sustainable sanitation alliance

SuSanA – factsheet

Cost and economics

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Key messages

Financial and economic analyses – by comparing the costs and benefits of alternative sanitation options – enable decision makers to allocate limited resources more efficiently. Sanitation projects and programs are increasingly applying financial and economic analysis – however, the large diversity of measures and settings make it hard to compare different studies and transfer findings across different locations. Hence, greater awareness of the analytical methods and indicators is required by researchers and research users.

Aims of this factsheet

The aims of this factsheet are to introduce the concepts of costs and economics, to present simple analytical tools for comparing sanitation interventions, and to illustrate these concepts and tools using evidence from previous economic studies. This factsheet serves as a background to future factsheets on costs and economics which will report results of field studies. The target group consists of sanitation practitioners, researchers and policy makers, as well as of development practitioners who are less familiar with the topic of sanitation. Readers are also referred to the factsheets of other working groups of the Sustainable Sanitation Alliance (e.g. treatment options, productive sanitation systems, operation and maintenance – www.susana.org). The reference section provides materials sources and suggests further reading.

Aims of financial and economic analyses

Financial and economic analyses are crucial in planning and delivering affordable and sustainable sanitation services. These analyses enable assessment of **intervention efficiency** for different sanitation options. Financial analysis focuses on the cash costs and cash returns of sanitation spending, while economic analysis also includes the broader societal costs and benefits, including both cash and non-cash. These various analyses assist decision makers to maximize the return on limited spending on sanitation programs, enabling the selection of appropriate approaches for a range of socio-economic, climatic, geo-physical and cultural contexts.

Furthermore, economic benefits can valuably support **sanitation advocacy efforts,** with the aim of increasing political support and household/community knowledge to lead to greater prioritization of sanitation and hygiene.

An established framework exists for conducting financial and economic analyses, enabling the comparison of sanitation interventions with respect to monetary as well as non-monetary outcomes, and from several perspectives. Outcomes of sanitation interventions measured in monetary units gives rise to **cost-benefit analysis (CBA),** while measurement of impacts in physical units (e.g. health gains) gives rise to **cost-effectiveness analysis (CEA)**. Where sanitation projects achieve similar or identical outcomes, **cost comparison** helps identify the most viable option.

Financial analysis: elements and indicators

The financial assessment of improved sanitation is based on investment costs (including both “hardware”, such as toilets, and “software”, such as awareness campaigns or social marketing), operation and maintenance costs.

Pic.1: Hygiene promotion activities for philippino children during Global Handwashing Day 2008 Source: Robert Gensch

The financial assessment includes monetary revenues from the sale of by-products (water for irrigation, compost, electricity) but does not include the valuation of economic costs or benefits without cash-flow (see economic analysis section below). A disaggregation of different perspectives is useful:

- Households - at the time of investment (e.g. connection fee, toilet investment, etc.) and during operation (e.g. wastewater levy, cost of sludge removal, etc); and
- Third parties - in the form of investment subsidies or recurrent subsidies, sourced from donor funds, state budget or cross subsidies such as from water sales.

To allow a comparison between different projects or different options within one location, the full cost per person served per year are related to national or regional per capita GDP (**Indicator 1: full cost of sanitation as % of GDP**). In case of subsidies, households will have to cover only part of the full cost, which is reflected in the cost born by households as % of local or regional per capita household income (**Indicator 2: annual cost of sanitation as % of household income**). These illustrative indicators are easy to understand and can give decision makers a first indication on required tariffs and affordability (see Table 1 on page 4).

If households must make a major contribution up-front (e.g. own investment or connection fee) without access to a functioning credit market, this single payment might constitute a serious hurdle. This can be expressed as per capita access cost as % of local or regional per capita household income (**Indicator 3: cost of access to sanitation as % of household income**).

