidence from a study in five resource-poor locations in India. *Ind. J. Med. Res.* **127**, 347–361.

FAO 2005 *Fertilizer Use by Crop in India*. Food and Agricultural Organization, Rome.

Fishman, S. M., Caulfield, L. E., de Onis, M., Blössner, M., Hyder, A. A., Mullany, L. & Black, R. E. 2004 Childhood and maternal underweight. In: *Comparative Quantification of Health Risks: Global and Regional Burden of Diseases Attributable to Selected Major Risk Factors* (M. Ezzati, A. D. Lopez, A. Rodgers & C. J. L. Murray, eds). WHO, Geneva, pp. 39–162.

Hutton, G., Larsen, B., Leebouapao, L. & Voladet, S. 2009 *Economic impacts of sanitation in Lao PDR*. World Bank, Water and Sanitation Program. Jakarta, Indonesia.

Hutton, G. 2013 Global costs and benefits of reaching universal coverage of sanitation and drinking-water supply. *J. Water Health* **11** (1), 1–12.

Hutton, G., Rodriguez, U., Napitupulu, L., Thang, P. & Kov, P. 2008 *Economic impacts of sanitation in Southeast Asia: a four-country study conducted in Cambodia, Indonesia, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)*. World Bank, Water and Sanitation Program. Jakarta, Indonesia.

IRC 2005 *Adolescent Girls and School Hygiene, Sanitation and Water. School Sanitation and Hygiene Education Notes & News*, Delft, the Netherlands.

MHUPA 2008 Integrated Low Cost Sanitation Scheme: Revised Guidelines. Ministry of Housing and Urban Poverty Alleviation (MHUPA), Government of India.

MICS 2001 Department of Women & Child Development and UNICEF Multiple Indicator Survey.

NCP 2006 National Commission on Population: Population Projections for India and States 2001–2026. Office of the Registrar General & Census Commissioner.

NFHS-3 (2005–06) International Institute for Population Sciences and Macro International National Family Health Survey (NFHS-3), India, 2005–06: Orissa, Mumbai, 2008.

NIC 2009 National Informatics Centre Economic Survey 2008–2009. Ministry of Finance, Government of India.

NIUA 2005 Status of Water Supply, Sanitation and Solid Waste Management in Urban Areas. National Institute of Urban Affairs.

NSSO 2004 Reports New Delhi National Sample Survey Organisation, NSSO, Ministry of Statistics and Programme Implementation, Government of India.

NUEPA 2004–10 *National University of Educational Planning and Administration State Report Cards 2004–10*: Elementary Education in India: Where do we stand? Department of School Education and Literacy, Ministry of Human Resource Development, Government of India.

Pattanayak, S. K., Poulos, C., Yang, J. & Patil, S. 2010 How valuable are environmental health interventions? Evaluation of water and sanitation programmes in India. *Bull. World Health Organ.* **88**, 535–542.

Toubkiss, J. 2006 *Costing MDG Target 10 on Water Supply and Sanitation: Comparative Analysis, Obstacles and Recommendations*. World Water Council, Marseille, France.

UNDP 2012 Orissa, Economic and Human Development Indicators.

UN-HABITAT 2007 *Water for Asian Cities Programme, India*, UN-HABITAT and Directorate of Urban Administration and Development. Government of Madhya Pradesh Rejuvenation of Community Toilets, Nairobi, Kenya.

UNICEF 2008 *Sharing Simple Facts: Useful Information about Menstrual Health and Hygiene*. UNICEF, New Delhi, India.

UNICEF/WHO 2009 *Diarrhoea: Why Children Are Still Dying and What Can Be Done*. New York.

UNICEF 2012 Pneumonia and Diarrhoea, Tackling the Deadliest Diseases for the World's Poorest Children; ISBN: 978-92-806-4643-6, 86 pages.

UN-Water 2006 *Gender, Water and Sanitation: A Policy Brief* [Report] http://www.unwater.org/downloads/unwpolbrief230606.pdf UN Water.

WaterAid 2008 *Feeling the Pulse, A Study of the Total Sanitation Campaign in Five States*. New Delhi.

WHO 2002 *The World Health Report 2002*. Reducing Risks, Promoting Healthy Life, World Health Organization, Geneva.

WHO 2008 *The Global Burden of Disease: 2004 Update*, World Health Organization, Geneva.

WHO/UNICEF 2013 Joint Monitoring Programme (JMP) Progress on Sanitation and Drinking Water.

WSP 2007 *Public Toilets in Urban India: Doing Business Differently: Water and Sanitation Program – South Asia*. New Delhi.

WSP 2008 Technology Options for Urban Sanitation in India: A Guide to Decision Making. Water and Sanitation Program and Ministry of Urban Development, Government of India.

WSP 2010 *The Economic Impacts Of Inadequate Sanitation In India*, World Bank, Water and Sanitation Program. New Delhi, India.

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