Economic analysis: elements and indicators

Economic analysis requires the valuation of economic costs and benefits. It is limited to the availability of reliable data. Important economic impacts are:

- Labour (economic cost: household labour for investment, operation and maintenance; economic benefit: economies of time).
- Reuse of nutrients, water and energy.
- Health impact (avoided deaths and avoided morbidity).
- Perceived improvement of living quality such as privacy, dignity, convenience and status.
- Environmental impact such as reduced water pollution or increased attractiveness for tourism.

Economic analysis of selected factors (e.g. reuse of nutrients and energy) can use the long run household costs and benefits per person served per year, as % of local or regional per capita household income (**Indicator 4: costs and benefits as % of household income**). Only larger programmes will justify research and full cost-benefit analysis. In these cases, the *ratio of total benefits divided by total costs* or the *internal rate of return* can provide additional information for policies and decisions (**Indicator 5: benefit-cost ratio (BCR)** and **Indicator 6: economic internal rate of return (EIRR)**).

Financial and economic data for policy making

Financial and economic analyses are key policy tools, which provide practical information and guidance on sanitation options which perform well with respect to financial and economic criteria. They can be used alongside or within other decision making frameworks such as multi-criteria analysis. The narrower cost-effectiveness analysis (CEA) can be used if valuation of benefits is difficult; while cost-benefit analysis (CBA) is a broader method that combines multiple impacts of improved sanitation in a single framework expressed in monetary units (e.g. economic gain per unit of investment).

Financial and economic evidence can be tailored to a range of target groups – groups that have some influence in decisions over choice of sanitation technology or programme implementation:

- For those controlling budgets for allocation to sanitation programmes, the primary concern is for overall programme efficiency, including household, community and external benefits of improved sanitation. Also important to policy makers are the overall financing needs for different programme components and the different sources from which to finance these programmes.
- For some implementers such as non-governmental organizations, concern will be not only the overall gains, but greater attention tends to be given to the fair distribution of the programme gains, and directing of subsidies to poor and vulnerable groups.
- While for the ultimate beneficiary – the household – the interest will be on private benefits and the investment and running costs that must be covered by the household.

In providing the results of financial and economic analyses to potential users, traditional measures such as the benefit-cost ratio (BCR), internal rate of return (IRR), or net present value (NPV) – which summarize succinctly the efficiency aspects of alternative programs – should be supplemented with easy-to-understand and relevant information that provide answers to key questions of target audiences. For example, a family may be considering a sanitation upgrade, but does not know if the more expensive models are worth the higher price. Therefore, financial and economic analyses need to provide the decision maker with very specific information about the real costs and durability of different technologies - from the decision maker's perspective (e.g. household). This means not just knowing the purchase price, but also operation and maintenance costs, the economic life-time of the technology and the associated additional (direct or indirect) benefits to the user such as health, comfort and protection of the local environment.

Depending on the sanitation baseline (starting position of household), outputs of economic analysis can show the overall

costs and benefits of improved sanitation compared to no or unimproved sanitation.

Pic. 2: National decision makers gathering at a national sanitation event in Hanoi, Vietnam Source: Guy Hutton

Hence, financial and economic evaluation seeks to provide further insight into the relative cost efficiency of different options – not just one or two standard options, but the locally adapted range of feasible alternatives – as a basis for informed choice. The inclusion of all feasible options is of key importance in informing decision makers and planners of the potential range of sanitation options in a single context.

To date, there is limited published cost and economic evidence relating to different sanitation options, and available evidence has not been systematically compiled. Many of the argued (or predicted) benefits of reuse oriented sanitation are hypothetical (not yet proven) or heavily related to context-specific program conditions. The size of benefit may be closely related to the degree of community acceptance of excreta reuse, hygiene behaviour change and other factors that determine successful adoption of technologies. In order to assess the relative sustainability of sanitation options, comparative studies need to be conducted in a range of countries and range of settings to show the real costs and benefits of moving from unimproved to better and more sustainable sanitation options.

Financial analysis: costs of sanitation

The cost of sustainable sanitation options is a very important variable for the decision whether to invest or not, and the choice of technology. Households, in particular poor ones, are highly sensitive to price in their purchase decisions, especially for sanitation which is not usually a priority item. Table 1 shows total costs of sanitation options as % of GDP per capita and household costs as percent of income from a range of locations. Comparability of studies is reduced as some options include wastewater conveyance and treatment while others do not.

Investment and recurrent costs: sanitation systems require upfront capital investment while the purchase price considers solely the up-front investment expenditure. Investors of sanitation systems (e.g. utilities, local councils) need to consider the recurrent costs for the operation and maintenance to ensure sustainability. The proportion of investment costs compared to the total cost varies between different sanitation options also as the proportion between construction and operation and maintenance costs varies according to the project scale (see Figure 1).

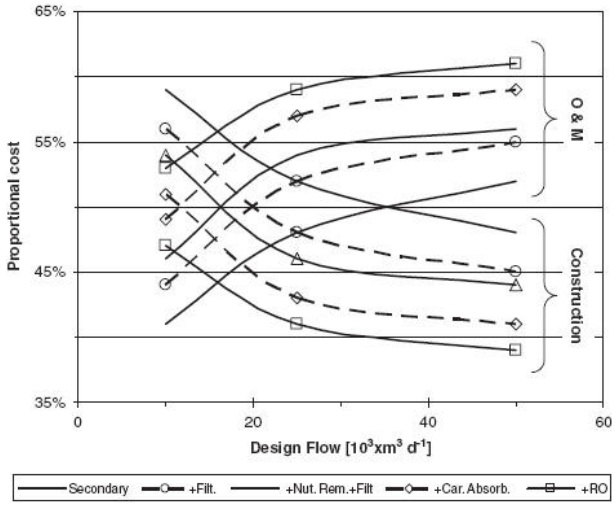

Fig. 1: Proportion of construction and operation and maintenance costs of the total annual costs of sewage treatment plants as a function of treatment level and flow rate Source: Friedler & Pisanty (2006)

Hardware and software costs: Hardware costs arise from the physical investment, including planning, works supervision and labour, while software costs include promotion and advocacy (demand creation), hygiene and system use education, sanitation supplier training, capacity development of stakeholders, monitoring and follow-up. Software components targeting community acceptance and behaviour change are increasingly recognized as being essential for the uptake, compliance and long-term sustainability of sanitation, and hence should be planned and fully budgeted for in scaling up pilot programmes to larger scale. In low-coverage developing world contexts, sanitation improvements that respond to user 'demand' – corresponding to the needs and preferences of the local population as well as affordability of sanitation options – are more likely to be effective in achieving the desired program outcomes.

The following table shows ranges on costs per sanitation option and considerable difference in the share of operation and maintenance costs as part of total costs, ranging from 0% in the Indian example of pour flush latrines to 42% in the case of a biological treatment plant in Turkey.

Location and type of sanitation	Inhabitants served	Indicator 1, Total LRMC as % of GDP	Indicator 2, annual costs of sanitation as % of household income	O&M as % of full cost	Software as % of investment	Source
Kuje, Nigeria combined sewage and offline treatment	582 (rural)	1,14%	1,82%	n.a	n.a	Illesanmi (2006)
Berlin, Germany conventional gravity based systems, WWTP	4,891 (peri-urban)	0,86%	0,84%	15%		Oldenburg (2007)
conventional gravity based systems, one stream, SBR		0,64%	0,63%	10%	n.a	
urine separation/storage, brownwater vacuum system and biogas reactor, greywater treatment SBR		0,69%	0,68%	5%	n.a	
Rajasthan, India* pour-flush and bathroom, on-site (mostly deep soak pit)	1,050,000 (rural)	0,5%	n.a	0% **	11%	KfW (2008)
Bahia, Brazil* mixed systems (ponds, anaerobic Imhoff tanks and gravel sand filters)	34,000 (rural)	0,6%	0,1 – 0,2%	27%	21%	KfW (2008)
Haikou, China* central system, reuse of energy and nutrients	850,000 (urban)	0,7%	0,4%	31%	2.4%	KfW (2008)
Fethiye, Turkey* mechanical-biological treatment, nutrient removal, disinfection	65,000 (urban + tourists)	0,7%	n.a.	42%	5%	KfW (2008)

Tab. 1: Total costs, household costs and operation and maintenance cost as % of total costs and software as % of investment expenditure for selected sanitation examples worldwide *Go to http://www.susana.org/index.php/lang-en/working-groups/wg02/case-studies-wg02 for case studies; **No cash; GDP – gross domestic product; SBR - sequencing batch reactor , WWTP – wastewater treatment plant

Tools of financial analysis

Given the range of sanitation stakeholders, there may exist different interpretations of the word 'cost' and the forms of cost presentation. Households naturally are interested in the costs of a single sanitation option as it relates to their particular household, including only the components they actually have to pay for. For a comparison beyond specific requirements of programme implementers or national governments, some basic tools and ratios are helpful:

- The combined investment and recurrent costs are expressed as a net present value (NPV) over the useful lifetime of major investment components, and can be subtracted from the NPV of financial benefits to estimate the **financial net present value (FNPV)**.
- Costs can be annualized to aid judgements about affordability. A concept similar to the accounting term of asset 'depreciation' encourages long-term thinking and investment in technologies that are financially sustainable.
- The ratio of the financial benefits to the costs is termed the **financial internal rate of return (FIRR)**. This measure expresses the average annual rate of financial return on the investment over the life span of the investment, and takes into account investment and recurrent costs.
- For a comparison of different sanitation approaches, costs are best expressed as **cost per inhabitant served per year** (long run marginal cost - LRMC). For central sewer systems, decision makers often prefer the cost of sanitation related to water sales. This allows correlating full costs to current sanitation tariffs.
- Costs expressed in local currency and in real prices of the base year of the study (i.e. without inflation) facilitate national and local ownership of financial analysis. In theory, the discount rate used should reflect the return on alternative capital investments in a given national economy. If there is no accepted national discount rate, many actors use a discount rate of 5%.

Economic costs and benefits of sanitation

Economic versus financial costs: while financial costs are those that need to be financed with cash, economic costs also include in-kind contributions of labour and materials. Together, financial and non-financial costs reflect the full 'opportunity' cost of resources employed: that is, the opportunity lost from using cash, labour effort and materials in sanitation rather than in another productive use.

The importance of this distinction is that financial costs to households can be reduced by encouraging in-kind contributions of household members, and hence not only

increasing participation (which is likely to increase use of sanitation, and make it easier for the household to maintain and repair their sanitation facility), but also reducing the requirement for cash funds. Populations, especially in rural areas, have access to materials such as sand, stones, wood or plant materials for latrine construction. Experience has shown that family members are willing to contribute their time and effort as substitute for local workmen who must be paid in cash. Also, for toilets with re-use options, or simply pit emptying, there will be costs for the work involved, transportation and storage, whether covered through cash payment or in-kind contribution. The most common approach for 'shadow price' valuation of own labour is the price of local non-qualified labour.

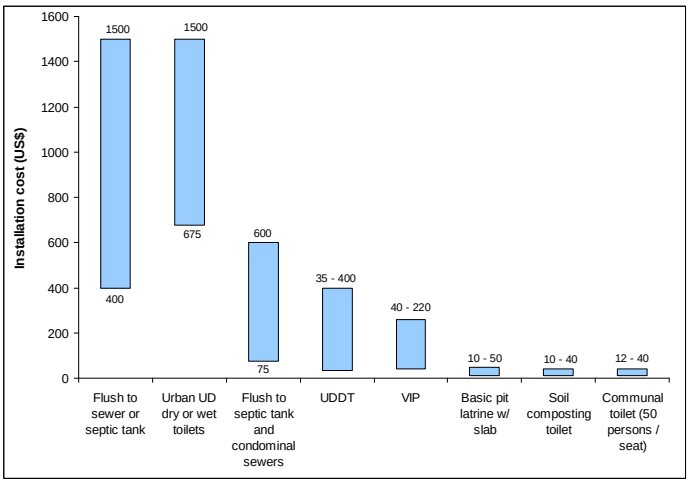

Fig. 2: Typical cost range for different sanitation options, per installation Source: Rosemarin et al. (2008)

Economic benefits of sanitation: Assessment of the benefits of improved sanitation has three linked purposes:

(1) To indicate what negative impacts poor sanitation has on the population, and, by implication, what gains in welfare are possible by improving sanitation.

(2) To feed into cost-benefit analysis or cost-effectiveness analysis, where the costs of each sanitation option are directly compared with the benefits of each option to conclude which are most efficient.

(3) To be able to compare the cost-effectiveness of sanitation interventions with other types of development interventions, e.g. building hospitals or schools.

Improved sanitation has a whole range of potential benefits, ranging along a continuum from the direct and more easily measurable to the indirect and difficult to quantify. Some of the major categories of benefit of improved sanitation include: health impact, water resources impact, time savings impact, intangible population preferences, value of the products of human excreta (fertilizer, biogas), and wider benefits for the economy related to tourism and the business environment. Where reliable data are available, these economic benefits can be quantified and converted to monetary units to include in full economic evaluation (see next section).

A study conducted by WSP in South East Asia in 2007 (Figure 3) found that poor sanitation and hygiene led to annual economic losses in the order of 1% (Philippines, Vietnam), 2.3% (Indonesia), 5.5% (Lao PDR) to as high as 7% (Cambodia) of Gross Domestic Product, equivalent to an average annual cost per capita of at least US$ 9.3 (Vietnam), US$ 16.8 (Philippines), US$ 28.6 (Indonesia), US$ 32.4 (Cambodia) to 33.6 (Lao PDR), at prices in the year 2005.

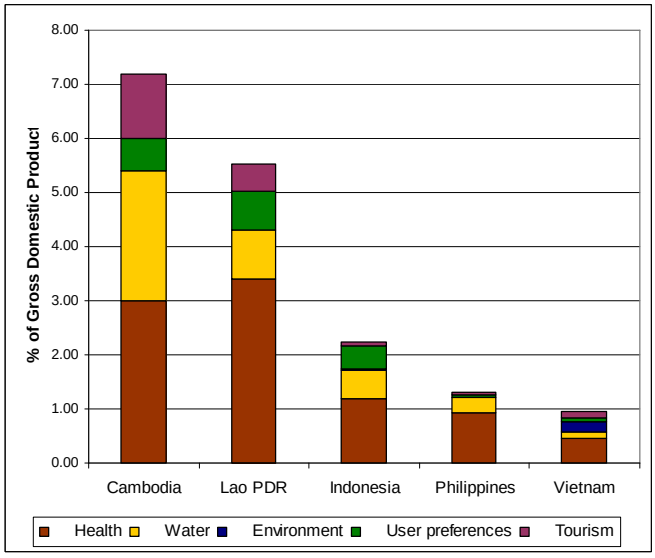

Fig. 3: Economic losses resulting from poor sanitation and hygiene in five countries of Southeast Asia, as % of annual GDP Source: Hutton et al. (2007)

As the above-mentioned study found, quantifying sanitation impacts and converting to monetary values to give accurate estimates of economic impact or benefit is a challenging task. First, improved sanitation is one of many ongoing development 'interventions' that affect socio-economic outcomes, such as health, education, agriculture and private sector development initiatives. Hence, robustly designed studies are needed which conduct data analyses adequately, accounting for a range of confounding variables. Second, the step of monetization adds a further layer of uncertainty on the already uncertain physical/natural measurements of sanitation benefits. Prices can be highly variable, or markets may be imperfect thus distorting prices from the market equilibrium price level (which is the standard measure of welfare impact in economics). Additionally, prices may not exist at all, such as for some benefits of sanitation (e.g. comfort value, increased security for women or social impacts of improved sanitation) and thus need to be ascertained through proxy pricing or contingent valuation techniques. Hence, the analyst must compare the methods available, justify selection of a single method; and conduct sensitivity analysis to assess how uncertainty in price assumptions affects the overall benefit estimation.

In evaluating and comparing sanitation solutions, **it should be noted that many benefits are common to re-use as well as disposal-oriented sanitation options.** For example, sanitation improvements that focus exclusively on the condition of the latrine, but not on what happens to human excreta after storage, can also have major health benefits, especially when improved hygiene practices are adopted. In developed countries, central sewer systems contributed to a major decline in waterborne diseases long before proper wastewater treatment started. In addition, well-designed pit latrines with no intended excreta re-use may have some water resource and environmental benefits when compared with open defecation practices and poorly planned pit latrines (e.g. near a water source). Furthermore, household members who have access to a private pit latrine will enjoy welfare gains (privacy, convenience) – especially women and the elderly – and users will spend less time accessing the toilet when compared with those practicing open defecation or using a shared toilet.

The economic advantages of sustainable sanitation options compared to unimproved sanitation options (e.g. pit latrines without a slab; wastewater collection without treatment) focus on **better environmental and health performance.** Sustainable sanitation options reduce release of pathogens from human excreta to the environment through leaking pit latrines, excreta flushed directly into water bodies, or incompletely treated wastewater. Human excreta in groundwater or surface water have potentially major implications for health and affect productivity or usability of the surface water body, e.g. for fishing or domestic water supply.

Pic. 3: Community water sources become contaminated with wastewater Source: Guy Hutton

A further financial or economic gain can be realised with re-use-oriented sanitation systems: **re-use of treated wastewater, human excreta fertiliser and biogas.** Human excreta (also in form of sludge from central treatment plants) can be used as fertilizer and soil conditioner (after composting). Based on the local price of mineral fertilizers, the estimate of the economic value of the nutrients (N,P,K) contained in urine and faeces shows that a person produces fertilizer worth between US$ 5 and US$ 10 (Schuen 2008).

The use of human excreta as fertilizer is especially relevant in land-locked countries where the cost of imported fertilizer is significantly higher than the world price; and given the increasing scarcity (and price) of phosphorus, the re-use value of human excreta also increases. Also, biogas generation in sludge digesters of larger wastewater treatment plants and household or community biogas digesters produce biogas as well as fertiliser. A household biogas digester mainly relies on organic waste from animals, because human excreta can cover only 15-30% of the household's energy need for cooking (according to climate and cooking habits).

Pic. 4: Tanks with sanitized urine for further distribution as fertilizer in Ouagadougou, Burkina Faso Source: Abdoulaye Fall

Available estimates of economic benefit of excreta re-use in the literature are largely based on hypothetical returns using expected excreta production, quality and prevailing market prices, as opposed to actual household economic impacts (Rockström et al. 2005; Oldenburg 2007; Renwick et al. 2007). Established markets for trade in human excreta are not yet documented, and it is not clear whether the same nutrient or fuel volume/weight would receive the same prices as, say, chemical fertilizer, conventionally produced compost or liquefied petroleum gas (LPG).

Many projects promoting excreta re-use as fertilizer or soil conditioner and biogas production involve own-use of the products by the household or the institution, such as a school or a prison. So far, few data exist to suggest the actual financial or economic value of these products. In the absence of in-depth research, a careful use of shadow prices is most appropriate to reflect the upper limit of economic value (i.e. equivalent fertilizer saved or increased crop or vegetable production – similar to treated wastewater re-use in agriculture). If the own-use of excreta products fully coincides with nutrient requirements of crops, nutrients can be valued at shadow prices of mineral fertilizers on local markets minus the value of additional own labour required. If nutrients are transferred to other farmers, the

effective payment (price) for transaction can be included in the financial analysis. Similarly, biogas for cooking can be valued at market prices for firewood or fuel, if there is a local firewood or fuel market. If faeces are converted to compost, the local price of compost can be used for economic estimates.

Other economic gains which need to be assessed:

- Water savings can be valued at the cost of provision of additional drinking water.
- Treated wastewater or greywater may be re-used for irrigation or aquifer augmentation. The market price for irrigation water from other sources can be used to value the benefit of own-use. If treated wastewater is used through an irrigation system, the effective payment (market price) for water minus cost of transfer is a more realistic approach.
- Households who re-use their waste do not need to pay for pit emptying services or build a new pit when the old one is full.

Tools of economic analysis

Economic analysis uses the same **cost-efficiency** tools as described in the financial analysis section. For economic analysis, input data will include not only the financial cash flows, but also in-kind or external costs and benefits. Most commonly, health and environmental outcomes are assessed in some form. The prevention of pollution of water bodies can be measured in terms of cost per kg of biochemical oxygen demand (BOD) removal. This approach is helpful if some costs and benefits (e.g. own labour for investment, time savings during use) can be valued easily, while there are no reliable data for other important benefits (e.g. health or environment). If monetary valuation of all major economic costs and benefits seems possible, a cost-benefit analysis may include the following outputs:

Costs and benefits as share of household income: the economic analysis on household level will include all costs and benefits of households (in cash and in-kind). This allows, e.g., to better assess whether the total economic costs are affordable or whether benefits are high enough to be perceived as such. Ratios can also be determined for institutions.

The **benefit-cost ratio** (BCR) is calculated by dividing the discounted benefits by the discounted costs of the sanitation intervention, and can be used to compare a sanitation option with 'doing-nothing'. This simple indicator can also compare different sanitation improvement options. Two types of studies reporting BCRs can be distinguished: (i) those reporting the costs and benefits generally associated with improved sanitation ('macro' studies); and (ii) those comparing the costs and benefits of alternative sanitation options in a single context ('micro' studies).

The **internal rate of return** (IRR) measures the equivalent return on investment in percentage terms, taking into account monetary cash-flows as well as non-monetary costs and benefits over the lifetime of the sanitation improvement. It allows comparison between the efficiency of the intervention with other potential uses of funds. Economic internal rates of return tend to be significantly higher than financial ones, due to non-financial health, environmental and re-use benefits of sustainable sanitation options. For example, a study of three African countries on integrated household biogas and sanitation showed a financial IRR of around 10% compared to an economic IRR of over 70% (Renwick et al. 2006).

The **cost-effectiveness ratio** is a more specific tool that compares costs with a single outcome of sanitation improvement, expressed in physical (non-monetary) units such as inhabitants better served, health gain or reduction in pollution. It is generally used in public sector planning.

Implications for sanitation financing

This factsheet has shown the differences between financial and economic analyses; the use of such analyses and the data generated which can have major implications for financing of sanitation programs. While on the one side, improvements in sanitation may have a large economic benefit for society as a whole. On the other side, the priorities of sanitation decision makers – such as individual households, school administrations, local governments, national governments – tend to set investment priorities differently, based on financial constraints and self-interest. Indeed, financial investment costs are often stated as one of the major barriers to increasing sanitation coverage – next to the lack of political will. Therefore, it is important to know what cash sum is affordable for the beneficiaries (households, communities, schools, etc.) and which share has to be financed either by the government, through grants (subsidies), loans from the bank, or in-kind contributions (Mehta 2005). Loans for individual households are one way to annualize the investment costs and thus facilitate investments, assuming the household prioritizes sanitation. Another way is to finance investment (wholly or partly) through water (and sanitation) utilities. Utilities will then re-finance the investment over time through user fees. Members of the Sustainable Sanitation Alliance are working on sanitation financing, and will produce further publications on this issue.

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